

ENERGY AND WATER DEVELOPMENT APPROPRIATIONS FOR 2020

HEARINGS BEFORE A SUBCOMMITTEE OF THE COMMITTEE ON APPROPRIATIONS HOUSE OF REPRESENTATIVES ONE HUNDRED SIXTEENTH CONGRESS FIRST SESSION

SUBCOMMITTEE ON ENERGY AND WATER DEVELOPMENT,
AND RELATED AGENCIES

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ENERGY AND WATER DEVELOPMENT APPROPRIATIONS FOR 2020

TUESDAY, MARCH 26, 2019.

DEPARTMENT OF ENERGY FISCAL YEAR 2020 BUDGET REQUEST

WITNESS

HON. RICK PERRY, SECRETARY OF ENERGY

Ms. KAPTUR. Good morning. The subcommittee will come to order as we begin our first hearing on the fiscal year 2020 budget request. Thank you, Secretary Perry for being here. Today's hearing will focus on the Department of Energy's budget request. The Department of Energy addresses our Nation's most pressing energy, environmental, and nuclear security challenges through transformative science and technology. With those challenges comes opportunity. Opportunity to make our Nation energy secured today and in perpetuity. Opportunity to drive down energy costs, opportunity to address climate change by making energy supplies cleaner and more resilient. Opportunity to invest in science and innovation that keeps our nation globally competitive. And, last but not least, opportunity to cost effectively sustain the Nation's nuclear deterrent while simultaneously working for nuclear non-proliferation.

Looking toward fiscal year 2020, however, the Trump administration proposes to cut the Department of Energy's budget by 11 percent. By drastically reducing or eliminating programs critical for Nation's needs and energy as well as our security, we can grow our economy by creating more jobs as our Nation transitions to a clean energy future and we need to get there faster rather than slower.

Emblazoned on the President's budget request are the words "A budget for a better America. Promises kept. Tax payers first." However, the proposals in this request tell a very different story. In fact, the President's budget request harms America's energy future, our competitiveness, our consumers, and our economy. Mr. Secretary, just when I think I can no longer be surprised by this administration, this budget request hits a new low and this is just from the small amount that has been made public to date. Once again, the budget justification documents we rely on have not been released.

In full and to say I am disappointed is an understatement. This request is riddled with backward looking proposals. Let's start with energy efficiency and renewable energy funding cut by 86 percent.

Notably, energy efficiency and renewable energy is responsible for creating and sustaining American leadership in the transition

to a global clean energy economy. Your budget even eliminates the Weatherization Program, which is critical for addressing the hidden pockets of energy asymmetry across our nation.

Then, the Advanced Research Projects Agency-Energy, which invents the future, is eliminated. Eliminated in your budget despite its history of success. Since 2009, ARPA-E has provided \$1.8 billion in research and development funding and 136 of those projects attracted more than \$2.6 billion in private sector follow on funding to propel our nation toward energy security and perpetuity.

Next, funding for the Office of Science is cut by over a billion dollars. This program funds research in vital areas such as advanced computing, biology and environmental sciences, chemistry, and materials research. All spur energy innovation that keeps our Nation globally competitive and strategically ready in a very competitive, often predatory, and, yes, even corrupt global marketplace. The energy future of our country cannot be left to chance. It depends on workers and clean energy, it depends on transition in coal country, it depends on a competitive U.S. industry, it depends on students and teachers and scientists who rely on the Department of Energy's investments to solve our toughest energy challenges. This request could eliminate over 6,100 jobs in our national lab system alone. Think about that. Something that you, Mr. Secretary, have called a crown jewel and we agree.

The fallout of this would be drastic given the multiplier effect on the Department of Energy's supported jobs that is in the range that could double or triple that job fallout. It is no secret that the innovation economy faces fierce international competition including those with true nefarious intent.

With respect to nuclear weapons, this is not a budget that establishes clear priorities with a responsible plan to fund and execute those priorities. Instead, this budget includes massive increases such as a 12 percent increase for weapons activities alone, which, as we have said before, is unsustainable. Sustaining the nuclear deterrent is a national priority, but it must be done in a cost-effective manner and I must express serious concern your request cuts key non-proliferation programs. With that, I'll close my remarks. I thank you, Mr. Secretary, for being here today. We look forward to discussing this request with you and adapting it accordingly and I'd like to turn to our ranking member, Mr. Simpson for his opening remarks.

Mr. SIMPSON. Thank you, Chairwoman Kaptur. I'd like to join you in welcoming Secretary Perry to today's hearing. Mr. Secretary, thank you for your continued service to our country. I look forward to hearing from you today on the fiscal year 2020 budget request and learning more about how it reflects your priorities for the Department of Energy. The Department of Energy's defense and non-defense missions are both critical to the strength of our Nation, but in distinct ways. The department's role in national security centers on its maintenance of our nuclear weapons stockpile and the support of nuclear navy. The department's role in economic security centers on its research and development efforts to understand and transform the Nation's energy systems.

The importance of DOE's defense activities is well-reflected in the fiscal year 2020 budget request with strong support for our nu-

clear weapons security programs including weapons activities, defense nuclear and non-proliferation and naval reactors. These programs and the other defense priorities in the Energy and Water bill must remain a high priority for this committee.

I am also pleased that the administration continues to propose funding for Yucca Mountain. It is the law of the land and I continue to support efforts to restart this stalled effort. The budget request for energy R&D programs, however, is not as robust. While certain select activities are well-funded, overall these programs are reduced by approximately 4.8 billion dollars from fiscal year 2019 enacted levels. That said, I think it is worth remembering that the DOE proposal is in the context of the President's budget request that adheres to the current law budget caps for non-defense discretionary spending. Congress passed and the President signed the law that created that cap level and if we want to change it, we will need to work together to once again craft a new budget deal that Congress can pass and the President will sign.

Secretary Perry, I'm trying to make you President right here, Secretary Perry, I appreciate you being here today to explain your budget request. I know my colleagues and I look forward to working with you to move forward a budget that will strengthen our Nation's security and advance our energy independence. Thank you, Chairwoman Kaptur.

Ms. KAPTUR. Thank you, Mr. Simpson, very much and I just want to commend members on both sides of the aisle for their appearance this morning. A very robust committee. A committee that cares deeply, Mr. Secretary, about this presentation today.

I will now turn to our witness, Secretary Rick Perry of the Department of Energy. Secretary Perry is the 14th Secretary of Energy. He previously served as the 47th governor of Texas for 15 years making him the longest serving governor in Texas history. Prior to his governorship, Secretary Perry served as Lieutenant Governor, Agricultural Commissioner, and in the Texas legislature. Thank you for taking the time to be here today. Without objection, your written statement will be entered into the record. Please feel free to summarize your remarks in approximately 5 minutes if you can. Mr. Secretary.

Secretary PERRY. Ms. Kaptur, thank you very much, Ms. Chairwoman, Ranking Member Simpson, and Members of the Committee. I'm honored to appear before you today to discuss the Fiscal Year 2020 Budget Request for the Department of Energy. I continue to say this is the coolest job I've ever had. It is a great privilege to serve as the 14th Secretary of Energy. This is an exciting time to be at the helm of DOE. I look forward to working with each of you on some incredibly important issues on passing a budget that invests in the Nation's priorities and our National Security while continuing our shared support of innovations that have led to America's world leading, yet I remind people often overlooked progress in reducing energy-related emissions.

When I appeared before the Committee last year, I committed to rebuild and restore our Nation's security; to protect to our critical electric grid and energy infrastructure from cyber threats; to improve the resilience and the reliability of the Nation's electrical system; to continue to seek a federal disposal solution for the Nation's

nuclear waste; to invest in early-stage, cutting edge research and development and to advance our leadership in exascale and quantum computing.

I'm proud to report to you and since then, DOE has advanced each of these goals. This budget request of \$31.7 billion seeks to build upon that great progress by making strategic investments that yield the best return on investment for taxpayers that benefit our country in the years to come. The Budget is a request to the American people through you, their representatives in Congress, to secure America's future through energy independence, scientific innovation, and national security.

As such, it represents a commitment for all of us at DOE to honor the trust of our citizens with increased stewardship, accountability, commitment to excellence. This request supports the Department's vast mission in a fiscally responsible way. It makes clear that success will be measured, not by the dollars spent, but by the results achieved on behalf of the American people. By investing in reliable affordable energy, transformative innovation, national security, we are approaching the dawn of what I call the new American energy era. A time of energy abundance and security and yes, even independence. American energy independence was used for a long time as just a sound bite, but thanks to innovation, today it is a reality. The Department's world-leading science and technology enterprise generates the innovations we need to fulfill our mission. Through support of cutting-edge research at our 17 national laboratories and at over 300 universities across the Nation, we are expanding the frontiers of scientific knowledge, accelerating the pace of discovery to address our greatest challenges.

This past fall, I fulfilled a commitment to visit all 17 of our Department's National Labs and I got to see first-hand the brilliant work performed by the dedicated individuals at each of these sites, and each one of these Labs has this rich history of science and innovation, and together, they have bettered countless lives around the world.

I am especially proud of the work the Labs are doing in collaboration with others to harness the power our world-class computing capabilities to maintain America's leadership in high performance computing, advanced exascale computing, and push for breakthroughs in artificial intelligence. To do that, this budget proposes investments in early stage research and development that will focus the intellectual prowess of our scientists and engineers on the development of technologies that the private sector can then convert to commercial applications to improve the lives and security of all Americans.

One example where this cross-cutting research and development will be done at the Department is in our new Cybersecurity Institute for Energy Efficiency and Manufacturing, which will provide 70 million dollars for early-stage research to help U.S. manufacturers remain resilient and globally competitive against cyberattacks.

This budget also requests significant funding to modernize our nuclear security enterprise, further nonproliferation efforts, and propel our nuclear Navy at sea, as well as supply the power for the fleet of the future. And, as we work to include America's nuclear

energy industry in our all-of-the-above strategy, we see really great promise in the next generation of advanced nuclear technology.

In the coming weeks and months, I look forward to working with you, your colleagues, your excellent staff, and others in Congress on the specific programs mentioned in this testimony and throughout the Department. Congress has an important role in the paths forward. I have met with many of you already; and I look forward to deepening our partnership for the benefit of the people that we serve. As we move ahead in this new American energy era, you have my pledge, Madam Chair, that we will continue to run DOE efficiently, and effectively, that we will accomplish our mission, and advance energy security, economic security, and national security for the American people. Thank you. I will be happy to attempt to answer any of your questions now.

[The information follows:]

**Testimony of Secretary Rick Perry
U.S. Department of Energy
Before the
U.S. House Committee on Appropriations Energy and Water Development
Subcommittee
March 26, 2019**

Chairman Kaptur, Ranking Member Simpson, and Members of the Subcommittee, it is an honor to appear before you today to discuss the President's FY 2020 Budget Request ("Budget Request" or "Budget") for the Department of Energy ("the Department" or "DOE").

It continues to be a great privilege and an honor to serve as the 14th Secretary of Energy.

This Budget is a request to the American people through their representatives in Congress to secure America's future through energy independence, scientific innovation, and national security.

As such, it represents a commitment from all of us at DOE that we will honor the trust of our citizens with increased stewardship, accountability, and commitment to excellence. For too long, government success has been measured by how much we spend on it. This Budget Request makes clear that success will be measured by how effectively and efficiently government is able to manage the precious resources entrusted to them by the American taxpayer to achieve its mission.

When I appeared before this Committee last year, I committed to protect our critical electric grid and energy infrastructure from cyber threats; improve resilience and reliability of the Nation's electricity system; make progress on the Federal Government's responsibility to dispose of the Nation's nuclear waste; focus resources on early-stage, cutting edge Research and Development (R&D); advance exascale and quantum computing; address responsibilities for the cleanup and disposition of facilities; and, rebuild and restore our Nation's security.

This FY 2020 \$31.7 billion Budget Request for the Department of Energy ("Budget") focuses on advancing these commitments – from opening a New American Energy Era to sustaining our recent historic economic growth by investing in reliable, affordable energy, transformative scientific innovation, and national security.

The Department's world-leading science and technology enterprise generates the innovations needed to fulfill our missions. Through support of cutting-edge research at our 17 National Laboratories and at over 300 universities across the Nation, we are expanding the frontiers of scientific knowledge and laying the groundwork for new technologies to address our greatest challenges.

When I became Secretary of Energy, I made a promise to visit all 17 of the Department's National Laboratories. I am pleased to report that I have fulfilled that promise and have witnessed first-hand the innovative and brilliant work performed by the dedicated individuals at each of these sites across the Nation. The National Laboratories are doing outstanding work in many areas. Each has a unique, rich history of innovation across a broad scope of scientific expertise, and the record of collaboration across the National Laboratory system – which makes its impact greater than the sum of its parts – has bettered the lives of millions across the globe.

For example, in 2018, the National Laboratories won 32 of the prestigious R&D 100 Awards, including technologies regarding new materials, protecting the environment, incorporating renewable energy reliably to the electric grid, and sophisticated cybersecurity tools. These are just a few examples of the work the National Laboratories have done just last year to push the boundaries of research, development, commercialization, and national security.

I am especially proud of the work the National Laboratories are doing in collaboration with other federal agencies, universities, doctors, and researchers to harness the power of our world-class supercomputers to maintain America's leadership in High Performance Computing (HPC), advance Exascale computing, and push for breakthroughs in Artificial Intelligence (AI).

To do so, this Budget proposes nearly \$11 billion in early-stage R&D that will focus the intellectual prowess of scientists and engineers on the development of technologies that the ingenuity and capital of America's entrepreneurs and businesses can convert into commercial applications and products to improve the lives and security of all Americans. The Budget also invests in laboratory infrastructure and test beds for future breakthroughs in energy. It prioritizes funding to maintain the world-class nature of national laboratory facilities and better facilitate private sector demonstration and deployment of energy technologies.

Securing Against Cyber Threats

In addition to nuclear security, our national security also depends on a resilient electric grid and successfully countering the ever-evolving, increasing threat of

cyber and other attacks on networks, data, facilities, and infrastructure. Among the most critical missions at the Department is to develop science and technology that advances these aims.

At stake is continued U.S. economic competitiveness and leadership, as well as the overall safety and security of the nation. We need to understand the increasing and evolving natural and man-made threats and develop the tools to respond to those threats across our energy infrastructure.

To that end, the Budget provides \$157 million for the Office of Cybersecurity, Energy Security, and Emergency Response (CESER) to develop tools needed to protect the U.S. energy sector against threats and hazards, mitigate the risks and the extent of damage from cyberattacks and other disruptive events, and improve resilience through the development of techniques for more rapid restoration of capabilities.

Securing against cyber threats means we must also protect against threats to the Department's own infrastructure in science, technology, and nuclear security. This Budget takes major steps to safeguard DOE's enterprise-wide assets against cyber threats. It provides \$71 million for the Chief Information Officer directed funding to secure our own networks, modernize infrastructure, and improve cybersecurity across the DOE IT enterprise. Funding for cybersecurity in the National Nuclear Security Administration (NNSA) is increased to \$208 million to enhance security for our nuclear security enterprise. In the Environmental Management program, we provide \$37 million for cybersecurity at seven cleanup sites.

This Budget provides the resources we require to secure DOE systems and energy infrastructure.

Improving Grid Resilience

As we protect our energy infrastructure from cyber threats, we also must improve the resilience and reliability of the nation's electricity system. The Budget provides \$183 million for the Office of Electricity to support transmission system resource adequacy and generation diversity. The Budget will explore new architecture approaches for electric transmission and distribution systems, including the development of the North American Energy Resilience Model that will provide unique and ground-breaking national-scale energy planning and real-time situational awareness capabilities to enhance security and resilience. The Budget continues to advance energy storage through the Advanced Energy Storage Initiative (AESI), including

development of a new Grid Storage Launchpad aimed at accelerating materials development, testing, and independent evaluation of battery materials and systems for grid applications. In addition, the Budget supports R&D at DOE's National Laboratories to develop technologies that strengthen, transform, and improve energy infrastructure so that consumers have access to reliable and secure sources of energy.

Addressing the Imperative of Nuclear Waste Management

The Budget includes \$116 million, of which \$26 million is in defense funds, to move ahead in fulfilling the Federal Government's responsibility to dispose of the Nation's nuclear waste. This request is dedicated to resuming regulatory activities concerning Yucca Mountain and initiating a robust interim storage program.

The Budget Request supports functions necessary to support regulatory activities, including legal support to represent the Department as well as responding to litigation and other legal matters. The Budget also provides for technical and scientific work necessary to support and respond to any challenges in the regulatory process. Resuming regulatory activities at Yucca Mountain and committing to a robust interim storage capability for near-term acceptance of spent nuclear fuel, our Budget demonstrates the Administration's commitment to nuclear waste management and will help accelerate fulfillment of the Federal Government's obligations to address nuclear waste, enhance national security, and reduce future burdens on taxpayers. This also will increase public confidence in the safety and security of nuclear energy, thus helping nuclear energy remain a significant contributor to the country's energy needs for generations to come.

Energy Independence and Innovation

The Budget requests \$2.3 billion in funding for energy independence and innovation. Within the applied energy program offices, the FY 2020 Budget focuses resources on early-stage, cutting-edge R&D conducted by the scientists and engineers at our 17 National Laboratories who are striving to develop the next great innovations that will strengthen American competitiveness and transform society as these breakthroughs reach the private marketplace.

The Harsh Environment Materials Initiative (HEMI) is a new coordinated effort within the Offices of Fossil Energy R&D (FE), Nuclear Energy (NE), and Energy Efficiency and Renewable Energy (EERE) to use common investments. This effort will coordinate interrelated R&D in materials, sensors, and component manufacturing R&D for advanced thermoelectric power plants between FE and NE.

For example, NE's budget includes \$23 million for the Nuclear Energy Enabling Technologies (NEET) Transformational Challenge Reactor program, which enhances the development of breakthrough technologies that provide the ability to manufacture small/micro advanced reactor components using additive manufacturing techniques. Investments will also be aligned with EERE's Advanced Manufacturing Office R&D in materials and manufacturing process research, as well as flexible combined heat and power systems.

The AESI is a coordinated effort across DOE that will accelerate the development of energy storage R&D as key to increasing energy security, reliability, resilience, and system flexibility technologies. The ASEI will focus DOE's efforts to take a broad, more holistic view of energy storage as a set of capabilities with temporal flexibility in the conversion of energy resources to useful energy services. The initiative will develop a coordinated strategy for aligning DOE R&D for cost competitive energy storage services.

The Budget supports, and makes for more efficient, programs focused on bringing technologies to the market in the Office of Technology Transitions, requesting a 7% increase from the FY 2019 enacted level. Through coordination with our Labs, these efforts will reduce costs to the taxpayer while at the same time providing an enhanced technology transfer program to transfer breakthroughs from the National Laboratories to the private sector.

Nuclear Energy

The Budget for Nuclear Energy focuses funding on early-stage R&D, such as the Nuclear Energy Enabling Technologies program, which includes \$23 million for the Transformational Challenge Reactor, at Oak Ridge National Laboratory, to continue to develop an advanced manufacturing technique to demonstrate a new approach to nuclear design, qualification, and manufacturing of advanced reactor technologies.

The FY 2020 Budget includes \$215 million for the Reactor Concepts Research, Development and Demonstration program. Within this total, the Budget provides \$100 million to put DOE on a path to construct the Versatile Advanced Test Reactor, a facility that would enable development and testing of advanced fuels and materials for the next generation of commercial nuclear reactors. This is one of the highest priorities for the Department. The Budget also provides

\$85 million for early-stage R&D on advanced reactor technologies, including \$10 million for the Advanced Small Modular Reactor R&D subprogram.

Within the Fuel Cycle R&D program, the Budget requests \$40 million for the high-assay low-enriched uranium (HALEU) Civil Nuclear Enrichment subprogram. This three-year cost-shared subprogram is designed to demonstrate a specific U.S. enrichment technology that could produce HALEU. We understand that multiple reactor designs under development by U.S. advanced reactor developers will require fuel containing HALEU. In addition, the Budget requests \$36 million for the Fuel Cycle R&D program's early-stage R&D work in support of industry's development of light water reactor accident tolerant fuels.

Finally, the Budget for Nuclear Energy also supports a safeguards and security program with funding at \$138 million for protection of our nuclear energy infrastructure and investments at Idaho National Laboratory facilities.

Fossil Energy Research and Development

The Fossil Energy Research and Development (FER&D) program advances transformative science and innovative technologies needed for the reliable, efficient, affordable, and environmentally sound use of fossil fuels. Fossil energy sources currently constitute over 81 percent of the country's total energy use and are critical for the nation's security, economic prosperity, and growth. The FY 2020 Budget focuses 89 percent, or \$501 million, on cutting-edge fossil energy R&D to secure energy dominance, further energy security, advance strong domestic energy production, and support America's coal industry through innovative clean coal technologies.

FER&D will support early-stage research in advanced technologies, such as materials, sensors, and processes, to expand the knowledge base upon which industry can improve the efficiency, flexibility, and resilience of the existing fleet of coal fired power plants. The request also focuses funding on early-stage component research that will enable the next generation of high efficiency and low emission coal fired power plants that can increase the resiliency and reliability of the electric grid by providing low-cost reliable power 24/7.

Funding is also provided to support competitive awards with industry, National Laboratories and academia geared toward innovative early-stage R&D to improve the reliability, availability, efficiency, and environmental performance of advanced fossil-based power systems. For example, the Advanced Energy Systems subprogram will focus on the following six activities: 1) Advanced

Combustion/Gasification Systems, 2) Advanced Turbines, 3) Solid Oxide Fuel Cells, 4) Advanced Sensors and Controls, 5) Power Generation Efficiency, and 6) Advanced Energy Materials. While the primary focus is on coal-based power systems, improvements to these technologies will result in spillover benefits that can reduce the cost of converting other carbon-based fuels, such as natural gas, biomass, or petroleum coke into power and other useful products in an environmentally-sound manner.

Energy Efficiency and Renewable Energy

The Energy Efficiency and Renewable Energy budget requests \$696 million, including the use of \$353 million in prior year balances, towards maintaining America's leadership in transformative science and emerging energy technologies in sustainable transportation, renewable power, and energy efficiency.

The Budget emphasizes early stage R&D and other activities, which private industry does not have the technical capability to undertake. Knowledge generated by early-stage R&D to facilitate U.S. industries, businesses, and entrepreneurs to develop and deploy innovative energy technologies, and to gain the competitive edge needed to excel in the rapidly changing global energy economy.

The request funds \$105 million for the AESI, which takes a holistic approach to energy storage and develops electric grid technologies to create flexible generation and load, thereby increasing the reliability and resilience of the U.S. electric grid.

The request supports DOE's Grid Modernization Initiative, which includes reliably integrating an increasing amount of variable generation into the electric grid through R&D infrastructure investments at the National Renewable Energy Laboratory (NREL) to accelerate the conversion of the National Wind Technology Center (NWTC) campus into an experimental microgrid capable of testing grid integration at the megawatt scale.

Strategic Petroleum Reserve

The Department of Energy is responsible for the Nation's energy security, and the Strategic Petroleum Reserve (SPR), one component of that effort, protects the U.S. economy from disruptions in critical petroleum supplies and meets the U.S. obligations under the International Energy Program. The Budget includes \$174

million to support the Reserve's operational readiness and drawdown capabilities. The Department is requesting authorization to deposit into the SPR Petroleum Account up to \$27 million in proceeds from the sale of one-million barrels of refined petroleum product (gasoline blendstock) from the Strategic Petroleum Reserve to fund the cost of drawdowns.

The Budget also proposes to disestablish the Northeast Home Heating Oil Reserve (NEHHOR). In its two decades of existence, the NEHHOR has not been used for its intended purpose, and the Administration believes the continued taxpayer-funded expense of maintaining the reserve is unwarranted, particularly as the existing commercial storage contracts are up for renewal in March 2020. The Budget also proposes to disestablish the Northeast Gasoline Supply Reserve (NGSR). The NGSR has not been used since its establishment, and is not considered to be cost efficient or operationally effective. Proceeds of the combined sales of the NEHHOR and NGSR (estimated at \$130 million in receipts, net of the \$27 million retained for mandatory sale drawdown costs) will be contributed to deficit reduction.

Power Marketing Administrations

The Budget includes \$78 million for the Power Marketing Administrations (PMAs). The Budget proposes the sale of the transmission assets of the Western Area Power Administration (WAPA), the Bonneville Power Administration (BPA), and the Southwestern Power Administration (SWPA) and to reform the laws governing how the PMAs establish power rates to require the consideration of market based incentives, including whether rates are just and reasonable. The Budget also proposes to repeal the \$3.25 billion borrowing authority for WAPA authorized by the American Recovery and Reinvestment Act of 2009.

Leading World-Class Scientific Research

The Department of Energy is the Nation's largest Federal supporter of basic research in the physical sciences, and the President's FY 2020 Budget provides \$5.5 billion for the Office of Science to continue and strengthen American leadership in scientific inquiry. By focusing funding on early-stage research, this Budget will ensure that the Department's National Laboratories continue to be the backbone of American science leadership by supporting cutting-edge basic research, and by building and operating the world's most advanced scientific user facilities, which will be used by over 22,000 researchers in FY 2020.

Support for Core Research and Facilities

We provide \$921 million for Advanced Scientific Computing Research, a decrease of \$15 million below the FY 2019 enacted level. This funding will continue supporting the Nation's world-class high-performance computers that make possible cutting-edge basic research, while devoting \$500 million in the Office of Science to reflect the Department's plan to deploy an exascale computing system in calendar year 2021. The FY 2020 Request also supports quantum computing R&D and core research in applied mathematics and computer science, and high-performance computer simulation and modeling.

The Budget also provides \$1.9 billion for Basic Energy Sciences, supporting core research activities in ultrafast chemistry and materials science and the Energy Frontier Research Centers. We will continue construction of the Advanced Photon Source Upgrade at the Argonne National Laboratory, and initiate the Advanced Light Source Upgrade project at the Lawrence Berkeley National Laboratory, and the Linac Coherence Light Source-II High Energy project at SLAC National Accelerator Laboratory. The operations of the light sources across the DOE science complex and supporting research across the Nation maintain U.S. world leadership in light sources and the science they make possible. The Budget also supports continued construction for Spallation Neutron Source Proton Power Upgrade and Second Target Station at Oak Ridge National Laboratory.

The Budget requests \$768 million for High Energy Physics, including \$100 million for construction of the Long Baseline Neutrino Facility and Deep Underground Neutrino Experiment at Fermilab, \$30 million below the enacted FY 2019 level. We will continue to fund ongoing major items of equipment projects, including three new projects at the Large Hadron Collider: the High Luminosity Large Hadron Collider Accelerator Project; the High Luminosity ATLAS; and the High Luminosity CMS detector upgrade projects. By supporting the highest priority activities and projects identified by the U.S. high energy physics community, this program will pursue cutting-edge research to understand how the universe works at its most fundamental level.

The Budget for the Office of Science provides \$403 million for Fusion Energy Sciences, including \$296 million for domestic research and fusion facilities and \$107 million for the ITER project to continue to support delivery of the highest priority in-kind hardware systems contributions. For Nuclear Physics, the budget provides \$625 million to discover, explore, and understand nuclear matter, including \$40 million for continued construction of the Facility for Rare Isotope Beams and operations of facilities. For Biological and Environmental Research,

the Budget includes \$494 million to support foundational genomic sciences, including the Bioenergy Research Centers, and to focus on increasing the sensitivity and reducing the uncertainty of earth and environmental systems predictions.

Advancing Exascale Computing

As I discussed last year, the Department’s leadership in developing and building the world’s fastest computers faced increasingly fierce global competition over the last decade. Maintaining the Nation’s international primacy in high-performance computing is more critical than ever for national security, economic prosperity, and a continued leadership role in science and innovation.

I am proud to say that, as of the present day, the Department is actively sustaining America’s leadership in this vital area. As of November, the world’s two fastest supercomputers were located at DOE National Laboratories – Summit at Oak Ridge and Sierra at Lawrence Livermore. In fact, the Summit system achieved the global number one ranking as the world’s fastest system in June 2016, was delivered nine months ahead of schedule and \$13.5 million below budget, and is another example of the DOE lab continued project management excellence. In all, the Department currently owns five out of the world’s top ten supercomputers. In addition, teams from DOE’s Oak Ridge and Lawrence Livermore National Laboratories captured the 2018 Gordon Bell Prize, the most prestigious award for achievement in high performance computing software and applications. These coupled achievements in both hardware and software are significant, since it is by sustaining integrated capabilities in hardware, software, algorithms, and applications – along with basic research in applied mathematics –that America will maintain leadership in this critical field.

To cement America’s leadership position, the Budget includes \$809 million to accelerate development of an exascale computing system, including \$500 million in the Office of Science (Science) and \$309 million in NNSA. This reflects the Department’s plan to deploy an exascale machine for the Office of Science in calendar year 2021 at Argonne National Laboratory, a second machine with a different architecture in the 2021-2022 timeframe at Oak Ridge National Laboratory, and provides support for the procurement of and site preparation for a third exascale system, architecturally similar to the second machine at Oak Ridge, delivered to NNSA at Lawrence Livermore National Laboratory in FY 2023.

To achieve these goals, the Science/NNSA partnership will focus on hardware and software technologies needed to produce an exascale system, and the critical DOE

applications needed to use such a platform. This world-leading exascale program will bolster our national security by supporting the nuclear stockpile, while also supporting the next generation of scientific breakthroughs not possible with today's computing systems.

Quantum Information Science

Even as we prepare to deploy exascale systems, we are pursuing research in Quantum Information Science (QIS), an emerging multidisciplinary area that has the potential to define the next frontier in information processing and a range of other fields. Our QIS effort is genuinely interdisciplinary, a \$168 million investment involving all six major DOE Office of Science program offices: Advanced Scientific Computing Research (ASCR), Basic Energy Sciences (BES), Biological and Environmental Research (BER), Fusion Energy Sciences (FES), High Energy Physics (HEP), and Nuclear Physics (NP).

The potential of QIS to contribute to a wide range of disciplines is striking. Quantum computing promises the capability to attack large problems that elude classical computing and to provide new insights into materials and chemistry through accurate modeling and simulation of quantum systems. In addition, QIS holds the potential of developing exquisitely sensitive quantum sensors, for applications ranging from biology to the effort to detect Dark Matter. Finally, QIS may hold the key to ultra-secure networking, at a time when cybersecurity is a mounting concern.

The Budget provides \$40 million to ASCR, BES and HEP to establish a new QIS center, which would integrate universities with National Laboratories, through investments across all six Science program offices. We are seeking to sustain U.S. leadership in this important and highly competitive area.

Artificial Intelligence/Machine Learning

Artificial Intelligence (AI), including Machine Learning (ML) defines another critical cross-disciplinary activity, with the potential to contribute to advances across multiple fields. This is another rapidly developing area in which it is vital for America to maintain a leadership role.

In a world awash with data, AI holds the promise of harnessing and deriving new insights from massive data sets. The massive quantities of data generated by DOE Office of Science user facilities such as X-ray lights sources are believed to provide a major opportunity for the development of new AI applications for data analysis.

It is also believed that AI may provide a pathway to improving the performance of particle accelerators and other key facilities. The FY 2020 Budget provides \$71 million for AI/ML spread across all six Science program offices for both the application of AI/ML to research and the development of new AI/ML approaches and algorithms as well as \$48 million requested in the FY 2020 Budget for NNSA for AI.

Microelectronics

By virtue of its leadership in supporting high-performance computing, as well as its longstanding sponsorship of research in materials science, the DOE Office of Science has been a major contributor over the decades to the development of microelectronics. Science has helped lay the fundamental scientific foundation for advances in these technologies, while partnering with industry in the development of new systems requiring new chips. This role is becoming increasingly important as we approach the end of Moore’s Law and stand at the threshold of what is likely to be a new era in microelectronics. In an important new initiative, the FY 2020 Budget provides \$25 million for redoubled research efforts on microelectronics. The research will benefit from groundwork laid at an October 2018 DOE workshop on “Basic Research Needs in Microelectronics,” bringing together top experts and co-sponsored by ASCR, BES, and HEP.

Biosecurity

As mentioned, back in 1986, the Department provided the original impetus and idea for the Human Genome Project, and later partnered with the National Institutes of Health, to successfully complete the sequencing of a human genome in 2000. Since then the Department’s Office of Science has remained on the cutting-edge of genomics-based system biology, making major contributions to the continued advancement of the relevant technologies. These dual use technologies have now advanced to a point where they pose new and unprecedented security challenges. To address this growing challenge, the FY 2020 Budget includes \$20 million for BER for research related to biosecurity.

Isotopes

One of the Department’s important contributions to medicine and industry is the Isotope Development & Production for Research and Applications Program, known more simply as the DOE Isotope Program. The program, managed by Science’s Office of Nuclear Physics, supports the production and development of production techniques, as well as radioactive and stable isotopes that are in short supply for

research and applications. In doing so, it provides a vital contribution to research, medicine, and industry. The Budget provides \$5 million to initiate a construction project for a U.S. Stable Isotope Production and Research Center at ORNL.

Fulfilling Legacy Cleanup Responsibilities

The mission of the Department's Environmental Management (EM) program is to complete cleanup of legacy nuclear weapons development and research sites. It is the largest program of its kind in the world and represents one of the top financial liabilities to the American taxpayer. EM is working collaboratively with regulators, federal, state, and local governments, and others toward a future that drives cleanup toward completion safer, sooner and at a responsible cost. As EM is put on a sustainable path forward, the FY 2020 Budget Request provides the resources necessary to build upon recent successes and bring a renewed sense of urgency to the program for meaningful and measurable progress at projects and sites throughout the cleanup complex.

The Budget Request includes \$6.5 billion for EM to address its responsibilities for the cleanup and disposition of excess facilities, radioactive waste, spent nuclear fuel, and other materials resulting from five decades of nuclear weapons development and production and Government-sponsored nuclear energy research. To-date, EM has completed cleanup activities at 91 sites in 30 states and Puerto Rico, and is responsible for cleaning up the remaining 16 sites in 11 states –some of the most challenging sites in the cleanup portfolio.

The Budget Request includes \$1.4 billion for the Office of River Protection at the Hanford Site for continued work at the Hanford Tank Farms and to make progress on the Waste Treatment and Immobilization Plant. This budget will continue progress toward important cleanup required by the Consent Decree and Tri-Party Agreement to include a milestone to complete hot commissioning of the Low Activity Waste Facility by December 31, 2023. The Budget also includes \$718 million to continue cleanup activities at Richland. The Budget continues River Corridor decontamination and decommissioning activities including remediation of the highly contaminated 300-296 waste site under the 324 Building. For Savannah River, the Budget provides \$1.6 billion, \$91 million above enacted FY 2019, to support activities at the site. This will include the Liquid Tank Waste Management Program, completing cold commissioning beginning operation of the Salt Waste Processing Facility, continued construction activities for Saltstone Disposal Unit #7 and #8/9 design and construction activities for Saltstone Disposal Unit #10-#12, and funding to support design and construction of the Advanced Manufacturing Collaborative facility.

The Waste Isolation Pilot Plant (WIPP) is essential for the disposition of transuranic defense-generated waste across the DOE complex, and the Budget provides \$398 million to safely continue waste emplacement at WIPP. The Budget Request will continue WIPP operations, including waste emplacements, shipments, and maintaining enhancements and improvements, and progress on critical infrastructure repair/replacement projects, including \$58 million for the Safety Significant Confinement Ventilation System and \$35 million for the Utility Shaft (formerly Exhaust Shaft). These steps will increase airflow in the WIPP underground for simultaneous mining and waste emplacement operations.

The Budget Request includes \$348 million to continue cleanup projects at the Idaho site, such as the Integrated Waste Treatment Unit, and to process, characterize, and package transuranic waste for disposal at offsite facilities. It provides \$429 million for Oak Ridge to continue deactivation and demolition of remaining facilities at the East Tennessee Technology Park, continue preparation of Building 2026 to support processing of the remaining U-233 material at the Oak Ridge National Laboratory, and support construction activities for the Outfall 200 Mercury Treatment Facility at the Y-12 National Security Complex and design for a new On-Site Waste Disposal Facility to support cleanup.

For Portsmouth, the Budget Request includes \$426 million to continue progress on the deactivation and decommissioning project at the Portsmouth Gaseous Diffusion Plant, safe operation of the Depleted Uranium Hexafluoride Conversion Facility, and construction activities at the On-Site Waste Disposal facility. At Paducah, the Budget Request includes \$277 million to continue ongoing environmental cleanup and depleted uranium hexafluoride (DUF6) conversion facility operations at the Paducah site. In addition, the FY 2020 Budget Request supports activities to continue the environmental remediation and further stabilize the gaseous diffusion plant.

The Budget continues funding of \$128 million to address specific high-risk contaminated excess facilities at Lawrence Livermore National Laboratory.

Together, these investments for EM will make significant progress in fulfilling our cleanup responsibilities while also beginning to address our high-risk excess facilities at NNSA sites.

National Security through Nuclear Security: Sustaining and Modernizing the Nuclear Stockpile and Infrastructure

Our national security rests upon the foundation of the Nation's nuclear security enterprise and the deterrent it provides. The Budget funds the overdue modernization of the nuclear stockpile and the aging infrastructure that supports it; strengthens key science, technology, and engineering capabilities that support stockpile modernization; reduces global nuclear threats through nonproliferation and counterterrorism initiatives; and designs and maintains safe and effective nuclear propulsion systems for the U.S. Navy for years to come.

The Budget fulfills the President's vision of rebuilding and restoring our Nation's security through investments in the Department's nuclear security mission. The Budget provides \$16.5 billion for the National Nuclear Security Administration (NNSA). Of this amount, the Budget Request includes \$12.4 billion for Weapons Activities. This \$1.3 billion increase supports maintaining the safety, security, and effectiveness of the nuclear stockpile; continuing the nuclear modernization program; and modernizing NNSA's nuclear security infrastructure portfolio in alignment with the Nuclear Posture Review.

The Budget includes \$2.1 billion for our ongoing Life Extension Programs (LEP), Major Alteration, and Modifications, a \$197 million increase. I am pleased to report that the W76-1 LEP completed its last production unit in December 2018. Final deliveries to the Navy will be completed by the end of this fiscal year. The W76-2 Modification, the low-yield variant of the W76, is on schedule, on budget, and will be completed consistent with Nuclear Weapons Council (NWC) direction. Funding for the B61-12 LEP and the W88 Alteration 370 will keep us on schedule to deliver the first production units in FY 2020. The Budget also supports the Air Force's Long-Range Stand-Off program through an increase of \$244 million from the FY 2019 enacted level for the W80-4 LEP to deliver the first production unit in FY 2025 of the cruise missile warhead. The request includes \$112 million for the W87-1 Modification Program, which will replace the W78, one of the oldest warheads in the stockpile, by 2030.

The Weapons Activities Budget request also includes \$309 million for NNSA collaboration with the Office of Science on the development of exascale computer systems; \$778 million for the protection of personnel, facilities, nuclear weapons, and materials across the Department's nuclear security enterprise; and \$232 million for information technology and cybersecurity protection.

The infrastructure portion in Weapons Activities increases investments to modernize our nuclear infrastructure, improve working conditions of NNSA's aging facilities and equipment, and address safety and programmatic risks through facility and equipment recapitalization and the stabilization of deferred maintenance. In this Budget is \$745 million for construction of the Uranium Processing Facility, which is needed to replace deteriorating facilities at the Y-12 National Security Complex, as well as \$123 million for the High Explosives Science and Engineering Facility at Pantex, \$27 million for a Tritium Finishing Facility at the Savannah River Site (SRS), and \$32 million for a Lithium Processing Facility at Y-12. The Budget also includes \$168 million to support the Department's commitment to finishing the Chemistry and Metallurgy Research Replacement Facility Project, which is necessary to support the pit production mission and other actinide activities at Los Alamos National Laboratory (LANL).

The highest NNSA infrastructure priority is re-establishing a plutonium pit production capability to meet military requirements, supported by numerous studies and analyses, of no fewer than 80 war reserve pits per year by 2030. Last May, the NWC endorsed NNSA's recommended alternative calling for plutonium pit production at LANL and SRS. This two-site approach bolsters the nuclear security enterprise's responsiveness and resiliency.

The Budget also includes \$2.0 billion for the Defense Nuclear Nonproliferation program to reduce global threats from nuclear weapons. This critical national security program prevents the spread of nuclear and radiological materials, and technologies, advances technologies that detect nuclear and radiological proliferation worldwide, and eliminates or secures inventories of surplus materials and infrastructure usable for nuclear weapons.

The Budget invests \$774 million at SRS in FY 2020, a 76 percent increase over FY 2019. NNSA will continue termination activities for the orderly and safe closure of the Mixed Oxide Fuel Fabrication Facility Project. The Budget will also continue to pursue a dilute and dispose strategy to fulfill the U.S. commitment to dispose of 34 metric tons (MT) of plutonium and modernize SRS infrastructure to support the tritium supply chain.

The Budget provides \$372 million for Nuclear Counterterrorism and Incident Response, \$53 million above the FY 2019 enacted level, to work domestically and around the world to improve our ability to respond to radiological or nuclear incidents, in conjunction with other agencies in a broader U.S. Government effort.

In the NNSA's Office of Naval Reactors, the Department has the ongoing

responsibility to provide militarily effective nuclear propulsion plants for the Navy and to ensure their safe, reliable and long-lived operation. The Budget provides \$1.6 billion to support the operation of the Navy's nuclear-powered fleet, the continuation of the *Columbia*-class reactor plant design, refueling of the land-based prototype reactor, and the construction of the Naval Spent Fuel Handling Facility.

Today, nearly 45% of the Navy's major combatants are nuclear powered. The Department's role in propulsion plant design, spent fuel handling, and recapitalization is critical to the Navy's ability to conduct its missions around the globe.

Finally, the Budget includes \$435 million for Federal Salaries and Expenses at the NNSA. This \$25 million increase is essential to ensuring our world-class workforce of dedicated men and women can effectively oversee NNSA's critical national security missions.

Focusing Priorities on Core Missions

The Budget continues to focus the Department's energy and science programs on early-stage research and development at our National Laboratories to advance American primacy in scientific and energy research in an efficient and cost-effective manner.

Also, in line with Administration priorities, the Budget terminates the Advanced Research Projects Agency-Energy, known as ARPA-E, and the Department's Loan Programs, while maintaining necessary federal staff to oversee existing awards and loans. Termination of these programs will save over \$850 million in FY 2020 alone while significantly reducing financial risk to the taxpayer moving forward.

Conclusion

In conclusion, I reaffirm my pledge that the Department of Energy, along with our National Laboratories, will continue to support the world's best enterprise of scientists and engineers who create innovations to drive American security, prosperity, and competitiveness. The President's FY 2020 Budget Request for the Department of Energy reflects the priorities to enhance our energy, economic, and national security today, while making strategic investments to accelerate the breakthroughs that will fuel America's tomorrow.

In the coming weeks and months, I look forward to working with you and your

colleagues in Congress on the specific programs mentioned in this testimony and throughout the Department. Congress has an important role in the path forward on spending decisions for the taxpayer, and I will, in turn, ensure DOE is run efficiently, effectively, and that we accomplish our mission-driven goals. Thank you, and I look forward to answering your questions.

Ms. KAPTUR. Thank you, Mr. Secretary, very much for your testimony. We will now begin questioning under our normal rules. I will ask one question so I can allow our members to proceed with theirs and then we will have more than one round. Mr. Secretary, your budget proposal cuts the office of science by 16 percent and the energy research and development programs by over half, 59 percent, two-thirds nearly. While the United States currently leads in research and development, in terms of total dollars spent, China is expected to surpass the United States by 2026. I might add parenthetically for they haven't already stolen. That would be a terrible moment in history. In looking at U.S. research spending relative to the size of our economy, the United States already dropped from 8th to 11th place between 2009 and 2015. We are sliding backward. We must sustain investments in innovation to maintain U.S. competitiveness in the future. So, how do you justify your budget's drastic cuts to the science and energy research and development programs at a time when China and other countries are investing trillions in innovative energy technologies? How do we keep up?

Secretary PERRY. Madam Chair, you are correct. We are in a real competition out there in the world and we see it every day. It is not always on a level playing field. As you rightfully point out that we have some competitors out there that do not follow the general rules of the game so to speak. China being one of those and their propensity to steal technology. One of the things, before I answer directly, I want to share with you that we recognize that—we understand that, and in our National Labs in particular, which is you fish where the fish are, and the Chinese and others understand that, and putting individuals into our National Labs, and putting individuals into our universities, is one of the great concerns that we have because they are in the business of collecting information, taking it back, and stealing it if you will. So, the Thousand Talents Program, the Department sent a very clear message out, not only to our National Labs, but to universities as well, that individuals and we would clearly define who these individuals are, and describe their characteristics, if you will. If they are involved in their labs, if they are involved in their universities, then there is not going to be federal dollars flowing into those.

So, I just wanted to address that up front. Since you brought that up, I think it is a very important role of which we play and that is to guard our very important secrets of our national defense.

So, with that said, one of the things that I am very proud of, as I said in my remarks, the results you are looking for I hope that is, and sometimes we have—as we were sharing backstage, having been an appropriator before I was a governor, is a very useful experience in life, I understand how this process works. I jokingly told Mr. Simpson that my governor's budget was a very useful doorstop from time-to-time. I understand how this process works. I respect it very much.

With that said, our crosscutting work that we have done at the Department, computing is a good example of it. Although there may be a reduction from 2019 Enacted, to 2020 Request, particularly in the area of artificial intelligence through other different line items, if you will, where we have focused on that particular ex-

penditure and that particular result, I am comfortable—we now have the two fastest supercomputers in the world, one of them at Oak Ridge that you oversee and the other at Argonne, where I was last week. Those projects are being funded and I think we may quibble about is this amount absolutely correct. The amount that you appropriate to us we will spend efficiently and effectively and I think the commitment to you and to your members of keeping America in this preeminent place relative to supercomputing. There may not be a more important role enterprise-wide than that. We understand it and we will work with you in any way that we can to make sure that the result is keeping America at that pre-eminent role in higher supercomputing capacity as we are on the road to quantum computing.

Ms. KAPTUR. Thank you, Mr. Secretary. I am glad you heard our deep concern about those massive cuts because you need intelligent people and we have to support a complex that is not viewed by others as being weakened so any additional material you wish to provide to the record on that topic, we would be grateful for. I would now like to turn to Mr. Simpson.

Mr. SIMPSON. Thank you. And to follow on that, you were constrained in this budget request by the law, which is the caps. And so, consequently, this is your budget priorities given this level of funding, not last year's level of funding or anything else. I have no idea what this year's level is going to be and what our 302B is going to be on this committee, but I understand the constraints that you have in trying to put this budget together within the caps, which are the law, which is what you have to do.

Let me start off by saying that I am pleased that the department has continued to request funding to reopen Yucca Mountain, the licensing process anyway. We need to move forward with the permanent repository without further delay. Could you tell us a little bit about the costs of delaying Yucca Mountain are in terms of the taxpayers dollars being spent as well as other negative impacts such as how willing are communities going to be to accept interim storage, which is on an interim basis if there is no likelihood of a permanent repository and they become the defacto permanent repository? Is that going to make it more difficult to have communities willing to accept waste from Yucca Mountain or waste from the sites that should be going to Yucca Mountain?

Secretary PERRY. Mr. Simpson, thank you. We have worked closely through my tenure at the Department, on this issue. I remind the Members and I remind the public that this is the law, and I held up my hand and committed to upholding the laws of this country, when I took this role. So, understanding that this is the law, and our budget asks for those line items that will, in fact, allow us to maintain the duties that we are required, by Congress, to conduct, the licensing of the site, for instance, Yucca. Also for the Nuclear Regulatory Commission, their funding of their, continuing, that is what this budget request is for, and there is also a request in there for interim storage. So, because if we do not do this, in some form or fashion, we will have 39 permanent repositories in America, and it is in every one of your states. I do not know if it is in every one of your districts or not, but it is certainly in every one of your states. I have a map, here, Madam Chair, that

is the 39 states where high level waste is now deposited, and I think that is the question for us, as the citizens, you as our elected officials. Is this going to be? I, certainly, hope that is not the case. We are going to be open to any of the ideas. The scientists that we have at the Department, in our labs, will work with Congress any way that we can to find the solutions here. We have been working with WIPP, out in New Mexico, to come up with some additional volumes, and the state agreed to that this last year, so that we can take more into that site. There is a site in West Texas, in Andrews County, that it is also a legitimate site, and, obviously, Yucca continues to—

Mr. SIMPSON. Let me ask you on that. Even the site in Texas, do you think that they would be willing to accept permanent storage?

Secretary PERRY. You know, I am going to leave that up to the current Governor to answer for you, directly. I can tell you what the previous Governor said, and he was very supportive of it being a permanent site. It worked that way. We had a low-level nuclear commission that worked towards that, while I was the Governor, and, again, I do not know, I am not going to speak for the current Governor or the current legislature, but for 14 years prior to those individuals coming on the scene, there was a clear effort to make, and the people of Andrews, the citizens of that county, are very, very supportive of that. So, my point is we have got to find a solution to this. Thirty-nine states as final repositories is not an appropriate solution to this. Thank you. Oh, and you asked me, I am sorry. You asked me, specifically, the cost. It is two million dollars a day. \$2 million a day is the cost of keeping the process that we have now in place, in these 39 states, eight billion dollars since 2010.

Ms. KAPTUR. Thank you, Mr. Simpson. We are now going to move to Congresswoman Wasserman Schultz.

Ms. WASSERMAN SCHULTZ. Thank you, Madam Chairman. Although, I need about 10 seconds to get myself organized, but thank you very much.

Mr. Secretary, it is good to see you. Thank you for your service, and I appreciate the opportunity to talk with you about some of our concerns and questions we have. Madam Chair, if I can just clarify, did you ask about the Office of Energy Efficiency and Renewable Energy?

Secretary PERRY. No.

Ms. WASSERMAN SCHULTZ. No? Thank you. Thank you. No, that is okay. Anyone that could answer the question is fine. Mr. Secretary, the mission of the Office of Energy Efficiency and Renewable Energy, or EERE, is to create and sustain American leadership in the transition to a global clean energy economy, but I was extremely disappointed to see that your budget request would cut funding for EERE by 86 percent. Effectively, what this does is shut down the office. I mean, there is no justifiable reason to devastate EERE like this. A cut like this is really a prime example of why this budget document is simply not a serious document, and one that we are likely to discard, and really focus on the priorities that we have, in terms of addressing our energy needs. So, what reason

does the Administration have for slashing this office and, basically, abdicating American leadership on energy?

Secretary PERRY. I think the focus on that we have, as I said in my remarks, the results that we are looking for that far outweigh just the straight up number of dollars that go into a particular line item. Our focus on battery storage, for instance, is one of the things that I would hold up and say, "Here is a proper focus of the Department; the \$90 million that we put into that program, the \$105 million into the Advanced Energy Storage Initiative, and FY2020, as well." The Advanced Energy Storage Initiative will also coordinate, across the Department, to integrate all of the storage sources, and that gets to the concept of crosscutting that I spoke about earlier, the coordination between different programs is, frankly, not accounted for in the way that we budget. In the line item process that we have in place. So, I am comfortable—

Ms. WASSERMAN SCHULTZ. Secretary, I need to be a little bit mindful that I am approaching two minutes left in my time, so.

Secretary PERRY. Okay. Yes, ma'am. Go ahead.

Ms. WASSERMAN SCHULTZ. Respectfully—

Secretary PERRY. Sorry.

Ms. WASSERMAN SCHULTZ [continuing]. That is, kind of, a Texas two-step answer.

Secretary PERRY. Well, I was just trying to Waltz with you.

Ms. WASSERMAN SCHULTZ. Yeah, and I—and I enjoy it. We do it backwards in high heels, like Ginger Rogers, but your budget request proposes to fund EERE for FY20 with \$353 million from last year's—last fiscal year's appropriated funds. Why have you not planned to spend this unobligated money, in accordance with Congressional direction, as specified in the FY19 Appropriations Bill and Report, and do you plan to move, for FY20, your appropriated funds to the FY21 budget? This is what I mean by two-stepping. At 86 percent, I mean, it is plain on its face, an 86 percent cut and not spending the money that Congress has—how Congress has directed you to spend clearly shows that these are not your priorities, or your values, and you are cutting the legs out from under the goal of this program.

Secretary PERRY. Well, I respect that observation, and here is my commitment to you, certainly, going forward is, as I have said to the Committee, having been an appropriator, I understand how this process works, and we will work with you, from the standpoint of you all will point to where the priorities are, and I am pretty sure you will follow up, and we will be diligent in our efforts to work with you, going forward, to make sure that not only does the agency follow the instructions of this Committee and Congress, as a whole, but to give you some comfort that the focus is in the right places.

Ms. WASSERMAN SCHULTZ. Thank you for that commitment. Madam Chair, I yield back.

Ms. KAPTUR. Thank you very much. Congressman Fleischmann.

Mr. FLEISCHMANN. Thank you, Madam Chairman. Mr. Secretary, thank you for appearing before us today. Before I begin with my questions, let me extend my heartfelt thanks for your effective, and competent, and strong leadership at the helm of the Department of Energy. It might be the Department of Energy is not only impor-

tant to our great United States, but also to my home state of Tennessee. I have the great privilege of representing the city Oakridge, where we have the Oakridge National Laboratory, the Y12 Security Complex. We are building the uranium processing facility, and, also, we have a great legacy cleanup, and we not only see great bipartisan, but also bicameral cooperation in these endeavors. So, I thank you for all that you are doing.

My question will start with advanced manufacturing, sir. I wanted to talk about the department's support for advanced manufacturing research and development. This is one area that I am particularly interested in because Oakridge National Lab has been leading an innovative program, in additive manufacturing and 3D printing, that is so important for future technology, but also for workforce development, and I might add, we are excited to see that Oakridge National Lab is hosting a large summit, on behalf of the Department of Energy, on this topic, in May.

As background, small businesses make up over 85 percent of the manufacturing companies in the United States, and three-quarters of these firms have fewer than 20 employees. Many of these companies do not have the resources for research and development, and, therefore, are lagging in the adoption of new advanced manufacturing technologies. The Department's Manufacturing Demonstration Facility, at Oakridge National Laboratory, has tremendous capabilities in additive manufacturing, carbon fiber, and composites, battery manufacturing, and cyber security, to name a few. We are seeing many of these small companies relocate near the MDF. So, I view this as a wonderful ecosystem for strengthening the public private partnerships.

My question, sir, how do we better provide access for these small companies to the tremendous capabilities and expertise of the national labs, and then, as a follow-up question, how do we further expand at the successful Manufacturing Demonstration Facility model, connecting national resources to local ecosystems? Thank you, sir.

Secretary PERRY. Sure. Thank you, Mr. Fleischmann. You give a good example of the transitional type of work, and the transformational type of work, that is going on at our National Labs. This is one segment that you talk about, the challenge reactor, our combined advanced manufacturing work that is being done at Oak Ridge is a great example of where we are, literally, building part of our reactors from these advanced materials and being 3D printed, literally, is a great example of the type of work that is going on out there. What I am trying to do is connect the dots, if you will, where some of the concerns that we have is about the line item funding may have been less than what was budgeted, and you are correct, Mr. Simpson, from the standpoint of living within the constraints of the requirements from the Administration, to which we support, and we will find ways to make this work, but having the ability to have private sector partners to transition this technology into the private sector, and into commercialization that is the real key to what is going on out there. I am going to be at Oak Ridge in May, I think the first week in May, for the X-Lab work that is going to be out there, showcasing exactly what we are all about, what we are doing, making our Office of Technology Transition bet-

ter known by the general public and, particularly, by those small and medium-sized businesses that are looking for ways to partner with our Labs and, most importantly, to get that into the private sector, so that people's lives can be improved.

Mr. FLEISCHMANN. Thank you, Mr. Secretary. Madam Chairman, I yield back.

Ms. KAPTUR. Thank you. Congresswoman Kirkpatrick.

Mrs. KIRKPATRICK. Thank you, Mr. Secretary. Thank you for being here today, for your testimony.

Secretary PERRY. Yes, ma'am.

Mrs. KIRKPATRICK. Arizona is home to the largest nuclear reactor in the country. The Palo Verde Generating Station provides 30 percent of the state's electricity generation, and 72 percent of the emission-free power across the state. It is my understanding that smaller, less capital-intensive reactors, called SMRs, are being designed, now, to help address climate change. Could you speak to what the department is doing to assist in this effort?

Secretary PERRY. Yes. Thank you. Just as a note, we were out in the Phoenix area, just South of town, at a big development, probably three or four weeks ago, I think it was a Dell Web Operation, and a massive amount of rooftop solar that are feeding into a big battery project that we are helping fund and work on out there. So, I mean, it is, again, another example of some of the technologies that come out of our national labs, and I do not know whether that is your district or not, but it is, certainly, your state.

Mrs. KIRKPATRICK. It is not exactly my district. I represent Southern Arizona, but some good—

Secretary PERRY. Yes, ma'am.

Mrs. KIRKPATRICK [continuing]. Energy work going on in Arizona.

Secretary PERRY. There is, and to be specific about your request, there are a number of new technologies, small, modular reactors being one of them. As a matter of fact, in Mr. Simpson's district, and out at the Idaho National Lab, some of the work that is going to be done out there on advanced reactors, using different fuels, safer fuels, fuels that have, substantially, a smaller footprint, if you will, from the standpoint of not just the size of the facility, but also from the amount of waste that is developed from these. You see a lot of interest from the private sector. There is a number of companies, Bill Gates being one of those, with Terra Power, and, New Scale is another that is going to be partnering out with the National Labs. I am a big believer that if we are going to be serious about the globe that we live on, the climate is within that globe, that we have to have an all-of-the-above approach, and nuclear energy has to be part of that. When you can develop as much energy as what nuclear power can, and doing it in a safe way, and in a thoughtful way, and in an emission-free way, then I think you must be committed to that source. The Department has sent a clear message that nuclear energy is cool again. We are committed to finding the new technologies that will continue to make it efficient, that will make it effective, that will make it safer, and it is already safe, but, making it safer, and I think that is the important message that you see, by this Administration, from the nuclear energy front.

Mrs. KIRKPATRICK. And are you partnering with state universities who are also doing similar research?

Secretary PERRY. Yes, ma'am. Can I get back with you, with the specificity of which ones and where—

Mrs. KIRKPATRICK. You can get back to me with it.

Secretary PERRY [continuing]. Of which ones and where, but I can assure you there is a number of universities that I know, and, in Nevada, we have some work that is being done with, I think, the University of Las Vegas. But we will get back to you, Mrs. Kirkpatrick.

Mrs. KIRKPATRICK. You mentioned your support for the advanced nuclear technologies. What—can you describe how the department's budget helps ensure the rapid development of advanced nuclear technologies?

Secretary PERRY. I think I mentioned, the Advanced Reactors Technologies Program, and that is funded. It conducts the research and the development in these long-term projects, and there is a couple of specific projects that we are working on. We have got experimental breeder reactors, at INL. Those are currently, underway. Those will end by 2023. I do not have the dollars on that one. I apologize, specifically, on that. These advanced reactors, they are going to require what is referred to as high assay, low enriched uranium. You will hear us talk about the term HALEU, and there is some really exciting work, I think, from my perspective, on those, and we are bringing that back in. That requires a domestic supply of that fuel. So, it is really important to the United States, in the future of advanced reactors, that we have this fuel, that it comes from the United States, and—that is—this work is done here. We have a project up in, I think, Ohio is where that is being done.

The second pathway to get to the destination you are making reference to is through a process that they refer to as a zirconium extraction, Zircex, and that is also at INL, and it should be available by 2025, and produce about four to five metric tons a year. The HALEU Demonstration Program, Zircex, all of those are intended to be in place by—between 2021 and 2025, and—

Mrs. KIRKPATRICK. Thank you.

Secretary PERRY. So, to answer your question, there is a number of things that we are doing on advanced reactors, and on small modular reactors. There is a new commitment. I will suggest to you a new commitment, by the DOE, to make sure that we have a sustainable, safe, and a substantially, commercially viable nuclear energy industry, as we go forward in the future.

Mrs. KIRKPATRICK. Thank you, Mr. Secretary and Madam Chairman. Thank you for allowing me to exceed my time limit. I appreciate that.

Ms. KAPTUR. Thank you. Congressman Newhouse.

Mr. NEWHOUSE. Thank you, Madam Chair. Welcome to the Committee, Secretary Perry. Thank you for your service to our country. It is always a pleasure to be able to welcome a fellow former Commissioner of Agriculture; appreciate you being here.

Secretary PERRY. A good training ground.

Mr. NEWHOUSE. Yes. Thanks for visiting my district. It must appreciate the attention and increased awareness of what we are—

the important work we are doing there. I am sure you are aware. I know you are aware that your department recently released its 2019 Hanford Cycle Report, which provided a dramatically increased cost range estimate, associated with the cleanup work at Hanford, that is happening in my district. The estimate provided a range of between \$323 billion to \$677 billion in costs associated to what needed to clean up—complete the cleanup on the River Corridor on the Central Plateau, all the tank waste and the mission support components. So, in light of that report, and considering the Federal Government's legal, moral, and ethical obligation to the cleanup of that waste at Hanford, which is also cemented in the tri-party agreement, can you—I guess, two questions, here, Secretary Perry. Could you, first, help me understand and explain such a dramatic increase in the cost estimates, first of all, but also help me understand how, on one hand, the department is telling us that the mission is going to become, exponentially, more costly, expensive, but then, on the other hand, with this budget, saying that you want to reduce and cut the funding that comes to Hanford for the Fiscal Year 2020 Budget? To me, those two messages are contrary, do not seem to mesh. So, could you help me understand that scenario?

Secretary PERRY. And it was a good experience for me to not only come to Hanford and Richland, that entire area, and walk that laboratory, walk that land where a lot of the Manhattan Project was conducted, and just absorb the history of what occurred there and the monumental work that went on there. And to view how America changed the world and, the cost to this country, and the cost to that region in the environmental cleanup side of it in particular.

I will tell you as a former chief executive for the State of Texas, keeping up with a timely observation of programmatic cost was important to me. One of the reasons I went out there was to see firsthand the challenges. You can read all you want about it, and what have you, but to see the size of the work that has got to go on there and when you look at all the different reactor sites along the Columbia River, you understand the importance of what we are talking about here from the standpoint of if we don't get this done and get this done right, the environmental disaster that could be at hand.

But I could not understand why are we not making any better progress? Why is this not moving along the way you would think it ought to move along? And I found a number of things that really disturbed me when I came back and I started looking at it.

Number one and this is just the facts, the previous administration did not take the time to really dig into this to give, from my perspective, new projections on what this costs. I mean we have gone about 7 or 8 years without giving an appropriate answer to Congress, to this committee, from the standpoint of what it really was going to cost to do that. And you have in hand now what that new estimate is, and it is a pretty shocking number, and the timetable out on that.

So with that as the basis, we basically did the tough work to get you the time and the cost that it is going to take to complete this cleanup. And that is why we are taking a very aggressive approach to meet the ultimate goal of getting the waste out of Hanford.

There is a number of initiatives that are going to be safer, and I might say at reasonable cost, and there is some significant accomplishments that have been made out there.

For instance, the K-West Basin sludge, it is going to be removed. It is going to be transferred to the Central Plateau, and there is going to be ultimate interim safe storage out there. It is going to be grouted and potentially go to that site in West Texas that we talked about. That is one of the locations for it.

Madam Chair, we are working with the tribal leaders there. When I was out there I sat down with them, we had dinner, we talked about the very sensitive part of this land of theirs, historically, and taking care of it and doing this right. And I think we have a really good working relationship with the tribal leaders.

And so again, let me finish up by saying I think it is important for us to recognize the cost, recognize the timetable and be honest about what this is going to be. But also to have a thoughtful plan going forward, which I think we have done. We are not going to make up in one budget cycle what got pushed off for the last seven or eight budget cycles. But I think, Mr. Newhouse, we give you our commitment that not only are we going to be working efficiently, we are going to be working timely. Hopefully, we will be as transparent as we certainly need to be, to make you and the committee members satisfied that we are getting this job done.

Mr. NEWHOUSE. I appreciate that. I thank you, and certainly look forward to continuing to work with you on not only to get the necessary resources, but also developing these new and innovative approaches that you have mentioned to make sure that the cleanup effort is as efficient and effective as it possibly can be. So look forward to continuing a good working relationship with the Department of Energy.

Madam Chair, I am way over my time. I appreciate your leniency in that. Thank you.

Ms. KAPTUR. Try to be fair here, you know. Congressman Simpson taught us how to do this.

We are going to move into a second round and we have some members who have concurrent hearings so we are going to try to get them in as they come back if we can.

Mr. Secretary, I wanted to ask you a question about the nuclear deterrent. And it is clear that the Department of Energy has to prioritize with a 12 percent increase for weapons activities. And this budget request doesn't really establish a baseline or a set of concrete priorities.

We know that the modernization program was begun in the last administration, and the 2018 Nuclear Posture Review included even more requirements on a complex already at its maximum.

So my question really goes to your views on the most essential priorities for the NNSA and how you view the future for NNSA. The budget request, and I do not know if you have follow along materials you could provide us, but it really does not establish a baseline or a set of concrete priorities for the expenditure of those dollars.

Secretary PERRY. Madam Chair, let us work with you on getting additional documentation—

Ms. KAPTUR. Thank you.

Secretary PERRY [continuing]. For you and your office so that any questions that you all may have going forward. The world looks different today than it did in the year 2000. I mean in almost a 20-year period of time the world is substantially more dangerous than it was. And I am like everybody sitting at that table, I wish that wasn't the case, but it is the reality that we live with.

And one of the things, Madam Chair, that was really good for me was being able to go to the National Labs, particularly to Los Alamos and Sandia, those two in particular from the standpoint of recognizing the challenge that we have in keeping our deterrent modern. When you start thinking about the deterioration that has occurred over the last 50, 60 years some of these weapons are getting up in age from the standpoint, and we are being able to use our technology to analyze where the deterioration occurs.

So I agree that the National Nuclear Posture Review was needed, and the previous administration and this administration are going forward with that was the appropriate thing to do.

It is going to take some time. The NNSA is going to be really strapped from the standpoint of both from financial and from staffing levels. I have great confidence in the new Administrator. Lisa Gordon-Hagerty is an amazing talent, a great manager, a very visionary individual who I have got every confidence in the world in from the standpoint of her historic background of working at the NSC, through her work after that, and understanding incredibly well the importance of our deterrent and the work that is going on on our nuclear Navy side. I think sometimes as we talk about the deterrent we sometimes give a little short shrift to the Navy, and our nuclear Navy in particular, and the work that NNSA does with them from the standpoint of building the new Columbia-class submarine, and the power plants that are going to be powering those. So there is some exciting work that is going on that the NNSA is partnering with the Navy on.

So I am confident that it is a heavy lift and I recognize that, but we have the right people in place to develop our deterrent and keep this country free and safe.

Ms. KAPTUR. We will look, Mr. Secretary, for your supplementary materials because it appears there is a great need for both DOE and DOD to prioritize in this area and to be very clear on what the goal is and when it will be achieved. I could say plenty about that in the Department of Energy. So the additional materials to the record on this topic will be quite welcome.

I am going to switch almost 180 degrees here to the subject of the Weatherization Program, one of the few areas where the Department of Energy actually meets the street directly.

And this is a program, as you know, that serves low-income households across our country, whether individuals live in mobile home parks or in cramped urban communities. And these folks spend more than twice as much of their income on energy than the median, it is amazing. In rural areas the disparity is even worse.

And your budget zeros out one of the most successful programs that DOE has managed for many years now, the Weatherization Program, which actually saves people, the taxpayers, money because of what it does in helping them to retrofit their homes.

At a time when one in five households have had to forego necessities to pay an energy bill, how do you reconcile your proposal to eliminate one of the few Federal programs addressing home energy efficiency?

Secretary PERRY. Madam Chair, this one is pretty simple for me. Having the background of being an appropriator back in my younger days in the eighties, and then having been the governor of Texas for 14 years that I had that privilege, I was always asking why in the hell is Washington, DC, telling us how to do our business down here?

And that is how I look at this program. I happen to think that these are dollars that should go to the states. The states make the decisions, they know better how these programs would work, where they would work better. There are states that have leveraged this program, and I think that is the solution to this, we should let the states fund and partner with them. But the decisions of this does not need to be made at the DOE, in my opinion.

Ms. KAPTUR. Well, you know, the sad fact is that state budgets are quite stretched right now and we have governors, including my own, who cannot even find the money to pave the streets, so they are proposing gas taxes and everything else.

The Department of Energy has always taken the lead on this program and we hope that as this bill moves forward you might really take a look at what this program has successfully done in partnership with the states, many times, and making a real difference. Certainly Texas is a state that benefits enormously from this program. So I was just really flabbergasted when I saw the budget come up with zero funding.

Secretary PERRY. Madam Chair, let me just say that I understand from historic purposes and from this conversation as late as this morning, that you all have a definite interest in this program. And we will continue to follow your directive.

Ms. KAPTUR. Thank you, Mr. Secretary. Congressman Simpson.

Mr. SIMPSON. Thank you. I have got a series of questions, Chair, and I hope the chairwoman will put up with this.

We talked a little bit earlier about HALEU. Many advanced reactors will need a modified fuel called HALEU, but right now there is no source of HALEU on the commercial market. The fiscal year of 2019 Energy and Water bill included \$20 million for activities to support HALEU development, and required the DOE to submit a plan and cost profile to the committee within 180 days of enactment.

Mr. Secretary, is the Department on track to provide this report by the quickly approaching deadline?

Secretary PERRY. Yes.

Mr. SIMPSON. In the fiscal year 2020 budget request it seems to support multiple potential technologies for developing HALEU for use in advanced reactors based on the demand projects and timelines, as I have seen. It seems likely we will need all of these efforts to get the necessary amount of HALEU at the appropriate times.

Do you agree with that assessment, that is why your budget request supports multiple HALEU efforts? And given this interest demonstration is not intended to produce material amounts of

HALEU, how does the Department plan to accelerate HALEU processing at INL so that it can meet the needs for the advanced reactor research and development? And is exploration of multiple possible solutions or technologies typical for the Department of Energy programs?

Secretary PERRY. Mr. Simpson, we will work with you and INL in any way that we need to to find the sources of fuel, because we agree with you that advanced reactors, if we are going to be serious about the next generation of nuclear energy, we have got to have this, the high assay low enriched uranium, to be able to do that.

Mr. SIMPSON. And it has to be domestically produced.

Secretary PERRY. Yes, sir.

Mr. SIMPSON. The budget request in this one includes \$40 million for the second year of funding for an agreement with Centrus to demonstrate a U.S. technology for enriching uranium to produce HALEU. The fiscal year 2019 amount was \$35 million, and we previously were briefed that the project is expected to need a third year of funding at a \$40 million.

Is this \$115 million still the projected Federal investment in this demonstration project? Because our concern, frankly, when I talked about this earlier with people from your Department, was that we always seem to overrun budget, and when the third year of this additional \$40 million comes in the third year, that there will be great pressure on members of this committee to fund it for a fourth year and a fifth year and a sixth year. We have seen that happen before.

I need the commitment that the Department is going to hold their feet to the fire and that the commitment made of \$115 million total over the 3-year project will be upheld by the Department.

Secretary PERRY. You have that, sir. Well, just leave it at that. You got it.

Mr. SIMPSON. And finally, on this same subject, what has the Department done in terms of transportation vessels, as yet they have not been designed? What additional research is DOE planning to support for the transportation infrastructure needed for the commercial HALEU?

As you know, it takes forever to design and certify a transportation vessel for these nuclear fuels. Is that in the plans?

Secretary PERRY. Yes, sir.

Mr. SIMPSON. Okay. Thank you.

Ms. KAPTUR. Congresswoman Frankel.

Ms. FRANKEL. Thank you. Thank you. I have been running back to other committees, but thank you so much for being here today. I really appreciate it. Thank you, Madam Chair, for this meeting.

You just took one of my questions, but the one that I really want to focus on is the question of offshore drilling off the Florida coast.

Our entire delegation, Republicans and Democrats, recently sent a letter, this was to the Secretary of the Interior, opposing offshore drilling off our coasts. And there are many, many good reasons for that.

Just in Florida, it would cost us 610,000 jobs, \$37.4 billion in economic impact for really relatively little oil and gas. It also would have dramatic impacts on our environment, effect a lot of our industries, especially fishing, recreation, which is very important to

our economy, our way of life in Florida. It threatens the marine ecosystems. And we had a terrible situation in 2010, the Deep Water Horizon disaster.

So my question to you is, I really want to know whether you will respect or add to our delegation's request.

Secretary PERRY. Ms. Frankel, your former governor, who is now a United States senator, is a friend of mine. We would talk about this from time to time because he liked to compete against the State of Texas in job creation, and I mean we had a great go of it.

And we both agreed that states, by in large, particularly when it dealt with issues that they were to make decisions on, whether it wasn't necessarily a legislative directive from Washington, should be respected, and that is certainly one of them. The State of Texas, they allow for that and they enjoy the benefits from it, recognizing that from time to time there is an event like you all saw that could be devastating.

Ms. FRANKEL. Mm-hmm.

Secretary PERRY. And so I certainly, from a former governor standpoint, DOE actually does not have any decision-making process on that, it is Department of Interior. But as a former governor, I would suggest that it is every bit in the citizens of your state's right to decide whether or not they want to develop those resources or not.

Ms. FRANKEL. Thank you. Thank you for that. Just to add that our citizens actually passed a constitutional amendment in Florida on the November 2018 ballot to ban offshore drilling in the state's water. So I thank you for your position. And I would hope that you could advocate on behalf of Florida to ban the offshore drilling off our coast.

Secretary PERRY. I will leave that to the folks of Florida. And if there is not any conflicts with our Federal statutes, then my bet is that there will be somewhere in the country that would be more than happy to develop the oil and gas needs for our country, like Texas.

Ms. FRANKEL. Thank you very much. And I yield back, Madam Chair.

Ms. KAPTUR. Thank you, Congresswoman. Congressman Fleishman.

Mr. FLEISCHMANN. Thank you, Madam Chairman. In this second round, Mr. Secretary, I appreciate this. This is very informative.

I do want to reiterate again what the distinguished ranking member, my friend from Idaho, said, anybody watching this. We fall in 2020 under the draconian effects of the Budget Control Act. We broke those caps in fiscal year 2018 and 2019, so I am fully cognizant that you are under these constraints as Congress will work through that with the administration. So thank you for working with some very difficult numbers that the law imposed on the Department.

I would like to talk a little bit about stable isotopes, if I may. The Department proposes to make significant investment in the research and production of stable isotopes, starting in fiscal year 2020. Isotopes for medical or industrial applications is one of a number of areas where the Department of Energy, Oakridge Na-

tional Laboratory, and other national labs have an incredible impact, including lives saved and billion-dollar impacts on the United States economy.

Two part question. So what role does the private sector play in the medical and commercial use of these isotopes? What kind of partnership does the Department of Energy have with the private sector?

And my second question would be, how will the proposed stable isotope production and research center help address the growing demand for stable isotopes and facilitate research on the beneficial uses of stable isotopes?

Thank you, sir.

Secretary PERRY. Mr. Fleischmann, the development of these stable isotopes cuts across a lot of different industries out there, obviously medicine. I am familiar with the Texas Medical Center, MD Anderson, and the work that is done there. I am intimately knowledgeable about the work that is done there.

It also cuts across other industries such as national security, quantum computing, and some of the fundamental research in which we require these types of stable isotopes.

I do not know the history of why we got into the position of Russia being the sole supplier of these isotopes some years behind us and I think we all know that is a problem, whether it is your gas supply in Europe or whether it is your medical isotopes that you are using in science. Having one supplier, particularly if that happens to be Russia, is not necessarily the best situation to be in.

So, with that, the Department is investing in U.S. developed isotopes and it became clearly a priority that needs to be addressed. I think there are now four companies that are participating in an effort to deliver, for instance, Molybdenum-99, is one and we have got a number of companies that are producing those at this point in time. The U.S. industry has the capability now to enrich what they call light elements, like boron and oxygen carbon, through a very cold cryogenic type of a process. The key is we have the ability now, we are funding, I think, four different companies in a project. One of them, as you know, is over at Oak Ridge National Lab and they have a gas centrifuge over there that is being used to enrich the heavier isotopes up to and including uranium.

We are going to be by 2020 producing those isotopes at the numbers of which we need to get us back and not be relying upon one single foreign source of those isotopes, those elements.

Mr. NEWHOUSE. Thank you, Mr. Secretary. I believe my time has expired. Madam Chairman, are you back?

Ms. KAPTUR. Thank you very much, Congressman Kilmer.

Mr. KILMER. Thanks, Madam Chair, and thanks, Mr. Secretary, for being with us. I want to start with something that keeps me up at night. I have folks in my neck of the woods that are already dealing with the threat of climate change representing 11 Native American tribes, including 4 that are in the process of trying to move to higher ground because of persistent flooding from sea level rise. A bunch of people in my neck of the woods work growing shellfish and they are dealing with the impacts of ocean acidification. We are representing communities on the water, they are seeing changing ocean conditions leading to an unprecedented number

of fisheries disasters and I think what concerns me is that, according to the Intergovernmental Panel on Climate Change and the 4th National Climate Assessment, these consequences are only going to get worse if we don't take action to significantly curb our carbon emissions.

So, doing nothing is not an option and the reality is right now our Nation lacks both the infrastructure and the technology to meet the goal of net zero emissions by 2050, as the IPCC recommends. And the Department of Energy has a critical role to play in developing these technologies, but it sure seems like in this administration, we are going backwards not forward.

Last year our carbon emission actually increased by 3.4 percent and rather than taking proactive steps to address this, your budget proposes massive cuts across the board on this front, including an 86 percent cut to the Office of Energy Efficiency and Renewable Energy that will severely limit our ability to curtail our carbon emissions by 2050.

I think my other concern is I represent a district that could sure use some jobs and I think there is real opportunity in this space, particularly with some of what our competitor countries are doing. So my question to you is do you agree that the U.S. should be a global leader in developing cost-competitive clean energy technology? And if so, what are you doing to make sure we are one?

Secretary PERRY. Well, sir, thank you. And before I get into my remarks, let me just thank you for your support of our quantum computing. I know you visited PNNL and I am pretty sure you are probably as impressed as I was when I got to see the work that they do out there. So thank you for that.

Mr. KILMER. You bet.

Secretary PERRY. With specificity you asked what are we doing about it and I am pretty excited about what I am seeing this country do as a whole, and what the Department of Energy is doing with specificity, and let me share with you why I say those things. I recognize we had a tick up last year, but when you look at the trend of which the U.S. is on from the standpoint of our mission, we are certainly headed in the right direction.

As a matter of fact, I think over the course of the last 10 years we have had a pretty substantial reduction. I can assure you that both in the transition away from older, inefficient power plants to cleaner burning natural gas, you have seen the U.S. become the number two producer of renewables. I am going to have to brag on Texas a little bit before I get out of here, but the State of Texas now produces 15 percent of its total energy from renewables. That is a higher percentage than Europe.

And so, there are some states out there that are being good examples for the rest of the country to follow, and I just wanted to pitch that one out from my home team. But the point is, we are doing some extraordinary work; the CCUS, the Carbon Capture Utilization and Storage technology that the Department is doing, we are headed in the right direction.

I think it is important for us to deliver to the world some of these cleaner burning and, in some cases, zero-emitting technologies, whether it is our LNG to replace in Europe some of the older, inefficient power plants. When you look at what India and China are

doing from the standpoint of polluting and the emissions that are coming, American LNG can go a long way to help putting those countries headed in the right direction. I think those small modular reactors that we have talked about, the advanced reactors, those zero emissions types of technologies can be very, very important going forward.

With the work that we are doing on renewables we have seen a 90 percent decrease in the cost of solar. We are seeing substantial increases of both our solar and our wind energy. I totally agree with you that the globe has got some real challenges.

I think the U.S. does not get enough credit, frankly, for the work that we have done, and the direction that we are headed. And so in the last 10 years our emission reduction has been the highest in the history of energy.

So, can we do more? Yes. Do we need to do more? Absolutely, but America can be a leader. And again, I think getting our technologies and our clean-burning fuels and technologies into the hands of those around the globe is one of the most important things.

And I go back to getting our LNG out. And I know the House does not have anything to do with approving FERC Commissioners, but getting a fully staffed-up Federal Energy Regulatory Commission in place, and being able to get the bottleneck permits opened up and moving, would be very helpful to being able to get those projects done and get that U.S. clean-burning natural gas into a lot of places around the world.

Mr. KILMER. Thanks, Madam Chair. I see I am out of time, but I appreciated the answer. I do think it is important, though, that we are not backtracking. I know some of the progress we have made was based on policies that we have since pulled away from and investments that are proposed for cuts, so I hope that we can do better going forward. Thanks, Madam Chair.

Ms. KAPTUR. Thank you, Mr. Kilmer. Mr. Newhouse.

Mr. NEWHOUSE. Thank you, Madam Chair. Mr. Secretary, first of all, keying off on one of Mr. Simpson's questions about our permanent waste storage facility at Yucca Mountain, I just wanted to add my 2 cents and thank you and the administration for inclusion of your provisions to restart the licensing process. Simply put, Yucca Mountain would be critical, not only for the waste that we have at hand, but for all the commercially produced waste at our Columbia generating station and around the country. So, I thank you for the inclusion of that.

I want to talk and ask you a little bit about the work at our National Laboratory in Richland, the Pacific Northwest National Lab. You and I visited that together and I think you were able to see some of the truly groundbreaking work that is being conducted there by world-class scientists.

I am very glad to see the Department is looking at how PNNL can further accelerate the development and the testing, as well as the validation of energy storage technologies for the grid, using the newly proposed grid storage launch pad that will be hosted there at the lab.

PNNL has emerged a real leader in this area. We have one of the largest concentrations of expertise in advanced grid scale en-

ergy storage technologies in the world. And I truly believe that the Department's best successes are the result of focused research here with clear outcomes. And I think, it seems to me, that the Department believes those goals are an important part of this initiative.

Could you just briefly tell us how the Department made decisions regarding the specific research and goals that are included in this initiative? And can you talk about some of the opportunities that you might see to advance this important technology.

Secretary PERRY. Mr. Newhouse, I think there are a couple of lines of thought here. One is about just the continual funding, overall science funding, and those science labs in particular. And then obviously the other thing I heard you talk about was the grid modernization. There is a laboratory consortium that we put together on the grid modernization initiative that is very important. I am going to talk about that grid modernization, if I could, because I think it is really important for the committee to know our focus on that, what our result is going to be and that partnership between DOE and the National Labs, bringing together, as you rightfully said, the experts that these labs have, the technologies, and the resources to collaborate on the goal of modernizing our Nation's grid.

The resilience modeling, energy storage, and the work that we are doing on cybersecurity on advanced sensors, and institutional support, all of that is being played out. I think we put somewhere north of \$200 million between fiscal year 2016 and fiscal year 2018 in that consortium, in that global modernization laboratory consortium, as we refer to it.

And I think you all recognize, we recognize, the importance of this partnership, and I will give you an example. Just recently there was a call for an estimated \$40 million of foundational work from DOE for applied energy programs in that same GMLC, that global modernization laboratory consortium. One of the things that we have been able to do is to have a lack of duplication in these labs on this particular kind of work. And it is one of the things I am proud of, Mr. Simpson, is being able to have the management recognize what all these labs are doing and try to coordinate them more so that there is less duplication of effort out there.

So, between the funding of our National Labs and I think, as you have recognized, with the challenge of saluting the flag on the 5 percent reduction across the board, but recognizing that the work that these labs do in a lot of different areas is what keeps America ahead, whether it is in the computing side of things, or whether it is in a lot of other areas. Being able to maintain the prioritization and get the results that you are looking for, even though, you know, the restraints and restrictions on the dollars are real and we respect that. But I am very proud of what the men and women of the Department and the National Labs have done collectively, and we appreciate the congressional respect of that as well.

Mr. NEWHOUSE. Well, thank you, Mr. Secretary. And I just might add in closing that you—now that you have had all 17 labs, it is time for round 2. And we would welcome for you to come back to Richland and see what folks are working on there. I would love to share it with you. Thank you, Madam Chair.

Ms. KAPTUR. Thank you, Mr. Newhouse. Mr. Secretary, I think it is impressive that you have gone to all of the labs and visited

them, and I know whenever any of us visit we are always amazed at some of what we see about the future. We see the future being invented. I am wondering in your many visits have there been any experiences you have had that you would want to share with the committee about something you saw that was truly revolutionary, that you saw being developed.

Secretary PERRY. Yes, and thank you, Madam Chair, for the opportunity just to kind of wax eloquently about these labs. I mean, they really are fascinating and I am going to take it up just a little bit higher and share with you something.

I have always had a great respect for the men and women who serve our country and the Department is almost 40 percent veterans. And when you think about it, it makes sense with the amount of weapons work done, from the nuclear, both the civil and the military aspect of it, the subs and the Naval side of it. It really kind of makes some sense, when you think about the Department.

But the supercomputing side of what we do blows me away. We were in Oregon this last week announcing the work on a new computer called Aurora.

Aurora will be able to do a billion billion transactions per second. You know, my small, mortal mind really has a hard time getting around a quintillion, which is what that is, a quintillion transactions per second, and to be able to answer questions that we have never been able to answer before, because we just did not have the computing capacity. That is what your National Labs are doing for this country, whether it is in the field of medicine, which I wanted to just share with you one thing that is happening.

The Department of Energy in relationship with the University of California-San Francisco, in their Neuroscience Department, they are being able to find answers to solutions dealing with brain science that we were never able to answer before. For instance, whether or not a young child has been concussed on a soccer field and that obviously goes on and expands in to the NFL, and to our warriors on the battlefield, and a person who has had an accident in a car, if you get the wrong diagnosis, if you get sent to the wrong hospital. It can have a devastating effect on you or your loved one forever.

This doctor, Dr. Jeffrey Manley, has come up with a device. He can take a drop of your blood, put it on a slide, put it inside of that little device that he has come up with, and in 10 minutes tell whether or not you have a concussion. That is life-changing work that is coming out of our National Labs, and that is just a glimpse into what is happening in a myriad of ways across the enterprise of the Department because of our supercomputing capacity.

Mr. Simpson, I have just given an example of what we are doing at the DOE, particularly on the supercomputing side. When you think about the host of questions that have vexed us throughout the history of mankind, and we are now being able to get answers to those today, that is what the DOE is all about. That is the most fascinating part of it to share and capture, it is fascinating stuff.

Ms. KAPTUR. You know, Mr. Secretary, I appreciate you sharing it very much. And the scientist you mentioned, you said worked in the area of neurology, is that correct?

Secretary PERRY. That is correct.

Ms. KAPTUR. I am very interested. I am glad you have put me on the trail to that particular site because I am very much interested in light technologies and imaging technologies, whether we look at the past inventions of MRIs or CT SCANS or PET SCANS or whatever, but at a very, very minute scale, to diagnose aspects of human illness that we really don't understand. And generally speaking, they say, well, you know, our ranking member always has something interesting to contribute.

Mr. SIMPSON. That wasn't me, that was my dog.

Ms. KAPTUR. So I know DOE doesn't necessarily see itself as directly responsible for health, however, the diagnostic capabilities that technologies coming out of DOE can contribute, I think can be world-changing. And so I am really interested in that single element as we try to unlock the human brain and understand what light technologies can do.

I saw one machine up here at the Intrepid Center at Walter Reed that just blew me away. It was invented by the Swedes. It is able to image the human brain and where a stroke pathway actually existed so they could begin to try to repair deep in the human—it was just, I thought, okay, what more can we do?

Secretary PERRY. Ms. Kaptur, I am telling you, you have turned me loose and, number one, rather than use up the time of the Committee here, I want to come up and sit down with you and share with you what is going on.

Dr. Manley and I are going to give you two examples, again, of what the computers at DOE are being able to do on human health. And, no, we are not in the health business.

Ms. KAPTUR. Right.

Secretary PERRY. We are in the computing business, but we are good partners and we stood up the Office of Artificial Intelligence and Big Data at the Department to do just this now. And I want to come share with you what the vision is, and we have had, with some great help from the Congress in the last budget cycle, to stand this up.

For instance, Dr. Manley, who is a neurologist, with a Ph.D. and M.D. in neuroscience. He is a neurosurgeon at the University of California—San Francisco. This is a world-renowned operation and using the computers at the DOE to give them answers to questions that they could not get before. For instance, historically, you have had mild, moderate, and severe, those are the three levels of concussion. He said what they have discovered is that there are 28 levels of this. We have found more answers to questions on the brain, this was a year ago, in the last 10 months than we did in the last 10 years.

That is where we are, I mean, that is the exciting part of what I think this work, particularly with our supercomputers. I could go on about this for a substantial amount of time. But with your permission, I would like to come up and sit down with you and your staff and share with you what we are doing, why this is important, and just the absolute, cutting-edge, break-through work that is occurring at the Department of Energy because of their supercomputers in the field of medicine.

Ms. KAPTUR. Well, we would enjoy that opportunity and we would invite every committee member who is interested, Mr. Secretary, and I see a blending of the sciences happening.

Secretary PERRY. Yes, absolutely.

Ms. KAPTUR. Even the names of the sciences are changing in our colleges and universities. I don't think they teach biology anymore, but I know there is a lot of bioengineering. So, I am very interested in the blending of the sciences and what this can instruct us and so we would welcome that opportunity. We will even serve you lunch. So thank you so much for that insight. I will go to our ranking member, Mr. Simpson.

Mr. SIMPSON. Thank you, Chairwoman. I appreciate that. The damn dog always calls at the wrong time. And as you know, that is a Texas dog, you have met him.

Secretary PERRY. Yes, sir.

Mr. SIMPSON. And he is hard to control. I will tell you what, I have been trying to get some Texas out of him for a long time, but just haven't been able to. But, anyway, thanks for those comments on what our National Labs do and the importance that they are. That is why I call them the crown jewels of our research and development in this country. They do incredible work in a variety of areas.

But let me ask one more question on the budget that I had. Your budget proposes \$79 million in the new construction line to advance and design the Surplus Plutonium Disposition Project, also called Dilute and Dispose, also called MOX Alternative. The plan includes permanent storage of the diluted plutonium at the WIPP facility in New Mexico. I understand that the Department is moving forward under a new calculation of the volume of waste being placed in WIPP, but that some in New Mexico are still challenging this issue. Where do we stand on that and what is the timeline? Do you have a timeline for the final resolution of that?

Secretary PERRY. Mr. Simpson, you are correct that the dilute and dispose method is proven scientifically. There is not any question about that, that we can, in fact, take that plutonium dilute it, and then dispose it properly in a facility like WIPP, which is a substantially deep cavern in New Mexico.

The State of New Mexico last year, at our request, the way that the volumetric measurement was done before. If you had a 55-gallon drum and you had a 5-gallon bucket of waste that you put inside the drum and then transport it, the volume was calculated as the 55-gallon drum, when the fact is there is a lot of empty wasted space.

So we asked the state if they would go back and consider recalculating based on the volume of the inner containers so that they would know with specificity the actual amount of waste, rather than including waste and some air volume. And they did, they agreed, and they made a change in the way you calculate volume.

I know there was some pushback from New Mexico, but we will work with them in any way that we need to in order to alleviate any concerns. But the point is, I think, from a national security standpoint, the place to be able to take the plutonium that we have in South Carolina and meet the legal requirements that we have

there to move that out of the state and dilute it, dispose it, in a very safe and scientifically proven way, is there and correct.

Mr. SIMPSON. Well, we are kind of counting on that being the case since we are going down this path. But if the policy is implemented, will the increase in overall amount of material that can be stored at WIPP—but as you know, it will increase the amount that could be stored at WIPP. But, as you know, it does not address how many shipments can be processed each week.

This capacity will be extremely limited for the next several years until a new permanent ventilation system is installed. Is full recovery of WIPP still the priority? And when do you expect the WIPP ventilation project to be complete and the mine fully restored to pre-incident operations?

Secretary PERRY. The process is ongoing. The new ventilation system should be completed in 12 to 18 months to the final disposition of that.

Mr. SIMPSON. What would be the impact of wrapping up shipments to dispose the plutonium at the same time the DOE is behind on waste shipments from Idaho and other states already in the queue for that? Would it delay our shipments to WIPP?

Secretary PERRY. Yes, sir, I think there is certainly that potential and we are going to do everything we can not only to speed that process up, but to also find some alternative locations, like across the border in New Mexico, into Texas at Andrews. That Andrews site would be an alternative as well.

Mr. SIMPSON. Thank you.

Ms. KAPTUR. Mr. Fleischmann.

Mr. FLEISCHMANN. Thank you, Madam Chair. Mr. Secretary, I would like to talk a little bit about neutron science, specifically the Spallation Neutron Source, and the second target station at Oak Ridge. Obviously the first target station has been tremendous, an international success in this field. I want to commend you and the Department for including funding in fiscal 2020 for a second target station at this Spallation Neutron Source at ORNL. It has obviously been planned for quite some time now and I think the mission for a second target station was first recognized in 2009. I am glad to see the Department taking the steps necessary to make it a reality.

Not only would this enable a wholly new capability for the study of quantum materials, polymers, proteins, catalysts, and other materials, but it will double the capacity of the existing SNS which is currently oversubscribed by a factor of three. And, as you know, this is critical to maintaining U.S. leadership in neutron sciences.

My question, sir, when is the Department planning for a CD1 review of the STS? And secondly, sir, as competition from Europe and Asia in neutron science increases, what resources does DOE need to baseline the STS? Sir, thank you.

Secretary PERRY. Yes, sir. According to the folks out at Oak Ridge, getting CD1 to completion and it should be by the end of this year, maybe a bit into 2020, but certainly, I am going to tell you sitting here in front of the committee that in a year's period of time that should be done.

And you asked about the competition that we have in Europe on the neutron sciences, and that is certainly true.

Our folks over in Europe and Asia are both working diligently to be world leaders and that foreign competition is real. And we will have capabilities and we are expected to exceed those of the present SNS. The projection is that we will have the user operation by 2023, and be up to 5 megawatts of power to be firing that bad boy by I think 2028. That is the projected timeline for the next one.

Mr. FLEISCHMANN. Thank you, sir. I yield back.

Ms. KAPTUR. Thank you, Mr. Fleischmann. I just have to say how wonderful it has been with the scheduling that we could actually have a hearing and not be interrupted by a vote. That is so welcome. So that will be the last question for this hearing this morning. And that concludes this morning's hearing.

Again, I would like to thank Secretary Perry for joining us today. And I ask that for the hearing record, questions for the record and any supporting information requested by the subcommittee are delivered in final form to us no later than 3 weeks from the time you receive them.

Members who have additional questions for the record will have until the close of business Friday to provide them to the subcommittee office.

And with that this hearing is adjourned.

Secretary PERRY. Thank you.

Ms. KAPTUR. Thank you.

[Questions and answers submitted for the record follow:]

QUESTIONS FOR THE RECORD
SUBCOMMITTEE ON ENERGY AND WATER DEVELOPMENT, AND
RELATED AGENCIES
HOUSE COMMITTEE ON APPROPRIATIONS

Hearing on the Department of Energy's FY 2020 Budget
Secretary Perry
Tuesday, March 26, 2019

Subcommittee Questions

1. DOE Reorganization

In December 2017, the Department announced a major reorganization primarily affecting programs related to the electric grid and cybersecurity, which appears to be complete.

Question: How is this reorganization working? Have the expected improvements been achieved?

Karen S. Evans was confirmed as Assistant Secretary for the Office of Cybersecurity, Energy Security, and Emergency Response (CESER) by the U.S. Senate in August 2018, and sworn in by U.S. Deputy Secretary of Energy Dan Brouillette on September 4, 2018. Under Assistant Secretary Evans's leadership, CESER continues to elevate the Department's focus on energy infrastructure protection and enable more coordinated preparedness and response to cyber and physical threats and natural disasters. By combining the elements within DOE that support response and recovery, CESER is enhancing the efficiency and effectiveness of the preparedness cycle for events impacting the energy sector.

CESER is enhancing the Department's ability to focus on DOE's sector-specific agency responsibilities. The office is working in an integrated manner in partnership with Federal agencies, industry, and other stakeholders to provide greater visibility, accountability, and

flexibility to protect our Nation's energy infrastructure and support asset owners. One example is through the joint Pipeline Cybersecurity Initiative. Launched in 2018 by DOE and the Department of Homeland Security (DHS), this collaboration leverages the sector-specific expertise of the Cybersecurity & Infrastructure Security Agency and the Transportation Security Administration (both DHS sub-agencies), as well as DOE and other Federal agencies, to support the efforts of the Oil and Natural Gas Subsector Coordinating Council in addressing threats to our Nation's pipelines.

CESER is also working closely with other DOE offices to enhance the resilience and security of the U.S. energy infrastructure. For example, on March 26, 2019, DOE announced up to \$70 million (subject to appropriations) to establish a new Clean Energy Manufacturing Innovation Institute focused on addressing cyber threats to more energy-efficient manufacturing. The manufacturing and industrial sector consumes about 25 percent of the Nation's energy. DOE estimates that the adoption of automated controls and sensors provide the potential for up to 15 percent improved energy efficiency in manufacturing, but these new technologies introduce cybersecurity risks, which can limit their adoption. Addressing these cyber risks can accelerate adoption of energy efficient technologies in manufacturing, helping U.S. manufacturers remain resilient against cyberattacks and globally competitive. The institute is co-managed by the Office of Energy Efficiency and Renewable Energy and CESER. While Congressional report language called for funding the manufacturing institutes, the FY 2020 Budget favors a transition away from the institute model because the mortgaging of future appropriations reduces budgetary flexibility. Instead, the Budget proposes a set of smaller and more directly managed, early-stage, R&D consortia activities.

The formation of CESER has also renewed the Department's focus on early-stage activities that improve cybersecurity and resilience to harden and evolve critical grid infrastructure. CESER continues to build partnerships with energy sector utilities, vendors,

universities, national laboratories, and cybersecurity service providers to reduce the risk that a cyber incident might disrupt energy delivery. These activities include early-stage research and development at national laboratories to develop the next generation of control systems, components, and devices with cybersecurity built in, and a greater ability to share time-critical data with industry to detect, prevent, and recover from cyber events. In 2018, CESER's Cybersecurity for Energy Delivery Systems division awarded \$28 million for eleven projects to support the research, development, and demonstration of next-generation tools and technologies that will improve the cybersecurity and resilience of the Nation's critical energy infrastructure, including the electric grid and oil and natural gas infrastructure.

2. Nuclear Technology and Arms Control

The Administration is pursuing an aggressive strategy to export advanced U.S. nuclear technology to foreign countries. The Department of Energy has a statutory responsibility for considering and authorizing the potential transfer of nuclear technology outside of the United States for peaceful uses.

Question: How will the Department ensure any exported U.S. nuclear technology will not present an arms control or nuclear proliferation threat to the United States or our allies?

Section 57, b.(2) of the Atomic Energy Act of 1954, as amended (AEA), prohibits the direct or indirect assistance in the development or production of special nuclear material outside the United States, unless authorized by the Secretary of Energy following a determination that the proposed activity “will not be inimical to the interest of the United States.” The Department of Energy (DOE) implements this provision of law in accordance with the regulatory procedures at 10 CFR Part 810 (Part 810).

As described in Part 810, DOE considers a range of factors in determining whether the Secretary should specifically authorize the export of unclassified civil nuclear technology. These factors include, for example: whether the country is in full compliance with its obligations under the Treaty on the Non-Proliferation of Nuclear Weapons; whether the country has accepted

International Atomic Energy Agency safeguards obligations on all nuclear materials used for peaceful purposes; the availability of comparable assistance or technology from other sources; and any other factors that may bear upon the political, economic, competitiveness, or security interests of the United States.

Further, the Department of Energy consults with the Departments of Commerce and Defense, the Nuclear Regulatory Commission, and, in certain cases, the Office of the Director of National Intelligence. Moreover, DOE must secure the concurrence of the Department of State for all specific authorizations under Part 810. The Department of State obtains nonproliferation assurances from the recipient government, which constitute politically binding commitments from the recipient state that the foreign end users are authorized to receive the technology, that the technology will only be used for peaceful purposes, and that the technology will not be re-transferred without the consent of the U.S. Government.

3. Advanced Energy Storage Initiative

This year's budget request includes \$158 million for a new crosscutting effort called the Advanced Energy Storage Initiative. It is described as part of the broader Grid Modernization focus on a holistic approach to energy storage. EERE and the Office of Electricity have been funding energy storage and battery research and development for years.

Question: What makes this initiative different from the activities funded in the past?

The proposed Advanced Energy Storage Initiative (AESI) will provide an integrated research and development (R&D) strategy across DOE's Offices of Electricity, Energy Efficiency and Renewable Energy, Fossil Energy, and Nuclear Energy to drive improvements in bi-directional energy storage and other technologies that can increase the reliability and resilience of the U.S. electrical grid. AESI will provide a platform to coordinate R&D activities across these program offices, as well as with energy storage efforts in DOE's Office of Science, and Advanced Research Projects Agency – Energy, to establish aggressive, achievable, and

measurable goals for the development of cost-competitive energy storage technologies, services, and applications. The application-specific cost and performance metrics developed under AESI will be utilized across DOE to target research objectives and enable accelerated development of new energy storage and technologies providing greater grid flexibility.

Question: Developing a strategic plan that sets performance targets and research and development goals has been a success of the Grid Modernization focus. Are there plans to do this with the Advanced Energy Storage Initiative?

AESI will establish aggressive, achievable, and measurable goals for the development of cost-competitive energy storage technologies, services, and applications. The application-specific cost and performance metrics developed under AESI will be utilized across DOE to target research objectives and enable accelerated development of new energy storage and technologies providing greater grid flexibility.

4. Coal FIRST Initiative

Advancing the Coal FIRST initiative is a top priority for the Fossil Energy R&D program in the budget request. This would include R&D on technologies for coal plants of the future that are highly efficient and flexible, with near-zero emissions.

Question: How is the Coal FIRST initiative different than coal research from the past?

Coal research is an integral component of the Office of Fossil Energy mission, with a focus on maintaining the highest environmental standards at reasonable cost by increasing the availability and efficiency of fossil energy systems integrated with carbon capture. Fossil Energy program elements include early-stage research on gasification, combustion, advanced turbines, advanced materials, and other advanced energy systems. For coal-based power systems, improvements in these technologies results in positive spillover benefits, such as developments in materials, sensors and controls, and environmental controls for fossil-fired power plants.

Changes to the U.S. electricity industry shifting how the Nation's generating assets are operated. Coal-fired power plants, optimally used as baseload resources, are being increasingly relied on as load-following resources to support electricity generated from intermittent renewable capacity, counter fluctuations in natural gas supply and pricing, and provide critical ancillary services to the grid. The need for considerable dispatchable generation, critical ancillary services, and grid reliability create opportunities for advanced coal-fired generation for both domestic and international deployment. The significant changes to the operating and economic environment in which coal plants function require a new approach to the deployment of new coal plants.

To that end, DOE's Coal FIRST Initiative is investigating the potential for electricity generating units that have higher overall efficiencies, are smaller unit sizes, emit near-zero emissions (including CO₂ capture), are capable of high ramp rates and minimum loads, can integrate energy storage, minimize water consumption, integrate modular designs, integrate with plant value streams, and are capable of natural gas co-firing. The Coal FIRST program integrates technological and practical advancements from all program areas to support new research to meet the requirements that future power generation demands.

5. Solid Oxide Fuel Cells

The budget request drastically cuts and nearly eliminates research on Solid Oxide Fuel Cells. That research has focused on R&D to enable efficiency, cost-effective electricity generation with minimal use of water and the use of abundant energy resources with near-zero atmospheric emissions.

Question: Do you believe all the technology challenges have been resolved for Solid Oxide Fuel Cells?

The Department is preparing a Report to Congress, as directed in the FY 2019 Appropriations Committee Report from the House of Representatives, detailing the status of the current technical challenges and the research and development (R&D) needs. DOE believes the

FY 2020 Budget Request is adequate to support the early-stage R&D that is necessary to address existing technology challenges for Solid Oxide Fuel Cells.

6. ITER

The United States has committed to participating in ITER, an international fusion science experiment to be the first fusion device to maintain fusion for long period of time. The National Academies recently has stated that U.S. should maintain its participation in the ITER project.

Unfortunately, the U.S. contributions to the ITER project have fallen behind schedule. And this budget proposal does not include even sufficient funding for fiscal year 2020, as estimated in the original project cost estimate, let alone increased funding to catch up on past underfunding.

Question: Does the Department believe the United States should remain a partner with ITER?

Yes.

Question: How does the Department's budget request for ITER compare to our commitment to our international partners, many of which are close allies, for the ITER project?

The Department's budget request ensures that the highest priority in-kind hardware systems being provided by the U.S. for ITER will not fall behind schedule.

Question: If we insufficiently fund ITER or pull out of the project, how would that affect international scientific cooperation?

Relations with the other ITER members could be strained if U.S. funding is insufficient.

7. Quantum Information Sciences

The budget includes \$168.5 million for quantum information science within the Office of Science.

Question: Please describe the new urgency for building U.S. competency and competitiveness in developing understanding of quantum systems and applications.

The emerging field of Quantum Information Science (QIS) – the ability to exploit intricate quantum mechanical phenomena to create fundamentally new ways of obtaining and processing information – is opening new vistas of science discovery and technology innovation.

It provides a basic foundation for countless application areas including computing/simulations, sensing and metrology and communication. QIS is currently at the threshold of a revolution, creating opportunities and challenges for the Nation, as growing international interest and investments are starting a global quantum race. China, the European Union (EU), the United Kingdom (UK), Canada, Australia, and the Netherlands are main players in this field. Both China and the EU have announced plans to invest multi-billion dollars and the UK already has a National Quantum Technologies Programme in place focusing more on technology development rather than on basic research. How this revolution will develop, how great will be the opportunities QIS can yield for the U.S. science and technology sectors, and how rapidly the field will proceed, will hinge on a strategic and targeted U.S. initiative, in which the Department of Energy's Office of Science will take a leadership role.

Question: How is the Office of Science ensuring that its quantum work is being coordinated with quantum activities throughout the Department?

Within the Department, the Office of Science (SC) is focused on early stage research in the Quantum Information Science (QIS) that builds on its expertise and capabilities in frontier computing, quantum materials, quantum information and field theory, control systems, isotopes, cryogenics, and other relevant topics spanning the National Laboratory system and multiple program offices. The six SC Associate Directors (AD) and their staff maintain awareness of each other's QIS activities as well as those across the Department. The Advanced Scientific Computing Research AD and staff meet regularly with counterparts in the National Nuclear Security Administration program to discuss and coordinate evolving QIS research and future hardware investments.

The Department also recognizes the urgency articulated in the National Cyber Strategy¹ for innovation in quantum information science that maintains the United States' strategic advantage in cyberspace. In particular, the Strategy prioritizes risk-reduction for seven key areas including national security, and energy and power.

As such, SC and the Department's Office of Cybersecurity, Energy Security, and Emergency Response (CESER) have further strengthened their well-established coordination of research activities to advance quantum technology for cybersecurity of our Nation's critical energy delivery infrastructure.

In addition to routine interactions, the SC and CESER Offices are both formal members of the Networking Information Technology Research and Development (NITRD) program that provides a highly-effective forum for coordination among multiple Federal agencies.

For example, SC and CESER are fully engaged with NITRD in the update of the Federal Cybersecurity R&D Strategic Plan, and recently participated in the NITRD Subcommittee Meeting on QIS.

SC research advances foundational, longer-term priorities that CESER leverages for more immediate application. For instance, CESER's applied research in quantum key distribution (QKD) leverages the more foundational advances in QIS pioneered by SC. The close and ongoing coordination between SC and CESER directly supports the National Cyber Strategy priority of QIS innovations that strengthen national security of the energy sector.

Question: How is the quantum research being coordinated across the Office of Science?

With its expertise and capabilities in, and likely impacts across a broad range of fundamental science areas, funding basic research in Quantum Information Science (QIS) is a priority for the Office of Science (SC). SC's QIS research program is unique because it was

¹ <https://www.energy.gov/sites/prod/files/2018/10/f57/National-Cyber-Strategy.pdf>

developed by all six SC Associate Directors and remains tightly coordinated across the program offices. The programs share draft funding opportunity announcements and initial funding decisions with each other and look for opportunities for further collaboration. In January, 2019, SC organized a QIS kick-off meeting to bring together all of the SC-funded QIS research teams to further promote collaboration and coordination across the programs. The FY 2020 President's Budget Request contains funding in the Advanced Scientific Computing Research, Basic Energy Sciences and High Energy Physics programs to jointly fund at least one quantum center. The three programs are working closely to identify possible center topics and plan to release a joint funding opportunity announcement when appropriated funds are available.

Question: Please describe how the budget request supports investment in quantum technology to secure the nation's electric grid and other critical infrastructure.

The Office of Science (SC) investments that advance basic Quantum Information Science (QIS) build the necessary foundation for directly applied research, such as CESER's innovations in quantum key distribution (QKD) tailored to the unique operational requirements of critical energy delivery infrastructure.

QIS has its roots in information theory, which recognizes that all information has some sort of physical manifestation. QKD is an application, founded in QIS, that encodes information in photons to establish shared secret keys at two different locations. Some QKD systems use polarized photons to generate the secret key, some use entangled photons, and other approaches are being developed as well. As an example of CESER applied research in the quantum physics technology domain, Los Alamos National Laboratory is partnering with the private company Qubitekk, and a military installation, to develop and demonstrate interoperability of various QKD technologies, which can be expected to reduce cost, broaden reach and accelerate adoption by the energy sector. In another example, Oak Ridge National Laboratory is leading a research partnership to advance cryptographic protection for energy delivery infrastructure by increasing

distance and decreasing cost of QKD systems for the energy sector as well as developing new quantum protocols for authentication and data integrity.

The SC budget request supports investment in foundational quantum technology that is essential to development and research of applied quantum technology, such as QKD, that the CESER Office is advancing in partnership with the energy sector and in coordination with SC. Continuing and close coordination between SC and CESER is accelerating the development of quantum-physics based technologies from the laboratory, into the real-world to strengthen cybersecurity of critical energy infrastructure.

Question: Is the Department taking steps to ensure that the quantum technology to be used by the U.S. is provided by domestic sources and not foreign companies like Huawei?

Quantum technology is in its infancy. DOE is working closely with key Federal agencies such as the National Institute of Standards and Technology (NIST) to ensure that the U.S. is building a domestic supply chain for quantum technology. In the future, DOE will build on the Advanced Scientific Computing Research's ESnet's success in working with U.S. networking vendors to build the technology needed to support and secure the next generation network.

The budget request calls for establishing at least one multidisciplinary Quantum Information Sciences center.

Question: What is the purpose and necessity for quantum centers?

To realize the full potential of Quantum Information Science (QIS) requires a detailed understanding of how quantum systems behave, accurate knowledge of how to integrate the components into complex systems, and precise control of the structures and functionalities. Numerous questions remain, ranging from how quantum interactions may enable innovation through the creation of novel quantum systems, to how these new quantum technologies can advance our understanding of the natural world at the most fundamental levels.

The traditional linear model of discovery science leading to design, development, and

commercial deployment will not alone meet these goals within an acceptable time, due to the urgency and scale of our mission. Rather, there is a need for bold approaches that better couple all elements of the technology innovation chain and combine the talents of universities, national labs, and the private sector in concerted efforts to define and construct the green, internationally competitive economy.

The purpose of one or more SC Quantum Information Science Centers will be to push the current state-of-the-art science and technology toward realizing the full potential of quantum-based applications, from computing, to communication, to sensing. The interdisciplinary nature of the field, the reliance on complex, sophisticated, and precise physical arrangements in order to observe and utilize quantum behavior, and the potential for substantial economic consequences are the major drivers of the proposed QIS Initiative. The SC QIS Centers, coupled with a robust core research portfolio stewarded by the individual SC programs, will create the ecosystem needed to foster and facilitate advancement of QIS with benefits in national security, economic competitiveness, and leadership in scientific discovery.

Question: How many quantum centers are necessary and what would be the relative funding sizes of those quantum centers?

The FY 2020 President's Budget Request includes funds in the Advanced Scientific Computing Research (ASCR), Basic Energy Sciences (BES) and High Energy Physics (HEP) programs within the Department's Office of Science (SC) to establish and fully fund at least one critical Quantum Information Science (QIS) Research Center. These centers may be funded at up to \$25 million per year for a five year award term.

Recognizing that broad community involvement is critical to defining the QIS research centers, SC invited attendees at SC's first QIS Principal Investigators meeting in late January to present their ideas for Centers. Using that information as input, ASCR, BES and HEP plan to release, in late Spring, a Notice of Intent (NOI) to release a Funding Opportunity Announcement

(FOA) for QIS Research Centers, subject to availability of funds, coupled with a Request for Information (RFI) inviting interested parties to provide input on possible topic areas, organization, requirements, review criteria, and assessment process to be described in a forthcoming FOA. The information from the RFI will further refine our plans for the number of centers needed and relative funding sizes that will result in an FOA to be released in FY 2020.

8. Versatile Advanced Test Reactor

The budget request includes additional funding for the development of a design for a new advanced fast test reactor, the Department announced the “launch” of the Versatile Advanced Test Reactor earlier this year.

Question: What does a new versatile advanced test reactor capability get us that we don’t currently have across the domestic nuclear enterprise?

The Versatile Test Reactor (VTR) will provide a fast neutron spectrum at high intensity (high neutron flux) testing capability essential for the United States to modernize its nuclear energy research and development (R&D) infrastructure and support the accelerated development of transformational nuclear energy technologies. Due to the very high neutron flux that will be provided by the VTR, the irradiation time for testing of new materials can be reduced by an order of magnitude compared to that for a standard thermal test reactor such as the existing Advanced Test Reactor located at Idaho National Laboratory (INL). The United States has not had a fast neutron spectrum testing facility for over 20 years. The VTR is one of the Department’s highest priorities, and the VTR subprogram serves as a cornerstone to the Administration’s focus on reviving and expanding the nuclear sector in the United States. The VTR will help allow the United States to regain its global technical leadership role in the field of nuclear energy, contribute to the creation of high-paying jobs and economic prosperity, and train the next generation of scientists and engineers needed for the future viability of our nuclear sector.

Question: Has the Department examined using existing infrastructure versus building new?

Yes. Current irradiation test reactor capabilities provide thermal neutron spectrum testing capability, which is ideally suited for the current fleet of light water reactors. While these reactors have very limited ability to provide some fast neutron spectrum testing capability, the size and number of their irradiation volumes is small and few. More importantly, the fast neutron spectrum flux from the current irradiation test reactors is woefully inadequate for the timely development of advanced reactor technologies in the United States.

Question: How is the Department going to coordinate with industry, researchers, and other potential users to ensure the new facility will contain the right capabilities?

Development of the Versatile Test Reactor is being led by INL, under the Department's direction. INL has assembled a team of scientists and engineers from Argonne National Laboratory, Oak Ridge National Laboratory, Los Alamos National Laboratory, Savannah River National Laboratory, and the Pacific Northwest National Laboratory. The team has engaged with several advanced reactor developers and universities to understand their needs and to develop conceptual experiments to ensure that the needed experimental test parameters are accommodated for in the design. The team receives input from industry trade groups and from the Office of Nuclear Energy's federal advisory committee, the Nuclear Energy Advisory Committee.

Question: What is the international context for this issue? Are there other fast reactors in use or being built abroad?

India, the Russian Federation, and the People's Republic of China have operating fast neutron spectrum irradiation test reactors. Japan's irradiation test reactor is currently shut down and its future uncertain. In addition to other considerations associated with conducting irradiation experiments for the development of U.S. advanced reactor technologies overseas, the

logistical challenges of shipping irradiated materials is challenging.

Question: What is the expected cost and timeline for building the versatile advanced test reactor?

The Department has prepared a preliminary cost estimate that ranges between \$3 billion and \$6 billion with an estimated completion date between 2026 and 2030. The next steps are for the Office of Nuclear Energy to fully develop the pre-requisite documentation for the next critical decision milestone and includes completing the analyses of alternatives, a conceptual design, and developing narrower cost and schedule ranges that are specific to the selected alternative.

9. **High Assay Low Enriched Uranium (HALEU)**

The budget request includes efforts for the investigation of technologies for providing high assay low enriched uranium (HALEU) feedstock for advanced reactor fuels and that may be needed for advanced reactors.

Question: Has the Department assessed the possible demand profile, in terms of quantities and timeframes, for HALEU feedstock?

The Department of Energy's Office of Nuclear Energy has assessed the possible demand profile in terms of quantities and timeframes for HALEU feedstock. A HALEU production capability utilizing U.S.-origin enrichment technology will enhance U.S. energy security as well as provide fuel to support development and deployment of advanced reactors, including the global use of U.S. designs. Based on current projections, there will be a need for HALEU in the early 2020s to support advanced reactor fuel qualification testing and for demonstration reactors. A new enrichment capability would be needed to satisfy any long-term commercial demand should it materialize.

Question: Has the Department considered the various sources and methods for producing the HALEU feedstock?

The Department is considering various sources and methods for producing domestic HALEU. For example, the FY 2020 Budget requests funding for the Department to continue to execute a cost-shared demonstration program with industry to complete one lead cascade of centrifuges to produce domestic HALEU by FY 2022. This is a three-year effort, and the Federal Government's cumulative cost share contribution for this project, during the entire life of the project, will not exceed \$115 million. This demonstration project is separate from the National Nuclear Security Administration's (NNSA's) Domestic Uranium Enrichment program, which is exploring options to meet certain long-term Departmental uranium enrichment needs.

Question: Should producing HALEU feedstock – for either the commercial sector or for government-owned advanced reactors – be a government or private sector role?

The Department believes that the production of domestic HALEU feedstock for the U.S. commercial nuclear industry should be pursued by the private sector. Therefore, the lead cascade that will be completed in the demonstration program discussed above will include only a small number of centrifuges for demonstration purposes only. The private sector is responsible for funding any expansion or commercialization of the technology to produce HALEU after this program concludes in FY 2022. Also, while a private sector option may also be able to serve some Government needs, the Department will explore all options when Government needs for advanced reactors are identified to ensure that its needs are met.

10. Exascale Computing

The budget request includes \$809 million for exascale computing, including \$500 million for the Office of Science and \$309 in the National Nuclear Security Administration.

Question: Are we still on track to achieve exascale computing in 2021 with a second system in 2022?

Recent Independent Project Reviews of both the Argonne and Oak Ridge Leadership Computing Facilities confirmed that the Office of Science is on track to begin deployment of the first exascale system in 2021 followed closely by the second system in 2022.

Question: How much money has been spent to date on exascale computing?

From FY 2009 through FY 2019, the Office of Science has spent \$2.1 billion on exascale computing. Of the total amount, Advanced Scientific Computing Research (ASCR) expended \$300 million from FY 2009 – FY 2015 for early stage research in software and with hardware vendors supported in the FastForward and Design Forward activities and from Basic Energy Sciences (BES) expended \$8 million for the development of exascale-ready computational materials software prior to the establishment of the Department’s Exascale Computing crosscut in FY 2016. Since the Department’s Exascale Computing Initiative was established in FY 2016, ASCR has provided \$1.05 billion to support its portion of the Exascale Computing Project (ECP), which is focused on the research and development of exascale applications, software and critical hardware components and \$412.5 million to support non-recurring engineering costs and site preparations for the anticipated exascale systems at the Argonne and Oak Ridge Leadership Computing Facilities (ALCF, OLCF); BES has provided \$89.5 million and Biological Environmental Research has provided \$50.4M to support targeted exascale application development in their areas. The President’s FY 2020 Budget Request includes \$499.7 million for the Exascale Computing Initiative distributed as follows: \$188.7 million ECP; \$150 million ALCF; \$125 million OLCF; \$26 million BES; \$10 million BER.

Since the start of ECI, NNSA has provided \$64 million (FY 2016), \$85 million (FY 2017), \$193 million (FY 2018), and \$157 million (FY 2019). The FY 2020 NNSA PBR includes

\$175 million Advanced Technology Development and Mitigation, \$50 million Construction, and \$85 million Exascale System.

Question: How much additional funding will be required to achieve exascale computing in 2021 and 2022?

The Exascale funding estimates for FY 2021 and FY 2022 are currently under development.

Chairwoman Kaptur

1. Nuclear Reactor Technology

DOE is supporting efforts to develop new reactor designs.

Question: What efforts has DOE and NNSA undertaken to address advanced reactor and fuel cycle technologies in terms of nonproliferation policy and technology? Are there any issues of concern?

The Department of Energy is working domestically, bilaterally with its foreign partners, and in multilateral export control regimes to ensure that such developments are performed in accordance with the highest nonproliferation standards. Domestically, the Department of Energy continues to review carefully all requests from U.S. companies to export unclassified nuclear technology controlled by 10 CFR Part 810 (Part 810), including advanced reactor and fuel cycle technologies. Exporters always require specific authorization from the Secretary of Energy under Part 810 for transfers covered by section 810.7 (c), including fabrication of nuclear fuel containing plutonium, a production reactor or reprocessing irradiated nuclear fuel.

In addition, the Department of Energy is working with the U.S. interagency to assess the state of current multilateral export control lists to ensure they adequately cover advanced reactor concepts. This multi-year effort will consider reactor concepts, significant equipment, materials of construction, operation and fuel, as well as associated technology to ensure current Nuclear Suppliers Group (NSG) controls in the Trigger and Dual Use Lists fully address known advanced reactor concepts. Securing consensus on these questions in the NSG will ensure that other major suppliers share the U.S. understanding of what is subject to NSG control and will enable the United States to confirm that other NSG governments will apply the NSG conditions of supply to exports of those controlled items.

Within the Department's Office of Nuclear Energy (NE), several activities are underway to reduce proliferation and security risks associated with advanced reactor and fuel cycle

technologies. These efforts are taking place within both the domestic and international context.

NE is conducting research and works closely with the NNSA, Department of State, and the Nuclear Regulatory Commission on issues related to nuclear nonproliferation. In the fuel cycle area, the Materials Protection, Accounting and Control Technology subprogram develops the tools and technologies to manage nuclear materials and improve domestic safeguards. NNSA and NE have established cost-shared public-private partnerships in specific areas to develop improved nuclear technologies that incorporate safeguards-by-design and improved security concepts. NE is also supporting the nuclear technology development community by facilitating access to DOE data, knowledge, and capabilities through the Gateway for Accelerated Innovation in Nuclear (GAIN) initiative. As a founding member of the Generation IV International Framework (GIF), NE engages directly with the international research community to assess proliferation resistance and physical protection attributes of advanced reactor technologies, as well as participating in a collaborative relationship with the International Atomic Energy Agency to advance nuclear safety, physical protection, and proliferation resistance of next generation reactor designs. Our ability to promote U.S. nonproliferation policies and norms across a growing international nuclear community depends on our continued leadership in nuclear technology development. Some new reactor technologies, such as nuclear reactors utilizing liquid fuel forms, present new challenges to implementing safeguards or material controls, and these issues are being addressed as part of the design development and regulatory review process. The FY 2020 Budget provides that NE's international staffing and work will be consolidated into the Department's Office of International Affairs.

2. Funding Priorities for Weapons Sustainment

During the hearing the Department committed to providing additional information to help the Committee understand the most urgent funding priorities to sustain the nuclear deterrent along with information about the baseline production capacity of the nuclear security enterprise.

Question: What additional materials or information can you provide to assist the Committee as it considers the funding request for Weapons Activities? What does DOE/NNSA consider to be the most urgent funding priorities within the requested 12 percent increase?

The request is the result of a year-long disciplined process to prioritize funding for validated requirements as determined by the Administration. It will continue the implementation of policies from the 2018 Nuclear Posture Review, including continued modernization of the stockpile and infrastructure. It also increases investments in the scientific tools that support the stockpile and includes significant increases for the experimental and computational tools for annual assessments, certification of life extension programs, and qualification of new technologies.

Generally, NNSA's strategic priorities for the account are as follows:

- Support to the current nuclear stockpile, including activities for Annual Assessments, limited life component exchanges, and secure transportation
- Delivery of the five current warhead modernization activities (B61-12 and W80-4 Life Extension Programs, W88 Alteration 370, W76-2 and W87-1 Modification programs)
- Implementation of the plutonium pit production strategy at Los Alamos National Laboratory and the Savannah River Site to meet the 2030 goal of no fewer than 80 pits per year
- Facility modernization activities at Y-12 National Security Complex to support production of secondaries and radiation cases (focusing on the Uranium Processing Facility, Buildings 9204-2E, 9215, 9995)
- Loading of two Tennessee Valley Authority reactors and the Savannah River Site tritium extraction plan
- Enhanced Capabilities for Subcritical Experiments and Exascale computing in

support of warhead modernization

- Modernization of the infrastructure and reduction of deferred maintenance
- Improvement of cyber security measures

Nuclear deterrence remains the bedrock of America's national security. Given the importance of effective U.S. nuclear deterrence to the safety of the American people, allies, and partners, there is no doubt that NNSA's Stockpile Stewardship program should be regarded as both necessary and affordable. The programs funded in the Weapons Activities account support the Nation's current and future defense posture and the associated nationwide infrastructure of science, technology, engineering, and production capabilities. Additional details to assist the Committee as it considers the funding request for Weapons Activities can be found in the annual Stockpile Stewardship and Management Plan.

Congressman Calvert

1. National Quantum Initiative

Question: In light of the \$1.2B National Quantum Initiative recently signed into law, how is the Dept. of Energy planning to invest in quantum technology to secure the electrical grid and other critical infrastructure?

The Department of Energy's Office of Science (SC), the National Institute of Standards and Technology (NIST), and the National Science Foundation are leading the federal effort established by the National Quantum Initiative (NQI) Act to accelerate basic research that advances Quantum Information Science (QIS). The NQI will foster the growth of U.S. high-tech companies that leverage the resulting advances in QIS as a foundation to support a business case and prosper in the quantum physics technology domain.

Within the Department, SC coordinates closely with the Department's Office of Cybersecurity, Energy Security and Emergency Response (CESER), to ease the transition of basic research into applied research that results in technology useful, and used, by the energy sector to reduce the risk that a cyber-attack might disrupt energy delivery.

The Department's CESER Office supports research partnerships, awarded through a rigorous competitive process, that bring together asset owners and operators, suppliers, universities, national laboratories and other energy sector stakeholders to develop cyber-resilient technologies to support the energy sector and their infrastructure to survive a cyber-attack while sustaining critical functions. Since 2011, the Department has invested over \$20 million in research and development of Quantum Key Distribution (QKD), an application of QIS, tailored to the unique operational requirements of energy delivery control systems. The budget allocation for CESER activities is not from the National Quantum Initiative, CESER-funded advances in QKD are built on the foundation of basic research pioneered by SC, and now being accelerated through SC's lead role in the NQI.

2. U.S. Technological Superiority

Question: We hear a lot about critical US systems relying on Chinese technology. What steps is DOE taking to ensure that US companies, and not foreign companies like Huawei, provide the quantum technology that the US relies on in the coming decade?

As part of the National Quantum Initiative, the National Institute of Standards and Technology (NIST) has established the Quantum Economic Development Consortium (QED-C) to expand U.S. leadership in global quantum research and technology development (R&D). The QED-C's mission is to align resources and quantum research and development efforts between federal, academic and industry partners to ensure America's position at the forefront of scientific discovery and technology development. To realize this mission, QED-C members will collaborate on precompetitive R&D; determine workforce needs; provide efficient public-private sector coordination; identify technology solutions for filling gaps in research or infrastructure; and foster sharing of intellectual property, efficient supply chains, technology forecasting and quantum literacy. DOE collaborated closely with NIST in establishing the QED-C and serves, with NIST, on the QED-C Governing Board, providing Federal oversight.

Congressman Newhouse

1. DOE PILT Funding

Report language that accompanied the Fiscal Year 2018 Energy Appropriations Act directed the Department not later than 360 days after the enactment of this Act, to provide to the Committees on Appropriations of both Houses of Congress a report that describes the terms and payment amounts for each new PILT agreement and certifies that the terms of each agreement and calculations for payments are consistent across all eligible sites and with the statutory policy direction.

The Committee further directed the Comptroller General to undertake an assessment of DOE's PILT program to examine: 1) which communities have received payments and in what amounts; 2) how payment amounts were determined by DOE; 3) the extent to which agreements differ across sites; 4) the consistency of adjustments made to payments that reduce or increase amounts paid; and 5) whether DOE has made substantive changes to its payment policy or individual agreements since the issue was last examined by GAO.

It was the Committee's intent that the Department of Energy would design a PILT funding formula that is consistent year to year and based on actual land assessments and tax rates of those local governmental units eligible for a payment.

Question: Can you please provide an update on the status of the assessment as well as the design of a new PILT funding formula?

The Department of Energy (DOE) under Section 168 of the Atomic energy Act of 1954, as amended (42 U.S.C. 2208), is authorized, as a successor to the Atomic Energy Commission, to make payments in lieu of taxes to States and localities. DOE administers the PILT program across the complex as authorized in the PILT statute.

Before PILT payments can be made, localities must apply with documentation that: (1) the real property for which a PILT payment is sought currently is being used for activities authorized by the Atomic Energy Act of 1954; and, (2) the real property had been on the tax rolls of the applicant Taxing Authority immediately prior to acquisition of the real property by the Federal Government.

DOE will convene a working group to assess GAO's findings and recommendations, and provide options for DOE leadership review and approval.

WEDNESDAY, MARCH 27, 2019.

**DEPARTMENT OF ENERGY—U.S. ARMY CORPS OF
ENGINEERS AND BUREAU OF RECLAMATION**

WITNESSES

BRENDA BURMAN, COMMISSIONER, BUREAU OF RECLAMATION
**R.D. JAMES, ASSISTANT SECRETARY OF THE ARMY FOR CIVIL WORKS,
U.S. ARMY CORPS OF ENGINEERS**
**TIMOTHY PETTY, ASSISTANT SECRETARY FOR WATER AND SCIENCE,
U.S. DEPARTMENT OF INTERIOR**
**LIEUTENANT GENERAL TODD SEMONITE, COMMANDING GENERAL
AND CHIEF OF ENGINEERS, U.S. ARMY CORPS OF ENGINEERS**

Ms. KAPTUR. The subcommittee will come to order. Thank you all for being here at 9:45 a.m. and for the extra arrangements it took to acquire this room and set it up. We want to thank all of our guests. Assistant Secretary James, General Semonite, Assistant Secretary Petty, and Commissioner Burman, thank you for being here today.

I also want to welcome the Corps Division Commanders. The work you do is of critical importance to our Nation and we all thank you for your patriotic service and for making the effort to be with us. We are just happy to see you here.

We are here today to discuss the fiscal year 2020 budget request for the Army Corps of Engineers and the Bureau of Reclamation.

These agencies play a vital role in the management and development of one of our most precious resources, probably the most vital, water. Your agencies have been under pressure over significant flooding, especially high rainfalls, and other extreme weather events. You are at the front lines. You see what is happening to our country and to our Earth. And I know you make the difficult choices regularly and we appreciate your leadership.

We are pressing for action on the disaster supplemental that passed the House in January which contains funding for both agencies to address recent hurricanes, wildfires, and other natural disasters, some of which are rather extraordinary. And I am sure more will be necessary to address the recent flooding in the Midwest.

The water resource needs of our country vary from region to region but all corners of our Nation require investments in this essential infrastructure. The Corps and Bureau support critical navigation and irrigation projects that enable farmers and manufacturers to bring their goods to market. Flood control projects protect our citizens' property and livelihoods. And ecosystem restoration projects protect and restore the environment and we are still all learning together on how to live in concert with our environment.

Unfortunately, the budget request is woefully inadequate to address the challenges before us. It slashes funding for the Corps and

Bureau by nearly a third each from 2019 levels. At a time when we should be investing in water infrastructure improvements, this budget moves us in absolutely the wrong direction.

And that is why we are all here. We represent the American people and we are going to make a difference. Examples of the variability of our country's water infrastructure needs include in the Great Lakes region, which I am privileged to represent, extreme rain events that exacerbate nutrient runoff problems and cause massive algae blooms in Lake Erie and other places threatening fresh water supplies to millions and millions of people.

In the West, despite recent above average rainfall, drought recovery efforts are ongoing and water challenges continue. Many states and territories are still recovering from devastating hurricanes and typhoons and, sadly, right now Midwest States are experiencing historic flooding caused by snow melt and increased rainfall.

And NOAA is predicting that 25 states are at elevated risk of historic flooding this spring. It is an understatement to say that this request simply does not address these critical needs.

There are some bright spots. I was pleased with the inclusion of \$75 million for the vital Soo Lock. This long-awaited update will keep critical cargo moving in the face of an unexpected outage.

However, I am disheartened to see that this request yet again does not respond to certain pressing needs of the Great Lakes region. Your budget abdicates responsibility to the people of the Great Lakes region. Asian carp is one of the greatest threats to the multibillion-dollar Great Lakes fishery yet your budget provides no funding to move forward on a project to keep the carp out of the lakes.

Furthermore, the Corps is an important partner in interagency efforts to control the carp and this request again slashes that funding.

The agencies with us today were created to address the unique water resource challenges across our great country. This must include the need to incorporate resiliency into projects and to address a changing climate that is producing more severe and frequent weather events.

However, the administration's budget is simply inadequate to make investments in robust, resilient water infrastructure that we so desperately need.

Nevertheless, the subcommittee recognizes and appreciates the importance of your work. Thank you for being here and we look forward to hearing from you.

And I will now turn to our ranking member, Mr. Simpson, for opening remarks.

Mr. SIMPSON. Thank you, Chairwoman Kaptur. It's nice to be here in the Ag Room. It is surprising when I look around there are no real good pictures of potato fields or anything like that, which is the number one source of fiber in our diets and a good source of potassium if you want to know it. I am just throwing that out there.

I would like to join you in welcoming our witnesses as well as the Army Corps Division commanders in the audience. We thank each of you for your continued service to our Nation.

I look forward to today's discussion of the fiscal year 2020 budget requests for the U.S. Army Corps of Engineers' Civil Works Programs and the Department of Interior's Central Utah Project and the Bureau of Reclamation.

Although I was not surprised since it happens almost every year, I was still disappointed to see the budget request included large cuts for these programs. The infrastructure investments carried out under these programs are critical to improving our national economy, public health safety, and the environment. And I am confident that this committee will work together to provide strong support for these programs once again.

More concerning than the reduced funding levels, though, are the proposals to do away with the Civil Works Program as we know it. In June of 2018, the Office of Management and Budget, one of my favorite places, released a proposal to reorganize the Federal Government that included elimination of the Civil Works Program with the Army Corps of Engineers.

The OMB proposed to transfer the navigation mission to the Department of Transportation to be implemented primarily as a grant program with reduced Federal funding. The OMB proposed to transfer the remainder of the Civil Works Program, including flood control and presumably the emergency response mission, to the Department of Interior.

This proposal was flawed on many levels and through the fiscal year 2019 appropriations process, Congress rejected it on a strong bipartisan bicameral basis. Yet I see some pieces of the fiscal year 2020 budget request that looks like an attempt to start moving toward implementing pieces of OMB's proposals.

For instance, the budget overview asserts that the current paradigm for investing in water resource development is not optimal. It goes on to state the budget also recognizes the need to challenge the way future construction investments are funded with less reliance on Federal appropriations.

The two new programs highlighted seem intended to move the Corps toward becoming a grant-making agency and to allow its non-Federal sponsors to jump in front of the line for the Federal funding by agreeing to fund a large portion of the costs overall for or earlier in time than required by law.

I do not support either of these goals. I expect to work with chairwoman and our other colleagues to recognize the importance of the Corps of Engineers and to reject OMB's misguided policy and funding proposals yet again.

Finally, I would like to mention that Congresswoman Granger, ranking member of the full committee, had planned to be here today, but due to unexpected events caused her to miss this hearing. I know that she, too, understands and appreciates the good work done by our witnesses and their agencies. I would like to ask unanimous consent that she be allowed to submit a statement for the record.

Ms. KAPTUR. Without objection, her remarks will be placed in the record.

Mr. SIMPSON. And I will have a question on her behalf at the appropriate time. Thank you, Chairwoman Kaptur, for calling this hearing and I look forward to the discussion with our witnesses.

Ms. KAPTUR. Thank you very much, Mr. Simpson. And I am sure when everyone walked into the room they noticed the sign out there that said, "Sustaining Life on Earth."

We are in the Agriculture Committee room, but the congressman who chairs this subcommittee now and I have agreed that that is our slogan for both of our committees. So you have got both water, energy, and agriculture here. So we kind of have a symbiotic relationship.

And we are pleased to have all of our witnesses here today. First we will hear from the Honorable R.D. James, assistant secretary for the Army for Civil Works. Mr. James serves as the 12th assistant secretary for the Army for Civil Works and was a Mississippi River commissioner for decades before, so he is no stranger to the Corps.

Next, Lieutenant General Todd Semonite, commanding general and chief of engineers. Lieutenant General Semonite assumed his current position on May 19, 2016. Prior to this role, General Semonite served in various leadership capacities within the Army, including as commanding general for combined security transition of command in Afghanistan.

Following that, Assistant Secretary Timothy Petty, the assistant secretary for water and science at the Department of Interior. Assistant Secretary Petty served as deputy legislative director for the U.S. Senator James E. Reich of Idaho and acting assistant secretary and deputy assistant secretary for water and science at the Department of Interior under President George W. Bush.

And last but not least, we will have Commissioner Brenda Burman from the U.S. Bureau of Reclamation. Commissioner Burman is the 23rd commissioner for the Bureau of Reclamation and the first woman to lead Reclamation. America is an exciting place to be.

Thank you all for being here today. Without objection, your written statements will be entered into the record. Please feel free to summarize your remarks in about 5 minutes each, starting with Assistant Secretary James.

Mr. JAMES. Now it is. Sorry about that. Thank you for the opportunity to be here today to discuss the fiscal year 2020 budget for the Civil Works Program of the Army Corps of Engineers.

I have been on the job for a little over a year and my goal now is the same as it was the day I was sworn in. Focus on outcomes, not process in order to get results.

Since the beginning of this year, I have had the pleasure to meet with each member of this subcommittee one on one to discuss both your concerns and the overall direction of the Corps of Engineers' Civil Works Program. The input that you provide is very much appreciated and I remain committed to working with each of you.

And I am pleased to be joined by Lieutenant General Todd Semonite, the 54th chief of engineers for the Army Corps of Engineers. I am grateful for his leadership and the energy he brings.

The fiscal year 2020 budget reflects the administration's priorities and provides \$4.8 billion for the Army Civil Works Program with a focus on investments that will yield high economic and environmental returns or address a significant risk to public safety.

This budget relies on a foundation of strong relationships between Congress, the Corps, and local communities which allow us to work together to help manage, develop, restore, and protect water sources.

The budget reflects the administration's priorities within the Corps' main mission areas: flood and coastal storm damage reduction, commercial navigation, and aquatic ecosystem restoration.

The budget supports a Corps program that has a diverse set of tools and approaches to working with local communities. Whether this means funding projects with our cost-sharing partners, providing planning assistance and technical expertise to help communities make better informed decisions, or participating in the national and international conversations on how to best address our water resource challenges, the budget helps us maintain and improve our efforts on resiliency and sustainability, one of the challenges associated with the ways we have used our water resources.

The budget also focuses on maintaining the vast water resources infrastructure that the Corps owns and manages and on finding innovative ways to rehabilitate or expand as necessary. I have been watching closely the flooding we have experienced in the Midwest and the South. As always, the Army Corps of Engineers is working with local communities to protect life and property and we will be there to help with the recovery.

Our citizens along the Missouri River have experienced the wettest conditions from last August until now in 124 years. The folks that live along the lower Mississippi are experiencing a top two or three all-time flood event. Flooding like this further underscores the importance of investment in critical infrastructure projects.

The Corps now has 867, and the general may correct me on this, this is the latest number I have, 867 personnel in the Missouri Valley and the Mississippi Valley deployed and 453 personnel providing remote support. I will visit these areas on Thursday and Friday of this week.

The fiscal year 2020 construction program includes a total of \$1.3 billion. This includes funding for nine commercial navigation projects, five aquatic ecosystem restoration projects and programs, and four flood risk management projects.

The construction program uses objective performance-based guidelines to allocate funding toward the highest performing economic environmental and public safety concerns.

Four construction projects are funded to completion in the fiscal year 2020 budget. They include three commercial navigation projects: Charleston Harbor; Monongahela Locks, and Melvin Price Lock and Dam; and one aquatic ecosystem restoration project, Mud Mountain Dam in Washington.

There are many more details regarding the fiscal year 2020 budget that I have submitted for the record as part of my official testimony.

Since receiving my appointment to BASA, I have had one mission: moving dirt. The intention is to start, continue, and finish projects in a more timely and efficient manner to ensure a better return on the taxpayers' investment and to better the lives of Americans.

We are working to refine our approaches so that we can optimize funding and allow the United States to appreciate all the benefits the Corps of Engineers has to offer.

Under my oversight and direction, and with the help of General Semonite and his team, the Corps of Engineers' Civil Works Program is taking bold actions to improve performance and engineer solutions for the Nation's toughest challenges.

I am committed to ensuring the Army Corps of Engineers does what they do better than any other organization in the world: design and build infrastructure projects, projects that protect lives, improve commerce, and benefit all Americans. Thank you for having me here today. I look forward to your questions.

[The information follows:]

DEPARTMENT OF THE ARMY

**WRITTEN STATEMENT
OF**

**MR. R.D. JAMES
ASSISTANT SECRETARY OF THE ARMY
FOR CIVIL WORKS**

**BEFORE
COMMITTEE ON APPROPRIATIONS
SUBCOMMITTEE ON ENERGY AND WATER DEVELOPMENT
UNITED STATES HOUSE OF REPRESENTATIVES**

ON

**THE FISCAL YEAR 2020 BUDGET
FOR THE CIVIL WORKS PROGRAM
OF THE ARMY CORPS OF ENGINEERS**

MARCH 27, 2019

Chairwoman Kaptur, Ranking Member Simpson and distinguished members of the committee, thank you for the opportunity to be here today to discuss the President's Budget for the Civil Works program of the Army Corps of Engineers.

The Fiscal Year 2020 Budget provides over \$4.8 billion for the Army Civil Works program, with a focus on investments that will yield high economic and environmental returns or address a significant risk to public safety. This Budget relies on a foundation of strong relationships between the Corps and local communities, which allow us to work together to help manage, develop, restore, and protect their water resources. The Budget focuses on the highest performing work within the three main missions of the Corps:

- commercial navigation,
- flood and coastal storm damage reduction, and
- aquatic ecosystem restoration.

The FY 2020 Budget includes approximately \$2.4 billion for the study, design, construction, operation and maintenance of inland and coastal navigation projects. The Budget gives priority to coastal harbors and inland waterways with the most commercial traffic. It also provides for the maintenance of channels at small ports, with emphasis on those that support significant commercial fishing, subsistence, or public transportation benefits.

The Flood Risk Management program is funded at approximately \$1.2 billion in the Budget and includes funding to provide technical and planning assistance to local communities to enable them to understand and to better manage their flood risks. The Budget assists these local efforts, with emphasis on non-structural approaches.

The Budget provides \$187 million to restore several large ecosystems that have been a focus of interagency collaboration and to support restoring aquatic habitat in ecosystems where the aquatic ecosystem structure, function, and processes have degraded.

These investments will enable communities to facilitate waterborne transportation, reduce their flood risk, and restore significant aquatic ecosystems.

The Budget supports a Corps program that has a diverse set of tools and approaches to working with local communities, whether this means funding projects with our cost-sharing partners, providing planning assistance and technical expertise to help communities make better informed decisions, or participating in the national and international conversations on how to best

address our water resources challenges. The Budget helps us maintain and improve our efforts on resiliency and sustainability – one of the challenges associated with the ways that we have used our water resources.

The Budget also focuses on maintaining the vast water resources infrastructure that the Corps owns and manages and on finding innovative ways to rehabilitate it or hand it over to others.

These goals will be met by funding capital investment in the inland waterways, and reforming the way that we finance these investments. Our proposal includes establishing an annual fee that will support infrastructure investment and economic growth by helping finance the users' share of future capital investment, as well as 10 percent of the operation and maintenance cost, associated with these waterways. The Budget once again proposes to divest the Washington Aqueduct, which is the wholesale water supply system for Washington, D.C.; Arlington County, Virginia; the City of Falls Church, Virginia; and parts of Fairfax County, Virginia.

The Budget proposes revisions to the appropriations language for the Construction, Operation and Maintenance, and Mississippi River and Tributaries accounts and the Harbor Maintenance and Inland Waterways Trust Funds to enable greater transparency and accountability in how these funds are budgeted and spent. The Press Book, which you have before you, reflects this by displaying the total account and project funding levels derived from each of these trust funds.

The Budget promotes increased non-Federal participation in the construction of Civil Works projects to improve project delivery and to increase cost savings. It includes \$150 million in the Construction account for the WRRDA 2014 Section 1043 Non-Federal Construction of Federal Projects program. The Corps would transfer this funding to non-Federal sponsors who have decided to construct an authorized project on their own under Section 1043 of WRRDA 2014, as amended. The Budget also proposes to extend this program's authorization, which currently expires on June 10, 2019. The Budget also provides \$150 million in the Construction account for the Innovative Funding Partnerships program. These funds would be used, in conjunction with funds voluntarily provided by non-Federal interests in excess of the non-Federal sponsor's statutory cost share requirements, to accelerate the completion of construction of authorized projects.

In addition, the budget proposes to return responsibility for management of the Formerly Utilized Sites Remedial Action Program (FUSRAP) back to the Department of Energy. The Army Corps would continue to perform cleanup of FUSRAP sites on a reimbursable basis with DOE. Consolidation of FUSRAP with

the other DOE federal cleanup programs under a single agency will allow DOE to consider a broader range of federal cleanup responsibilities in prioritizing work each fiscal year and result in efficiencies for taxpayers.

The FY 2020 Investigations program is funded at \$82 million in the Budget, including \$5 million from the Mississippi River and Tributaries (MR&T) account, of which \$26 million is to fund studies to determine the need, engineering feasibility, and economic, environmental and social return of potential solutions for water and related land resources problems.

The Investigations account includes funding to complete one preconstruction engineering and design (Mobile Harbor, AL), and three dredged material management plans (Buffalo Harbor, NY, Cleveland Harbor, OH and Corpus Christi Ship Channel, TX).

The FY 2020 Construction program includes a total of \$1.3 billion. This includes funding for nine commercial navigation projects, five aquatic ecosystem restoration projects and programs, and four flood risk management projects. The construction program uses objective, performance-based guidelines to allocate funding toward the highest performing economic, environmental, and public safety investments.

Four construction projects are funded to completion in the FY 2020 Budget. They include three commercial navigation projects – Charleston Harbor, SC; Locks and Dams 2, 3 and 4, Monongahela River, PA; and Melvin Price Lock and Dam, IL & MO; and one aquatic ecosystem restoration project – Mud Mountain Dam, WA.

The FY 2020 O&M program is funded at \$3 billion. For O&M, the Budget emphasizes performance of existing projects by focusing on those coastal harbors and inland waterways with the most commercial traffic. The allocation of funding for maintenance among projects reflects a risk-informed approach that considers both project and project component conditions and the potential consequences of a failure. The Budget also makes important investments in the O&M program to promote the sustainable management of the lands around Corps facilities, by providing funds to update the plans that govern how we manage our facilities and helping to combat invasive species.

The Budget proposes to derive \$965 million from the Harbor Maintenance Trust Fund to maintain coastal channels and related work, and \$55.5 million from the Inland Waterways Trust Fund to complete the Locks and Dams 2, 3, and 4, project on the Lower Monongahela River.

The FY 2020 Regulatory Program is funded at \$200 million to protect the nation's waters and wetlands and provide efficiency in permit processing.

Lastly, the Budget provides a total of \$32 million for the Emergency Management program, a robust level of funding to help ensure that our people are properly trained and equipped, so that they will be able to help communities respond to a flood or other disaster.

Thank you all for inviting me here today. I look forward to your questions.





U.S. ARMY CORPS OF ENGINEERS

BILL DING STRONG OVER 2A3 YEARS

Engineering solutions for the Nation's toughest challenges.



Brig. Gen. D. Peter Helminger
Commander, Northwestern



Maj. Gen. Richard G. Kaiser
Commander, Missionary Valley



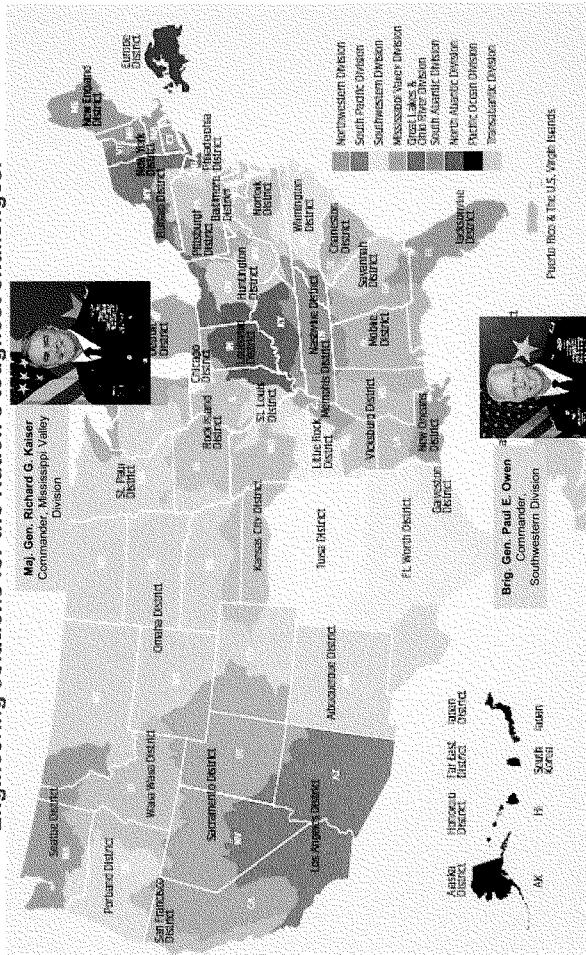
Maj. Gen. Mark Toy
Commander, Great Lakes and
Ohio River Division



Maj. Gen. Jeffrey L. Minnich
Commander, North Atlantic
Division



Brig. Gen. Diana M. Holland
Commander, South Atlantic
Division



U.S. Army Corps
of Engineers.



Brig. Gen. D. Peter Helminger
Commander, Northwestern



Brig. Gen. Kimberly M. Colletton
Commander, South Pacific Division

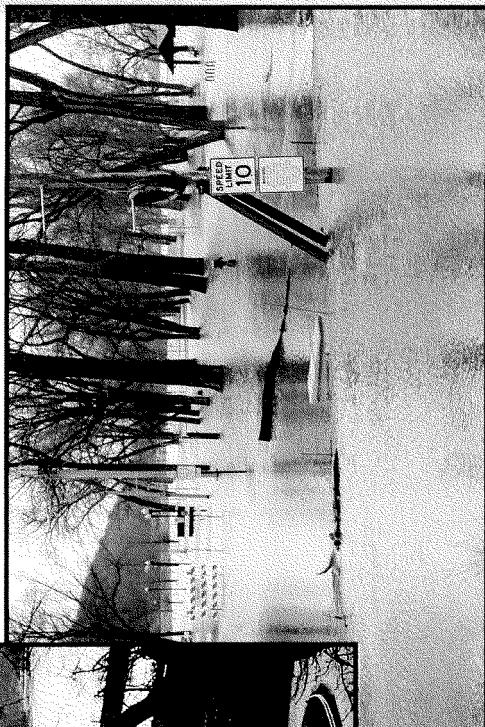
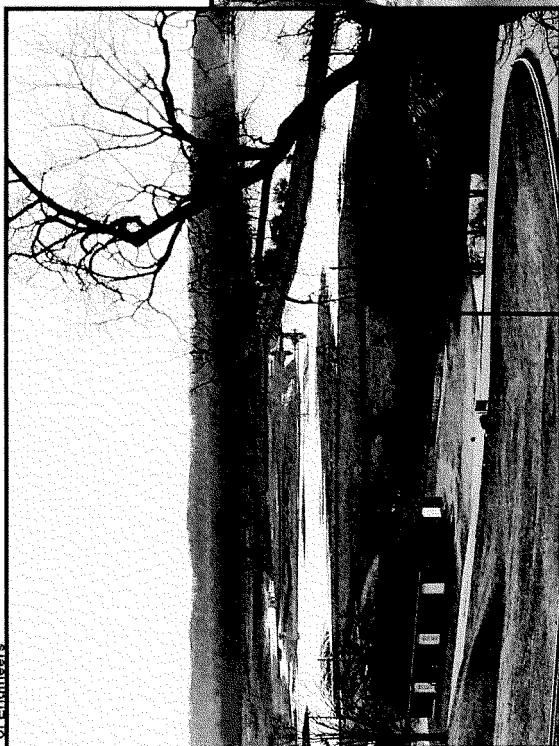


Brig. Gen. Thomas J. Tickner
Commander, Pacific Ocean
Division



FLOOD RESPONSE

US Army Corps
of Engineers





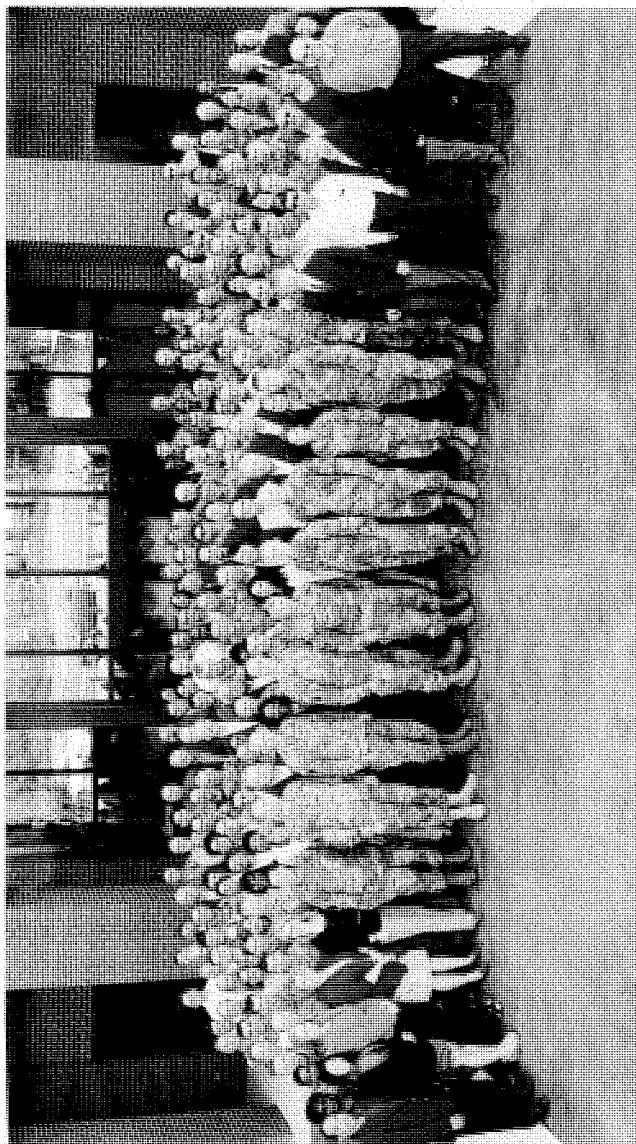
OLMSTEAD LOCK & DAM



U.S. Army Corps
of Engineers.

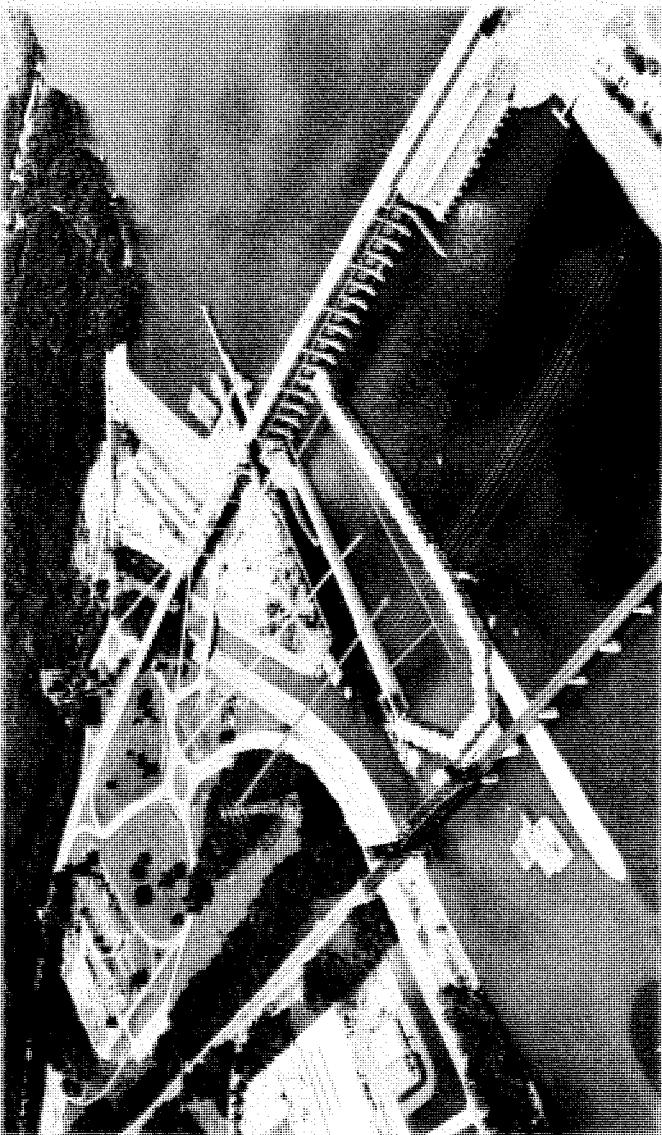


OUR PEOPLE MAKE USACE WORLD-CLASS!



US Army Corps
of Engineers.

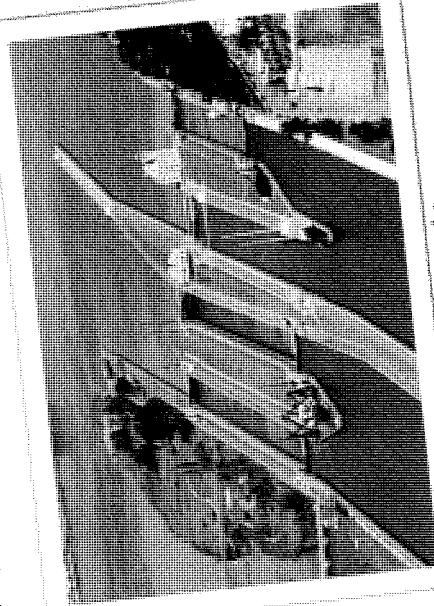
CHICKAMAUGA LOCK



US Army Corps
of Engineers.



GREAT LAKES NAVIGATION - SOO LOCKS



Existing Locks



Conceptual rendering of new locks



REVOLUTIONIZE USACE CIVIL WORKS

THREE OBJECTIVES

Accelerate Project Delivery

Transform Project Financing
and Budgeting

Improve Permitting and
Regulation Reform

DESIRED END STATE

Start and finish projects faster

New tools to more efficiently and
effectively deliver projects

Streamlined permit processes and
elimination of duplicative reviews
to expedite delivery of projects



REVOLUTIONIZE USACE CIVIL WORKS

Accelerate Project Delivery

Accomplishments to Date:

- **Project Delivery:**
 - ✓ Established accelerated schedules for emergency supplemental projects
 - ✓ Streamlined contracting processes (e.g. Increased threshold for certain contract consolidations)
- **Risk Informed Decision Making and Delegations of Authority:**
 - ✓ Modifications to completed Civil Works projects (Section 408)
 - ✓ Design and Construction deficiencies <\$500K

Key Actions In Progress:

- **Execution of Authorized Projects by Non-Federal Sponsors:**
 - Developing guidance per WRDA to allow potential credit for reimbursement of the Federal share.
 - Developing guidance on recent VRDRA amendment that negates Federal permit requirement when a non-Federal interest constructs a USACE project under certain conditions.
- **Continued Streamlining Acquisition:** Identify and implement additional acquisition changes to support accelerated project delivery.





REVOLUTIONIZE USACE CIVIL WORKS



Transform Project Financing and Budgeting

Accomplishments to Date:

- **P3 Policy:**
 - ✓ Policy from ASA(CW) issued Sep 2018, CW Guidance issued Jan 2019
 - ✓ Public Request for Information – Feb 2019
 - **WIFIA Loans:**
 - ✓ MOU with EPA to share resources and experience
 - ✓ Developed program plan consistent with OMB A-129 and A-11
 - **Civil Works Budgeting:**
 - ✓ Developed draft metrics that increase leveraging of Federal funds
- Key Actions In Progress:**
- P3 Request for Information** (due 2 April 2019)
 - WIFIA:**
 - Finalize credit subsidy model
 - Development of program structure and rules (spring 2019)
 - Civil Works Budgeting:**
 - Finalize, develop justification and support for new multi-year budget approach



REVOLUTIONIZE USACE CIVIL WORKS



Improve Permitting and Regulation Reform

Accomplishments to Date:

- ✓ Streamlined permission requests to modify Civil Works projects (Section 408)
- ✓ Alignment of Section 404/10/103 and 408 Programs
- ✓ Lead District policy for projects that span multiple districts
- ✓ Improved Public Access to Tracking Systems
- ✓ Mitigation - Regulatory Guidance Letter on removal of obsolete structures
- ✓ One Federal Decision Implementation Guidance
- ✓ Guidance for State Assumption under Section 404(g)
- ✓ Regulation Reform – reviewed 53 regulations

Key Actions In Progress:

- Mitigation:** Revise 2008 Mitigation Rule to streamline third party mitigation process/approvals
- Tracking Systems:** Establish public website to view status of permit applications
- Nationwide Permits:** Streamline processes & pre-construction notification reqs.
- Civil Works Projects:** Eliminate duplicative reviews for authorized Civil Works projects undertaken by non-Federal interests
- Regulation Reform:** Continue working efforts to repeal, replace, or modify regulations



OUR GOAL: TO "REVOLUTIONIZE" USACE

US Army Corps
of Engineers.

Accelerate
Project Delivery

01

Transform Project
Financing and
Budgeting

02

Improve Permitting
and Regulation
Reform

03



REVOLUTIONIZE
U.S. Army Corps of Engineers

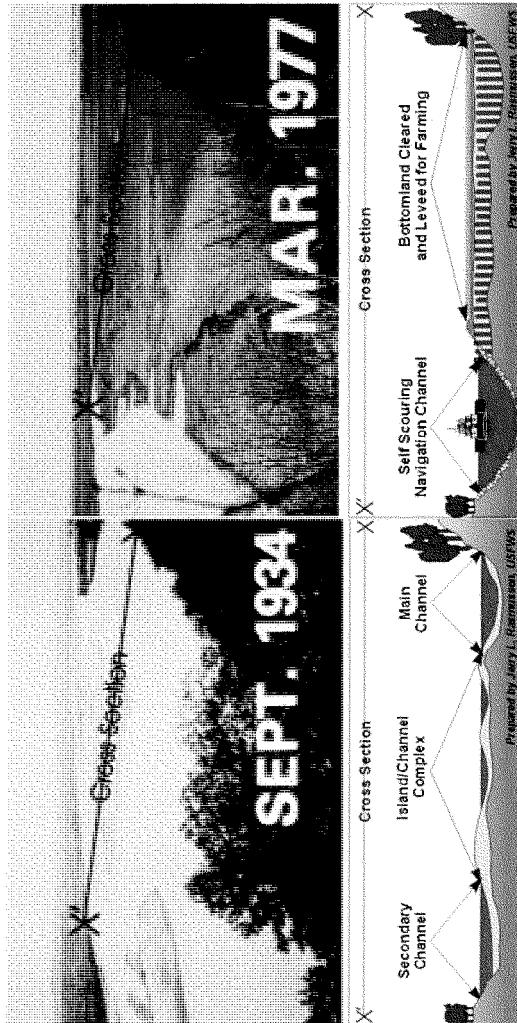
Whole-Of-Government Readiness • Healthy-Agency Blueprint

October 2019



BANK STABILIZATION AND NAVIGATION PROJECT

- Self scouring navigation channel created with rock structures
- Stabilized meandering river providing economic benefits
- 522,000 acres of land formed (additional economic benefits, particularly for agriculture)



US Army Corps
of Engineers

FLOOD RESPONSE

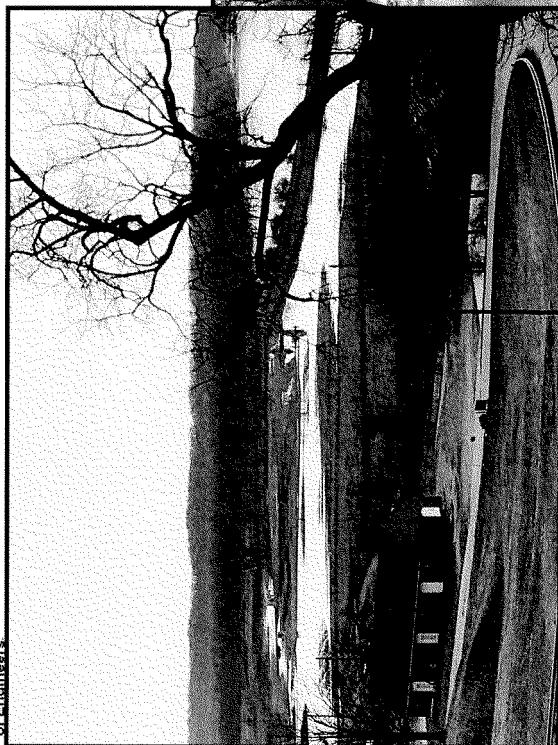


U.S. Army Corps
of Engineers.





FLOOD RESPONSE



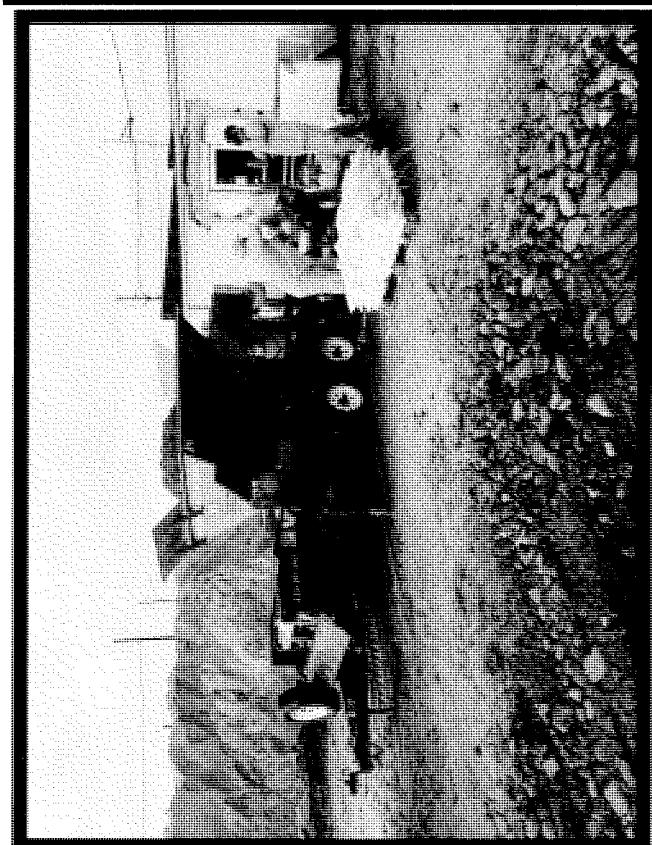
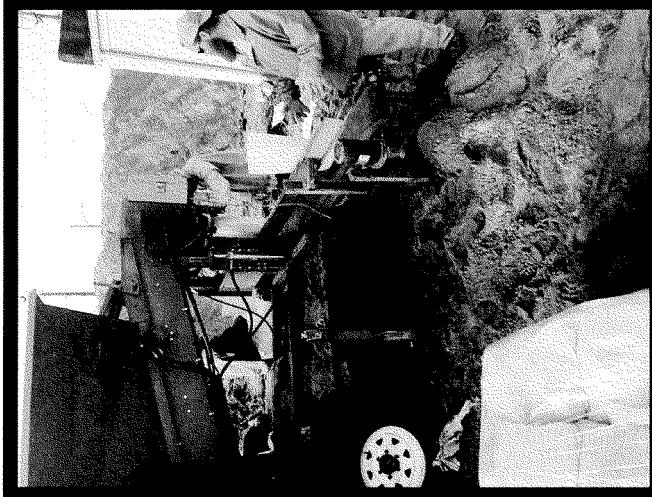
FLOOD RESPONSE



U.S. Army Corps
of Engineers



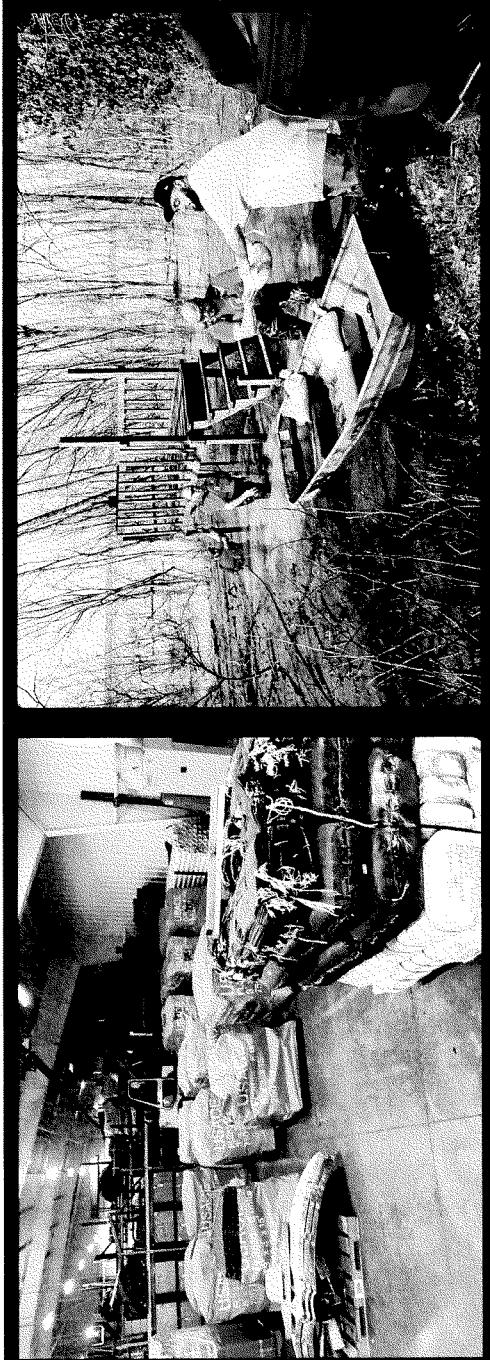
FLOOD RESPONSE



FLOOD RESPONSE

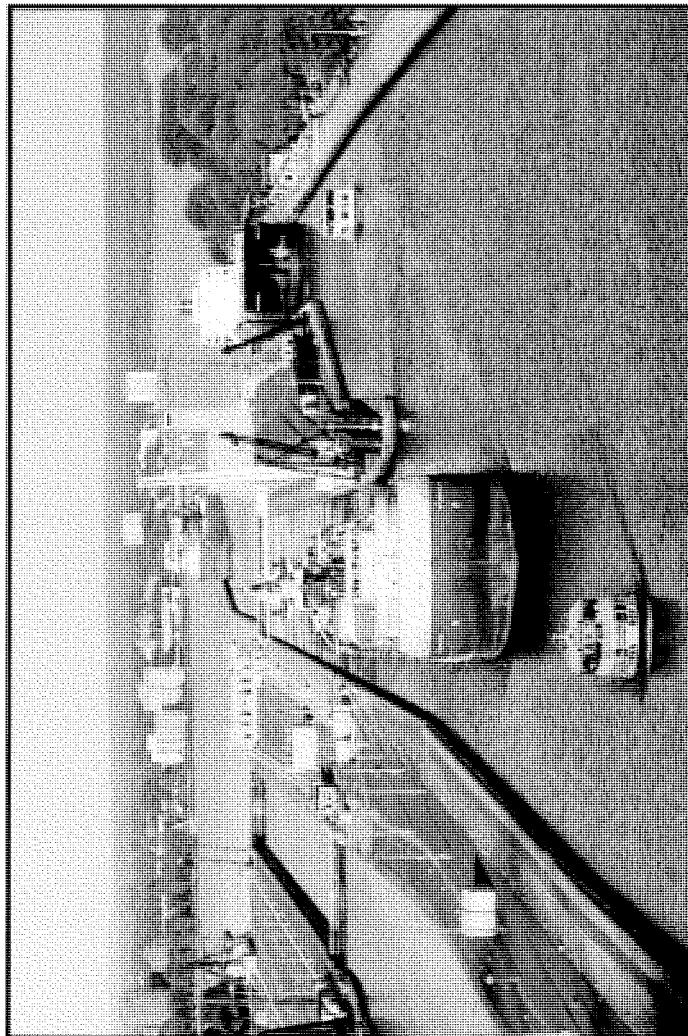


U.S. Army Corps
of Engineers.



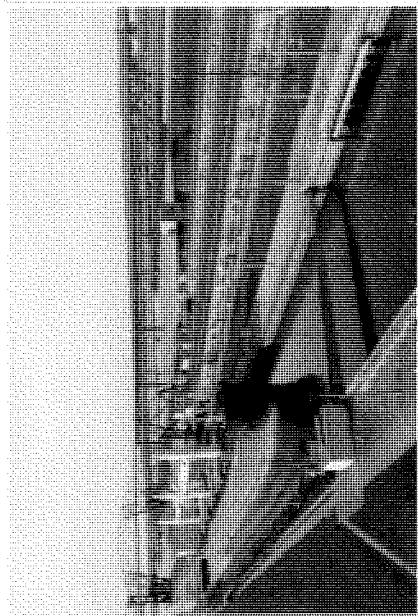


GREAT LAKES NAVIGATION - 500 LOCKS

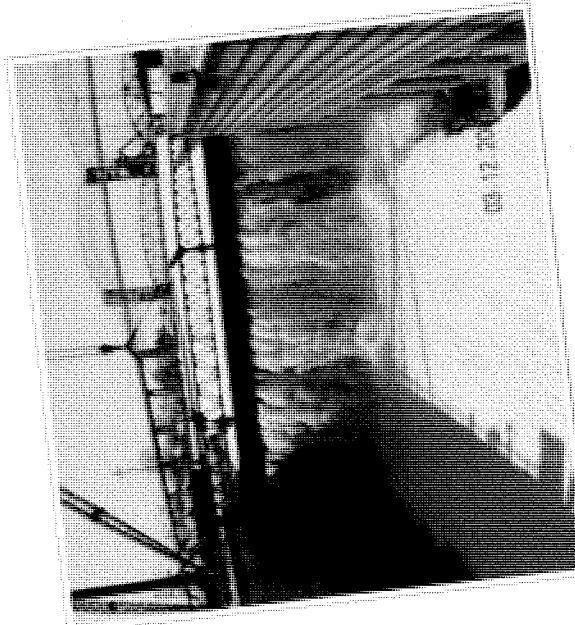


U.S. Army Corps
of Engineers.

GREAT LAKES NAVIGATION - SOO LOCKS



\$500B of iron ore passes
through the locks each
year, saving \$2.7B in
transportation costs



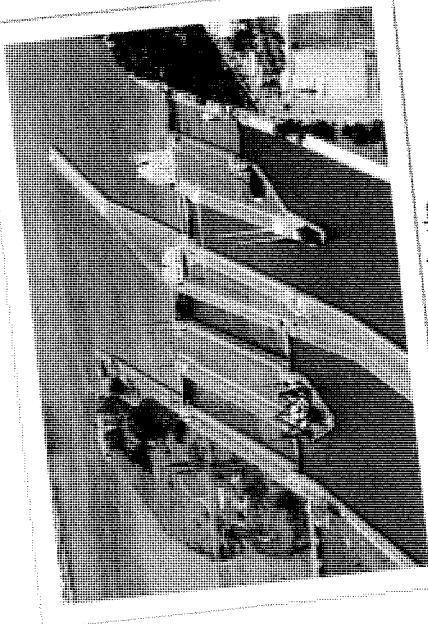
U.S. Army Corps
of Engineers



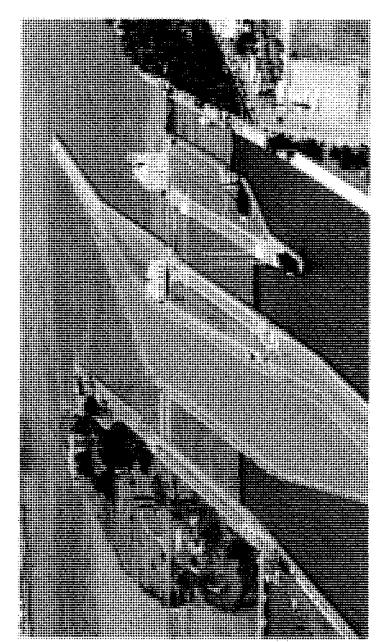
GREAT LAKES NAVIGATION - SOO LOCKS



U.S. Army Corps
of Engineers.



Existing Locks



Conceptual rendering of new locks

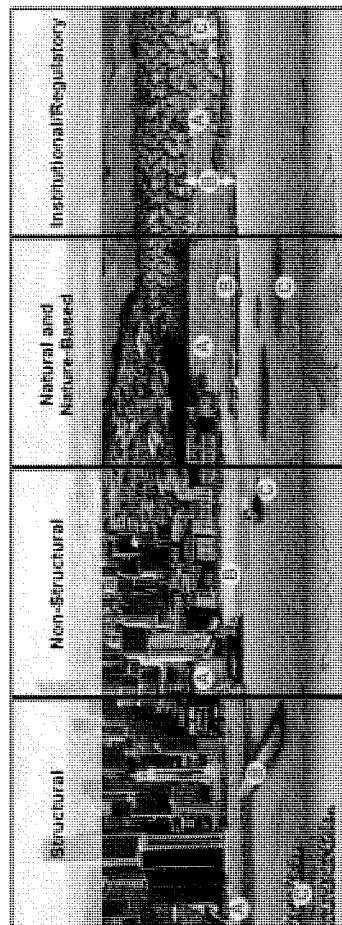
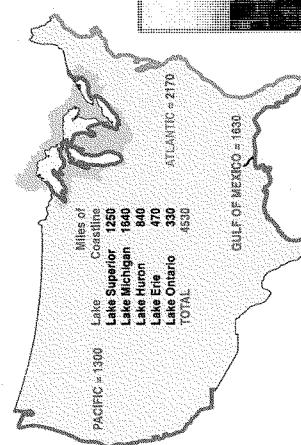


US Army Corps
of Engineers.

GREAT LAKES COASTAL RESILIENCY STUDY



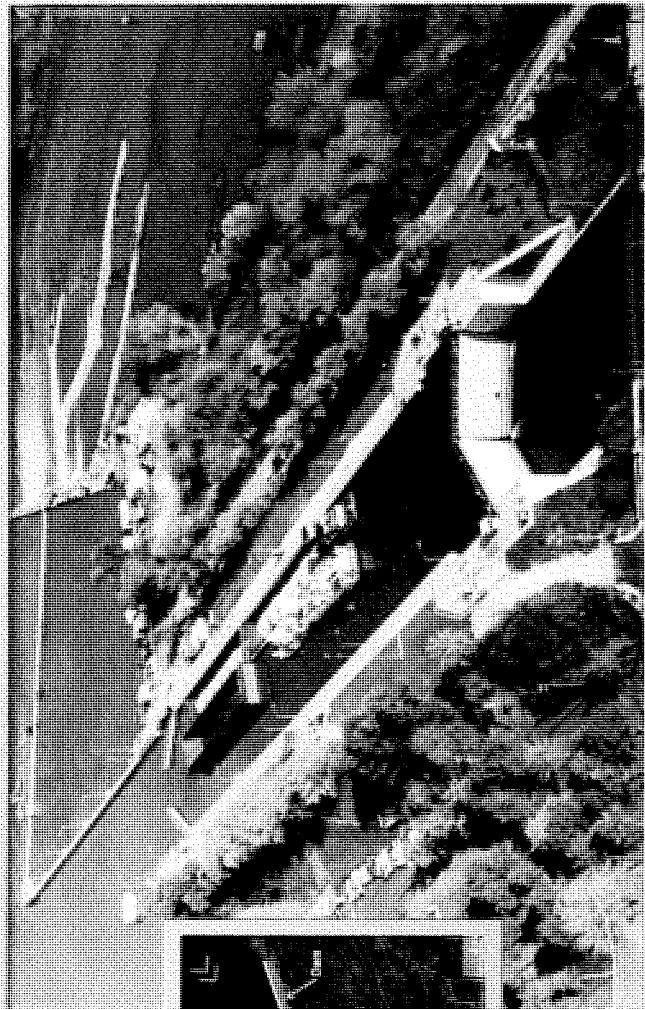
A *Coastal Resiliency Study* will identify opportunities to increase the ability of the Great Lakes coast to withstand, recover and adapt to increased frequency and severity of storm systems, and changing water levels.



- A. Coastal Armoring
 - B. Groins
 - C. Breakwaters/Revetments
- A. Dredging
 - B. Beach Nourishment
 - C. Littoral Sediment Supply
- A. Conservation
 - B. Wetland Creation
 - C. Barrier Island Creation

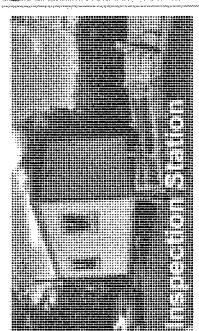
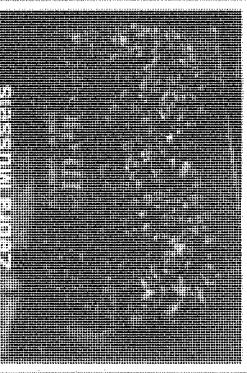
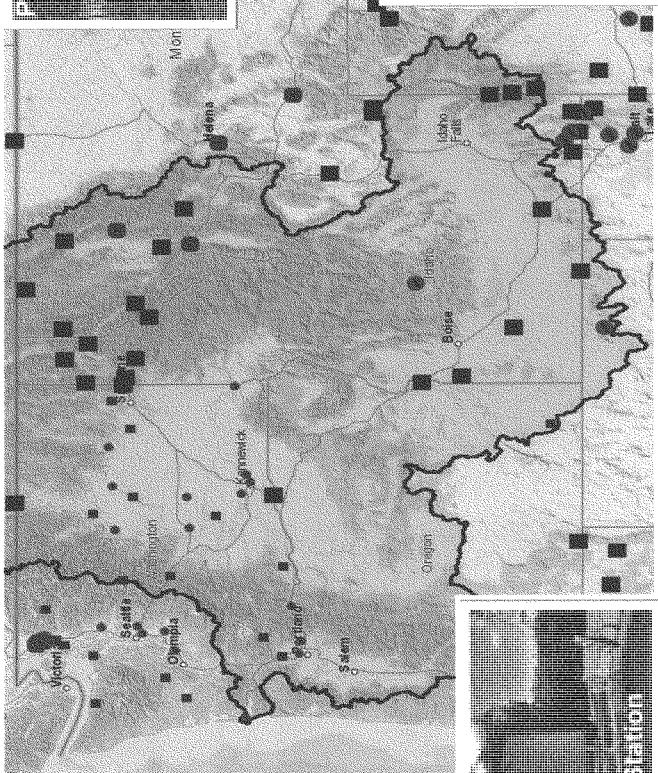
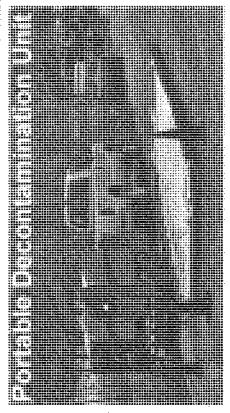
- A. Land Use Planning
- B. Setbacks/Zoning
- C. Resilient Design Standards

BRANDON ROAD



US Army Corps
of Engineers.

WATERCRAFT INSPECTION STATIONS



COLUMBIA RIVER SYSTEM OPERATIONS



U.S. Army
Corps
of Engineers

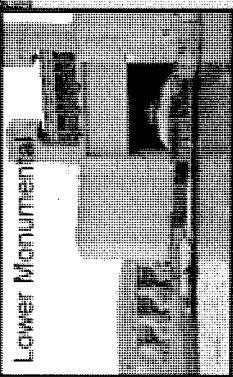


U.S. ARMY

Columbia River System Operations Projects



Lower Monumental



Chief Engineer
Glenel Gobin

Liberty
Huntington



Albeni Falls
Lamar



MONTANA

Louise Wittenberg
Lisa Simeone

Lower Granite
Mike Hersey

Libby



Lower Granite

Upper Granite
Mike Hersey

Libby

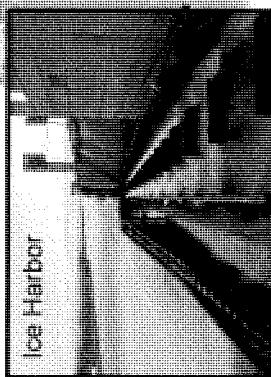
John Day
Tim Gobin
Mike Hersey

John Day
Mike Hersey

John Day
Mike Hersey

John Day
Mike Hersey

OREGON



Ice Harbor

Ice Harbor

John Day

Mike Hersey

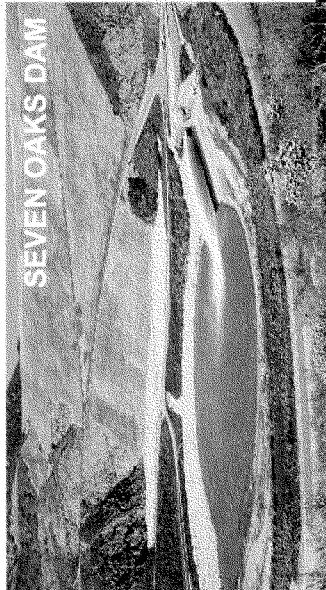
SANTA ANA RIVER MAINSTEM



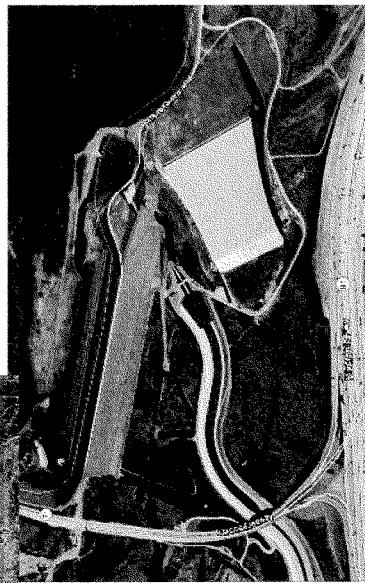
U.S. Army Corps
of Engineers.



SEVEN OAKS DAM



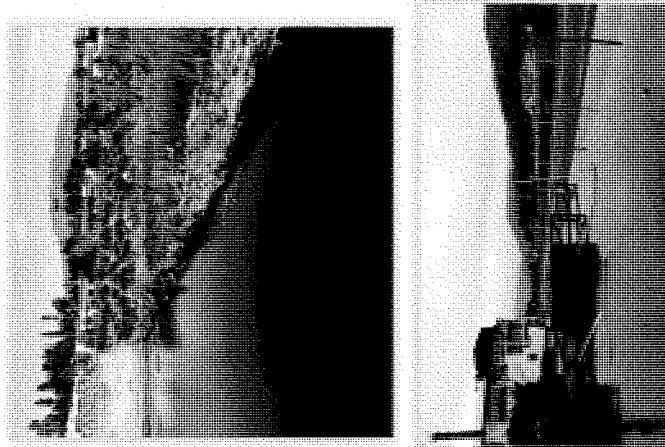
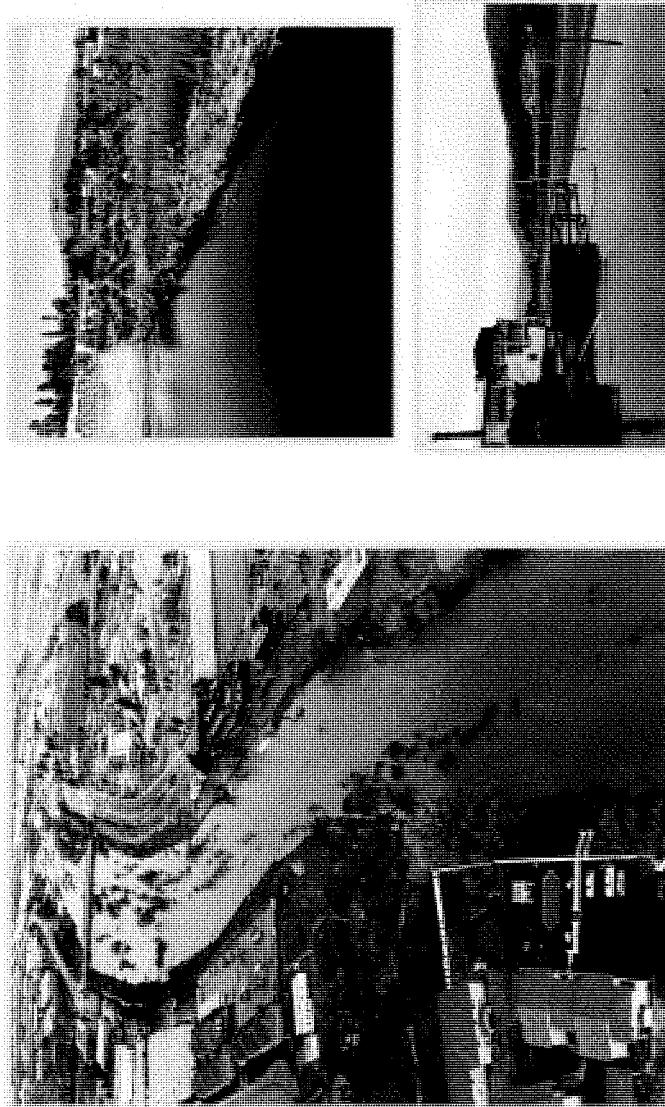
PRADO DAM



MURRIETTA CREEK



U.S. Army Corps
of Engineers.

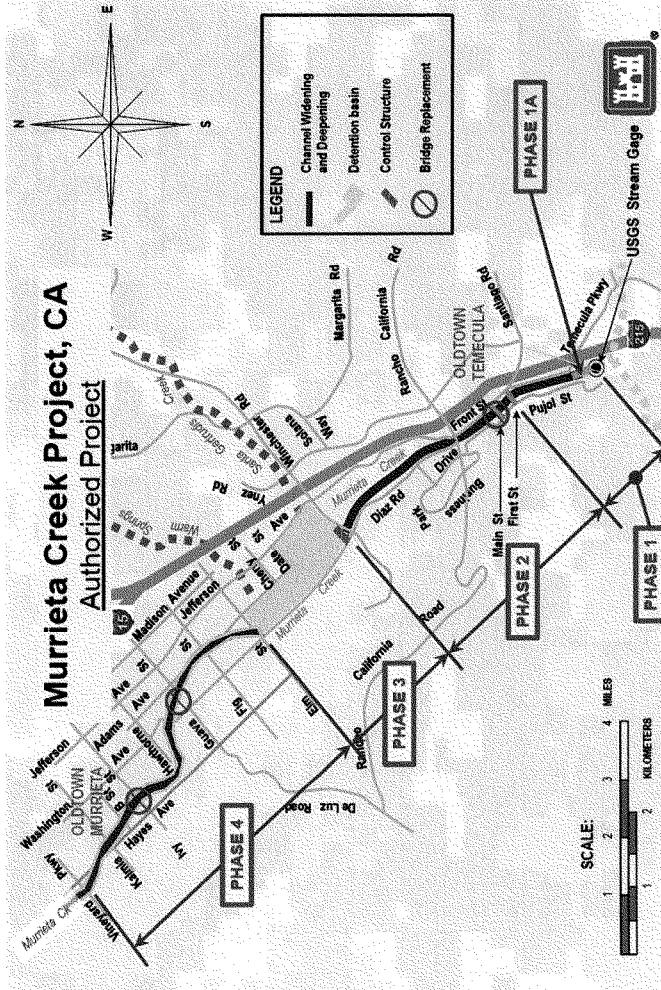


MURRIETA CREEK



U.S. Army
Corps
of Engineers.

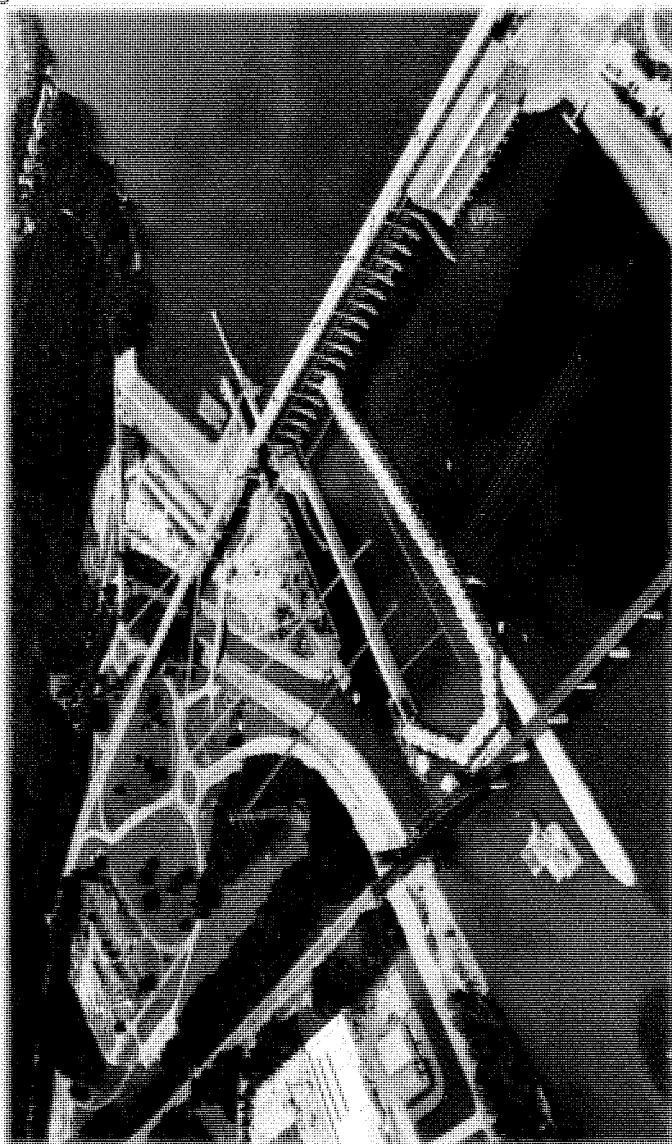
Murrieta Creek Project, CA Authorized Project



SCALE:
1 2 3 4 MILES
1 2 KILOMETERS

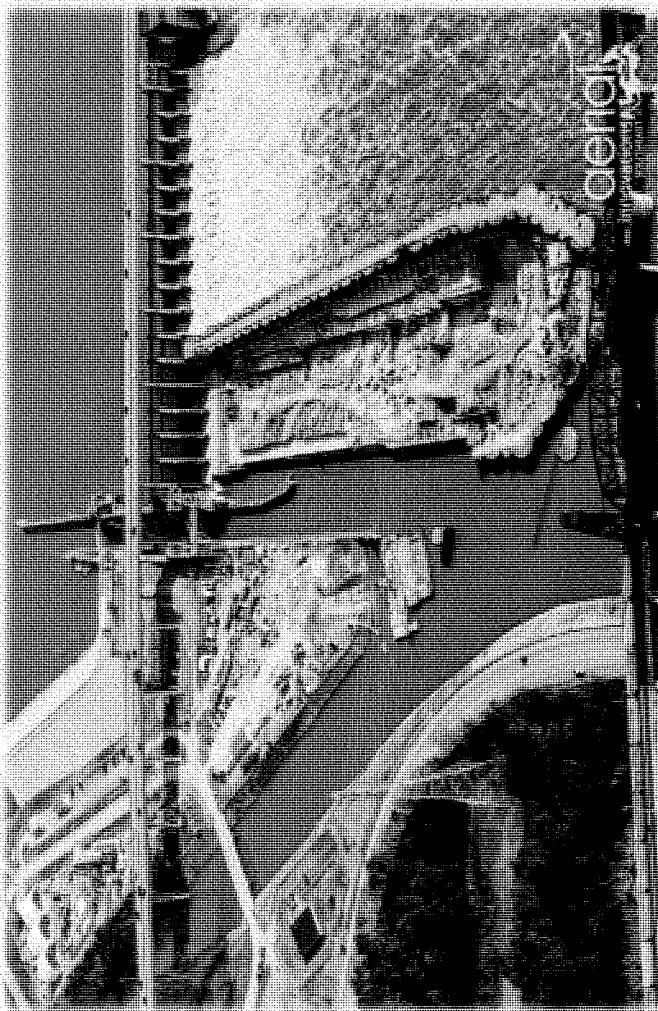


CHICKAMAUGA LOCK



US Army Corps
of Engineers

CHICKAMAUGA LOCK





CHICKAMAUGA LOCK



US Army Corps
of Engineers



SOUTH FLORIDA EVERGLADES RESTORATION



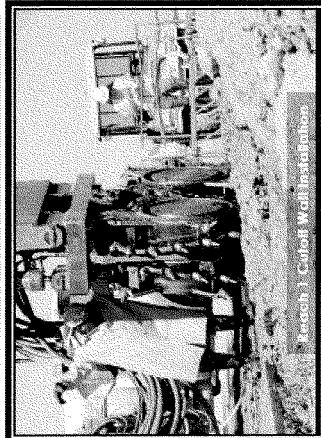
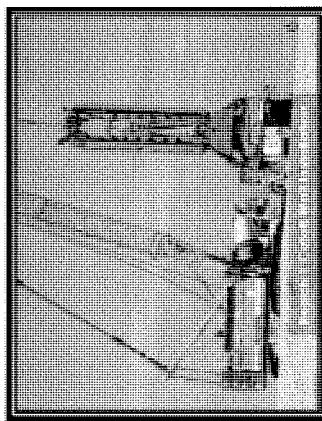
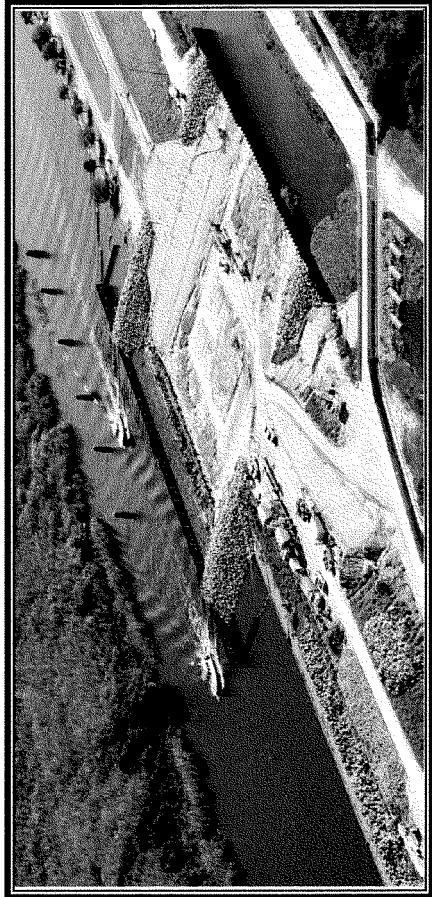
US Army Corps
of Engineers.



HERBERT HOOVER DIKE

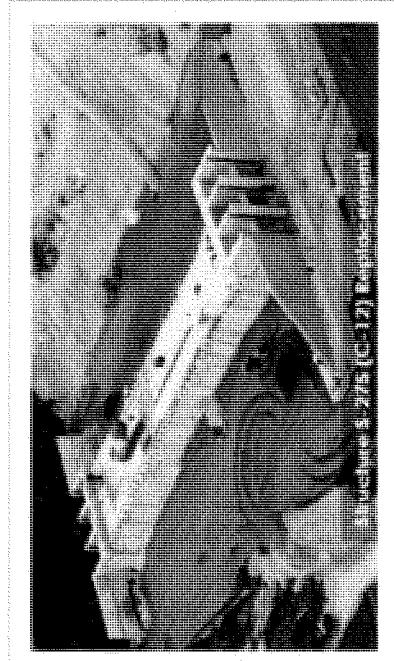
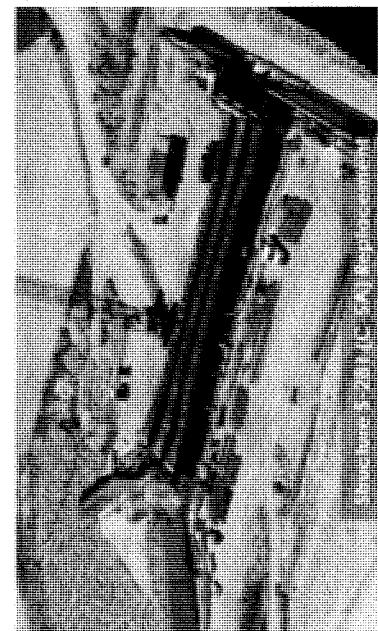


U.S. Army Corps
of Engineers



Section 3, Cut-off Wall, Photo by Bob

HERBERT HOOVER DIKE





LAKE OKEECHOBEE



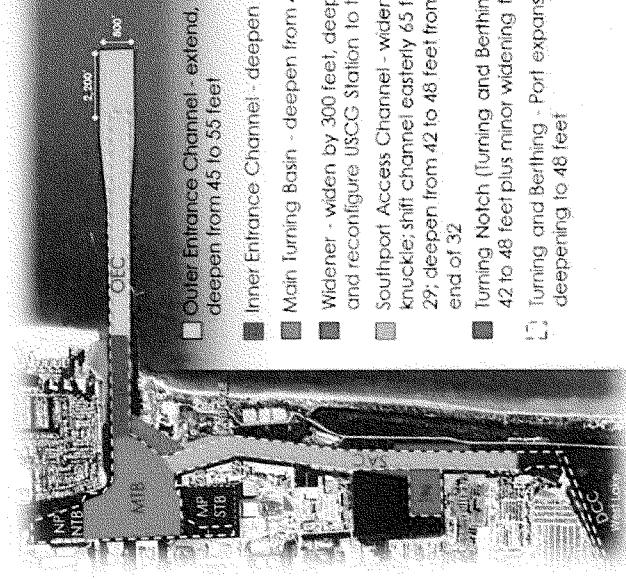
US Army Corps
of Engineers.



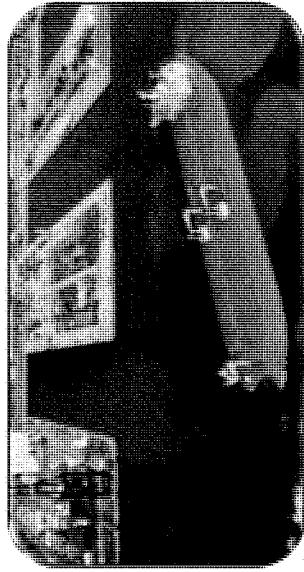
PORT EVERGLADES PROJECT



U.S. Army Corps
of Engineers.



Berth 32 Southport Access Channel



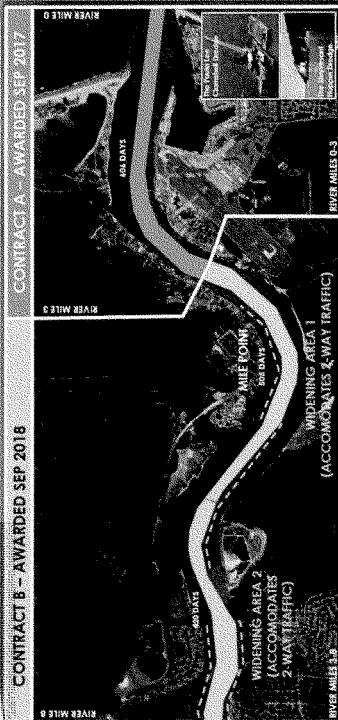
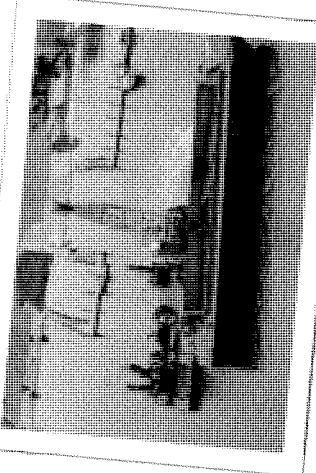
Main Turning Basin

- Outer Entrance Channel - extend, widen, and deepen from 45 to 55 feet
- Inner Entrance Channel - deepen from 42 to 48 feet
- Main Turning Basin - deepen from 42 to 48 feet
- Widener - widen by 300 feet, deepen to 48 feet; and reconfigure USCG station to the east
- Southport Access Channel - widen by 250 feet at the knuckle; shift channel easterly 65 feet from berth 26 to 29; deepen from 42 to 48 feet from berth 23 to south end of 32
- Turning Notch (turning and Berthing) - deepen from 42 to 48 feet plus minor widening features
- Turning and Berthing - Port expansion plus USACE deepening to 48 feet



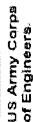
JACKSONVILLE HARBOR DEEPENING

US Army Corps
of Engineers.

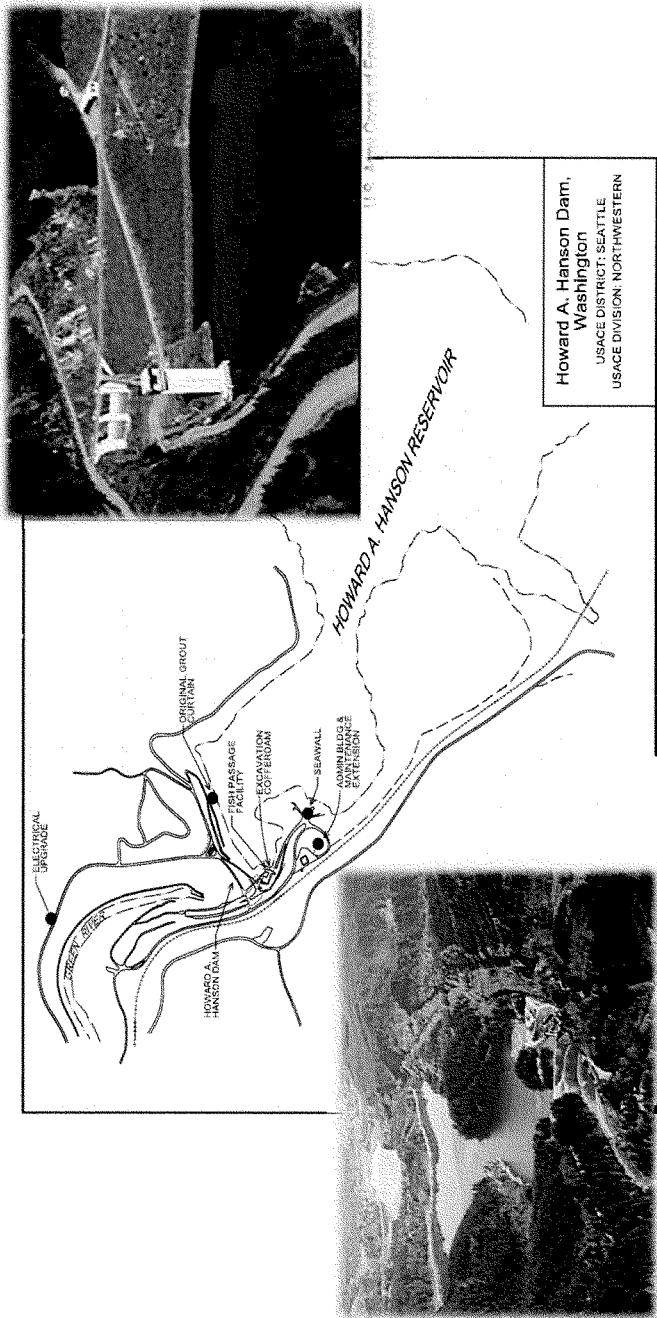




HOWARD A. HANSON DAM



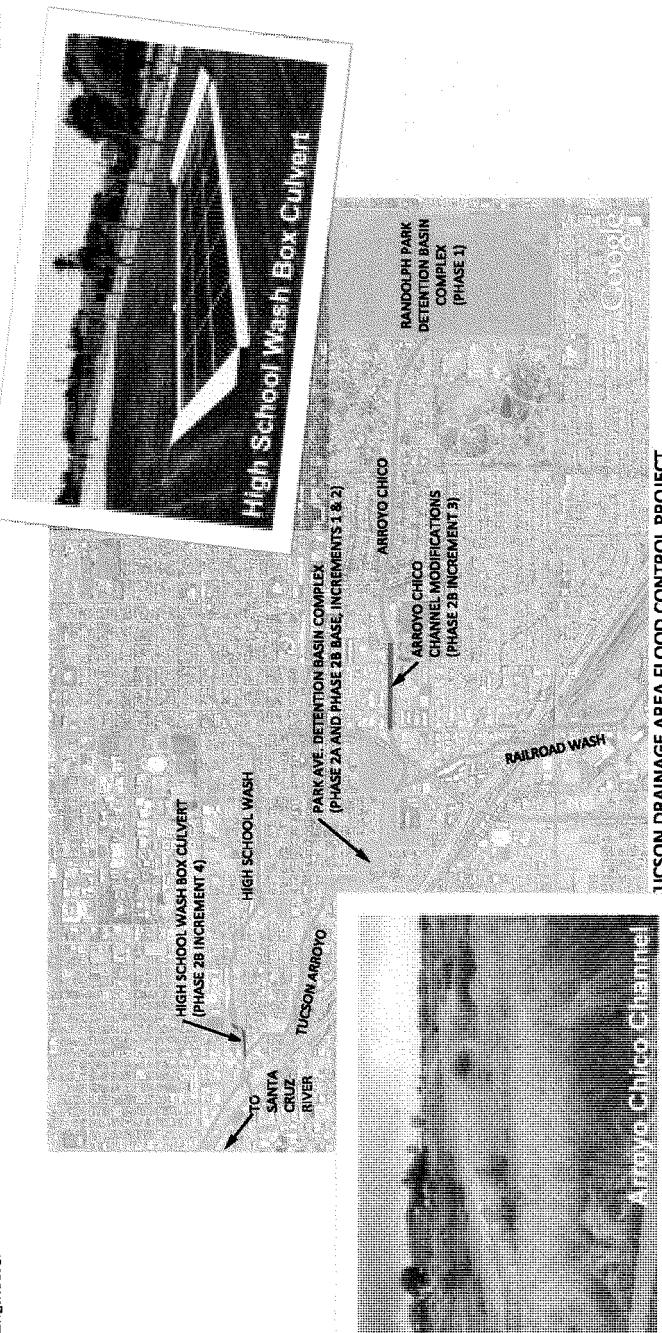
US Army Corps
of Engineers.



TUSCON AREA DRAINAGE PROJECT



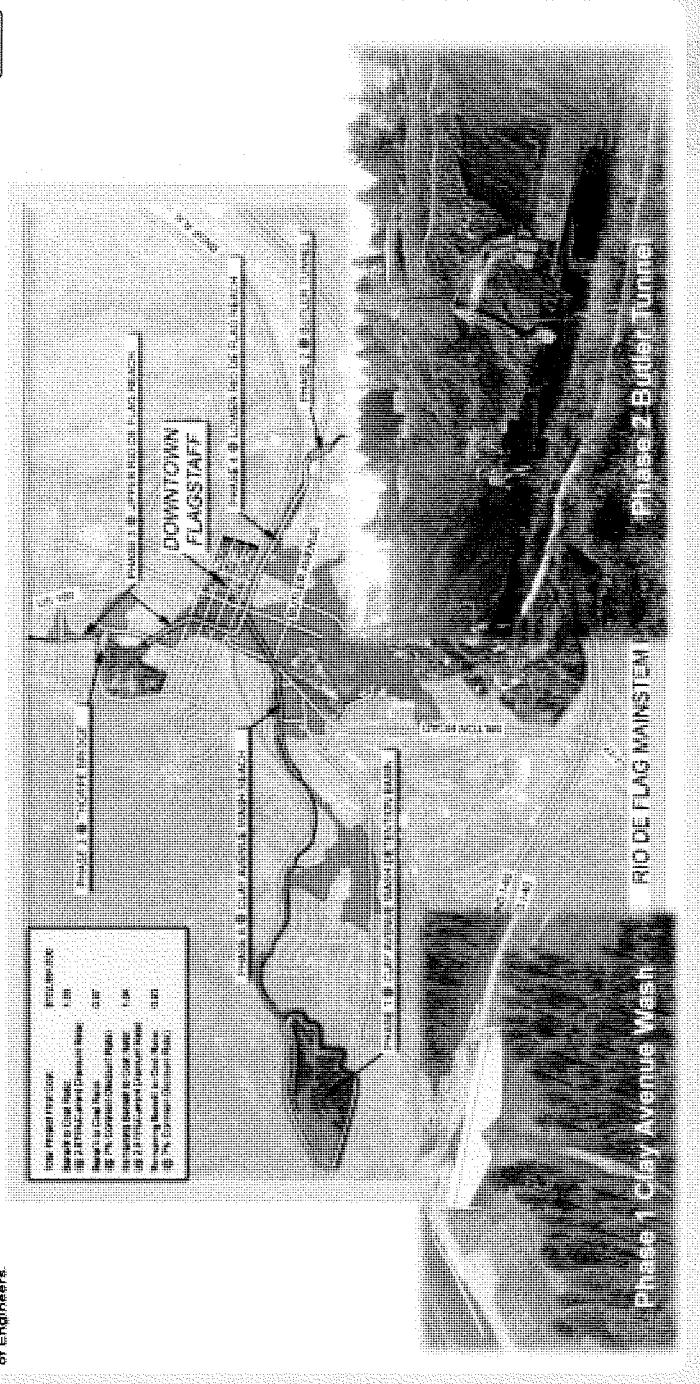
U.S. Army
Corps
of Engineers.



RIO DE FLAG



U.S. Army Corps
of Engineers.





U.S. Army
Corps
of Engineers

NESP – ECOSYSTEM RESTORATION



U.S. ARMY
CORPS OF ENGINEERS

TYPICAL ISLAND PROTECTION AND RESTORATION PROJECT

PERIODIC EROSION - FORT DE SOTO PARK - ST. PETERSBURG, FL



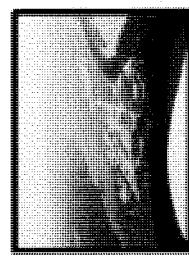
1981 - Pre-Degradation

1994 - Degraded

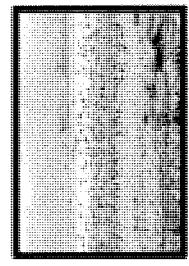
2000 - Island Restoration and protection complete



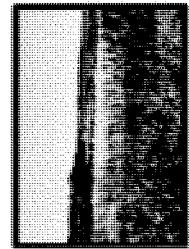
Post-Project



5-7 years Post-Project



2-3 years Post-Project



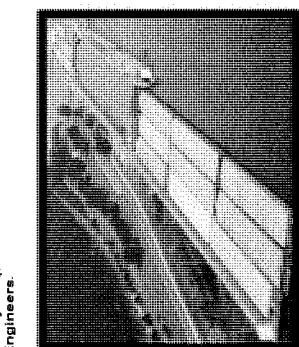
5-7 years Post-Project

TYPICAL FLOODPLAIN RESTORATION PROJECT PROGRESSION (The Nature Conservancy—Spukey Bottoms near Metropolis, IL)

NESP - NAVIGATION



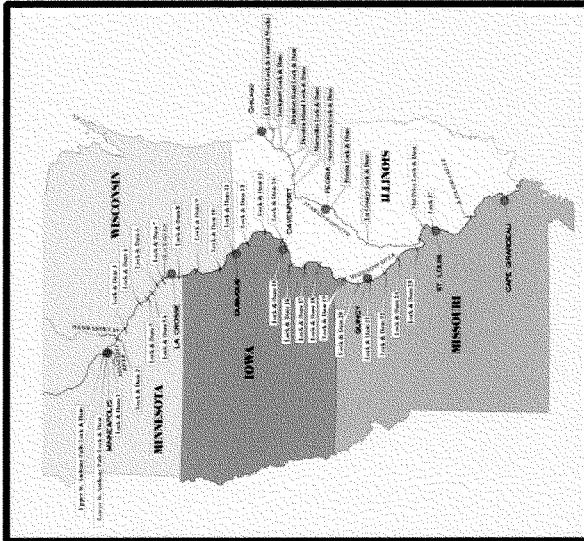
U.S. Army
Corps
of Engineers.



Over 8 barges, barge crews must "cut" their tows (shown above), increasing lockage times by approximately 60 minutes



The Upper Mississippi River and Illinois River Systems have over half (19 out of 36) of the most delayed lock sites in the nation

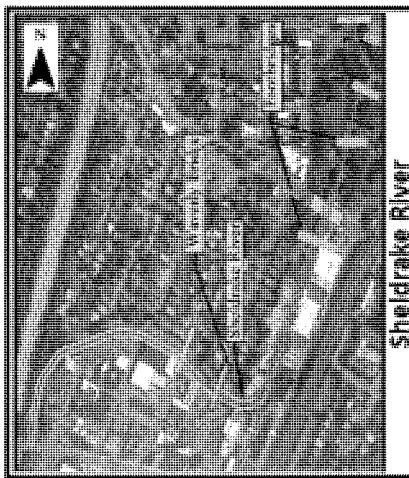


The NESP study area extended from Minneapolis-St. Paul downstream to the confluence of the Ohio River and the Illinois Waterway at Chicago. It included 37 locks (23 on the Mississippi and 8 on the Illinois River) and approximately 1,200 miles of navigable waterway within portions of Illinois, Iowa, Minnesota, Missouri, and Wisconsin.

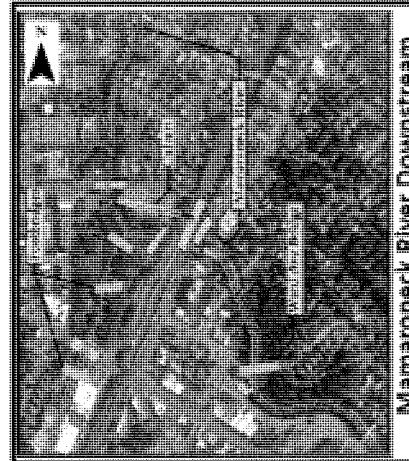
MAMARONECK & SHELDRAKE RIVERS



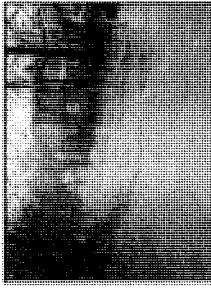
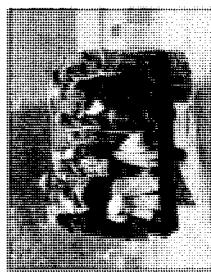
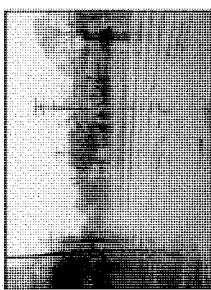
US Army Corps
of Engineers.



Sheldrake River



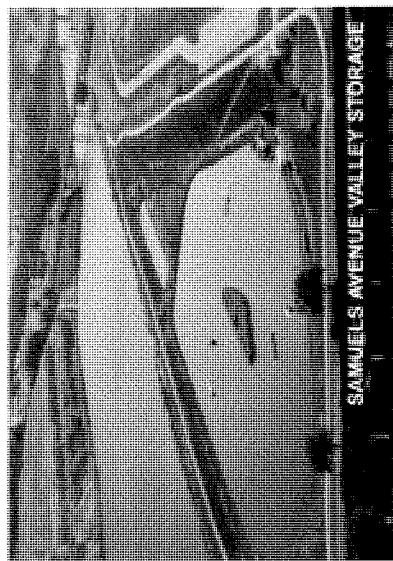
Mamaroneck River Downstream



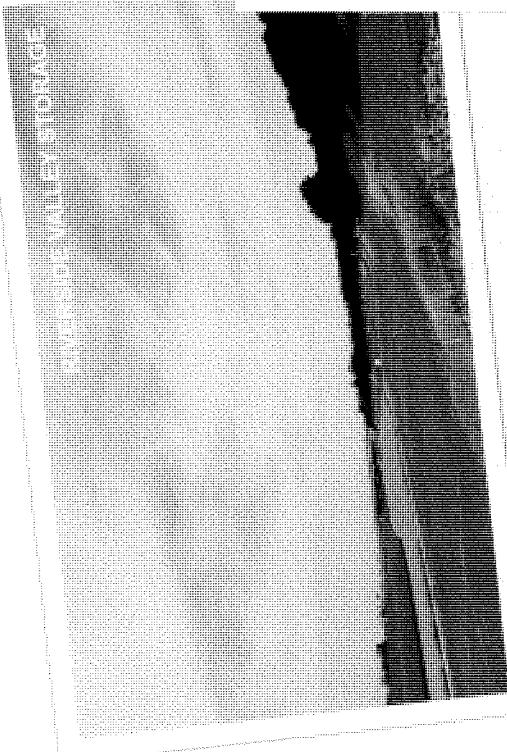
CENTRAL CITY



US Army Corps
of Engineers.



SAMUEL'S AVENUE VALLEY STORAGE



CENTRAL CITY



U.S. Army Corps
of Engineers



GATEWAY OXBOW VALLEY STORAGE



Ms. KAPTUR. Thank you, Secretary James, very much. As you have been speaking, various slides have been coming up on the board there and I just ask in the future because we want to help showcase the important work you do, if somehow there could be a legend underneath or explaining where that might be and what it represents or if you could reference it in your testimony, I think it would help a great deal. We are trying to educate the Nation in addition to ourselves. Thank you very much. General Semonite, please begin.

General SEMONITE. Chairwoman Kaptur, Ranking Member Simpson, and distinguished members of the subcommittee, thank you for the opportunity to testify today. I am glad to be appearing with the Honorable R.D. James as we both continue to work together to address water resources challenges across the Nation.

I would also like to take a moment to welcome our division commanders and I would like to ask them to all stand up. Every one of these officers is a proven combat veteran with multiple overseas tours and they are proven leaders and they are absolutely dedicated to the Corps mission. They represent each of the eight divisions with the Civil Works Mission. Thanks.

The fiscal year 2020 Civil Works budget is a performance-based budget which will reduce flood risk in communities across the Nation, facilitate commercial navigation, restore aquatic ecosystems, and generate low-cost, renewable hydropower.

The budget uses a targeted approach to invest in our water resources and focuses on high-performing projects and programs within the three main water resource missions of the Corps commercial and navigation, flood and storm damage reduction, and aquatic ecosystem restoration missions.

The budget includes \$4.827 billion in gross discretionary funding for civil works activities which will benefit the Nation's economy, environment, and public safety now and in the future.

The fiscal year 2020 budget represents a continuing fiscally prudent investment in the Nation's water resources infrastructure and restoration of aquatic ecosystems.

Since Congress first authorized our navigation mission in 1824, the Corps has worked hard to develop and implement solutions to our Nation's water resource challenges. We are able to do this because we have a world-class workforce of talented and dedicated professionals who are passionate about what we do. None of our work is done alone.

We appreciate the value, the support of the administration, the Congress, and all of our partners to success in our mission. I am very proud of the work that we do, however we can, and must revolutionize the Corps of Engineers.

I have been in command of the Corps for close to 3 years and I have challenged the enterprise to revolutionize the way we do business. This does not imply that the Corps is not a world-class organization. Rather it demands that we anticipate and respond to changing requirements in externalities, like all world-class organizations.

We embrace our authorities in current mission areas as a guide to change how we do business with a strategic vision taking pioneering steps to remain relevant and ready for the challenges of to-

morrow. Successful civil works project delivery supports the current and future infrastructure priorities.

The Corps' credibility is measured on our ability to deliver results that are on time, on budget, and of exceptional quality. The Corps is taking bold actions to improve performance and engineer solutions for the Nation's toughest challenges. These actions are realized through modernizing the traditional delivery of the annual Civil Works Program with innovative tools, streamlining external processes, and exploring alternative financing approaches.

The effort to revolutionize the Civil Works Program focuses on three primary objectives, and they are shown here on the screen; accelerating project delivery, transforming project financing and budgeting, and improving permitting and regulation reform.

The first objective, accelerating project delivery, focuses on innovative ways to deliver high-quality outcomes as top Corps priority, through looking internally at our organization, we are identifying policy and administrative changes that increase the efficiency and effectiveness of infrastructure delivery. We believe risk-informed decision-making should be implemented and documented without being subject to numerous time-consuming reviews.

Our second objective is alternative financing. Fiscal responsibility and constraints demand that we utilize innovative approaches and mechanisms which allow for accelerated project execution and earlier realization of benefits which increases efficiency and effectiveness.

Finally, our third objective is to improve our permitting processes. Through Executive Order 13807 we have adopted the one Federal decision and are coordinating our processes to comply with NEPA and other environmental laws. Our goal is to simplify the process for gaining infrastructure permits while protecting the environment in accordance with the law.

For more than 243 years the Corps of Engineers has adapted to meet the challenges of the day. Today is no exception. Our current efforts to revolutionize—simply represent the next chapter in this remarkable journey. I placed a copy of our revolutionized brochure in front of you today to reference, and there is over 150 different initiatives that we are doing to change some of the processes to be able to untie our hands, and to be able to facilitate execution.

Thank you, Madam Chairwoman, and members of the committee. This concludes my statement. And I look forward to answering any questions you or other members of the subcommittee may have.

[The information follows:]

DEPARTMENT OF THE ARMY CORPS OF ENGINEERS

COMPLETE STATEMENT OF

**LIEUTENANT GENERAL TODD T. SEMONITE
CHIEF OF ENGINEERS
U.S. ARMY CORPS OF ENGINEERS**

BEFORE

**COMMITTEE ON APPROPRIATIONS
SUBCOMMITTEE ON ENERGY AND WATER DEVELOPMENT
UNITED STATES HOUSE OF REPRESENTATIVES**

ON

**THE FISCAL YEAR 2020 BUDGET
FOR THE ARMY CORPS OF ENGINEERS, CIVIL WORKS**

MARCH 27, 2019

Madam Chairwoman and Members of the Subcommittee:

I am honored to testify before your committee today, along with The Honorable R.D. James, the Assistant Secretary of the Army for Civil Works, on the President's Fiscal Year 2020 (FY 2020) Budget for the United States Army Corps of Engineers (Corps) Civil Works Program.

I have been in command of the Corps for close to three years, and I want to briefly update you on where we are going. As I said last year, the Corps' credibility is measured by our ability to deliver results that are on time, on budget, and of exceptional quality. Focusing on innovative ways to deliver high quality outcomes sooner is a top Corps priority.

The Corps is taking bold actions to improve performance and engineer solutions for the nation's toughest water resources challenges. We continue to work on policy and administrative changes that can improve the way that we plan, design, construct, and operate and maintain our projects. Through looking internally at our organization, authorities, policies, regulations and procedures we are increasing efficiency and effectiveness.

The effort to revolutionize the Civil Works program focuses on accelerating project delivery, transforming project financing and budgeting, and permitting and regulation reform. We are applying risk-informed decision making to the entire project life, and working to provide non-federal sponsors with tools to enable the successful completion of authorized studies and construction. The FY 2020 Budget seeks to transform project financing by proposing two new, innovative construction programs in the FY 2020 Budget. In the Regulatory program we continue to streamline permit processes, this includes efforts to reduce redundancy and delegate authority for decision making to the most practical and appropriate level.

The Corps focuses on work that provides the highest economic, environmental, and public safety returns to the Nation. The Corps also operates and maintains water resources infrastructure that may no longer meet its authorized purposes or for which the needs of the Nation have changed. There are six studies funded in the FY 2020 Budget to ascertain the viability of deauthorizing projects and removing them from the Corps inventory.

The Corps' Military program also continues our work across the globe with presence in more than 110 countries supporting national security and our Combatant Commanders with civil works, military missions, and water resources research and development expertise.

SUMMARY OF FY 2020 BUDGET

The FY 2020 Civil Works Budget is a performance-based budget, focused on reducing flood risk in communities across the Nation, facilitating commercial navigation, restoring aquatic ecosystems, and generating low-cost renewable hydropower. The Budget uses

a targeted approach to investment in our water resources, which will benefit the Nation's economy, environment, and public safety – now and in the future.

The Budget focuses on high-performing projects and programs within the three main water resources missions of the Corps: commercial navigation, flood and storm damage reduction, and aquatic ecosystem restoration. The Budget includes \$4.827 billion in discretionary funding for Civil Works activities throughout the Nation.

The Budget also proposes the necessary level of funding for the Regulatory program to protect and preserve water-related resources of the Nation.

INVESTIGATIONS PROGRAM

The FY 2020 Budget provides \$77 million in the Investigations account, and \$4.96 million in the Mississippi River and Tributaries account to evaluate and design projects within the Corps three main mission areas and for related work, including research and development. The Budget also supports the Corps planning and technical assistance programs, including using its expertise to help local communities increase their resilience to, and preparedness for, flood risks.

CONSTRUCTION PROGRAM

The Budget provides \$1.301 billion for the construction program, including \$1.170 billion in the Construction account, \$56.8 million in the Mississippi River and Tributaries account, \$55.5 million in the Inland Waterways Trust Fund account and \$18.3 million in the Harbor Maintenance Trust Fund account.

The Budget funds two new, innovative programs in the Construction account:

- \$150 million for the WRRDA 2014 Section 1043 Non-Federal Construction of Federal Projects program, under which the Corps would transfer appropriated funds to non-Federal sponsors who decide to construct a project on their own. This approach will improve project delivery and achieve cost savings; and
- \$150 million for the Innovative Funding Partnerships program, which would be used in conjunction with funds voluntarily provided by non-Federal interests in excess of the non-Federal cost share to accelerate the completion of construction of specifically authorized projects.

In addition, the Budget proposes to extend the authorization for Section 1043 of the Water Resources Reform and Development Act of 2014, as amended, which under current law expires on June 10, 2019.

The goal of the construction program is to produce as much value as possible for the Nation from the available funds. Projects funded primarily due to their economic return, require a benefit-to-cost ratio of 2.5-to-1 or higher, calculated at a 7-percent discount

rate. Projects funded on the basis of their environmental return must demonstrate that they will restore degraded ecosystem structure, function and/or process to a more natural condition. Ongoing projects that can complete all remaining construction work during the budget year or the following year may be funded at the level needed to complete that work if the project has a BCR of 1.0-to-1 or above, at a 7-percent discount rate. Funding is also prioritized for mitigation work at ongoing construction projects, and work needed to comply with biological opinions and with treaties. The selection process prioritizes investments, on a risk informed basis, in dam safety assurance, seepage control, and static instability correction work at dams that the Corps owns and operates, and work to address significant risk to human safety, as well as construction of dredged material disposal facilities for high and moderate use segments of commercial deep-draft, shallow-draft, and inland waterways projects.

OPERATION AND MAINTENANCE (O&M) PROGRAM

All structures age and can deteriorate over time, causing a potential decline in reliability. As stewards of a large portfolio of water resources projects, we are working to sustain the benefits that the key features of this infrastructure provide.

The Corps continues to improve the efficiency and effectiveness of its operation and maintenance program. The Budget focuses on investments that address infrastructure maintenance needs on a risk informed basis. It invests in the highest priority needs among the infrastructure that the Corps owns and operates, and in work that will reduce long-term O&M costs in real terms.

The Budget for the operation and maintenance program provides \$1.93 billion in the O&M account, \$148.1 million in the Mississippi River and Tributaries account, and \$946.7 million in the Harbor Maintenance account. The allocation of funding for maintenance among projects reflects a risk-informed assessment that considers both project and project component conditions as well as the consequences in the event of a failure.

Generally, the O&M program supports completed works owned or operated by the Corps, including administrative buildings and laboratories. Work to be accomplished includes: operation of locks and dams along the inland waterways; dredging of inland and coastal Federal channels; operating multi-purpose dams and reservoirs for flood risk reduction, hydropower, recreation, and related purposes; maintenance and repair of facilities; monitoring of completed projects; and general management of Corps facilities and the land associated with these purposes including work to serve as a responsible steward of the natural resources on Corps lands.

Typically, the concerns that lead to dam safety modifications and/or interim risk reduction measures first become apparent through the inspections and monitoring that the O&M program funds. Additional measures are considered and evaluated as new and existing issues are identified.

The FY 2020 Budget provides \$214 million in the O&M account for hydropower activities to maintain power components such as generators, turbines, transformers and circuit breakers at Corps hydropower facilities and keep them operating efficiently and effectively. The Corps also receives approximately \$275 million each year derived from Department of Energy revenues related to power sales, and from contributed funds. The Corps is the largest hydropower producer in the U.S., operating 24 percent of the Nation's hydropower capacity.

NAVIGATION TRUST FUNDS

The Budget reproposes revisions to the appropriations language for the Construction, Operations and Maintenance, and Mississippi River and Tributaries accounts and new appropriations language for the Harbor Maintenance and the Inland Waterways Trust Funds. This language would provide greater transparency to the public in how these funds are spent, including the users that pay fees to finance some of the Trust Funds costs, improve accountability, and ensure that appropriations are used for the purposes for which the Congress intended. Specifically, the proposal would make trust fund amounts definite and executed out of the trust funds rather than transferring them to the expenditure accounts for execution. Doing so will simply clarify the accounting for expenditure of funds from each account. The Corps has developed an interim solution to help with the financial management of these funds, but the revised appropriations language will enable the Corps to manage these resources more easily.

REIMBURSABLE PROGRAM

Through the Interagency and International Services (IIS) Reimbursable Program, the Corps assists other Federal agencies, state, local, tribal governments, and those of other countries with timely, cost-effective solutions. These agencies can turn to the Corps, which already has these capabilities, rather than develop their own internal workforce and expertise to act as their design and construction agent. Such intergovernmental cooperation is effective for agencies and the taxpayer, and uses the skills and talents that we bring from our Civil Works and Military Missions programs. The work is principally technical oversight and management of engineering, environmental, and construction projects. The work itself is typically performed by private sector firms and is financed by the agencies we service. We only accept agency requests that are consistent with our core technical expertise, in the national interest, and that can be executed without impacting our primary mission areas.

EMERGENCY MANAGEMENT

The FY 2020 Budget provides \$27 million in funding for the Flood Control and Coastal Emergencies account to enable the Corps to prepare for emergency operations in response to natural disasters. The Budget for the emergency management program also includes \$4.5 million for the National Emergency Preparedness Program.

APPROACHES TO FLOOD RISK MANAGEMENT

The Investigations account also includes \$25 million for Corps efforts, in conjunction with state floodplain management authorities, to provide technical and planning assistance to enable local communities to reduce their flood risk, with emphasis on non-structural approaches. The Budget continues to invest in the interagency teams known as Silver Jackets, which work to enable communities to understand their flood risks and to develop and implement their own non-structural flood risk management solutions.

The Silver Jackets program is an innovative program, which provides a way in each of the participating states to address State and local flood risk management priorities. The Corps participates in these efforts, along with FEMA, other Federal agencies, and the state agencies with expertise in flood risk management. The Budget for the Civil Works program funds the Corps staff work on these teams. Each team is developed at the state level. The teams share lessons learned at the state level with each other, and each team works to apply the available resources effectively to meet its State's flood risk management priorities. These intergovernmental flood risk management teams are now active in nearly every State.

CONCLUSION

The FY 2020 Budget represents a continuing, fiscally prudent investment in the Nation's water resources infrastructure and restoration of aquatic ecosystems. The U.S. Army Corps of Engineers is committed to a performance-based Civil Works Program, based on innovative, resilient, and sustainable risk-informed solutions.

Thank you, Madam Chairwoman and Members of Subcommittee. This concludes my statement. I look forward to answering any questions you or other Members of the Subcommittee may have.

Ms. KAPTUR. Thank you, General, very much. And thank you for bringing supplementary materials as well as the slides. I think it is fair to say that you and those under your command do great work for our country, but many people in the country are not aware of it. And so we thank you for helping us tell your story.

Assistant Secretary Petty, please begin.

Mr. PETTY. Yes. Thank you, Chairwoman Kaptur and Ranking Member Simpson and all the subcommittee. It is a great honor to be able to be here with you this morning, and for the opportunity to discuss with you the President's fiscal year 2020 budget for the Department of the Interior and the Bureau of Reclamation, as well as the Central Utah Project Completion Act, also known as CUPCA.

I am Tim Petty, the Interior Assistant Secretary for Water and Science. I greatly appreciate your ability to come and support for our programs, including the timely passage of the fiscal year 2019 Appropriations Bill for Reclamation and CUPCA last fall.

The overall Department of the Interior, first of all, in the 2020 budget request is a total of \$12.6 billion in current funding which supports the administration's economic goals to manage Federal spending.

It also reflects our commitment to strike the right balance of protecting yet, sustainably using our natural resources in a manner that provides proper conservation stewardship of our public lands and water, enhances the safety of our communities, increases our energy security, and allows our Nation to continue to prosper.

This request enables Interior to meet our diverse core missions and continue the progress we are making in advancing the administration's priorities and supporting the Nation's economic growth and prosperity.

Of course reliable water supply and energy security are keystones in supporting the economic prosperity of the communities in the West. The Bureau of Reclamation's activities include recreation which supports over \$62 billion in economic activity with over 457,000 jobs each year. Reclamation's average annual power outcome is 40 billion kilowatt hours of electricity providing more than \$1 billion in gross power revenues for the Federal Government.

The 2020 budget supports our efforts to address the challenges that impact the availability and reliability of water supply of the United States, of the states, the tribes, the local governments, and other water users that we partner with.

Interior's \$1.1 billion budget request for reclamation, including a \$10 million request for Utah's CUPCA Program, invests in our water and power infrastructure, facilitating the delivery of water to 31 million people in the West.

In addition, our programs invest in ecosystem protection and restoration so that we can continue to supply water and power reliability as we have historically.

This budget also features Interior's commitment to working with Indian Tribes toward tribal prosperity. Across Interior the budget includes a total of \$178.6 million for Indian settlement water rights commitments, and this includes \$132.9 million in Reclamation toward fulfilling those responsibilities.

Interior is developing and executing a program that will streamline processes and better serve the American people. We are working to reform regulations that are ineffective and obsolete and ensure that we reflect advances in the science and technology of the day.

To address water infrastructure challenges in the western U.S., we are working on agreements to partner with other Federal agencies and streamline those western water infrastructure regulatory processes and remove unnecessary burdens. This collaboration will help to coordinate regulatory action and drive more efficient decision-making through clear leadership, teamwork, and integrated coordinated review.

Finally, Interior's budget request includes resources for the Central Utah Project, which falls under the jurisdiction, specifically, under my Office of the Assistant Secretary for Water and Science.

The 2020 budget for this office project is \$10 million. This money is available for planning, construction activity, and administrative work that works with the Central Utah Water Conservation District, and continuing our partnerships in that ongoing work. The Central Utah Project annually provides 62,000 acre-feet of water for irrigation, and over 100,000 acre-feet for municipal and industrial purposes, supplying nearly 400,000 people in that community of Utah.

In keeping my opening comments brief, I would like to make sure that we get my full testimony submitted into the records here.

And thank you again for your support. I am looking forward to any questions.

[The information follows:]

**Statement of Timothy R. Petty, Ph.D.
Assistant Secretary for Water and Science
U.S. Department of the Interior
Before the
Subcommittee on Water, Power, and Oceans
Committee on Natural Resources
U.S. House of Representatives
On The President's Fiscal Year 2020 Budget**

Wednesday, March 27, 2019

Thank you, Chairwoman Kaptur, Ranking Member Simpson, and members of this Subcommittee for the opportunity to discuss with you the President's Fiscal Year 2020 budget for the Department of the Interior's Bureau of Reclamation and Central Utah Project Completion Act, or CUPCA, office. I am Tim Petty, Interior's Assistant Secretary for Water and Science, and I appreciate your ongoing support of our programs.

The Department of the Interior touches hundreds of millions of people, and plays an active role in western communities and the national economy. That could not be more evident than when looking at the contributions of the Bureau of Reclamation and CUPCA to our Nation. The Department's 2020 budget supports the Administration's economic goals to manage Federal spending. This reflects our commitment to strike the right balance of protecting yet sustainably using our natural resources, in a manner that provides proper conservation stewardship of our land and resources, enhances the safety of our communities, increases our energy security, and allows our Nation to prosper.

The 2020 budget request for Interior is \$12.6 billion in current funding, with access to an additional \$300 million if there is another severe wildfire season. This request enables Interior to meet our diverse core missions and continue the progress we are making in advancing the Administration's priorities in supporting economic growth and prosperity. America's Federal lands and waters support more than 1.8 million jobs in energy, recreation, grazing, conservation, hospitality, and more. In order to foster innovation and economic growth, Interior is working to reduce regulatory burdens and red tape.

President Trump signed an Executive Order to modernize and reform the executive branch and Interior is leading the way, developing and executing a program that will streamline processes and better serve the American people. We are working to reform regulations that are ineffective and obsolete, and ensure they reflect advances in science and technology. Interior has also established parameters for streamlining environmental review and permitting processes to reduce delays in Federal infrastructure projects and other public and private sector uses of Interior lands.

For decades, uncoordinated regulatory actions diminished the ability of Federal, State and local agencies to efficiently deliver water and power to the West in a cost-effective manner. On October 19, 2018, President Trump signed the "Presidential Memorandum on Promoting the Reliable Supply and Delivery of Water in the West", which directs the Secretary of the Interior and multiple other agency Secretaries to "work together to minimize unnecessary regulatory

burdens and foster more efficient decision-making so that water projects are better able to meet the demands of their authorized purposes.” For example, to address water infrastructure challenges in the western U.S., it instructs the Secretaries of the Interior and Commerce to streamline western water infrastructure regulatory processes and remove unnecessary burdens. In response, Interior and Commerce signed an Agreement to promote the directives established in the Presidential Memorandum, and designated one lead official to coordinate the agencies’ regulatory compliance requirements in California’s Central Valley and in the Klamath River basin. Interior is similarly working with the U.S. Army Corps of Engineers and Department of Energy to coordinate regulatory actions and drive more efficient decision-making through clear leadership, teamwork, and integrated and coordinated reviews in the Columbia River basin pursuant to the significant direction provided by the President’s Memorandum.

In other cross-agency efforts focused on increasing coordination and reducing duplication across Federal agencies when it comes to water issues, I am actively working with my counterparts from multiple agencies with water-related responsibilities. We recognize that working collaboratively we can better support the work that is underway to address water challenges in priority areas including drought, water quality, water reuse, and weather forecasting, among others. These efforts along with the President’s Memorandum will help to ensure Reclamation’s funding is more effectively leveraged with related programs across the Federal government.

Promoting Economic Growth and Prosperity

Interior’s 2020 budget emphasizes the crucial contributions the Department’s diverse missions make to the Nation’s economy. According to Interior’s latest economic report, Interior supports \$292 billion in estimated economic benefit and the Bureau of Reclamation’s activities, including recreation, support over \$62 billion in economic activity and over 457,000 jobs each year.

As the largest wholesaler of water and the second largest producer of hydroelectric power in the Nation, Reclamation’s projects and programs ensure millions of customers receive the water and power essential to support daily life and healthy economies in Western communities. The 2020 budget request of \$1.1 billion supports Reclamation’s work to improve water supply reliability and availability to 31 million people in the West. It invests in efforts to improve hydropower generation efficiency and reliability. To ensure that millions of customers continue to receive essential water supplies and hydroelectric power, the 2020 budget includes \$962 million for Reclamation’s Water and Related Resource programs. Many Reclamation projects provide multi-purpose water resource development benefits, including recreation. Reclamation’s recreation areas represent some of the most popular areas for water-based outdoor recreation activities in the Nation.

The Central Utah Project annually provides 62,000 acre-feet of water for irrigation of over 30,000 acres and over 100,000 acre-feet for municipal and industrial purposes, supplying water to nearly 400,000 people. This water will help address the water demands of the growing population in the Wasatch Front, one of the fastest growing areas in the Nation.

Government Reform: Reorganizing the Department of the Interior

Over the years, Interior's bureaus were established with their own unique regional organizations, which ultimately resulted in a complicated series of 49 regional boundaries among eight bureaus. This complexity led to the situation where bureau regional leadership was often focused on different geographic areas and did not have adequate and shared understanding of the needs and perspectives of regional stakeholders. Opportunities to share administrative capacity across bureaus were difficult to recognize and implement. Members of the public were often frustrated by problems in inter-bureau decision making where uncoordinated timelines and processes could lead to unnecessarily long delays in reaching a decision. The Department's reorganization is focused on making improvements across each of these areas. Interior is working to reorganize its operating structure to establish unified regional boundaries to provide better coordination across the Department to improve mission delivery and focus resources in the field.

On August 22, 2018, after working closely with stakeholders across the country on options to consolidate Interior's 49 different regions into common regions, the Department announced the designation of Interior's 12 new unified regions. As a result of Tribal consultation, the Bureau of Indian Affairs, the Bureau of Indian Education, and the Office of the Special Trustee for American Indians will not realign their regional field structures. Interior will leverage the unified regional structure to improve and streamline business operations using shared services and best practices across the Department, focusing primarily on human resources, information technology, and acquisition services. Work is underway in 2019 to plan implementation, conduct analysis, and identify areas for collaboration within the new regions. The Department's 2020 budget includes a total of \$27.6 million across Interior to support this reorganization. The 2020 budget request for Reclamation includes \$2.3 million to support its participation in these efforts.

Advancing America's Energy Security

The Department has a significant role to play in securing America's energy needs. Through increasing access to public lands and alleviating unnecessary regulatory burdens while balancing conservation objectives, the Department is working to advance economic growth through responsible energy and mineral development on Federal lands and waters. Interior's energy programs help generate some of the Federal government's highest revenues, benefitting local communities as well as the U.S. Treasury.

Reclamation's 2020 request includes \$1.0 million to support hydropower development and research. These activities will support strategic investment in hydropower as an integral part of the Nation's energy strategy. Funding will provide for technological and operational innovation, deriving both additional value from existing Federal infrastructure as well ensuring its continued safe and reliable operation.

The 2020 budget also supports innovation by using prize competitions to target difficult scientific and technological problems related to infrastructure, water availability and hydropower generation. Reclamation's budget includes \$1.3 million to incentivize such research through Reclamation Water and Power Technology Prize Competitions.

Meeting Western Water Needs

Ensuring the availability of water to communities, farmers, ranchers and residents across the West is a central component of Interior's stewardship mission. The 2020 budget supports Interior's work to address America's water reliability and availability and modernize existing water infrastructure. Improving reliability must include addressing water conflicts as well as making technological improvements that increase the capability of our water managers.

As the largest wholesaler of water in the country, Reclamation has a leading role – in coordination with other Federal agencies, State officials, local water users, and interested stakeholders – in developing strategies to help ensure water supplies for future generations. To help address the many challenges faced by water managers, Interior continues the implementation of the WaterSMART Program. The funding proposed in Reclamation's 2020 WaterSMART budget supports collaboration with other Federal agencies and our non-Federal partners in efforts to address emerging water demands and water shortage issues in the West, to promote water conservation and improved water management, and to support local innovation efforts to stretch water supplies.

The WaterSMART funding request for Reclamation in 2020 is \$19.9 million. This investment includes \$10.0 million to continue WaterSMART conservation grants and \$3.0 million for Title XVI water recycling and reuse research grants and is highly leveraged through partner cost-share funding. It also includes \$2.0 million to continue Reclamation's collaborative efforts with non-Federal partners to evaluate water supply and demands in water basins and develop strategies to meet current and future water demands through Basin Studies.

Investment in Interior's infrastructure is crucial to local economies and public safety. Reclamation's state of the art Dam Safety Program continues to be one of the Department's highest priorities, utilizing the latest information and technology to evaluate and address the most pressing safety risks in order to ensure reliability and protect the downstream public. The Dam Safety Program has identified 363 high and significant hazard dams. Reclamation evaluates dams and monitors performance to ensure that risks do not exceed current Reclamation public protection guidelines. The 2020 budget request includes \$92.8 million for Reclamation's Dam Safety Program.

Reclamation's budget request includes funding for specific Extraordinary Maintenance activities that are central to mission objectives of operating and maintaining projects to ensure delivery of water and power. Through constant monitoring and assessment, Reclamation strives to effectively and efficiently use its limited resources to ensure dam safety and to maintain operational capabilities. Reclamation's 2020 budget includes \$114.1 million for extraordinary maintenance, repairs, and replacements.

Expanding Access to Grow the Outdoor Economy

Interior's public lands and waters provide opportunities for all types of recreation, and increasing those opportunities for Americans of all abilities is a significant priority for the Department. Access to public lands and waters not only provides for personal enjoyment and tranquility for Americans, but also supports local economies and unique educational and interpretive

opportunities. Interior's budget proposes to reauthorize the Federal Lands Recreation Enhancement Act, which expires in September 2020.

Reclamation projects play a major role in meeting the increasing public demand for water-based outdoor recreation opportunities. Reclamation projects include approximately 7.8 million acres of land and water and over 240 recreation areas available to the public. This includes 12 designated National Recreation Areas that are managed by the National Park Service or U.S. Forest Service. Through non-Federal partnerships, Reclamation assists local communities in attracting recreation-related investments and involves local citizens in the decision-making process.

With increased use of Reclamation reservoirs for recreation comes the increased need for monitoring and early detection of invasive quagga and zebra mussels, and for outreach and education to prevent infestation. The 2020 Reclamation budget includes \$5.1 million for prevention, early detection and monitoring, containment and control at existing facilities, outreach and education, and research focused on these issues. This funding will support Reclamation's efforts to proactively stop the spread of invasive mussels in the West.

Fulfilling Our Trust Responsibilities

The Department of the Interior is responsible for fostering the government-to-government relationship with Indian Tribes and Alaska Native Villages. The Department is committed to Tribal prosperity and working together with Tribes to address challenges in economic development, education, and law enforcement. Interior supports Indian self-determination to ensure Tribes have a strong voice in shaping Federal policies directly impacting their ability to govern and provide for the safety, education, and economic security of their citizens.

Interior's 2020 budget continues to support Federal responsibilities and tribal needs related to education, social services, infrastructure, and stewardship of land, water, and other natural resources. Interior's budget maintains a strong commitment to meet Tribal settlement agreements. Across Interior, the budget includes \$178.6 million for Indian Settlement commitments. This includes \$132.9 million in Reclamation and \$45.6 million in the Bureau of Indian Affairs.

Central Utah Project

The Central Utah Project Completion Act (CUPCA), Titles II - VI of P.L. 102-575, provides for completion of Central Utah Project construction by the Central Utah Water Conservancy District. The Act also authorized funding for fish, wildlife, and recreation mitigation and conservation; established an account in the Treasury for deposit of these funds and other contributions; established the Utah Reclamation Mitigation and Conservation Commission to coordinate mitigation and conservation activities; and provided for the Ute Indian Rights Settlement.

The 2020 budget for the CUPCA program is \$10.0 million. Of this amount, \$3.7 million will be available for planning and construction activities administered by the Central Utah Water

Conservancy District, continuing our partnership in the ongoing construction of the Utah Lake System facilities. The budget includes \$4.5 million for program oversight and administration, operations and maintenance in support of fish and wildlife conservation, and endangered species recovery. In addition, \$1.8 million will be transferred to the Utah Reclamation Mitigation and Conservation Account for use by the Utah Reclamation Mitigation and Conservation Commission. The 2020 budget also supports Interior's required program oversight activities and endangered species recovery program implementation through the Department's CUPCA Office.

Conclusion

Thank you for the opportunity to testify on behalf of the President's 2020 budget for the Department of the Interior's Bureau of Reclamation and Central Utah Project Completion Act program. I look forward to working with the Committee further on this budget. This concludes my testimony, and I am happy to answer any questions.

Ms. KAPTUR. Thank you very much, Assistant Secretary Petty. Commissioner Burman, please begin.

Ms. BURMAN. I won't make that mistake again. Thank you, Chairwoman Kaptur, Ranking Member Simpson, and members of the subcommittee, for the opportunity to discuss with you the President's Budget for the Bureau of Reclamation.

I am Brenda Burman. I have served as Commissioner of Reclamation since being confirmed in 2017.

Before I begin, I would also like to thank the committee for making the very timely passage of our bill a priority in fiscal year 2019. Having full funding at the beginning of the year makes a profound difference in Reclamation's ability to fulfill our mission with the resources Congress intended for that purpose.

Before I start, there is a map of the hydrology of this year in the West. I wanted to bring this up, because what a difference a year makes. Last year when we were looking at this map, Arizona, New Mexico, Colorado, Utah, were all very red. We were having some record-setting drought in those areas, and we have managed to eke by with California having an average year, but the rains came late and so it was very difficult to deliver water last year.

And this year, when you take a look across the West, as you heard, there is flooding in some areas, but overwhelmingly, we will be able to deliver water this year. It is a year for Reclamation where we can take a breath and that doesn't happen very often.

What I think it does is it emphasizes that when you are a water manager you have to deal with what comes to you, year by year, and it is infrastructure and partnerships that allow you to make it from a dry year to a wet year, and then survive more dry years again. But I just thought this would be a good reference.

Ms. KAPTUR. Excuse me. Could you please explain to those who don't live in the West what this means? Take a look at your precipitation levels, your snow melt, you see percentages. Just very quickly, explain.

Ms. BURMAN. So, unlike many Eastern States, in the West it is year-by-year whether we have enough water supplies to serve our needs. What has allowed us to go from year-to-year, is often storage. But when you look across the West here, you can see, for example, the Upper Colorado Basin, we see precipitation and snow levels well above average. That is going to mean that we have above average runoff into Lake Powell this year, which will make a big difference for the Colorado River system. It is one good year out of a 19-year drought on the Colorado River system, but that makes a big difference.

In California, you can see California is all blue, that rarely happens. Often the South is dry, whether the North is wet or the converse. You can see that our dams and our storage, they show less than 100 percent, and that is because of flood control. Largely in California, we have been in flood control for over a month, and so we are letting loose, water supplies that we cannot capture because we lack either the capacity or the storage ability to do that.

That is just an example. And I will be happy to answer questions later as well.

Ms. KAPTUR. Thank you.

Ms. BURMAN. It is my goal today to testify to the strength and purpose of Reclamation's fiscal year 2020 budget, a budget which continues to address water supply challenges in the West. Our goal remains to ensure water reliability and the efficient generation of energy, to celebrate America's recreational opportunities, and uphold our commitments to tribal nations and to the environment.

The 2020 budget prioritizes these functions and fully support Reclamation's vital role out West.

Our budget emphasizes the following principles. First, water reliability. Reclamation recognizes the importance of maintaining water supplies that can withstand future drought conditions. Moreover we recognize the importance of securing and modernizing our dams and water projects, particularly any that rely on aging infrastructure.

Second, efficient energy generation. As the Nation's second-largest producer of hydroelectric power, Reclamation's projects and programs continue to strongly support economic growth and opportunity. The maintenance and modernization of this infrastructure thus remains a high priority for Reclamation as we seek to improve generation, efficiency, and reliability as well as cost-effectiveness.

Third, providing multipurpose recreation access. Many reclamation projects provide multipurpose water resource development benefits, including recreation.

Fourth, is our mission of conservation. Reclamation strives to ensure future water delivery and power generation through the responsible use and conservation of its resources.

With that said, I would like to take a moment to highlight and discuss the challenges Reclamation faces in each of our Western regions, as well as the role of the President's budget in addressing these issues.

In the Upper Colorado Basin, the Bureau of Reclamation continues to seek and implement mutually beneficial tribal settlements that avoid expensive and contentious litigation.

For fiscal year 2020, we are requesting funding for the Navajo-Gallup Water Supply Project, and the Aamodt litigation settlement. In the Lower Colorado Basin, home to Hoover Dam and the districts of Representatives Calvert and Kirkpatrick, the priority remains protecting against and mitigating effects of a 19-year drought on the Colorado River, with the significantly diminished water storage of Lake Mead. Over 75 percent of this region's budget is either paid for directly by our partners or through the sale of hydropower generation.

The California Great Basin has suffered from its own unique set of drought-related problems. Good hydrology this year has highlighted the importance of maintaining and improving Reclamation's infrastructure. The region works with a diverse group of stakeholders to implement water management solutions.

In the Missouri Basin, and in our Rio Grande Texas Gulf regions, we continue to collaborate with our stakeholders to manage the wealth and protect resources throughout the area.

We are requesting funding for both the Crow and BlackFeet Water Right Settlements. Further, we are coordinating with numerous local and state entities to improve drought resiliency and better prepare communities for future water needs.

Finally, in the Columbia Pacific Northwest region, home to the Grand Coulee Dam, one of the largest hydropower facilities in the world, this region is represented by Representatives Kilmer, Newhouse, and Simpson. Our focus here for the coming year is on the Boise River Feasibility Study. The study is designed to increase storage opportunities, Reclamation's Anderson Ranch and Arrowrock Dams, along with the Corps' Lucky Peak Dam.

In closing, the Bureau of Reclamation and this administration remain committed to addressing the water and energy needs of the West in an environmentally and economically sound manner for the American people. 2020 promises to be a critical year.

And thank you and thank the committee for inviting us here today. Thank you.

[The information follows:]



United States Department of the Interior

BUREAU OF RECLAMATION
Washington, D.C. 20240

IN REPLY REFER TO:

**Statement of Brenda Burman, Commissioner
U.S. Bureau of Reclamation
Before the
Subcommittee on Energy and Water Development
Committee on Appropriations
U.S. House of Representatives
on the President's Fiscal Year 2020 Budget**

March 27, 2019

Thank you, Chairwoman Kaptur, Ranking Member Simpson, and members of the Subcommittee for the opportunity to discuss with you the President's Fiscal Year (FY) 2020 Budget for the Bureau of Reclamation. I am Brenda Burman, Commissioner of the Bureau of Reclamation.

The Bureau of Reclamation's FY 2020 Budget provides the foundation to support Reclamation's mission to manage, develop, and protect water and related resources in an environmentally and economically sound manner in the interest of the American public. The FY 2020 Budget supports the Administration's and Department of the Interior's (Department) goals to provide secure, reliable water supplies for irrigation, people, and the environment; ensure the efficient generation of energy to meet our economic needs; ensure outdoor recreation opportunities; and fulfill our commitments to tribal nations. To be successful in achieving these results, Reclamation will continue to work with a wide range of stakeholders, including water and power customers, Tribes, State and local officials, conservation organizations, and others.

In fulfilling these Department priorities, the FY 2020 Budget promotes economic prosperity in the West and ensures that the Nation's natural resources are used for multiple, beneficial purposes. Reclamation will continue to deliver water and generate hydropower in FY 2020, consistent with applicable State and Federal law. Reclamation plans to focus on enhancing water supply reliability by paying attention to local water conflicts, making investments in modernizing infrastructure, and providing support for water development benefiting Native Americans and rural America. The 2020 Budget addresses these priorities by allocating funds to implement Reclamation's management responsibilities in the most cost-effective manner.

Reclamation is requesting \$1.1 billion in Federal discretionary appropriations, which is anticipated to be supplemented by over \$1.0 billion in other Federal and non-Federal funds in FY 2020. Of the total discretionary appropriations, \$962.0 million is for the Water and Related Resources account, which is Reclamation's largest account; \$60.0 million is for the Policy and Administration account; and \$33.0 million is for the California Bay Delta Restoration account. A total of \$54.8million is requested for the Central Valley Project Restoration Fund, to be offset by expected discretionary receipts in the same amount. We will continue to seek to optimize non-Federal contributions to accomplish more with limited federal dollars.

Reclamation is the largest supplier and manager of water in the nation and the second largest producer of hydroelectric power. Reclamation's projects and programs are foundational to driving and maintaining economic growth in hundreds of basins throughout the United States. Reclamation manages water for agricultural, municipal and industrial use, and provides flood control and recreation for millions of people. This includes water for 1 out of 5 (or, 140,000) Western farmers irrigating more than 10 million acres of farmland, which yields approximately 25 percent of the nation's fruit and nut crops, and 60 percent of the vegetable harvest. We deliver 10 trillion gallons of water to more than 31 million people each year.

With respect to hydropower, Reclamation owns 76 hydroelectric power plants, of which it operates 53, that account for 15 percent of the hydroelectric capacity and generation in the United States. Annually, Reclamation generates on average 40 billion kilowatt hours of electricity, enough to meet the annual needs of over 3.8 million households and collects over \$1.0 billion in gross power revenues for the Federal government.

Many Reclamation projects provide multi-purpose water resource benefits, including recreation. Reclamation's recreation areas represent some of the most popular areas for water-based outdoor recreation activities in the nation. Reclamation projects include approximately 7.8 million acres of land and water and 289 recreation and wildlife areas (42 of which are directly managed by Reclamation), 550 campgrounds and over 1,300 miles of hiking trails available to the public resulting in approximately 34 million visits annually.

According to *the Department of the Interior's Economic Report FY 2017*, Reclamation's activities support nearly \$62.6 billion in economic activity annually, and support approximately 458,000 jobs.

Reclamation has several major issues and areas of focus requiring considerable attention in the past year to which I would like to bring your attention. These include Reclamation's infrastructure, and dam safety; the Colorado River and the effects of the long-term drought; and California water and power reliability.

Reclamation's dams and reservoirs, water conveyance systems, and power generating facilities are integral components of the Nation's infrastructure. This infrastructure is key to Reclamation's continued success. We operate 492 dams throughout the 17 Western States, impounding 338 reservoirs with a total storage capacity of 140 million acre-feet. Approximately 50 percent of Reclamation's dams were built between 1900 and 1950, and approximately 90 percent of the dams were built before adoption of currently used, state-of-the-art design and construction practices. Effectively managing the modernization of this infrastructure and the benefits that these structures provide is among the significant challenges facing Reclamation in the next several years. The reliability, safety, efficiency, and cost effectiveness of Reclamation's infrastructure to ensure water deliveries and power generation is a high priority. The FY 2020 Budget proposes an increase in funding for extraordinary maintenance, including dam safety, to modernize infrastructure.

The Department and Reclamation have worked continuously over the past several years with the Colorado River Basin states, key water districts, non-governmental organizations and Tribes to develop Drought Contingency Plans (DCPs) that provide a framework to reduce the risk of Lake Powell and Lake Mead reaching critically low elevations. Given the ongoing 19-year period of drought, Lake Powell and Mead's combined storage sits today at 40 percent, which is the lowest

level since 1966 when Lake Powell was initially filling and reducing downstream water deliveries. Lake Mead projections show that shortage conditions could be declared as early as 2021. There is real risk of further rapid declines in reservoir elevations, particularly at Lake Mead, in the very near future. When implemented, the DCPs will result in water demand reduction and water management flexibility through 2026 to help protect critical elevations in Lake Mead and Lake Powell.

In California, great progress has been made to help balance the needs of farms, cities and the environment. Reclamation renegotiated critical water operational agreements with the State of California that will help balance the share of contributions toward environmental flows between the State Water Project (SWP) and Reclamation's Central Valley Project. In addition to updating this critical operational agreement, Reclamation and partners made progress toward voluntary agreements that help provide water and habitat for fish and wildlife in the Sacramento-San Joaquin river basins, while finding reasonable solutions to mitigate impacts to farms and cities that contribute to increased environmental flows. The progress made in 2018 and early 2019 toward voluntary agreements may be the building blocks of solutions that strike a balance between farms, cities and the environment as Central Valley stakeholders continue to work towards a sensible solution.

Reclamation continues to prioritize hydropower as a core mission component that not only adds value to the western grid and economy, but helps allow for the delivery of reliable and cost-effective water supplies across the West. Reclamation's hydropower has a long history of success, and that success is a result of partnership and investment with our power customers. Reclamation continues to evaluate economical capital upgrades at our hydropower facilities; we partner with WAPA, BPA and power customers to fund them. An example of Reclamation-wide actions is the deployment of hydropower optimization software, which has shown efficiency gains of almost one percent without any capital upgrades. Reclamation's efforts to improve efficiencies and capacity resulted in an increase of generating capacity by more than 45 MW between 2016 and 2018.

Changing demographics and competing demands are increasingly impacting already strained systems. Water management, improving and modernizing infrastructure, using sound science to support critical decision-making, finding opportunities to expand capacity, reducing conflict, and meeting environmental responsibilities were all addressed in the formulation of the FY 2020 budget. Reclamation continues to use appropriated resources to address challenges faced in water resources management and to improve the way it does business.

Account Level Details

The FY 2020 budget allocates funds to projects and programs based on objective, performance-based criteria to most effectively implement Reclamation's programs and its management responsibilities for its water and power infrastructure in the West.

Following is additional information on the FY 2020 Budget for Reclamation by appropriations account.

Water and Related Resources - \$962,000,000

The FY 2020 Budget for Water and Related Resources provides funding for five major program activities – Water and Energy Management and Development (\$249.8 million), Land Management and Development (\$43.0 million), Fish and Wildlife Management and Development (\$141.9 million), Facility Operations (\$297.3 million), and Facility Maintenance and Rehabilitation (\$230.0 million). The funding proposed in Reclamation’s FY 2020 Budget supports key programs important to the Department and in line with Administration objectives.

Reclamation’s Dam Safety Program has identified 363 high and significant hazard dams. Through constant monitoring and assessment, Reclamation strives to achieve the best use of its limited resources to ensure public safety and to maintain our ability to store and divert water and to generate hydropower. Our Dam Safety Program utilizes the latest information and technology to evaluate and address the most pressing safety risks. The program helps ensure the safety and reliability of Reclamation dams to protect the downstream public. Reclamation evaluates dams and monitors performance to ensure that risks do not exceed current Reclamation public protection guidelines. The Dam Safety Program continues to be one of Reclamation’s highest priorities. The FY 2020 budget request includes \$92.8 million for the Dam Safety Program.

The proposed budget also includes appropriations for specific projects for Extraordinary Maintenance (XM) activities across Reclamation. This request is central to mission objectives of operating and maintaining projects to ensure delivery of water and power benefits. Reclamation’s XM request is part of its overall Asset Management Strategy that relies on condition assessments, condition/performance metrics, technological research and deployment, and strategic collaboration to better inform and improve the management of its assets and deal with its infrastructure maintenance challenges. The FY 2020 budget includes \$114.1 million for XM related activity. Additional XM items are directly funded by revenues, customers, or other Federal agencies (e.g., Bonneville Power Administration).

Reclamation’s budget includes a substantial request for enacted Indian water rights settlements that support the Secretary’s trust and treaty obligations. The FY 2020 Budget includes third-year funding to support the Blackfeet Water Rights Settlement, which by statute requires full funding by the enforcement date of January 21, 2025. The FY 2020 Budget also continues funding to keep implementation of other water settlements on track for completion consistent with legislated schedules. These include the Navajo-Gallup Water Supply Project, part of the Navajo-San Juan settlement, the Aarnoht litigation settlement, and Crow Tribe settlement. Funding is also included for the Ak-Chin, San Carlos Apache, Colorado Ute (through the Animas-La Plata project), and Nez Perce (through the Columbia/Snake River Salmon Recovery Program) settlements. The FY 2020 Budget includes \$132.9 million for Indian water rights settlements.

The Native American Affairs Program budget of \$11.7 million continues support for Reclamation activities with Indian Tribes. These activities include providing technical support for Indian water rights settlements, and to assist tribal governments to develop, manage, and protect their water and related resources. The office also provides policy guidance for Reclamation’s work with Tribes throughout the organization in such areas as the Indian trust responsibility, government-to-government consultation, and Indian self-governance and self-determination.

Reclamation’s efforts to support water supplies for tribal nations are long standing and extend beyond water rights settlement implementation. This includes \$27.8 million in the FY 2020

Budget for certain rural water projects in Montana, North Dakota, and South Dakota. Examples of other activities that benefit Tribes include Klamath, Trinity River Restoration Program within the Central Valley Project, Yakima River Basin Water Enhancement Project, and the Rio Grande Pueblos Project.

Reclamation's mission objective of continued water delivery and power generation cannot be accomplished without meeting our legal and environmental responsibilities. Reclamation meets these responsibilities on its projects through a large number of activities, including Reclamation's Endangered Species Act recovery programs, and other programs that contribute towards these efforts, such as the Columbia/Snake River Salmon Recovery Program, the Middle Rio Grande Project Collaborative Program, the San Juan River Recovery Implementation Program, the Upper Colorado Recovery Implementation Program, and the Multi-Species Conservation Program within the Lower Colorado River Operations Program, among many others.

Among other efforts, Reclamation helps address the West's water challenges through the WaterSMART competitive grant program. This program helps local water stakeholders address current and future water shortages, including drought; degraded water quality; increased demands for water and energy from growing populations; environmental water requirements; and the potential for decreased water supply availability due to drought, population growth, and increased water requirements for environmental purposes. The FY 2020 Budget includes \$19.9 million for WaterSMART programs.

Within our research and development program, Reclamation has identified several key areas for investment where coordination with other Department bureaus will leverage results to more effectively achieve mission outcomes. Reclamation's FY 2020 budget for research and development (R&D) programs include both Science and Technology, and Desalination and Water Purification—both of which focus on Reclamation's mission of water and power deliveries.

The Science and Technology program supports engineering innovation that promotes economic growth, supports maintaining and improving our water and power infrastructure, and enhances continued generation of energy. Program outcomes also enable reliable water and power delivery to our customers, improve safety, limit the impacts of invasive species, and ensure that Reclamation can meet its environmental compliance responsibilities. These activities support the Administration's priorities for the FY 2020 Budget, by supporting technology transfer activities that may lead to new business opportunities for private industry. The program also supports Administration priorities related to maintaining and improving our water and power infrastructure by partnering with the U.S. Army Corps of Engineers to foster research projects to develop technologies that extend the operating life and reduce maintenance costs of Reclamation's structures. The Administration priority related to energy from all sources is supported by hydropower research that ensures that Reclamation is maximizing reliability, reducing maintenance costs, and exploring new energy development opportunities. Research on safety is ensuring our workers can perform their jobs safely and securely.

The Desalination and Water Purification program priorities include development of improved and innovative methods of desalination and reducing costs to develop new water supplies. The research and testing funded from this program supports the Administration's priorities for the FY 2020 Budget by supporting innovative new solutions that spur the creation of new businesses by entrepreneurs and by advancing Reclamation's competitive edge in water treatment and desalination.

Central Valley Project Restoration Fund (CVPRF) - \$54,849,000

This fund was established by the Central Valley Project Improvement Act, Title XXXIV of P.L. 102-575, October 30, 1992. The budget of \$54.8 million is expected to be offset fully by discretionary receipts collected from project beneficiaries under provisions of Section 3407(d) of the Act. The discretionary receipts are adjusted on an annual basis to maintain payments totaling \$30.0 million (October 1992 price levels) on a three-year rolling average basis. The FY 2020 Budget represents an administrative decision to “reset” the three-year rolling average to stabilize the year-to-year variability in discretionary receipts. Reclamation identified the reset of the three-year rolling average as a prudent decision to reduce the variability in annual funding that was created in the first three years of the fund’s establishment, which resulted in high, middle, and low funding years. The reset will allow stable collections targeting \$30.0 million (October 1992 price levels) each year, resulting in more stability in annual payments from water and power customers and for restoration and mitigation programs funded by the Restoration Fund.

California Bay-Delta Restoration Fund - \$33,000,000

The CALFED Bay-Delta Restoration Act (P.L. 108-361), as amended, authorized multiple federal agencies to participate in the implementation of the CALFED Bay-Delta Program as outlined in the August 28, 2000, Record of Decision (ROD) for the CALFED Bay-Delta Program Programmatic Environmental Impact Statement and Environmental Impact Report. The legislation directed the implementing agencies to undertake a set of broadly described programmatic actions identified in the ROD to the extent authorized under existing law. In addition, the Act authorized \$389.0 million in Federal appropriations for new and expanded authorities. Reclamation is requesting an extension of the CALFED Bay-Delta Authorization Act through FY 2020.

The FY 2020 Budget of \$33.0 million implements priority activities pursuant to P.L. 108-361. Six Federal agencies – the Department of the Interior, Department of Commerce, Department of Agriculture, Department of the Army, Environmental Protection Agency, and the Council on Environmental Quality — work together to ensure that the Federal actions and investments the Administration is undertaking are coordinated in a fashion to help address California’s current water supply and ecological challenges. This budget supports actions under the following program activities: \$1.7 million for Renewed Federal State Partnership, \$2.3 million for Smarter Water Supply and Use, and \$29.1 million to address the Degraded Bay Delta Ecosystem.

Policy and Administration - \$60,000,000

The \$60.0 million budget will be used to: 1) develop, evaluate, and directly implement Reclamation-wide policy, rules, and regulations, including actions under the Government Performance and Results Act; and 2) manage and perform functions that are not properly chargeable to specific projects or program activities covered by separate funding authority.

Ms. KAPTUR. Thank you, Commissioner Burman. And to all of our witnesses today, thank you for your statements and we will now begin questioning under the normal rules. I will ask one question, to give all of our members an opportunity to ask theirs.

I will begin with Secretary James. The administration's budget request emphasizes the leveraging of non-Federal funds. As evidenced, I would point to two specific projects, a \$150 million line item in the request, one for funding what is called the innovative funding partnership, and one for funding projects authorized under Section 1043 of the Water Resources Development Act of 2014.

It sounds quite innovative, but I have to raise concerns that the administration may be advancing a pay-to-play system where those that can bring funds in excess of their statutory required cost share are being moved to the front of the line for Federal funding. This budget request appears to do this to the detriment of those communities and non-Federal project sponsors who struggle to meet cost share requirements.

This is something that this subcommittee has monitored closely to ensure that the haves are not receiving unfair treatment while the have-nots are left behind.

Before I ask you a specific question, Secretary James, I would like to remind you of section 1166 of the Water Resource Development Act of 2018. This provision states that the President cannot give preference to local sponsors that utilize provisions for advanced and contributed funds when developing the annual budget submission to Congress.

So, Assistant Secretary James, can you please explain the rationale behind these two new items in the President's budget request? And can you assure this subcommittee that the administration's funding decisions aren't being driven by desire to reward those communities that can afford to pay more than their statutorily required cost share of a project?

Mr. JAMES. Yes, ma'am. I understand your concern—I get that you are concerned about more wealthy communities may be able to advance infrastructure more than the less fortunate communities. I get that.

The statute that allowed—there is a program, I think it is 1043, that actually expires in June by law, that the administration looked at to try to locate and determine areas that could afford and had the ability to advance a project with funding from the Federal Government for the Federal share, and not for the entire share, only for the Federal share, but it is an advanced funding.

So, the community, whatever it may be, the only one we have got under that right now is Soo Locks—not Soo Locks, McCook Reservoir in Illinois, in Chicago. And they had the ability to do the construction, the planning, and more to move out with their project, and that is what the 1043 allowed them to do.

Now, the other funding, the advanced funding, it comes from the same notion actually that there are areas that think they could save money by taking Federal funds and applying it to their project, and them doing either the study or the work on those particular projects. And that is what is advancing that from the administration.

Ms. KAPTUR. Well, can you assure the subcommittee, Mr. Secretary, that the administration's funding decisions aren't being driven by a desire to reward those communities that can afford to pay more than their statutorily required cost share of a project?

Mr. JAMES. I wouldn't describe it as rewarding them. I would describe it as locating the communities that, number one, want to do this and, number two, have the ability to do this. With those funding, it has to be determined by the communities that they can do these projects on their own.

Ms. KAPTUR. And we are going to take a very close look at these provisions, and to make sure that all citizens of this country are treated equally.

Mr. JAMES. Yes, ma'am. I understand that totally. And if there is any way I can help in that effort, let me know.

Ms. KAPTUR. Thank you very much. Ranking Member Simpson, please?

Mr. SIMPSON. Thank you. That was interesting. I know that is a difficult question to answer. Last year I had an amendment in the committee that said that OMB can't mess around with the Army Corps' work plan once it has been developed. I was actually offering it just to make a point. When members from both sides of the aisle came up in the committee and said don't withdraw this amendment; it passed unanimously by voice vote. The Senate adopted it. Of course, OMB went nuts over that because they want to do exactly what you are talking about. They want to be able to go in and say, hey, we can get this done because this community can raise the funds to do it. So we are going to authorize this plan or this project as opposed to the one you have done.

I want the Army Corps to develop a work plan based on the law and not have OMB mess with it. And if there is one thing that I don't like about what is going on, it is OMB and what they are doing. And they are doing OMB earmarks essentially. This is not a fault of yours. It is a fault of OMB. So I appreciate the question that that Ms. Kaptur was asking and I will guarantee you that language will either be in the base bill or it will be an amendment again this year.

But I also wanted to say, Ms. Burman, my colleagues here really liked to hear you talk about the West going from red to blue. We have got kind of a problem with that. Maybe we need to change colors here. I do not know.

But as I mentioned in my opening statement, I would like to ask a question on behalf of Ranking Member Granger. Secretary James, you have expressed the Army Corps' support for the Central City Project to Congresswoman Granger on several occasions. However, no new Federal funds have been out and included in the Corps' work plan for the past 2 fiscal years. This has obviously raised concern locally about the Army Corps of Engineers' commitment to the project and this funding issue will eventually delay construction if not addressed. That would put people and property in danger and is simply unacceptable.

Secretary James, do you and the Corps remain supportive of the project? Has Congress given you the necessary authorities you need to finish this project and can you tell us when we might expect you

to recommend a resumption of the Federal funding to support continued construction?

And General Semonite, along those same lines, do you believe the Corps has an obligation to complete a project once it has begun? And can the people of Fort Worth, who have already invested so much of their local resources in this project and who depend on the Corps, be assured that the Corps intends to complete this project?

Mr. SIMPSON. Secretary James.

Mr. JAMES. I very strongly support the project and I am not sure that the administration does not support the project there. They are trying to elevate projects based on their priorities, economic return to the nation, et cetera, et cetera. I have talked with Ms. Granger before, and tend to again, to see if there are other ways or other authorizations that that project needs. At this time, I do not know of any, but it is a good project. There has been misunderstandings about the project.

Mr. SIMPSON. General Semonite.

General SEMONITE. Sir, your question on are we committed to finishing things, absolutely. And most of my frustration in the last 2½ years is when Congress has given us money to start something, given us the authority to do it, and then we do not finish a project out there. Chickamauga is a great example of something like that. On this one here, we do not have the funding. If the administration, Secretary James, gives us the green light, we are absolutely committed to ruthlessly continue to be able to complete all these projects and get them done.

Mr. SIMPSON. Thank you. I will save the rest of the question for the next round.

Ms. KAPTUR. Thank you very much, Mr. Simpson. Mr. Kilmer.

Mr. KILMER. Thank you, Madam Chair and Assistant Secretary James. I want to start by just saying thank you for meeting with me back in January to talk about my region's priorities as my district has a lot of Corps projects, so I value your partnership. And as I said when we met, I appreciate that you have not put a restraining order out against me or my office since we call so much.

During that meeting, we talked about some of the unique challenges that the Seattle district is experiencing in implementing the Regional General Permit 6. And I want to thank you for your commitment to working with NMFS and with the Seattle district to ensure that these issues get resolved.

We also talked about the recent biological opinion that was issued for the Howard Hanson Dam, and that includes a jeopardy decision under the Endangered Species Act, which mandates that the Corps move forward with construction of a critical downstream fish passage facility at the Howard Hanson Dam. That fish passage facility is not just critical to meeting your agency's ESA obligations, it is also really important for recovering Chinook salmon and that will help with Orca recovery, not to mention tribal and recreational and commercial fisheries. And I was really encouraged by our discussion and your apparent commitment to seeing that project move forward.

So I was a little surprised and concerned that the budget request does not include any funding to begin moving that project forward.

And I was hoping you could explain first why that funding wasn't included in the fiscal year 2020 request. And second, the legal consequences if the Corps that you all face if the facility is not constructed.

Mr. SIMPSON. I hope I do not get confused on this, Congressman. There was 93 million allocated through fiscal year 2018 with 5.3 million to complete and, as you said, zero in the fiscal year 2020 budget. My understanding is that the project was about to exceed the 902 cost limit, so the project was halted. Now, the cost limit is 138 million, the way I understand it, and even though the 2019 BiOp directed the Corps to build the fish passage, the funding, or override of funding rules in this case, I think that can be worked out. I think there may be some areas of the project could be examined, changed, that would allow the Corps to build under the 902 limit. But that is where we are today.

Mr. KILMER. I guess I would just, in follow-up, like to ask your commitment to work with me and the members of this committee to ensure that the Seattle district gets the resources it needs to complete this project. Because I think there is not only importance from a fish recovery standpoint, I think the agency's in legal jeopardy if it does not get it done.

Mr. SIMPSON. Well, I think that is exactly correct. And you have my commitment, sir, to continue to work on this and work with the Corps to see if not bypass that cost limit, but at least lower the cost somewhat in order to meet the cost limit.

Mr. KILMER. Okay. I wanted to take the remaining time to just recognize and express my gratitude for the Seattle district in particular. I have represented a bunch of coastal communities and they are struggling with the threats of coastal erosion and sea level rise. And we call you into action quite a lot and you have done an amazing job of shoring up jetties or addressing seawalls that have been breached to really prevent catastrophes. And I want to recognize the value of that. I also recognize it comes with an important—with a price tag. And I think we may be missing some opportunities to make some smart investments in resilience upstream rather than waiting for infrastructure to fail and urgently calling you guys to come in and fix it.

Either Assistant Secretary James or Lieutenant General Semonite, can you talk about the opportunities you see for the Corps to take a more active role in sort of pre-disaster mitigation efforts? What resources do you need to be able to carry out more of these projects so that we are not calling you after something fails?

General SEMONITE. Okay, sir, you hit it right on the head. The more we can be preventative and try to anticipate what is going to happen, sometimes a couple of dollars spent up front before a problem can save a hundred times that later on. I think the challenge is, is that because of the constraints in the Federal budget, we are putting Band-Aids on things that have to work, I mean, locks and dams and harbors and other kinds of things. And so there is less and less money available for some of those things that are more proactive. It is not that we do not want to do it, and wherever we can figure out how to help advise, we want to, but I

think that is the challenge that we have on how much we can do proactively. I will defer back to the secretary.

Mr. JAMES. I agree 100 percent on that. You did hit it right on the head and that is what we are trying to do. But it is very complicated and it is very difficult within the budget limitations.

Mr. KILMER. Time is up, so I yield back. Thank you, Madam Chair.

Ms. KAPTUR. Thank you very much and thank you for staying within the time limit. Congressman Calvert.

Mr. CALVERT. Thank you, Madam Chairman. Assistant Secretary James, General Semonite, thank you for both being here. I think I have talked about this with you guys once or twice before. So I think you know what I am going to talk about. It is Marietta Creek, a flood control project.

As you know, the project is under construction. We intend to keep moving that project through. We have been working closely with Commander Barta and the L.A. district to ensure the funding is provided to the Marietta Creek Project to continue construction of phase two and phase one environmental vegetation removal. This rain we had, heavy precipitation we had, underscored how important it is. The current channel was at capacity throughout the February storms and this was only a 25-year event, not the 100-year event that this project is designed to take care of when it is fully completed.

And some of the funds received by the Corps of the project were intended to be used to advance the validation report. I have been frustrated the progress on this draft validation report to date. As you know, we have been pushing the Corps for nearly 6 years to complete the validation report, which will update the project's economics, hydraulics, and hydrology. The local sponsor, the Riverside County Flood Control and Water Conservation District, recently met with the Corps to discuss the status and elements of the draft report. The district has now had the opportunity to review the Corps' recently updated economic analysis within the report. I have some serious concerns. For example, the flood district has found instances where certain maintenance costs are double counted or where cost estimates greatly exceed the actual bids. There is a host of specific corrections, additional identified benefits, and cost savings recommendations the flood control district is making to the Corps, which would properly incorporate the full range of benefits in the validation report.

Secretary General, would you commit to me that you both, both the Corps leadership, we will work with the L.A. district and the local sponsor, address these concerns and incorporate the full range of projects, benefits, into the validation report?

General SEMONITE. Sir, let me go first on that one. We are absolutely committed to getting this done and that is the theme of what I am going to say throughout the day here. I have just talked to General Colloton yesterday and today on this. I am going to ask her to look at this packer. This is the report we have got to do to get through there.

I am not aware of what you talked about on double counting of billings. So I will blow into that this afternoon and have General Colloton, she is right here, I will have her come back and make

sure that they brief your staff. If there is anything that is confusing, we will make sure that we understand exactly what is out there.

I think the main thing is that we certainly see a lot of value in this project. We are absolutely committed to get it done. And if there is anything we do with respect of the work plan of 2020, if Congress is so inclined to give us money above and beyond the President's budget, then we have the authority to be able to allocate some of that in key places to be able to get some of these projects done.

Mr. CALVERT. Well, with that, I had a couple of other questions I was going to ask about that, but that is a pretty concise answer. I accept that and look forward to working with you to see if we can get this thing done. I would like to get it done—well, I have only been in Congress 27 years, I hope to get it done while I am still here. Commissioner Burman, I am intrigued by your map here. Of course, being from California, the panel here hears me talk about California water all the time. We like Idaho because we like looking at their water as it comes down to California where it belongs. On the Colorado system, obviously the Bay Delta right now, we are in pretty good shape as far as our reservoirs. The Colorado system, is there any estimates how much flow will go up in this so far?

Ms. BURMAN. I am trying to remember the numbers, but as average inflow into Lake Powell, we look at it usually for the kind of springtime runoff. And last year, it was at 36 percent, for example. And this year, as of last Friday, we believe it is going to be at about 133 percent of average. So a significant flow of water is going to be coming to Lake Powell this year.

Mr. CALVERT. I mean, save something for Las Vegas because obviously, right now, they are the most concerned about this. As you know, they are having to do extraordinary things to get water to enter that area. So this is good news and, gosh, you have only been in office for a little while and you have already been able to increase the reservoir capacity at Lake Mead.

Ms. BURMAN. I am committed to turning around flows in the West.

Mr. CALVERT. Congratulations and I look forward to working with you. Thank you.

Ms. BURMAN. Thank you, Congressman.

Ms. KAPTUR. Thank you very much, Mr. Calvert. I would ask, when you calculate these percentages, how do you relate that to demographics and population growth? Do you just measure water?

Ms. BURMAN. So we measure water on a map such as this. So we also have programs. This is through USGS gauging, through working with universities, working with NOAA Fisheries, National Weather Service. We use all of our assets and sources and partners to look out at what is the current hydrology and what is the predicted hydrology. What can we predict in the short-term and the long-term?

Ms. KAPTUR. Hydrology, but is that related to demographics in any way?

Ms. BURMAN. So what we do have is under the WaterSMART Program. We have a basin program and so we have been able to go out, and I believe it is over 20 basins at this point, work with

local partners and to look at those things. We look at what future demand is going to look like? What is growth out of different cities or footprints? What are the tribal needs? We recently completed a 10 tribes study on what will their future water needs be and what are the sources that are out there. And the idea is that by doing these studies we can also start looking at the next steps of when you see the gap between supply and demand in the future, how are we going to fill it?

Ms. KAPTUR. Yes.

Ms. BURMAN. And so that program has helped us work with the different parties about what are the different ideas out there. Everything from conservation, infrastructure, new partnerships, exchanges really trying to look at all of the above of what is right for a particular area.

Ms. Burman, I thank you for that clarity. If there is any way you can provide in a decipherable manner to this committee, those futuring estimates by watershed or basin that would be most interesting, I think to all of—the whole country really. Are you able to do that yet?

Ms. BURMAN. I will work with my team. We have a really amazing team at Reclamation and we will compile all of those. I know we have them for separate basins. I do not believe we have compiled them yet, but I think that is something we could do for the committee.

Ms. KAPTUR. Thank you. Supply and demand, very important in this arena. Obviously, Mr. Calvert, Mr. Simpson, are your experts because they live in the area, but for those that do not, this would be most instructive.

Mr. CALVERT. Madam Chairman, we are just a small state in California, we just have a lot of needs. Thank you.

Ms. KAPTUR. Thank you. Congressman Pocan.

Mr. POCAN. Thank you, Madam Chair. Thanks for being here, everybody. My district, my state, upper Midwest has a lot of reliance on the Army Corps of Engineers for a lot of different projects, whether it be helping to site power lines, but really more around some of the flood management issues and around navigation down the Mississippi and the issues that that has.

It has been a long, cold winter in the upper Midwest and now we have got a lot of flooding. I think it was a couple of weeks back, I left on a Monday, we had four-feet snow banks, and I came back on a Thursday and there was no snow on the ground. It is a lot of melting really fast and I just saw it this weekend driving around, a lot of flooding. About 280,000 water wells in my state are at risk, severe impact, property damage, et cetera, from that.

When it comes to dredging, I know we have had the conversation, Mr. James, specifically and the Army Corps comes in every year and I appreciate that, into the office, but Wisconsin happens to have the perfect shape sand for fracking. We do not frack, but that fills every train car leaving Wisconsin. But we also have this other thing called agriculture in Wisconsin and then that cannot get on the train cars and we really need the Mississippi to get product down. We also need to get coal up for power plants. We need to get timber up for paper mills and we have got all sorts of issues, making sure that it is proper dredge and locks are working.

So having said all that, I did notice there is about a billion dollars being cut in construction and then this week it was announced that a billion dollar is going to be coming to the Army Corps of Engineers to build border wall. And when I look at what we care about in the upper Midwest, it is not empty parts of the desert having a border wall, but it is making sure that corn and soy and other products are getting down the Mississippi, not just from Wisconsin, but Minnesota, Iowa, and other places.

So I was just curious if you could, Lieutenant General Semonite and Mr. James, if you had a billion dollars, if there truly is a surplus billion dollars out there apparently, what would that go towards? What levees and floodwalls are next in priority that would be happening, and what dredging and navigation construction projects would be realized if we really had a billion-dollar surplus?

General SEMONITE. Sir, I think that the most important thing we have to do is probably work off the backlog. Right now, we have a \$98 billion backlog of mainly construction requirements that have not been done. And so what we have got to do, some of these things are just barely hanging alive. We have got a quarter of a trillion dollars in the ground, 50 percent of that is over 50 years old. So as much as I would love to be able to build new things, we are committed to finishing what we have started, but also go back in on some of these to maintain navigation and the life safety is absolutely critical. I mean, levees, anywhere, people being damaged. So I would put it worst first and a billion dollars would probably just barely scratch the surface of some of the worst challenges we have.

Mr. JAMES. I would not put it exactly that way. Let us address NESP. That is part of what you are talking about, the upper river up there. Right now, we are not getting any funding for NESP, and either out of the budgets or out of the work plans, and for your part of the world that is a catastrophe. Because if one of those locks and dams fail in that part of the world, you are landlocked, you are blocked. And so I hope to see funding for NESP. Right now we are doing—I signed a letter for an economic update on NESP to see whether hopefully we can finish a study and start funding NESP. That update won't be out until later this year.

But, you know, we have got projects all over this country that people are flooding, we have got locks and dams that are wearing out, we have got ports that are not being dredged on schedule. So, you know, that is bad enough in itself. But then we have got projects that are not complete.

But I do say, on behalf of the administration and anybody else that touches our budget, that this no new start declaration. I can't say it is the right thing, but I can understand the rationale behind it. We have got a lot of things we need to complete, and every time we add a new start we get further away from completing what we have already got started.

And then the other thing, our ONM is exploding. We are spending so much money in this country on ONM it is ridiculous, and that is due to the fact that our infrastructure is aged. The locks and dams in the Mississippi River were built in the 1930s and they are held together with baling wire and duct tape, basically. And we have got them in other areas as well the same way. We have got floodwalls and levies that are getting past their design life.

You know, that is what makes my job so difficult is, okay, I realize and understand what all we need in this country and I see it every day. Besides that I have seen it for 37 or 40 years what we need in this country. And we just don't have the money to do it all. So there comes to me the importance of doing the right things with what money we have. And there is a lot of people that touch those tent poles.

So, sir, I didn't answer anything, I don't guess. I kind of went off on you.

Mr. POCAN. No, you brought up my next point, too, and I appreciate it. Thank you. I yield back.

Ms. KAPTUR. Frankly, if it were up to this member alone, I would move these budgets as the sort of first base hit for an infrastructure bill. We are ready. We know what needs to be repaired around the country. And take this message back to the administration, they really ought to consider it. They have some of our members' attention up here, and it would be you are organized, you are ready to go, and wouldn't that be a great thing for the country.

Congressman Fleischmann.

Mr. FLEISCHMANN. Thank you, Madam Chairman. To this distinguished panel, thank you very much. Mr. James, thank you for personally visiting our office. And General Semonite, thank you, sir, for your service to our Nation, and thank you for honoring the men and women who have served us so well in the United States Army, and of course in both capacities, combat and with the Army Corps, sir.

I want to personally thank you for actually being onsite at Chickamauga Lock with General Torrey. That meant an awful lot to actually see the progress. This, candidly, sir, has been probably one of the most arduous projects I have had to work on in Congress. And to the credit of Republicans and Democrats, of senators and members of the House, we actually worked together to reform the Inland Waterway Trust Fund to properly fund the Trust Fund, and then to create a priority system. And Chickamauga Lock has clearly benefitted from that new lock. You have done a great job keeping the old antiquated lock. Mr. James is right, those old locks are old, and I have been in them when they are dewatered, it is tough, but you all have done a good job. So thank you.

If I may, since we have been providing funding for Chick and some ongoing projects in the inland waterway system, if efficient funding is provided, sir, until completion, when are we expected to see the new Chickamauga Lock completed, sir?

General SEMONITE. So, Congressman, if, in fact, there is sufficient annual funding, we would predict December '24. And I would just go on to say that Chickamauga, for the committee's knowledge, is probably the poster child of how not to build something. If we are efficiently funding we could have knocked this out in probably 3 or 4 years.

What happens is we made a commitment, Congress did, of over \$300 million and then went dormant for 3 years with no money whatsoever. And it sat there as a block of concrete and probably lost the trust of a lot of taxpayers, saying why wouldn't we see this thing through? And so what we have to do is to be able to finish these, to be able to make sure we can get that one going. So this

is where the committee's ability to give us adequate work plan money allows us to come back in and to be able to continue, to be able to get those kind of projects done.

And as you know, we did \$37 million a couple years ago, \$76 million last year, \$89 million this year, and our guys are telling us the next logical increment would be about \$90 million, \$45 Federal, \$45 Inland Trust Fund, and we could continue to be able to get that done. And that would be the 2024 date, would mean we would have to continue to see money coming in.

Mr. FLEISCHMANN. Thank you, sir. As you are aware, you have seen the flooding all around our great Nation, but Chattanooga was particularly hit hard, as was much of East Tennessee, sir. And I notice that the cofferdam apparently was flooded. Can you give me a status update, please, sir, as to where that is?

General SEMONITE. So we think we got most of the critical equipment out. There was no significant damage. It is going to slow us down on time. We don't see any significant impact to the standards of construction or anything else out there. So I think once we know, when the water comes back down and we can get back in and make those assessments, if there are some ramifications back, we will make sure we get back with your staff and kind of say whether that is going to work out on time.

But I do not see a significant change in the amount of money other than the fact the contractor couldn't work for some time, and then we have got to be able to continue to recaulk that.

Mr. FLEISCHMANN. Thank you, sir. And lastly, I would like to gain a better understanding of the Corps' process for the administration of larger construction contracts and how it relates to the dollars appropriated for the current fiscal year.

For example, I understand the new Chickamauga Lock Chamber contract consists of 13 options, sir, with options 4 and 6 and 8 expected to be exercised in the coming months. Can you briefly explain the process for exercising the remaining options, sir?

General SEMONITE. So you are right, there are 13 different options that have been awarded back in September '13. And then as those work plan monies come available, we try to work our way down through what would be a logical increment. And that is how the options are kind of designed.

So, therefore, we would say maybe there is 37 million and we could exercise that option. And then whatever the funds that are available, we want to certainly be able to bring those in.

Now the options are designed, obviously, in a logical sequence so we have to build them in a certain way. But our goal is to be able to make sure that at no point are we leaving money on the table. And whatever money Congress gives us, we want to aggressively get that in the ground. And if there is more specifics on the contractual piece, I am more than willing to have my guys walk you through that in great detail, sir.

Mr. FLEISCHMANN. Thank you, sir. Let me conclude with the way that I began, sir, with a sincere thank you to each and every one of you all for the work that you are doing and to assure the citizens of East Tennessee that the new Chickamauga Lock is being constructed, it is doing exceedingly well, and I thank you for that. At

the same time, we maintain that antiquated lock which is still functional. Thank you, sir.

I yield back.

Ms. KAPTUR. Thank you, Congressman. Congresswoman Kirkpatrick.

Mrs. KIRKPATRICK. Commissioner Burman, I first want to acknowledge your legislative experience working with our Senator Jon Kyl, who is well known for being an expert in Western waters.

But more importantly, it is rare, but really a pleasure to have a fellow Arizona Wildcat before the committee. So bear down.

Ms. BURMAN. Bear down. Tough year, but bear down.

Mrs. KIRKPATRICK. Yeah. We are building, rebuilding. My question, I have to tell you, I was initially alarmed when I saw Lake Mead's percentage of capacity at 42 percent, Lake Powell at 38 percent. And I think you addressed Lake Powell, you expect that to come back with the spring runoff. Could you also address what you are expecting with Lake Mead?

Ms. BURMAN. So Lake Mead's level is very much controlled by what is released from Lake Powell, and we make certain projections about that. And as part of our routine, in August we put out a 24-month study that predicts what will happen in the next year. And at that time we will determine how much water will flow from Lake Powell down to Lake Mead in the next year.

So at this point I would say there are different predictions out there, but more snow and rain is good for the system. One good year is not going to fix our 19-year drought, but we will take it. So at this point I would say it is more likely than not that we will not be in shortage in 2020. But we still see that possibility in 2021.

Mrs. KIRKPATRICK. And do the summer monsoons make a difference in those two lakes? Because you said your projections will be made in August. That is probably right around the time the monsoons are at their highest.

Ms. BURMAN. So it is a relatively small amount. We absolutely watch the tributaries that come in below Lake Powell and above Lake Powell. So below Lake Powell as far as Lake Mead, it is a very small percentage, but it can make a difference.

Mrs. KIRKPATRICK. Thank you. My next question is for you, General Semonite. I want to say I really appreciate your commitment to taking care of the backlog. Thank you for that.

And I strongly disagree with the President's decision to cut your budget by over 30 percent. But I also know that this subcommittee cannot provide you the type of resources you will need to substantially cut down on that backlog of critical, authorized projects.

That brings me to WIFA, which has helped other Federal agencies leverage their money. As you know, Congress authorized the WIFA Program for both the Corps and the EPA, but only the EPA has utilized it. In its first year the EPA used 25 million in appropriated dollars. Excuse me for that, insult to the committee. The EPA used 25 million in appropriated dollars and made an astounding \$2.3 billion in loans. This subcommittee gave the Corps 6 million last year to prepare the program for loans.

General, is your WIFA Program ready to process loans in fiscal year 2020 if this subcommittee provides you with the funding?

General SEMONITE. Ma'am, I think I am going to let the secretary hit that first. Then once he answers, then I will talk about the implementation.

Mrs. KIRKPATRICK. Okay.

Ms. KAPTUR. Mr. Secretary.

Mr. JAMES. Yes, ma'am. Thank you.

The WIFA alone, we are taking EPA's dashboard, if you will, their methods of doing WIFA loans, because they started before we did. And we are working now on making ours mesh with that so that we can actually start doing the loans. We should have that completed by the third quarter of this year. And then we will be in the position to start actually making WIFA loans.

General SEMONITE. And so, ma'am, to build on that, this is where I talked about on revolutionize, our second objection. There is a lack of some innovative financing. It is great to always ask for more money, but we as a Nation just cannot afford all the bills. We have got to think through what are some better ways to do that.

And this is where we are working very closely with the secretary to make sure that we have got those documents ready and those processes ready. This is something new so we have got to learn and then be, I think, flexible to understand it as we go through this, keep reevaluating and assessing ourselves on what can we do to do this better.

But are aggressively moving forward based on the secretary's direction.

Mrs. KIRKPATRICK. Thank you. I yield back my time. Thank you.

Ms. KAPTUR. Thank you very much. Mr. Newhouse.

Mr. NEWHOUSE. Thank you, Madam Chairman. I appreciate all of you being here this morning. You are all engaged in something that is very important to the economic wellbeing of our country and it is very important work, so thank you for taking the time to be with us.

I do want to acknowledge, I am sure Congressman Simpson was referring to the quality of Washington State potatoes when he was giving a shout out to—I knew it was, and I wanted to thank you for that.

So I have got one particular thing I want talk about. And, Ms. Burman, it is great to see you again. Thank you for being here.

As we have talked about on several occasions, you are aware that the Odessa Groundwater Replacement Project, it is a targeted plan within the Columbia Basin, which is in Central Washington, in my district. Its goal was to replace depleted groundwater supplies.

The subarea groundwater is being withdrawn at a rate that is well beyond the aquifer's capacity to recharge. Aquifers in the sub-area are, as a result, quickly declining. Groundwater is virtually depleted to such an extent that wells are as deep as 2,400 feet today.

Water pumped, as you know, from those depths, is hot and has dangerously high sodium concentrations. So municipal, agricultural, commercial, industrial, and domestic supplies, as well as the quality levels are so compromised that this is most certainly and clearly at a crisis level.

In 2016, a deep well that supplies a municipal water system in the city of Lind began to fail. Maybe you are familiar with that.

The well pumped white foam with high chloride content at approximately 80 degrees in temperature. Other wells in the area are at the point of drawing air. Irrigation wells near the city of Othello have been recording temperatures as high as 105 degrees and are smelling of sulfur. And we all know what that smells like.

High levels of sodium in groundwater used to irrigate crops are posing a serious threat to agriculture in that area. The city of Othello itself projects it will run out of water potentially in 3 years.

So I just want to say thank you and the administration for updating the cost-benefit ratio last spring, already it has been almost a year, so that we can more easily secure the desperately needed resources for the Othello program. And I am glad to see that your budget justification points to support of the program. So thank you for that. Though we must be providing much, much more towards this precarious and potentially dire situation.

So for the record, do I have your firm commitment that the Federal Government will ensure that these small farming communities in Central Washington are equipped with the resources and the support that they need to prevent a potentially catastrophic emergency?

Ms. BURMAN. Congressman, we are absolutely committed to bringing surface water supplies to the Odessa region. Our regional director has made it a prime focus of hers. She has been working very closely with the district, with your office, and with others.

We have funding this year to move forward and working with the district on design and construction oversight. We will be working very closely with the district about what the next step should be.

Mr. NEWHOUSE. I appreciate that very much. I have gone way over my time limit here, but I appreciate that commitment. And this truly is a potential crisis, and I think the last thing that we want to see is another Flint-like situation in this country. And so we have time to address it and I want to make sure that not only the committee, but the rest of the Congress is aware of that. I appreciate your commitment.

Thank you, Madame Chair. I yield back.

Ms. KAPTUR. Congressman Newhouse, if you were again to restate the reason for the situation that you are facing. What has happened from an ecosystem standpoint?

Mr. NEWHOUSE. So when the Columbia Basin Project was put into place years ago, there was a commitment at the time, until the project was totally completed, that areas within the project that were not receiving surface water from the Columbia River could temporarily use well water, groundwater. And that is in an aquifer that does not replenish quickly and it is being depleted now over the past almost 50 years of being used. And so we are finding ourselves in a, like I said, a crisis situation.

Ms. KAPTUR. Thank you very much for that clarification. Congresswoman Frankel.

Ms. FRANKEL. Thank you, Madam Chair. Thank you to the Army Corps. Sorry I have been in and out, I have other meetings I have been required to be at. First of all, I just want to start by saying that the Army Corps has worked very well with my office and I am—you do really, very important work for this country, so thank you for that. So, that is why I am a little—I am very disappointed

with the budget because of the cuts, but I am not going to blame you on it, because it probably didn't come from you. But I just did want to comment and say that some of the things that concern me are the billion-dollar reduction in the construction account, the reduction on Everglades restoration which I am going to talk about in a moment, the lack of inclusion of any new start studies.

And I also want to say, I am here with my colleague, Debbie Wasserman Schultz, who between the two of us are going to try to cover some of the Florida issues. But I wanted to just emphasize that Florida's economy depends a lot on tourism, which means the proper maintenance of our beaches, our waterways, our harbors, obviously our drinking water. And so a 30 percent overall decrease hurts us because we have to have our waterways maintained and we need to have our beaches renourished and we need to have our drinking water, so just to tell you that that disappoints me.

Again, I think it is probably coming from—all of the budgets, there is a request for all the budgets being cut, but just Madam Chair, to let you know, I am going to fight strongly not for this budget. Okay.

Let me get to an issue of tremendous importance, a couple of them in Florida. I was once the mayor of the city of West Palm Beach. And there was a time, I believe it was in the 1990s, no, I think it was 2000, it was in the 2000s, anyway, we had a terrible drought and came literally within days of losing all our water. I mean, we were terrified; I don't know if anybody remembers that. I see you shaking your head.

Not only were we not going to have drinking water, we were not going to have water to put out fires. So that is why there is a great alarm coming from my local authorities from the city of West Palm Beach, and from Palm Beach County Commission concerning the talk about lowering the lake levels to 10.5 feet or less in Lake Okeechobee.

There is a little bit of a political—you are shaking your head. You obviously know about it. There is a political—there are some politics involved which I really—because what is happening in the Martin County area, parts of the east coast and west coast have been getting these algae blooms, which are terrible for them, especially as it has economic consequences, and I know they have been urging the Corps to lower the lake levels. What I want to ask you about and to be assured, that any decision made is based on scientific evidence and research and not on the politics of who is pressuring you to lower the lake.

General SEMONITE. So, ma'am, I will guarantee you that we live in a world of science and engineering and we fight to stay out of the politics. And that is—we are not getting pressure to go to a certain number from internally. There have been some calls from both elected officials and—to be able to come to a certain level.

We work this under the LOR system, you are probably very aware of it. The normal band is 12.5 to 15.5, and we in the Corps have to live in the world of balance. Last year it was 14.5 and some people had proposed that maybe going into the summer with a higher number could have had some correlation back to the algae.

So, this year, we are coming down. We don't have a target. We are going to continue to look every single day at what the weather

is doing. How do we continue to set the conditions? We are lower than we were last year. As of this morning we were at 12.07, so we are down about 2 feet. We still think, though, and just as you said, there is a bunch of reasons to keep a certain amount of water in there. We have got to take care of the ecosystem, its water supply. There is some recreation, some navigation; it is not all just about getting the lake as low as possible.

So we are going to continue to keep all of the elected officials informed as to what we are doing and there will be no surprises. We are relooking at LORs. We will continue to be able to advise you on that. But we are trying to figure out, is there a way we can maybe find a sweeter spot going into the summer so we can prevent algae while at the same time preserving water supply?

Ms. FRANKEL. That is good because otherwise I was going to request that you have a contingency plan to get water to the city and the county if we ran out. And Madam, are we going to have another round because I didn't get to the Everglades funding, which I would like to do if my colleague, Representative Wasserman Schultz, doesn't get to that? Thank you and I yield back.

Ms. KAPTUR. Thank you very much. Congresswoman Wasserman Schultz.

Ms. WASSERMAN SCHULTZ. Thank you, Madam Chair. Thank you all for being here and for your service. I am going to ask two questions and I am not sure if I am going to be here in the second round, but the first one focuses on Port Everglades, Mr. Secretary.

I think you know that we are going on 20 years that we have been working on trying to dredge our port so that we can accept post-Panamax ships. And I am thrilled that you are joining me on April 15 to do a tour of the port and spend some time seeing firsthand the vital economic importance of this deepening and widening project.

We have discussed the project before last year when you first came into the administration, and you understandably weren't quite as up to speed as you might have been at this point now. But it is time for this project to move into the construction phase and my understanding is that the Corps is working with the appropriate Federal resource agencies to complete the supplemental and environmental assessment this calendar year.

Can you corroborate that, please? Do you see any hurdles to completing that assessment this year? I know I am going to be working hard with my colleagues to ensure that this committee, despite the irresponsible decision to not include any funding for new starts, provides the Corps with appropriate funding for new starts because that is the only way that we can actually move into the construction phase of this project.

Why does the budget not include any money for new starts? And it is not a good enough answer that we have too many other projects pending and that are taking too long, to not add others. That just means that we are going to have a backlog on what exists and we are going to create more of a backlog and what would be the next step for the project upon completion of the environmental work. And if you could save time in your answer for me to ask you my Everglades question, I would appreciate it, and General Semonite or Secretary James or both of you.

General SEMONITE. I will give you a quick answer, ma'am. There are three things we are working right now. We are working on the NEPA report, we have also got to have the ESA report, and then we need the Florida Department of Environmental Protection. All of those are working and we need three permits that will come in. The design is being done right now, so that should be done somewhere toward the next year.

We were setting the conditions, so all we really need is funding. Now, to be honest with you, though, this is a heavy lift because of the benefit-cost ratio. So that is where the committee is going to have to figure out how to work through that. You are at 1.29 and the normal metric or OMB metric is about 2.5. So all I am saying is if you—if the Congress gives us the authority to build, we are ready to build, but this is going to be a challenge when it comes to the funding level.

Ms. WASSERMAN SCHULTZ. Okay, you are going to have to come back and come to my office——

General SEMONITE. We certainly will do that.

Ms. WASSERMAN SCHULTZ [continuing]. And explain what you are talking about to me because I was not aware that we had a ratio issue. So, is the answer yes, that the environmental assessment is going to be completed this year?

General SEMONITE. Yes. In 2020, all of those permits should be done by those different Federal agencies next year.

Ms. WASSERMAN SCHULTZ. So how do we get into the construction phase if the assessment isn't going to be done this year?

General SEMONITE. So we are going to need the new start.

Ms. WASSERMAN SCHULTZ. Right.

General SEMONITE. And we are going to need the funding allocation.

Ms. WASSERMAN SCHULTZ. Okay.

General SEMONITE. And we will lay that out for you, ma'am. General Hollen is here, she could——

Ms. WASSERMAN SCHULTZ. We have to have that happen in 2020. That has to happen. We cannot go another fiscal year without this beginning. We have to begin moving the Coast Guard Station.

General SEMONITE. Yes, ma'am. So we will work with the secretary. That means that this will have to then compete in the fiscal year 2020 war plan for both the new start and the funding.

Ms. WASSERMAN SCHULTZ. Yes, exactly. Okay, and quickly, with the Everglades, the EAA, the Everglades Agricultural Reservoir, that component of CEPP, the Central Everglades Planning Project, was authorized in the last quarter. It is a project that will store and clean and deliver badly needed water to Everglades National Park and Florida Bay. I know certain work has to be done before this reservoir can move forward. I hope you are working with the South Florida Water Management District in order to identify the steps that have to be taken to move EAA Reservoir to construction in a timely and expeditious manner.

So what are the specific studies or other steps that must happen to prepare the reservoir for actual construction? Can some of those steps be taken concurrently, and could you give me an estimate of the time it will take to move to construction of the EAA Reservoir?

Because that would be an example of a project that is taking entirely too long to move forward.

General SEMONITE. Ma'am, this is mainly in the design challenges. This is a massive reservoir, probably one of the biggest ones ever built in the United States.

Ms. WASSERMAN SCHULTZ. Mm-hmm.

General SEMONITE. It is one-fourth the size of Washington, D.C., 78 billion gallons. This is about 30 feet high with 20 feet of water. So although the concept was done by South Florida Management District, the design is not, so that is where we have to sit down and figure out. How do we make sure we build this reservoir so it doesn't have life safety challenges? Well, we are working through all of that. I am not even worried about the funding right now. The main challenge is get the design done, set the condition, so then when funding is available, we can do it. I don't have a—

Ms. WASSERMAN SCHULTZ. Time estimate.

General SEMONITE [continuing]. Timeline right here, but I have got it in the book, but I will certainly come back and lay you out on what the road to it, the path forward, and what are the obstacles along that path.

Ms. WASSERMAN SCHULTZ. Okay, that would be incredibly helpful. And then, lastly with my last, well, I have no more time, but when Congresswoman Frankel addresses the paltry, unacceptable 63 million request in the President's budget for Everglades restoration, I will associate myself with her remarks. Thank you, I yield back.

Ms. KAPTUR. Thank you, Congresswoman, very much. I was reflecting as I was listening to the questions by our members about the diversity of our membership from each region of the country and some of the unique challenges they face. I certainly face those in my region, and because we have so many division commanders here today, thank you for your service.

I think one thing that would benefit this subcommittee and perhaps others, would be to take a topic like water, fresh water, for human consumption and agriculture, and take a look at that in a comprehensible way for the country.

What tends to happen in this subcommittee, and I love this subcommittee, but we do talk about projects: this project, that project, this dam, that lock, whatever. And they are all important, but what gets lost is we talk about the particular, but we don't generalize.

I thank Commissioner Burman for the start of some information regarding a region of the country. But I think for the sake of the Nation, it would be very beneficial, and I may be the only person that attends, but if you could take your collective wisdom and help the country understand what it needs to do to prepare for the future. Your budgets fit into that bigger picture.

And I think we need to be more effective in communicating with the public. That is hard for you because you all have pieces of the puzzle. I also think we need to relay our work to the demand issue for water.

Now, the community I represent is 1/435th of the puzzle and its water was shut off half a decade ago for 3 days because of toxic algae blooms coming into the water system. We are not part of the

Bureau, but you need to understand our pain. Flint, Michigan, has not been able to completely recover from the disaster that it faced. Until this morning I was unaware of Mr. Newhouse's situation, but there are things happening across the country where we need to muscle up faster to meet the environmental challenges that future generations will face. And I don't think we completely can articulate it because we are focused on projects as opposed to the larger environment in which those projects exist.

So, I would ask the district commanders, think about how you could help General Semonite to communicate with us in a way where we could share it with all of our other colleagues, maps that really help us see the truth, whatever that environmental truth is now, and what we have to do to use our resources, particularly related to water, to transition better to the future.

According to a recent United Nations report, climate change is already causing water shortages in many places. What evidence do we have of that here? There are increased incidences of flooding that threaten drinking water and wastewater facilities across the globe.

I can tell you in my own area, the amount of rain coming into the Great Lakes region is at historic levels. One of the things that is happening is that Lake Erie, the southernmost of the Great Lakes, has been full of these algae blooms, but one of the related issues is that over 40 percent of the septic tanks in the region have breached. That is not your job, right, septic tanks. That is the state's job, but they are not doing their job. And those septic tanks have been flushed out underneath the top layer of the soil and that is helping to contribute to some of the issues that we are facing in that fresh water lake on which millions of people in the United States and Canada depend for their fresh water.

I don't know how we better communicate this. Whether we get National Geographic Magazine to sit down with us here and to kind of take the information you have and to generalize from the specific, but I really feel a need to do that at the beginning of this 21st century for the American people.

We have massive washout of agricultural lands in our very flat region of the country. Other places are water short; California is fighting about water all the time. I have not been a part of those battles, but Congressman Calvert is an expert in that. We have drought impacting other places in the country and, Commissioner Burman, you talked very eloquently about measurements. But most people I represent, if I showed them this, it would mean nothing to them. As good as it is, it isn't in language people can understand.

So I am saying to each of you, in order to meet these new challenges more forcefully, could you clarify a little bit what your agencies might do to help us better present the big picture to the American people to address the challenges that climate change is certainly creating in our country and around the world? And what are your agencies considering to better explain to the American people why a specific project fits a bigger picture and why it is necessary, and how we make those investments to be more resilient and robust.

You must be debating this inside the various regions that you represent, but somehow, how can we better communicate it? I just sense that we are divided up into 435 pieces and then within those 435 pieces into specific projects, and we are kind of losing the big picture.

The recent flooding in Missouri, Iowa, and Nebraska, to me, I looked at that and I thought, how do we explain this to the American people, more than a fly over by the Vice President, but what does it mean? What is happening in that part of the country? How can we explain it?

So, I guess, I am sort of begging you to help me figure out what assets do you have that could help us grapple with the changes? And every member has got some little footprint in their area of this change, but it is not generalized from the specific. Do you have that ability, General, in your purview, or Mr. Secretary, do you have it in your purview to help us generalize from the specific?

General SEMONITE. I think, ma'am, we might not necessarily have answers, but we certainly have enough data and enough understanding of the problems. The challenge I think is, is that this is not a given project or a given Federal requirement. It is about eight. So how do you balance things like water supply, water quality, irrigation, flood control, recreation, and navigation, all of those different things? And that is the challenge.

And you are exactly right, so many times we get so focused on a parochial interest that maybe only deals with one of those, but I think we as a Nation have to look at integrated water management. How do we put all of those on the table and then figure out how are they affected by things like climate change, sea level rise, urbanization? And then how can we anticipate the future requirements so we can then help shape what we need to do in the years out there? Things like, how do we get more water supply perhaps because we know eventually water is going to be more and more important?

I think these are some of the things that we have got to have this dialogue on. It is not just the Corps. It is working with all the other Federal agencies because we all have a role in this, and the international community has got a lot of thought on this. So, I think we need to take the discussion to a higher level.

Ms. KAPTUR. I agree with you, General, and you have a convening authority. The secretary has a convening authority other agencies do not have. Mr. Secretary.

Mr. JAMES. Yes, ma'am, I just wanted to explain quickly, he went through several uses for water, which is true, all of them are. But one that really concerns me at this point is that water supply is becoming more needed across this country, yearly, daily. And when we decide that there is this beautiful flood control reservoir, and we decide to contract more and more for water supply, that sounds good. You are taking water out of the flood control reservoir. But when you make a reservoir for water supply you have to guarantee the water is going to be there or you try to guarantee it. I don't think there is a guarantee.

But the thing of it is, that water supply water takes up room in that flood control reservoir. So that reservoir can hold less flood-

water than it could without any water supply. Those are the kind of things the general is talking about. They are going to be vicious.

And you are exactly right, ma'am, they need to be addressed now. Because out West, I was out there last fall sometime, gosh, Mr. Calvert, Congressman Calvert's left, but I was out there last fall in the Columbia area and systems and they basically have the same problem. It is just more exacerbated by the droughts they have had.

Water supply is a big deal. And, oh, by the same way, so is flood control. The same areas that need water also need to be protected when the snow and the rains come and flood their cities. And that is the way it is all over this country. There is going to have to be a real discussion about water supply and bring in all the variables to figure out what it has to be.

Ms. KAPTUR. Help me find the three brightest people in this country who think about that.

Mr. JAMES. I can't volunteer, but you can draft me.

Ms. KAPTUR. I would take both your recommendations, the committee would welcome that, on how to generalize from the specific to help the country, you know, because the mayors care about what we do, our governors care about what we do. But we have to present a more clear picture to the American people, in my opinion. Did you wish to comment from the bureau's standpoint, Dr. Petty?

Mr. PETTY. Yes, if you wouldn't mind.

Ms. KAPTUR. Dr. Petty.

Mr. PETTY. Just a quick comment on that, which is that as different agencies within this administration as well have actually tried to make an effort in our working to get together at Assistant Secretary James' level, my level, EPA, USDA, Department of Energy, and others that deal with water. Because we all have water issues, and getting on the same level of what you are asking about, of coming together and really talking literally on a monthly basis, at least with each other, on these bigger areas that we need to discuss and these topics that you were just discussing.

So, we actually look forward to maybe sometime in the future getting time with you to discuss what are those big picture priorities that really play into not only projects, but regional areas, and how technology and the science benefit those issues. Also, we are coming into this kind of new age of understanding how to incorporate these different discussions in a big picture.

So I will stop there, but looking forward to having some more interaction with the thoughts that you are having as well.

Ms. KAPTUR. Congressman Newhouse.

Mr. NEWHOUSE. Thank you, Madame Chair, and thank you, Mr. Simpson, for deferring to me first. And first of all, let me just say, Ms. Kaptur, thank you for paying attention to what I was talking about with the Odessa subarea and I look forward to working with you and your staff on trying to prevent the—a crisis from happening while we still have time to do so. So thank you for that.

And I like the way this conversation is going as well. And my question I had, I wanted to direct to Dr. Petty, had to do with the Columbia River Treaty. And there is a lot of things my constituents are concerned about, but I have got to tell you, this is one thing that I get questioned about all the time. And it has a lot to do with

exactly what Mr. James was talking about, the balance of flood control versus other needs.

And to complicate it more, we have another country involved in this. The Canadian River System is integral to how we manage the Columbia River. So I guess I have got a few ideas I would like to share with you, but I would just like to welcome—ask for you to share with me some of your ideas on the topic of the Columbia River System. I know that I am—excuse me, the Columbia River Treaty negotiations.

I know that ongoing negotiations are happening, getting to a point where getting more than just general reports there are some details starting to emerge. I know Ms. Smeal, I always butcher her name, is that—

Mr. PETTY. Yes, that's her correct name.

Mr. NEWHOUSE. Smeal. Smeal. She is going to be holding another round of town halls soon and to speak with people in my district particularly in the tri-cities area, which is an opportunity for them and we greatly appreciate that.

But I just wanted to give you an opportunity to speak a bit about the Columbia River Treaty, the progress that is being made because, like I said, this is an area of huge importance to the Pacific Northwest and of tremendous interest.

Mr. PETTY. Yes. Well, Congressman, I greatly appreciate having that opportunity. And first of all, I would like to be able to come up and actually spend some time with you and bring the negotiator from the State Department, Jill Smeal, so you are saying it correctly.

Mr. NEWHOUSE. I have met her before.

Mr. PETTY. Yes.

Mr. NEWHOUSE. And I still can't pronounce her name.

Mr. PETTY. She is working constantly on this and she has a high commitment to the staff. We actually just came up recently and met with all, both House and Senate staff, and gave an update on what is going on there. But there is a real commitment this spring to meet with all the different members of the Pacific Northwest on this topic.

The State Department is specifically in negotiations, but we want to be able to individually talk to you about kind of where we are at with the negotiator. I am specifically the designee of the Department of Interior by the secretary. I am part of her technical advisory team with Reclamation on these balances.

So, it is a balance with water demand and how to use water with Reclamation. At the same time it is the demand for the U.S. Army Corps of saying we need to move this water out of the system because we have more water coming in.

And so with that, the area that I really would love for us to be able to sit down and talk about where the technical areas are in the discussions of flood control, of hydropower, of ecosystems, as well as discussion areas working with the Canadians.

There is a good dialogue going on and being able to give you more details, I think individually, I think will be a huge help with the negotiator included in our discussions. My job is to make sure she has all the technical and knowledgeable information which both General Spellman behind me, and his team out of the Pacific

Northwest is right there with them in these discussions and we would be happy to bring you even more up to speed on the Columbia River Treaty.

Mr. NEWHOUSE. Yes, I appreciate that.

Mr. PETTY. Great.

Mr. NEWHOUSE. Look forward to it. Thank you.

Mr. PETTY. Yes, great.

Mr. NEWHOUSE. Thank you. Thank you very much. Thank you, Madame Chair and Mr. Simpson. I yield back.

Ms. KAPTUR. Thank you. Congresswoman Frankel.

Ms. FRANKEL. Thank you, Madame Chair. And thank you again for being here. So I just, I want to start by just adopting by a reference a lot of the comments of my colleague, Representative Wasserman Schultz.

I just, again, I think I commented on the disappointment of you not having any money for new starts and I just—we have been trying to dredge Port Everglades. It has been what I think she said 20 years, it is maybe 20 years we waited to even get it, get an authorization. So just in terms of the economic prosperity of south Florida and even all Florida, I am hoping that we will be able to accomplish that with a new start for Port Everglades. And I also want to just agree with her on the need for the—to move forward on the reservoir project in south Florida.

I want to talk a little bit about Everglades, not Port Everglades, which is a port, which we just commented, but Everglades, which is for Florida is the drinking water for about 8 million Floridians and visitors and very important for our economic vibrancy as well our environmental vibrancy.

And there has been a longstanding agreement between the Federal Government and the state to put a certain amount of funds in to accomplish several projects which I am—I know you are fully aware of and which have been underway.

The Florida—and this has been a very bipartisan effort. Thank goodness, there is something bipartisan in this Congress, but Republicans and Democrats are really very together on our support for Everglades restoration.

Our delegation, the state—the Florida delegation as well as I know our governor's office are requesting \$200 million for the Everglades Restoration Project. Your budget puts in \$63 million.

So my question to you is how the discrepancy in this funding would or would it—any delay in getting completed the projects that have already been authorized? Or how would it affect getting those projects completed? Someone going to answer that?

Mr. JAMES. I am thinking.

Ms. FRANKEL. It would, okay. So okay. You are thinking. So maybe I will just—I am trying to be diplomatic for you. So it would affect, and let me put it this way, it would affect the completion, the speed of the completion. Let's put it that way.

Mr. JAMES. Yes, yes, it would.

Ms. FRANKEL. It would, okay.

Mr. JAMES. It would.

Ms. FRANKEL. All right. So thank you for your honesty and for your good work. And with that I would just like to say to our chair and to the—my colleagues, that we are going to urge, I know those

of us from Florida is this \$200 million request be put into our budget because of the importance of the restoration.

And you would—I see you shaking your head. You would agree it is a very important project.

Mr. JAMES. Well, it is an important project. It is an important project to the administration. I understand the President is going down there Friday. So, I mean, like you said bipartisan, yes, probably it is a bipartisan but it is a—I have a modest home in Palm Beach Gardens and have had since 1979. So I probably don't know as much about the area as you do, but almost.

Ms. FRANKEL. Well, you do drink the water and—right? I am assuming.

Mr. JAMES. I won't answer that.

Ms. FRANKEL. Okay. Anyway, listen, thank you so much for your time. I am sorry, Madame Chair, that I have been in and out, but I do appreciate it and I yield back to you.

Ms. KAPTUR. Thank you very much. Ranking Member Simpson.

Mr. SIMPSON. Thank you. Interesting to listen to the Chairwoman's discussion on the global aspect or at least nationwide the aspect of a lot of this. And it is kind of interesting. There are 435 different districts and we all do have our parochial interests.

The one thing that I always found interesting when I became chairman and sometimes it is hard to explain this to your constituents, I care every bit as much about Lake Okeechobee and what is happening in Florida as the members from Florida. I care every bit as much about what is happening in Dallas Fort Worth as Ranking Member Granger.

I care every bit as much what is happening with carp, the Asian carp in the Mississippi as the chairwoman and members from the delegation. You have to do that as chairman of the committee. You have to expand you view of just not your local interests but the interests of the Nation and what is best in the Nation.

And frankly, that is what the Army Corps of Engineers work plan is supposed to do. And that is why I am so opposed to anybody messing with it once it has been determined by the law and our appropriation level. And I will continue to fight that fight and if you want to have a fight with OMB, I am on your side.

A couple of questions that I need answered. One, last October the President issued an executive order promoting the reliable supply of delivery of water in the West. Commissioner Burman and Dr. Petty, how has this executive order helped you implement your programs and what is the status of your effort to implement this executive order?

Mr. PETTY. Yes, Ranking Member Simpson, thank you for the question. Actually I have in my hands the memorandum that the President signed. The Pacific Northwest, Section 6 is two sentences.

Also, part of those two sentences is the idea that there would be one Federal lead. Working with each of the agencies allows—each of the agencies to work together, but what we have been able to do with the Columbia River and the biological opinion, which is specifically in that memorandum, is the ability to say amongst yourselves, choose someone who will actually be the lead, take

work and responsibility and let us move this ahead and let us get it done.

We are in round four of the biological opinion. We have been doing this for a long time. There is a lot of things that we have learned, we continue to learn, and we are going to learn into the future on how really we are to work with that river. But the whole idea in that aspect of the Pacific Northwest in those two sentences was to say let us work together.

We made the Corps of Engineers the lead. I think they are a fantastic lead. All the Federal agencies were in agreement of who that lead was going to be. And now we work with USACE, side by side, to say let us get this done. Let us get this done in a good manner that we put all of our ideas and thoughts together so that we can have an outcome, but that outcome is going to continue to develop.

I think we would all agree is once we get this one biological opinion done that doesn't mean that we are always done. Research is going to continue. We have that ability for science and technology to continue to develop and to work with those communities and states side by side on what we are trying to accomplish a good way to run the Columbia River.

So, Commissioner or even Assistant Secretary James, I am sure they can add some more thoughts into that.

Mr. JAMES. Go ahead, ma'am.

Ms. BURMAN. I just want to say the presidential memo from October, I found so exciting because it put a focus on water supply. It said we are looking at water supply reliability in the West. And when I looked back in the history, and I am sure I could have missed something, but I think John F. Kennedy was the last President who did that.

So while the memorandum does name specific projects in California, Oregon, in the Columbia Snake River system, it also talks about using our best technology, you know, using our ability to forecast, working with the Army Corps of Engineers, with NOAA, with other departments.

But it is putting a focus on making water supply reliable and that is what Reclamation does. That is what we are charged with doing and so we have seen it as very exciting as a way to really hone down to how are we going to get projects done. How are we going to move forward with our environmental compliance? How are we going to make use that water is becoming more reliable?

Mr. SIMPSON. Thank you. Secretary James, your agency is required to submit various reports to the status of executive—of executing appropriated funds. The committee needs those reports to carry out effective oversight.

I think we have had this discussion in this committee for as long as I have sat on it, which is about 18 years. Yet many of the reports are long overdue, including some that have not been submitted since fiscal year 2015. What steps are you doing to make sure that you will get these timely submission of these reports? Because oftentimes they are necessary for us to make an assessment when we are doing an appropriation.

And I guess I will just ask you, do we require too many reports? It seems like every time we do something, we say make a report, you know, every year like this and then that goes on forever.

Mr. JAMES. I wouldn't say many. I would like to get with you to pick out the ones we could eliminate. The ones you are talking about now, yes, we are behind. I discovered that about 3 months ago, didn't know it before then. And we are going to work hard to get those caught up to you just as best we can, as fast as we can.

Mr. SIMPSON. If I could, Chairwoman? Secretary James, the budget request proposes to move the Formerly Utilized Sites Remedial Action Program, or FUSRAP, from the Corps of Engineers back to DOE. And I would remind you that Congress moved FUSRAP from DOE to the Army Corps of Engineers because we weren't happy with what DOE was going.

Can you please explain the reasoning behind the budget proposal to move the program back to DOE? What guarantee would you have that DOE would implement the program better than in the past and what would be the roles and responsibility of the two agencies under this proposal?

And since DOE really doesn't do clean up, they hire contracts to do cleanup, are we going to up that program under them and then them hire you to do what you are doing now? And is that more effective?

Mr. JAMES. Yes, and I don't know.

Mr. SIMPSON. Okay.

Mr. JAMES. Yes, we are going to do that. Time will tell whether it is more effective. I think the original thought was we might actually get more funding that way than we are being allowed for funding on FUSRAP.

The other thing I really think that DOE wanted that program back and I can't answer why on that.

Mr. SIMPSON. I just find it very bizarre, when I haven't had any complaints about the program that is being run now.

Mr. JAMES. Yes, sir.

Mr. SIMPSON. How the Army Corps of Engineers is running it. You know, my dad said when something isn't broken, don't try to fix it.

Mr. JAMES. Yes, sir.

Mr. SIMPSON. And so I have some concerns. Along that same line, General Semonite, the Corps implements the Columbia River Fish Mitigation Program.

The Pacific Northwest ratepayers, including my constituents in Idaho, reimburse a substantial portion of this funding through the Bonneville Power Administration. Are you working to make sure that you are working with the BPA to make sure that the BPA ratepayers are getting the best value for the project and activities under this program? And for the hearing record, please provide a list of those projects and activities to be funded under the program for fiscal year 2020, the budget request, and please include the estimated cost and mitigation benefits for each.

General SEMONITE. Congressman, we will certainly get those projects to you. I don't think I have that list here, but, on the other hand, we certainly work very, very closely with BPA. I am convinced that one of our mandates is to be able to make sure that the ratepayers are necessarily getting the right rate.

I think we stay in the engineering lane of technical advice, and I would let BPA probably make that assessment. And whatever we

can do to be able to facilitate a good value to the taxpayers, we certainly want to do that.

Mr. SIMPSON. Thank you. And I guess one last question. As I said in my opening statement, and this is what I was getting to, the only reorganizational proposal includes transferring Corps mission areas to multiple other Federal agencies. The Corps doesn't just build single-purpose projects, the Corps also manages entire river systems for multiple purposes.

Do you think it would be more challenging for multiple agencies to be responsible for various missions within a river system? And can you please describe the kind of expertise the Corps brings to its water management responsibilities?

Mr. JAMES. I can't tell you about all of the areas that the Corps has to handle, but I can tell you that flood control and navigation has to be under one agency, that the structures in a river for navigation also contribute to the ability of that same river that do have flood control, like levees, dikes, training of the river channel itself for navigation helps past floods.

So, the bottom line is navigation and flood control has to be under the authority of one agency in my opinion.

General SEMONITE. Ranking Member Simpson, this is a system. I talk about the eight different parts of the system. Congress has authorized some projects to have all eight. Other projects might only have four or five of those authorized purposes. It is our job to be able to be the balancer of those eight, and we are accountable, and so while it might be impossible to optimize all eight variables, some do compete against each other.

As the secretary said, flood control could very easily be at odds with water supply, but we owe it to you to be able to be that honest broker to come forward and say, give us what your authority is and what you want us to do. And then we are going to be absolutely passionate about giving you the best option and the best solution within those eight variables.

I think if you were to fragment those functions into different agencies, we have a hard enough time synchronizing now among state, local, Federal, and if you take something that is going relatively well and break it apart, I would just think we have a lot more challenges. That is my personal assessment, though.

Mr. SIMPSON. Thank you. I do have one more. Your brochure that you gave us here, the picture on the front of it is the Army Corps of Civil Works' leaders visit Folsom Dam Joint Federal Project, and then it says, "By partnering with the Bureau of Reclamation, completed the project faster and more cost effectively."

Could you guys explain to me what you did to do this, to partner together? What required it? Or did you just decide this was a good idea? Because I am impressed by that. I would like to see more of it.

General SEMONITE. And we have a briefing on this, and I think we really want to come and lay it out for you, but we started out with probably a relatively risk-averse process to be able to make sure that we could get this done exactly the right way, but it would take a lot longer.

And if we ended up saying, how can we do some things concurrently versus sequentially, and as a result we shaved millions of

dollars off, and we also ended up taking probably 2 years off the overall completion.

So, it goes back to how can we maybe do things a little bit different than we have been doing them for 243 years and find a better value? Because at the end of the day the taxpayers certainly appreciate it.

I would defer to—if there is another opinion as well.

Mr. PETTY. Let me just give a little comment. Both the Commissioner and I were deputies when the USACE and DOI started this back in the early 2000s, and I think it had a lot to do with the leadership of both U.S. Army Corps of Engineers, the Department of the Interior, and the commissioner that said, “let us get this done”.

And it was, DOI sees their part, USACE sees their part. It became a very effective group and we got things done faster than we said we would and under budget, and it worked really well for the community and the State of California that was also the big partners.

It was everyone coming together and basically saying, let us do some good and let us get this done, and it was a very, very successful project. I think we could replicate that into future projects as well.

Mr. SIMPSON. Thank you, all. I would like to see more of this, and this is what we expect. So, I appreciate it. And I want to thank you all for being here. I want to thank your division commanders for being here. You are doing incredibly important work for this country, for our economy, for safety, for protection of property, and other things. And thank you for what you do.

Ms. KAPTUR. Thank you, Mr. Simpson. I wanted to put a couple of your associates on the spot, General. If either yourself or someone you wish to call up from the divisions, if you were to explain to the American people what just happened in Missouri, Nebraska, Iowa, and what is likely to happen down the road over the next several weeks with the flooding, how would you explain that to the American people?

Is there someone you can bring to the table or do you want to discuss that, General?

General SEMONITE. Ma'am, this is a great opportunity for professional development of a general officer, so I am going to bring Rick Kaiser up.

Ms. KAPTUR. All right.

General SEMONITE. Rick is our most senior division commander, and he is actually the president of the Mississippi River Commission. So whatever comes out of lakes and rivers with General Toy or General Helmlinger coming down the Mississippi, Rick is the guy who is going to receive this. So, Rick, keep it kind of short, so why don't you go ahead and step right here?

Ms. KAPTUR. And I would be interested in their professional opinion. As you watch the reporting on television about what has happened, how good do you think it is? How does it explain to the American people what is going on out there?

General KAISER. Congresswoman, it is good to see you again. I was the lakes and rivers commander, and we talked multiple times about the Maumee River.

Ms. KAPTUR. Thank you.

General KAISER. First, I would explain in a simplistic way what you have in the Mississippi Valley Division is a system called the Mississippi River and Tributaries Program, which was put together after the Great Flood of 1927. And that system simply does not exist elsewhere in the country.

The MRT System, and you heard the secretary say, we have passed a number two or number three level flood and you haven't heard much about because it was designed properly to take the waters that will inundate that part of the country. So you don't have that out, you know, in the Western portions. So, what you are seeing here is a record amount of snow and ice pack, and then huge amounts—

Ms. KAPTUR. Lodged where, sir? Lodged where? Where was the snow pack? Where did it start?

General KAISER. Well, I would defer exactly. I focus on the Mississippi Valley, but you see it in the mountain regions, the northern Dakotas, and all. So, the Western regions has record amounts of snow and ice.

Ms. KAPTUR. I haven't seen, maybe it exists, I don't know, but I saw the big chunks of ice, a picture, and I thought, so where did it come from? And where did it move? I haven't seen any good reporting on that, that that is why I am just communicating to you that we need to explain to people what is happening, and I haven't seen it meteorologically on the television.

General KAISER. Well, combine when you have record amounts of snow and ice followed by extremely heavy rain events, what it does it melts and it causes that large formation to move down the waterways, which is exactly what you have seen.

So, the systems that exist out in the Missouri Basin are not like the ones in the Lower Mississippi, and so, quite frankly, those levees were designed for lower levels of flooding on purpose. And so, as this water and ice moves down, it inundates and it overcomes those particular levees, and that is what you have seen happen, because the system wasn't designed to take the load that came its way.

If you look at the Mississippi River and Tributaries Program, that particular program has saved the American taxpayer \$80 for every dollar we have invested in it. And so we are worried, as you see on the chart, that we will have flooding later this spring. We are confident right now that the system as it is designed is going to be able to handle that. I mean, it is the simplistic version.

Ms. KAPTUR. I am not sure which chart you are talking about.

General KAISER. I think you don't have it in front of you, Chairwoman, but if you have seen the news where NOAA has predicted flooding, and I have believe you said it, that 25 percent of the country—

Ms. KAPTUR. Yes. Again, it is a piece here, a piece there, a piece there. Who has got the whole piece? Who has got it all pasted together so we can explain what just happened?

Mr. JAMES. I will pitch in just a little bit on that. Where did it come from? The Missouri River runs all the way to Montana, actually Western Montana, and so that comes to some very cold country, North and South Dakotas, and till it gets down to Nebraska,

and then into Iowa and Missouri. So, as the temperatures warm the snow melts, the ice breaks loose and it starts down this river, and it causes flooding because it causes ice jams in certain areas that holds back the water.

Then, oh, by the way, what has happened? This year it rained at the same time in that area, in that area, that entire Midwest area, to contribute to that ice flooding which really hasn't hit yet.

The snow melt and ice flooding hasn't really hit yet. It is coming, but that is why they say the flood is not over. So most of this flood was from rainfall.

So that comes down and it hits the Mississippi River at St. Louis, then the Mississippi River flows from Lake Itasca, Minnesota, down to Cairo, Illinois. The Iowa River comes in at Cairo, Illinois, and joins the big river for the MRT Project starts from Cairo to the Gulf of Mexico. And that is now.

I will tell you this. As bad as the Missouri River is flooding, that flow is only about 30 percent of what the Iowa River flow can be during a flood. So when it comes past Cairo, Illinois, into the Mainland Mississippi River, the Lower Mississippi, there is about 30 percent coming out of the Upper Miss and the Missouri, and 70 percent out of Ohio.

Ms. KAPTUR. They need to get you on TV, Mr. Secretary. It is the most complete explanation I have heard. How many people in the room would agree with me?

Mr. JAMES. Ma'am, I lived that for 37 years. I want to be able to—maybe that will make up for some of the things I didn't explain today. How is that?

Mr. SIMPSON. Madam Chairwoman?

Ms. KAPTUR. Yes.

Mr. SIMPSON. Would it be accurate to say, just like droughts, we can't really control those, but we can mitigate them by storage and other types of things? No matter what we do, we are never going to be able to control every flood that happens. Sometimes there is just too damn much water, but we have mitigated the effects of those to some degree, and some of them are going to be worse than others, and we have prevented flooding by the projects that we have had in some cases. So, you know, we are not going to be able to fix everything.

General SEMONITE. And so the other important point, we know where there are certain areas we can't mitigate, and people are still at risk. So then how do they get informed? How do local authorities know when to make an early call, the time to evacuate, all that? So it is not just structural things, it is how you make sure you have the other systems in place so that people that could be in harm's way, get out of there.

Mr. SIMPSON. And along that line, when you do your work plan, you have to take into consideration those things, and what is the effects of the 500-year or 100-year flood versus the more immediate effects of something breaking. Those are the things you take into effect when you do a work plan?

General SEMONITE. We definitely do, sir.

Ms. KAPTUR. And as you look at the damage that has occurred, what does it instruct you about the current way in which that part of the United States is retrofitted against flooding?

General SEMONITE. So, there is a lot of questions now, ma'am, about how did we run this back in 1937 and/or there is a certain way the river was able to meander, but then an inability to be able to foster more economic value we actually constrained and the river couldn't move quite as wide as it used to. So, we put it into a nice, neat channel with great big levees, and everybody had farmland on the side.

If you look at this picture right here, 1934, that is what the river looks like. This is the Missouri River, and it might be hard to see, but look down in the lower left, that is the width of the river. And notice how the river kind of goes back and forth, and I don't know exactly what that is, but that might be 2 or 3 miles wide.

Then in 1977, through a lot of different guidance from the administration, and through Congress and through us, we said, let us discipline that. And if you look at those vertical things, those are actually like wooden poles that were put down in through the fields. And what happens is when the water comes through that area, it slows down, the silt drops, and that is beautiful farmland. Those great, big, beautiful green areas right there are massive farmlands, a lot of wheat, it is one of the best places to farm, apparently, in America.

So the problem then is that at some given point, are we taking care of the habitat? The problem here is that there was a decision that was administered that the pallid sturgeon didn't do very well in that picture on the right. There was nowhere where they could off ramp.

Think about an interstate where you can pull off on a rest area. So we are instructed to go back into that area and make certain shoots I will call them. So a sturgeon could go into those areas and rest and be able to, you know, continue to increase the habitat.

So this goes back to this balance. And initially you might have something that is very, very good for the river, but then we want to take care of the economy and then we take care of the sturgeon, and then where is that place where it is the optimal solution?

And maybe some of that change is based on social norms and culture because every single day, things are continuing to change. But this goes back to right now, where we look in this to say, what is that right balance? And how do we make sure that we are doing the right thing for the best interest of those variables?

And I would say that the most important has to be life safety. We are worried about the economy, we are worried about habitat, but we can never put people in harm's way because those other things are perceived to be more important.

Ms. KAPTUR. It is very interesting you mentioned sturgeon because we are just trying to restore them to Lake Erie right now. There is a big project underway. And I thank you. That is very, very interesting.

Mr. SIMPSON. I didn't know we had sturgeon rest areas.

Ms. KAPTUR. It is amazing what you find out when you dig deep, right? But I wanted to mention to the secretary and general, as you are well aware, it is critical to the health of the Great Lakes that we keep invasive Asian bighead carp out of the lakes, if they get into the lakes they will ruin fisheries that are worth billions of dollars. Lake Erie alone is over \$7 billion annually, and supports over

75,000 jobs. So, this is a very massive challenge to us in our region, and I have a deep concern we aren't moving quickly enough. And that is why, I along with many of my Great Lakes colleagues, I am anxiously awaiting the release of the Corps' Brandon Road Chief's Report.

I have three questions. When must the chief's report be issued in order for Brandon Road to be eligible for Corps 2020 work plan funding for preconstruction engineering and design?

Secondly, the chief's report should include a recommendation that includes a robust suite of measures to effectively counter Asian carp at Brandon Road. Can you please update the subcommittee on the status of the Chief's Report?

And thirdly, it is particularly important that the final report narrow the contingency currently at 66 percent, and potentially raising the proposed costs by hundreds of millions of dollars.

The Corps must also communicate closely with Illinois as your non-Federal partner about its letter of intent and sponsorship of the project. We need a report that can push the project forward after the chief's report is issued. I would like your commitment that you will brief Congress and the Great Lakes Task Force on next steps.

And I might say, parenthetically, I am concerned that in 2019, the administration chose not to fund the Corps' work with the Interagency Task Force and stakeholders to keep the carp out of the Great Lakes. The budget request, again, does not include the funding for the Corps involvement in this, and can you commit that you will work to ensure funding in the FY 2020 work plan?

General SEMONITE. Just real fast. We are on track right now to sign the chief's report in April 2019, so in the next 45 days. You have a very, very good point, though, that we normally need a non-Federal sponsor and we have seen change in attitude in the State of Illinois, where we want to try to bring them on board.

So I think it is good that we use some degree of strategic patience, and I have directed General Kaiser, who was just testifying here, to go see the Governor of Illinois. There are three things he has got to do. We have got to, first of all, make sure that we can find a way that Illinois is going to be a non-Federal sponsor. We have got to work a little bit. There is a thing we have got to do with the financial viability. They have got to be able to make sure that they have got the financial assets to do it.

And there is also some policy things we have got to work out, but once we get Illinois on as a non-Federal sponsor, we want to sign that chief's report, posture it. We don't see a problem right now with a 2020 budget as far as being eligible, because I think enough time to stay on track and continue to be aggressive. Even if we are delayed for a month or two, I still think we will be postured to be able to come back in to 2020.

I would think personally, and our recommendation, back to Mr. James, is that the ability to secure funding in the 2020 work plan for whatever we need to do for pre-engineering and design would compete very, very favorably. Because we all know how important this is, and we have seen a lot of momentum in the last 3 or 4 months by everybody to say, let us get together, let us find a way of being able to get to where we can make this thing happen.

So, there is probably some other things that you might have asked that I didn't touch, but we are working hard on the non-Federal sponsor, we are working hard on PED, we are working hard on ways to figure out a way to diminish these populations. Other places in the country have been able to remediate, get rid of the critters.

Mr. JAMES. Put a bounty on them.

Ms. KAPTUR. Yes, put a bounty on them and we really—well, any observations you have on that from your experience in other parts of the country would be very valuable to us, though that is not directly your job. Right now, fishing, wildlife is contracting to do this with the Great Lakes Restoration Initiative.

Mr. JAMES. I am sure there are scientists that know a lot more about this than I do, but they claim that below the electric barrier that is in the system now preventing the fish from going up, not to New Brandon Road, but the one that is in there now, just below it, they are doing that extreme fishing or whatever you call it and they are giving it a lot of credit for the fish having not moved upward. So I—that is not scientific. That is what I have been told.

Ms. KAPTUR. Yes.

Mr. JAMES. If I could, Chairwoman, just real quickly. I know the Department of Interior and with some of my notes, we have got in our budget \$107 million on invasives and that is over with USGS, which is also under my purview. We are doing a lot of work in this area with Asian carp and some of the other specific carp family components that are up in there. There is this EDNA that I think you have had some interaction with as well of what USGS is doing, working side-by-side with Fish & Wildlife Service and in other parts of these agencies as a critical part of trying to help you solve that Asian carp problem.

Ms. KAPTUR. I just think that with the folks that exist down at the bottom of the Mississippi River since they are raising a lot of catfish, why can they not find an economic use for these things and start fishing them out down there as well, so we sort of take it from the bottom and the top? Do you want to comment, Mr. Secretary?

Mr. JAMES. Yes, ma'am, that is where they came from.

Ms. KAPTUR. I know. That is why—I know and so I am saying, if there is an economic use, let them pay attention.

Mr. JAMES. You know, China has had several different facilities over here trying to capture them, clean them, and send them back, but there is one close to my hometown back in Missouri. For some reason, it is just not working out. And surely, it is economics. I think they are well liked in China from what I understand, so.

Ms. KAPTUR. I have never understood that either, Mr. Secretary, why we cannot move the market faster.

Mr. JAMES. They are very prolific. They just—they take over.

Ms. KAPTUR. Thank you. I will have to speak for the Soo Locks and my region of the country. Assistant Secretary James, the request proposes a sizeable investment in the construction of this new Soo. The general has talked about that as well and I know, Mr. Secretary, that you have visited the Soo Locks and you are well aware of the national security importance of the system. Could

you provide us with an update on the status of the new Soo Locks constructions?

And I just want to say, your commitment in the 2020 budget is a huge victory for the economic vitality of our region. Other members have spoken of it as well and I would appreciate any comments you wish to make to update us on this really vital project for our area and any roadblocks you might anticipate.

Mr. JAMES. Yes, Chairwoman. I will ask General Semonite to follow me up on details, but I can tell you, it is total commitment to Soo Locks. I hope the funding comes as fast as I wish it to in future years. And I think it will due to the strategic nature of those locks and the strategic nature of what comes through those locks. So, I think it is going to be a good luck story. It is like all the other things we do. If we just put enough money to it, to do it, it costs half as much. I mean, really, put the money to it, to what the General can actually execute, and keep moving forward is my hope. General, can you—

General SEMONITE. Yeah, just a quick update, ma'am. So we put about \$32 million of fiscal year 2019 work plan into that. Michigan matched; they put about \$52 million. So that is around 74 and the design is going on right now. Obviously, in the '20 budget, there is 75.3, so we think that there is adequate funding right now to keep up on schedule. And just to be able to give you a couple of deliverables, we are right now getting ready to award the Upstream Channel Deepening Contract. That will address the full scope of the required work. We are also working the design of the approach walls and then we will restart the design in the new lock chambers.

So, in other words, there are several different parts to this. We are taking it chunk-by-chunk, just as I talked about on Chickamauga. What were the logical type increments we can do, build it into the work plan to supplement the President's budget, and be able to continue to keep this thing moving. But this has got dramatic ramifications to our country if this thing ever went down. The Department of Defense is worried about this. So, we are very pleased to see this in the administration's budget and whatever we can do through the work plan to continue to keep this on track, we want to be very aggressive here.

Ms. KAPTUR. Thank you for your cooperation in this regard. The entire Steel Caucus, a bipartisan caucus, met this morning with several of the companies and so forth. There is a major hearing here and this is all part of America's story. So, thank you very, very much.

I wanted to go back and just have you reiterate with additional facts. If, in fact, the administration's budget as proposed were to decrease funding for both the Corps and the Bureau, what would you do? How would you—what would you have to do with your projects? What pain would that cause you inside of your respective agencies? How would—General Semonite, a recent press report stated that you said the budget then would be enough to fund the agency's day-to-day operations, but what would be the impact on the Corps' projects if it were—and Assistant Secretary Petty or Commissioner Burman, what programs and activities would not be funded if your budget were cut by a third?

General SEMONITE. So, ma'am, there is a minimum C-O-R-E amount of work that has to be able to happen just to be able to keep things operational, to keep hydro going. We need guys on the hydroplants, the locks, and dams. All this stuff to be able to keep America moving, keep like 90 percent of all of our goods coming through this inland navigation system. The things that we would not do is those that maybe we could end up delaying.

So, I hate to say Everglades restoration, but if we had to take a knee there for a while, if we had to do less ecosystem, if there is some other thing we are going to start and put on hold, I think also, the backlog would get bigger. There are things that we would end up putting, just as the secretary said, put some more bailing wire on it and hold it for a little bit longer.

Mr. SIMPSON. If I could, Madam Chair, I was going to ask this question. If this budget request is approved as is, your backlog maintenance goes up, the 98 billion, most likely.

General SEMONITE. I would personally say yes.

Mr. SIMPSON. Does the backlog of the Army—of the Bureau of Reclamation go up with a 38 percent cut to their budget?

Mr. PETTY. Yes, it would have that longer term consequence that would affect our programs as well.

Mr. SIMPSON. So, all we are doing is putting stuff off and risking things.

Ms. KAPTUR. All right, I just wanted to say to those who have traveled a great distance to be here today in the audience and obviously, to our witnesses, thank you so very, very much for the effort you made to be here today. We really have a good subcommittee and we work on a bipartisan basis. This is the way the country is supposed to work. So, no national presses here. They are off somewhere else, right.

But everything you do really matters to the people of this country and to our future and you deserve more play. I am trying to figure out a way to do that, to elevate you more, and to explain to people in ways they can understand why what you do is so important, so some of the graphics we have asked for, some of the mapping, some of the additional documentation so that the public can grasp something really complicated. We have someone to my right and to your left here, the ranking member who is at a real profession before coming here to Congress and is very technically and highly scientifically trained. You have members of this subcommittee who come from phenomenal backgrounds. This does not happen all the time. Yours truly spent many, many years of her life as a city and land planner and a regional planner. So, the questions we ask, some reflect our own view of the world and we believe we are in a position to really help the country by working together. So, we have pushed you a little bit today on asking for ways we can help inform our colleagues as well as the country, and I hope that you think about some of what we have requested and help us help the country.

Whoops, this tells me that I have to be quiet. I will call right back. So, I just want to thank you very much for being here today. Our hearing will conclude. I want to thank everyone who has joined us and ask the witnesses to record the questions for our record and any supporting information requested by the sub-

committee are delivered in final form to us no later than 3 weeks from the time you receive them. And members who have additional questions for the record, will have until the close of business on Friday to provide them to the subcommittee office.

The hearing is adjourned, thank you all.

[Questions and answers submitted for the record follow:]

QUESTIONS FOR THE RECORD
SUBCOMMITTEE ON ENERGY AND WATER DEVELOPMENT
U.S. HOUSE COMMITTEE ON APPROPRIATIONS

**Hearing on U.S. Army Corps of Engineers and
The Bureau of Reclamation FY 2020 Budget Request
Wednesday, March 27, 2019**

Subcommittee Questions

1. Dam safety

The Administration and the Subcommittee have both recognized the most critical dam safety projects as being very high priorities for funding. In past hearings, the Corps has projected that funding requirements for dam safety needs would continue to grow, as our infrastructure continues to age, as we continue to refine our understanding of risks, and as design standards continue to evolve.

- In general, what are the current projections for future funding requirements for the Corps?

Response: The Corps develops a funding recommendation for the dam safety program each year. We develop estimates of future funding capabilities for ongoing projects, but not for the program as a whole.

- Does the fiscal year 2020 budget request include the maximum funding levels that can be obligated within the fiscal year for all DSAC-I dams? If not, why not?

Response: The Budget funds ongoing work at these dams each year based on the Corps capability estimate of what it is able to use, effectively and efficiently, for that work.

2. Construction Backlog

Current estimates place the backlog of authorized Corps' Construction projects at approximately \$98 billion. This creates uncertainty for non-federal sponsors, increases project costs, and causes delays.

- Can you please describe any impacts that this backlog may have on the overall ability of the Corps to accomplish its missions?

Response: The \$98 billion is not a current estimate and does not represent the cost to complete active projects.

The Corps has three main missions: flood and storm damage reduction; commercial navigation; and aquatic ecosystem restoration. Within these areas, the Budget seeks to focus the Federal investment where it is most warranted.

The construction "backlog" is a compilation of potential work on projects that the Congress has authorized for construction. The goal of the Corps construction program is to produce as much value as possible for the Nation within the three main missions from the available funds. The Budget funds the projects that will best advance that goal, by addressing the most significant risks to public safety, or providing a high economic or environmental return to the Nation.

- What plans do you have to address this backlog?

Response: The Corps seeks to construct those projects that provide the highest return to the Nation. In addition, the Corps is working to implement alternative delivery mechanisms, such as non-federal implementation of projects under Section 1043 of the Water Resources Reform Development Act of 2014, as amended, and Innovative Funding Partnerships that non-Federal entities can employ to reduce costs or implement the projects on their own, thereby reducing or removing them from the backlog. Since the construction backlog is defined as the total federal cost share of the balance to complete construction of authorized water resource projects and includes the federal share of projects that have never been funded, continuing to identify projects eligible for deauthorization on an annual basis as required by Section 1001(b)(2) of the Water Resources Development Act of 1986

will assist in reducing the construction backlog. Finally, the Army is tracking construction projects in two categories – projects that are under active construction and those that have never been funded. This tracking will provide transparency on the cost to complete projects that are actively being constructed and those projects that have never been started.

3. Operations and Maintenance Backlog

It is evident that reliable funding for the operation and maintenance of our aging infrastructure is vital to our economic competitiveness and national security. Further, it is clear that as our nation's water resources infrastructure ages and crumbles, the demand placed on the Corps' Operation and Maintenance account grows and we struggle to meet the needs of a 21st century economy.

- Can you please describe the status of the current backlog of Corps' operations and maintenance projects?

Response: Overall, the level of unfunded maintenance work has been decreasing. The Corps does not keep track of a backlog of maintenance work as such on an ongoing basis, and would not fund the operation and maintenance program on that basis. The Budget funds the Corps operation and maintenance program each year based on the Assistant Secretary of the Army for Civil Works (ASA-CW) assessment of the priority work of the civil works program for that year.

- What plans does the Corps have to address this backlog?

Response: The Budget funds all priority operation and maintenance work each year. In developing those funding priorities, the ASA-CW considers all of the potential work that its project managers identify, and sets priorities using performance-based metrics and risk-based analysis.

At the funding levels provided in the Budget, the Corps is able to operate and maintain the projects that it owns and operates. It also is able to invest in maintenance work to improve the reliability of key infrastructure including the navigation channels that serve the Nation's largest ports and the inland waterways with the most commercial use.

4. February 2018 supplemental funding

In February 2018, just over \$17 billion was appropriated to the Corps in response to Hurricanes Harvey, Irma, Maria, and other flood-related disasters. Of that amount, approximately \$1.8 billion was to repair damages to existing projects.

- General Semonite, can you please describe the status of work to be accomplished with this repair funding?

Response: Public Law 115-123 provided \$1.788 billion for such work, consisting of \$608 million in the Operation and Maintenance (O&M) account, \$810 million in the Flood Control and Coastal Emergencies (FCCE) account, and \$370 million in the Mississippi River and Tributaries (MR&T) account. The Corps is using the O&M and MR&T funds to repair damages caused by recent floods to projects owned and operated by the Corps, and to dredge sediment deposited by those floods in navigation channels. It is using the FCCE funds to support ongoing emergency operations, repair damage caused by recent floods to eligible non-federal projects, prepare for future flood, hurricane, and other natural disasters, and support future emergency operations.

Against the advice of this Subcommittee, the Administration posted a list of project damages eligible for supplemental funding. Many local sponsors viewed the list as a promise of immediate funding. We have had more storms and more project damages since the 2018 supplemental, however. The Corps – consistent with longstanding practice – incorporated the new damages based on relative priority, which means some of the original projects must wait for funding.

- Has this situation prompted the Administration to re-evaluate the idea of posting lists of project damages following enactment of supplemental appropriations?

Response: No. The Army published these lists to provide transparency and improve accountability over the use of these public funds.

An additional \$15 billion was provided to advance new studies and new construction to protect against future storms.

- Can you please describe how the Corps has implemented this portion of the supplemental?

Response: The Corps has allocated funds to many of the studies and projects identified as recipients of the supplemental funding. The Corps conducts monthly updates with senior leadership to track status and delivery target dates. The remaining funds needed to complete each study and project will be allocated on an as-needed basis. Feasibility cost sharing agreements have been executed for all feasibility studies that required a new agreement. In line with the current execution schedules for funded construction projects, planning, engineering and design activities are underway, along with the NFS real estate acquisitions. The award of contract actions will be heavy during the years 2019-2021. The current projected forecast for construction complete activities is 94% completion in the year 2024.

- How have you integrated decisions about use of the supplemental funds with decisions about the work plan funds this year and this budget request?

Response: Army has committed to completing all studies and projects that are receiving the 2018 supplemental funds using those funds. Some funds were not allocated to specific studies or projects in order to provide for additional contingency in order to meet that commitment. Therefore, there is currently no expectation that future funding will be needed in a work plan and none of the subject studies and projects were included in the FY 2020 Budget. The Army considered the supplemental funds when formulating the FY 2020 Budget.

- How will you keep this Committee and the public informed of your decisions and activities to implement this portion of the supplemental?

Response: The ASA-CW is committed to keeping the Congress and the public informed of how it is spending these funds. The Corps continues to post information on the Emergency Supplemental program on the Corp's public website (www.usace.army.mil) in the 'Most Requested' section. The link includes Policy Guidance, Project Names, Geographic Locations, Current Working Estimates and Scheduled Industry Day / Outreach Events. New solicitations and other contracting related actions can be found at FedBizOpps (www.fbo.gov).

5. Transfer of Formerly Utilized Sites Remedial Action Program

The proposal includes a request to move the Formerly Utilized Sites Remedial Action Program (FUSRAP) from the Corps of Engineers to the Department of Energy. The request within DOE for FUSRAP for \$141 million, a decrease of \$9 million from FY 2019 enacted levels. As you're aware, the FUSRAP program was created by Congress in FY 1998 and specifically directed the Corps to take over the cleanup of these sites due to the perceived deficiencies in the Department of Energy's work.

- Can you please explain to us the rationale for moving the FUSRAP program from the Corps to DOE?

Response: This proposal would improve the execution of the FUSRAP program, and builds upon the existing relationship between the Department of Energy's Office of Legacy Management (DOELM) and the U.S. Army Corps of Engineers (Corps).

DOE established this program in 1974 to clean up non-federally owned properties with radiological contamination resulting from Manhattan Engineering District or Atomic Energy Commission activities. DOE was responsible for the program until FY 1998, when the Congress started to fund administration and execution of the cleanup of these sites to the Corps. However, DOE remains responsible for the disposition of these properties and for identifying additional sites for cleanup. A 1999 interagency Memorandum of Understanding (MOU) defines the respective roles of the two agencies in implementing the current program. The DOELM program manages DOE's responsibilities under this MOU.

The Budget's proposal would consolidate responsibility for the entire program (identifying sites, cleanup, and disposition) in DOE, by transferring responsibility for the administration and execution of the cleanup activities back to DOE. Going forward, the Corps would use its prior year balances and would then continue to provide construction management for the cleanup activities on a reimbursable basis.

Consolidating this cleanup program under a single agency, as proposed in the Budget, will facilitate more efficient cleanup of sites by allowing the DOE to consider the full range of cleanup responsibilities in prioritizing work each fiscal year. Consolidation in DOE would also reduce the costs of

activities now undertaken by both agencies, such as budget administration, records and data management, real property, and public affairs. It would also simplify the current site transfer return process, including for the long-term surveillance and maintenance of completed sites.

6. \$300 Million Request for Section 1043 and Innovative Funding Partnerships

The fiscal year 2020 budget request includes two new items: A \$150 million request for “Innovative Funding Partnerships” and a \$150 million request to fund projects authorized under Section 1043 of the Water Resources Development Act.

- What are the Corps’ plans for selecting projects to be funded under these lines?

Response: The authority to commence a Section 1043(b) pilot project terminates June 10, 2019. If Congress extends the authorization for Section 1043(b), further guidance will be issued detailing specific selection criteria. In furtherance of the purposes of Section 1043 pilot program, the selection criteria will include economic justification, readiness, the non-Federal interests’ technical and financial capability, and the potential to realize cost savings or project delivery efficiencies through non-federal implementation.

- Section 1043 is a relatively new authority. Has the Corps of Engineers released implementation guidance for the section? How does the Corps plan to provide oversight and accountability of funds used under this authority?

Response: The implementation guidance for WRRDA 2014 Section 1043(b) is under development. Section 1043(b) provides that all laws and regulations that would apply to the Secretary, if the Secretary were carrying out the project, shall apply to a non-federal interest carrying out the project. The non-Federal interest is responsible for the oversight of activities undertaken to design and construct the project or separable element and must monitor its activities to assure compliance with applicable Federal laws and requirements. Section 1043(b) requires regular reporting to monitor and audit each project to ensure that construction activities are carried out in compliance with approved plans. Accordingly, the Corps will require non-Federal interest to submit progress reports on a monthly basis, to include

documentation of onsite technical inspections and certified completion of construction data. Additionally, the non-Federal interest will be required to provide financial reports on a monthly basis in accordance with 2 CFR 200.327 using Standard Form 425.

7. Hydropower Manufacturing

As the largest provider of hydroelectric power in the nation, the Corps can have a significant impact on the domestic manufacturing sector.

- What percentage of the Corps' hydropower manufacturing needs currently are sourced domestically?

Response: We do not track that information. However, the Corps does follow the applicable requirements, in law and regulation, including the Federal Acquisition Regulation that address domestic sourcing considerations in Federal contracting.

- Does the Corps have or follow any guidelines or restrictions on foreign-sourced components for strategic grid assets?

Response: The Corps' Hydropower Program follows all applicable clauses of the Federal Acquisition Regulation, National Electric Reliability Corporation (NERC) Critical Infrastructure Protection (CIP), and DOD Cyber requirements when evaluating and operating components related to hydroelectric power generation.

- To what extent is proven experience considered when making awards for fish passage projects?

Response: Proven past experience is typically considered when making acquisition awards of this type. However, the weight of consideration given to this experience will vary depending on the type of acquisition strategy employed.

Congressman Calvert

1. Question to Hon. R.D. James and Lt. Gen. Semonite

The Committee has been made aware that the closure to traffic on the Tennessee-Tombigbee Waterway could continue for more than a month. It has been brought to our attention that one customer has 10 barges waiting to be delivered to a multi-billion dollar project which is linked to more than 4000 jobs. While we appreciate the Corps is mobilizing resources next week to cut a pilot channel, I hope that you will keep the Committee apprised of your progress.

Question: Can you provide an estimated date when traffic will resume?

Response. The Tennessee-Tombigbee Waterway navigation project is expected to re-open to commercial traffic in late May 2019.

Congressman Fleischmann

1. Closure of Traffic on the Tennessee-Tombigbee Waterway

Question: Hon. James/Gen. Semonite, the Committee has been made aware that the closure to traffic on the Tennessee-Tombigbee Waterway could continue for more than a month. It has been brought to our attention that one customer has 10 barges waiting to be delivered to a multi-billion dollar project which is linked to more than 4000 jobs. While we appreciate the Corps is mobilizing resources next week to cut a pilot channel, I hope that you will keep the Committee apprised of your progress. Can you provide an estimated date when traffic will resume?

Response. The Tennessee-Tombigbee Waterway navigation project is expected to re-open to commercial traffic in late May 2019.

WEDNESDAY, APRIL 3, 2019.

DEPARTMENT OF ENERGY—SCIENCE, ENERGY, AND ENVIRONMENTAL MANAGEMENT PROGRAMS

WITNESSES

PAUL DABBAR, UNDER SECRETARY FOR SCIENCE, U.S. DEPARTMENT OF ENERGY

MARK MENEZES, UNDER SECRETARY FOR ENERGY, U.S. DEPARTMENT OF ENERGY

Ms. KAPTUR. The subcommittee will come to order. And we thank our guests and our witnesses for waiting for us. We apologize. We do not control the floor schedule.

As we begin our hearing on the Department of Energy's fiscal year 2020 budget with respect to energy, science, and nuclear clean-up programs, all are vital priorities for our Nation.

Thank you to both under secretaries, Mr. Menezes and Mr. Dabbar, for being here. And thank you for waiting for us.

The Department of Energy addresses our Nation's most pressing energy, environmental, and nuclear security challenges through transformative science and technology. But the Trump administration's budget request drastically reduces or eliminates the very programs necessary for the Department to pursue and achieve its mission.

The Department of Energy's budget request is 11 percent below last year's levels, with most cuts in the nondefense side of the Department. In fact, nondefense programs relating mostly to the innovation programs that create new technology innovation are cut by 37 percent, while defense programs are increased by 4 percent.

As I said last week at our hearing with Secretary Perry, this request is riddled with wrongheaded proposals. First of all, Energy Efficiency and Renewable Energy funding is cut by 86 percent.

EERE's research over the last nearly four decades has invented the future. I have seen it with my own eyes. It has driven down the costs of clean energy technologies that save consumers money and reduce carbon pollution, and move America into a new era of the 21st century.

For example, since 2008, the cost of wind energy has dropped by 75 percent, electric vehicle batteries by 79 percent, and we are not finished yet; and LED light bulbs by 94 percent.

Further, this budget, yet again, eliminates the Weatherization Program, which has a direct, positive impact on the lives and pocketbooks of Americans, particularly elderly and low-income Americans, at a time when one in five households have had to forego necessities to pay energy bills.

The Weatherization Program saves average citizens, our tax-payers, hundreds of dollars per home annually. Since these Ameri-

cans pay the bills, it seems to me they deserve some additional recognition.

Funding for the Office of Science, the Nation's largest Federal supporter of basic research in the physical sciences, is cut by over \$1 billion. That is a lot.

These programs invest in foundational science to address our Nation's needs, promote scientific discovery, and develop 21st century tools. In fact, this research has yielded over 100 Nobel Prizes. Let me repeat that. That research has yielded over 100 Nobel Prizes.

And its researchers have made key scientific advances ranging from solar energy and batteries to inventing new materials, to decoding DNA. And as the Secretary affirmed about a week ago in testimony before the committee, has even taken us into the far recesses of neurology, and using light science to help us heal the human brain. Those all are wows, historically speaking.

Finally, this request cuts Environmental Management by over \$700 million, and thus fails to meet our moral and legal obligation to clean up the nuclear legacy of nuclear weapons production and government research.

In addition to opposing these destructive cuts, I want to be clear that we will not support the use of budget gimmicks, in this case, the use of prior-year balances to fund future projects.

Last week we heard from Secretary Perry, who repeatedly committed to executing congressional intent as directed. This means the Department of Energy must continue to execute in dollars appropriately and expeditiously, and this subcommittee will be closely monitoring that implementation.

The energy future of our country depends on DOE's vital investments to solve our toughest energy challenges, and the President's budget request harms America's energy future, our competitiveness, our consumers, and our economy.

The Trump budget also falls short in meeting our obligations to the communities that have sacrificed and still bear the brunt of costs borne from winning World War II. We are still cleaning up after World War II.

With that, I will close my remarks. Thank you, Mr. Menezes and Mr. Dabbar, for being here today. We look forward to discussing the Department's budget request and adapting it accordingly.

And I would like to turn to our ranking member, Mr. Simpson, for his opening remarks.

Mr. SIMPSON. Thank you, Chairwoman Kaptur. I would like to join you in welcoming our witnesses to today's hearing. I look forward to hearing from them about the priorities included in the fiscal year 2020 budget request from the Department of Energy programs, including Nuclear Energy, the Office of Science, and Environmental Management Program.

As I mentioned at last week's hearing with Secretary Perry, the budget request for many of the programs we will discuss today are not as robust as most of us on this committee would prefer. But we must remember, however, that the DOE proposal is in context of the President's request that adheres to the current law budget caps for nondefense discretionary spending. Congress passed and the President signed that law that led to the budget caps, so if we want to change it, we will need to work together once again to craft

a new budget deal that Congress can pass and the President will sign.

I know the Budget Committee is meeting this afternoon to discuss a proposal to change the caps, but until there is a final bipartisan deal, we will not have the certainty.

Previous Department of Energy investments in basic science research and research into improving existing energy technologies and developing new energy technologies have provided a great deal of benefit to our Nation's economy, national security, and to the everyday lives of our constituents.

The Federal Government also has a responsibility to clean up five decades of nuclear weapons development and production, and to proceed with a permanent repository for commercial spent nuclear fuel.

I am pleased that the administration continues to propose funding for Yucca Mountain. It is the law of the land and I continue to support efforts to restart this stalled effort.

Under Secretary Menezes and Secretary Dabbar, I appreciate you both being here today to explain your budget request. I look forward to hearing more about the administration's priorities in these areas.

And Chairwoman Kaptur, I want you to notice that today I am silencing my phone, so that my dog will quit calling us in the middle of a hearing. So, I appreciate that.

Chairwoman, I yield back to you.

Ms. KAPTUR. Ranking Member Simpson, we like to hear from that dog. It lightens up our hearings a little bit here.

Thank you, Mr. Simpson, very much.

And we will turn to our witnesses, Under Secretary Mark Menezes and Under Secretary Paul Dabbar.

Under Secretary of Energy Mark Menezes serves as the Department's principal advisor on energy policy and a wide range of existing and emerging energy technologies. And prior to confirmation as under secretary for energy, Mr. Menezes was an executive with Berkshire Hathaway Energy, and was a partner at Hunton & Williams law firm.

Under Secretary for Science Paul Dabbar serves as the Department's principal advisor on fundamental energy research, energy technologies, and science. Prior to confirmation as under secretary for science, Mr. Dabbar worked in operations, finance, and strategy roles in the energy sector, including as managing director at JPMorgan. He has also served our country as a nuclear submarine officer.

Thank you for taking the time to be here today. And, without objection, your written statements will be entered into the record. And please feel free to summarize your remarks, if you wish, in about 5 minutes.

Mr. Menezes, please proceed.

Mr. MENEZES. Chairwoman Kaptur, Ranking Member Simpson, members of the committee, it is an honor to appear before you here today to discuss the President's fiscal year 2020 budget request for the Department of Energy's Applied Energy Programs.

Accompanying me here are my, really, entire office is here, and I would like to just briefly introduce them. I have made them available so that they can hear your questions and concerns.

To my far right is Assistant Secretary Karen Evans, she runs our Office of Cybersecurity, Energy, Security, and Emergency Response; Principal Deputy Assistant Ed McGinnis for Nuclear Office; we have Assistant Secretary Dan Simmons for the Office of Energy, Efficiency and Renewable Energy; Assistant Secretary Steve Winberg runs our Office of Fossil Energy; and Assistant Secretary Bruce Walker runs our Office of Electricity.

So, I have asked them to join me. When I was chief counsel on the Authorizing Committee of House Energy and Commerce years ago, I often had the struggle with getting DOE to get witnesses, and I made a pledge that would not occur while I was over at DOE, so that you have our full panoply here of assistant secretaries.

We are awaiting the confirmation by that other body of Dr. Rita Baranwal, our assistant secretary for nuclear. And although Ed has done a wonderful job, if you could ever talk to your colleagues over there from time to time, we would appreciate the suggestion.

Protecting our energy infrastructure from cyber and other attacks, encouraging domestic energy production, advancing nuclear energy, supporting renewable energy in progress, in storage, protecting our Nation's grid, and of course empowering our DOE experts in our national laboratories, especially regarding early stage R&D, these were the key commitments in the President's fiscal year 2020 budget request. Our 17 national laboratories drive our goals and progress. I have visited a number of them, and have witnessed their incredible work.

This budget proposes a \$2.5 billion funding level that will support R&D activities that will help scientists and engineers in these great labs develop technologies that America's entrepreneurs and businesses can convert into applications and products that can help us overcome our great challenges while improving the lives and security of all Americans.

Turning to the Office of Cybersecurity, Energy Security, and Emergency Response, which goes by the acronym of CESER, one of our greatest challenges is the evolving danger of cyber and other threats, both natural and manmade. Our concern is reflected in the almost \$37 million increase from the fiscal year 2019 enacted, which will support the Department's efforts to secure U.S. energy infrastructure as the electric grid evolves and becomes more flexible and modern.

CESER is the lead office for DOE's responsibilities for energy support function under the National Response Framework, and is the sector-specific agency for cybersecurity for the energy sector under the FAST Act.

Turning to the Office of Electricity, this office leads the Department's efforts on modernizing our electricity delivery infrastructure and consumer access to affordable, reliable, secure and clean sources of energy. The President's budget request for this office includes continued investments in grid modernization to deliver energy on a more flexible and secure energy system; the Transmission Reliability and Resilience Program, to develop new capabilities for modeling performance and flexibility and to find new

ways for improving long-term grid resiliency; and the very important storage initiatives that support grid-related improved performance.

Now regarding Puerto Rico, this office has provided an abundance of support and technical assistance, including modeling and various analyses through our national labs. And it has produced at least eight DOE reports from determining the ideal amount of generation in its location to the optimal siting of microgrids on the island. This office continues to work with DHS, FEMA, Treasury, and HUD to assist the recovery efforts from Hurricanes Irma and Maria.

Turning to nuclear energy, it is impossible to speak about electricity without mentioning nuclear energy, which has given us around-the-clock emissions-free electricity for the past seven decades.

Our Office of Nuclear Energy has three main missions: revitalizing the Nation's nuclear fleet, developing advanced nuclear reactor concepts, and supporting fuel cycle technologies.

The total fiscal year 2020 budget request of 824 million funds advanced nuclear reactors, which will deliver improved performance and efficiency, enhance versatility, safe designs, reduce cost, greater resource utilization, and other applications. It also funds early-stage R&D into advanced reactor technologies at 75 million to improve the economic competitiveness, safety, and environmental contributions of nuclear energy, and \$10 million for small module reactors.

Turning to the Office of Energy Efficiency and Renewable Energy, its request is for 696 million of which 353 is prior-year unobligated balances. But as the Secretary had pledged, we intend to spend those dollars as directed by Congress. And this will fund R&D infrastructure, energy storage, and other early-stage activities such as fuel cell components.

This office will continue to conduct cutting-edge R&D to improve the affordability of clean energy technologies. EERE will build on and expand its Beyond Batteries Initiative with a request of \$105 million in fiscal year 2020 for the crosscutting advanced energy storage initiative.

EERE will also be a part of a coordinated effort to find synergies in component manufacturing in the Harsh Environment Materials Initiative.

The Office of Fossil Energy, the President's budget provides \$750 million for our Office of Fossil Energy of which 562 million is for fossil energy R&D to enable the reliable, efficient, affordable, and environmentally sound use of fossil fuels, including—this also includes funding for our National Energy Technology Laboratory.

Other highlights of Fossil Energy's budget request include \$174 million for the Office of Petroleum Reserves, as well as a request for authorization to sell 1 million barrels of SPR crude oil to raise revenue for drawdown operations; 450 million is for the SPR's Life Extension II Program, which is mandated by Congress.

These funds will be offset by revenue raised through sales of SPR crude oil. And \$220 million has been requested for the advanced energy systems initiative, and \$69 million for carbon capture utilization and storage program.

We will continue to support early-stage R&D which can provide CO₂ capture for economic utilization, enhance oil recovery operations, and conversion to high-value products while making coal cleaner.

In conclusion, the President's fiscal year 2020 budget request positions DOE to continue to advance energy security, economic security, and national security by unleashing our DOE experts, our national laboratories and its world-class scientists and engineers. Through innovation and technology we can and will continue our progress while meeting our challenges given the appropriate funding.

And before I close I would like to thank the committee staff for working with the Department, not only to prepare for this hearing, but since my tenure there, your staff works in a bipartisan, bicameral manner, and we—as I have made my staff available through the CFO's Office, but we want to be available to you.

They know that they can call me at any time, but the staff has really been remarkable in making themselves available. I think how difficult it is to get bipartisan, bicameral staff together for meetings, and it is greatly appreciated. And we respect their time and efforts to do that.

Thank you, again, members of the committee, to be here. And I look forward to your questions. Thank you.

[The information follows:]

Testimony of Under Secretary Mark W. Menezes
U.S. Department of Energy
Before the U.S. House of Representatives
Committee on Appropriations
Subcommittee on Energy and Water Development
April 3, 2019

Chairwoman Kaptur, Ranking Member Simpson, and Members of the Subcommittee, it is an honor to appear before you today to discuss the President's FY 2020 Budget Request for the Department of Energy's (the Department or DOE) applied energy programs.

Accompanying me today in the front row are our Assistant Secretaries from the Department's applied energy offices.

Protecting our energy infrastructure from cyber and other attacks, advancing domestic energy production, pursuing advancements in nuclear energy technologies, focusing on early-stage research & development (R&D) at our National Laboratories, supporting renewable energy technologies and advancements in energy storage, and protecting our Nation's electric grid, are some of the many goals and commitments we are making in the FY 2020 Budget Request.

These advancements and breakthroughs are happening because of the innovative research being done at our 17 National Laboratories. I have had the opportunity to visit a few of the laboratories over the past seventeen months since being confirmed, and have witnessed first-hand the outstanding work done by the dedicated workforce across the nation.

Across the applied energy programs, this budget proposes approximately \$2.3 billion in funding for energy independence and innovation, and emphasizes intradepartmental collaboration, joint capabilities, integration, and development of energy sector and advancing energy storage, security, reliability, and resilience. This early stage R&D will focus the intellectual capacity of our scientists and engineers on the development of energy technologies that the ingenuity and capital of America's entrepreneurs and businesses can convert into commercial applications and products to improve the lives and security of all Americans.

Through coordination with our labs, R&D efforts reduce costs to the taxpayer while at the same time providing an enhanced technology transfer program to transfer breakthroughs from the National Laboratories to the private sector. This private-public effort is the mission of the Office of Technology Transitions (OTT), which expands the commercial impact of the DOE R&D portfolio, advancing U.S. economic, energy, and national security interests. OTT is helping to ensure access to the cutting edge results of DOE's early stage research across the DOE complex, program offices, and National Laboratories. It pursues this mission by facilitating industry and other partnerships. To accelerate these interests, last year DOE authorized the National Laboratories to use Agreements for Commercializing Technology (ACT). Adding to existing available agreements, laboratories will have fewer barriers for potential business partners to access lab expertise and capabilities.

Crosscutting Initiatives

The President has requested \$267.7 million in FY 2020 for the Grid Modernization Initiative focusing on grid integration and reliability, allowing energy loads to be combined with generation from all power sources to optimize the use of existing assets. In the FY 2020 request, as part of this effort, \$157.6 million (\$104.6 million from EERE, \$48.5 million from OE and \$4.5 million from FE) is for R&D to support a new Advanced Energy Storage Initiative which builds on and expands EERE's Beyond Batteries initiative from FY 2019, and focuses on advances in controllable loads, hybrid energy systems, and new approaches to energy storage. The Advanced Energy Storage Initiative, part of DOE's grid modernization efforts, also considers energy storage holistically and coordinates across the applied energy offices to enhance the flexibility of both generation and demand, thereby increasing the reliability and resilience of energy systems.

The Harsh Environment Materials Initiative (HEMI) is a new coordinated effort within the Offices of Fossil Energy R&D (FE), Nuclear Energy (NE), and Energy Efficiency and Renewable Energy (EERE) to use common investments. This effort will coordinate interrelated R&D in materials, sensors, and component manufacturing R&D for advanced thermoelectric power plants between FE and NE. For example, NE's budget includes \$23 million for the Nuclear Energy Enabling Technologies (NEET) Transformational Challenge Reactor program, which enhances the development of breakthrough technologies that provide the ability to manufacture small/micro advanced reactor components using additive manufacturing techniques. Investments will also be aligned with EERE's Advanced Manufacturing Office R&D in materials and manufacturing process research, as well as flexible combined heat and power systems.

Office of Cybersecurity, Energy Security, and Emergency Response (CESER)

The President's FY 2020 Budget Request provides \$156.5 million for the Office of Cybersecurity, Energy Security, and Emergency Response (CESER). The Secretary has conveyed that one of his highest priorities is to support the security of our Nation's critical energy infrastructure. CESER leads the Department's efforts to secure our Nation's energy infrastructure against all hazards, reduce the risks of and impacts from cyber events and other disruptive events, and assist with restoration activities. Among the most critical missions at the Department is to develop science and technology protections that advance at a pace that stays ahead of evolving natural and man-made threats. A resilient and secure energy infrastructure will ensure Americans have energy where and when they need it.

Unfortunately, cyberattacks pose an increasing threat to the Nation's networks, data, facilities, and infrastructure. A secure (able to protect system assets and critical functions from unauthorized and undesirable actors) and resilient (able to maintain critical functions during a disruption) power grid is critical to U.S. economic competitiveness and leadership, and to the safety and security of the Nation. We need to understand increasingly sophisticated cyber threats and develop the tools to stay ahead of those threats across our energy infrastructure.

DOE's role in energy sector cybersecurity is established in statute and executive action. In 2015, Congress passed the Fixing America's Surface Transportation (FAST) Act (P.L. 114-94), codifying

DOE as the Sector-Specific Agency (SSA) for cybersecurity for the energy sector, consistent with existing policy. In preparation for, and in response to, cybersecurity threats, the Federal government's operational framework is provided by Presidential Policy Directive-41 (PPD-41). A primary purpose of PPD-41 is to clarify the roles and responsibilities of the Federal government during a "significant cyber incident," which is described as a cyber incident that is "likely to result in demonstrable harm to the national security interests, foreign relations, or economy of the United States or to the public confidence, civil liberties, or public health and safety of the American people." With the formation of CESER, the Department's role as the SSA is strengthened and the Department has undertaken its responsibilities with the highest degree of dedication and commitment.

CESER will allow more coordinated preparedness and response to emerging cyber and physical threats and natural disasters and support the Department's national security responsibilities. To work toward this critical objective, the FY20 budget invests in the development of tools needed to protect the U.S. energy sector against threats and hazards, mitigate the risks and the extent of damage from cyberattacks and other disruptive events, and improve system survivability through the development of techniques for more rapid restoration of capabilities.

CESER will work in an integrated manner with private industry, as well as Federal, state, and local jurisdictions and other DOE offices, to enable industry to enhance the security and survivability of U.S. energy infrastructure through investments across:

- R&D to deliver game-changing tools and technologies that help utilities secure today's energy infrastructure from advanced cyber threats and design next-generation future systems that are built from the start to automatically detect, reject, and withstand cyber incidents, regardless of the threat.
- Cybersecurity Tools and Development to strengthen the energy sector's cybersecurity posture through public and private sector partnerships that leverage DOE-supported tools, guidelines, outreach, training, and technical assistance.
- Emergency Preparedness and Response to pursue enhancements to the security and survivability of energy infrastructure, and facilitating faster recovery from disruptions to energy supply.

Program Highlights

The Cybersecurity for Energy Delivery Systems (CEDS) program seeks to reduce the risk of energy disruptions due to cyber events. CESER's mission to enhance the security and survivability of the Nation's energy infrastructure cannot be achieved without both near and long-term activities to strengthen cyber security across the Nation. The request reflects the critical need to prioritize efforts to strengthen energy infrastructure against cyber threats and mitigate vulnerabilities, focusing on enhancing the speed and effectiveness of cyber threat and vulnerability information sharing, establishing a national cyber supply chain assessment capability in partnership with industry, and accelerating game-changing R&D.

The Infrastructure Security and Energy Restoration (ISER) FY20 budget request is \$70 million, an increase of \$51 million from the FY19 enacted level. The request supports on-going efforts,

maintains capability to respond to energy sector emergencies through a regionalized volunteer delivery model, and improves the Federal national energy infrastructure threat monitoring and visualization capabilities provided by the Department's outage management tool. ISER will strengthen its efforts with state, local, tribal, and territorial partners to ensure their energy assurance plans integrate cyber information sharing mechanisms and are aligned with energy sector industry efforts.

Office of Electricity (OE)

OE leads the Department's efforts to strengthen, transform, and improve electricity delivery infrastructure so that consumers have access to reliable, secure, and clean sources of energy. OE provides solutions to market, institutional and operational failures that go beyond any one utility's ability to solve. To accomplish this critical mission, OE works with private industry and Federal, state, local, and tribal governments on a variety of initiatives to modernize the electric grid.

Grid modernization is critical to achieving public policy objectives, sustaining economic growth, supporting environmental stewardship, and mitigating risks to national security. The goal for the future grid is to deliver reliable, affordable, and clean electricity to consumers where, when, and how they want it. Within the next decade, proactive, coordinated, and innovative steps are needed to address four critical challenges:

- Increasing challenges to the reliability and security of the electric infrastructure.
- Changes in demand driven by population growth, adoption of more energy efficient technologies, dynamic economic conditions, and broader electrification.
- Changes in the supply mix and location (centralized, distributed, and off-shore) of the Nation's generation portfolio.
- Increasing variability and uncertainty from both supply and demand, including integration of variable renewables, more active consumer participation, and accommodating new technologies and techniques.

Due to the critical role the electric grid plays across Federal, state, and local jurisdictions, OE programs work in an integrated manner in partnership with industry and other stakeholders as well as other DOE offices, to enhance key characteristics of the U.S. electric transmission and distribution systems.

Timely action is needed to perform the early-stage R&D that will enable industry to deploy a reliable electric power grid that supports the vitality of other critical sectors that depend on electricity, such as telecommunications, banking and finance, water, and public health and safety. A reliable and resilient power grid is critical to U.S. economic competitiveness, leadership, and, most importantly, national security.

Within the FY 2020 request is \$182.5 million for OE to fund:

- R&D -- pursuing early-stage research for technologies to improve grid reliability, efficiency, flexibility, and functionality.
- Modeling and Analytics -- developing core analytic, assessment, and engineering capabilities

that can evolve as the technology and policy needs mature to support decision making within the Department and for stakeholders; analyses explore complex interdependencies among infrastructure systems, such as between electricity and natural gas systems.

- Institutional Support and Technical Assistance -- building capacity in the industry and convening stakeholders to coordinate efforts to transform the electric grid; providing technical assistance to states and regions to improve policies, utility incentives, state laws, and programs that facilitate the modernization of the electric infrastructure.
- Coordination of Federal Transmission Permits -- streamlining permits, special use authorizations, and other approvals required under Federal law to site electric transmission facilities.

Program Highlights

The Transmission Reliability and Resilience program is focused on ensuring the reliability and resilience of the U.S. electric grid through early-stage and foundational R&D on measurement and control of the electricity system and risk assessment to address challenges across integrated energy systems. The FY 2020 request supports the development of new modeling-based capability for monitoring the long-term resilience of our grid and identifying opportunities to improve resilience and mitigate risks associated with the energy systems interdependencies. Within this program, OE will lead an ambitious effort to develop the North American Energy Resilience Model (NAERM). The NAERM will ensure reliable and resilient energy delivery across multiple sectors, spanning multiple organizations and authorities, while considering a range of large-scale, emerging threats. A collaboration between DOE, its National Laboratories, and industry, the NAERM will develop a comprehensive resilience modeling system for the North American energy sector infrastructure, including the United States and portions of Canada and Mexico. \$70.5 million is requested for Transmission Reliability and Resilience, including \$30.0 million for NAERM and \$8.5 million for sensors and data analytics.

The Resilient Distribution Systems program focuses on the development of innovative technologies, tools, and techniques to modernize the distribution portion of the electric delivery system. Results from the research in Advanced Distribution Management Systems, microgrids, and Dynamic Controls and Communications (DC&C) will enable industry to strengthen the resilience of electric infrastructure against adverse effects of future extreme weather phenomena and other unforeseen natural and man-made occurrences. \$27.9 million is requested for Resilient Distribution Systems, a reduction of \$12.1 million from the FY 2019 appropriation that is primarily due to the completion of funding for two Congressionally-directed projects, sensing intelligent machines and low-cost distribution sensors, which were fully funded in FY 2019.

The Energy Storage program focuses on accelerating the development of new materials and device technologies that can lead to significant improvements in the cost and performance of utility-scale energy storage systems and accelerate the adoption of energy storage systems into grid infrastructure. The request supports materials research on the next generation of battery chemistries, development of new materials and new device technologies for efficient power conversion, development of optimal design and control architectures for energy storage integration into the grid infrastructure, and development of open source models and software tools for system level energy storage planning and evaluation. \$48.5 million is requested for Energy Storage, including \$5.0 million for design and

construction planning of a Grid Storage Launchpad project aimed at accelerating materials development, testing, and independent evaluation of battery materials and battery systems for grid applications.

The Transformer Resilience and Advanced Components (TRAC) program supports modernization, hardening, and resilience of the grid by addressing the unique challenges facing transformers and other critical grid components that are responsible for carrying and controlling electricity from where it is generated to where it is needed. TRAC will continue research to support innovative concepts and designs for solid-state power substations, including advanced materials and system architectures. Research to improve asset monitoring capabilities and equipment performance under stress will enhance the portfolio of solutions available to industry to increase grid security, reliability, and resilience.

The Transmission Permitting and Technical Assistance (TPTA) program's mission is to promote a secure and resilient electricity system through regulatory and policy solutions. TPTA evaluates existing laws, policies, and regulations to better understand the regulatory landscapes, and provides technical assistance to Federal, state, tribal, territorial, and regional entities in their efforts to address the changing dynamics and uncertainties in the energy environment. TPTA also implements a number of legal authorities and seeks to improve transmission infrastructure by facilitating better coordination between Federal agencies for transmission lines that require multiple Federal authorizations and by permitting transmission facilities crossing U.S. international borders. \$9.0 million is requested for TRAC to build on material research and design innovations for next-generation grid hardware, moving towards prototypes for technologies and concepts related to solid-state power substations and advanced conductors.

In FY 2020, TPTA will focus its technical assistance work to provide stakeholders an in-depth understanding of how to best modify existing market structures or build new resilience into the electricity subsector system. As potential infrastructure investments are identified to improve resilience and mitigate risks associated with energy systems interdependencies, TPTA will provide institutional support, such as evaluating regulatory and market-based policies, to help States and tribes make infrastructure investments that contribute to national security. TPTA will also continue to carry out its regulatory responsibilities and evaluate regulatory reform to reduce Federal burden associated with investing in our Nation's electricity infrastructure. \$7.0 million is requested for TPTA, which is level with the FY19 appropriation.

Office of Nuclear Energy (NE)

The President's FY20 budget request provides \$824 million for the Office of Nuclear Energy. As the major source of reliable, resilient and clean baseload electricity, nuclear energy is a vitally important strategic national asset for the United States. It is an essential element of our Nation's diverse energy portfolio helping to sustain the U.S. economy and support our national goals. A strong domestic nuclear industry enabled by the existing nuclear fleet and enhanced by game-changing advanced nuclear technologies is critical to our Nation's energy security, national security, environmental sustainability, and economic prosperity.

The United States pioneered the development and peaceful use of nuclear power to produce around-the-clock, emissions-free electricity. As a result of U.S. leadership in nuclear energy, American citizens have benefitted from this clean source of electricity for nearly 7 decades. Nuclear power plants have served as bedrocks to communities across the country, providing jobs to hundreds of thousands of Americans. Today, nuclear energy is the third largest source of domestic electricity generation and is the largest source of clean energy. As baseload electricity sources, nuclear power plants also contribute to the reliability and resilience of the electric grid and can provide price stability.

However, the U.S. nuclear energy sector is now under historic downward pressure. As a result of market challenges and state policy decisions, a number of nuclear reactors are retiring prior to their license expiration. Since 2013, seven reactors have retired prematurely and 12 more are scheduled to retire. In response, the President, on June 29, 2017, announced that we would conduct a complete review of U.S. nuclear energy policy to help find new ways to revive and expand this crucial energy resource. This Civil Nuclear Review is underway, and outcomes are informing how the Administration can best enable a revitalization of the nuclear sector. The FY 2020 Budget Request reflects some of these outcomes as evidenced by the Department's efforts to pursue the Versatile Advanced Test Reactor (VATR) and demonstrate the capability of U.S. technology to produce high-assay low-enriched uranium (HALEU).

The Department of Energy believes it is not too late to reverse the downward trajectory of our Nation's nuclear energy sector. In fact, we have much to build on. The United States, for example, still has the largest fleet of reactors in the world. We lead the world in efficient operation of our fleet and we have the world's leading nuclear safety regulatory authority. We are still the world's leader in innovation, demonstrated by the burgeoning number and variety of U.S. advanced reactor designs. Coupled with this are our world class DOE National Laboratories and U.S. universities.

In support of the President's direction for the future of the nuclear industry, the FY 2020 Budget Request emphasizes activities to revive and expand the U.S. nuclear energy sector. Within NE, we focus our technical work in three major mission areas: revitalizing the nation's existing nuclear fleet, developing advanced nuclear reactor concepts, and supporting fuel cycle technologies and associated infrastructure. Utilizing the Department's greatest strengths, we are emphasizing early-stage R&D with universities and National Laboratories, mobilizing and expanding our unique National Laboratory capabilities, and implementing targeted R&D partnerships with the U.S. nuclear industry.

Revitalizing the Existing Nuclear Fleet

NE is working to ensure the long-term economic viability of our existing nuclear reactor fleet by partnering with industry to develop the technical basis for the continued reliable and economic operation of the current fleet of nuclear plants, as well as developing technical solutions to enhance the economics and performance of nuclear power plants. This includes developing technologies such as accident tolerant fuels, \$36 million in the FY20 request, which have the potential to significantly increase the performance of our nation's current fleet of reactors, while reducing costs.

The FY 2020 Budget Request also includes \$30.2 million for cost-shared efforts to extend the life of the existing commercial nuclear reactor fleet through early-stage research in areas such as materials

aging and degradation, safety margin characterization, safety technologies, instrumentation and controls. We are focused on cost-shared, private-public partnerships to resolve the U.S. industry's highest priority and highest uncertainty technical issues that are not currently being addressed. By continuing to support improvements to the efficiency, productivity, and operating lifetimes of our Nation's nuclear fleet through technology R&D, the Department is helping industry realize its full potential in contributing to our Nation's energy independence, security, and emission-free, reliable supply of electricity.

Developing Advanced Reactor Technologies

In parallel with our work to extend the operating lives and improve the performance of the existing fleet, NE is working to advance our Nation's next generation of advanced nuclear reactors. For example, the Budget Request includes \$100 million towards a Versatile Advanced Test Reactor (VATR). For the United States to regain a global leadership role in the development of the next generation of advanced reactors, a fast spectrum test reactor will be an important experimental tool, providing the capability to perform tests in an extreme environment. The VATR is one of the Department's highest priorities, and will accelerate innovation in advanced fuels and materials for U.S. vendors and help pave the path to U.S. global leadership in advanced nuclear R&D.

In addition, the FY 2020 request includes \$85 million for advanced reactor concepts that have the potential to deliver improved performance and efficiency, enhanced versatility such as load following and multipurpose roles, passive designs, reduced costs, enhanced resource utilization and waste minimization, and non-electric and hybrid applications. These design features, if proven and commercialized, could represent truly transformational nuclear energy sector impacts.

NE is conducting early-stage R&D into advanced reactor technologies that can improve resource utilization, reduce waste and produce electricity and high temperature process heat to improve the economic competitiveness and enhance safety and environmental contributions of nuclear energy. Research into advanced reactor technologies will address high-value fundamental research for long-term concepts, early-stage R&D needs of promising mid-range concepts, early-stage development of innovative technologies that benefit multiple advanced reactor concepts, and stimulation of new ideas for transformational future concepts.

Through cost-shared, early-stage R&D and related technical assistance, the Department will help accelerate the timeline for commercialization of new, advanced, and more financeable reactor technologies. These advanced reactor technologies will help revive and expand the domestic nuclear industry and advance America's leadership role in the global nuclear sector.

Further, the FY 2020 Budget Request includes \$23.5 million to continue the Transformational Challenge Reactor (TCR) effort. The TCR is a revolutionary platform to demonstrate our ability to reduce the deployment costs and timelines for designing and constructing nuclear energy systems. These innovations will be demonstrated using breakthrough technologies allowing us to manufacture advanced small and micro-reactor components by combining additive manufacturing techniques and digital predictive analysis capabilities to deliver a new approach to nuclear design and qualification for advanced reactor technologies.

Supporting Nuclear Fuel Cycle Capabilities

The Department is also working to support the civilian nuclear fuel cycle and associated infrastructure. We recently took an important step toward revitalizing our fuel cycle R&D capabilities when Idaho National Laboratory (INL) resumed operations at the Transient Reactor Test Facility (TREAT), which had been shut down since 1994. This capability is an important asset to nuclear scientists and engineers as they work to increase the safety and performance of current and future nuclear reactors.

Activities in FY 2020 will continue operation of TREAT, investments at the Advanced Test Reactor (ATR) and the Materials and Fuels Complex (MFC) to improve reliability and availability, and performance of construction activities for the Sample Preparation Laboratory, which will address gaps in advanced Post-Irradiation Examination (PIE) capabilities vital to nuclear R&D.

Lastly, many U.S. advanced reactors developers have identified HALEU (uranium enriched in U-235 to greater than 5% but less than 20%) as a fuel requirement. Currently, the U.S. lacks a sustainable domestic supply of HALEU. The request therefore includes \$40 million for the Civil Nuclear Enrichment subprogram, initiated in FY19, aimed at demonstrating the capability to produce HALEU utilizing U.S. centrifuge technology. These activities support industry's demonstration of advanced reactors, including micro reactors.

The Administration is fully committed to nuclear energy as a vital component of our Nation's energy system. The FY 2020 Budget Request leverages private-public partnerships and our world-class National Laboratory system to support a revitalized nuclear sector. It focuses on early-stage R&D to support the development of a new class of U.S. advanced nuclear reactors, an innovative and responsive nuclear energy supply chain, and advanced nuclear energy fuel cycle technologies, positioning the U.S. for energy dominance in the 21st century.

Office of Energy Efficiency and Renewable Energy (EERE)

The President's FY 2020 Budget Request provides \$696 million for EERE to help promote America's energy dominance through technologies that will make our energy more affordable, reliable, and efficient. EERE funds early-stage research to spur private-sector research, development, and commercialization of critical energy technologies in sustainable transportation, renewable power, and energy efficiency. The FY 2020 Budget Request focuses EERE resources toward early-stage R&D, where the Federal role is strongest, and reflects an increased reliance on the private sector to fund later-stage research, development, and commercialization of energy technologies. It emphasizes energy technologies best positioned to advance American energy independence and domestic job-growth in the near to mid-term. Knowledge generated by EERE early-stage R&D supports U.S. industries, businesses, and entrepreneurs to develop and deploy innovative energy technologies and gives them the competitive edge needed to excel in the rapidly changing global energy economy. Industry deployment of these technologies can increase energy affordability, create jobs, improve energy security, and offer Americans a broad range of energy choices.

The President's request is also focused on sustaining the National Renewable Energy Laboratory's (NREL) world-class R&D environment by maintaining and, where necessary, upgrading its equipment and facilities. The FY 2020 Budget Request includes a \$22 million to accelerate the expansion of the diverse capabilities of the National Wind Technology Center (NWTC) campus at NREL, creating a fully integrated, large-scale experimental research campus (Flatirons Campus). This expanded campus includes building an enhanced grid/Energy Systems Control Center and a High-Speed Data Link that connects the NWTC campus to the Energy Systems Integration Facility at NREL's main campus and to other National Laboratories. The mission of the NWTC will expand to support a fully integrated, large-scale experimental research platform, including a Beyond Megawatt Scale Extreme Fast Charging Station to research, integrate, and evaluate electric vehicle fast-charging station impacts on the grid. These investments support research for DOE's Grid Modernization Initiative, which includes reliably integrating variable generation into the electric grid. These expanded capabilities will allow DOE to test a suite of technologies supported under the Advanced Energy Storage Initiative and leverage the NWTC's future power capacity of 19.9MW with the capabilities of NREL's Energy Systems Integration Facility.

Sustainable Transportation

EERE's Sustainable Transportation portfolio supports analysis-based, early-stage research that supports industry efforts to accelerate the development and widespread use of a variety of technologies to make our transportation energy more affordable, efficient, and secure. Broadly, Vehicle, Bioenergy, and Hydrogen and Fuel Cells Technology programs within EERE pursue four key parallel solution pathways: (1) fuel diversification, replacing conventional fuels with cost-competitive, domestically produced alternatives; (2) vehicle efficiency, using less fuel to move people and freight; (3) energy storage, delivering durable, reliable, resilient and affordable energy storage technology R&D across sectors, and (4) improving the overall energy efficiency and efficacy of the transportation or mobility system. The pathways and activities also include those necessary to address statutory requirements and the supporting advanced data-driven, technical, economic, and interdisciplinary systems analyses critical to informing R&D investment priorities.

Renewable Power

In the Renewable Power portfolio, EERE will perform early-stage research to support solar, wind, water, and geothermal industries to develop, and ultimately deploy, low-cost novel power generation technologies. The overarching objective of the Renewable Power portfolio is to lower costs and improve the reliability of renewable energy technologies, which would support the adoption of affordable renewable energy options, allow for regional optimization, maximize the use of domestic resources, and contribute to a resilient, reliable, and secure electricity grid. The Renewable Power technology sector pursues three key parallel solution pathways: (1) Technology Innovation; (2) Validation and Analysis; and (3) Systems Integration, including efforts coordinated through the Grid Modernization Initiative. Through investments in DOE labs, industry, and academia, EERE's Renewable Power technology offices will continue to lead the work in developing domestic, clean, reliable energy choices in power generation, which strengthen the U.S. economy while increasing energy security.

Energy Efficiency

EERE's Energy Efficiency portfolio will build on the considerable progress made over the last 40 years and pursue early-stage R&D targeted at high impact technology areas such as advanced lighting, space heating and cooling, building envelopes, and manufacturing materials and processes. The overall goal of the energy efficiency portfolio is to strengthen the body of knowledge that supports businesses, industry, and the Federal Government to improve the affordability, energy productivity, and resilience of our homes, buildings, and manufacturing sectors. The knowledge generated by this research can support a foundation for economic growth and job creation as American businesses and families develop and deploy new energy-efficiency and manufacturing technologies. The request will also assist Federal agencies in their energy and water management and provides funding needed to meet legal requirements for appliance standards and building energy codes.

Office of Fossil Energy (FE)

The FY 2020 Budget Request provides \$750 million for FE. This request is guided by the principles of energy dominance, security, and strong domestic energy production and is promoted by the FE R&D portfolios and the Office of Petroleum Reserves portfolios.

Within the request, the President's FY 2020 budget provides \$562 million for FE R&D to enable the reliable, efficient, affordable, and environmentally-sound use of fossil fuels. The request develops transformational energy technologies as part of the Administration's all-of-the-above energy portfolio that enables greater private-sector participation in driving market outcomes to enhance America's competitiveness. These investments will enable industry to commercialize and deploy advanced technologies necessary to support a secure and reliable power grid. This request also includes funding for the National Energy Technology Laboratory, the nation's pre-eminent fossil energy laboratory.

Advanced Coal Energy Systems & CCUS

Within FE R&D, the Advanced Coal Energy Systems & Carbon Capture, Utilization and Storage (CCUS) program invests in early-stage energy technologies that improve the affordability, competitiveness, and environmental performance of advanced coal technologies; improve electric grid reliability and resilience; and increase the domestic and international accessibility to American energy resources. The program prioritizes investments that will improve the efficiency and performance of the existing coal fleet; advance technologies under the Coal FIRST (Flexible, Innovative, Resilient, Small, Transformative) initiative to enable flexible, small, coal plants of the future that have near-zero emissions; reduce the cost of CCUS technologies; and promote new market opportunities for CO₂ and coal utilization.

Oil and Natural Gas

In the area of oil and natural gas research, the President's request provides \$29.7 million across three programs. The request provides \$19 million for the Unconventional Fossil Energy Technologies program, which includes field-based and laboratory research on improving the

efficiency of oil and natural gas production in the Nation's shale plays. The request also provides \$8.7 million for research focused on evaluating the occurrence, nature, and behavior of naturally occurring gas hydrates. This funding will support continued gas hydrates field work on the Alaska North Slope. The request includes \$2 million for a new Natural Gas Infrastructure program that would focus on early-stage, foundational research to enhance the operational efficiency of natural gas delivery infrastructure, which will be furthered developed and commercialized by industry.

National Energy Technology Laboratory

The National Energy Technology Laboratory (NETL) works hand-in-hand with the FE R&D portfolios to plan, administer, and execute world-class fossil energy research and development. The FY 2020 request for NETL supports its capabilities in science and technology development and commercialization, including: Computational Science and Engineering; Materials Engineering & Manufacturing; Geological & Environmental Systems; and Systems Engineering & Analysis. The request also funds NETL's technical program management; and staff that provide Acquisition, Finance and Legal functions to FE. The request also funds NETL's research sites and maintains the Laboratory's three-campus footprint in Morgantown, WV; Pittsburgh, PA; and Albany, OR. These sites include approximately 240 acres of land, including 116 buildings with over 1,100,000 square feet of space.

Strategic Petroleum Reserve

The President's request provides \$188 million for the Office of Petroleum Reserves, with \$174 million for the operation of the Strategic Petroleum Reserve (SPR) and \$14 million for ongoing federal responsibilities at the Naval Petroleum Reserves. The SPR is a critical national asset which provides an insurance policy against potential interruptions in U.S. petroleum supplies, whether originating from domestic or international supply disruptions, natural disasters, sabotage, or acts of terrorism, and to meet the U.S. obligations under the International Energy Program. The \$174 million is to support the Reserve's operational readiness and drawdown capabilities. From the sale of 1 million barrels of gasoline blendstock from the Northeast Gasoline Supply Reserve (NGSR), \$27 million would go to the SPR Petroleum Account to help fund future sales of SPR crude oil mandated by law. The request also includes \$450 million for the Energy Security and Infrastructure Modernization Fund, which is offset by revenue raised through sales of SPR crude oil.

The Budget Request also proposes to disestablish the Northeast Home Heating Oil Reserve (NEHHOR). In its two decades of existence, the NEHHOR has not been used for its intended purpose, and the Administration believes the continued taxpayer-funded expense of maintaining the reserve is unwarranted, particularly as the existing commercial storage contracts are up for renewal in March 2020. The Budget Request also proposes to disestablish the NGSR. The NGSR has not been used since its establishment, and is not considered to be cost efficient or operationally effective. Proceeds of the combined sales of the NEHHOR and NGSR (estimated at \$130 million in receipts, net of the \$27 million retained for mandatory sale drawdown costs) will be contributed to deficit reduction.

Conclusion

The President's FY 2020 Budget Request positions DOE to utilize the world's best enterprise of National Laboratories, scientists and engineers to create, push innovation and continue to advance technologies and research in fields that support American prosperity, security and competitiveness. Thank you for the opportunity to testify before you today, and I look forward to answering your questions.

Ms. KAPTUR. Thank you, Mr. Menezes, so very much. And we agree with you on our staff's efforts, and also our members' efforts, to try to ferry the ship.

Mr. Dabbar, please begin.

Mr. DABBAR. Thank you, Chairwoman Kaptur, Ranking Member Simpson, and members of the subcommittee. It is an honor to appear here today to discuss the fiscal year 2020 budget, and it is an honor for Under Secretary Menezes and myself to head the top research organization in the world.

I would like to thank this committee for their extraordinary leadership supporting innovation. The Nation notes your very strong interest for the national lab complex, including the 60,000 people at the 17 national labs.

Our lab complex has invented whole industries and technologies, including nuclear power, nuclear medicine, nuclear imaging, the white LED light, the Human Genome Initiative. And the complex is also the number one generator of Nobel Prize winners in the world. I think I have cribbed off of the chairwoman's speaking points. We did not actually coordinate, so just for clarity.

I will briefly summarize the recent accomplishments and innovation in environmental management and commercialization, and what is on the horizon for those areas.

In the Office of Science this last year, we completed a series of major research facilities, maintaining America's global leadership in innovation.

We just commissioned the number one and number two supercomputers in the world, including the top AI supercomputer in the world.

We completed the top nuclear physics research facility at Jefferson Lab, and we launched the world's first entangled quantum Internet in Chicago.

We also accelerated our work in beyond lithium batteries, lithium-ion batteries, working with America's leaders in electric vehicles, personal electronics, and utilities.

In environmental management, I am happy to report on footprint reduction and risk mitigation occurring across the complex, including completion of major D&D operations at West Valley and at SPRU, the AMWTP project in Idaho, and commencement of the clean-up of the last reactor along the river corridor in Hanford. And at the end of this year we will be done with the last reactor at Hanford cleanup from the Cold War. And we are now 90 percent complete with the construction of the low-activity waste facility at Hanford.

Finally, we are in negotiations of returning access at Hanford of a large amount of land to the tribe that lived on the land prior to World War II. These are exciting times for cleanup in the complex.

We are also committed to policies that support commercialization, combining the expertise of the labs with the energy of the private sector to speed the movement of technologies to the marketplace. We have eased the process of our labs commercializing our research through significant legal reforms, started InnovationXLab events, including the next one at Oak Ridge National Laboratory on advanced manufacturing. And we are already seeing results of

using lab technologies to fuel domestic innovation in the private sector.

But we believe in the dreams of the future more than the history of the past. Upcoming in the Office of Science we look to continue to construct the world's leading user facilities, including the 2-mile-long X-ray-free laser at Stanford, the large neutrino facility at Fermi National Lab, and light source upgrades at Berkeley, Oregon, and Brookhaven. These projects will fuel U.S. innovation, scientific leadership, and support world leading science and technology workforce. And we look forward to accelerate the exascale computer construction maintaining the DOE national labs' leadership in the world in supercomputing, which is where it has been since the beginning of supercomputing, while increasing support for quantum technologies and artificial intelligence.

In environmental management our request supports completion of 66 regulatory milestones in the coming year, completion of large waste processing facilities at Savannah River and at Hanford, and retrieval at the accelerator retrieval project in Idaho. And we are implementing a wide degree of contracting reforms that were much needed in the EM complex, focusing on in-state contracting, a model that was very successful at Rocky Flats.

In conclusion, let me finish with a few personal thoughts on behalf of our fellow Americans who you support for innovation. The story of this millennium is the expansion of knowledge and how this expansion of knowledge can create positive impacts for humanity. The people you support in the complex and throughout all this Nation's great universities through our grant programs exemplify in their lives what we as free people should focus on, which is expanding the bounds of knowledge for the betterment of humanity. They are restless in questing opportunities granted to them by the freedom and the promise of this country. It is a quest to learn a little bit more of this unlimited universe.

We do this in the spirit of optimism and belief in our country and humanity's future. This country has certainly felt the support of this committee this last year with bipartisan support of optimism, and we look forward to that continuing collaboration. Thank you and we look forward to your questions.

Ms. KAPTUR. Thank you both for your testimony. We will now begin questioning under normal rules. I will begin with one question for Mr. Menezes and one for Mr. Dabbar, and then we will move to the ranking member.

Mr. Menezes, Congress on a bipartisan basis, as has been noted in your testimony, continues to provide funding for the very programs that this administration proposes to cut or eliminate, and they do it year after year, including the energy efficiency renewable efforts and ARPA-E. We fully expect the Department to judiciously execute all appropriated funds as you are legally required to do.

In December of 2017, the Government Accountability Office found that DOE violated the Budget and Impoundment Act of 1974 by withholding \$91 million from ARPA-E from fiscal year 2017 appropriated funds. It is alarming to see that in your budget proposal you plan to use \$353 million in prior year unobligated balances to partially fund EERE, including 210 million from fiscal year 2018. This subcommittee was briefed in December and at that time the

Department of Energy had a plan to fully execute those 2018 dollars.

Mr. Menezes, will DOE continue to execute these funds as promised? And I would like a yes or no answer, please.

Mr. MENEZES. Yes.

Ms. KAPTUR. I am glad to hear that. And how soon can we expect that?

Mr. MENEZES. To spend those particular dollars, well, I know that we have been issuing FOAs on a regular basis for fiscal year 2019. On fiscal year 2018, of those specific dollars, I would have to probably see specifically what those dollars, you know, are meant to be. But the commitment is to follow congressional direction on all previously appropriated dollars, and we will continue to use those monies.

Ms. KAPTUR. I would very much appreciate for the committee if you could go back with your staff and by the end of next week give us a timeline, please, on that.

Mr. MENEZES. I would be happy to do that.

Ms. KAPTUR. Thank you very much. I just wanted to ask Mr. Dabbar, you mentioned in your opening statement about the light source upgrades and the imaging and the importance to health. Can you give us a little more detail on that, please?

Mr. DABBAR. Yes, Chairwoman. So, light sources have the ability to look at atomic structures from many different aspects. They could be used for general science applications, but they are also useful, for example, for materials and materials for the commercial sector. For example, we could work with companies such as General Electric or others that work on turbines for airplane engines and take a look at those engines and how they work so they could design them better.

The last example I will give will be in the healthcare sector. These light sources are applicable for looking at biotech drugs and how they operate attacking certain proteins. So, for example, we could use these light sources for the ability to take a look at a particular biotech drug and in situ as it is going and attacking a certain protein to see how it is working. We could actually image it live as it is going through. And we work not only with ourselves and the Federal agencies, but are working with the private sector, who compensate us for use of those.

So, the light sources have broad applications across energy, across the sciences, that is a wonderful tool for all Americans.

Ms. KAPTUR. Could I ask you this, please? In the State of Ohio, and frankly nationally, there are alarming rates of citizens who have diabetes; in fact, a third of the population of Ohio. It is a shocking number. Would your scientific capabilities allow us to examine how various insulin formulations work and how we could make insulin available to millions of Americans at more affordable prices?

Mr. DABBAR. I am not certain about the availability of drugs, because we don't deal with that, but in terms of efficacy associated with potential treatment, I think both from a light source point of view and from an advanced computing point of view those are things that we clearly could support research on. You know, the ability to take a look at vast amounts of data and see how, with

data across a whole trial base of different people given drugs of different types—

Ms. KAPTUR. Yes.

Mr. DABBAR. Those are things that clearly we are set to support.

Ms. KAPTUR. I am one member of this institution that believes, in fact, I have witnessed, the blending of the sciences; the blending of agriculture and energy in ways I won't go into, the conversion of sunlight directly to power. I have a really—in the international labs, I have been able to see things that are truly—I have never imagined.

Mr. DABBAR. Yes.

Ms. KAPTUR. And so in this area of human health and the cross-over with energy on imaging technologies and light sources, you have a member who is extremely interested on walking down that path and understanding what exists and what might exist through the labs to meet, really, crying needs for the American people.

So I will now turn to our ranking member, Mr. Simpson.

Mr. SIMPSON. Thank you. I look forward to following up with your staff on this very particular topic. I would like to try to see where your connections are in terms of research and how we can directly connect with them and support that.

Ms. KAPTUR. Thank you. You know, the Secretary, when he was here talked about his fascination with something he had seen in, was it San Francisco, somewhere in Northern California relating to brain concussions. And I was just talking to Congressman Gonzalez today from Ohio who has been very active in the National Football League looking at concussions, concussions of people who have brain situations. We actually were in a very deep conversation about this today, but not just in football; in soccer, in lacrosse, in wrestling. And I was thinking about what the Secretary said about light imaging and what more we might do to help heal what—I can't imagine how many thousands of people have these injuries, both on the military side as well as on the civil side. So the Secretary seemed to have a personal interest in that and so do I.

Mr. DABBAR. We have a meeting coming up in San Francisco with the DOD-supported University of California research, our national labs, and the NFL.

Ms. KAPTUR. Really? Okay, I will just say this as a woman, you would be surprised how many injured women there are in field hockey and soccer. And I know that there are wrestlers, some of whom I think may be even in this Congress, who were injured when they were playing and competing maybe—

Mr. SIMPSON. I won't ask about that.

Ms. KAPTUR. But I know what you are thinking. Thank you so very much. I appreciate that, Mr. Dabbar.

Mr. SIMPSON. Thank you, Chairwoman Kaptur. I will tell you that Secretary Perry was so excited about that—

Ms. KAPTUR. Yes.

Mr. SIMPSON [continuing]. That when he was out there and saw this, he called me and this was during the August recess, saying you have got to see this. It is fascinating stuff.

But let me ask you, the budget request includes what some might call a moonshot, our D&D effort called the Advanced Energy Storage Initiative. It appears to be a crosscutting initiative with ag-

gressive yet achievable goals. The Department has used this type of approach before with great success.

For both of you, wouldn't it be beneficial to launch similar initiatives aligning resources and competencies toward an ambitious goal for critical technologies like advanced nuclear and carbon capture for coal and gas as well?

Mr. MENEZES. Yes, sir. You know, that is an excellent suggestion and a recognition of what you can accomplish when you do things through crosscutting and a collaborative effort.

You had mentioned the Grid Modernization Initiative and the Advanced Energy Storage Initiative. When you think about the carbon capture and storage technologies that you mentioned, while we tend to think of it as post-combustion coal, the fact is we have it on natural gas, post-combustion, but importantly, pre-combustion. When you process natural gas to put it into pipelines, you pull out CO₂ at that point. Now, if you can utilize that technology on a pre-combustion while you are processing it, think of the efficiencies that you can achieve.

So, that is a pre-combustion, processing carbon capture possibility, and then you add that to what we are doing right now on the coal post-combustion, like Petra Nova for example, and you can now use that similar technology on post-combustion for natural gas if you don't pull it all out at the beginning. So, that has great cross-cutting benefits. That is what our offices are set up to do, to collaborate, so certainly that would be key.

Similarly, the future of nuclear is on the next generation of advanced reactors. While we are building the AP1000 in Vogtle, and it is a great plant, and we went down there just 2 weeks ago to see the actual vessel reactor head being attached to the vessel reactor. It is a 745-ton device that was being put on there. We are now well on our way to completing the AP1000.

But let us be honest, unless economic conditions change, we really—we have no plans to build any AP1000s here in the U.S., as good as that technology is. So, the future is small, modular, and even micro, potentially. We have to drive down the costs; we have to make them more flexible, small, scalable and most importantly, affordable.

And so that, likewise, I think would be a great opportunity for a moonshot. We are already seeing quite a bit of interest in the private sector, particular with small, modular, and micro, but I think to put a challenge out there shows that the government is interested in supporting the technology breakthroughs that it will take for us to maintain our global leadership in the nuclear area.

Mr. SIMPSON. Thank you. Do you have anything you want to say on that?

Okay, just one question, and maybe you guys can explain this; I have been trying to figure it out for some time. The budget request proposes to move the Formerly Utilized Sites Remedial Action Program, FUSRAP, from the Army Corps of Engineers to the Department of Energy. I would remind you that Congress moved FUSRAP from DOE to the Corps because it wasn't doing a satisfactory job with the program. Can you please explain to me why we want to move it back now?

And to tell you the truth, I have not heard one complaint about the FUSRAP program that the Army Corps of Engineers is doing now. The only reason I can think of to upset what seems to be working is, you are going to be doing it more efficiently, and you are going to save money or something like that. If all we are going to do is move it back to the Department of Energy and then contract out with the Army Corps of Engineers to do what they are doing now, that is a loss of money it seems like, to me. So, can you explain why we want the DOE to take back the FUSRAP program?

Mr. DABBAR. Yes Congressman, that is in my area in Legacy Management. You know, I was not around about, I think, a little bit over two decades ago when the FUSRAP program was moved to the Army Corps. At the time, the Department and the Legacy Management Program was not really where it is today. We don't talk a lot about legacy management because it actually works pretty well. And for those that may not know about Legacy Management, it is really about taking the sites after environmental management to a large degree, and some other smaller sites all around the country, that need longer term monitoring and sometimes ground water remediation that they are experts in. And so, LM runs very well and has lots of small sites all over the country; mines and various things that we cover and we monitor for long term.

The Army Corps has a lot of big things that they need to focus on. I am not an expert at the Army Corps but obviously many things dealing with large flooding, dealing with storms, dealing with large port issues that are needed for the country for economic—to expand ports. The Army Corps—these projects are quite small compared to the scope of what the Army Corps is focusing on.

And so, they are actually quite happy that these much smaller sites all over the country in which long-term monitoring of them is not at core to what they need to focus on today, maybe as compared to a few decades ago. So, what the plan is, is that they are very happy for them to clean up those sites, so those will continue. And that once they are done, that the monitoring of that program, the FUSRAP sites, will get transferred over to Legacy Management at the Department who has a skill set of monitoring multiple minor sites all over, and does that very well in today's world.

Mr. SIMPSON. So is it that we are not transferring the entire FUSRAP program over to the Department of Energy, just the monitoring afterward? The Army Corps of Engineers will still continue to do the cleanup work?

Mr. DABBAR. That is right.

Mr. SIMPSON. Because that is not the impression I got from the budget request.

Mr. DABBAR. Yes.

Mr. SIMPSON. It was like the Army Corps was going to be out of it.

Mr. DABBAR. No, the Army Corps is going to be finishing the cleanup and then we are going to be taking over monitoring. So, I apologize if it wasn't clear in the proposal.

Mr. SIMPSON. Okay, then we need to look at the proposal and see exactly what is being proposed there.

Mr. DABBAR. Glad to follow-up with your staff.

Mr. SIMPSON. I appreciate it. Thank you.

Mr. DABBAR. Yes, sir.

Ms. KAPTUR. Thank you, Mr. Fleischmann.

Mr. FLEISCHMANN. Thank you, Madam Chairwoman. Secretary Menezes, Secretary Dabbar, and to all of the assistant and under secretaries present, I want to thank each and every one of you all for being here today. And, Madam Chair, I would like to say something very strong to this group.

I am privileged to serve on this committee and as an appropriator I have enjoyed immensely working with the Department of Energy, Secretary Perry. We initiate bipartisan caucuses: the Nuclear Cleanup Caucus, the National Labs Caucus. And to a person, when we have had events—Ed McGinnis has been there, Secretary White has been there—just last week, Secretary Dabbar came to our kickoff of our National Labs Caucus.

Why was that important? It shows cooperation between the administration, the Department of Energy, and those of us in Congress. And it is mutual. The Department has done an excellent job in the area of avocation and education and the atomic wings program that I think Mr. McGinnis has worked so hard on. It has been wonderful.

We get people from industry, we get people from education, we get state and local leaders to come up here. And I think it is a shining example of how we can actually show our constituents at home how we really can work together and get things done. And it is—I wish we saw this more across Congress, but I am very proud to work with each and every one of you all, and I thank you for that.

Secretary Menezes, the Department of Energy is recognized for its unique set of scientific user facilities, managed by national labs that are accessed by thousands of university, government, and private sector researchers every year. In the case of the Office of Science, the program offices fund facility operations separately from research applications so that each user facility has base operating funds.

However, the Applied Energy Offices do not have a similar model for facility operations. The Applied Energy programs fund research, but the operation of numerous technology user facilities, especially at the national labs stewarded by the Office of Science, are not funded in a similar manner, oftentimes requiring lab overhead.

Mr. Secretary, as you examine plans, budgets, and infrastructure needs for the Department-supplied energy programs, has this come to your attention, sir?

Mr. MENEZES. Thank you for the question, Congressman. What has come to the attention of the Secretary, the deputy secretary, and both Secretaries Dabbar and myself is that we are trying to increase the use by the private sector of our wonderful national laboratories. And that is across all labs.

We hope to increase the excellence that is shown by certain labs over others. We hope that we can emulate what is working in the other labs, and we are looking very closely at this. Each lab is probably different from the others. Certainly just in the applied labs NETL is the only GOGO, for example, Government Owned,

Government Operated. There may be some issues related to that, say as opposed to, you know, to INL or NREL in the applied area.

But this is something that is frequently talked about at the Lab Operations Board. And we talk about it to how we can figure out how to increase the use and access of our great facilities, particularly the user facilities where it is just an invitation for those that have great ideas as entrepreneurs to come in and use our labs, really at cost, to do experiments and conduct, you know, the work that they think is necessary.

Mr. FLEISCHMANN. Yes, sir, and I appreciate your answer. To further define it or refine it, what is the Department's strategy for maintaining these technology user facilities and ensuring they remain state of the art, sir?

Mr. DABBAR. So, Congressman Fleischmann, yeah, clearly there is a number of different facilities across a lab complex that had a history of doing various operations and supported by various offices.

You know, clearly there was nuclear operations dealing with isotopes at Oak Ridge National Lab, which had a bit of a history there. There is actually nuclear operations at Idaho. There is also nuclear operations and hot cells at PNNL, just off the top of my head.

And I think it is a great question because I think what has happened at a number of these sites is that historically they were funded by one program or another, and over the course of time, as research shifts or, you know, different programs shift, that there is infrastructure there. And to your good point, sometimes the labs feel like they want to keep it going even though a particular program office of one of the two of us where the under secretary for nuclear security didn't cover.

I think what is actually important is for us to have good dialogue with the lab directors for them to say you realize we no longer are getting support from here or there on a particular facility. And then talk with us about the importance for us to maintain those capabilities and what they are going forward.

You know, I think we have to have a balance because, you know, if research changes over the course of decades, I think we need to be thoughtful about the taxpayers' money. But conversely, if something falls through the cracks between the various programs offices, it behooves for us, as well as the lab directors, to have that dialogue for us to know what is going on and see if there is something that should be covered.

By the way, we not only do that, you know, with ourselves, but with our fellow agencies, you know, such as DOD and others.

Mr. FLEISCHMANN. Thank you, Mr. Secretary. Madam Chair, I yield back.

Ms. KAPTUR. Thank you. Congresswoman Wasserman Schultz.

Ms. WASSERMAN SCHULTZ. Thank you, Madam Chair. Gentlemen, come down to my district in South Florida and you will see how my constituents are already feeling the impacts of climate change. Whether you are living in the South Lake or the North Lake neighborhood in Hollywood, Florida, in the town of Davie and numerous other places in my congressional district, you will see

fish swimming in the streets due to king tides and sometimes just a random rainstorm, even when it is sunny.

Broward County has already drawn new flood maps predicting higher waters. Fort Lauderdale has increased the height requirement for sea walls and raised the elevation of home sites. Miami Beach's climate plan involves building elevated roads and installing pumps to keep out saltwater intrusion. Owners of coastal properties are worried about sinking into the sea and about sinking property values. In South Florida we do not have the option of denying climate change because we deal with it every day.

And that is why it is so important to keep supporting climate science. Technologies developed and deployed today can help to decrease the risks for future generations and lessen the negative consequences of climate change.

Under the Obama administration, for example, we saw real progress on addressing climate change, including technology development. From 2008 to 2016, the cost of clean energy technologies drastically fell because of DOE-funded research. But under the Trump administration we have repeatedly seen proposals to gut the programs and regulations that support clean energy.

So my first question, if you could answer, both of you, yes or no, do you believe climate change is real, that we are already seeing its impacts, and that humans are responsible?

Mr. MENEZES. I believe the climate is changing and man is partly responsible for the changing climate.

Mr. DABBAR. I agree with—I say the same thing as Under Secretary Menezes voiced.

Ms. WASSERMAN SCHULTZ. So if that is the case, then why does this budget request slash DOE climate science programs by 50 percent? What do you view as the role for the Department of Energy in adjusting climate change? And how can DOE perform the innovation needed to address climate change with these proposed cuts to DOE's energy R&D programs, effectively eliminating the Office of Energy Efficiency and Renewable Energy?

Mr. DABBAR. Congresswoman, we agree that the Department is a leader, I would argue probably the leader in the world in terms of energy technologies and the accomplishments of the past leadership team and what we continue across the board in terms of research. To a very large degree, the DOE is just a very large research organization, and certainly from a dollar point of view it very much is.

Certainly if you take a look in your particular area, I know the utility there just announced a 409 megawatt battery that is connected with solar. It is the largest utility battery ever announced, lithium-ion, and it is economic. And they have to go submit that to the Public Service commissioner of Florida. And they are going to defend that actually that technology is cost-effective without any mandates or any support. It is very exciting what is going on.

Florida is really at the cutting edge, and obviously you have the leading renewables company in the world headquartered in Florida. And so they work a lot with Argonne, with PNNL, and others.

Ms. WASSERMAN SCHULTZ. But if you can answer my specific questions. Why does this budget request slash DOE climate science programs by 50 percent? Why are we eliminating, effectively, the

Office of Energy Efficiency and Renewal Energy? You are not suggesting that the private sector is going to be able to pick up the slack for all of the funding that the main driver of R&D and energy research has been?

Mr. DABBAR. No. Clearly DOE is the leader in technology development. I think it is very important to the country and the world. You know, budget decisions are based on priorities overall. I think as the ranking member mentioned, the budget priorities that were laid out were based on caps that are currently expected, that may or may not change.

What we do as an organization is for us to execute what you appropriate. And once again, whatever you decide to go appropriate, we want to do that in an efficient way as we promised in talking about the various dollar amounts.

Ms. WASSERMAN SCHULTZ. You are correct, budgets are an expression of priorities and values. And, unfortunately, this administration's priorities and values are clear as a result of their proposal.

Under Secretary Menezes, the budget request proposes an 86 percent cut to EERE, and this cut would effectively shut it down. The proposal is utterly ridiculous, and it is exactly the opposite of what we as a Nation need to be doing right now to expedite our transition to a clean energy economy.

It represents yet another step backward for American global leadership. And I couldn't get Secretary Perry to give me a straight answer, as sweet as he was in the exchange, so perhaps you can.

Why would you propose such a backwards budget cut? And it is clear that Congress is not going to implement these severe cuts to EERE, so why do you keep proposing them?

Mr. MENEZES. Well, on the keeping proposal, you know, we are basing this year's proposal off of the fiscal year 2019 request, and so the budget caps—so we have an overall reduction, if you will. The goal was 5 percent, so that is in that context.

But specifically with EERE, first of all, we are committed to continue to fund the funds that we have, both from fiscal year 2018 and fiscal year 2019, and any obligated funds are out there. So those will continue to be spent.

With respect to technological advancements that Madam Chair had referred to that this office has achieved over time, it has really been nothing short of remarkable. In fact, it has been so remarkable that these technologies have been pushed out into the private commercialization and they are fully deployed, essentially, at this point. I read a survey recently that predicts that 86 percent of private companies are predicting that between this year and 2030, \$500 billion will be invested in renewable technologies in the U.S. alone, and a significant number of them are predicting that by 2031, a trillion dollars will be invested by the private sector into these technologies.

Now, while a lot of this funding goes to making photovoltaics even, you know, more efficient, it is interesting we see, when you go to NREL and you see what they are doing, while they are doing great work with photovoltaics, the real breakthrough is the liquid crystal and perovskite, for example, where it is not hard to imagine that the future will not be photovoltaics, but they will be in the

windowpanes, in the glass structures, in the shingles, in the building technologies themselves generating electricity.

And even more importantly, like when we work with countries like India, to bring electricity to 300 million of their people, imagine that you are able to put this new technology on a Mylar balloon and be able to generate electricity in remote locations in such countries.

When we say basic research, that is the kind of thing that we are hoping to break through.

Ms. WASSERMAN SCHULTZ. My time has expired, but I do hope you realize that you have just made the case exactly for why we shouldn't be severely making the cuts to this office. I appreciate you doing that for me. Thank you.

Mr. MENEZES. You are welcome.

Ms. WASSERMAN SCHULTZ. I yield back the balance of my time.

Ms. KAPTUR. Thank you, Congresswoman. Mr. Menezes, I am going to ask some questions that every American will understand and ask you to comment. And if you cannot answer, to provide for the hearing record more comprehensive answers.

These are what you might know about innovative technologies that impact the grid in every community; the provision of water and wastewater; and thirdly, homes, dwellings that people live in. I am going to ask you who and where, and have you ever seen best practices and the most innovative or low-cost technologies for the following areas?

Number one, if I were to go anywhere in this country and try to find the most breakthrough electric grid transmission, who is leading the way in developing the most efficient and cost-effective transmission lines that might be 100 percent efficient from point of generation to point of use? Do you have any sense of that? That is question one.

Number two, many of our cities, I represent several major cities, are paying a boatload of money. Cities that are having trouble paving their streets, paying a boatload of money to process water for fresh drinking water, and managing their wastewater and bio solids associated with that. Who, if anybody, in America is leading the way in creative and innovative approaches to providing, to producing electricity to perform these functions and making it the most efficient so that those dollars can be dedicated to other prime purposes in these places?

And thirdly, who in America is building net zero homes and buildings? Yes, we have LEED certified. But I have heard that there are companies in the West in particular that are building net zero homes, extremely energy efficient. Actually there is no power bill once the investment is made in the structure itself.

So could you think about this, and do you have any comments on that, the grid itself, water/wastewater treatment and dwellings?

And then on another tack, electricity prices vary by region across our country, and the price of electricity is a huge factor in, for example, manufacturing. I have a heavy manufacturing region that I represent. It is very different than cornfields in Kansas. And it is my understanding that electric power prices differ in regulated and unregulated markets. And I am curious as to the Department

of Energy's knowledge about how electricity prices impact manufacturing costs and thus economic competitiveness across our country.

Is there a way for you to drill down in the Department and get us some comments on that?

So why don't we go to very practical applications that most Americans are aware of: the grid itself, water/wastewater treatment, and the associated electricity bills, and, finally, net zero homes and buildings.

Mr. MENEZES. All excellent questions and excellent topics. Certainly from the Department we are probably doing something in each of these areas on the grid transmission. EPRI, you might be aware of the EPRI, the Electric Power Research Institute. You know, they study the grid, the technology that goes into the grid, the wires that are actually used, and they work well with our labs, including Oak Ridge and others, INL Labs, to develop a much higher efficiency, you know, gauge of wire, for example. Okay. And that could eliminate transmission by a third, for example.

Ms. KAPTUR. Do you know that exists anywhere in our country? Have you seen it deployed?

Mr. MENEZES. I think there is some direct current. Yeah, so.

Ms. KAPTUR. I didn't hear that.

Mr. MENEZES. Yeah, he said that we have some direct current and superconductor work that is being done on our grid today.

Mr. DABBAR. Yeah, maybe I will comment a little bit further on the kind of efficient use of transmission. I think one of the leaders in this area is at Pacific Northwest Lab in Representative Newhouse's district.

One of the interesting things about the electric grid is there is tremendous amounts of data about how do you optimize the transmission lines and how do you get power to the right place at the right time. And also how do you identify problems before they become problems, and including trips associated with substations? It is obviously a major issue in California at the moment.

What we are working on, and actually have up and working strings of development, is on artificial intelligence and machine learning for the grid operations to optimize when you dispatch power plants and identify when weather is going to come in, when the wind is blowing, and how much wind is going to go and how much water is behind all the dams. This is tremendous amounts of data; and how to give recommendations to the operators who run the transmission grids.

I think as you probably know, the RTOs and the transmission systems, historically, have been a bunch of humans sitting in a room taking a look at dials, trying to figure out the best way how to optimize the transmissions lines, you know, the question you asked.

The reality is there is tremendous amounts of data over history of all those different areas, all those different data points. And the development of AI or a machine learning algorithm could give recommendations to that RTO and MISO or PJM in Ohio to say it is better, you know, to do it this way or that way, to reduce a potential trip, which obviously there was one that happened in Ohio about a decade ago.

Ms. KAPTUR. Thank you for knowing that.

Mr. DABBAR. And also how to increase the efficiency, which was your question. So we actually have a great amount of using AI and supercomputing on how to develop this, and how to work with RTOs to try to roll this out to other grids across the country.

Ms. KAPTUR. I am not disagreeing with what you are saying, you are using the existing system. I am looking for places that have innovated and have a much more efficient—they are building a much more efficient system. Has Long Island done it? You mentioned the Pacific North. Is there any place where a new town has developed where there is grid functions in a different way for those who work or live there?

Mr. DABBAR. Well, one place which is clearly at the cutting edge is I think a number of towns in California. This gets into a much larger conversation. But what is actually interesting about what is going on with distributed generation in batteries, especially in homes with electric vehicles, that whole kind of complexity which is beginning to happen. California, in particular, is at the cutting edge of that just because there is more electric vehicles, more homes with solar because it is sunny.

And it is actually a little bit less transmission than it is the distribution grid. So being efficient with all that distributed load, the load moving because of electric cars, batteries at homes, solar at homes, and how that integrates with an IT system and how to allow that to work, is very much a work in progress. It is very interesting.

Let me give you one interesting data point that they are looking at in California. They are looking at that if you have solar on your home in California, how you can trade it with your neighbor where you want to buy, like get a carton of eggs from your neighbor and you can buy it for a certain number of kilowatt hours. And what they are looking at is using Venmo to actually trade between individuals on the system, and how to—from a regulatory point of view, is actually to use a peer-to-peer system to trade electricity. They have not done it yet, but they are actually looking at whether they would allow those sort of, you know, kind of retail apps to allow people to be more efficient about the sort of resources that they control.

Ms. KAPTUR. Thank you very much. We will look for further—yes, Mr. Menezes.

Mr. MENEZES. Yep, and if I could just add one thing. Assistant Secretary Walker reminded me of one of the things that we have requested is to fund the North American Energy Resiliency model that we are doing. This arose out of the work that we did with Puerto Rico, which started as a static modeling project through our Grid Modernization Initiative, where we got the labs to help model their electricity system. So, this is a great opportunity to step this up for the North American model. We do not have that model today. This model will do precisely—will analyze our current energy system writ large, both in the U.S. and Canada, and we will be able to—as we put additional sensors on our current system, we can begin to see how it functions, and where efficiencies can be improved.

We can—we hope it will take—what is it, a 3-year process, probably?

Mr. DABBAR. To make it real-time, yeah.

Mr. MENEZES. Yeah, to make it real-time, but this is where we are going to bring the best new technologies where they should be on the system to ensure that it is resilient, and that it can operate in a very efficient manner. It is very likely that we are going to achieve savings to where, you know, the current amount of reserve capacity that you might have, just in the normal operation of your—of a utility, would go to be—to lessen that a lot. That will ratchet out of the current system a lot of efficiencies and cost savings. And this gets to your last point about how it is that you will be able to save, ultimately, drive down the cost for your constituents that use large amounts of power to be able to, you know, to manufacture or to do the industrial work that they do, and it would also apply to commercial.

Ms. KAPTUR. Thank you very much. I have gone over time, and Mr. Newhouse.

Mr. NEWHOUSE. Thank you, Madam Chair, and I apologize for stepping out. You were talking about the future, Paul. A class of high school students in front of the Capitol steps took precedent over you guys. Sorry.

Mr. DABBAR. And you missed me talking about how wonderful PNNL is.

Mr. NEWHOUSE. Oh, well, go on.

Mr. DABBAR. Sorry.

Mr. NEWHOUSE. Well, welcome to both of you, and I appreciate you bringing such a large contingent from DOE here today. That means a lot. Let me just get right to my questions.

Some of your testimony, I heard both of you, and it brought a lot of things to mind that I would like to visit with, particularly some of the milestones we are meeting at—on the Hanford Reservation, exciting stuff, but also the carbon capture that you mentioned. I was just down at—saw Petra Nova, myself, last weekend. So, lots of good things happening in your world that I appreciate you coming in and letting us know.

Secretary Menezes, last week, when Secretary Perry was here with us, I was able to ask him about the newly proposed grid storage launch pad that is going to be hosted at the Pacific Northwest National Laboratory in my district. I would just like to get a little bit deeper into that with you, if I could.

I am glad to see the Department is looking into PNNL to see how it could further accelerate the development testing and validation of energy storage technologies for the grid through this launch pad effort. As you know, PNNL has emerged as a leader in the area with one of the largest concentrations of expertise in advanced grid scale energy storage technologies in the world. You also may be have not heard that the Washington state legislature is currently looking at robust investments in this effort as well, which I think is—speaks well for the importance of this to our area and to the Nation.

Now, I certainly strongly believe that the Department's best successes are the result of focused research with clear outcomes. It appears the Department believes that these goals are an important part of this initiative. I would just like to ask you how did the Department make decisions regarding this specific research and goals

that are included in this initiative, and you—can you talk about some of the opportunities you see to advance this important technology?

Mr. MENEZES. Thank you for the question, Congressman. Indeed, as Secretary Perry has said, and Assistant Secretary Walker has said, the next big breakthrough, and I myself have said, the next big breakthrough is energy storage. We need to develop energy storage because as we are modernizing our grid, making it more flexible, and bringing on intermittent resources more and more, we need to be able to up the storage from the devices that we use up to grid scale, and that is going to be the big breakthrough, and it is very challenging, but we have identified that as our big commitment. That is where I think that we can bring true changes in the way that we provide electricity across this country.

Specifically, on the grid storage launch pad, you know, this is aimed at accelerating materials development, testing, and independent evaluation of the battery materials and the battery systems for grid applications, and that is what we are committed to. That is where we are focusing our resources.

Mr. NEWHOUSE. Good. Excellent. And, like I said, with the excitement being generated, along with the state of Washington, I think we have some real potential here, but thank you.

Mr. MENEZES. Well, I want to also share in the compliments with PNNL that Secretary Dabbar had said in your absence, and so it is a lab that our offices use quite frequently and not limited to the things that Secretary Dabbar mentioned, but also in cybersecurity, having developed, you know, really the first Cyber Risk Information Sharing Plan, CRISP, which actually gave rise to being so successful and sharing it with our energy partners that Congress saw fit to name Department of Energy as a specific agency for energy, for cybersecurity. So, you know, that was done at PNNL.

Mr. NEWHOUSE. Hmm. Hmm. There is some critical work being done. Every time I go, I am amazed at the things I come to find out they are working on.

Mr. MENEZES. Oh, and I have not had the privilege of visiting the campus proper—

Mr. NEWHOUSE. Mm-hmm.

Mr. MENEZES [continuing]. But I have been to the Seattle office—

Mr. NEWHOUSE. Mm-hmm.

Mr. MENEZES [continuing]. When we were doing our XLabs, which is something else, I think, that the committee would be interested in. You know, under the leadership of the Secretary, but also pushed, in large part, by Undersecretary Dabbar, we have launched these XLab initiatives. And the goal here is to help educate people as to what we do at our labs because while you all know very well what we do at our labs, and the people who live in the states where our labs are located, our job is to try to get everybody across this country to really know and identify our labs as true, you know, treasures of this great country. And so, as a way to bring out the message, so to speak, we have had two XLabs. The first one was in Silicon Valley on storage. It attracted many, many folks from all over the country. That was a big success on lessons we learned there. We then had the next one, and PNNL really put

this one together. It was done in Seattle, and that topic was the grid modernization.

Mr. NEWHOUSE. Yeah.

Mr. MENEZES. And so it, too, attracted experts and interested parties from all over there, and it highlighted the work of our labs. And then the next one that we are going to have is for advanced manufacturing at Oak Ridge, or maybe Knoxville if not at Oak Ridge, itself, but, again, we are going to bring people in. They will see it. It will include, you know, the knowledgeable science—scientists. It will be people interested in investing in it, and it is a good public-private venture with DOE sponsoring this, and your labs are playing a key role in putting these things together.

Mr. NEWHOUSE. They absolutely are, and I am glad that I was able to allow you to have some time to talk about the labs, that they truly are the jewels of the country that a lot of people are not aware of the important stuff that happens there. So, thank you for pointing that out.

And with that, Madam Chair, I will yield back.

Ms. KAPTUR. Thank you. Congressman Simpson.

Mr. SIMPSON. I saw Congressman Fleischmann. His ears perk up when you mentioned Oak Ridge and Knoxville. And Congressman Newhouse is correct, the labs across the country do some incredible work that the general public does not understand, that is very important. I do not feel like I should have to say this, but I will because of my dear friend from Florida's comments, and she is a dear friend, but the President proposes a budget and it has to be according to the law, and the law is sequestration. That means some ugly choices have to be made.

Every president I can remember has always cut down about \$2 billion in the Army Corps of Engineers, knowing that Congress is going to put the money back into it, but that frees up money that they can spend somewhere else and plus-up their priorities and that kind of stuff. It is not that the President does not support EERE or ARPA-E or climate change funding or any of these other things, but he has prioritized with a limited amount of resources.

To tell you the truth, I have often wondered why a president does a budget because I do not really look at the numbers. I do not really care what the numbers say. We are going to make those final determinations about what the numbers are in the various programs. For the last couple years, they have cut down EERE in their budget proposal. Guess what? That does not happen. We put money back into it and fill those accounts back up as Congress sees fit.

The reason I look at the President's budget is because they sometimes have interesting proposals, like moving FUSRAP from the Army Corps of Engineers to the Department of Energy. Does that make sense? So, I mean, some of those proposals are what are the most interesting part to me, but on to my question.

If anybody asked me what keeps me up at night, it is our grid security, and what a difficult and challenging process that is. Ms. Evans, you have an enormous task on your hands with grid security. It is complicated. It is hard. It is diverse. And much of our grid is privately owned. And when I have looked into this over the

last couple years, one of the challenges is the threats. You have security clearance.

Now, you are going to go out to a utility with a CEO that does not have security clearance. How are you going to convince them of the potential threats that are coming in? And how are we all going to all get on the same page of protecting the grid? And then, exactly what are we going to do to protect the grid? Do you want to respond to that, or what are we doing for grid security in this country?

It does not have to be a nuclear bomb that takes us out. With several well-placed adverse intentions, they could take this economy through the floor by taking down our grid. How are we protecting against that?

Mr. MENEZES. An excellent question, and one that we spend an—all of our time thinking about. It is—

Mr. SIMPSON. Let me say, I realize much of this. Hopefully, we will be able to set up a classified briefing because a lot of the information is classified. But what you can tell us here?

Mr. MENEZES. Right. First of all, it is an all-of-government obligation and effort. So, we work with our other agency partners and, as you mentioned, a lot of this is on the intelligence side, you know, as well as our own office, which is outward-facing, working with industry. You know, we have the ESEC, the Electric—the coordinating counsels, both for electricity and oil and natural gas, and all of the industries, all of the sectors, telecommunications, and finance. So, it is a collaborative effort to identify the threats.

We have in place technology. I have mentioned CRISP that had been developed at PNNL. Now, this is generally on IT. We have expanded our machine-to-machine learning and artificial intelligence and our modeling to look at the operational technology side of the equation. So, historically, it has been IT. You know, you think of your phishing, but, now we are—now the threats are moving toward the—for the operational technology side of it, the industrial control systems, the SCADA systems that we use—that are used ubiquitously, you know, across our country. So, we have been identifying those threats, and we have been having secret briefings with members of industry, so that we know whether we see something on their system or, frankly, they see something on theirs, and they can share information with us.

These threats are growing in number and sophistication, and you can just open up the paper and read about it, whether it is Huawei or ZTE. We react to those things.

At the Department, we have a chief information officer. His job is to make sure that our Department, enterprise-wide, goes through a risk assessment. And when we reach an intolerable level, if we are using any of the devices that may be compromised through the cybersecurity threats, we share that information as promptly as we can with our industrial partners.

So, we work with—we have a worldwide threat assessment that comes out from ODNI. We follow that. We implement that. We monitor that and we react accordingly. It is—you had mentioned about the potential threats. You have heard many experts say that we may never see the use of another kinetic weapon because the weapon of today is really the cybersecurity threats that we have.

And we know from published reports that our energy system, the U.S. energy system, is targeted. So, we take it very seriously.

We set up the Office of CESER. You and your staffs have been working very well with us, and know that what we are setting up is working together with DHS, DOD, and the intel community, but we take the responsibility very seriously that you saw fit to give to us, and that is what we are committed to doing. Going forward on this, the key is to be able to get the data.

Secretary Dabbar talked about data. We are awash in data now, but that data contains a lot of good information. So, we need to develop the techniques and the tools to be able to analyze that data. Now, it needs to be anonymized, so that, you know, we do not have access to information that may be proprietary or anything, but the industry knows that it is in their best interest and, indeed, the best interest of the United States, to be able to get that data together.

We can run our analytical tools; CRISP is one, Coyote. The operational technology evaluation that I had mentioned in the past is going to be part of it. And that is going to be our tools of the future that we are developing to be able to ensure that our grid and our energy system is secure as it possibly can be, and that it is resilient.

Mr. SIMPSON. Is it still a challenge having the private sector without security clearances, working with them, trying to get information to them?

Mr. MENEZES. Well, the security—granting security clearances, you know, is a process that goes beyond the Department of Energy.

Mr. SIMPSON. Oh, believe me, I know.

Mr. MENEZES. Okay. We are doing what we can to get the clearances for DOE, but when you need to share with them information that may come from other agencies, you know, they own that information, and so it is up to them to really grant the clearances, but it is a process. But we are committed to move those as expeditiously as we can because, as you said, it is one thing that we can share it with them. We tend to have to share it at the secret level. I cannot go beyond that and then they cannot—still cannot talk about it, but we hope that they can then make decisions—

Mr. SIMPSON. Yeah.

Mr. MENEZES [continuing]. As to what to do about it. And that is why, significantly, we at DOE are sharing with them. When we make a decision that we cannot use a certain software product that we might use, or a certain industrial control system that we may have on the enterprise somewhere, when our risk tolerance is too high, we share that information. So, that is another way, not that we do not order them to do anything, but sharing the information allows them to make the decisions.

Mr. SIMPSON. I know that Florida Power—you worked for Florida Power to do some work down there when there was a threat assessment, but it only really occurred because of the personal relationship between the CEO of Florida Power and somebody in DOE.

Mr. MENEZES. Yeah, right?

Mr. SIMPSON. They knew each other before, and they could, kind of talk and trust each other. We got some problems here, and talk to them. We need to somehow overcome that, but I appreciate your work on that. And I would like to set up sometime in the future,

maybe when we are done with this crazy budget cycle and we have a little time, I would like to come down and do a classified briefing with what is going on in that arena. Thank you, Chairwoman.

Ms. KAPTUR. Thank you, Mr. Simpson. We will work with you on that. Congressman Fleischmann.

Mr. FLEISCHMANN. Thank you, Madam Chairman. Secretary Menezes, you were correct on two fronts. The Oak Ridge National Lab actually does run the manufacturing demonstration facility, but the facility is actually located in the city of Knoxville. So, they actually went off their reservation.

Mr. SIMPSON. Are both in your district?

Mr. FLEISCHMANN. Well, no, but we fixed that. Oak Ridge National Lab was kind enough. Very astute, Mr. Chairman. Oak Ridge National Lab has now formed a partnership with the Electric Power Board, our great utility, EPB, and is now in Chattanooga as well. So, ORNL is doing well across the state, and, yes, thank goodness, Chattanooga is still in the Third District.

Secretary Dabbar, thank you. The Department proposes to make significant investment in the research and production of stable isotopes in fiscal year 2020, isotopes, both radio isotopes and stable isotopes for medical and industrial applications are one area where the Department of Energy, Oak Ridge National Laboratory, and other national labs have had an incredible impact, including lives saved and billion-dollar impacts on the U.S. economy.

I discussed this with Secretary Perry last week, but I am interested in your perspective as well, Mr. Secretary. I will ask four questions.

Why is the Department investing in stable isotopes now? Does the United States have any capacity to produce these isotopes currently and, if so, where? How would the proposed Stable Isotope Production and Research Center help address the growing demand for stable isotopes and facilitate research on the beneficial use of stable isotopes?

And lastly, sir, the Basic Energy Science Advisory Committee, or BESAC, was recently charged by the Department to provide input on the long-term strategy concerning HFIR, the High Flux Isotope Reactor, at Oak Ridge National Laboratory, which is among the highest flux reactor-based neutron sources in the world. How critical is HFIR to the future of isotope reduction? Thank you, sir.

Mr. DABBAR. Thank you, Congressman. So, as Congressman Simpson mentioned about budgets and about priorities, and taking aside quants of dollars, that actually in the Office of Science you have actually six areas that were increases or new line items, and I think gives the signals, one of them is in isotope production, where we are actually requesting an increase for that. And let me talk through that, because it addresses your questions.

Clearly, the Department is a leader in the production of isotopes in the country. It comes from a history of the nuclear program and obviously the history of the national labs.

And the Department runs a very well-honed, almost business in isotope production. It is done for a mixture of decaying isotopes that are mostly medical, although certainly supportive of the oil and gas industry and log wells and so on, and also stable isotopes.

To talk about the decaying isotopes, mostly for the medical community, the leader—our headquarters for that is at Oak Ridge National Lab. But what is actually really important is that we actually have started a process that has been going on for a while, but we are really enhancing it, across all the universities in the country with all the research reactors and accelerators that are at hospitals on how to coordinate to figure out some 40-odd isotopes that we produce at the DOE, and the 20 or so that we have under research, in large part, for the medical community.

Ohio is actually, because of the medical focus of Ohio and such at the great universities and the medical institutions in Ohio, there is actually a—a strong part of our partnership is across Ohio, is how can we produce some of it at HFIR at Oak Ridge? How can we produce some of it at the research reactor at the University of Missouri? How can some of it be produced at accelerators at specific university hospitals in Ohio and elsewhere?

And so we actually provide the leadership across all these different institutions, and we actually meet with the medical community and try to figure out which isotopes should we increase production on and why, based on demand pull of the medical community.

And we meet with doctors across this country as they try to convince us that for the next trials, for the next cancer to go after, about which isotopes to try to basically convince us for us to put our R&D in, to put our dollars in that you give us, to try to help with the next set of trials.

It is a very exciting part that many people don't realize the DOE does. It is a very important part of the medical community.

Why should we do it? I have sat before, you know, the House here before, with former—not former, medical doctors, who talk about isotopes that they couldn't get in the past. We took that very seriously as we listened to Members of Congress about that, and we actually came up with a plan, and it is not a lot of dollars. But how do we increase some of the production capabilities in order to address some of those lacking availability for the medical community, and which are seen in our budget is a focus on that particular priority, and I think it is important for the country?

The second part that you talked about was about stable isotopes, which is actually different than the medical side. There is obviously many different aspects of stable isotopes, including for our DOD and other friends that are in a bit more of a confidential, you know, topic.

We identify from our various demand polls, including from the confidential side that was important for stable isotopes, it is a lot of the same capabilities that we do for isotopes that are radioactive or that decay, and we do a very similar analysis. Clearly, a leader in that is Oak Ridge, but there are others who deal with that across the complex.

Mr. FLEISCHMANN. Thank you, Mr. Secretary. I want to thank you all for this great hearing. And Madam Chairman, I yield back.

Ms. KAPTUR. Thank you very much. Following up on the isotope capabilities, we had the director of Brookhaven before us several months ago. And I was talking about all the research that has been going on in the human brain. And the confluence between what

NIMH does and the Department of Energy, and how—and the director spoke up, the lab director saying, do you know, we might have something at Brookhaven that makes a difference in unwinding what is going on in the human brain as a circuitry.

In trying to understand both the physical and chemical reactions occurring that cause such conditions as bipolar, schizophrenia, schizoaffective disorder, there is a whole range of conditions that medical science really doesn't completely understand.

But I have looked at some of the light imaging machines that DOE has been involved in helping to develop in the medical field, you are talking about cancer.

But in terms of brain imaging, and this kind of comes along with my interesting concussions and what is going on inside the skull, in the human body, to your knowledge, well, and also with the pharmaceutical engagement with some of our light machines, light sources, trying to understand.

Let me give you a practical problem. If you are at the university hospitals in Cleveland, Ohio, and you have been diagnosed as mentally ill, and maybe the sheriff brought you over there and the doctors are trying to figure out what is going on, and you don't come from a family that has health insurance, you fall under Medicaid.

And there is an unwritten rule that, well, you can't afford medicines, so we are going to give you the generics. And within our pharmaceutical industry, this was a perfect generic, it is equivalent. Equivalent, but it is not efficacious.

And so, someone who may have been stabilized at some point in their life on a brand name pharmaceutical product is devolved, because they don't have enough money, to a generic that is equivalent, they say, but efficacious. So how do we use the light machines of DOE to figure out, and the law says that you have to be within, I don't know what it is, 85 to 95 percent of what should be 100 percent equivalency?

So, you don't even have to be 100 percent, and somebody gets sick again, so they end up back in the sheriff's jail or the emergency room, and the whole cycle starts over again.

This costs America, I guarantee you, billions of dollars, because we have repeaters.

I was in hospital in Chicago, outside of Chicago, where it was the 19th readmission for a particular veteran. So, the costs on the VA are huge, the costs on civil society are huge. And I keep saying to myself, we have got these pharmaceutical companies coming into DOE. They are testing the chemical organic formulation, and we have got evidence on the medical side that, do you know what, we get this wrong a lot of the time.

So, how can we work with you and NIMH? Where do you have strengths? You might not be able to answer my question now, but, boy, could we make a difference for the world if we could figure out, from a chemical standpoint, what is going on, what is going on with the existing medication, with the knockoff brand, or whatever.

And I guarantee you that I have been told in all my meetings on opioids up here, half the people who are addicted in this country to horrible things are mentally ill. So, imagine that. Imagine that. So this is a national problem, and you say, well, this is the Energy

Committee, what do we have to do with that? Well, do you know what? We have got 60,000 out there brilliant, brilliant people. I think we ought to contribute something to the solution.

Mr. DABBAR. So, Chairwoman, let me describe within the context of that problem set the sort of capabilities that we have.

Ms. KAPTUR. Good.

Mr. DABBAR. So, I think there are major kind of pieces of capabilities that fits. One of which you touched on, which is light sources, which allows us to take a look at the efficacy of a drug on a particular problem. The other one is computing. Let me start with computing and then I will come back to light sources.

So, one of the things that we do with the top-end supercomputers in the world, top-end AI in the world, is taking a look at trial data and identifying what within trial data is working and not working, and how to actually help develop trials.

And so you talked about traumatic brain injury. What we are actually doing with traumatic brain injury is that we have identified that there are significantly more markers than people thought in the past, and how can we use an AI supercomputer to go through massive amounts of traumatic brain injury data in terms of people who have had problems, whether it is soccer or the military or in the NFL. And to see what sort of trials should be actually set up to identify whether a particular drug or treatment works. That sort of thing that we are doing for TBI could be done for anything.

You know, for any of the things that you talked about or many, many, many others, using that same framework that we were—you were talking about San Francisco and the NFL. That is actually what we were doing with that particular one, which is taking a look at markers, treatments, and looking at data to identify what works and doesn't.

And so you can apply that to the problem that you just mentioned, it could be done to vast amounts of the life science community.

I will give you another data. It is a little bit off, but I think a really interesting one. One of the things that we are doing with one of the big biotech companies is that we have been working a year on this. It is that they gave us all their failed trial data for decades.

Now, I think, as you know, many of the drug treatments that we come up with are actually ancillary to the original reason why the trial was done on the drug. Right? We thought it was for cancer, but it turned out it was good for blood pressure. Right?

And so what happened is that before there was all this computing power and AI capabilities, many times these trials were done and they said it failed. Well, in reality it actually succeeded, but they didn't catch it on a particular aspect. And so we are working with one company who has given us decades of their—one of the large pharma companies. And we have gone through decades of their trial data, and they have uncovered a massive amount of things from their failed trial data that they never thought they would find.

So, once again, you can apply that to taking a look at trials or taking a look at treatments that are done. If you have enough data and, you know, whether it is a drug efficacy, and you were talking

about, Chairwoman, or any of the other like different types of treatments, you know, different types of drugs that could be applied broadly.

I will go back to light sources. That was computing. Light sources are clearly a major tool and, as I talked about earlier, could easily be applied to taking a look at the efficacy of any particular biotech drug.

So if there is a question about whether a particular drug is actually working or not, for some of the reasons that you ask, we have the capabilities to do it. Now, once again, we are not a life science, you know, area. We do support life science research.

So, you know, we have the capabilities, and if someone wants to come along and say, we want to do research of whether this biotech drug has efficacy, and we think the light source that you have at X-Y-Z lab would be useful.

You know, the answer from us would be yes, and we have got to schedule it, and so on. Yeah, absolutely, Chairwoman.

Ms. KAPTUR. There will be more follow-on from me on that. I wanted to—I have gone over time here. I wanted to give Mr. Newhouse a chance here.

Mr. NEWHOUSE. Thank you, Madam Chair. No problem. A very interesting topic.

And a question for you, Secretary Dabbar. As you are well aware, we have got a huge challenge with the Hanford cleanup, not the least of which are some of the many technical challenges that we face there that the site contractors are addressing and must address as they continue their work in the cleanup effort. But also, as probably many of us in the room also know that the Hanford site is incredibly complex, and success in this effort is going to also depend in large part on making sure we have a robust workforce that is maintaining and enduring site-specific expertise and continuity.

The lab serves a critical role supporting DOE and many of the site contractors on the technical challenges at Hanford. And again, as you are aware, there are several significant transitions taking place in the coming months at the site.

I understand that while I stepped out you brought up the idea of maintaining capacities, and that is what my question is about. I simply wanted to be certain that you and the Department are paying attention to maintaining and enduring capabilities at the PNNL through this transition, something that I am tracking, we are tracking in our office, because it has a great impact on the continued efforts at the Hanford site, and just would welcome any thoughts that you might have on this issue.

Mr. DABBAR. So, as I like to talk about the complex, it is wonderful to talk about large facilities, like DFLA or light source or so on, but the reality is the reason why we accomplish what we accomplish is because of the people. And it doesn't matter what the site is in Idaho or Oak Ridge or at Hanford, it is the people. And I want to make certain that we understand that.

When you talk about the workforce at Hanford, the workforce at Hanford is the reason why things work, or there are challenges, and that is why we really want to make certain that they are trained.

I am going to go give my annual, you know, sit-down at the meeting with HAMMER which is a training facility. One of the exciting—you know, when I look at every site, every site has its unique positives about how the local community contributes. And what I like to talk about Hanford, about what it is about, you know, what is unique about Hanford, is that the engagement with the unions, and the energy and the focus that the unions have on training, on safety, on the workforce is unique across the complex.

And as the leadership team, the Secretary, myself, and right here behind me, is extremely focused on that. We pushed OMB to get additional funds that had not gotten out of the executive side, the Department to support, the needed investment at HAMMER. And we got additional funds this last year with our engagement with OMB, and I very much enjoyed calling up the union heads and telling them that we got additional funds.

And I look forward to going to the House of Labor, to AFL-CIO Headquarters here next week, sitting down with them to talk about workforce training with all the union heads from Hanford and to talk about the importance of that for us as a leadership team.

Obviously, you all fund it, so you all show that by your appropriations, but we do it by our execution and our advocacy. And I look forward to sitting down with all the union heads from Hanford here in Washington at the AFL-CIO next week.

Mr. NEWHOUSE. Great. Great. That was the answer I was hoping to hear. Certainly, one of our best natural resources are the human resources we have. And so I appreciate your recognizing and your intentions on that. Thank you, Madam Chair. I yield back.

Ms. KAPTUR. Thank you, Mr. Simpson.

Mr. SIMPSON. It has been interesting. And as I think we have mentioned earlier about the competition between sites, you know, a little competition is good. But I can tell you, if 20 years ago when I came here the competition between sites of the project was being proposed, we would all be fighting each other to get it at our site.

You know, whether that was the right place to do it or not—and I think most of this, it is coming to the conclusion that if DOE proposes something, I want it done where it is right.

If it can be done at PNNL or Idaho, either one just as well, I will fight for Idaho and he will fight for PNNL. But if PNNL is the right place do to do it, I am not going to try to steal it from—and you see that within the lab directors, they are working together much better than I think they ever have in the past, which is a benefit both to us on the Appropriations Committee, and to the labs in what gets done. So, that is a very important aspect.

One other thing I did want to mention is that when we talk about cybersecurity, we are not just talking about threats from foreign nations. It also includes how you harden our energy systems against EMPs and GMDs and those kind of things, because those are natural that are going to hurt or that are going to happen, and we need to figure out a way to harden the systems.

But the question I am going to ask is, Under Secretary Dabbar, DOE's contract management for the National Nuclear Security Administration in the Office of Environmental Management, continues to be highlighted as high-risk areas by the GAO.

Specifically, the GAO noted a concern that EM has not identified the root cause of its contract and project management problems.

And until that is done, it will be challenging to develop an effective action plan. What steps have we taken to address this concern?

Mr. DABBAR. Yes, Congressman Simpson. This has been a particular focus to talk about contracting. I can talk about this for far too long. But one of the things that the Secretary identified and us as the leadership team in the EM realm, myself, Assistant Secretary White behind me, was how to actually focus on contracting that would actually get to an end state and get to cleanup.

It is important for us to invest in local communities, but the EM program is to reduce risk and to indicate cleanup. We focused a lot on what worked in the past and what was not working here today.

I think Idaho works very well, but there are some other challenges that happened. In particular the waste treatment side of the Office of River Protection, the major plateau in Hanford, in Congressman Newhouse's district. That is the main challenge of the EM complex in terms of both the scale of the complexity.

What we decided and we are in the process of executing on this, and I think GAO should hopefully see that because we are in the middle of the execution, when it comes around next year, hopefully they will, is that we are looking at changing the contracting structure to focus on in-state contracting. That is to actually incentivize and to focus the contractors on getting the work done, getting the cleanup done. To a large degree it was done once at the EM complex. That was done in kind of early 2000s, and that was on Rocky Flats. I don't know Rocky Flats very well, amount of the TRU that—

Mr. SIMPSON. You have Rocky Flats success.

Mr. DABBAR. And in Idaho, which we are, of course, very focused on, on getting that moved. As you know, it is the number one priority for movement of TRU for the Department.

But how do we take the success of contracting that worked really well at one complex site, and succeeded at Rocky Flats in Colorado, and how can we take a look at that contract structure and move it to other places?

We are in the middle of doing that right now. The very first bids on in-state contracting using that successful model, we have taken bids at Hanford. And we have a whole team under Assistant Secretary White of doing contract by contract about how do we focus on getting things done.

And that is what we are doing. We are very excited about that. It is a major focus of the Secretary as he came in, and he said looks like things are not working in a number of particular areas, in particular at Hanford, and we want to change things out. And contracting is a major focus of what we are doing.

Mr. SIMPSON. Well, I certainly want to see DOE off the high risk list, as I am sure you would to.

A couple other things. One is we already talked about small module reactors, you did, and the importance of that. And we want to make sure that that continues because this test we are doing with VAMPS and other things has got to be successful. So that is a very

important aspect and we will be looking at that in the budget request.

I have talked with other agencies that report. I talked with the Secretary about HALEU and why the Department is pursuing several different avenues to develop this fuel. But I want to bring up something that was not on my list, but it is certainly something that I would like to see pursued by the Department, and we started to do this at the last of the Obama administration. That administration has changed and it kind of got dropped and left in the way-side.

Every DOE site is treated differently when it comes to payment in lieu of taxes. Some sites pay the local communities money. Of course that is money that comes out of cleanup at Hanford and it goes to the communities there at Richland and other things. And the reason that this came up is that I had to sign a reprogramming request where they asked for a whole bunch more money because the county commissioners had decided to assess that property there as if Hanford never existed, and that it would be wineries now.

And so they were getting a whole bunch more money in Hanford. Some sites don't do any of that. But it is up to the local DOE site if they want to do that or not, so it is treated differently across the whole complex.

And what we were working on is all of you getting together and figuring out how should we do this. Either we do it the same for all the sites or we don't do it at all. And to me, and of course the Hanford people who are at the very top of what they get in these payment in lieu of taxes are saying, oh, man, they are trying to take our money away. I am not. I am trying to figure out a fair system so that all the sites are treated equally. Even if you look at the INL, we went out and asked the counties. Some counties get a minor payment; some counties that have DOE on their site, in their county, don't even request it. I mean, even within one site it is different between counties.

We need to figure out, and this would take probably authorizing legislation to change the law that currently exists, but we need your help in developing how we can change that to make it fair across the complex. And I am not trying to reduce anybody's payment or increase anybody's payment, I am just trying to make it fair.

So if you could help me in that respect and in trying to develop a proposal that makes sense, I would appreciate it very much.

Mr. DABBAR. So Congressman, why don't we take that back and think about that? I think, as you probably know, when you look at PILT, when you look at payment in lieu of taxes, it is based on a lot of history with the locality.

Mr. SIMPSON. Exactly.

Mr. DABBAR. Many times, decades and decades and decades of history about how it was done a certain way based on how a local community feels like it should be supported based on the sort of services that they have. And I think to a large degree PILT is more based on precedent now than on any particular near-term set of arguments because it doesn't happen right now. It is usually just based on history.

Mr. SIMPSON. And what bothered me about the reprogramming with Hanford is that when you look at the law, the law says the land is to be assessed as it existed before the site was there. Well, now they are saying, well, if the site wasn't there, this would all be vineyards. Well, maybe. I know that the INL, it would be kind of like New York City out there. So we are going to assess it at a high level, you know what I mean? It is just that unfairness that exists between these sites, and actually the communities, their association, they all now want to be assessed the same way that Hanford is because Hanford gets the most.

And I am not criticizing Hanford. I served on the City Council, I know I am going to have the Federal Government pay for everything I can get them to pay for. I mean, I understand how that works, but we need a fairer system. And like I say, it would take a change in the reauthorizing law, I think, but I am more than willing to work with you, and if we can find something that works. But I appreciate your effort on that. Thank you.

Ms. KAPTUR. Thank you, Mr. Simpson. I will just have two concluding pathways I am going down. One is the electrochemical pathway of the human nervous system, particularly centered in the brain. And the other one deals with some reporting requirements that I want to ask you about, which will be simple to answer.

I will just read this definition for the record. "The neuron signaling process in the human body and brain is partly electrical and partly chemical. Neurons are electrically excitable due to maintenance of voltage gradients across the membranes. If the voltage changes by a large enough amount over a short interval, the neuron generates an all or nothing electrochemical pulse called an action potential. This potential travels rapidly along the axon and activates synaptic connections as it reaches them. Synaptic signals may be excitatory or inhibitory, increasing or reducing net voltage that reaches the soma."

All right. The reason I wanted to put that in the record is because the supercomputing capacity of DOE, and perhaps other organizations in our country, and the knowledge we have of chemistry need to be wedded in a way that we can understand better what is happening with millions of people across this country and world who have no answer for their illness.

And I really do think that the Department of Energy has an enormous role to play in this. As I have said to the Secretary and others, I was up at Walter Reed recently and I saw a machine invented in Sweden, and it just blew my mind. Because it could image at a granular level where you could literally see this invisible pathway that was damaged in stroke victims. That was breathtaking.

This is a little more complicated. This has to do with the actual movement of signals in a human body where you have power and chemistry interacting, and we need to understand it. And we are beginning to develop all of the analytical tools to do it.

So I wanted to put that on the table and say to both of you that the Ohio National Guard has been collecting thousands of DNA samples from vets that present with PTSD. That is just one form of stress that makes things happen inside the brain. But I really do urge you, and I am saying on public record, the Department, to

recognize the blending of the sciences. And no one department can win this alone, and we have got to help our scientists figure out what is going in the human body.

Remember the old experiments they used to do with people when they would give them electric shock and for some it worked and for some it didn't? Why did that happen? How can we explain this? And they were moving in a certain direction, but we didn't have the analytical capabilities that we have today.

There is a great book written by a former broadcaster, I think he was on CBS News. The title of the book is "Nobody Cares about Crazy People." I do. And so I will use every bit of energy I have to try to move every department in this government to a better solution than we have today.

Thank you very much for listening to that request. And I would be very interested in what you might come forward with in terms of ideas or ongoing interdepartmental research that exists.

I believe the man's name is Ron Powers. I think I have the name right, pretty well-known broadcaster. Tragic story. Tragic story if you read the family history.

Now, in a way of a simple question, in terms of congressional reporting requirements, I was going to ask Mr. Menezes, the Department has not complied with our request for certain reports. One of them is the artificial intelligence efforts the Department wishes to undertake. And the other one is something you mentioned, the North American grid model under way at the Office of Electricity. Neither of those reports have come back to us.

And so I am just pleading with you, we have to answer certain questions that will be helped by what is in those reports so we can understand the full scope in funding that you are requesting, given that this Committee is often faced with significant funding constraints. In putting together our bill it is critical that we have this information when making those difficult choices.

Mr. Menezes and Mr. Dabbar, can you commit to us that the Department will provide timely information in response to congressional inquiries and requirements, including these reports that I mentioned?

Mr. DABBAR. I will say yes. And in particular in AI, which is my area, I have emailed to your staff our review of that program as requested, and I am scheduled to sit down with your staff on Friday.

Ms. KAPTUR. Thank you very much. Mr. Menezes.

Mr. MENEZES. And on the plan for the North American energy resilience model, I have actually gone a step further than emailing. I have actually had a conversation face-to-face with the Assistant Secretary Bruce Walker and your staff, so that he can come up here and provide that briefing as soon as practical.

And just as a general rule, from the Secretary on down, we have always pledged to Congress that our intent is always to meet our deadlines. We have a list of all the congressional mandated reports, we keep as current on it as possible, and I know that—remember we do have to get a review by OMB. But I have been informed that any reports that are forthcoming, if you don't have them and they are overdue, they are at OMB or they are about to be concluded.

And that I think we are on time with fiscal year 2019 requests. So I think we are making some progress.

Ms. KAPTUR. Well, maybe we just get them from OMB.

Mr. SIMPSON. Call OMB up here for a hearing sometimes.

Ms. KAPTUR. There you go, Mr. Simpson, I like that.

Mr. SIMPSON. The only people they have to testify before is the Budget Committee.

Ms. KAPTUR. All right.

Mr. SIMPSON. You don't want to get into OMB with me.

Mr. MENEZES. Nor was I suggesting that you subpoena OMB to come up here.

Ms. KAPTUR. All right. Well, this has been an exhaustive hearing. I want to thank all the members who have come. And, unfortunately, we have many competing hearings that are occurring simultaneously, plus we had a lot of floor activity today, so we apologize that some of our members who are regular attenders couldn't be here. But, believe me, your remarks and full testimony will be made available.

This concludes this afternoon's hearing. Again, I would like to thank Under Secretary Menezes and Under Secretary Dabbar for joining us today. We thank you for your service to our country and all of the staff and very intelligent, committed individuals you have brought with you and work at the Department.

I ask for the hearing record—that questions for the record and any supporting information requested by the subcommittee are delivered in final form to us no later than 3 weeks from the time you receive them. And members who have additional questions for the record will have until close of business on Monday to provide them to the subcommittee office.

This hearing is adjourned.

WEDNESDAY, NOVEMBER 20, 2019.

THE DEPARTMENT OF ENERGY'S ROLE IN ADDRESSING CLIMATE CHANGE

WITNESSES

HON. VI LYLES, MAYOR OF CHARLOTTE, NORTH CAROLINA
RICH POWELL, EXECUTIVE DIRECTOR, CLEARPATH
BOB KEEFE, EXECUTIVE DIRECTOR, ENVIRONMENTAL ENTREPRENEURS (E2)
HON. ERNEST MONIZ, FOUNDER AND CHIEF EXECUTIVE OFFICER, ENERGY FUTURES INITIATIVE

Ms. KAPTUR. The subcommittee will come to order. I want to thank everyone for coming, and especially thank our witnesses today, many have traveled a great distance.

We are here to discuss the topic of climate change, a global issue that challenges our ability to sustain life on Earth.

Our job in Congress is to frame the magnitude of this challenge and provide a practical pathway forward that is regionally sensitive. Ninety-seven percent of scientists agree that the Earth is warming at an unsustainable rate, and that humans and human activity are the primary cause. Burning fossil fuels like coal and oil for energy are the main contributors to greenhouse gases.

NOAA has issued several predictions that this year of 2019 is increasingly likely to be the planet's second or third warmest calendar year on record.

Our witnesses and all of us see the impacts of this every day, from the growing intensity of extreme weather events, like recent wildfires in California, to increasingly hurricanes across the Gulf and East Coast. Glaciers and sea ice are melting at historic rates with the Arctic warming at twice the rate of the rest of the world.

Our oceans are warming and acidifying. It is dangerous to ignore these facts, and if we fail to work together to address this crisis it is to our collective peril.

In my district, impacts can be seen in record rainfall and the rising water levels of the Great Lakes, now at a 124-year high, including Lake Erie, the southernmost of the Great Lakes, which broke records in September, and is currently over 2 feet higher—2 feet higher—than long-term averages.

In 2014, a massive harmful algae bloom resulting from nutrient runoff from the largest watershed in the Great Lakes forced the city of Toledo to shut off its water supply for days. Hundreds of thousands of people could not drink, bathe, or cook with tap water.

In this particular watershed, which is, as I mentioned, the largest in the Great Lakes, the number of farm animals has more than doubled from 9 million to 20 million over the past 13 years, with a corresponding increase in manure. All of these have helped create the algae bloom problem that we face in that lake.

Globally, we must commit to addressing these new challenges by engaging the world through the Paris Climate Agreement. Unfortunately, the President ceded American leadership on this vital concern by withdrawing from this agreement without any backup plan in place. As the second largest global emitter of harmful gases, producing nearly one-fifth of all global emissions, our country's withdrawal will have significant consequences on the environment, public health, and the economy.

However, we are lucky to have a Department of Energy, the Federal Government's leading agency for research and development of new, clean energy technologies within this subcommittee's jurisdiction. Technologies developed with Department of Energy funding are already helping address climate change. Decades of investments have driven the prices of wind, solar, energy storage, and efficient light bulbs by 59 to 94 percent over the last decade, leading to widespread deployment and consumer savings. But, of course, there is more work to be done.

Continued robust investments in Department of Energy programs will create new tools to prevent and reverse the impacts of climate change while boosting our economy and creating good paying jobs across every state.

Currently, there are more Americans in energy efficiency jobs than waitresses and waiters across our country. We must continue to transition not just sectors, but people and communities.

Additionally, as clean energy becomes cheaper consumers can save their hard-earned dollars by paying less for the energy they use.

Our Nation must undertake mitigation now, but we must also pursue future energy innovation. The Department of Energy's research agenda achieves the next series of breakthroughs and clean energy which is vital to saving our planet.

As the rest of the world continues to act and to innovate, our country must be a technology leader or we will be not only left behind, but we will have abdicated our responsibilities in this new era.

To our witnesses, we look forward to hearing from you all. I will turn to our able Ranking Member, Mr. Simpson, for opening remarks.

Mr. SIMPSON. Thank you, Chairwoman Kaptur. I was glad to see that we at least mentioned the algae blooms in the opening statement. I know that is a passion of yours. Thank you, Chairwoman Kaptur.

I would like to echo your welcome to our witnesses. We thank you all for being here this morning, and look forward to hearing your testimony and engaging in a productive discussion of the Department of Energy's role in addressing climate change.

First, let me address one of the biggest climate change straw man arguments. Members of Congress and stakeholders across the politic spectrum can acknowledge that climate change is real, and that industrial emissions around the globe are contributing to it without concluding that big government command and control schemes, like the Green New Deal, are the solution.

In fact, such proposals would harm the American economy, boost our economic competitors such as China, and quite likely lead to increased global emissions.

Instead, real solutions will involve innovation in clean energy technology. The United States can continue to grow our economy and provide good-paying jobs to hardworking Americans by being at the forefront of improving current clean energy technology and developing new technologies.

This subcommittee and the Department of Energy programs it funds have been pursuing bipartisan climate change solutions for decades now, and have numerous successes to show for it. For example, U.S. emissions have dropped by historic amounts over the past decade or so, one of, if not the single, largest contributor to that decline has been the shale gas revolution. Abundant supply produced economically has allowed energy to be provided with fewer emissions and at a lower cost to consumers.

What enabled the shale gas revolution? Technology innovation such as the diamond drill—or diamond head drill bit stemming from Department of Energy research and development.

The U.S. leads the world in clean energy R&D investment. We must continue to make smart, targeted investments in clean energy R&D so that we can provide the world with affordable, reliable, clean energy solutions. Doing so, will benefit the American economy while providing the best path forward for addressing climate change.

One area of focus right now is energy storage, which is necessary to better incorporate variable energy sources like wind and solar into the electrical grid. And, in fact, there is a project in my district, the Cat Creek Energy Storage Project, that Doug Jones here, who is from Idaho, could tell you all about. It has an innovative public-private partnership that has the potential to improve grid security across the West, and provide needed new upstream water storage to our growing Boise Valley.

I look forward to hearing from each of our witnesses about the successes of past investments and the promise of new investments, both in continuing to improve current technologies as well as ensuring that the United States will continue to be a leader in developing new energy technologies.

Again, I thank Chairwoman Kaptur for calling this hearing. And I look forward to hearing from our witnesses.

Ms. KAPTUR. Thank you very much, Congressman Simpson. And I am very excited that we have such a stellar panel joining us here today.

First we will have Mayor Vi Lyles of Charlotte, North Carolina. Mayor Lyles has been a leader in addressing climate change at the local level, where leadership is so desperately needed, adopting a strategic energy action plan for the City of Charlotte.

She is also a constituent of our dear, hardworking, and insightful Representative Alma Adams, who is here today to introduce her. I yield 2 minutes to Representative Adams.

Ms. ADAMS. Thank you very much, Chairwoman Kaptur. Thank you to the committee for having me today. I am so very proud to have the privilege of introducing my mayor, Mayor Vi Lyles of Charlotte, the Queen City.

In 2016, Mayor Lyles became the first African-American woman ever elected to serve as mayor of Charlotte. Before being elected as mayor, she spent almost three decades in public service working for the City of Charlotte, serving two consecutive terms as a member of the Charlotte City Council.

Her decades of leadership from budget analyst to mayor have helped mold Charlotte into one of the fastest-growing cities in America, and a beacon of a progress and growth in the South. Today Charlotte is a tech, banking, and entrepreneurship hub, and welcomes 100 new Charlotteans every day.

Mayor Lyles has also led Charlotte's innovative and ambitious plan to ensure that our city is at the forefront of the fight against climate change. In 2018, our city council unanimously supported a plan to make Charlotte a low-carbon city by 2050, and to set an aggressive goal for reducing citywide greenhouse gas emission levels.

Additionally, under Mayor Lyles, Charlotte has launched an initiative to become a zero waste city, and was named winner of the Bloomberg American City's Climate Challenge.

Thank you, Mayor Lyles, for your work and the city's work to combat climate change, to reduce carbon emissions, and to invest in green technologies.

We welcome you, Mayor Lyles, and we look forward to hearing more about the important work that you are doing and how Congress can further support your efforts.

Ladies and gentlemen, my mayor, Mayor Vi Lyles.

Ms. KAPTUR. Thank you very, very much, Congresswoman Adams. And I know you had to change your schedule to be here, and I thank you so very, very much for that.

We are going to introduce all of the witnesses, and then we will proceed with the Mayor's testimony.

Next we will have Mr. Rich Powell, the Executive Director of ClearPath and ClearPath Action. Mr. Powell has also served as a member of the 2019 Advisory Committee to the Export-Import Bank, and was previously with McKinsey & Company in the Energy and Sustainability practices.

Following that we will have Bob Keefe, the Executive Director of Environmental Entrepreneurs, or E2. E2 recently released a report highlighting the economic benefits of addressing climate change. Bob has spent more than 20 years as a political, business, and environmental journalist.

And finally, we welcome back a preeminent scientist, innovator, diplomat, Dr. Ernest Moniz. Dr. Moniz was formerly the Secretary of Energy in President Obama's administration. His accomplishments and accolades are well known, and we are very fortunate to have him today.

Again, I want to thank all of you for taking the time to be here. Without objection, your written statements will be entered into the record. Please feel free to summarize your remarks in about 5 minutes each, starting with Mayor Lyles.

Ms. LYLES. Thank you very much. First of all, good morning. And really, I am so grateful for the opportunity to come here. I am especially honored to be joined by the preeminent climate addressers, people that are doing all of this great work.

The invitation to come and talk about our city, and what we are doing to address climate changes, one that we don't take lightly, we are doing all that we can to create a resilient city, and be a model for economic and environmental sustainability.

I want to tell you a little bit about our city. We are one of the top-five fastest-growing large cities in the past 2 years in the country, and Charlotte is only one of three cities in our country that has grown by double digits since the decade of 1960.

Our population has doubled to almost 900,000 residents, and we are now the 16th largest city in the country. You know, we are welcoming all of the new residents that Representative Alma Adams talked about, those 100 new people coming every day, and I have been told that they bring 1.6 cars for every visitor that comes or every resident that comes.

But we are adding jobs. We added 15,000 jobs last year and another 12,000 jobs this year. And most of our new jobs are in the realm of tech. Charlotte has been recently named as the fastest-growing tech talent market 2 years in a row. But today as mayor, the way I see Charlotte, it is a destination for families and young people who want to have a great place to live. We often talk about being a livable city.

And we have grown really, really well, and we are very fortunate, and we recognize that. But, more importantly, we also recognize there are certainly challenges that come with growth, and I want to talk a little bit about that.

You know, we have realized that had two choices: we can embrace the reality that long-term plans are needed to change the way we consume energy or we could keep what we are doing, and leave it to the next generation to figure out, and maybe it will be too late to do that.

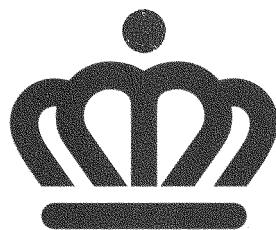
So we made a conscious choice that we were going to change the course of Charlotte history; that we were going to do something and not leave it to our grandchildren to have to resolve.

So, as Congresswoman Adams said, our city voted unanimously for the Sustainable and Resilient Charlotte Resolution by 2050. The resolution states that we will strive to source 100 percent of our energy use from zero carbon sources, and to become a low-carbon city by 2050, bringing citywide greenhouse gas emissions to below 2 tons per person annually.

Then we adopted the city's first *Strategic Energy Action Plan*, because as mayor you know that you can have resolutions all day long, but unless you put some feet behind it, it doesn't really work. So, we have a framework to guide our transition to a low-carbon future.

[The information follows:]

Towards Resilience:



CHARLOTTESM



Strategic Energy
Action Plan

December 2018

FOREWORD

In February, the NBA All-Star game will be held here. In 2020 the Queen City will host its second major political convention. Our population is growing. Business is booming. We boast a world-class urban tree canopy. We are a welcoming and diverse city, that is resilient with beautiful community spaces, and where every person can thrive and prosper.

As a signatory to the Global Covenant of Mayors since 2015, the City of Charlotte has joined thousands of cities and regions in a commitment to accelerate ambitious, measurable climate and energy initiatives that lead to an inclusive, equitable, low-emission and climate resilient future; this will help us to meet and exceed the Paris Agreement objectives. Charlotte City Council, who voted unanimously on June 25, 2018 resolution to direct Charlotte down this low-carbon path, and city leadership are committed to achieving our community's aspirations.

As part of our commitment to the Global Covenant of Mayors, we are pleased to introduce the City's first Strategic Energy Action Plan (SEAP) that sets out a framework to guide Charlotte's transition to a low-carbon future. By implementing this plan, Charlotte will take advantage of a unique opportunity for growth. The SEAP provides solutions for reducing our carbon emissions but will also make Charlotte a more attractive place to live and work and be globally competitive.

Charlotte is approaching the approval of the SEAP, and the associated accomplishment of the aspirational 2030 internal goal outlined in the resolution, using a two phase approach. The SEAP focuses on community based efforts, though it includes some general recommendations about how the city might strive toward zero-carbon facilities and fleet. Internal operational efforts for the transition of Charlotte's government fleet and facilities are presented as an appendix to the SEAP. The appendix will contain implementation and cost information and data to support early actions recommended to move toward

the accomplishment of the internal aspirational goals. This information and data will be updated annually as the SEAP progresses.

Achieving a low-carbon future for Charlotte will require a transformational change in the way we consume and generate energy. We have set aggressive targets to achieve by 2030 and 2050. We know that this will be challenging and require new and innovative ideas, projects and collaborations. The City will provide the leadership and some of the resources, but it will take the entire community and collaborative partnerships to make Charlotte a sustainable and resilient community. It requires companies and organizations to look at their role in this, as well as citizens to look at how they are using energy each day.

The year of 2018 will go down in Charlotte history books as the year Charlotte became a globally recognized leader in resiliency. We are in the process of making an extraordinary effort to coordinate and connect a series of catalytic and integral strategies, laying a robust foundation for a resilient and sustainable future for Charlotte. This means that all our communities and neighborhoods are hubs for innovation where there is equitable access to green jobs and training, and where an atmosphere of entrepreneurship and inclusion are fostered.

Charlotte has a strong tradition of unparalleled public participation and engagement. This is not something the City of Charlotte can implement on our own – we need the community to collaborate with us and bring innovative projects and solutions to improve our neighborhoods and City and meet our targets. The City will build on the successful engagement that helped develop the SEAP, and we continue to work to engage all communities and citizens across the City as we implement the SEAP to achieve our targets. We understand the enormity of the challenge before Charlotte and the world, but together we can meet this challenge and succeed!



Vi Lyles

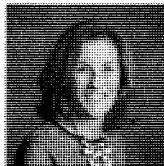
Vi Lyles
Mayor



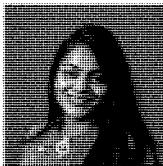
Marcus Jones

Marcus Jones
City Manager

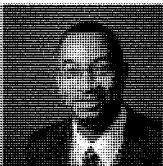
CHARLOTTE CITY COUNCIL



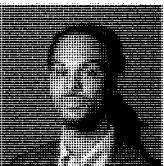
Julie Ewell, Mayor Pro Tem



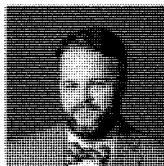
Dimple Tansen Ajmera, At-large



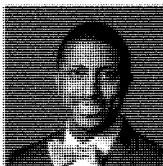
James Mitchell Jr., At-large



Braxton Winston, At-large



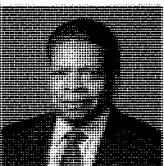
Lorren Egleson, District 1



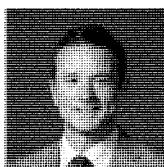
Dr. Justin Harlow, District 2



LaWanda Mayfield, District 3



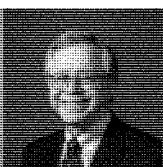
Gregory A. Phipps, District 4



Matt Newton, District 5



Fariq Bokhari, District 6



Edmund H. Driggs, District 7

Charlotte has a council-manager form of government with a mayor and 11 council members elected every two years in November, and a professional city manager to run the day-to-day operations. The mayor and four council members are elected at-large by a city-wide vote. Seven council members are elected from districts by voters who reside in each district.

The mayor and city council are the "board of directors" for this municipal corporation. As such, they set policy, approve the financing of all city operations and enact ordinances, resolutions and orders. Their responsibilities also include appointing the city manager, city attorney, city clerk and members of various boards and commissions.

Together, the mayor and city council members are responsible for establishing the general policies under which the city operates.

These include:

- Appointing the city manager, city attorney, city clerk and members of various boards and commissions enacting ordinances, resolutions and orders.
- Reviewing the annual budget, setting the tax rate and approving the financing of all city operations.
- Authorizing contracts on behalf of the city.

ACKNOWLEDGEMENTS

A body of work like a Strategic Energy Action Plan does not come together without a substantial amount of effort from many people over a long period of time. What started with a vision went through many iterations and changes to reach the final document before you. In addition to the people identified in the Credits, I would like to call out a few individuals who went above and beyond expectations.

Emily Yates, with Envision Charlotte, was the heart and soul of this project. The City partnered with Envision to produce the SEAP, but Emily was its constant champion, editor, and visionary. Without Emily's dedication and expertise, we would not have been successful.

Dr. Sebastian Carney has been identified as the technical expert on the SEAP, which he was, but his input went far beyond just the technical components. He shared his wisdom and experience with the team as well as strategic guidance. He also endured multiple course and scope changes as we worked through what was the right direction for Charlotte.

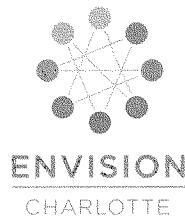
Finally, our internal team of Kim Eagle, Gina Shell, Erika Ruane and our newest team member, Katie Riddle, spent countless hours editing, strategizing, meeting, and envisioning the best course of action with multiple partners and stakeholders. Their dedication to this project and community has been humbling and instrumental to its success.

We have a lot of work left to do as we move into implementation, but we should all take a moment to appreciate how far we have come and the commitment we have made to a better quality of life for all Charlotteans.

Sincerely,

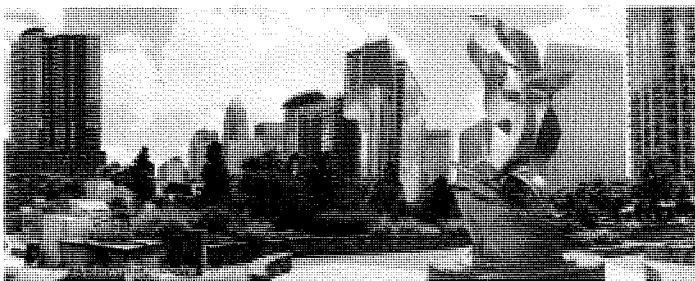
Rob Phocas
Sustainability Director
The City of Charlotte

The SEAP was developed in partnership with:



COMMUNITY ACTION AREAS52
ACTION AREA 7: NEAR ZERO CARBON NON-MUNICIPAL BUILDINGS BY 205052
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INTRODUCTION



Charlotte is a vibrant and growing city with over 400 people moving to the City each day. In 2015, the City of Charlotte committed to ensuring that the City continues to grow in a more sustainable and resilient way by joining the Global Covenant of Mayors (GCoM). Charlotte is now one of many cities around the world that is working to uphold the Paris Climate Agreement – an agreement to reduce greenhouse gas emissions to combat climate change and create a resilient future.

As part of their commitment, Charlotte has taken the necessary steps to produce this Strategic Energy Action Plan (SEAP). The SEAP is a guide for how Charlotte can deliver a low carbon and resilient future by 2050. Developed through extensive stakeholder engagement, the successful implementation of the recommended tasks and actions will rely upon extensive partnerships with corporations, utilities, communities, non-governmental organizations (NGOs), and universities both inside and outside of Charlotte.

Beyond the requirement to develop a SEAP to maintain compliance with the GCoM, Charlotte set ambitious targets and developed the SEAP. The City did this recognizing that to be a globally competitive city, there must be a strategy in place to grow more sustainably and resiliently. Through a more integrated and inclusive approach to urban growth, the SEAP will form one part of the City's broader resiliency strategy.

The SEAP focuses on three key pillars that align with the areas where Charlotte's emissions are highest and where there is the opportunity for drastic reduction in emissions: buildings, transportation, and energy generation. Innovation provides the foundation upon which these pillars sit. The recommended 11 Action Areas provide targeted guidance and are the backbone

of the SEAP.

The City of Charlotte and Envision Charlotte, a local non-partisan 501 c(3) organization focused on sustainability, worked in partnership to produce the SEAP to meet the City's commitment to the Global Covenant of Mayors. Commitment and leadership from the Mayor, City Manager, and City Council will ensure the success of the SEAP as it is implemented.

This Executive Summary provides a summary of the full SEAP. For a more detailed explanation of each section, please refer to the full document.

Charlotte's Vision for Sustainability and Resilience

A vision for sustainability and resilience has been produced for the City. This was produced in partnership with the community. The purpose of the vision was to provide a common goal under which sustainable and resilient projects can sit. This vision was developed across multiple workshops and culminated in the following:

"Charlotte will lead, as a global city, by continuously improving, protecting, and preserving the environment, its community, and economy, while ensuring equity and resilience - for today's and future generations."

This vision is intended to be used by all stakeholders in Charlotte when promoting their work and attracting funds for initiatives that they want to undertake.

As part of its commitment to the Global Covenant of

GREENHOUSE GAS EMISSIONS

Mayors, the City produced a greenhouse gas (GHG) emissions inventory. To do this, the City utilized the Global Protocol for Cities (GPC). The GPC is a global standard for estimating emissions at the city scale which is used to facilitate transparency and consistency among cities reporting their emissions. As part of the requirements of the GCoM, Charlotte reports its GHG baseline and will continue to submit annual updates to CDP (formerly known as the Carbon Disclosure Project).

Via an intense data collection process, the City developed its most granular GHG baseline yet. Setting the baseline year as 2015, because that was the year the most comprehensive and reliable data was available, it was determined Charlotte's GHG baseline was 12tCO₂ per capita. This covers emissions for the entire geographic area of the City of Charlotte.

To stay in line with Paris Climate Accord objectives, the City set a 2050 target of below 2tCO₂ per capita, and City Council approved the target via the 'Sustainable and Resilient Charlotte by 2050' Resolution.

There are two types of inventory available under the Global Protocol for Cities: BASIC and BASIC+. For Charlotte, a BASIC inventory was produced. As shown in Figure 1, Charlotte's waste emissions account for 4%. The other 96% are different types of energy, making it the biggest GHG emitter. Buildings, both residential and commercial, comprise approximately 48% of emissions in Charlotte. Industry and Construction account for 6% of total emissions, while transportation accounts for 40%. This chart supports the premise that tackling emissions in the building and transportation sector will make the greatest contributions to achieving the SEAP targets.

The City is using CO₂e, or carbon dioxide equivalent, as the standard unit for expressing its GHG emissions. The purpose of this is to express the impact of each greenhouse gas in terms of the amount of CO₂ that would create the same amount of global warming. Like the GPC, Charlotte is using CO₂e because it is a global standard and creates consistency among cities reporting their emissions.

Greenhouse Gas Emissions

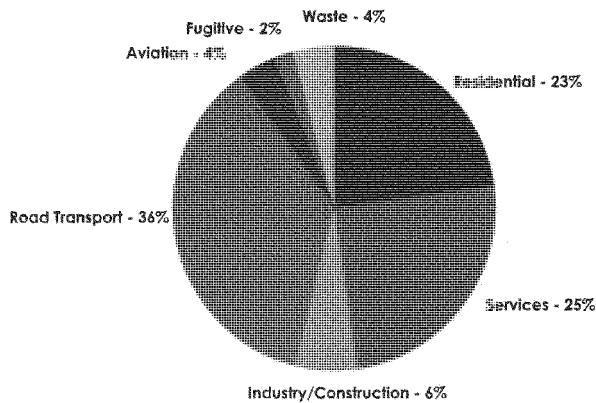


Figure 1: 2015 Baseline Greenhouse Gas Emissions for Charlotte, North Carolina

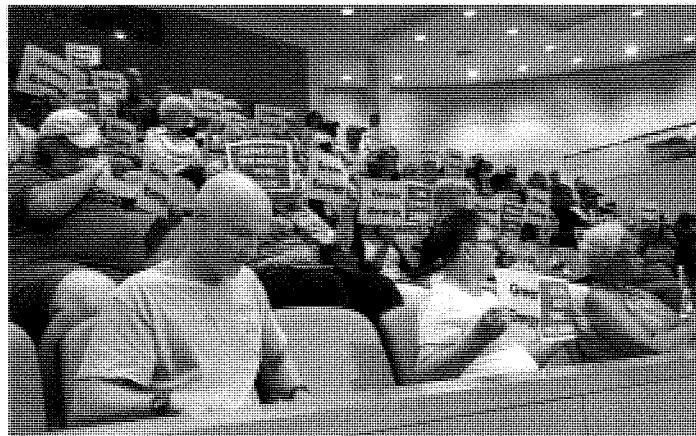
THE SUSTAINABLE AND RESILIENT CHARLOTTE BY 2050 RESOLUTION

In November 2017, Charlotte City Council considered a Clean Energy Resolution (CER) that would, among other items, commit the City to 100% renewable energy by 2050. City Council voted to send the resolution back to the City Council Environment Committee and asked that a new resolution be drafted that would be tailored to Charlotte, and have an action plan for how to achieve it. City staff worked in close partnership with stakeholders and drafted a new resolution that encompassed the City's commitment to the GCoM and broadened the target to a low carbon future, while also specifying that the SEAP would provide the action plan for achieving the goals. City staff presented the final resolution to City Council on June 25, 2018 and received widespread support from community stakeholders. Charlotte's City Council unanimously passed the resolution.

Charlotte's Sustainable and Resilient Resolution provides targets that will allow the City to achieve a low carbon future. In the resolution, the City committed to striving to reduce emissions to less than 2tCO₂e by 2050. Another ambitious target in the Resolution

has the City strive to source 100% of its energy use in municipal buildings and fleet from zero carbon sources by 2030.

As the understanding of climate change and the resulting impacts continues to increase, the required emission reductions may need to go further. The SEAP provides a mechanism that can be used to deliver on the existing targets as well as stronger ones that may develop in the future.



Community members showing their support for the Sustainable and Resilient Charlotte by 2050 Resolution. Photo Credit: Michael Zytkow.

Sustainable and Resilient by 2050 Resolution



A PLAN FOR ALL:
FORMING AN ACTION PLAN

The SEAP is an ambitious, aggressive action plan for delivering a low carbon, resilient Charlotte. Achievement of the 2030 goals will be dependent on many factors, including technological advancements, operational compatibility and risk management, and the availability of appropriate resources and funding. For some segments of City fleet and facilities, achieving the goal may not be possible because operational and other concerns will outweigh or not allow for carbon reduction benefits. However, the City is committed to and will look for all opportunities to achieve the goal. While the plan has been developed by City government, and City government is responsible for leading its implementation, the SEAP is a citywide strategy intended to improve the quality of life for all citizens of Charlotte.

Charlotte is fortunate to have many community stakeholders that are actively engaged and knowledgeable in topics relevant to a resilient future. The recommendations set out in the SEAP's framework require collaboration with Mecklenburg County, the community, and other key stakeholders. Through the implementation of recommendations and biennial updates, the SEAP will align and support locally led efforts to deliver solutions that enable Charlotte to transition to a low carbon future. A key goal of the

SEAP is to enable and empower Charlotteans to make informed decisions regarding energy generation and consumption.

The SEAP process began with capacity building within city hall, and included staff across all departments. For the duration of the project, further engagement has occurred with staff and department heads. The project team also executed an extensive public engagement strategy, strongly supported by the City Council's Environment Committee. These sessions attracted large participation and were supplemented with independent bilateral meetings. Feedback from all stakeholders was encouraged throughout the process, and the project team worked to incorporate that feedback where relevant.

In addition to the data collection and stakeholder engagement, it was necessary to understand what existing work had been completed that could be built upon or leveraged. A thorough review of existing and relevant City strategies and plans occurred, as well as in-person interviews and meetings. This helped provide a deeper understanding and facilitated identification of key points between strategies to create better cohesion.

DEVELOPMENT OF ACTION AREAS AND TASKS

The Action Areas are the outcome of many months of engagement. The Action Areas create an environment that allow for new ways of doing things so that the resolution's targets can be delivered. The Action Areas have been developed to be adaptable given the 32-year timeline of the SEAP. All Action Areas have been designed to create new workforce development opportunities and to support the City's efforts to increase equity and economic opportunity.

Figure 3 represents a visual guide to the 11 Action Areas and how they connect with each other to form a low carbon, resilient future for Charlotte. These recommended Action Areas will result in fundamental changes to how decisions are made in relation to investment within the City, most notably how the City approaches cost. It also requires a change in the way in which energy is thought about, particularly in understanding consumption patterns. Through the combination of structural change and physical projects, Charlotte will have a greater chance of successfully achieving the 2050 target.

5 Stages to Zero Carbon

The Five Stage Approach to Zero Carbon Energy is a logical and clearly described tool that can be applied to buildings or transportation. By following this tool, the City of Charlotte and its citizens are able to identify cost-effective and realistic paths to delivering the GHG reductions sought. It is a continuous approach and consists of the following five repeating stages.

Shifting Energy Demand

The biggest challenge to energy planning is ensuring peak demand is met. This challenge becomes more complex with high levels of intermittent renewables into the energy system, due to the production of electricity from intermittent renewables. This stage's goal is to shift when energy is demanded.

Reducing Energy Consumption

Reducing the amount of energy consumed is nearly always the most efficient way to meeting a zero carbon target. This is because the less energy required on the demand side, the less zero carbon energy that is required on the production side.

¹ Combined cooling, heat, and power (CCHP), also known as *tri-generation*, is an extension of combined heat & power (CHP). While CHP only generates electricity and heat, CCHP adds cooling to the list, which means some of the heat that is produced is also used to generate cooling energy.

Changing the Energy We Consume

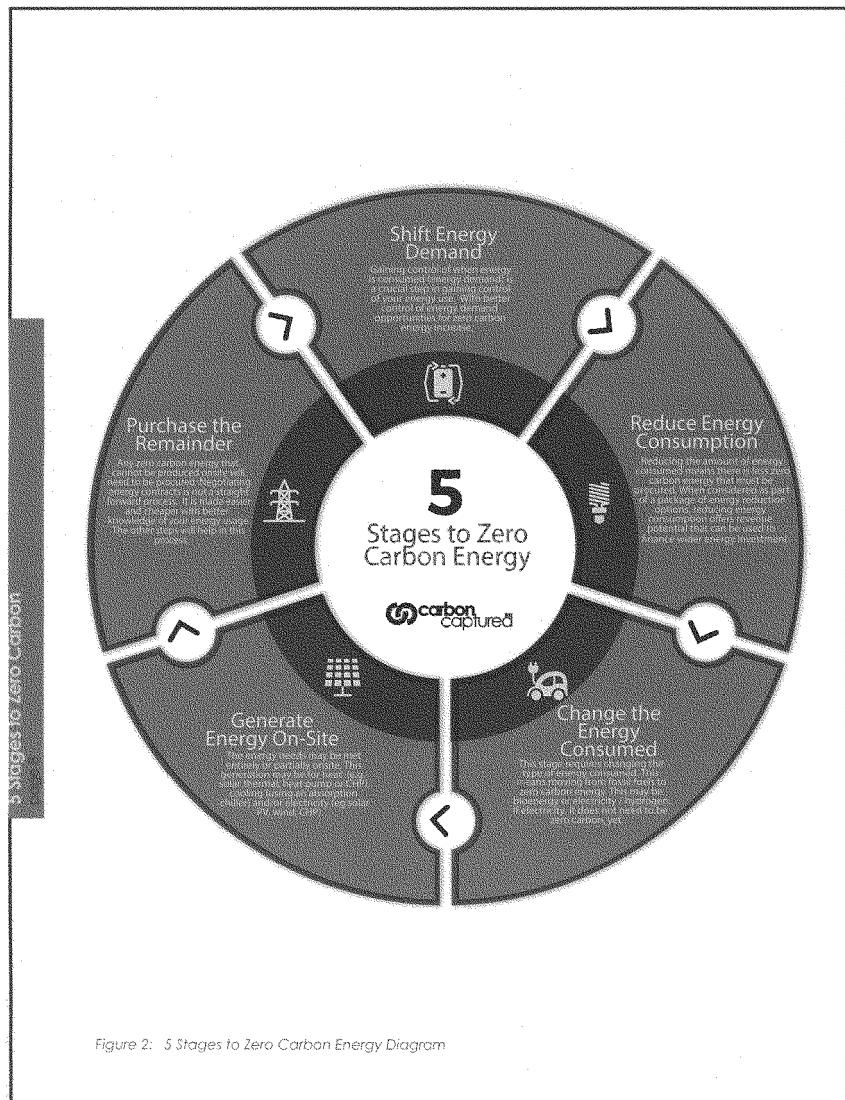
The types of energy we consume dictate emissions. Therefore, changing the type of energy consumed can lower emissions. This step does not have to be immediate; for example, the transition away from fossil fuel-based vehicles to electric vehicles can be started now and extend over many years.

Generating Energy Onsite

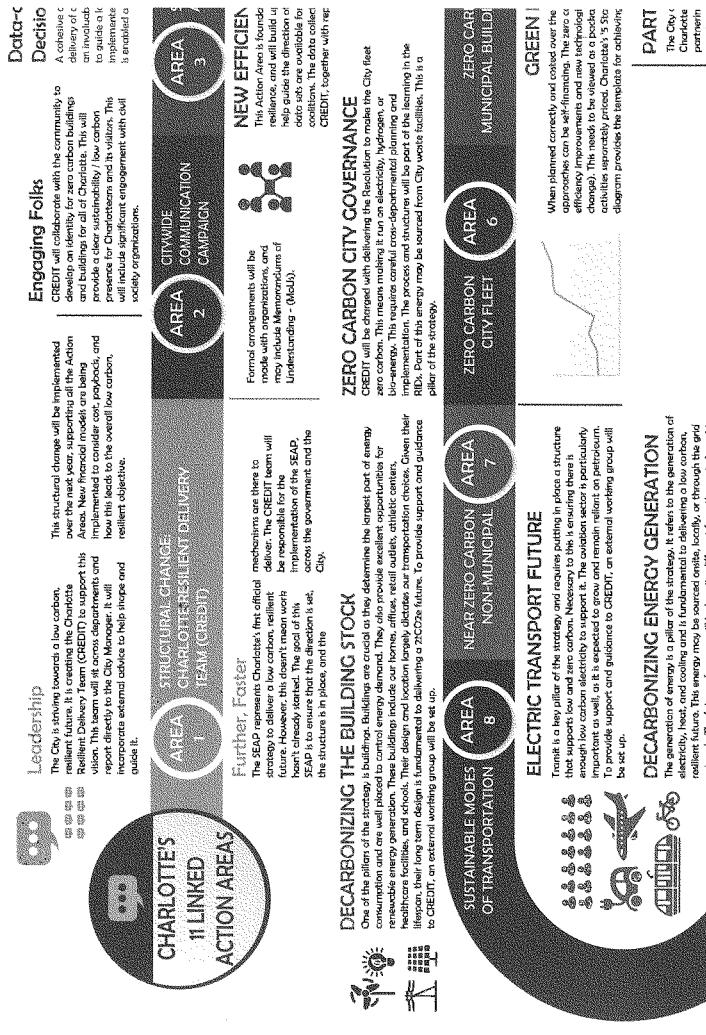
The generation of energy onsite includes heating, cooling, and electricity. Onsite generation may come from geothermal heat pumps or solar thermal. It may also include heating and cooling produced by a boiler or an onsite combined cooling, heating, and power (CCHP)¹ system running on zero carbon energy. Then, there is solar PV and wind, which may all be supplemented by storage opportunities. These options each reduce reliance on the grid.

Procure the Rest

When steps have been taken on each of the above stages, the remaining energy should be purchased from zero carbon sources – in the form of a tariff from a utility. This is meant to be the last resort when the other four options are not sufficient.



The 11 Action Areas are the outcome of many months of engagement. The purpose of the Action Areas is to create an environment that allows for new ways of doing things so that the Resolutions, Milestones can be delivered. The Action Areas have been developed in the second year timeline of the SEAP. All Action Areas have been designed to create new and more developed opportunities and to support the City's efforts to increase quality and economic opportunity.



KEY RECOMMENDATIONS FROM THE SEAP

There are 11 recommended Action Areas that address opportunities for the greatest reduction in GHG emissions for Charlotte. Critical to successful implementation, the following two Action Areas can be seen as the key infrastructure for implementing many of the other recommended Action Areas and tasks.

The Charlotte Resilient Delivery Team (CREDIT)

For Charlotte's transition to a low carbon future to be successful, it is essential to create supporting roles within the City to facilitate this process and establish long-term programs. A lot of effort is required of the utility, businesses, community, and universities, but a fully-fledged transition to a low carbon future is not

likely to happen on its own without initial leadership and guidance from the City government.

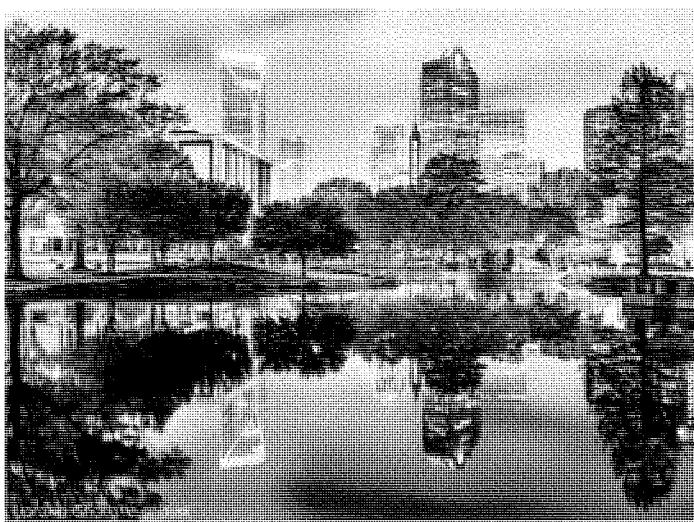
A new team will be assembled and implemented within the City. It will be called CREDIT and will drive implementation of the SEAP. CREDIT's initial focus will be on solidifying key partnerships, encouraging structural change, catalyzing high-impact projects, and driving broad scale stakeholder engagement. As the success of their work increases, the groups' responsibilities and scopes have the capacity to grow over time.

Within CREDIT, it has been recommended to appoint both a Team Leader and an Energy Ambassador to guide the assembly of the team and drive the SEAP



Marshall Park in Uptown Charlotte

Key Recommendations

Key Recommendations

forward. The Team Leader is ultimately responsible for overseeing and implementing the SEAP, while the Energy Ambassador will work closely with the Team Leader to drive forward projects and have a strong knowledge base within the energy sector.

Resilient Innovation Districts

A resilient city is one that can deal with shocks and stresses. Shocks may include climatic events such as floods, or it could be the disappearance of an industry upon which the city is highly dependent. Stresses are issues that weaken a city and include income inequality, high unemployment, and energy poverty. Ensuring resilience at various scales (city, district, community, neighborhood) requires stakeholder engagement to produce greater understanding of these vulnerabilities.

Resilient Innovation Districts (RIDs) are areas that can facilitate this better understanding of vulnerabilities by acting as "testing grounds" for new technologies and pilot projects that maximize economic advantage and speed up the innovation process. There should be RIDs located in different areas of Charlotte that will integrate the three pillars, allowing the City to address

economic mobility. The RIDs will produce proven low carbon, resilient business models and will look to overcome obstacles while promoting energy efficient projects, new developments, and job creation. This will enable emissions to be reduced, City exports to be increased, and resiliency to be promoted. The proposed Resilient Innovation Districts are a combination of Energy Innovation Zones, Resilient Innovation Neighborhoods, and the Smart District concept.

CHARLOTTE SEAP DELIVERY STRUCTURE

The graphic below demonstrates the overall structure of the SEAP, which is based upon three pillars: buildings, transportation, and energy generation. The first two pillars can be broken into two parts: government owned and non-government owned. These pillars sit upon a foundation of workforce development and innovation, with each of these representing a working group. As the sole group responsible for overseeing the success of the SEAP, the CREDIT team will sit beneath all of these groups to shape, learn, and guide the SEAP's implementation. With the Resilient Innovation Districts being the implementation mechanism for many of the resulting SEAP projects, it naturally sits above each of these pillars, combining them. Engagement of stakeholders and communities will be required to ensure a strong focus on equity as the projects and SEAP are implemented. The outcomes of these will be delivered through various partnerships, both within and beyond Charlotte.

The buildings working groups will look at all new and existing buildings. They will develop strategies to use less energy, shift when peak energy is needed to allow for more zero carbon energy on the grid, increase on-site generation, and increase other zero carbon sources. The group will use the 5 Stages to Zero Carbon to guide and explain their work.

The transportation working groups will look at road, rail, and air transportation. The two groups will do this

in different ways; the group focused on government owned transit will explore how to transition the City's vehicle fleet to zero carbon by 2030, while the non-government group will focus on how to facilitate the rapid uptake of sustainable modes of transportation. Transportation is a significant source of emissions and offers major opportunities for reductions. The groups will focus heavily on road transportation and infrastructure provision, and will also need to utilize the '5 Stages to Zero Carbon' diagram to guide and explain their work.

The generation working group will look at the production of electricity, heating, and cooling. It will develop strategies needed to create a low carbon future, which will include new technologies and processes. This will also include new business models that will be tested in the Resilient Innovation Districts, and like the other groups, they will need to use the '5 Stages to Zero Carbon' diagram to guide and explain their work.

The workforce development working group will underpin each of these by developing a strategy to ensure that there is access to jobs and training, creating a workforce pipeline that is available to the three pillars. The group will be driven by an equity mandate to ensure access and distribution of jobs across all Charlotte communities, and will promote entrepreneurship and new models to achieve it.

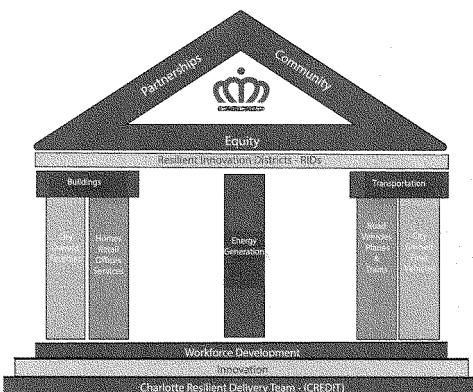


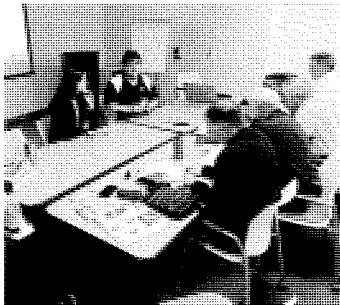
Figure 4: A graphic representation of the Charlotte SEAP Delivery Structure

STAKEHOLDER ENGAGEMENT

This strategy was developed through extensive stakeholder engagement; there have been formal engagements in the form of public meetings, external advisory group meetings, GRIP scenario sessions, internal stakeholder meetings, and informal meetings where project team members have had one-on-one sessions with community stakeholders, advocates, and City staff and leadership.

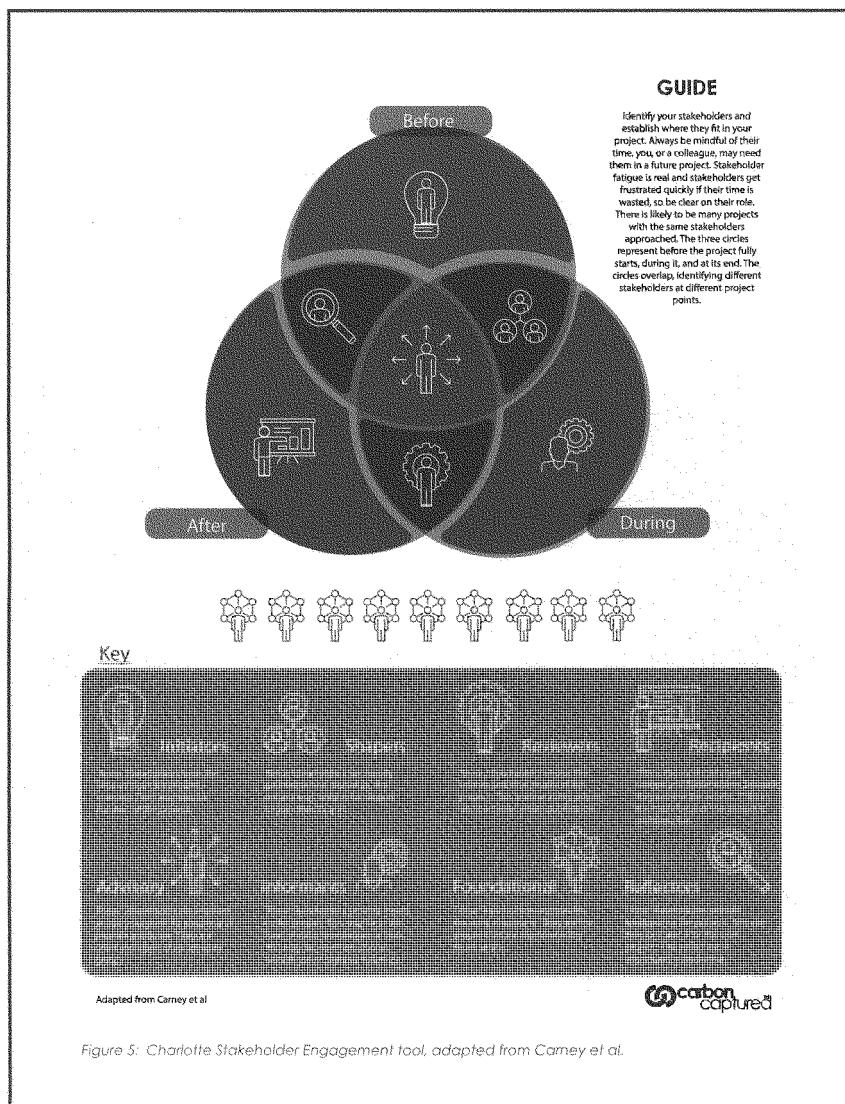
To ensure success of this plan, collaboration with organizations, community members, and advocacy groups already engaged in zero carbon efforts and programs will need to increase. The local knowledge and enthusiasm of the wide range of community and advocacy groups in Charlotte needs to be leveraged through catalytic partnerships and collaboration.

The City sees and understands the great opportunity for extensive stakeholder engagement during the SEAP's implementation, which will enable many community organizations to be involved. To ensure success of the SEAP, collaboration is necessary. CREDIT will be guiding the stakeholder engagement and will utilize the Figure 5 to help address the challenges around effectively and authentically engaging stakeholders within processes, especially the SEAP. The Stakeholder Engagement Tool is there to support mapping out when and how stakeholders will be engaged in advance of a project.



GRIP Scenario Sessions

Stakeholder Engagement



ACTION AREAS + TASKS

INTERNAL ACTION AREAS

ACTION AREA 1: STRUCTURAL CHANGE

- Task 1: Set Up Internal City Resilience Delivery Team (CREDIT)
- Task 2: Setting the CREDIT Programmatic Agenda in FY20
- Task 3: Set Up Internal Revolving Fund Mechanism
- Task 4: Develop strategy for stakeholder group engagement in FY20
- Task 5: Hold a Meeting of Content Expert Advisory Group (CEAG) and Internal Working Group

ACTION AREA 2: INITIATE A CITYWIDE COMMUNICATION CAMPAIGN TOWARDS A LOW CARBON FUTURE

- Task 1: Form a Branding Team in FY20
- Task 2: Create a Striking Visual for Zero Carbon Buildings and Vehicles in FY20
- Task 3: Finalize Full Website Development in FY20

ACTION AREA 3: DEVELOP SMART DATA APPROACHES

- Task 1: Through CREDIT, Develop a Smart Data Implementation Plan in FY22
- Task 2: Internalize Long Term Vision for Energy in FY20
- Task 3: Standardize Data-based Decision Making into Practice in 2021
- Task 4: Annually Monitor and Submit Emissions Inventory and Questionnaire to CDP
- Task 5: Timeline and Measuring Progress

*Achieving zero carbon fleet and facilities by 2030 is an aspirational and ambitious goal for the City organization. Achievement of the 2030 goals will be dependent on many factors, including technological advancements, operational compatibility and risk management, and the availability of appropriate resources and funding. For some segments of City fleet and facilities, achieving the goal may not be possible because operational and other concerns will outweigh or not allow for carbon reduction benefits. However, the City is committed to and will look for all opportunities to achieve the goal.

ACTION AREA 4: DEVELOP AND IMPLEMENT RESILIENT INNOVATION DISTRICTS (RIDs)

- Task 1: Formalize the Concept of a Resilient Innovation District Through Dialogue with all Relevant Stakeholders and in Line with The Comprehensive Plan Process in FY21
- Task 2: Implement a Set of Criteria that will Guide the Selection and Development of Resilient Innovation Districts in FY22

ACTION AREA 5*: STRIVE TOWARD 100% ZERO CARBON MUNICIPAL BUILDINGS BY 2030

- Task 1: Revise the Policy for Sustainable Facilities to align with the Sustainable and Resilient Charlotte Resolution in FY20
- Task 2: Identify Specific Building Targets for Action in FY20
- Task 3: Focus on specific projects in FY21

ACTION AREA 6*: STRIVE TOWARD 100% ZERO CARBON CITY FLEET BY 2030

- Task 1: Update the Fleet and Motorized Equipment Asset Management Policy in FY20
- Task 2: Begin installation of a telematics system across the City's entire vehicle fleet in FY21
- Task 3: Establish the Staggered Introduction of Electric and Other Alternative Fuel Vehicles
- Task 4: Consider Opportunities for Retrofitting of Vehicles to Electric Drive train in FY21

COMMUNITY ACTION AREAS	
ACTION AREA 7: NEAR ZERO CARBON NON-MUNICIPAL BUILDINGS BY 2050	Approaches to Meeting Energy Demand in 2022
Task 1: Form a Building Working Group in FY21	Task 4: Reduce the Carbon Intensity of Grid Supplied Electricity by at Least 90% by 2045
Task 2: Make Existing Residential Buildings Low Carbon by 2050	Task 5: Target a carbon intensity on the grid of at least 90% per kWh by 2045
Task 3: Influence the Energy Requirements of New Residential Buildings to be Near-Zero Carbon by 2050	Task 6: Identify Opportunities for a Bioenergy with Carbon Capture and Storage (BECCS) Combined Heat and Power (CHP) Unit by 2030
Task 4: Make existing non-residential buildings low carbon by 2050	Task 7: Negotiate to Develop Tariffs for Low Carbon Electricity in 2022 and Identify a Period for their Rollout by 2030
Task 5: Make New Non-Residential Buildings Low Carbon by 2050	
ACTION AREA 8: FACILITATE RAPID UPTAKE OF SUSTAINABLE MODES OF TRANSPORTATION	ACTION AREA 10: DEVELOP GREEN WORKFORCE PIPELINE IN SUPPORT OF ENERGY TRANSITION
Task 1: Form a Transportation Working Group in FY19	Task 1: Form a Working Group for Workforce Development and Equity in FY19
Task 2: Develop a Promotion and Awareness Campaign Around Electric Vehicles (EVs)	Task 2: Establish and Produce the Training Pipeline for Skilled Labor Jobs and Entrepreneurship Opportunities in FY22
Task 3: Deploy a Citywide EV Charging System for Charlotte by 2030	
Task 4: Increase Access to Zero Carbon Mobility Options	ACTION AREA 11: ESTABLISH PUBLIC-PRIVATE-PLUS PARTNERSHIPS TO ACCELERATE TRANSITION TO A LOW CARBON FUTURE
Task 5: Continue to Integrate Transportation Orientated Development (TOD) Policies into Land Use Policy Frameworks, Namely the Comprehensive Plan and UDO Update	Task 1: Identify, Build, and Formalize Relevant Partnerships in FY20 and FY21
ACTION AREA 9: DEVELOP AND IMPLEMENT STRATEGY FOR DEPLOYING LOW CARBON INFRASTRUCTURE GENERATION	
Task 1: Form an Energy Generation Working Group Focused on Near-Zero Carbon For Buildings in FY19	
Task 2: Develop a Suite of Educational Tools that can be Utilized Throughout the City in FY22	
Task 3: Demonstrate New and Integrated	

NEXT STEPS

The SEAP is a long-term action plan with a 32-year implementation timeline with Action Areas, tasks, recommendations, targets, and projects that span this period. For the first two years, the key focus will be on implementing immediate-term (1-2 years) structural changes and internal projects within City government. This will include implementing Legacy Projects that can be showcased at the Republican National Convention as a demonstration of Charlotte's leadership within this space. The following three years will be focused on delivering short-term (3-5 years) projects that include larger scale infrastructure projects that have been feed up by these key structural changes. The medium-term (5-12 years) will see the implementation and completion of projects that will deliver on the 2030 GHG reduction target of reaching 7tCO₂e and City target for sourcing 100% zero carbon energy for municipal buildings and transportation. The longer-term (12-32 years) will see a multipronged approach that includes working to scale up pilot projects and accelerate impact, and implementing larger scale infrastructure projects. As the projects are being implemented, they will be continuously monitored by CREDIT to ensure an equitable approach is taken.

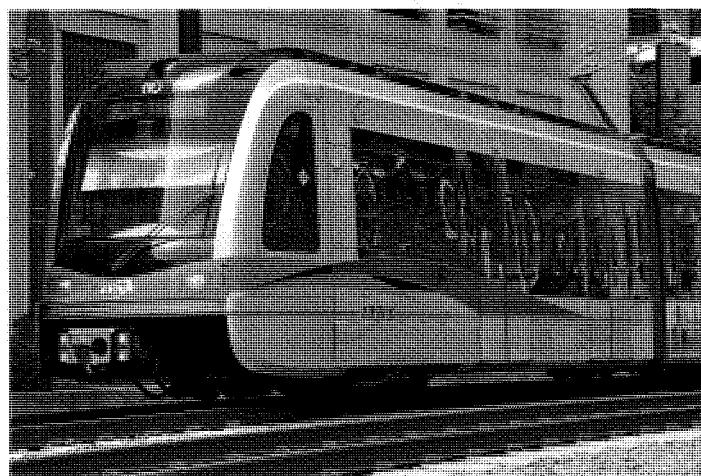
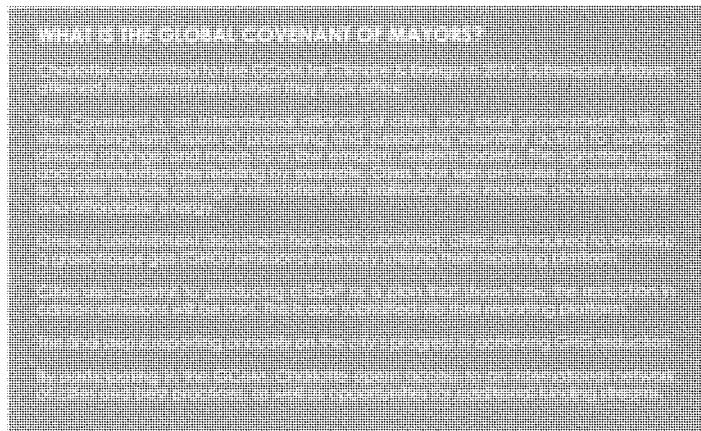
The SEAP has been designated a "living document" due to its long-term target of 2050 and knowing that there will be technology advances, new research findings, and inevitable changes in government policies within this period. This will require an initial biennial review with the CREDIT team leading this review, identifying known risks or issues, and providing solutions in collaboration with stakeholders.

This Executive Summary is simply an overview document to help interested stakeholders understand Charlotte's ambitious and aggressive approach to reducing greenhouse gas emissions - how it was created, why it is necessary, and what steps will be taken to address the problems. For a more detailed plan, please visit: charlottenc.gov. This website provides more detailed information and status updates regarding CREDIT's implementation efforts.

The City is committed to providing transparent progress updates citywide, as well as work to communicate our success to cities nationally and globally to share what has been learned. Charlotte is committed to providing a low carbon resilient future for all of its citizens.

NEXT STEPS





LYNX Blue Line light rail.

GREENHOUSE GAS EMISSIONS + TARGETS FOR EMISSIONS REDUCTION

A core requirement of the GCoM includes the development of a baseline for GHG emissions and a SEAP based upon relevant mitigation targets. The project launched in early December 2017 with a starting point of collecting the necessary data to develop the City's most granular greenhouse gas baseline yet.

Prior baselines have been developed for Charlotte, but have lacked granularity due to difficulty in obtaining the necessary data in the right format. Through engagement and a common working goal, this data was obtained and a structure identified to continue its collection. This engagement included multiple meetings with Duke Energy leadership, which eventually culminated in a meeting with Duke Energy's CEO, Charlotte's City Manager, and Envision Charlotte's Executive Director regarding the City's vision and proposed path toward a low carbon future.

There are many ways to report on GHG emissions. However, since Charlotte has committed to report its GHG baseline and submit annual updates via CDP (formerly the Carbon Disclosure Project) Cities reporting platform⁵, the City has adopted the Global Protocol for Cities (GPC) methodology. There are two components to this: 1) a BASIC inventory that covers energy and waste emissions; and 2) a BASIC+ inventory that further includes agricultural, land use change, and industrial processes and product use

emissions.⁶ The energy component includes buildings and transportation. By utilizing this methodology and associated reporting, the City ensures it is following an "apples to apples" comparison with other cities globally.

Utilizing the Global Protocol for Cities to Set GHG Reduction Targets

A global standard for estimating emissions at the city scale has recently been established. This is called the Global Protocol for Community-Scale Greenhouse Gas Emission Inventories (GPC).⁷ This was formed through a coalition between the World Resource Institute (WRI), ICLEI, and C40 Cities Climate Leadership Group. Through the GCoM, hundreds of cities across the globe have committed to use the GPC to report their greenhouse gas emissions. For this reason, the CDP Cities reporting platform utilizes the GPC.

As the discipline of emissions accounting is so complex and is further complicated by variations in data collection techniques, the GPC affords a consistent framework for accounting and reporting citywide greenhouse gas emissions. Importantly, it guarantees international recognition of the approach used by Charlotte.

⁵ CDP collaborates with the other various organizations like ICLEI, C40, and WRI to support the global efforts to provide transparency and consistency in tracking and reporting global GHG emissions. (<https://www.cdp.net/en/cities-disclosure>)

⁶ This is referring to emissions released due to specific industrial processes such as cement manufacture and GHG leakage in products such as air conditioner units.

⁷ This methodology will be the minimum used against which progress will be measured. The project team is careful to use the words minimum here to allow for the potential to incorporate wider 'embodied carbon emissions' into the calculations in the future. This is a further example of leadership being demonstrated by the City and recognition of the changing landscape of policy in this area. (<https://ghgprotocol.org/greenhouse-gas-protocol-accounting-reporting-standard-cities>)



Traffic light and sign at E. Trade Street.

CHARLOTTE'S CARBON EMISSIONS + ENERGY CONSUMPTION PROFILE

The SEAP focuses on carbon dioxide equivalent greenhouse gases, which can be expressed as a single unit associated with energy demand and generation. The following section provides context around Charlotte's greenhouse gas emissions and energy consumption profiles, as well as the targets set for 2030 and 2050.

Charlotte's GHG Baseline

While 1990 is the standard year recommended as a baseline for countries for emissions reductions, cities most often utilize 2005 due to data availability. The GCoM recommends choosing the year for which a city can get the most comprehensive and reliable data. In Charlotte's case, the baseline year for the SEAP and the determined GHGs is 2015.

Charlotte's 2015 Baseline Emissions Inventory is 12tCO₂ per capita. This covers emissions for the entire geographic area of the City of Charlotte,

and includes all emissions from energy and waste. Charlotte's biggest emitter is energy at 96%, with waste emitting 4%. Buildings (residential and commercial) comprise approximately 56% of the emissions, with transportation rounding out the remainder at 40%. There is a small amount of industry included in these figures. What this shows, is that tackling emissions in the building and transportation sector will make the greatest contributions to achieving the SEAP targets.

The City is using CO₂e, or carbon dioxide equivalent, as the standard unit for expressing its GHG emissions. The purpose of this is to express the impact of each greenhouse gas in terms of the amount of CO₂ that would create the same amount of global warming. In this way, a baseline consisting of many different greenhouse gases can be expressed as a single number.

⁸ While agriculture is currently at 0% of Charlotte's emissions inventory, it is anticipated to grow as the Circular Charlotte strategy is implemented. A key part of developing a circular economy paradigm within a city is redesigning food systems and recognizing that growing locally is a key part to this. So, while it's anticipated that agriculture emissions might increase minimally by growing locally, other emissions, like transportation, will subside.

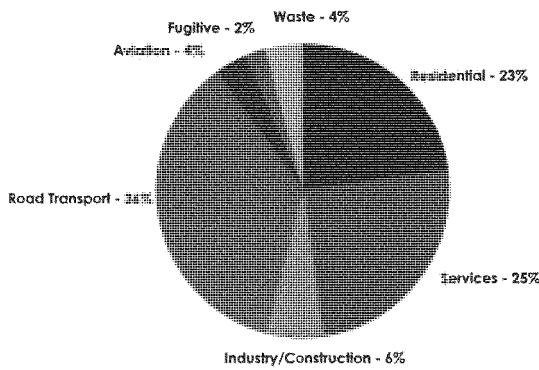


Figure 1: 2015 Baseline Greenhouse Gas Emissions for Charlotte, North Carolina

A Science-Based Target⁹

A science-based target requires an awareness of how much carbon dioxide and other greenhouse gases are being pumped into the atmosphere because of human activity (both within Charlotte and beyond). To meet the goal of the Paris Climate Accord – to stay below a temperature increase of 2°C globally – the global community must reach peak global GHG emissions by 2030 and reduce them by at least half by 2050. It is important to understand that these targets for 2050 represent mid-points, as the reductions of GHG emissions must continue beyond this point.

Climate change is caused by global warming and global warming is caused by a buildup of greenhouse gas emissions in the atmosphere. This concentration of gases in the atmosphere is built up over time for differing periods – for example, carbon dioxide lasts for 100 years, while methane⁹, which is 28 times more potent than CO₂, lasts for 10 years in the atmosphere. It is therefore the total amount of greenhouse gases released, between now and 2050, that will determine the level of global warming that cities around the world will experience.

⁹ Emissions of methane in the energy sector come from leakage of natural gas when it is distributed and extracted. The level of methane released when extracting 'fracked' gas is significantly higher than from conventional techniques. The total amount of emissions across the USA associated with the extraction of natural gas (whether conventional or fracked) is 2%. This can be compared to emissions of methane from agriculture which amount to 4% (<https://tinyurl.com/y9br7pi7>). This highlights the damaging amounts of emissions associated with extraction of natural gas. There is a wider issue attached to 'fracked gas,' which is associated with how it may hinder renewable deployment and encourage longer term use of fossil fuels. This has a far more damaging impact in the long-term. This is because demand for fracked gas has come about because of the price of conventional natural gas. This makes renewables less cost competitive in the short-term, which may in turn lead to further investment in natural gas infrastructure (for homes, businesses, industry and power stations) which has long-term lock-in implications and will lead to long-term issues associated with greenhouse gas emissions reduction brought about by short-term cost influenced energy investment decisions.

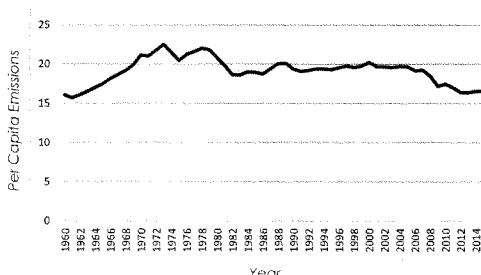


Figure 2: USA Emissions of CO₂ Per Capita 1960-2015

A per capita target helps to address many of these concerns. The concept of a per capita target is displayed in Figure 2, alongside the targets for the Paris Climate Accord. The use of a per capita target allows for a forward-looking approach, as well as setting the pathway for a carbon budget (should one be set in the future by Charlotte).

The concept of using a per capita target was discussed and presented to the community at one of the Stakeholder Meetings and was widely endorsed. Bilateral meetings also took place with a range of advocacy groups, government departments, and businesses within Charlotte to further discuss the approach and assess support. The per capita target of 2tCO₂e was subsequently unanimously supported by City Council on June 25, 2018.

To achieve the 2tCO₂e per capita target, Charlotte's City government needs to 'show the way'. The City, therefore, adopted higher targets for its own buildings and fleet. These commitments extend far beyond that of the original resolution. The City ultimately committed to 'striving to source 100% of its energy use in [City of Charlotte] buildings and fleet from zero carbon sources by 2030' via a unanimous vote by City Council.

The Paris Climate Accord commits signatory countries to keeping global temperatures "well below" 2.0°C (3.6°F) above pre-industrial times and "endeavour to limit" them even more, to 1.5°C (2.7°F). This is to prevent dangerous climate change. Increased temperatures will cause increases in severe weather events. This would lead to considerable negative impacts on our health and economies.

Delivering such a target is not a small undertaking and will require City Council commitment, innovative thinking on behalf of City staff, changes to procurement approaches, and a desire to be an international leader. This will require strong internal leadership, including forward-thinking, acceptance, engagement, and experimentation.

Is it Possible to Reduce to 2tCO₂e by 2050?

To effectively achieve the 2050 target, collaboration and innovative approaches are required. More importantly, if Charlotte wants to remain economically competitive and play its part in mitigating climate change, then it is a necessity.

Urban density presents opportunities to create a greener way to live by creating the possibility for a better quality of life and a lower carbon footprint through more efficient infrastructure and planning. This affords significant opportunities for efficiency improvements through promoting public transportation opportunities and accelerating the transition to electric vehicles. There are also real opportunities for on-site energy generation. These, together, provide real opportunities for change that can accelerate Charlotte's transition to a low carbon future.

In addition, Charlotte is home to the largest U.S. energy utility, Duke Energy, and the third-largest U.S. banking sector, with both Bank of America headquarters and Wells Fargo corporate offices located within

City boundaries. By having these three corporations located within the City, opportunities for partnerships and innovative financing prospects are created that can allow Charlotte to leapfrog other cities in urban innovation and action.



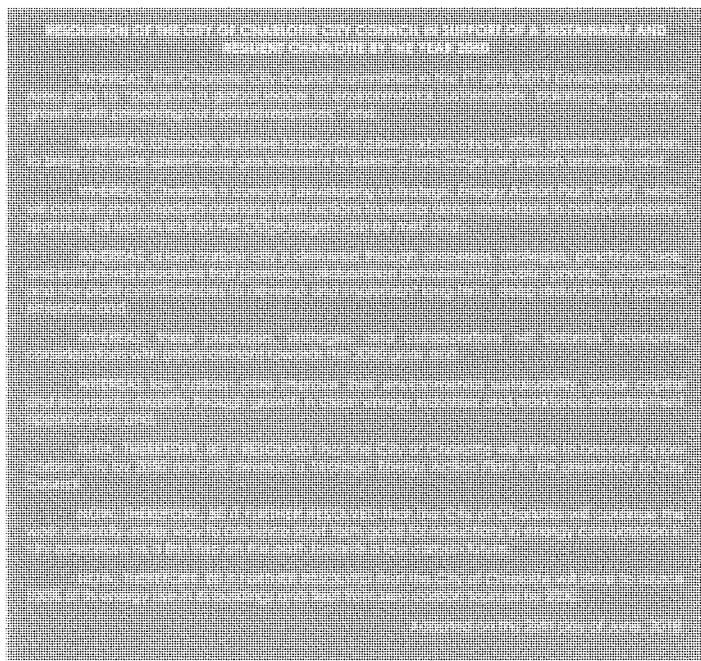
THE SUSTAINABLE AND RESILIENT CHARLOTTE BY 2050 RESOLUTION

In November 2017, City Council considered a Clean Energy Resolution (CER) that would, among other items, commit the City to 100% renewable energy by 2050. City Council voted to send the resolution back to the Environment Committee for further discussions and asked that the Committee draft a resolution appropriate and tailored to Charlotte, as well as develop an action plan for the goals that would be achieved. City staff worked in close partnership with stakeholders and drafted a new resolution that encompassed the City's commitment to the GCoM and broadened the target to

a low carbon future, while also specifying that the SEAP would provide the action plan for achieving the goals. City staff presented the final resolution to City Council on June 25, 2018 and received widespread support from community stakeholders and a unanimous vote by City Council¹⁰. The stakeholder engagement required to develop the Resolution gave clear insights into the kind of structures and understandings that need to be put in place to realize change.

¹⁰ The full 'Sustainable and Resilient Charlotte by 2050' resolution can be found here: <https://tinyurl.com/yclmboqn>

The Sustainable and Resilient Charlotte Resolution
language



The 'Sustainable and Resilient Charlotte by 2050' Resolution language

A PLAN FOR ALL: FORMING AN ACTION PLAN

The SEAP is an ambitious, aggressive action plan for delivering a low carbon, resilient Charlotte. While the plan has been promulgated by City management, and the City is responsible for leading its implementation, the plan is a citywide strategy. It is intended to improve the quality of life for all citizens of Charlotte. While there are recommendations and projects that fall to the responsibility of the City to implement, there are many that require public-private-plus-partnerships¹¹ as well as collaborative approaches with community stakeholders.

Charlotte is fortunate to have many community stakeholders that are actively engaged and knowledgeable in topics relevant to a resilient future. The SEAP's recommendations set out a framework in which collaboration with Mecklenburg County, the community, and other key stakeholders can be leveraged. This facilitates access to additional expertise, innovation, and engagement opportunities. Together, these enable the implementation of SEAP recommendations that drive the adoption of the resilient energy solutions required by the Resolution.

Through its implementation and updates, the SEAP will support locally led efforts to deliver solutions that enable Charlotte to transition to a low carbon future. A key goal of the SEAP is to enable and empower Charlotteans to make informed decisions regarding

energy generation and consumption. As part of the data exercise for the strategy and the Resolution's production, the project team identified and engaged with many community groups and organizations. Many of these are actively engaged in moving forward low carbon initiatives. This wealth of knowledge and experience provides an excellent foundation from which to begin implementing the SEAP's Action Areas.

Vision

A vision for sustainability and resilience has been produced for the City. This was produced in partnership with the community. The purpose of the vision was to provide a common goal under which sustainable and resilient projects can sit. This vision was developed across multiple workshops and culminated in the following:

"Charlotte will lead, as a global city, by continuously improving, protecting, and preserving the environment, its community, and economy, while ensuring equity and resilience - for today's and future generations."

This vision is intended to be used by all stakeholders in Charlotte when promoting their work and attracting funds for initiatives that they want to undertake.

¹¹ A public-private-plus-partnership or P4 is defined as a cooperative agreement between public and private sectors in addition to universities and utilities.

5 STAGES TO ZERO CARBON ENERGY

The Five Stage Approach to Zero Carbon Energy is a logical and clearly described tool that can be applied to buildings or transportation. It is a continuous approach that consists of five repeating stages:

1. Shifting energy demand
2. Reducing energy consumption
3. Changing energy we consume away from fossil fuels
4. Generating energy on-site
5. Meeting the remainder through energy purchases

By following this tool, the City of Charlotte and its citizens can identify cost-effective and realistic paths to delivering the GHG reductions sought. This tool is being applied by the City to identify and communicate how it is delivering zero carbon solutions to non-experts.

Shifting Energy Demand

The biggest challenge to energy planning is ensuring peak demand is predicted and met through supply. This challenge becomes more complex with the introduction of intermittent renewables into the energy system. Because the production of electricity from intermittent renewables is partially unpredictable, the goal of this stage is to shift when, during the day, electricity is being demanded. This requires moving certain energy consuming activities like hot water production to when renewable energy production is at its highest. It may mean ensuring the City's electric vehicle fleet is charged overnight when zero carbon electricity may be cheaper to procure. It may require weekends to be used to provide power for weekdays. It can also mean shifting electricity demand in buildings where solar PV¹² exists to maximize the use of the renewable electricity produced. These are called demand side responses and they are key to a cost-effective system.

Being able to shift when electricity is demanded means there is a need for less power generation, less need for storage, and a smaller infrastructure footprint resulting in efficiency and potential cost savings.

Using Less Energy

Reducing the amount of energy consumed is nearly always the most efficient way to meet a zero carbon target. This is because the less energy required on the demand side, the less zero carbon energy that is required on the production side. Reducing energy consumption can come in many forms including switching lights off, turning the thermostat down, and increasing space density. There is also the opportunity for behavioral changes such as eco-driving, which may result in lower energy consumption in current fleets of fossil-fueled vehicles. This presents a good habit for driving bioenergy¹³, electric, or hydrogen-based vehicles.

Changing the Energy we Consume

The next step to consider is to change the types of energy we consume toward lower carbon alternatives. This step does not have to be immediate; for example, the transition away from fossil fuel-based vehicles to electric vehicles can be started now and extend over many years. However, the structures should be in place to facilitate the transition. Changing the energy we consume could also result in moving from fossil fuels to bioenergy, or indeed natural gas to biogas¹⁴.

Generating Energy On-Site

The generation of energy on-site includes, but is not limited to, electricity. On-site generation may also include heat produced from geothermal heat pumps, air pumps, or solar thermal. It may also include heating and cooling produced by a boiler or an on-site combined cooling, heat, and power¹⁵ (CCHP) system running on zero carbon energy. It may also be

¹² Solar PV references solar photovoltaic (PV) cells that convert sunlight directly into electricity (<https://www.nrel.gov/workingwithus/rephotovoltaics.html>)

¹³ Bioenergy is classified as a form of renewable energy derived from biomass—organic material—that can be used to produce heat, electricity, transportation fuels, and products. <https://www.energy.gov/eere/bioenergy/bioenergy-basics>

¹⁴ Biogas is derived principally from the anaerobic fermentation of biomass and solid wastes and combusted to produce heat and/or power. Included in this category are landfill gas and sludge gas (sewage gas and gas from animal slurries) and other biogas. Liquid biomass, which includes bio-additives such as ethanol, is also included in this category. (<https://stats.oecd.org/glossary/detail.asp?ID=4585>)

¹⁵ Combined cooling, heat & power (CCHP), also known as tri-generation, is an extension of combined heat & power (CHP). While CHP only generates electricity and heat, CCHP adds cooling to the list, which means some of the heat that is produced is also used to generate cooling energy.

supplemented by storage opportunities. These options each reduce reliance on the grid.

Procure the Rest through Contracts

When steps have been taken to shift energy demand, reduce the amount of energy consumed, and switch

the type of energy being used, and current on site generation options have been exploited, the remainder should be purchased from zero carbon sources – in the form of a tariff from a utility¹⁶. This is meant to be a last resort when the other four options are not able to reach the desired result at the desired time.

¹⁶ This could include Duke Energy, Energy United, or a Landlord depending on who is involved.

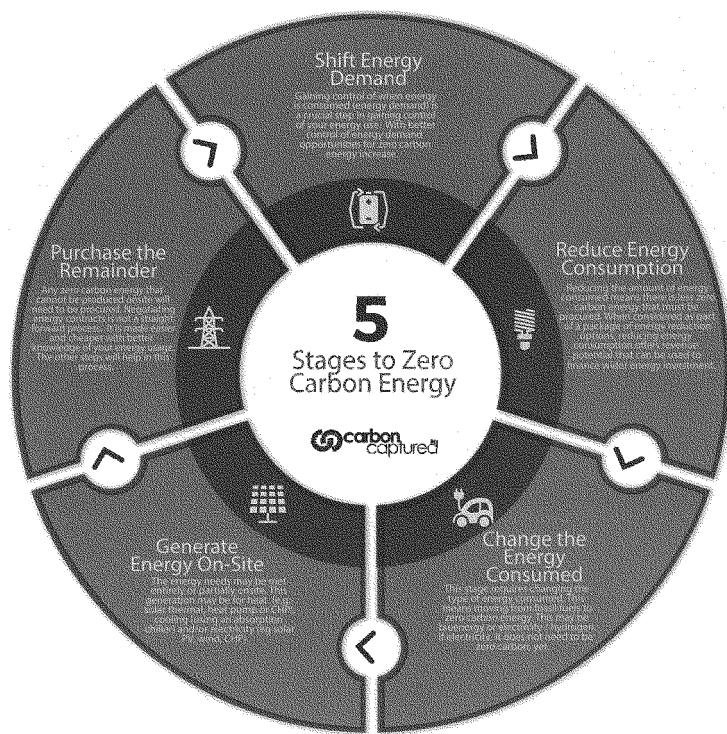


Figure 3: 5 Stages to Zero Carbon Energy Diagram

THE STARTING POINT IN THE CITY

This section provides an overview of the current situation regarding governance, procurement, transportation, and buildings in Charlotte through a lens of carbon emissions impacts, and will provide the basis for the recommendations in the Action Areas. Like any city, Charlotte will face obstacles in the implementation of the Action Areas. However, as this section points out, Charlotte already has many things happening, which through further coordination, provide a solid foundation to guide the transition to a low carbon, resilient Charlotte.

City Government – Sustainability & Resilience

There is currently a sustainability team that is comprised of a Director, a sustainability coordinator, and a sustainability analyst. The role of this department is to provide oversight and coordination on all sustainability and smart city projects and issues within the City. In addition, there is a wealth of City staffers that are personally passionate and engaged around sustainability issues. Finally, some departments have individual staff members that have specific sustainability responsibilities as parts of their role.

General Procurement Practices

There is opportunity within the City to develop and improve current procurement practices to give a greater sustainability focus. While current procurement policy does have some green procurement requirements and recommendations, strengthening and enhancing current policy can be used to stimulate a local green economy and with it associated jobs. It can also be used to address wider supply chain requirements with service providers that relate to sustainability.

Charlotte's Urban Forest

When viewed from above, Charlotte's tree canopy covers 47% of the City, which makes Charlotte one of the highest canopy cities in the U.S. On top of the aesthetic benefits Charlotte's trees provide, the City receives over \$335 million in real benefits and services from these trees every year. Charlotte's trees provide a cooling effect to the City, helping to drop temperatures caused by the Urban Heat Island Effect. The canopy also acts as a carbon sink; this means it helps to reduce emissions of CO₂ globally. If these trees are cut down and not treated appropriately, they could increase emissions in Charlotte. Their removal would also mean that they no longer reduce emissions, ultimately resulting in an overall increase in time. The tree canopy therefore has a significant impact on both mitigating and adapting to climate change.

Despite these valuable benefits, the City's tree canopy is at risk. The two most pressing concerns are a large population of mature trees reaching the end of their natural lifespan, along with significant losses from development as the City grows. Loss of tree canopy results in serious public health issues, including poor air and water quality, and declining communities and wildlife habitats. To ensure that this canopy is preserved and maintained for generations to come, in 2017, the City completed an Urban Forest Master Plan (UFMP) with the goal of preserving and enhancing Charlotte's urban forest. The UFMP outlines twelve steps for the community to take to achieve City Council's goal of a 50% tree canopy by 2050. Charlotte's Urban Forest Master Plan provides the blueprint for the engagement and purposeful action of community leaders, residents, and organizations in sustaining Charlotte's tree canopy.

For more information about Charlotte's Urban Forest Master Plan, see charlottetreeplan.weebly.com.



Figure 4. Potential Annual Benefits from Charlotte's Urban Forest

BUILDING RESILIENCY

Buildings

Buildings are significant energy consumers through demand-side practices of space conditioning and appliance use and charging; we consume energy through them for our daily activities. They are also rapidly becoming the places where we charge our cars. A significant transportation impact occurs because of their location. Therefore, buildings and facilities are fundamental components of how and when the City uses energy, both today and in the future.

There are two primary considerations for the SEAP: municipally owned buildings and non-municipal buildings. The Sustainable and Resilient Charlotte Resolution has a specific target for municipal buildings run on zero carbon energy by 2030.

Municipally Owned Buildings

Like the citywide emissions of Charlotte, the largest source of greenhouse gas emissions within the City Government comes from its buildings. This is through the direct combustion of natural gas in these buildings for heating and, indirectly, the fossil fuels used to produce electricity. The Policy for Sustainable Facilities (PSF) is a plan that will see all new and existing government buildings (over 5000 sq. ft.) upgraded to LEED¹⁷ Certified requirements, with an additional requirement to achieve Energy Star certification¹⁸ by 2026. The implementation of this plan is overseen by the Sustainable Facilities Oversight Team (SFOT)¹⁹.

The PSF is comprised of 13 points and a detailed list of actions. The policy encompasses the "fix-it-first" approach of the City government and contains provisions for incorporating publicly accessible electric charging points. This policy is in support of the City's Environment Focus Area Plan (EFAP) that charges Charlotte with becoming a global leader in environmental sustainability which includes a requirement to increase renewable energy usage within City facilities.



LEED and Energy Star certification logos

Non-City Owned Buildings

Charlotte has strong building stock of existing buildings and is adding new buildings to the skyline daily. Currently, building permitting and code enforcement sits with Mecklenburg County and the State, the entities responsible for issuing building, electrical, plumbing, and mechanical permits. The City of Charlotte helps in the review process, but does not control it, which poses policy challenges. The County has developed a new Hybrid Collaborative Delivery Team (HCDT)²⁰ that is designed to review projects via 3-D and digital renderings and make the process more efficient and effective.

Charlotte is currently going through the process of developing a Comprehensive Plan which would then inform the regulations laid out in an updated Unified Development Ordinance (UDO). These documents will provide a regulatory mechanism that provides a vision and regulates public policies not related to building codes, such as transportation, land use, and housing, among other areas. A key part of updating these two critical land use documents is to drive greater urban density, address issues of walkability, and improve the quality of life for the residents of Charlotte which help reduce overall energy consumption. Like the SEAP, this process will be informed by other City strategies like Charlotte Bikes, Charlotte Walks, and the 2040 Transportation Action Plan.

¹⁷ There are four levels of LEED certification: certified, silver, gold, and platinum. The levels refer primarily to the building design. Additional accreditations using the same levels refer to the building's ongoing use. The LEED certification goes beyond energy, encompassing water, materials and waste, and human & health experience. (<https://new.usgbc.org/leed-v4>) Departments can also pursue other third-party certifications like Green Globes. (<http://www.gsa.gov/gbcertificationreview>)

¹⁸ The use of LEED and Energy Star provides a standardized set of guidelines that address all environmental issues. The intention is to minimize the environmental impact of these buildings while also conserving and protecting all resources – therefore extending beyond energy.

¹⁹ They are tasked with providing reporting metrics that are included in the Internal Environmental Operations Plan (IEOP). The team is partly guided by the 'Policy for Sustainable Facilities' (PSF). This team spans seven City departments.

²⁰ <https://www.mecknc.gov/LUESA/CodeEnforcement/permitting/Pages/Special-Projects-Team.aspx>

Retail and Mixed-Use Buildings

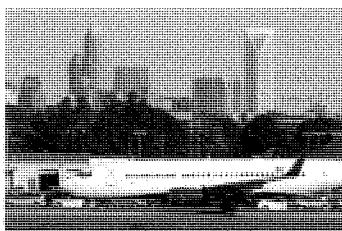
The General Development Policies (GDP)²¹ set requirements for mixed-use development, and includes the need for transportation networks that provide a variety of travel choices. These mixed-use centers have a requirement to include key retail and service outlets in one location to reduce transportation requirements and increase livability. The GDP recognizes the importance of an ecological footprint and includes a requirement to reduce ground temperatures (heat island effect), to minimize impacts to natural environment, to use water efficiently, and to improve the quality of storm water run-off.

Transportation

Transportation, in an emissions inventory, is comprised of four modes: road, rail, aviation, and marine. Road transportation is one of the largest sources of emissions globally, along with aviation. There are no marine emissions²² attached to Charlotte under the emissions reporting structure as it has no inland waterways or maritime borders. Together, these emissions form a significant opportunity for reduction, and require putting the right mechanisms in place to achieve it.

Road transportation is the second largest source of emissions in Charlotte, while aviation is the third largest source. Road transport emissions are caused by vehicle ownership and their use for business, private, and social means. These vehicles are owned by private citizens, businesses, and governments and span all vehicle types from motorcycles through to tractor-trailers. Aviation emissions are also particularly significant due to Charlotte Douglas International Airport, ranked seventh²³ in the world for aircraft movements. This accounts for a reasonable proportion of emissions, even just accounting for domestic flights. This proportion will make up a large component of the

2tCO₂e per capita target unless planning is made to address these emissions.



Uptown Charlotte skyline and aircraft from Charlotte Douglas International Airport

City Government Owned Fleet

The second largest source of City government emissions comes from the vehicles that it owns. These heavy-duty vehicles are mostly run on petroleum, although alternative fuel vehicles (AFV) have been incorporated, for example, within Solid Waste Services (SWS)²⁴ as well as in Charlotte Area Transit System (CATS)²⁵.

For light-duty fleet, the City has a fleet of electric vehicles (EVs) based largely at the Charlotte Mecklenburg Government Center. These are complemented by charging points at many City-owned buildings. The City also offers a motor pool service that includes EVs and hybrids that are available to all City staff. One of the challenges that the City²⁶ currently faces with the motor pool is range anxiety, largely brought about because lack of education around how to effectively drive an electric vehicle to maximize driving range. Internally, departments determine which make of vehicle is driven by their staff, further developing cultural associations between vehicles, types, and

The Starting Point in the City

21 <http://charlottenc.gov/planning/AreaPlanning/Plans/GDP/Pages/Home.aspx>

22 There are emissions attached to the goods that rely on the boats that bring them to the ports. In addition there are emissions associated with boat trips that Charlotteans take. These are, however, not included in a GPC inventory.

23 <https://aci.aero/news/2018/04/09/aci-world-releases-preliminary-2017-world-airport-traffic-rankings-passenger-traffic-indian-and-chinese-airports-major-contributors-to-growth-air-cargo-volumes-surge-at-major-hubs-as-trade-wars-thre/>

24 These vehicles run on Compressed Natural Gas (CNG). This is still a fossil fuel, albeit less carbon intensive and more efficient than petroleum. These vehicles get a "clean image" as the local air emissions (the pollution that affects breathing) are significantly lower than their petroleum counterparts. This often causes confusion with greenhouse gas emissions.

25 This largely refers to hybrid vehicles, although these are not plug-in hybrids and are therefore mostly targeted at reducing local air emissions. They may actually cause higher CO₂ emissions than the more efficient buses that are available.

26 The PSE extends to consider the link to wider infrastructure specifying the need for rapid charging based on proximity of the building to the interstate. The SPOT is required to review its policy annually recognizing the changing direction of Council's sustainable priorities and goals.

positions²⁷.

The long lifespan of vehicles means that their procurement today to meet the resolution's requirements is critical. The Fleet Maintenance Advisory Team (FMAT) guides the procurement process to reduce maintenance costs²⁸. However, the budget for maintenance comes from the general fund²⁹, making it harder to demonstrate potential cost savings. There is a fuel efficiency recommendation as part of the fleet policy, but it has had limited success.

Transportation Strategies

The City has a set of strategies that are targeted at reducing the use of automobiles. These include Charlotte Bikes, Charlotte Walks, and the 2040 Transportation Action Plan. These strategies identify ways to facilitate the use of alternative means of transportation. Consequently, they identify ways to



Electric Vehicle charging station at the Charlotte-Mecklenburg Government Center parking deck

make it safer to walk and cycle around the city, which has a positive effect on reducing carbon emissions by reducing automobile trips.

The various plans that the City has developed to facilitate use of alternative modes of transit all support the concept of Transit Oriented Development (TOD). The intent is to create livable communities where people can get to the office, grocery store, restaurants, libraries, and parks without requiring the use of a car. The TOD approach makes provisions for providing extensive pedestrian systems throughout neighborhoods to minimize walking distance for residents. The approach makes provision for buffering cyclists from automobile activity with few conflict points.

A significant example of this is the proposed Charlotte Gateway Station³⁰ that will provide a multi-modal transportation facility that will merge public transit with intercity modes, increasing transportation options. Moreover, the project team also developed a Multi-modal Station Area Plan (MSAP) that identifies current priorities and transportation needs, like locating high density mixed-use development around the station.

Workforce Development

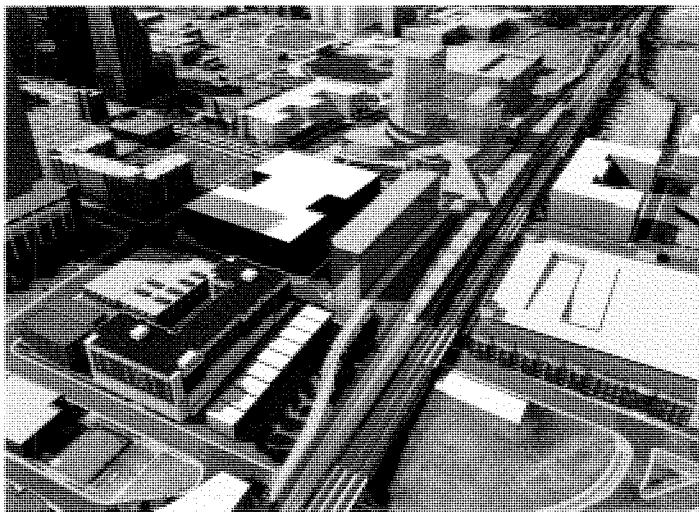
Over the past five years, the City of Charlotte has amplified their role in equitable economic development through workforce development initiatives to remove the seemingly insurmountable barriers facing Charlotte residents in poverty. As part of this effort, the City's Economic Development department partnered with Goodwill Industries of the Southern Piedmont and the Urban League of Central Carolinas to sponsor the Partnership for Inclusive Employment and Career Excellence (P.I.E.C.E.), a workforce development program that provides skills and training as well as supportive services to help people obtain and keep jobs. This innovative program connects individuals with multiple barriers to employment to meaningful career paths while fulfilling labor market shortages in key industries, and makes a lasting impact on its participants and the Charlotte community.

27 A highly important issue to consider when looking to transition the fleet to a low carbon one is to see that these cultural implications are not challenged too much.

28 Procurement varies between departments based partly on whether they are an enterprise or general fund. Enterprise funds get their rates and fees in a manner to recover the full cost of their operation and necessary capital investments. The following City departments' budgets are part of the enterprise funds: Aviation, Storm Water Services, CATS, and Charlotte Water.

29 General fund service departments' budgets and performance achievements are funded by the City's property and sales taxes.

30 <http://charlottenc.gov/cats/transit-planning/charlotte-gateway-station/Pages/gateway-station.aspx>



The proposed Charlotte Gateway Station Transportation Facility

The Starting Point in the City

WHY DOES THE CITY NEED A SEAP?

The overarching purpose of a SEAP is to provide a strategy for a city or region to follow as it strives toward a 'low carbon, resilient future'. A successful SEAP will focus on 'how do we get there?' rather than answering the question 'can we actually get there?' The key focus of a SEAP is GHG emissions reduction, but also explores the opportunity to align economic development policy, such as the creation of green jobs with the actions necessary to transition to a low carbon energy future.

Like many strategies, a SEAP can be thought of as being comprised of three core components: (1) a baseline assessment; (2) a vision; and (3) a roadmap for how to achieve the targets. The SEAP is a living document. This means that every two years, progress will be benchmarked by City staff that are tracking key data points. If necessary, the SEAP will undergo a formal update process that will realign it to ensure the City is continuing to move towards its 2030 and 2050 GHG reduction targets as stated in the Resolution. Formal reviews and updates are required due to policy change, technology innovation, and shifting of resources.

A SEAP has targets and structures that set out the pathway for a city's future energy consumption that spans decades. It requires a mindset that embraces change and looks for opportunities to: reduce energy consumption (everyone being energy conscious); change the energy that we use (using bioenergy rather than oil); and, change the way that we generate it (using renewables rather than fossil fuel).

The SEAP requires high level buy-in from City government leadership to be successful because it requires resources, including program-focused funding and staff who are dedicated to implementing the recommendations. Because of a need for integration into daily living, it also requires widespread engagement of stakeholders, which are comprised of City staff, private sector corporations and businesses, NGOs, utilities, advocacy groups, and community members.

Charlotte's SEAP makes recommendations that address the necessary structural and behavioral changes, as well

as physical projects that can help the City achieve a low carbon future. These recommendations, in the form of Action Areas, will result in fundamental changes to how decisions are made in relation to investment within the City, most notably how the City approaches cost. It also requires a change in the way in which energy is thought about, particularly in understanding consumption patterns. As energy is fundamental to our business and working lives, a SEAP provides many opportunities for job creation, increased resilience, enhanced health, and improved energy security among other issues. While there are various factors to navigate in the implementation of the Plan, there is an exciting opportunity for Charlotte to shape and implement change with significant positive outcomes in the form of job creation and keeping revenues within the city.

Addressing Climate Change and Associated Challenges

Cities are hubs of innovation, commerce, and culture, and by 2050 nearly 70% of global population is projected to live in urban areas. As cities grapple with the effects of climate change and global warming, the need to understand the embedded challenges within these complex systems becomes critical.

Charlotte's development of the SEAP shows the City's leadership in their desire to address the fact that the impacts of climate change significantly affect all communities, and the need for solutions that are effective, fair, and equitable. Like many cities throughout the world, Charlotte is experiencing the challenges of energy poverty³¹, resilience³², demand for job opportunities and training, equitable economic development, and many other urban issues.

Energy Poverty

While Charlotte's energy costs are approximately 10% lower compared to the national average³³, energy poverty is still an issue for many low-income families in Charlotte. The average price of electricity has grown by 30% in NC over the last ten years and 28% nationally³⁴. The Action Areas recommended in the SEAP will work to address these challenges by providing more affordable

³¹ Energy poverty occurs when households spend more than 10% of their incomes on energy expenses each year. In North Carolina, many low-income families often spend 20% of their income on energy. (www.resaset.org/)

³² Resiliency is defined as "the capacity of individuals, communities, institutions, businesses, and systems within a city to survive, adapt, and grow, no matter what kinds of chronic stresses and acute shocks they experience." (www.100resilientcities.org/)

³³ [https://www.eia.gov/electricity/data/state/](http://www.eia.gov/electricity/data/state/)

³⁴ [https://www.energy.gov/energy-economy/prices-trends](http://www.energy.gov/energy-economy/prices-trends)

options and access for households experiencing energy burdens.

Resiliency

Having a stable energy grid with reliable and diverse energy generated locally is key to a resilient strategy for Charlotte. The alternative, depending on finite resources like oil, gas, and coal, is not a resilient approach. The SEAP focuses on ways to decentralize the energy supplies within a regulated state. This will drive an increase in the use of renewable energy, localized energy generation, and procurement of zero carbon energy. This will help the City develop a resilient future for generations to come while minimizing environmental impacts from using fossil fuels.

City Bond Ratings

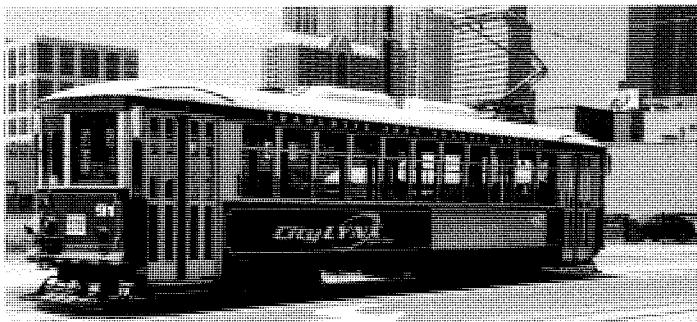
Climate change is quickly becoming a credit issue for city and state governments as they become more vulnerable to extreme weather events and natural disasters. Credit rating agencies like Moody's³⁵ have started factoring in the impact of these climatic events on infrastructure, economy and revenue base, and environment. This means that if cities do not have strategies in place to mitigate and adapt to climate risks, the costs of borrowing money will start to become

more expensive. By developing the SEAP, Charlotte is taking a proactive approach to ensuring its bond ratings remain at the very top of the municipal credit market as that market evolves.

Equitable Economic Development and Jobs

Through the expansion of a low carbon energy sector, employment opportunities expand. Part of the focus of implementing the SEAP is on how the workforce pipeline will be filled to ensure well-paying jobs and sustained employment.

Economic development and job creation opportunities range from energy efficiency measures like retrofitting residences and buildings, to installation of solar PVs, to retrofitting internal combustion engine (ICE) cars with electric motors. There is approximately the same number of people employed in the green energy sector in the USA as there are in telecommunications³⁶. North Carolina has established itself as a clean energy leader by ranking third in the US for gigawatt-hours of solar power produced annually³⁷.



LYNX Gold Line Trolley in Uptown Charlotte

35 https://www.moodys.com/research/Moody's-Climate-change-is-forecast-to-heighten-US-exposure-to--PR_376056 35
<https://www.eaf.org/energy/clean-energy-jobs>

36 <https://www.bizjournals.com/charlotte/news/2018/07/18/how-north-carolina-is-pushing-beyond-solar-to.html>

37 While agriculture is currently at 8% of Charlotte's emissions inventory, it is anticipated to grow as the Circular Charlotte strategy is implemented. A key part of developing a circular economy paradigm within a city is redesigning food systems and recognizing that growing locally is a key part to this. So, while it's anticipated that agriculture emissions might increase minimally, but growing locally other emissions, like transportation, will subside.

Why Does the City Need SEAP?

CHALLENGES + OPPORTUNITIES

Charlotte will face many challenges as it works to implement the SEAP and transition to a low carbon energy future. However, with these challenges come opportunities to implement equitable and inclusive low carbon solutions that improve the quality of life for all citizens of Charlotte, grow our local green economy, and create new job opportunities.

Growing Population

Charlotte was ranked as the second fastest growing large City in the U.S. in 2017³⁸. Current statistics state that 43 people were moving to Charlotte per day in 2017³⁹. The City's current population sits at around 860,000⁴⁰ with the population projected to hit 1.1 million by 2030 and 1.4 million by 2050⁴¹. Charlotte is attracting proportionally more millennials to it than any other city in the USA; this cohort represents a key demographic in awareness of climate change issues.

Rapid population growth can be a challenge because with rapid growth comes the demand for quality housing (existing and new) and the associated upgraded infrastructure. However, there are many opportunities that arise as a result. With high rates of rental housing, Charlotte could work with landlords to transition all lighting to LED, or incentivize on-site generation of zero carbon energy that is then sold to tenants. While this increase in population can increase GHG emissions, it also presents the opportunity to pilot projects, scale up existing successes, and drive zero carbon developments.

The City of Charlotte currently has a mandate to deliver 5,000 affordable housing units within the next three years (2017-2020)⁴². In addition, the City is putting together a \$150 million fund for delivering the housing. An opportunity exists to work closely with the organizations helping to deliver the affordable housing units and ensure that they are Energy Star certified, powered only by zero carbon energy sources, and built by a local workforce that have been trained specifically in the field of green buildings.

Non-residential Buildings

One of the biggest areas that Charlotte can address to reduce GHG emissions is through its buildings. Every building that is constructed without a focus on energy is a missed opportunity with an impact that may last over 100 years. Construction that occurs without thought to multi-modal transportation is a barrier to future change. These are both examples of 'lock-in,' which must be avoided to facilitate an innovation-minded approach.

Charlotte is already in a prime position to make their commercial buildings throughout Charlotte more energy efficient. Envision Charlotte has successfully piloted Smart Energy Now, in partnership with Duke Energy and the University of North Carolina – Charlotte's Sustainably Integrated Building Systems program (UNCC-SIBS), which worked with 61 commercial buildings in Uptown Charlotte and achieved energy savings of 19% over five years. The pilot was expanded by a grant from the U.S. Department of Energy for an additional three years and successfully reduced energy by 13.1% in an additional 81 buildings. This program has already developed a framework, now it just needs to be aggressively scaled throughout the City of Charlotte.

Energy Transition in a Regulated State

One of the larger challenges Charlotte faces is transitioning to a low carbon energy future in a regulated state. North Carolina is a regulated energy market with clear controls over how, who, and when energy may be bought and sold. Regulated markets feature vertically-integrated utilities that own or control the entire flow of electricity from generation to meter.

Duke Energy Carolinas (DEC) is currently in control of this. However, it has recently been announced that Duke Energy Progress (DEP) and DEC are to merge⁴³. This presents greater opportunities for the integration of a variety of energy sources. With intermittent

³⁸ <https://wallethub.com/edu/fastest-growing-cities/7010/#overall>

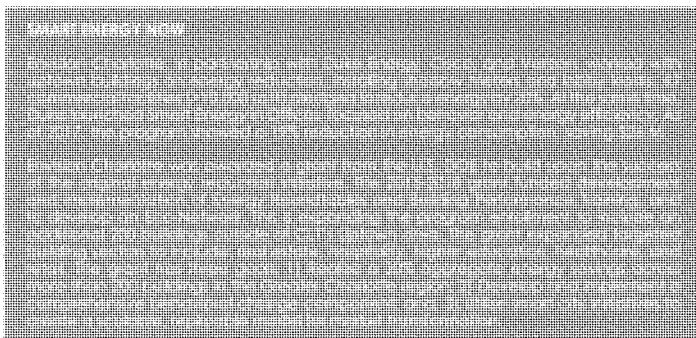
³⁹ This represents an annual growth rate of 1.8%. (<https://www.bizjournals.com/charlotte/news/2018/05/31/with-charlottes-population-growth-among-the-top-in.html>)

⁴⁰ US Census Bureau estimated Charlotte's 2017 population to be 859,035 people. (<https://www.census.gov/quickfacts/fact/table/charlotnecty/northcarolina/AFN120212>)

⁴¹ Extrapolated from Personal Communication, Lowry, Evan, 14th Feb 2018. Sphere of influence.

⁴² <http://charlottenc.gov/HNS/Housing/HAB/Pages/default.aspx>

⁴³ Page 15. Duke Energy Integrated Resource Plan 2018.



renewables being distributed over a larger area, the opportunity for an ultra-low carbon grid expands.

Recognizing that Charlotte exists in a regulated energy market, the SEAP utilizes the '5 Steps to Zero Carbon Energy' as an organizing framework for the recommendations, so that when energy is procured, it is being done at a non-peak time and for a minimal amount. This is to help reduce demand on the grid and drive up demand for zero carbon energy sources.

Local Resources in Charlotte's Backyard

One of the biggest opportunities Charlotte has is with the amazing resources in their own backyard. Besides having the headquarters of the largest U.S. utility located in Uptown, they also have the third largest banking center with Wells Fargo and Bank of America having headquarters within the City. In addition, Charlotte has 148,000 students enrolled at 175 Charlotte-Mecklenburg Schools, several universities, a leading community college, and two world-class healthcare systems.

These organizations are key to successfully implementing the SEAP and achieving the targets. The private sector, like the banks, will need to engage to add additional skills, knowledge, and investment. Charlotte's universities and school system are key assets to the plan with their role being focused on research and development. The CMS school system is a targeted audience where efforts focused around education and behavioral changes can be addressed and scaled.

Sustainable Transportation

With the recent expansion of CATS Lynx Light Rail

Blue Line extending up to UNCC's main campus and the ongoing construction for the Light Rail Gold Line, sustainable transportation options are increasing. Charlotte WALKS and Charlotte BIKES are two comprehensive plans that the Charlotte Department of Transportation is currently implementing. Both guide the development of communities that offer zero carbon modes of transit and are connected, and in turn help reduce greenhouse gas emissions within the transportation sector. The 2030 Transportation Action Plan is another recently developed comprehensive plan that works to enhance the quality of life in neighborhoods through providing a safe, balanced, and efficient multi-modal transportation system.

Republican National Convention

The Republican Party recently chose Charlotte to be the host for the 2020 Republican National Convention (RNC) which provides a great opportunity to shine a light on Charlotte's transition to a sustainable and resilient future. Having already successfully hosted the Democratic National Convention (DNC) in 2012, Charlotte is aware of the opportunity the RNC provides to develop legacy projects that will live on beyond the Convention.

The RNC provides opportunities to showcase Charlotte's various ambitions and will include its desire for a 'resilient and sustainable' future. People from around the world will be coming to Charlotte or watching the Convention from afar and by identifying and piloting ambitious projects, such as providing only electric vehicle transportation for Convention participants, Charlotte can showcase their leadership in sustainability.

THE APPROACH TAKEN

A key part of the development of the SEAP was understanding what the objectives and goals of the project were. Charlotte is not starting from scratch in this transition to a low carbon, resilient future. This section will set out the approach to developing the SEAP and the ensuing rationale for the development of Action Areas and recommendations.

Building on Existing Work

In preparation for developing the SEAP, a thorough review of relevant City strategies and plans occurred, as well as in-person interviews and meetings. One point of constant feedback provided in meetings with various stakeholders was that there needs to be a stronger cohesion between efforts. The goal of the SEAP is to be a connector that links and leverages various relevant City strategies and policies.

Key plans and policies that influence the SEAP include the Policy for Sustainable Facilities (PSF), the 2030 Transportation Action Plan, and the Urban Forest Master Plan. To build and accelerate these efforts, it is important that the City put in place structural changes that align efforts, resources and staffing.

Most recently, Charlotte City Council voted unanimously to approve the 'Sustainable and Resilient Charlotte by 2050' resolution. By committing to reduce GHG emissions, the City provided a foundation upon which all the implementation items of the relevant plans and policies can be grounded.

Data Collection

The project launched with the start of data collection. A list of key data points was provided by CDP cities as part of their resources available in support of their GHG reporting platform. Additional information was added to the list to help refine and/or fill in gaps where data was not available.

Additionally, the project team worked closely with Duke to gather more granular data than prior GHG baseline efforts. The process was iterative, as Duke was gathering and compiling new data points. The project team worked closely with Duke to define the correct data sets and ensure alignment with broader GHG data.

Through this intense data collection period that lasted several months, it was determined that 2015 was the

year where the most comprehensive and reliable data was available, making it ideal to set as the baseline per guidance from the GCoM and CDP Cities.

Understanding the Current Energy Situation

North Carolina is a regulated state; therefore customers within it have a specific utility from whom they must buy their electricity and natural gas. In the case of Charlotte, more than 99% of this energy is supplied by Duke Energy Carolinas (DEC) with the small remainder supplied by Energy United. As there is no competition between suppliers for active customers, the regulator (North Carolina Utilities Commission) manages and approves rates with the utility, meaning there is little opportunity for competition.

Energy Research, Development and Innovation

Charlotte is a thriving hub of energy-related research and development and has multiple opportunities for development. This is guided in part by policies such as House Bill 589⁴⁴ which sets out maximum requirements for utilities to incorporate intermittent renewables into their systems. HB 589 also contains a moratorium on new wind farms being constructed (in North Carolina) due to military reasons. North Carolina has already laid a strong foundation for deploying low carbon innovations as the state is ranked third in the US for the largest deployment of solar PV.

Lock-in a Barrier to a Low Carbon Future

The lifespan of power stations, often at least 40 years, is important when making climate-oriented energy policy decisions. The current intention of DEC is to construct a set of new natural gas power stations by 2033, suggesting their existence in 2070. While natural gas emits approximately half as much as coal, it remains a high carbon source.

This will hinder the main target of getting to less than 2tCO₂e per capita, unless the power stations run on a different fuel e.g. biogas/hydrogen - or if carbon capture storage (CCS) is fitted. This is the level required for Charlotte to play its appropriate part in delivering the international climate agenda.

Current Emissions and Projections

The future energy mix, and resulting carbon intensity, is provided in the projections provided by DEC in

⁴⁴ <https://www.ncleg.net/Sessions/2013/Bills/House/PDF/HB589v8.pdf>



Charlotte B-Cycle station. Photo Credit: James Willamor

its Integrated Resource Plan (IRP)⁴⁵ and shows a substantial increase in natural gas capacity. The IRP argues that this is necessary to ensure grid stability when incorporating intermittent renewables.

The projections assume increases in electricity consumption and demand changes, and low levels of electric vehicles and electric heating. These changes would help the City deliver on its 40% reduction goal by 2030, but would 'lock it in' to a high carbon future in the period beyond - stopping the kind of reductions in CO₂ intensity necessary to meet Charlotte's 2tCO₂ per capita goal.

The DEC system links to nine transmission operators including Duke Energy Progress (DEP). These provide a larger area that renewable generation can be sourced between, thereby reducing the CO₂ intensity and increasing greater opportunities for demand-side responses, storage mechanisms, and distribution of renewable technology⁴⁶.

The IRP recognizes the limitations of its projections and particularly identifies the limitations attached to data, as customers 'change from passive consumers of energy'. This means technical opportunities are overlooked and become an issue of risk management. The projections are based upon past experience, rather than current and near-term technological opportunities. This has significant implications for medium- to long-term cost consideration and as a

result, decisions move away from low carbon options. The electricity mix available to Charlotteans is that supplied by DEC. The chart in Appendix 3 shows the production of electricity, by technology, which dictates emissions from Duke Energy. In this case, coal is the largest polluter, followed by natural gas. This mix largely defines the emissions from electricity usage⁴⁷.

There is potential for the cities of North Carolina to come together with Duke and others to provide signals to the North Carolina Utilities Commission of their combined desire to lower the carbon intensity of electricity production. This is needed in a world where other countries are reducing their GHG emissions, which means their goods and services in the future will have a lower carbon intensity associated with them and is likely to become an important component of international trade.

The limitations attached to the projections, and therefore how low carbon the grid could become, offer opportunities for collaboration and job development. This could propel Charlotte to the forefront of low carbon energy systems. Such opportunities are discussed in the Action Areas.

⁴⁵ http://www.energy.sc.gov/files/2018%20DEC%20Annual%20Plan_SC_Final.pdf

⁴⁶ Overcoming issues such as cloud coverage.

⁴⁷ Unless zero carbon electricity is procured via a separate contract.

Stakeholder Engagement

Stakeholder engagement has taken place throughout the duration of the project starting at the end of January 2018 and running through to delivery of the SEAP to City Council. There have been formal engagements in the form of public meetings, external advisory group meetings, GRIP scenario sessions, internal stakeholder meetings, and informal meetings where project team members have had one-on-one sessions with community stakeholders, advocates, and City staff and leadership.

Throughout the project, the project team sought to utilize these meetings to educate the stakeholders on the overall process objectives of the work, and proposed focus pillars where recommendations would have the greatest impact on reducing GHG emissions. In addition to the process, constructive feedback from the stakeholders was sought on a variety of topics, including: challenges the City is currently encountering, opportunities for improvement, ongoing and upcoming projects that reduce GHG emissions, and other stakeholders that should be engaged.

Some of the consistent feedback from the stakeholders was that this strategy needed to be an implementable plan that did not just sit on a shelf, that there was effective and clearly designated leadership to guide implementation of the SEAP, and that the City government ensure stakeholders remain actively engaged through implementation.

Figure 5 was shared with stakeholders to help address the challenges around effectively and authentically engaging stakeholders within processes, especially the SEAP. The key takeaway of the figure is to map out in advance of a project which stakeholders fit in which role, how they will be engaged, and when they will be engaged.

The City of Charlotte is in the midst of massive stakeholder engagement efforts around a variety of plans and policies, like the Unified Development Ordinance and Comprehensive Plan updates. However, it is important to note that while the City has conducted stakeholder engagement for the development of the SEAP, the stakeholder process that is currently underway is different from other stakeholder engagement processes. A key motive behind this is that a large portion of this Plan is extremely technical – it is for these reasons that an external expert was

brought on as a consultant to develop the SEAP and ensure the recommendations will help the City achieve the targets. Whereas most stakeholder engagement processes have relied more heavily on the community and advocacy groups on the front end of the project, the City sees the opportunity for heavier stakeholder engagement existing after the SEAP has been approved by Council and the behemoth task of implementation lies ahead. It was determined that many organizations and groups would like to be involved, and the SEAP implementation will build on that.

To ensure success of this plan, collaboration with organizations, community members, and advocacy groups already engaged in zero carbon efforts and programs will need to increase. The local knowledge and enthusiasm of the wide range of community and advocacy groups in Charlotte needs to be leveraged through catalytic partnerships and collaboration.

GRIP Scenario Sessions

The Greenhouse Gas Regional Inventory Protocol (GRIP) is a three-stage process for forming energy action plans at the local or regional level⁴⁸. The first stage is to compile a GHG emissions inventory and energy baseline, the second stage is to, as a group, form future scenarios that reduce overall emissions with the goal of achieving or going beyond set targets, and the third stage is to use the results and experience to inform the development of the SEAP. The project team hosted five scenario workshops, forming four scenarios, in addition to an initial introductory scenario session with a total of 8-10 participants each time, excluding the first workshop.

The first workshop engaged 30 City employees along with four representatives from Duke Energy and set the scene for the project and ensuing discussions. This workshop began the journey of identifying opportunities for a cohesive SEAP and showed that stakeholder engagement in this manner was possible. The primary objective of this session was to raise awareness and understanding of the GRIP process and how it connected overall with the development of the SEAP and to educate participants as to the complexity of reducing GHG emissions.

The objective of each of the four scenarios was to produce an energy future that achieved the 2050 target of below 2tCO₂ per capita and the 2030 target of under 7tCO₂. The scenarios all adopted the population

⁴⁸ The Greenhouse Gas Regional Inventory Protocol (GRIP™) is an award-winning approach that has been applied in fifteen countries. It was developed by Dr. Camey as part of his research. This dialogue focused approach was crucial to the engagement that was achieved in the project. Carbon Captured created a customized version of the tool for Charlotte to help increase the engagement (www.carboncaptured.com)

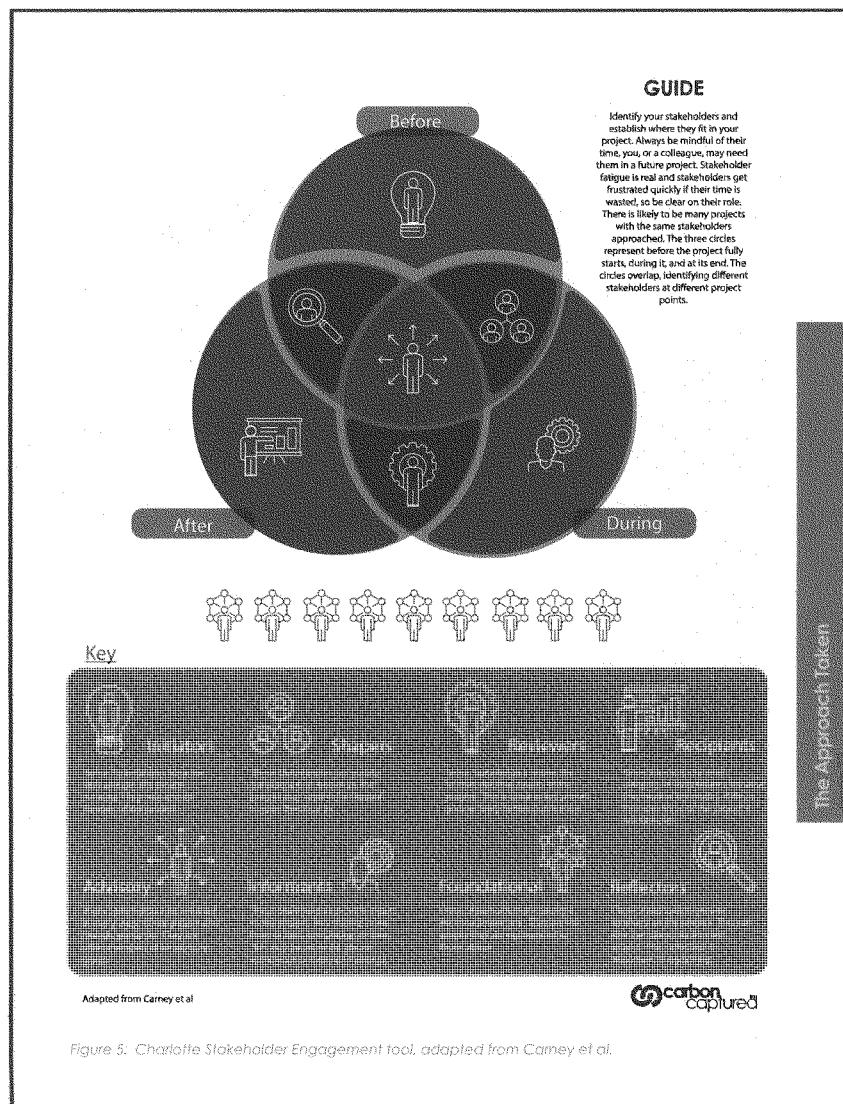


Figure 5: Charlotte Stakeholder Engagement tool, adapted from Carney et al.

C-17

The Approach Taken

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projections of 1.1 million by 2030 and 1.4 million by 2050, but each scenario session opted for different levels of economic growth varying between an average of 1.5% and 2.5% annually over the period.

All of the scenario sessions achieved the emissions reduction by 2050 with two of the three meeting the targeted reduction for 2030. There were broad similarities between the different scenarios with each delivering similar levels of emissions reductions overall.

In each session, the largest emissions reductions came from residential and commercial buildings followed by transportation, which was largely driven by a low carbon electricity supply. The groups had remarkably similar grid mixes that were dominated by nuclear power, due to extending the life of existing plants, which also aligns with Duke Energy's most recent Integrated Resource Plan (IRP)⁴⁹.

A significant factor in each of the scenarios was a drive for efficiency in both the building stock and appliances. The changes represent the overall change in energy consumption in each sector. For the residential sector, this is per household. Due to electrification, the transportation sector had the largest efficiency gains. The improvements to the building stock were generated through new construction with further efficiency improvements occurring due to behavioral change.

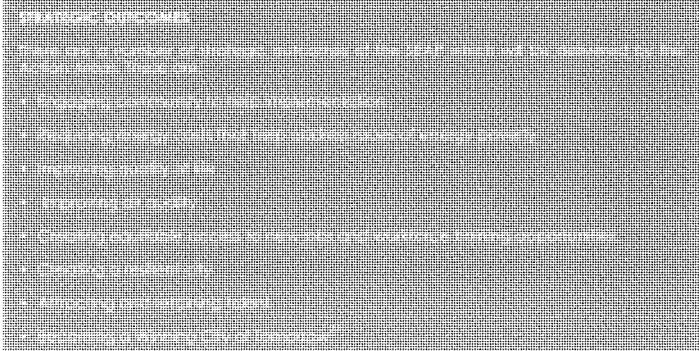
Delivering the Plan

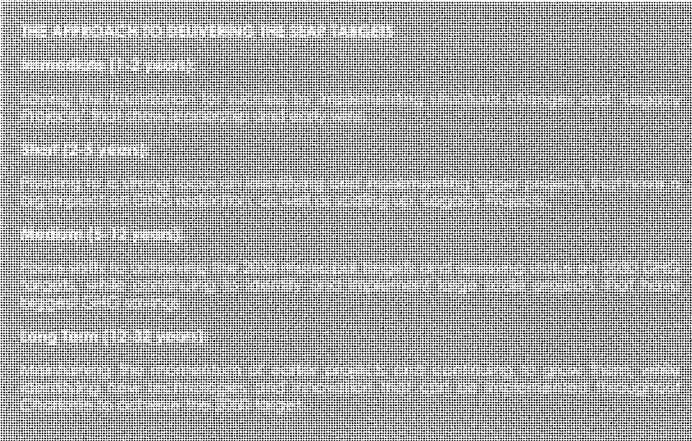
The SEAP is a long-term action plan with a 32 year implementation timeline. The Action Areas, recommendations, targets, and projects that come out of this plan will span the duration of that period. However, to ensure that energy is sustained beyond the planning process, recommendations and projects will include 'immediate' implementation items that showcase both ambitious projects and the City government's leadership in transitioning to a zero carbon energy future.

In the call-out box titled 'The Approach to Delivering the SEAP Targets,' the approach to delivery of the SEAP is shown. For the first two years, the key focus will be on implementing structural changes and internal projects within City government to facilitate delivery of the plan, as well as implementing 'Legacy Projects' that can be showcased at the RNC as a demonstration of Charlotte's leadership within this space. The following three years will be focused on delivering larger scale infrastructure projects that have been preceded by the structural changes. Medium term will see the implementation and completion of projects that will deliver on the 2030 GHG reduction target and City target for sourcing 100% zero carbon energy for municipal buildings and transportation. The longer term will see a multi-prong approach that includes working to scale up pilot projects and accelerate impact, and implementing larger scale infrastructure projects. The focus of implementing the plan should be

49 Page 10, 43, 44 & DUKE Integrated Resource Plan http://www.energy.sc.gov/files/2018%20DEC%20Annual%20Plan_SC_Final.pdf

50 http://www.charmeck.org/Planning/Commission/2017/2017_09_Sep_Presentation_01.pdf





achieving the targets set out in the resolution and overall improvement in quality of life for citizens of Charlotte. However, as the projects are being implemented, they should continuously be viewed through the lenses of environmental, social, and economic impact, ensuring an equitable approach to all projects.

FORMING AN ACTION PLAN

This section sets out the Action Areas and subsequent recommendations and projects. Factored in to these are an understanding of the current state of energy in Charlotte, state level regulations, existing and proposed projects, and City and County priorities. Some of the projects are implementation ready, while others will require collaboration, planning, and identification of funding opportunities.

Leading by Example

The City acknowledges that the 2030 and 2050 targets are aspirational, but achievable. To maintain energy and support around the SEAP, it is important that the City take a role of leadership through demonstration. There is an additional component of the City being host to the 2020 RNC from August 24-27, 2020. This provides an ideal deadline for executing 'Legacy Projects' that show both the citizens of Charlotte and the world, that Charlotte is a leader in the zero carbon energy space.

Pillars and Working Groups

The SEAP has an overarching focus on energy; the following three pillars have been determined to be the areas where the biggest GHG savings can occur and highlight significant areas of opportunity for the City to transform policies and procedures:

- Buildings
- Energy generation
- Transportation

Underpinning these three pillars is a foundation of innovation. Innovation in this case is defined as putting in place the structures and policies that allow for people and businesses to try something for the first time.

Buildings

Buildings are crucial to a low carbon future because they represent much of the energy consumption, and therefore emissions, in Charlotte. They therefore provide a significant component of the strategy, which covers both existing and new buildings. When looking at existing buildings, thought needs to be given to how much energy consumption can be reduced, how much energy can be produced on-site through renewable means, and how much energy can be provided from

low carbon sources. Additional considerations for new buildings must include the longevity of the building and their energy consumption together with the potential for low carbon energy sources. It must also be considered how they will interact with current and future infrastructure, as well as the people that exist within them.

Energy Generation

Generation of energy includes the production of electricity, heat, and cooling. Decarbonized electricity is crucial to delivering a low carbon future. This means embracing new technologies onto the grid and learning how to match them to consumption. Most low carbon generation technologies are not susceptible to primary energy costs (as wind, solar, and hydro are free), enabling significant opportunities for providing low carbon cost effective energy whose costs are not linked to international energy trade. There are also opportunities for distributed heating and cooling which could be in individual buildings or small districts. This would mean customers purchasing heating or cooling, rather than electricity or gas and would allow for sales from landlords rather than utilities⁵¹.

Transportation

Transportation in the case of Charlotte is comprised of three categories (as there are no boats). These include road vehicles (passenger cars, busses/coaches, freight, and various utility vehicles); rail (including light rail, freight, and intercity) and aviation (including national and international covering both freight and passenger transportation). This sector is a significant consumer of fossil fuels in the form of gasoline. It has the potential to deliver rapid change and deep cuts in emissions. Policy in the case of this sector can support change through infrastructure development and planning policies. There are significant opportunities associated with electrification, hydrogen, and bioenergy.

The City government will lead the development of six working groups that will align with the three main pillars of buildings, energy generation, and transportation. Within the building and transportation sector there are two working groups per topic, with one working group focused on municipal assets and a second working group focusing on citywide implementation. These working groups will be developed and engaged once the plan has received Council approval and will be further explained in the implementation section of this document.

51 <https://www.ncuc.net/ncrules/Chapter22.pdf>

ACTION AREAS + TASKS: OVERVIEW

INTERNAL ACTION AREAS

ACTION AREA 1: STRUCTURAL CHANGE

- Task 1: Set Up Internal City Resilience Delivery Team (CREDIT)
- Task 2: Setting the CREDIT Programmatic Agenda in FY20
- Task 3: Set Up Internal Revolving Fund Mechanism
- Task 4: Develop strategy for stakeholder group engagement in FY20
- Task 5: Hold a Meeting of Content Expert Advisory Group (CEAG) and Internal Working Group

ACTION AREA 2: INITIATE A CITYWIDE COMMUNICATION CAMPAIGN TOWARDS A LOW CARBON FUTURE

- Task 1: Form a Branding Team in FY20
- Task 2: Create a Striking Visual for Zero Carbon Buildings and Vehicles in FY20
- Task 3: Finalize Full Website Development in FY20

ACTION AREA 3: DEVELOP SMART DATA APPROACHES

- Task 1: Through CREDIT, Develop a Smart Data Implementation Plan in FY22
- Task 2: Internalize Long Term Vision for Energy in FY20
- Task 3: Standardize Data-based Decision Making into Practice in 2021
- Task 4: Annually Monitor and Submit Emissions Inventory and Questionnaire to CDP
- Task 5: Timeline and Measuring Progress

ACTION AREA 4: DEVELOP AND IMPLEMENT RESILIENT INNOVATION DISTRICTS (RID'S)

- Task 1: Formalize the Concept of a Resilient Innovation District Through Dialogue with all Relevant Stakeholders and in Line with The Comprehensive Plan Process in FY21
- Task 2: Implement a Set of Criteria that will Guide the Selection and Development of Resilient Innovation Districts in FY22

ACTION AREA 5*: STRIVE TOWARD 100% ZERO CARBON MUNICIPAL BUILDINGS BY 2030

- Task 1: Revise the Policy for Sustainable Facilities to align with the Sustainable and Resilient Charlotte Resolution in FY20
- Task 2: Identify Specific Building Targets for Action in FY20
- Task 3: Focus on specific projects in FY21

ACTION AREA 6*: STRIVE TOWARD 100% ZERO CARBON CITY FLEET BY 2030

- Task 1: Update the Fleet and Motorized Equipment Asset Management Policy in FY20
- Task 2: Begin installation of a telematics system across the City's entire vehicle fleet in FY21
- Task 3: Establish the Staggered Introduction of Electric and Other Alternative Fuel Vehicles
- Task 4: Consider Opportunities for Retrofitting of Vehicles to Electric Drivetrain in FY21

* Achieving zero carbon facilities and fleet by 2030 is an aspirational and ambitious goal for the City organization. Achievement of the 2030 goals will be dependent on many factors, including technological advancements, operational compatibility and risk management, and the availability of appropriate resources and funding. The City will look for all opportunities to move toward the goals.

COMMUNITY ACTION AREAS

ACTION AREA 7: NEAR ZERO CARBON NON-MUNICIPAL BUILDINGS BY 2050

- Task 1: Form a Building Working Group in FY21
- Task 2: Make Existing Residential Buildings Low Carbon by 2050
- Task 3: Influence the Energy Requirements of New Residential Buildings to be Near-Zero Carbon by 2050
- Task 4: Make existing non-residential buildings low carbon by 2050
- Task 5: Make New Non-Residential Buildings Low Carbon by 2050

ACTION AREA 8: FACILITATE RAPID UPTAKE OF SUSTAINABLE MODES OF TRANSPORTATION

- Task 1: Form a Transportation Working Group in FY19
- Task 2: Develop a Promotion and Awareness Campaign Around Electric Vehicles (EVs)
- Task 3: Deploy a Citywide EV Charging System for Charlotte by 2030
- Task 4: Increase Access to Zero Carbon Mobility Options
- Task 5: Continue to Integrate Transportation Orientated Development (TOD) Policies into Land Use Policy Frameworks, Namely the Comprehensive Plan and UDO Update

ACTION AREA 9: DEVELOP AND IMPLEMENT STRATEGY FOR DEPLOYING LOW CARBON INFRASTRUCTURE GENERATION

- Task 1: Form an Energy Generation Working Group Focused on Near-Zero Carbon For Buildings in FY19
- Task 2: Develop a Suite of Educational Tools that can be Utilized Throughout the City in FY22
- Task 3: Demonstrate New and Integrated

Approaches to Meeting Energy Demand in 2022

Task 4: Reduce the Carbon Intensity of Grid Supplied Electricity by at Least 90% by 2045

Task 5: Target a carbon intensity on the grid of at least 90% per kWh by 2045

Task 6: Identify Opportunities for a Bioenergy with Carbon Capture and Storage (BECCS) Combined Heat and Power (CHP) Unit by 2030

Task 7: Negotiate to Develop Tariffs for Low Carbon Electricity in 2022 and Identify a Period for their Rollout by 2030

ACTION AREA 10: DEVELOP GREEN WORKFORCE PIPELINE IN SUPPORT OF ENERGY TRANSITION

Task 1: Form a Working Group for Workforce Development and Equity in FY19

Task 2: Establish and Produce the Training Pipeline for Skilled Labor Jobs and Entrepreneurship Opportunities in FY22

ACTION AREA 11: ESTABLISH PUBLIC-PRIVATE-PLUS PARTNERSHIPS TO ACCELERATE TRANSITION TO A LOW CARBON FUTURE

Task 1: Identify, Build, and Formalize Relevant Partnerships in FY20 and FY21

ACTION AREAS

INTERNAL ACTION AREAS

ACTION AREA 1: STRUCTURAL CHANGE

The transition to a low carbon economy is a substantial undertaking and cannot rest solely within the city government. It requires active buy-in from a range of groups, businesses, NGOs, advocacy, regulatory bodies, and individuals. Ultimately it requires partnerships, within and beyond Charlotte. Stakeholders such as those in the working groups, help build the community's knowledge base and awareness that are critical to bringing about change. The Content Expert Advisory Group (CEAG) helps provide a wider business, construction, and academic perspective that can help to guide the implementation of the SEAP.

Structural Change is therefore required for the following reasons:

1. To build a core capacity within the City for low carbon, resilient Charlotte delivery;
2. To ensure buy-in from leadership down;
3. To ensure alignment and integration with other City initiatives and projects;
4. To provide a basis from which additional projects may be formed and funding secured;
5. To ensure common understanding in project management approach - to reduce project costs and overrun;
6. To engage with external stakeholders and partners to ensure ongoing momentum and support change;
7. To enable a strategic approach to cost that considers packages of approaches rather than individual costs of actions.

Task 1: Set Up Internal City Resilience Delivery Team (CREDIT)

To realize the goals and recommendations set forth in the Resolution and the SEAP requires internalization of knowledge and a structured approach to sustainability and resilience within the City. A dedicated team is recommended to help guide Charlotte towards the low carbon, resilient future determined by the resolution.

INTERNAL ACTION AREAS
Page 10

Step 1: Appoint a team leader in FY19

A team leader is needed that has a personal interest in sustainability and resilience and will oversee all of the work of the CREDIT team. This person will demonstrate leadership and need to work closely with the team, especially the Energy Ambassador. This person will engage with a wide variety of people, will have international awareness and a proven ability to win funds, and coordinate projects and programs. This role requires a unique blend of technical awareness combined with strong communication abilities.

Step 2: Identify citywide Energy Ambassador in FY19

Working closely with CREDIT's team leader will be an entrepreneurial, solution driven Energy Ambassador. This person will be responsible for focusing largely on projects and have a strong knowledge base within the energy sector. They will be championed by the team leader. This working relationship will be key to the successful implementation of the SEAP. The Ambassador will work with external experts and will be the designer of the Resilient Innovation Districts, as outlined in Action Area 4.

Step 3: Assemble team in FY19

It is recommended that CREDIT is formed of representatives from existing teams, including the sustainability team, SFOT, and individuals within departments. CREDIT will need to operate across City Government Departments. CREDIT's team members should be recruited based on their skills, knowledge, and personalities. While assembling the team, it is important to specify roles, responsibilities, and reporting requirements for each team member.

Step 4: Arrange for project management training for all team members as appropriate in FY20

CREDIT's members will require training in project management to maintain consistency and oversight.

Task 2: Setting the CREDIT Programmatic Agenda in FY20

This is an evolving process but requires an understanding of common goals within the team. This will need to follow project management structures to define them and set the tone that will

feed into all projects.

Step 1: Review the SEAP and progress requirements

This requires developing a strategy for stakeholder engagement, identifying any data gaps, and addressing those gaps.

Step 2: Identify reporting requirements and timeline

Internal team reporting is required, and will be determined based on individual staff types.

Task 3: Set Up Internal Revolving Fund⁵² Mechanism

By utilizing an Internal Revolving Fund mechanism for driving energy efficiency efforts within municipal buildings and fleet, the City can take savings and reinvest in additional energy efficiency efforts. This requires new modes of working, embracing uncertainty, and entrepreneurial ways of dealing with cost and difficulty.

Step 1: Establish preferred financing model

It is recommended that a structure similar to a Revolving Fund or an Energy Service Company (ESCO) is implemented to enable cost to be spread between projects within a program. There is currently such a model called Internal Service Providers that could be adapted. In this regard, deep energy retrofits to reduce energy consumption and shift energy demand need to be considered in tandem with savings. In short, cost savings need to be considered at a program, rather than project level, ensuring buildings and fleet projects are considered in tandem.

Step 2: Establish reporting requirements

Clear reporting requirements need to be developed and standardized so that targets can be established and finances tracked. This should encompass how often and when reporting should be performed.

Step 3: Internal team to identify weaknesses and gaps in knowledge base

CREDIT should determine the frequency of meetings with the Internal Leader and the Energy Ambassador to ensure alignment of efforts. The stakeholder group should work with the CREDIT team to nominate two representatives (solution orientated, subject matter experts) that can provide feedback of the views of the group to CREDIT.

Task 4: Develop strategy for stakeholder group engagement in FY20

This is an important link and needs to be based on mutual trust. Both groups have a desire to transition to a low carbon energy future as fast as possible. The importance here will be developing clear connections that leverage the knowledge and expertise of the stakeholder group.

Step 1: Internal team to identify weaknesses and gaps in knowledge base

See Action Area 1, Task 3, Step 3.

Task 5: Hold a Meeting of Content Expert Advisory Group (CEAG) and Internal Working Group

Charlotte is a rapidly growing city benefiting from a business community open to engagement with local policymakers. The CEAG members were selected due to their knowledge, experience, and the organizations they are associated with. The members are well placed to provide a sounding board for solutions and helping the City guide implementation. Energy transitions are complex, so engaging people across the spectrum of the community is crucial.

Step 1: Agree on reporting structures and set out meeting dates for the following year

To avoid misunderstandings and ensure ongoing comfort, the personalities involved need to agree to structures that best suit their mutual ways of working.

Step 2: Identify any options for extending the group (max size of 12)

For reasons of group dynamics, a size of between 8-12 people is needed to maximize dialogue between participants. The individuals may change due to various personal and organizational reasons.

Step 3: Consider a figurehead for promotion of the integrative work

A figurehead is useful for promoting the work of the SEAP. The person best suited to this role may emerge following the SEAP. This could be a celebrity, business person, or similar person with a status within the community.

⁵² This is comparable to the use of an Energy Service Company (ESCO) model.

ACTION AREA 2: INITIATE A CITYWIDE COMMUNICATION CAMPAIGN TOWARDS A LOW CARBON FUTURE

The success of the SEAP is dependent upon clear promotion and communication of the SEAP and its central focus for resilience work across the City. The website will serve as a point for sharing and finding information relevant to sustainability and resiliency efforts in Charlotte. There are different stages required to form and maintain this campaign. The main effort will need to be developed by the City with the anticipation that ultimately, the campaign will be taken up and added to by the community.

Task 1: Form a Branding Team in FY20

To encourage the wider community to reduce their CO₂e emissions, it is critical to actively engage them. Moreover, it is important that Charlotte can communicate to the world that it is a sustainable and resilient city with an eye on the future. This requires a branding campaign that can grow with it.

Step 1: Identify team

The team needs to be representative of the larger community, non-profit, and business interests. This team will comprise a chair from CREDIT and include cross-sector representatives that represent the City, community, arts and science, and hospitality and tourism industries.

Step 2: Set up organizational mechanisms for branding team and formalize purpose

It is recommended that the branding team is structured and assigned clear roles and responsibilities. There will be many organizations and individuals involved so having a clear common understanding is important to the smooth running of the campaign. This will help to manage expectations.

Step 3: Establish list of initiatives and engagement

Create an interactive and informative SEAP website, together with video releases and updates, promote the '5 Steps to Zero Carbon' diagram and the 'Charlotte Stakeholder Engagement' tool to show how organizations and individuals can get involved. In order to encourage ongoing sign-up to the SEAP, it is recommended that the SEAP website be a source for training materials, guides to best practices, guidance on how to reduce personal emissions, and companies that specialize in low carbon technologies, and be incorporated into

Charlotte travel guides. The SEAP also highlights specific opportunities for engagement and explains issues of concern and priority actions. The City will host a dashboard for emissions data that will highlight the progress being made in achieving the emissions targets.

Step 4: Agree on communication performance metrics

There are different performance metrics in this space. These include Charlotte, the State, the wider US, and international audiences. The intended audience should be considered when using topic specific language to promote Charlotte as an aspiring world leader in this space.

Task 2: Create a Striking Visual for Zero Carbon Buildings and Vehicles in FY20

Charlotte is known as the Queen City, and this branding campaign needs to sit under that. To maximize visibility and impact, the campaign will need to be deployed by 2020 and focus on vehicles and buildings.

Step 1: Utilize the various groups (internal, stakeholder, and external advisory) to provide feedback

The role of the various stakeholders is significant within this Action Area. The criteria may include a mascot, a logo, and/or a color scheme for building entrances. The idea is to give an identity that residents and visitors can link to the low carbon, resilient future.

Step 2: Launch a citywide competition for schools and colleges to design the branding package

The purpose of this is to bring wider attention and focus to the work of the SEAP and CREDIT. By utilizing local talent, it is a great way to educate and engage a new group of stakeholders.

Task 3: Finalize Full Website Development in FY20

The website and other forms of electronic outreach require an individual within the CREDIT team to take a leadership role in driving the development and completion of website content. The CREDIT team member should work with the community to provide feedback and ways to better incorporate into community efforts.

Step 1: Encourage local resources, like university students, to collaboratively develop promotional films and campaigns

Developing content and keeping it updated is the biggest challenge. Ensuring the website is active will add value to the SEAP implementation and will guarantee it is used as a resource.

Step 2: Encourage core content

It is recommended that certain aspects are included, such as Charlotte's sustainability and resilience history. This could sit alongside performance metrics such as the number of buildings and vehicles that are zero carbon.

Step 3: Include carbon calculators and educational resources

One of the best forms of communication is storytelling, and therefore, stories of successful low carbon approaches in Charlotte could be promoted on the website. Carbon calculators for individuals and Small and Medium Enterprises (SMEs) could be incorporated onto the site, utilizing existing widgets.

ACTION AREA 3: DEVELOP SMART DATA APPROACHES

Charlotte has two great data resources. The 'Quality of Life Explorer'⁵³, formerly the Quality of Life Study, has been around for more than 20 years. In 2012, it was transformed into an interactive dashboard that included all of Mecklenburg County. In 2013, Charlotte expanded their 'open data' platforms and created 'Open Charlotte'⁵⁴. This is an online, largely static, repository of data. It is an excellent building block upon which a data driven approach can be based.

To achieve a low carbon future, there has to be a considerable change in the energy system. Today's energy system has largely evolved, without guidance, largely due to market forces. To create a new energy system requires foresight, which is greatly aided by data. The data that is required to inform a low carbon future is similar to the data that is required for other areas such as local air quality, equity, transportation flows, workforce development, and economic development.

One of the challenges of transitioning to a low carbon future is the demand on the electricity system, due to a growing population, and increase in EVs, and

⁵³ <http://charlottenc.gov/HNS/CE/CommunityInfo/Pages/QOL.aspx>

⁵⁴ <https://cit-charlotte.opendata.arcgis.com/>

electrification of heating and cooling. Under the existing regulatory structure, Duke Energy Carolinas (DEC) has a significant role to play in this.

In its Integrated Resource Plan (IRP), Duke recognizes that the traditional approaches to utility resource planning need to be improved to keep pace with the changes that are happening and will continue to happen as the energy system becomes more decentralized. This provides significant opportunities for Charlotte to truly build and shape an energy system capable of supporting the low carbon future that is built on the collection of smart data. That can then be used as a model and exported elsewhere. Charlotte's rapid growth provides significant opportunities in this regard.

Task 1: Through CREDIT, Develop a Smart Data Implementation Plan in FY22

With the increasing number of players entering into the energy market, the complexities of monitoring and tracking will continue to increase. This is not a problem specific to Charlotte, as other cities are grappling with the same challenge and have developed data programs in response. The issue has been incorporated into planning in cities around the world. Further strengthening the City's relationship with UNCC's Data Science Initiative (DSI) will be a key component to delivering this.

Step 1: Establish the data collection as part of the RIDs

The RIDs will provide a significant source of data and provide learning outcomes that can be utilized as part of developing jobs within the 'green economy'. This will serve, in part, as a mechanism through which progress can be measured. The data here will also capture neighborhood related information, so that these areas can be better understood and resilience efforts supported.

Step 2: Identify areas for dynamic data

The RIDs will provide opportunities for a wide-ranging amount of live data. Encompassing traffic flows, street lighting, residential and commercial energy use, energy generation, and similar data can help to inform decision making centrally on such issues as refuse collection, street repair, and lighting repair.

Step 3: Identify specific areas where data is required

Key non-dynamic data sets include workforce performance on projects. This may include time to completion, number of staff, delays due to absence, and similar. The precise data to be collected should be determined between CREDIT and the work packages.

Step 4: Establish requirement for consistent data collection as a step towards resilience.

The CREDIT team will conduct a baseline study of best practices from cities around data collection. A part of this study will look at consistent points of data collected and the frequency in which data is collected. These will be provided as recommendations to City Government Leadership to ultimately become standard practice.

Step 5: Utilize data visualization techniques for enhanced communication and education opportunities

A member of CREDIT should engage with the IT Department and UNCC students and staff to develop visually pleasing interfaces. This data visualization is something that could be incorporated into online resources.

Task 2: Internalize Long Term Vision for Energy in FY20

It is recognized that there are considerable risks and associated learning curves with respect to transitioning to a low carbon future. Data collection approaches will need to help promote and inform the internalization of the long-term vision and will need to be promoted through Action Area 2. This will then need to be promoted with links to transportation, weather impacts, and onsite generation opportunities.

Task 3: Standardize Data-based Decision Making into Practice in 2021

Duke identifies that many customers have come to recognize the benefits that technology can bring and are no longer passive consumers of cheap energy. These changing practices may be seen elsewhere as Charlotteans increase the amount of data they have available.

Step 1: Provide training on data opportunities and integration

The amount and type of data can appear overwhelming so staff training should be offered.

with data visualization techniques employed - potentially using dashboards.

Step 2: Demonstrate value through success stories to staff

Successful utilization of data should be promoted. Providing real life stories as to how data has been used to help Charlotteans is particularly helpful, especially where individual stories can be highlighted.

Task 4: Annually Monitor and Submit Emissions Inventory and Questionnaire to CDP

CDP (formerly the Carbon Disclosure Project) requires annual submissions relating to climate change. This includes an assessment of energy and emissions within the City. This inventory is based upon the Global Protocol for Cities (GPC) methodology. This is the methodology underpinning the targets within the Resolution. Additionally, there is an assessment of resilience and adaptation as part of the questionnaire. The report will need to be completed by July each year.

Step 1: Appoint a member of CREDIT to compile the energy and waste datasets

The energy and waste datasets represent the largest sources of emissions within Charlotte. These are broken into three main parts. The first part takes the waste and energy consumption data from City-owned buildings and fleet. The second part is the electricity and gas data provided by Duke. The third part is non-government owned transportation. The reporting is usually two years in arrears, meaning that in 2017, 2015 data would be reported.

Step 2: Compile internal energy and waste data

This data comprises the amount of natural gas and electricity consumed by buildings, the amount of fuels consumed by vehicles, the amount of renewable energy generated onsite, and the data pertaining to waste deposited to landfill sites.

Step 3: Collect energy data from Duke Energy

Duke holds the data on the total amount of electricity and gas consumed by customer type. This data will include the data from Step 2, so it will need to be subtracted. They also hold the data relating to the generation mix and its carbon intensity. In addition, Duke can provide the data on renewable energy facilities registered in Charlotte.

Step 4: Collect data from North Carolina Department of Transport (NCDOT)

NCDOT provides data on vehicle odometers by vehicle type. These datasets are provided on request; however ample time is suggested to collect the data and it is recommended that data is requested at least three months ahead of when it is required.

Step 5: Appoint a member of CREDIT to compile the resilience assessment as part of the CDP questionnaire

The resilience/adaptation assessment needs to be performed annually. This can be performed through the running of a workshop with the correct members of departments required to answer the questionnaire present. The questionnaire varies each year so the CREDIT member will need to check the questionnaire and establish the right people to bring together to provide the answers.

Task 5: Timeline and Measuring Progress

The SEAP will need to be updated and reviewed after the first two years, and then at five-year intervals in the period beyond. The reporting of progress will be to the CREDIT board in the first instance and then in the form of an annual report to Council. The precise structure for this will need to be established when CREDIT is formed. The timeline spreadsheet in the appendix should be used to identify progress on specific tasks. Wider measures of success linked to the projects external facing should also be included.

ACTION AREA 4: DEVELOP AND IMPLEMENT RESILIENT INNOVATION DISTRICTS (RIDs)

A resilient city is one that can deal with shocks and stresses. Shocks may include climatic events such as floods, or it could be the disappearance of an industry upon which the city is highly dependent. Stresses are issues that weaken a city, and may be associated with income inequality, high unemployment, a lack of affordable housing, poor education, and high rates of crime. Ensuring resilience at various scales (city, neighborhood, district) requires the ability of cities to engage with their stakeholders to form a greater understanding of vulnerabilities that span communities, government agencies, city departments, businesses, and utilities.

The SEAP is based upon the three pillars of buildings, transportation, and generation, with these being set on a foundation of innovation. To maximize economic advantage and speed up the innovation process, structures need to be put into place to prove and realize the transition to a low carbon future. The suggested approach is to establish a set of Resilient Innovation Districts⁵⁵ (RIDs) as the City seeks to 'rid' itself of CO₂ emissions while ensuring resilience and maximizing job opportunities. These RIDs should be in different areas of Charlotte and will integrate the three pillars - this will allow the City to address economic mobility. The proven low carbon, resilient business models can then be applied elsewhere with revenue opportunities returning to Charlotte, and at the same time deliver greater resilience.

The suggested concept of a Resilient Innovation District (RID) builds upon the existing Smart City District Model (SCDM). The SCDM promotes energy efficient projects and renovations for neighborhoods and communities that lead to a scaling up of proven energy efficiency solutions.

Through the RIDs, barriers to action due to policies and regulations can be overcome through piloting projects and data collection. This will enable emissions to be reduced alongside costs, while at the same time creating jobs and exports from the City that can be deployed around the United States and beyond, bringing finance with them.

Task 1: Formalize the Concept of a Resilient Innovation District Through Dialogue with all Relevant Stakeholders and in Line with The Comprehensive Plan Process in FY21

To be successful, the RID concept cannot be deployed in isolation. Rather, it needs to link to other activities, including the Comprehensive Plan process and the UDO Update. The RID concept requires a partnership approach along with a clear idea of how learning from them can be incorporated into a wider planning.

The technologies and processes exist for living in a low carbon future, however the business models required to realize them have not yet been established. The RID concept allows for collaboration and realization. The regulatory structure of North Carolina could be used positively to address this. The business models need to exploit low carbon, resilient technologies require development to facilitate a more rapid transition to the target of 2tCO₂ per capita.

⁵⁵ The proposed Resilient Innovation Districts are a combination of Energy Innovation Zones (EIZs), Resilient Innovation Neighborhoods, and the Smart Cities Concept. They are there to deliver low carbon, resilient approaches in order to establish the business models that can see their deployment elsewhere.

Task 2: Implement a Set of Criteria that will Guide the Selection and Development of Resilient Innovation Districts in FY22

The precise structure of each individual RID is still to be determined. It is recommended that the RIDs include at least some or all of the following:

1. Located near to research centers whether they be university-based or private;
2. Linked to City government-owned sites, businesses, residences, and/or transportation infrastructure;
3. May contain micro-grids and other forms of distributed generation.

Step 1: Utilize CREDIT to identify policies that would be a barrier to the creation of RIDs

Ideally, a RID would be located in an area that already has policies and structures in place to support it, for example, areas such as University City, South End, and Uptown. High levels of engagement will be required to achieve and deliver such a model if these areas are to form part of a RID. To establish the RIDs, engagement with regulatory bodies will be necessary, although part of their purpose is to overcome such barriers. This is part of the learning process.

Step 2: Update and/or create policies to support the creation of five RIDs in FY22

The target of five RIDs is aspirational, and should seek to cover different elements of Charlotte's demographics. The RIDs should engage with the

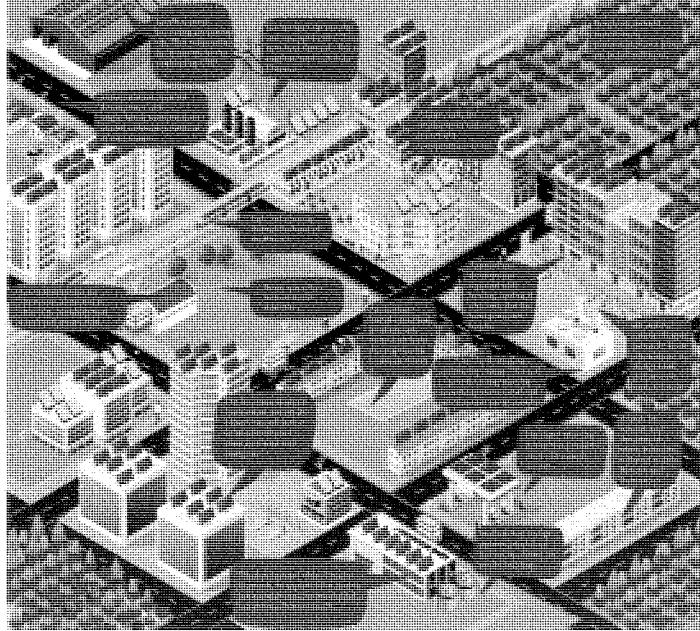


Figure 6: An example of what a Resilient Innovation District can consist of.

INNOVATION AREAS

operations functions of various relevant Charlotte government service departments like Charlotte Solid Waste Services and Charlotte Water. The plans should be clearly visually set out and developed in tandem with the community through CREDIT and incorporate feedback from relevant groups.

ACTION AREA 5: STRIVE TOWARD 100% ZERO CARBON MUNICIPAL BUILDINGS BY 2030

The Sustainable and Resilient Charlotte resolution sets an expectation that the City will strive to run all City-owned buildings on zero carbon energy by 2030. The approach needs to address behavioral change as well as changes in mechanical systems and operations. Data gathered through analysis of current energy consumption and facility audits will extend staff knowledge about the opportunities for demand and consumption reductions. This Action Area will be delivered by the CREDIT team in consultation with City leadership.

Achieving zero carbon facilities by 2030 is an aspirational and ambitious goal for the City organization. Achievement of the 2030 goal will be dependent on many factors, including technological advancements, operational compatibility and risk management, and the availability of appropriate resources and funding. For some segments of City facilities, achieving the goal may not be possible because operational and other concerns will outweigh or not allow for carbon reduction benefits. However, the City is committed to and will look for all opportunities to achieve the goal.

Task 1: Revise the Policy for Sustainable Facilities to align with the Sustainable and Resilient Charlotte Resolution in FY20

The resolution expectation and the implementation of the '5 Steps to Zero Carbon' diagram pushes beyond the current policy requirements. Among other things, this will mean incorporating additional metrics into the policy, including carbon emissions calculations for the Global Protocol for Cities (GPC).

Step 1: Adjust the policy to meet the requirements of the Sustainable and Resilient Charlotte resolution

It should be a function of CREDIT to establish the weighting of the Council resolution goals against the other goals laid out in the current LEED-based policy. The policy should include a clear process for staff to follow to make the best decisions about

facility construction and renovation in light of the resolution.

Step 2: Align the roles of the SFOT to CREDIT

The team structure of SFOT will have significant synergies with CREDIT. Consequently, careful thought needs to be given to how these two approaches will exist. Recognizing capacity challenges, merger of these two groups can be explored.

Task 2: Identify Specific Building Targets for Action in FY20

A complete listing of buildings by operational type and their potential for being subject to the '5 Steps to Zero Carbon' process will need to be established by CREDIT. This will require widespread engagement, particularly with departmental leadership and building managers. One or more example buildings will need to be identified earlier – in FY20.

Step 1: Make data-gathering and analytical capacities more robust

As a starting point, data needs to be carefully examined and incorporated into the decision-making process. This will entail making good use of all energy consumption data, and conducting energy audits in a strategic way. Combined approaches to the five steps then need to be identified – establishing if there are any equipment synergies.

Step 2: Build employee awareness and identify individual(s) that will carry messages about reducing energy consumption and demand in each building

CREDIT cannot deliver this work on its own. The projects to deliver zero carbon futures require that individuals with a working understanding of each building are incorporated into each stage of the project planning. The stakeholder engagement tool should be used to identify who will be involved.

Step 3: Consider compulsory training on energy efficiency and demand reduction for building operators and facility managers

This program could be an updated version of the highly successful UNCG-SBS Building Re-tuning Training (BRT) program supported by the U.S. Department of Energy.

Building operators and facility managers will

need to go through a compulsory education and awareness program to help them to identify the difference and how their actions can support the transition to a zero carbon future. This is part of a change management activity to change behaviors and understand new procurement requirements.

Step 4: Ensure that procurement processes support cost-efficient approaches to meeting the goal

CREDIT will need to work with procurement teams and identify how to standardize decisions and minimum efficiency standards for new equipment that do not impact operational performance. Individual user requirements will need review, e.g. who requires two monitors for their work, when servers are required to update, etc. An enforcement process needs to be put in place. The total cost of ownership, including the equipment lifespan and financing opportunities, need to be incorporated into the cost projections.

Task 3: Focus on specific projects in FY21

The level of data required needs consideration; too high a level becomes unwieldy and a barrier to action, while too little provides a lack of certainty. However, certain things are known – LED lighting requires less energy, and more efficient monitors and computers can pay back on energy savings – and these types of aspects can be put into place ahead of more detailed data requirements.

Step 1: Through strategic audits, identify the buildings and/or building types with the capacity for incorporating renewables in financially viable ways today or in the future

The cost of on-site generation technologies continues to decrease. They are not always cost competitive in all areas today. This cost competition is linked to the right time frames, as well as the certainties of energy pricing that comes attached to them. With an understanding of the onsite potential for each building (part of the energy audit) the price opportunities can be known and identified with projections.

Step 2: Identify buildings with largest opportunity for savings and payback

Consider selection of a flagship building to retrofit as a demonstrator. This will require additional considerations and weightings that incorporate softer issues such as location and awareness raising. This will need to be determined by CREDIT.

Step 3: Reduce the demand for heating and cooling of internal spaces. Some suggested areas for achieving this include:

1. Reduce the area that needs to be heated / cooled through passive measures
2. Develop strategy for enforcing no new natural gas boilers in retrofits or new buildings
3. Ensure Building Automation Systems (BAS) or Energy Control Systems (ECS) are being effectively utilized and building operators are knowledgeable about operating standards (see Task 2, Step 3)
4. Modify building envelopes to ensure climate appropriateness and reduction of leaks
5. Analyze chilled, hot water, and steam solutions – particularly in areas where there are clusters of buildings
6. Utilize on-site renewable energy generation technologies to provide space and water heating

The specifics of these will be identified through the energy audits. These bulletts should form part of the training afforded to staff. The considerations for linking buildings together is one that should be considered and goes beyond most energy audits.

Step 4: Reduce energy consumption and shift energy demand from appliances and lighting

These are key for day to day aspects of procurement in every building, with policies that can be established for them rapidly. This aspect of procurement policy should be in place by FY20. This could require at-desk guidance for staff, or localized smart sockets for certain devices to facilitate charging.

Considerations:

1. Change procurement requirements of lighting and appliances
2. Set parameters for the use of small appliances in the workplace
3. Maximize natural light and minimize artificial light
4. Integrate onsite electrical renewables
5. Load shift to zero carbon availability

6. Identify and replace early opportunities where payback is proven

These considerations will all be featured as part of the energy audits to be conducted, or developed. Part of this auditing is to understand how these buildings are being used. If staff are often off-site or regularly collaborate away from their desks, then consideration needs to be given to how they use the space and if it is used appropriately.

ACTION AREA 6: STRIVE TOWARD 100% ZERO CARBON CITY FLEET BY 2030

The Sustainable and Resilient Charlotte resolution sets an expectation that the City will strive to transition the City's vehicle fleet to zero carbon by 2030. The requirement to become zero carbon means that the vehicles must run on electricity, hydrogen, biogas, or biofuel by 2030. The electricity or hydrogen consumed by these vehicles in 2030 (and beyond) must be produced using zero carbon electricity sources (either on-site or through procurement contracts).

There are more than 4,000 vehicles that are owned by the City, and they have varying degrees of 'life expectancy' attached to them. This means that a staggered introduction of zero carbon vehicles will need to be introduced over the next 12 years, with EVs being prioritized in areas where they best suit operational needs.

There are additional benefits that extend beyond the zero carbon component required by the resolution. When the total cost of ownership is considered, electric vehicles often cost less to run than their internal combustion engine counterparts. This is because the energy on which they run costs less and with significantly fewer engine parts, electric vehicles have a far lower maintenance requirement. Beyond fuel and maintenance benefits, electric vehicles also mean cleaner air and less noise pollution.

Achieving a zero carbon fleet by 2030 is an aspirational and ambitious goal for the City organization. Achievement of the 2030 goal will be dependent on many factors, including technological advancements, operational compatibility and risk management, and the availability of appropriate resources and funding. For some segments of the City fleet, achieving the goal may not be possible because operational and other concerns will outweigh or not allow for carbon reduction benefits. However, the City is committed to and will look for all opportunities to achieve the goal.

Task 1: Update the Fleet and Motorized Equipment Asset Management Policy in FY20

The procurement decisions will need to incorporate the Resolution and the calculations set out by the Global Protocol for Cities upon which these figures will be determined. The policy will require standardization and seek to develop the "fix-it first" requirement of the Policy for Sustainable Facilities. The opportunities for vehicle conversions or retrofits should be an active consideration.

Step 1: Form an action team comprised of existing Fleet Maintenance Advisory Team (FMAT) and CREDIT

The fleet maintenance team will need to remain in place but work closely with CREDIT because they remain central to delivery of the aftercare of the vehicles. There will need to be training and awareness raising of vehicle opportunities that are available today along with those in the pipeline of existing manufacturers going forwards.

Step 2: Revise the Fleet and Motorized Equipment Asset Management Policy to align with the goals of the Sustainable and Resilient Charlotte resolution

The Fleet and Motorized Equipment Asset Management policy will need to be revised to reflect how decisions will be made about vehicle replacement so that at each decision point, consideration and analysis is given to purchasing a vehicle that would reduce or eliminate carbon emissions.

Step 3: Raise awareness of the resolution goals and increase acceptance among staff

Engage staff to show how resolution goals will be met. Right-sizing the fleet and choosing an alternative fuel option for departments, dependent on the vehicle application will serve as an example to the community.

Step 4: Establish requirements per vehicle type based upon their expected lifespan to align with the 2030 goal

A clear, staggered timeline attached to existing vehicles and their anticipated lifespans should be formed. This builds upon the existing data repository. The timeline for replacement should incorporate vehicle retrofitting opportunities particularly those of heavy fleet where known opportunities exist.

Task 2: Begin installation of a telematics system across the City's entire vehicle fleet in FY21

Telematics should be installed across the vehicle fleet to identify which vehicle usage lends itself best to different fuel choices and resources can be allocated accordingly. This will help identify which vehicles should be transitioned to electric, which can be retrofitted to electric, which may be biofuel-based, and so on. The telematics may also provide opportunities for reducing the fleet size, making opportunities for using vehicles for more than one purpose, identifying more efficient routes, and where to locate charging stations.

Step 1: Utilize a pilot project lasting three months using the selection of the fleet that already has telematics to identify potential fuel savings opportunities

Collect data to inform an education program that sets expectations for improvement and train drivers on eco-driving. The fuel savings achieved as a consequence can then form a benchmark for performance as well as a revenue source. The current telematics are not being used to monitor fuel use.

Step 2: Identify the type of telematics that will have the largest impact and consider telematics with filming technology to reduce insurance liabilities

The City provides its own insurance; however, telematics can still be used to reduce liabilities, as they can help to prove speed at the time as well as record incidents. This is likely to reduce insurance settlements. The savings attached would then be a revenue source.

Step 3: Utilize the combination of fuel savings, insurance payments averted, and any other savings to finance the rollout of telematics across the vehicle fleet

This is made possible through the revolving fund structure of CREDIT. This telematics data is then to be used to inform the staggered procurement exercise. This is part of the wider considerations of total cost of ownership.

Step 4: Roll Out Education Program that Provides Training on Eco-Driving to all City Staff.

Training on vehicle driving and 'eco-driving' should be rolled out to all staff, especially those that run City vehicles. Eco-driving is being aware of the vehicle to better conserve fuel and reduce

emissions, including using gears correctly, keeping tires inflated, accelerating at a slower rate, and practicing mindful breaking, among others. This will then be incorporated into their day-to-day activities. Training should also be provided on the use of the existing electric vehicles.

Step 5: Identify any drivers falling short of development marks and provide additional training

The telematics information and benchmarking should be used to identify any drivers who continue to drive in an un-economical way to provide further training to help reduce energy consumption.

Task 3: Establish the Staggered Introduction of Electric and Other Alternative Fuel Vehicles

Electric vehicles (EVs) are the current preferred car to transition the fleet to and the data for the establishment of their staggered introduction will come about through the previous steps. The procurement will also need to integrate the introduction of the charging infrastructure needed to meet the requirements.

Step 1: Update the centralized procurement policy and/or process to enable the consideration of total cost in FY20

The total cost of ownership, including the vehicle lifespan and financing opportunities, need to be incorporated into the cost projections. This is because EVs have less moving parts and have the potential to replace the batteries, extending their lifespan.

Step 2: Align efforts with Action Area 5 to identify potential for producing electricity on site.

There is opportunity to provide the electricity upon which the vehicles will run through onsite means. This is particularly true of parking lots and decks. The transition could consider battery storage seasonal variations and vehicle charging opportunities to establish the opportunities for onsite generation more fully. These calculations will be the responsibility of the CREDIT team.

Step 3: Identify resilience strategies required to ensure continuity of electricity supply by 2022

As electric vehicles require a source of electricity rather than the availability of petroleum, a

resiliency strategy will need to be in place to ensure continuity for vehicles. This will need to provide a priority function. Such a resilience strategy should not be a barrier to change if restrictions are higher than those in place today.

Step 4: Work with existing retail partners to install a charging network that makes use of gas station canopies by 2025

It may be possible to work with existing gas stations and their solar opportunities to provide charging and storage opportunities to help with resilience.

Task 4: Consider Opportunities for Retrofitting of Vehicles to Electric Drivetrain in FY21

There are opportunities to retrofit vehicles with electric drivetrains, which extend the life of much of the vehicle, and potentially change how well a vehicles shell may be maintained. This has the opportunity to change the approach to procurement and the value of a vehicle currently considered to end of life. It may also mean that drivetrain conversion occurs before the end of life of the combustion engine.

Step 1: Identify existing areas of expertise within the Fleet Maintenance Advisory Team (FMAT) and other City Departments

As the cost of batteries declines and the technologies and understanding of battery vehicles improves, opportunities for conversion are increasing. This brings job opportunities and revenues associated with it to Charlotte.

Step 2: Identify opportunities for workforce development

There are opportunities for increased employment and entrepreneurial opportunities, as well as additional prospects for the workforce pipeline.

Step 3: Pilot a diesel bus or heavy equipment retrofit at the City maintenance facility.

The City maintenance team has a large site and skilled staff. A pilot project could see an existing CATS bus or other heavy-duty vehicle retrofitted as an electric one.

Step 4: Align with the City's circular economy strategy

The retrofitting of vehicles to electric helps to close the waste cycle. This closed loop approach is central to the circular economy strategy. If a retrofitting strategy was adopted it could align with the activities of the City's innovation barn.

and would then provide an additional revenue stream to CREDIT's revolving fund structure.

COMMUNITY ACTION AREAS

ACTION AREA 7: NEAR ZERO CARBON NON-MUNICIPAL BUILDINGS BY 2050

Buildings are crucial to a low carbon future. They are the biggest energy consumers and therefore are the biggest component of emissions in Charlotte. The City will use the '5 Stages to Zero Carbon Energy' diagram when retrofitting existing buildings and constructing new ones. It is necessary to consider the longevity and energy consumption of new and existing buildings, together with the potential for low carbon energy sources and on-site generation. It is also important to consider how buildings will interact with current and future infrastructure and the people within them.

The City is expanding rapidly. New residents require housing, workplaces, and the infrastructure to support them. This includes healthcare, schools, retail outlets, leisure facilities, and the hospitality industry. The location of these buildings and their proximity to facilities and transportation infrastructure affects how people live in the short, medium, and long term. This means that in the absence of coordinated planning efforts, energy consumption patterns can be set for decades.

This action area identifies two overarching categories where the greatest impact can be had: 1) retrofitting (deep weatherization) of existing buildings and, 2) low carbon construction of new buildings.

Task 1: Form a Building Working Group in FY21

CREDIT will not be able to deliver a near zero carbon building stock itself. It will need to work through and with partners. It is therefore recommended to set up a working group specializing in getting to near zero carbon for buildings. This group will need to comprise experts from academia, construction, planning, energy systems, and infrastructure to inform and direct it. To achieve such a future will require, per the scenarios produced, a system for buildings that is largely based on electricity.

Task 2: Make Existing Residential Buildings Low Carbon by 2050

The existing building stock is the biggest challenge to nearly every city striving towards a low carbon future. They require a considerable amount of work and effort with a diverse ownership, including homeowners, landlords, mixed use developments and multi-family occupancy.

Step 1: Develop an ongoing educational program with partners on the opportunities associated with retrofitting

Understanding how to reduce energy consumption, shift demand, and increase renewable generation onsite is limited and needs to be increased as part of this long-term transition to near zero carbon. CREDIT will need to support and develop programs through the working group with for-profit partners such as Duke, as well as through non-profit organizations like RETI.

Step 2: Develop deep retrofitting example demonstrations (or varying types – detached, multi-family, attached single family development) to net-zero energy levels

CREDIT, in partnership with the working groups, will need to utilize RDIs to pilot and show proofs of concept for varying types of buildings, including carbon negative, high carbon, and low carbon buildings. Like the North End Smart District Smart Homes program, these demonstrations could use technology to inform their inhabitants on how to reduce future utility bills.

Step 3: Consider policy to stop natural gas boiler implementation and replacement by 2025

Delivering a near zero carbon building stock by 2050 requires discontinuing the installation of gas boilers and their replacements as soon as possible. This was the policy that stemmed from each GRIP scenario session, due to the longevity of the boilers (over 20 years). Continuing to use and install natural gas distribution for hydrogen or biogas was consistently discounted as unviable.

Step 4: Develop a workforce pipeline of qualified workers trained in deep energy retrofits

Deep energy retrofits at the scale required to drive the transition will require many laborers to deliver. The development of a low carbon future is dependent on achieving such energy retrofits of differing sizes. These will all require an expansion in the labor force above that of today.

Step 5: Utilize the RIDs as further proof of concept and move forward with retrofitting roll out

The working groups will need to establish with the Energy Ambassador the criteria for the RIDs. Retrofitting will need to be a key component of each of the RIDs with the level to be established. With an estimated number of households of approximately 500,000 by 2050, homes will likely need to be retrofitted at an increasing rate from 2030 onward. The scale of this will need to be established but is likely to be around 1,000 per month in 2030, increasing to as much as 5,000 by 2045. This level of retrofitting will also need to be maintained and will require additional workforce.

Task 3: Influence the Energy Requirements of New Residential Buildings to be Near-Zero Carbon by 2050

New buildings exist on average for over 100 years, so buildings constructed today ensure a particular energy pathway going forward. Strong policies, in collaboration with the County and State, are therefore required to achieve a near zero carbon building stock.

Step 1: Exert influence to establish minimum building standards for energy efficiency with scaled introductions to net zero energy by 2030

Raising the minimum building standard is required to ensure that the future energy system is not overburdened with meeting the future energy needs of its inhabitants. This requires a scaled introduction of minimum building standards, appropriate training, and effective rollout. There are standards in place, but to achieve the target, a design that permits net-zero energy development by 2030 is required. This necessitates an appropriate skill set that places additional requirements onto workforce development.

Step 2: Incentivize alternatives to gas boilers by 2022

See Action Area 7, Task 2, Step 3.

Step 3: Incorporate cutting-edge low-carbon residences into Resilient Districts targeted with new mixed-use developments.

The RIDs should trial opportunities for low carbon developments at new mixed-use sites. CREDIT should work with the County, developers, and home owners to help identify and incentivize ways to make the residence low carbon. These

developments allow for the implementation of new systems of heat, cooling, and electricity provision. An option could be to direct projects to the Hybrid Collaborative Design Team (HCDT) for a quicker permit and approval process.

Step 4: Ensure sufficient capacity at all developments for electric vehicle infrastructure.

Meeting the electricity requirements for charging vehicles requires a grid capable of supporting it. Sites should include charging points and spare capacity to connect additional ones. These systems could share the electricity supply to enable rapid charging where required, when other vehicles on the same supply do not require rapid charging.

Step 5: Exert influence to implement minimum requirements for renewable generation of 10% by 2022 sliding up to 40% by 2030.

A minimum standard specifying the percentage of energy consumption to be sourced from onsite renewable energy generation is needed to facilitate the long term installed infrastructure that is needed to deliver a near-zero carbon building stock. The gradual introduction of a minimum requirement is necessary to support the 2tCO₂e target. This will need to be done in collaboration with the County and the State.

Step 6: Identify incentives or programs that help to incorporate installation of batteries into new residences

Storage in the form of batteries is a very helpful component of shifting energy demand throughout the day. Such storage can be topped off through solar during the day for deployment at night. It can also charge at night through smart grids in anticipation of cloudy days. These technological approaches are made possible through specifications at the point of construction and can serve as a data input to the data requirements of Action Area 11.

Task 4: Make existing non-residential buildings low carbon by 2050

The existing non-residential building stock requires retrofitting in much the same way as the existing housing stock. There are additional challenges associated with ownership, lease length, construction quality, and associated standards of energy efficiency. This makes the use of RIDs particularly valuable for testing solutions in order to identify business models that can deliver near-zero carbon buildings.

Step 1: Exert influence to establish minimum building standards for energy efficiency with scaled introductions to net-zero energy by 2030

See Action Area 7, Task 3, Step 1.

Step 2: Incentivize alternatives to gas boilers by 2022

See Action Area 7, Task 2, Step 3.

Step 3: Ensure sufficient capacity at all developments for electric vehicle infrastructure.

See Action Area 7, Task 3, Step 4.

Step 4: Establish opportunities with demand side management to link heat requirements in mixed-use developments

Through the RIDs, innovative approaches can be incorporated that have been proven in other countries. These include the ability to share waste heat between buildings, as well as utilize heat dumps⁵⁶ such as swimming pools.

Step 5: Establish Smart Energy Now 2.0 and PACE programs

CREDIT will need to establish a partnership with a local organization and UNCC to deploy a Smart Energy Now 2.0 program that works on educating building operators and facilities managers to operate buildings more efficiently. CREDIT should also work with the working group to establish how this could be incorporated into PACE funding programs to encourage active standards today.

Step 6: Incorporate best energy practice into developer outreach and communication

CREDIT will, through the working group, establish mechanisms of communication with current and potential developers within Charlotte to improve efficiency standards for new developments. The knowledge attached to these development types can also be incorporated into retrofitting projects.

Task 5: Make New Non-Residential Buildings Low Carbon by 2050

The development of new non-residential buildings brings with it opportunities for minimizing energy requirements, integrating renewable energy generation, and being creative with transportation

solutions.

Step 1: Exert influence to establish minimum building standards for energy efficiency with scaled introductions to net-zero energy by 2030

See Action Area 7, Task 3, Step 1.

Step 2: Incentivize alternatives to gas boilers by 2022

See Action Area 7, Task 2, Step 3.

Step 3: Develop a shared solar model where each owner pays solar installation cost based on their peak demand

There will need to be innovative energy service style solutions to reducing energy costs into the future and ensuring that they come from low carbon sources. This means looking to solutions at sites where there is a landlord and multiple businesses within the property. A set of example buildings would need to done in the first instance to test and demonstrate the opportunity.

Step 4: Form educational packages on the benefits of consistent pricing for renewables

CREDIT, with the working group and partners should form training packages, for commercial building owners and their tenants to inform them of the opportunities attached to energy in a low carbon future. This type of outreach and engagement is a key component of building links to commercial building operators that can bring about the needed transition. This can be used to demonstrate how low carbon building design can be useful to their business both in terms of energy savings and in terms of their Corporate Social Responsibility.

Step 5: Work with new building owners to trial an Energy Service Company (ESCO) on site, where all lessees pay for heat, cooling, lighting, and local transportation rather than electricity

CREDIT, in partnership with the building working group, can work to include in a RID a commercial building or district where energy services are sold, rather than electricity, to establish working business models. These services may include lighting, refrigeration, cooling, heating, and local transportation.

⁵⁶ A heat dump is a term for where heat can be placed instead of being wasted entirely. This is usually a space that requires heating, it may be one like a swimming pool that doesn't need heat but may want it.

Step 6: Incentivize ongoing reporting and minimum standard targets for sites

Identify opportunities for incentives for providing consistent reporting and setting of minimum targets in the development phase. This can help develop a greater real-time understanding of energy data and should be developed in tandem with recommendations in Action Area II.

Step 7: Maximize potential for renewables on-site

CREDIT, in partnership with the building working group and partners, should identify opportunities to incorporate on-site renewable energy generation for heating and electricity in new development construction across Charlotte.

Step 8: Enable fast-tracking of applications that meet minimum standards

CREDIT, in partnership with the City of Charlotte and Mecklenburg County, should develop a pilot process and clear project requirements to accelerate applications through the approval process that meet high efficiency standards. These developments would then be approved faster and receive dedicated support opportunities with them. This may include buildings that utilize passive temperature.

ACTION AREA 8: FACILITATE RAPID UPTAKE OF SUSTAINABLE MODES OF TRANSPORTATION

The transportation sector is the second largest source of greenhouse gas emissions in Charlotte. This is primarily due to the structure of the economy, the efficiency of the vehicles, and the availability of alternative transportation options. This also considers the emissions from Charlotte Douglas International Airport, which is one of the busiest airports in the USA and is a hub for American Airlines.

In order to reduce emissions from the transportation sector there needs to be focused efforts:

- Change how people move about
- Improve efficiency in vehicles (whether technological or behavioral)
- Change the fuels that are being used by the vehicles
- Make the last mile of a person's journey zero carbon

- Provide the new infrastructure required to support alternative modes of transportation

- Change the existing transportation infrastructure to support a range of transportation choices

Fundamental to the transition to a zero carbon energy transportation future is the infrastructure to support it. This comes with a series of complex issues that need to be resolved. Some of these challenges include where to locate the charging points, how many charging points are required, what type of charging point is needed, how to connect electricity infrastructure to support the charging points, how charging points can be incorporated into older buildings, how to make provisions for charging points in new buildings, how to procure zero carbon electricity to support electric vehicle growth, and how to design the system so that peak demand is controlled.

There are also opportunities for external companies providing services in the form of short-term rental bikes, scooters, and similar. These latter options have become more possible with the advancement of technology and help to address last mile transportation challenges.

Air transportation is likely to remain the area that is hardest to mitigate. This means that a sizeable chunk of the 2tCO₂e target will be absorbed by aviation in the future. This also means that other sectors will likely need to reduce by more to accommodate this industry, moving forward.

Task 1: Form a Transportation Working Group in FY19

CREDIT will not be able to deliver a sustainable transportation system on its own; it will need to rely on developing key partnerships to support implementation. It is therefore recommended to set up a working group specializing in getting to a sustainable future transportation system. This group will need to comprise experts from academia, construction, planning, energy systems, and infrastructure to inform and direct it. To achieve such a future will require, according to the scenarios produced, a system built largely on electricity.

Task 2: Develop a Promotion and Awareness Campaign Around Electric Vehicles (EVs)

The challenges associated with EVs largely relate to their perceived reliability and technical abilities, i.e. the distance that they can go, where they can be charged, etc. As a result, continuous awareness

raising and education is required to support the rapid uptake of EVs. A large part of this will be visual and collaborative. One way to accomplish this is to locate charging stations in high foot traffic areas so that people see the EVs parked and charging out in public. This will need to align with the broader communication strategy of Action Area 2.

Step 1: Create a visible monthly event, to educate the community around zero carbon modes of transportation

This may include activities such as closing N. Tryon St. for one day during the week to internal combustion engine (ICE) vehicles, with opportunities to test EVs.

Task 3: Deploy a Citywide EV Charging System for Charlotte by 2030

Facilitating the uptake of EVs requires a visible charging network. These chargers need to be located where people remember them, such as in retail outlets, in government buildings, and at work places. The EV network initially needs to be ahead of the vehicle fleet, but this will change in time. As an electric fleet has not been present before, it is difficult to know what the optimum number of chargers and locations precisely is. The charging system will need to grow with the number of vehicles that require it.

Step 1: CREDIT and transportation working group will produce an EV transportation deployment strategy and business case.

This strategy may include a requirement to provide priority parking and/or free parking to electric vehicles in areas of high density, like Uptown or South End, and at transit sites with charging opportunities. The strategy can also explore the possibility of limiting access to certain roads to electric only vehicles at particular times and providing access to carpool lanes. The strategy may also make provisions for charging at particular locations such as restaurants and at places of work.

Step 2: Ensure sufficient capacity at all developments for electric vehicle infrastructure.

See Action Area 7, Task 3, Step 4.

Task 4: Increase Access to Zero Carbon Mobility Options

Getting people out of automobiles requires providing them with alternative transportation options, making areas more walkable, or providing an alternative that removes the transportation requirement.

Step 1: Create a taskforce to review and update policies that support rapid uptake of last mile modes of transit

The purpose of this taskforce is to target the 'last mile,' a specific but crucial element of transportation. The taskforce will need to include internal team members from CATS and CDOT, as well as community stakeholders to identify how this may be better addressed. Last mile modes of transit can include scooters and dock-less bikes.

Step 2: Actively support and further the work of CATS and transportation stakeholders to develop a series of campaigns to overcome negative perceptions of public transportation

This step should work with the communication aspects in Action Area 2 and specifically work with the Content Expert Advisory Group to identify how best to address this. Wider groups for engagement may include the hospitality industry, CMS, and CRVA, among others.

Step 3: Increase last mile opportunities at transit development sites

The development of new sites enables construction that encourages low carbon transportation options such as cycling and mass transportation. The existing planning needs to involve the existing corridors and see the implementation of the additional light rail lines.

Step 4: Develop app or platform that provides for one-stop purchase of tickets for all modes of transit available in Charlotte

The idea behind this is to extend the ticket to include rental of the scooters/bikes as part of the ticket purchase. A further extension could see pre-booking of electric vehicle parking in areas linked to light rail stops.

Task 5: Continue to Integrate Transportation Oriented Development (TOD) Policies into Land Use Policy Frameworks, Namely the Comprehensive Plan and UDO Update

TOD encourages the development of systems that decrease reliance on the automobile. Integrating such policies has long term implications for a downward pressure on transportation. The Comprehensive Plan will have far reaching implications for direct and indirect energy requirements and this should be part of it.

Step 1: Assign a person from CREDIT responsible for ensuring effective communication and alignment between the SEAP and the Comprehensive Plan update

The role of energy must be reinforced within the Comprehensive Plan to ensure that it is firmly integrated into it.

ACTION AREA 9: DEVELOP AND IMPLEMENT STRATEGY FOR DEPLOYING LOW CARBON INFRASTRUCTURE GENERATION

The adoption of zero carbon electricity sources needs careful planning today to ensure that it is in place for the long-term. Power stations, such as coal and gas, are often promoted by power companies as a means to support renewable technologies. Implementation is likely to result in long-term difficulties. This demands careful thought to be given to how electricity requirements will be met in the future. This is complicated by federal policy that has reduced the requirements for CO₂ reductions. This has the trickle-down effect of CO₂ reduction not becoming a requirement in setting energy policy in North Carolina.

The resolution's 2050 target necessitates minimal CO₂ in the electricity system (a reduction of more than 90% against today's carbon intensity⁵⁷) in order to meet the less than 2tCO₂ per capita target. In order to reach the target, we must focus on innovative solutions, such as Bioenergy Carbon Capture and Storage (BECCS).

With no clear solution as to how to achieve such deep carbon cuts, the strategy will require detailed consideration, and should include the implementation of on-site electricity generation that addresses heating and cooling needs, rather than solely electricity. Given these requirements, there are strong connections to the Buildings and Transportation pillars in this strategy, as well as being heavily reliant on the underpinning innovation pipeline of trained individuals.

This Action Area is complementary to Action Area 3, as many of these recommendations require key public-private-plus partnerships to drive rapid implementation.

Task 1: Form an Energy Generation Working Group Focused on Near-Zero Carbon For Buildings in FY19

Because Charlotte is in a regulated state, CREDIT will not be able to deliver a 90% reduction in the carbon intensity of electricity provided by the grid on its own. It will therefore need a targeted working group specializing in getting to this point. This group will need to comprise experts from academia, construction, planning, energy systems, and infrastructure to inform and direct it. To achieve such a near-zero carbon future will require, according to the scenarios produced, a system that takes advantage of the widespread opportunities for renewable integration across Charlotte and wider North Carolina.

Task 2: Develop a Suite of Educational Tools that can be Utilized Throughout the City in FY22

Education and training are key to leveraging change. These educational tools can come in a variety of forms and will need to recognize the equity elements relating to access to this information.

Step 1: Incorporate CO₂e values onto energy bills

The CO₂e emissions associated with a customer's energy use can be added to both electricity and gas statements. This can be displayed alongside percentages of generation by technology for electricity and by type of gas used (natural gas, fracked gas and biogas). This can help to inform customers of the level of CO₂e emissions that are associated with their energy consumption. This information can be linked to efficiency and demand guides to drive behavior change in customers and help them reduce their impact.

Step 2: Create a mechanism that links emissions to smart meters to help educate customers on when CO₂e is at its highest or lowest

To provide real-time updates, smart meters can be used to guide customers to when the CO₂e associated with their electricity demand is at its lowest (e.g. during the night when energy is generated largely by nuclear) and highest (at times of winter peak demand when solar generation is at its lowest and fossil generation at its highest). This can then be linked to live CO₂e monitoring and conveyed in their bills.

⁵⁷ Carbon intensity is defined as the amount of carbon (in terms of weight) emitted per unit of energy consumed.

Step 3: Encourage training on demand side management

Further developing the information under Steps 1 & 2 enables the development of demand side responses⁵⁸. This can be automated through the use of smart appliances such as washing machines and electric vehicles. It can also be manual, making the change a conscious behavioral choice. This demand side management may be linked to utilizing onsite generation for appliance use when energy generation is at its peak, rather than relying on grid availability.

Step 4: Utilize RIDs to understand and overcome demographic variance in technology and process uptake

The RIDs may be used to better understand the business models needed to see the uptake in low carbon technology and processes. This is likely to vary by income group and awareness levels, as customers become more aware of their energy usage as access to more granular data improves.

Step 5: Provide training and events on alternative technologies

A key component of the uptake of renewable energy generation is to provide demonstration of the technologies to show that it is possible to incorporate their utilization into buildings. This may include solar thermal, geo-thermal, and solar photo-voltaic (PV).

Step 6: Create an 'outward bound' and other demonstration site(s)

As well as events, demonstration sites can serve as a year-round opportunity to demonstrate the ability of renewables to provide the energy required for a building. Such sites could include schools. Additionally, a site (similar to a campsite) could be formed for team building activities where participants would be required to 'keep the lights and heating on'. This could be located within a proposed RID.

Task 3: Demonstrate New and Integrated Approaches to Meeting Energy Demand in 2022

The Resilient Innovation Districts (RIDs) will provide opportunities to establish how proven technologies can be integrated into the energy system that provides

us with our energy needs (heating, cooling, or electricity). This may mean combining technologies (e.g. solar thermal, geo-thermal, and bio-energy CHP system) to produce heating and cooling for a site (the solar thermal and geo-thermal providing a lower grade heat). The RIDs offer an opportunity to test as well as diffuse technologies and processes.

Step 1: Identify new technologies, processes, and opportunities for demonstration in the RIDs

The identification of new technologies can come from multiple sources and these may be subject to procurement requirements. Ultimately, part of the reason for the RIDs is to demonstrate technologies and processes produced in Charlotte that can then be diffused throughout the U.S.

Step 2: Utilize the RIDs to demonstrate district heating and cooling opportunities

The RIDs offer the opportunity to incorporate approaches that are not well known in the U.S., which includes district heating and cooling systems. One of the RIDs could be used to extract methane (bio-gas) from waste sites and compress it for carbon-free CNG (it is not actually natural gas - but has the same chemical composition). The same bio-gas could also be distributed in the gas network.

Task 4: Reduce the Carbon Intensity of Grid Supplied Electricity by at Least 90% by 2045

The requirement to get to 2tCO₂e per capita by 2050 requires that the majority of energy consumption is low carbon. This is because, of the 2tCO₂e target, approximately 1.2tCO₂e will be from energy. The remainder will be largely associated with waste and agriculture. The likeliest carbon intensive category will be aviation – a return trip in economy represents 0.5tCO₂e. This greatly limits emissions from other sectors. The development of this future needs to be developed through the working group in strong alignment with Duke Energy, the commission, further partners, and other cities.

Task 5: Target a Carbon Intensity on the Grid of at Least 90% per kWh by 2045

This target is comparable to a figure of approximately 0.4 CO₂ per kWh today. It is necessary to set targets

⁵⁸ Demand [side] response provides an opportunity for consumers to play a significant role in the operation of the electric grid by reducing or shifting their electricity usage during peak periods in response to time-based rates or other forms of financial incentives. (<https://www.energy.gov/oe/activities/technology-development/grid-modernization-and-smart-grid/demandresponse>)

in terms of kWh as this is what will determine the emissions. A 90% reduction in the kWh does not mean a 90% reduction in electricity emissions, as this number could vary. This compares to figures of 0.18CO₂/per kWh for natural gas and 0.24CO₂/per kWh for gasoline. The electricity equivalent would need to be around 0.035CO₂ per kWh. As electrification of transportation and heating increases, the carbon intensity of electricity production becomes even more important. This carbon intensity is a function of the electricity that is supplied on average over a given year.

Task 6: Identify Opportunities for a Bioenergy with Carbon Capture and Storage (BECCS) Combined Heat and Power (CHP) Unit by 2030

This is currently an unproven technology. However, it is the ‘cornerstone’ of each Intergovernmental Panel on Climate Change (IPCC) scenario produced immediately prior to the Paris summit to identify a future that is well below a global temperature rise of 3.6°F. This technology, deployed globally, is therefore required to keep warming below 2.7°F – which is the ultimate goal of the Paris Accord.

Task 7: Negotiate to Develop Tariffs for Low Carbon Electricity in 2022 and Identify a Period for their Rollout by 2030

The City will need to negotiate new electricity contracts that incorporate zero carbon generation to be implemented now until 2030. This negotiation will require an understanding of how rates could link to capacities, onsite generation, demand side management and other points. These models for tariffs could then be implemented elsewhere.

HB 589 provides low carbon electricity tariffs for high energy consumers. The Global Protocol for Community-Scale Greenhouse Gas Emissions Inventories (GPC) allows for such tariffs to be reflected in emissions inventories. This requires changes to how such tariffs are formed and applied. The rollout of these should be identified through Action Area 3.

Step 1: Smart sub-meters that link to CO₂ to encourage behavioral change at work

Individual organizations and the departments within them may use sub-metering systems to encourage the uptake of zero carbon energy use. This can be used to track and reward individual

department activities.

Step 2: Tariffs for different customer types and level of renewable integration

Structures and agreements to introduce new tariffs could be negotiated between Duke, other cities, and the North Carolina Utilities Commission (NCUC). These have a direct impact on emissions calculations, but should not be used to bypass local energy reduction and production opportunities.

Step 3: Tariff for 100% zero carbon energy for Charlotte government in place before 2030

The final component of the ‘5 Steps to Zero Carbon Energy’ diagram is the procurement of zero carbon electricity, which is a last resort option. This definition includes nuclear power and can therefore, with the correct contract, reflect both demand and consumption of electricity (which a renewable only tariff may fail to do).

ACTION AREA 10: DEVELOP GREEN WORKFORCE PIPELINE IN SUPPORT OF ENERGY TRANSITION

Workforce development is a national issue referring to the development of skilled labor jobs. Currently, the average age of those in these roles is 47⁵⁹. This means there will soon be a considerable employment gap. As Charlotte works to develop a green economy through transitioning to a zero carbon energy future, there is a wealth of job creation opportunities for various skill levels.

Charlotte currently has high unemployment rates in specific communities⁶⁰. There are many groups in Charlotte, including the City of Charlotte government, that are actively working to address this issue of inequity and include organizations like: Goodwill Industries of the Southern Piedmont, the Urban League of Central Carolinas, and Charlotte Works.

It is necessary to ensure that the job creation opportunities are equitably distributed across all communities. It is also important to consider the opportunities of entrepreneurship in this space together with the mechanisms and models that realize it.

As with many transitions that we have seen in history, there is a process of ‘creative destruction,’ where new

59 <https://tinyurl.com/y9bmwadq>

60 <https://mcmmap.org/zol/#38/>

technologies and ways of doing things lead to the destruction of certain jobs and the creation of new ones. There is a need to formalize and predict what these jobs of the future are in order to ensure an adequate workforce labor pipeline. It is through these initiatives that guidance can be provided by the City in collaboration with its various current and future partners.

There is likely to be conflict in the investment priorities and resource allocation between the public and private space. This Action Area is fundamental to the innovation pathway that is foundational to each of the pillars of buildings, transportation, and generation.

Task 1: Form a Working Group for Workforce Development and Equity in FY19

CREDIT will not be able to ensure the workforce required to deliver the low carbon future on its own and will require inputs and guidance from multiple groups to ensure equity in job creation and deployment of low carbon technologies. A working group is needed in partnership with CREDIT and other partners. This group will need to comprise experts from nonprofits, government, academia, construction, and energy systems to inform and direct it.

Task 2: Establish and Produce the Training Pipeline for Skilled Labor Jobs and Entrepreneurship Opportunities in FY22

Additional knowledge will be gathered through efficiency activities under Action Area 5.

Step 1: Develop mechanisms and partnerships to support and encourage energy efficiency job opportunities and pipeline creation

There are a series of job opportunities attached to energy efficiency, which can include, for example, energy auditors that identify a building's energy performance before and after the implementation of energy efficiency measures, and project management associated with deployment of large-scale energy retrofits – such as intense weatherization. In addition, there are training opportunities for the public, businesses, and educational establishments.

Step 2: Develop mechanisms and partnerships to support and encourage shifting energy demand response job opportunities and pipeline creation

There are job opportunities associated with building management systems, their integration into existing structures, and their ongoing proper use, as well as property performance management to ensure the integration of efficiency approaches in combination with onsite generation. Educational programs relating to the use of smart metering, smart products, and similar should be implemented so that all consumers can benefit.

Step 3: Develop mechanisms and partnerships to support and encourage onsite generation, job opportunities, and pipeline development

There are multiple job opportunities attached to the installation and maintenance of onsite and distributed generation, which includes solar PV, wind generation, heating and cooling networks (together with combined and tri-generation), and solar and ground source heat pumps. Finally, there are integrated opportunities that combine one or more of these technologies. We can learn from the existing solar portfolio being offered by Duke Energy and the zero carbon building target the City government set.

Step 4: Develop mechanisms and partnerships to support and encourage third party intermediary jobs and opportunities

Jobs and entrepreneurial opportunities exist for these organizations which should be encouraged through various established communities, like faith-based communities. The entrepreneurial opportunities attached to new businesses in this field provide opportunities for building equity. New approaches may see energy services being sold rather than the energy itself. This option may be considered in terms of the circular economy and job opportunities attached to approaches such as the retrofitting of vehicles to make them zero carbon. There are already opportunities that are being explored by companies in this space. With the targeted scheme relating to municipal buildings, there are additional opportunities for entrepreneurship with a program being put into place.

ACTION AREA 11: ESTABLISH PUBLIC-PRIVATE-PLUS PARTNERSHIPS TO ACCELERATE TRANSITION TO A LOW CARBON FUTURE

The City government cannot deliver the resolution or large aspects of the strategy on its own. It needs to form strong links, with various partners to achieve it.

This requires identifying the key individuals in various companies, organizations, and universities that can help realize this future. Charlotte presents a unique blend of stakeholders and this includes the nation's largest utility, as well as headquarters for the second and third largest banks in the United States. In addition, there is a bustling energy sector and strong research base grounded at UNCC's EPIC. This provides excellent opportunities for developing and implementing the SEAP. There is also potential for the cities of North Carolina to come together to help achieve a regional or state level low carbon energy system.

Task 1: Identify, Build, and Formalize Relevant Partnerships in FY20 and FY21

There are various working relationships that are already in place between the City and the organizations within Charlotte, including Duke Energy, Bank of America, Wells Fargo, UNCC, and various non-profit groups. The City will also look to develop relationships beyond Charlotte. Once all relevant relationships are identified, steps should be taken to formalize the relationship with a recognition that the overall goal of the relationship is to accelerate Charlotte's transition to a low carbon future.

Step 1: Identify, in partnership with selected organizations, key areas of alignment focused on a low carbon future in FY20

These partnerships will require a strategic focus on areas that organizations can work on. The strategic focus area(s) that will be tackled and addressed, along with the timelines for their assessment and viability, need to be established. This will require building on the links to formal research units as well as training facilities, and will include universities and businesses. They can expand into the financial service space, as well. Each partner should appoint a lead person to ensure effective communication throughout the duration of the partnership.

Step 2: Utilize project management tools to map out the overall trajectory of the partnership to ensure SEAP wins for both partners in FY21

The lead person from each partner should work closely together with CREDIT team members to identify areas within the SEAP that align with each partnerships' key areas of focus - they will need to be defining the necessary strategic focus. As part of the solution-oriented approach, understanding the ever-changing positions of organizations is vital. As an example, Duke Energy's latest Integrated Resource Plan identifies areas as challenging that align with what this SEAP structure is proposing.

IMPLEMENTING THE SEAP

Implementing the SEAP

To effectively deliver and implement the SEAP, actions and change need to be monitored. An important requirement will be providing adequate resources - staff, knowledge, finances, etc. - for the SEAP. The purpose of this section is to emphasize the key mechanisms that need to be in place to support its successful implementation.

City Leadership

The City will take ownership of the plan once approved by City Council, and will work to rapidly begin implementation of immediate-term and short-term tasks. The tasks chosen will accelerate the City towards achieving the 2030 goal of driving zero carbon energy within their own buildings and fleet. However, as noted earlier in the document, the City will also need

to display leadership in creating and driving public-private-plus partnerships to accelerate the transition to a zero carbon energy economy – this is a citywide strategy that will require citywide collaboration to be successful.

The City's role as a leader in this process will require the recognition of the resources that exist within the City's boundaries. This means creating unique consortiums of partners to drive the transition by connecting people and knowledge, and harnessing disruptive technologies and innovation.

Structural Change

To ensure the success of the SEAP, a key role of the City will be to ensure that critical structures and decision-making processes are in place that support

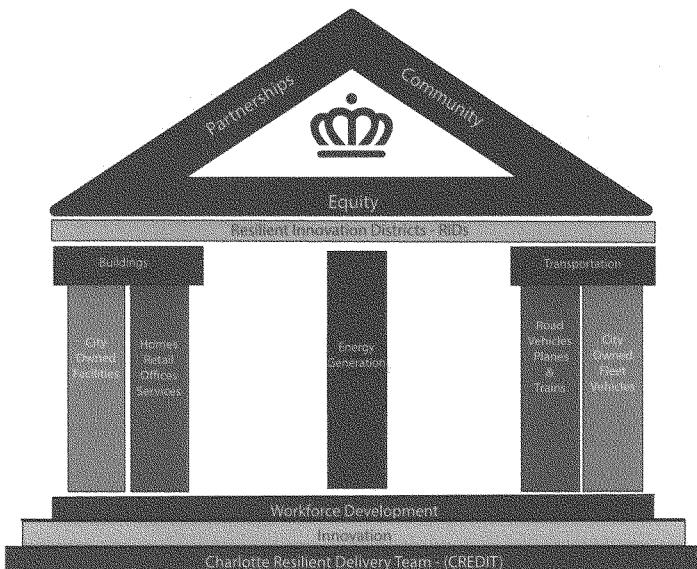


Figure 7: A graphic representation of the Charlotte SEAP Delivery Structure

and encourage internal and external implementation – this includes setting up clear roles, providing sufficient resources (including staff and skills), and reporting and tracking mechanisms. Regardless of the scale of a project, it will be necessary to have clear project plans and budgets aligned with roles, responsibilities, and reporting structures.

The SEAP has been designated a living document due to its long-term target of 2050. To account for technology advances, research findings, and inevitable changes in government policies, resources, and practices, a biennial review will be necessary. The City will lead these review efforts to realign, if necessary, as well as identify any known risks or issues that affect implementation of the plan. As part of this review, tracking all data points necessary to measure the progress towards the 2030 and 2050 targets and how effectively projects are reducing emissions, will be a key focus.

Monitoring and Reporting Structure

One of the largest challenges in developing the SEAP was the collection of data. The City of Charlotte has two great repositories of data – ‘Open Charlotte’ - the City of Charlotte Open Data Portal, and the Charlotte-Mecklenburg Quality of Life Explorer’.

Creating a dashboard to have all City data in one easily accessible location is paramount to the success of the SEAP and is an immediate task under Action Area II. Cities are large entities and one of the biggest difficulties is prioritization. However, by developing this SEAP, the City has already expressed the outcome they desire – a low carbon city with a zero carbon energy future. By developing a dashboard that collects the broader spectrum of data needed to prioritize, the City can increase transparency, create a strong culture of data-driven decision making, and begin to create a narrative that drives collaboration among residents, businesses, and the City.

Innovative Funding

While the overall cost to deliver the SEAP is undetermined, it will be necessary to explore the wide selection of additional funding opportunities. This includes government grants and international grants with a specific focus on EU funding opportunities, leveraging local relationships with corporations for private-sector investment, as well as understanding ways to navigate City funding.

One of the key tools that could be deployed to help the City achieve the 2030 municipal goals is to explore how the model of an Energy Service Company (ESCO) could

be applied. The concept of an ESCO is that it essentially acts as project developer for a comprehensive range of energy efficiency actions and assumes the technical and performance risks associated with such a project. ESCOs utilize a performance-based contracting methodology so that when an ESCO implements a project, the company’s compensation is directly linked to the actual energy cost savings. The City could deploy this model and funnel the savings directly back into a fund for energy efficiency projects.

As energy efficiency and reduction of GHG emissions becomes more and more a part of everyday vernacular among different industries, it will also create additional opportunities for funding that should be explored. With the green economy as a new buzzword, a quick search will find multiple foundations offering grants for the creation of green job training programs – which could be great ways to develop a low-cost workforce to implement projects within the City.

In addition to raising funds, looking at overall project costs need to be viewed through a creative lens. Oftentimes, project costs are broken out into capital expenditures and operational expenditures, and thus the long-term savings are not fully understood. A new perspective can be gained by looking at the lifecycle costs. By requiring the development of a project plan and lifecycle budget, total cost and a better understanding of a project’s overall impact can be determined.

Communication

Urban sustainability and resiliency are complex topics that are often difficult to communicate. The project team has started to develop a communication strategy for the delivery of the SEAP, and will continue after the SEAP has been approved by Council. The communication strategy will focus on addressing how information and updates will be disseminated to the various stakeholder and City leadership groups. It will be vital to provide regular and consistent updates to the stakeholders and community groups that have been participating in this process.

CONTACTS + FURTHER INFORMATION

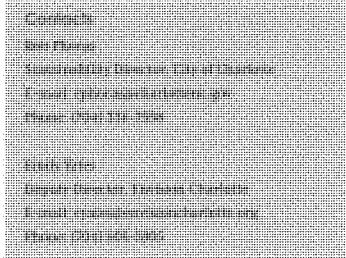
Getting Involved

While the City has taken the lead in developing the SEAP, it is a citywide strategy that requires all people that work, live and play within City boundaries to play a part in reducing emissions for a greener future. As a living document, the SEAP will constantly be adapting and adjusting based on the engagement of ALL stakeholders.

Ongoing opportunities to engage community groups, advocates, business and citizens at all levels of implementation will be developed.

You can also access additional information on the Environment Committee website:

<http://charlottenc.gov/CityCouncil/focus-areas/Pages/EnvironmentFocusArea.aspx>



This report is a synopsis of the work conducted and does not necessarily reflect the views of any individual consulted.

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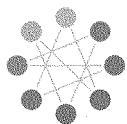
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Credits

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State of North Carolina

ROY COOPER

GOVERNOR

October 29, 2018

EXECUTIVE ORDER NO. 80

**NORTH CAROLINA'S COMMITMENT TO ADDRESS CLIMATE CHANGE AND
TRANSITION TO A CLEAN ENERGY ECONOMY**

WHEREAS, North Carolina residents deserve to be better educated, healthier, and more financially secure so that they may live purposeful and abundant lives; and

WHEREAS, N.C. Const. art. XIV, § 5 requires the conservation, protection, and preservation of state lands and waters in public trust; and

WHEREAS, North Carolina is well positioned to take advantage of its technology and research and development sectors, along with its skilled workforce, to promote clean energy technology solutions and a modernized electric grid; and

WHEREAS, public-private partnerships in North Carolina foster market innovations and develop clean energy technology solutions that grow the state's economy; and

WHEREAS, the effects of more frequent and intense hurricanes, flooding, extreme temperatures, droughts, saltwater intrusion, and beach erosion have already impacted and will continue to impact North Carolina's economy; and

WHEREAS, climate-related environmental disruptions pose significant health risks to North Carolinians, including waterborne disease outbreaks, compromised drinking water, increases in disease-spreading organisms, and exposure to air pollution, among other issues; and

WHEREAS, to maintain economic growth and development and to provide responsible environmental stewardship, we must build resilient communities and develop strategies to mitigate and prepare for climate-related impacts in North Carolina.

NOW, THEREFORE, by the authority vested in me as Governor by the Constitution and the laws of the State of North Carolina, **IT IS ORDERED**:

1. The State of North Carolina will support the 2015 Paris Agreement goals and honor the state's commitments to the United States Climate Alliance.

The State of North Carolina will strive to accomplish the following by 2025:

- a. Reduce statewide greenhouse gas emissions to 40% below 2005 levels;
- b. Increase the number of registered, zero-emission vehicles ("ZEVs"; individually, "ZEV") to at least 80,000;
- c. Reduce energy consumption per square foot in state-owned buildings by at least 40% from fiscal year 2002-2003 levels.

2. Cabinet agencies shall evaluate the impacts of climate change on their programs and operations and integrate climate change mitigation and adaptation practices into their programs and operations. Council of State members, higher education institutions, local governments, private businesses, and other North Carolina entities are encouraged to address climate change and provide input on climate change mitigation and adaptation measures developed through the implementation of this Executive Order. Consistent with applicable law, cabinet agencies shall actively support such actions.
 3. The Secretary or designee of each cabinet agency and a representative from the Governor's Office shall serve on the North Carolina Climate Change Interagency Council ("Council"), which is hereby established. The Secretary of the North Carolina Department of Environmental Quality, or the Secretary's designee, shall serve as the Council Chair. The North Carolina Department of Environmental Quality shall lead the Council by providing strategic direction, scheduling, and planning Council meetings, determining the prioritization of activities, facilitating stakeholder engagement, and assisting in the implementation of pathways to achieve the goals provided in Section 1 of this Executive Order.
- The duties of the Council shall include the following:
- a. Recommend new and updated goals and actions to meaningfully address climate change;
 - b. Develop, implement, and evaluate programs and activities that support statewide climate mitigation and adaptation practices;
 - c. Establish workgroups, as appropriate, to assist the Council in its duties;
 - d. Consider stakeholder input when developing recommendations, programs, and other actions and activities;
 - e. Schedule, monitor, and provide input on the preparation and development of the plans and assessments required by this Executive Order;
 - f. Review and submit to the Governor the plans and assessments required by this Executive Order.
4. The North Carolina Department of Environmental Quality ("DEQ") shall develop a North Carolina Clean Energy Plan ("Clean Energy Plan") that fosters and encourages the utilization of clean energy resources, including energy efficiency, solar, wind, energy storage, and other innovative technologies in the public and private sectors, and the integration of those resources to facilitate the development of a modern and resilient electric grid. DEQ shall collaborate with businesses, industries, power providers, technology developers, North Carolina residents, local governments, and other interested stakeholders to increase the utilization of clean energy technologies, energy efficiency measures, and clean transportation solutions. DEQ shall complete the Clean Energy Plan for the Council to submit to the Governor by October 1, 2019.
 5. The North Carolina Department of Transportation ("DOT"), in coordination with DEQ, shall develop a North Carolina ZEV Plan ("ZEV Plan") designed to increase the number of registered ZEVs in the state to at least 80,000 by 2025. The ZEV Plan shall help establish interstate and intrastate ZEV corridors, coordinate and increase the installation of ZEV infrastructure, and incorporate, where appropriate, additional best practices for increasing ZEV adoption. DOT shall complete the ZEV Plan for the Council to submit to the Governor by October 1, 2019.
 6. The North Carolina Department of Commerce ("DOC") and other cabinet agencies shall take actions supporting the expansion of clean energy businesses and service providers, clean technology investment, and companies with a commitment to procuring renewable energy. In addition, DOC shall develop clean energy and clean transportation workforce assessments for the Council to submit to the Governor by October 1, 2019. These assessments shall evaluate the current and projected workforce demands in North Carolina's clean energy and clean transportation sectors, assess the skills and education required for employment in those sectors, and recommend actions to help North Carolinians develop such skills and education.
 7. Cabinet agencies shall prioritize ZEVs in the purchase or lease of new vehicles and shall use ZEVs for agency business travel when feasible. When ZEV use is not feasible, cabinet agencies shall prioritize cost-effective, low-emission alternatives. To support implementation of this directive, the North Carolina Department of Administration ("DOA") shall develop a North

Carolina Motor Fleet ZEV Plan ("Motor Fleet ZEV Plan") that identifies the types of trips for which a ZEV is feasible, recommends infrastructure necessary to support ZEV use, develops procurement options and strategies to increase the purchase and utilization of ZEVs, and addresses other key topics. DOA shall complete the Motor Fleet ZEV Plan and provide an accounting of each agency's ZEVs and miles driven by vehicle type for the Council to submit to the Governor by October 1, 2019, and annually thereafter.

8. Building on the energy, water, and utility use conservation measures taken pursuant to N.C. Gen. Stat. § 143-64.12(g), DEQ shall update and amend, where applicable, a Comprehensive Energy, Water, and Utility Use Conservation Program ("Comprehensive Program") by February 1, 2019, and biennially beginning December 1, 2019, to further reduce energy consumption per gross square foot in state buildings consistent with Section I of this Executive Order. The Comprehensive Program shall include best practices for state government building energy efficiency, training for agency staff, cost estimation methodologies, financing options, and reporting requirements for cabinet agencies. DEQ and cabinet agencies shall encourage and assist, as requested, higher education institutions, K-12 schools, and local governments in reducing energy consumption. To achieve the required energy consumption reductions:
 - a. By January 15, 2019, each cabinet agency shall designate an Agency Energy Manager, who shall serve as the agency point of contact.
 - b. Each cabinet agency shall develop and submit an Agency Utility Management Plan to DEQ by March 1, 2019, and biennially thereafter, and implement strategies to support the energy consumption reduction goal set forth in Section I of this Executive Order. DEQ shall assess the adequacy of these plans and their compliance with this Executive Order.
 - c. By September 1, 2019, and annually thereafter, each cabinet agency shall submit to DEQ an Agency Utility Report detailing its utility consumption, utility costs, and progress in reducing energy consumption.
 - d. DEQ shall develop an annual report that describes the Comprehensive Program and summarizes each cabinet agency's utility consumption, utility costs, and achieved reductions in energy consumption. DEQ shall complete this report for publication on its website and for the Council to submit to the Governor by February 1, 2019, and annually thereafter beginning December 1, 2019.
9. Cabinet agencies shall integrate climate adaptation and resiliency planning into their policies, programs, and operations (i) to support communities and sectors of the economy that are vulnerable to the effects of climate change and (ii) to enhance the agencies' ability to protect human life and health, property, natural and built infrastructure, cultural resources, and other public and private assets of value to North Carolinians.
 - a. DEQ, with the support of cabinet agencies and informed by stakeholder engagement, shall prepare a North Carolina Climate Risk Assessment and Resiliency Plan for the Council to submit to the Governor by March 1, 2020.
 - b. The Council shall support communities that are interested in assessing risks and vulnerabilities to natural and built infrastructure and in developing community-level adaptation and resiliency plans.
10. DEQ shall prepare and manage a publicly accessible Web-based portal detailing the Council's actions and the steps taken to address climate-related impacts in North Carolina. Cabinet agencies shall submit data, information, and status reports as specified by the Council to be published on the portal. In addition, DEQ shall develop, publish on the portal, and periodically update an inventory of the state's greenhouse gas emissions that, among other things, tracks emissions trends statewide by sector and identifies opportunities for additional emissions reductions.
11. By October 15, 2019, and annually thereafter, the Council shall provide to the Governor a status report on the implementation of this Executive Order.
12. This Executive Order is consistent with and does not otherwise abrogate existing state law.

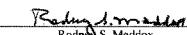
13. This Order is effective October 29, 2018 and shall remain in effect until rescinded or superseded by another applicable Executive Order.

IN WITNESS WHEREOF, I have hereunto signed my name and affixed the Great Seal of the State of North Carolina at the Capitol in the City of Raleigh, this the 29th day of October, in the year of our Lord two thousand eighteen.



Roy Cooper
Governor

ATTEST:



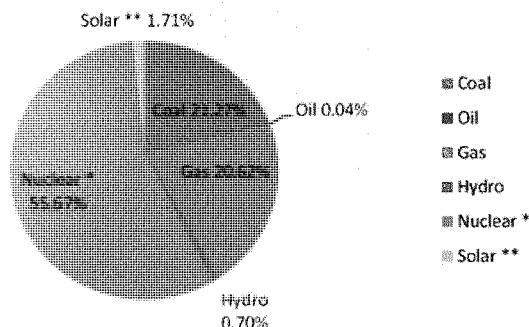
Rodney S. Maddox
Chief Deputy Secretary of State



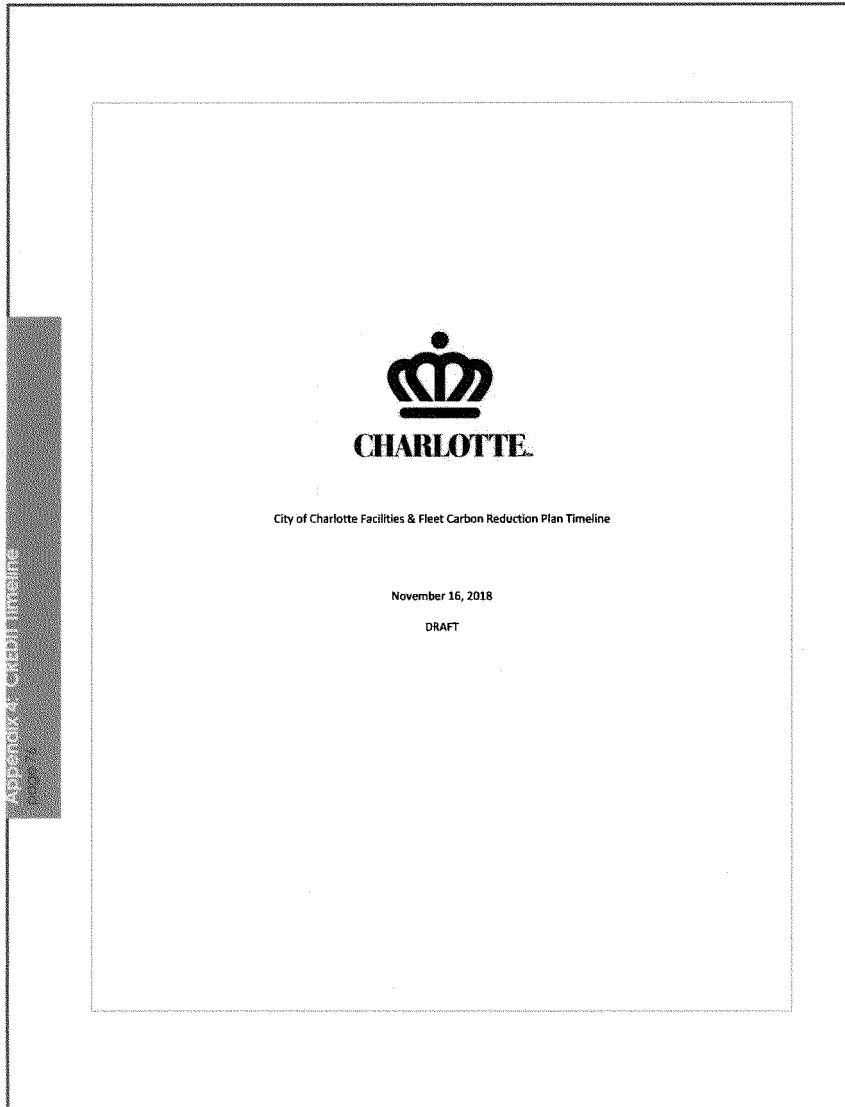
Energy and Carbon Fact Sheet

Renewable Energy	Clean Energy
<ul style="list-style-type: none"> Wind, solar PV, hydro, biomass, geothermal, bio-energy, and storage. Cost is usually associated with high capital requirements (funded from public subsidies) and higher lifecycle costs (due to lower performance). Growth in electricity generation is decoupled and focus has been mitigation, the fossil fuel transition seems to be somewhat stalled in the three horizons. 	<ul style="list-style-type: none"> Usually renewables and nuclear. Can be renewables with natural gas and 'clean coal'.
Zero Carbon/Fossil Free Energy	Low Carbon
<ul style="list-style-type: none"> Renewables and nuclear (if necessary). It refers to no GHG emissions other than those released when combusting/distributing/producing bioenergy. It does not mean nuclear will be in mix, but it does keep the door open. 	<ul style="list-style-type: none"> Spans all GHGs across all sectors: energy, waste, industrial processes, and agriculture. Does not mean that zero carbon dioxide is ruled out in any or all sectors. It recognizes that all emissions must be included.

Chart of Duke Energy Mix



It is important to note that these figures are constantly changing.



This summarized timeline and set of goals comes from the City of Charlotte's Facilities and Fleet Carbon Reduction Plan. To see the plan in its entirety, please visit charlottenc.gov. This plan specifically addresses the goals and strategies set by the internal CREDIT team to meet the third intent of the 'Sustainable and Resilient Charlotte by 2050' resolution regarding sourcing 100% of energy use in municipal facilities and fleet from zero carbon sources by 2030. Achievement of the 2030 goals will be dependent on many factors, including technological advancements, operational compatibility and risk management, and the availability of appropriate resources and funding. For some segments of City facilities and fleet, achieving the goals may not be possible because operational and other concerns will outweigh or not allow for carbon reduction benefits. However, the City is committed to and will look for all opportunities to achieve the goals.

Short Term Goals and Objectives

Short term goals are anticipated to occur within one to three years (2019-2022). They are organized into five categories based on their mode of impact as taken from the Community SEAP. The five categories are illustrated in 5 Stages to Zero Carbon Energy Diagram and are further described below:

Future Building Project Short Term Goals

Shift Energy Demand

- Evaluate lighting control technology at least three facilities which will adjust lighting based on scheduling and occupancy
- Investigate ice storage opportunities across City-owned facilities & Optimize Animal Control Facility Ice Storage System.

Reduce Energy Consumed

- Conduct an energy treasure hunt per Energy Star guidelines, calling upon employees to pinpoint prospects for energy-saving improvements
- Implement deep energy retrofits based on audit findings
- The city would like to partner with a local community college such as CPCC in training students and providing hands-on experience to perform energy audits and potentially weatherize fire station targeted based on benchmarking
- Change work practices and renovate facilities to reduce workspace needs in CMGC (ie. increase daylighting)

Change Energy Consumed

- Investigate electrification of heating needs for City-owned facilities; removal of gas sources heating systems.

Generate Energy OnSite

- The city proposes to achieve one zero-carbon facility within the short term range. Fire Station 43 is currently being designed to zero-carbon standards. This design would henceforth be replicated for additional stations.
- Investigate solar installation on all new facilities under design.

Purchase the Remainder

- Assess entering into power purchase agreement (PPA) with Duke to purchase solar or wind

Future Fleet Short Term Goals



Shift Energy Demand

- PV Battery Storage (facility requirement) on EV and on parking deck at CMGC

Reduce Energy Consumed

- Implement Staff Training and behavior change
 - Increase efficiency and Reduce Fossil Fuel Usage, Reduce Mileage (Modes of Op, Routing)
 - Increase confidence and usage in alternative fuels (EV Rodeo)
- Begin "right-sizing" fleet vehicles
 - Centralize fleet procurement, operations, and maintenance
 - Decentralize locations for staff motor pool
 - Pilot Internal Light duty driver / Uber/Lyft motor pool
 - Develop internal rental fleet pool for heavy equipment
- Shift from travel between facilities for meetings to teleconferencing/videoconferencing

Change Energy Consumed

- Expand EV charging stations to 10 city facilities, using solar where practical
- Increase number of alternate fuel vehicles (CNG, biogas, biodiesel)

Generate Energy OnSite

- Evaluate WWTP Biogas

Purchase the Remainder

No short-term goals identified at this time.

Mid-Term Goals and Objectives

Mid-term goals are anticipated to occur within four to seven years (2023-2026). They are organized into five categories based on their mode of impact as taken from the Community SEAP. The five categories are illustrated in 5 Stages to Zero Carbon Energy Diagram and are further described below:

Future Building Project Mid-Term Goals

Shift Energy Demand

- Implement lighting control technologies from previous 3 facility pilot across City-owned facilities.
- Reduce Energy Consumed
- Continue effort to close gaps for implementation of onsite PV at any sites with available space based on results of PV Assessment, or other emerging technologies

Reduce Energy Consumed

- Change work practices and renovate facilities to reduce workspace needs in CMGC (i.e. increase daylighting)
- Implement deep energy retrofits based on audit findings

Change Energy Consumed

- Install Solar Array at the Statesville Landfill property and/or other large city-owned properties

Generate Energy OnSite

- Investigate battery storage needs based on recommended installation of solar systems.
- Modify designs and implement construction standards to be net-zero ready for all City-owned buildings under construction (heavy emphasis on PV installations)

Purchase the Remainder

- Determine percentage of energy used to apply to power purchasing agreement based on 8 yrs.
- Of

Future Fleet Mid-Term Goals

Shift Energy Demand

- PV Battery Storage on EV and on parking deck city buildings (bi-directional charging, solar storage, battery storage, meter cycling)

Reduce Energy Consumed

- Expand use of an EV-based motor/van pool
- Implement heavy-duty/equipment pool
- Fleet maintenance centralization, management and consolidation

Change Energy Consumed

- Expand EV charging stations to 10 city facilities, using solar where practical
- Increase number of alternate fuel vehicles (CNG, biogas, biodiesel)

Generate Energy OnSite

- Implement WWTP Biogas

Purchase the Remainder

No mid-term goals identified at this time.

Long Term Goals and Objectives

Long term goals are anticipated to occur within eight to eleven years (2027-2030). They are organized into five categories based on their mode of impact as taken from the Community SEAP. The five categories are illustrated in 5 Stages to Zero Carbon Energy Diagram and are further described below:

Future Building Project Long Term Goals

Shift Energy Demand

- Implement battery storage and Innovative Technologies

Reduce Energy Consumed

- Change work practices and renovate facilities to reduce workspace needs in CMGC (ie. increase daylighting)
- Implement deep energy retrofits based on audit findings

Change Energy Consumed

Net Zero Buildings and Resilient City Services

Generate Energy OnSite

No long term goals identified at this time.

Purchase the Remainder

- Continue effort to close gaps for implementation of onsite PV at any sites with available space based on results of PV Assessment, or other emerging technologies

Future Fleet Long Term Goals

Shift Energy Demand

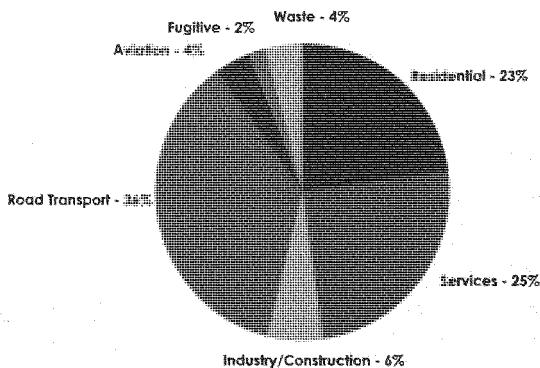
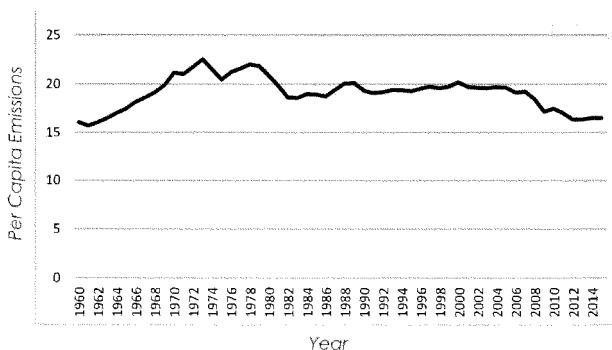
- Have infrastructure in place to have EV charging at night and allow public to use EV chargers during the day

Reduce Energy Consumed

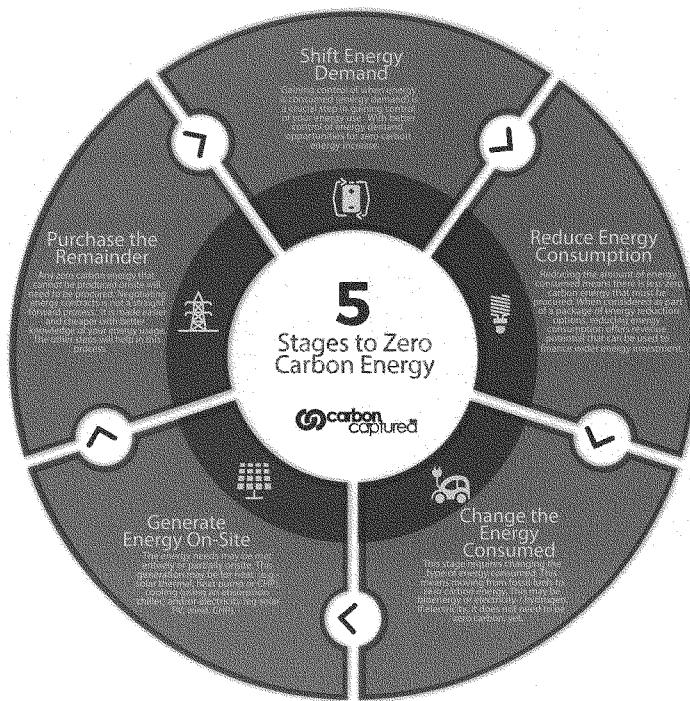
- 100% EV-based and/or zero carbon motor/van pool
 - Utilize private-based EV charging networks
- Change Energy Consumed**
- 100% renewable fuels (biogas, biodiesel)
- Generate Energy OnSite**
- Continuation of WWTP Biogas
 - PV at EV charging stations
- Purchase the Remainder**
- No long term goals identified at this time.

Content Expert Advisory Group (CEAG)

Name	Organization
Astrid Chirinos	YMCA
Chris Paynter	CPCC
DeAndrea Salvator	REII
Eric Lewis	Charlotte Works
Jeff Austin	Formerly with Wells Fargo
Megan Green	Mecklenburg County Air Quality
Rob Cox	UNC Charlotte
Sara O'Mara	Choate Construction Company
Zoe Gamble	Pine Gate Renewables

Appendix C: Literature and Figures*"Figure 1: 2015 Baseline Greenhouse Gas Emissions for Charlotte, North Carolina" on page 13**"Figure 2: USA Emissions of CO₂ Per Capita 1960-2015" on page 14*

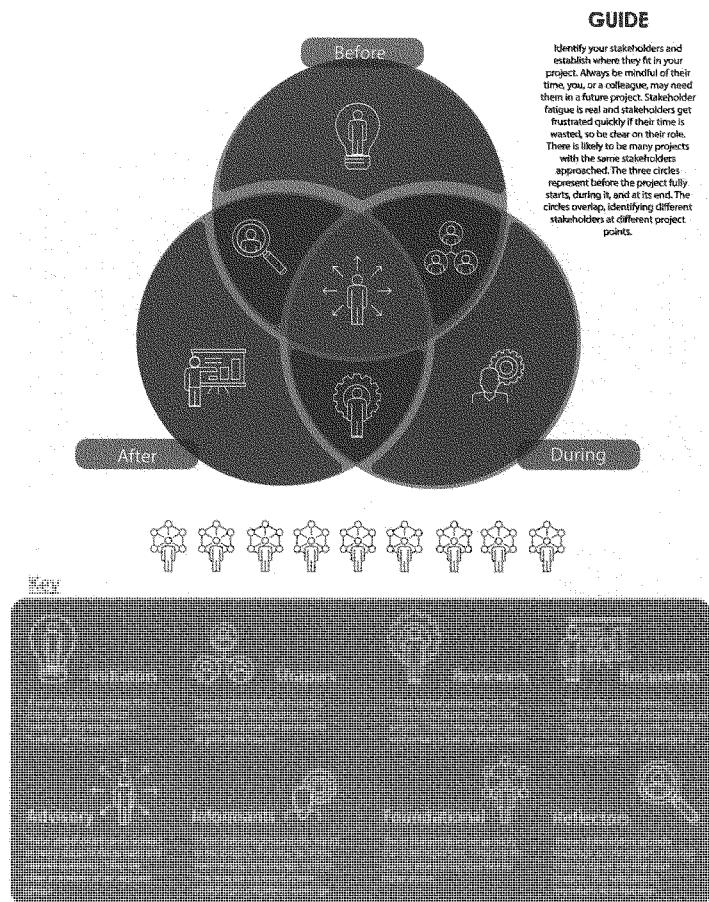
"Figure 3: 5 Stages to Zero Carbon Energy Diagram" on page 19



"Figure 4: Potential Annual Benefits from Charlotte's Urban Forest" on page 20

	Charlotte City	Area	Total
Charlotte Spruce/Balsam Firwoodland Losses	31,200	Acres	31,200
POCF Projected Increases in Property Values	3	\$,000,000	
Area's Current Municipal POCF Resources	3,357,000	Acres	3,357,000
Area's Average Spruce/Balsam Firwoodland	581,000	Acres	581,000
Area's Current Total POCF	4,938,000	Acres	4,938,000
Area's Current POCF Remaining	445,000	Acres	445,000
Estimated Spruce/Balsam Firwoodland Losses	4,443,000	Acres	4,443,000
Estimated Spruce/Balsam Firwoodland Remaining	0	Acres	0
POCF: Spruce/Balsam Firwoodland	1,300	Acres	1,300
POCF: Total Remaining	4,443,000	Acres	4,443,000
Estimated Total Annual Benefits			4,443,000

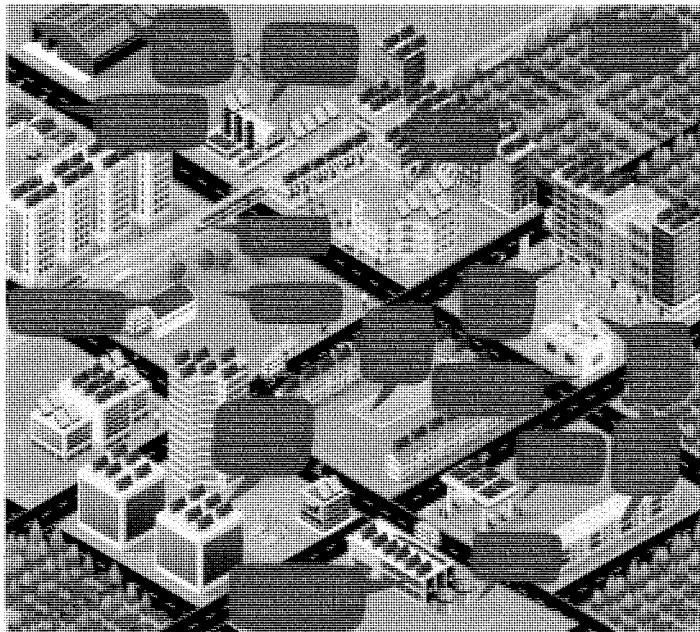
"Figure 5: Charlotte Stakeholder Engagement tool, adapted from Carney et al." on page 33



Adapted from Carney et al

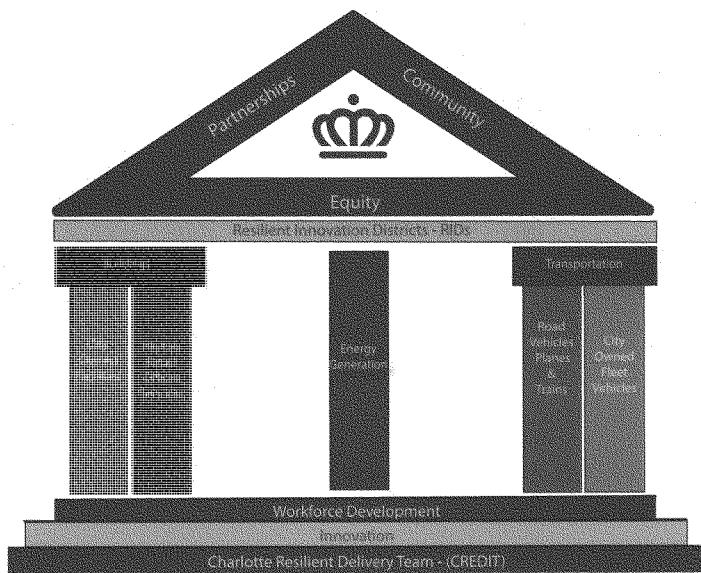
carbon
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"Figure 6: An example of what a Resilient Innovation District can consist of," on page 46



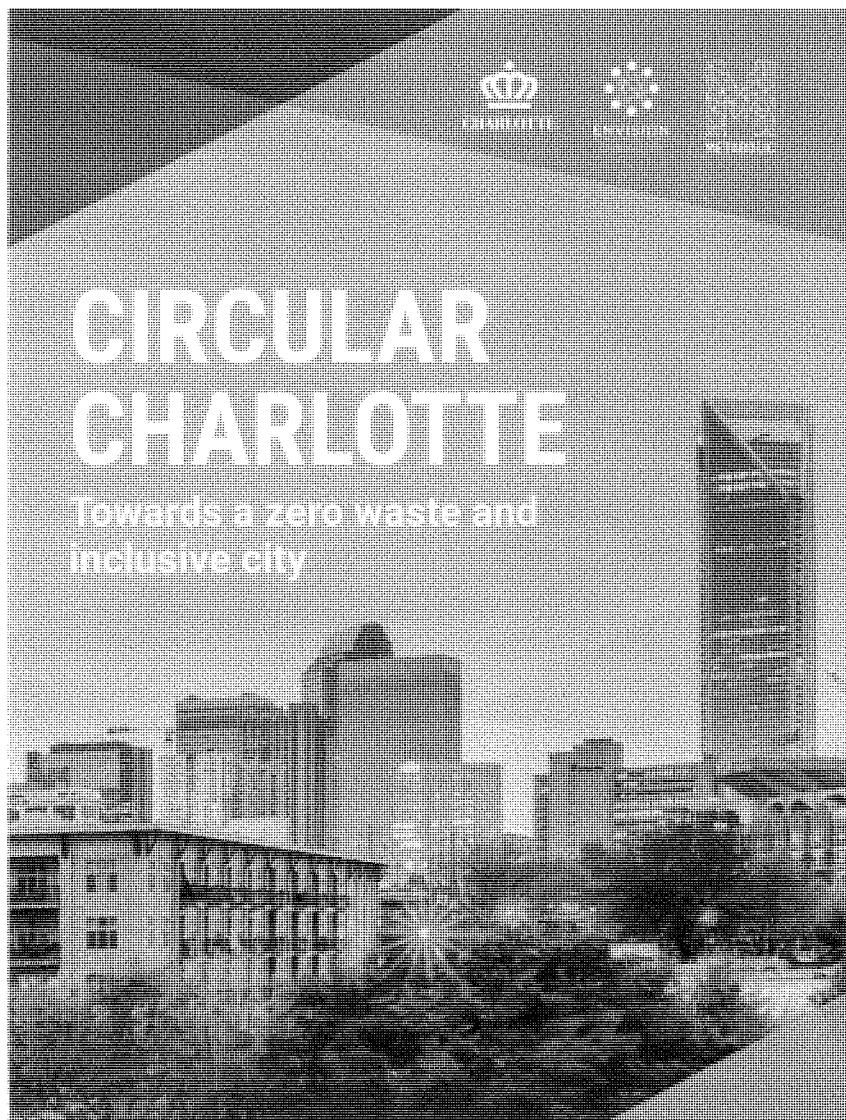
Partnerships
Community
Equity
Resilient Innovation Districts - RIDx
Workforce Development
Innovation
Charlotte Resilient Delivery Team - (CREDIT)

"Figure 7: A graphic representation of the Charlotte SEAP Delivery Structure" on page 63



Ms. LYLES. We want to thank Mayor Bloomberg and Bloomberg Philanthropies who named Charlotte as the winner of the American City's Challenge because that has allowed us to launch a bold and innovation vision called *Circular Charlotte* to become a zero waste city, and to turn \$100 million worth of annual waste, to reclaim it so that we can have a great economy and create additional jobs.

[The information follows:]



EXECUTIVE SUMMARY

Charlotte is the first city in the United States to make a commitment to adopting the circular economy as a public sector strategy. In its circular future, all of the material resources that now end up in landfills will be the basis for Charlotte's next industrial revolution: the foundation for an era of green manufacturing that unlocks new technological advances, increases local resilience, and supports workforce development.

Our report, "Circular Charlotte: towards a zero waste and inclusive city," explores how Charlotte can start implementing a strategy to become the first circular city in the United States. We investigate how many valuable resources are currently lost through Charlotte's waste system, and how these could be diverted into new, high-value uses. We present a vision, co-created with stakeholders from the city, for how a Circular Charlotte could look and function. Finally, we describe a roadmap of actions that should be taken on the pathway towards this vision, and detail five initial business cases that can serve as a starting point for action.

Growth brings transition opportunities

Charlotte is in the midst of a building boom. This expansion of the city points to Charlotte's increasing popularity as a place to live and work: it is now ranked as one of the fastest-growing metropolitan regions in the United States (Thomas, 2018) and was recently named the number one city for attracting millennials (Abadi, 2017). Beyond changing physically, Charlotte is undergoing a broader transformation in its character, evolving from a banking-focused city with a history of manufacturing and logistics, to a dynamic urban center with unique specialties in high-tech industry. This growth is not only an opportunity to cash in on Charlotte's successes, but also to address challenges, such as economic mobility, on which Charlotte is currently ranked lowest out of America's 50 largest metro areas (Chetty, 2017).

The circular economy – a new economic system that is regenerative and waste-free by design – can not only eliminate negative environmental impacts and create new sources of value, but also be used to bridge the wealth divide and create new pathways for upward mobility in Charlotte. Within a circular economy, products and materials are circulated at high value for as long as possible, extending the life of products and enabling high-value component and material recovery for reuse or recycling. The systemic transformation required for a circular economy – from the development of new technologies, to the evolution of new forms of collaboration and business models – has also been shown to have great potential in generating new employment and creating opportunities for skills development.

THE CIRCULAR ECONOMY

The vast majority of our economic system can currently be defined as linear. We extract resources, which are then transformed to products via the use of labor, energy, and money, and then, soon after their use, these products are thrown away. Every time a product that we have crafted and manufactured with care ends up in landfill, not only do we lose the physical resources it is made up of, but also all of the time and energy that went into its creation. McKinsey estimated that up to 630 billion dollars a year is lost in Europe alone through the loss of materials in the linear economy (EMF & McKinsey, 2011).

In parallel, these material losses translate to unrealized employment potential. The U.S. EPA and the Institute for Local Self Reliance estimate that low-value activities that result in material losses (like incineration and landfilling), only generate 1–6 jobs per 10,000 tons of goods disposed of. Recycling generates an estimated 36 jobs for the same amount of material, while reuse and refurbishment are by far the biggest winners, creating almost 300 jobs for each 10,000 tons of "waste."

To move towards a circular economy, where the value-generating life-cycles of products are extended to the maximum extent possible, we should:

- Design all products for easy repair, disassembly, and full recyclability.
- Create the necessary business structures and incentives to get these materials back into the economy at their highest possible value (preferably as whole products or components).
- Strive to use only responsibly-sourced renewable resources for both energy and material provision.
- Avoid the use of toxic substances that may continue to circulate in our environment.

Successfully achieving this transition is not simply about product reuse and recycling; it means a systems change that requires a new mindset. Preserving the complexity and value of our products should be structurally incentivized, and negative impacts on people and the environment should be eliminated by design. This transition can be supported through alternative business models and purchasing patterns that will support the recovery of materials, such as leasing models and advanced approaches to extended producer responsibility (systems that make manufacturers responsible for what they create and sell, even after the products are sold). Perhaps most importantly, achieving this transition will require a shared vision and strong leadership from both government and civil society.

VISION OF A CIRCULAR CHARLOTTE

If we take these high level ideas about the circular economy and actually apply them to Charlotte, what kind of changes would potentially take place? Here we envision, from a 2050 perspective, how Charlotte might look if it achieves the full spectrum of a circular economy. We have organized the vision around four thematic areas. For each of these four areas of performance, we have also developed Key Performance Indicators (KPIs) to monitor Charlotte's progress (see page 30).



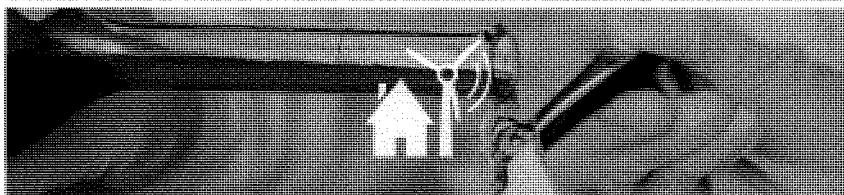
In 2050, Charlotte might proudly call itself a Zero Waste City, where 98% of all residual materials are separately collected. Every household could be equipped with smart sorting containers with built-in technologies to tell users if they've sorted something incorrectly. Residents would get reward points paid directly into their digital wallets for every pound of correctly sorted waste. They could use their earnings for the purchase of local goods branded with the Circular Charlotte label, many of which might have been remanufactured or grown from those same residual streams. If they have reward points left over, they could also use them to pay for their fully-renewable energy bill, or even pay their taxes. A real-time resource monitoring platform, the Charlotte Circularity Dashboard, would continuously reports how much is available of different kinds of residual goods – from citrus peels to old shoes. These resources would be automatically diverted to various processing facilities throughout the city, run by large companies and small entrepreneurs alike. The Dashboard would keep a record of orders placed requesting different materials, and ships off materials to the earliest bidders. Due to Charlotte's strong position as a logistics hub, the city would also accept and process materials from nearby counties, adding to the base of resources used for local manufacturing.



As other circular industries develop, Charlotte and its surrounding region could become increasingly independent of foreign imports, with almost all materials sourced from local cycles. Even local food production has the potential to grow immensely, with the advancement of vertical farming technology and the reuse of organic waste streams as fertilizer. Most of Charlotte's schools would also have their own small-scale aquaponics facilities, which would be used both for hands-on science education as well as to provide farm-fresh produce and fish to the schools' cafeterias. Further efforts to increase the city's health and resilience could focus on the decentralization of certain utility services. Renewable energy, decentralized battery storage, and smart distribution of energy through the city's smart grid could make Charlotte's energy system resistant to the impact of storms or floods, with most damage remaining localized.

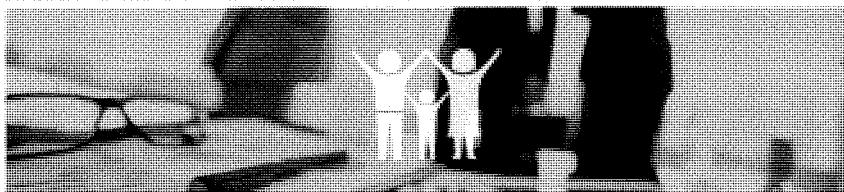
Though some of these ideas may seem farther off in the future than others, every plan starts with imagining the reality we aim to achieve. The picture we describe here will certainly not be a perfect reflection of what actually transpires, but it can provide a starting narrative and inspiration for the next decades of Charlotte's development.

CHARLOTTE AS AN INNOVATIVE CITY OF THE FUTURE



With Charlotte's innovations in waste collection and sorting, which would result in the supply of previously-unavailable high-quality and pure resource streams, a whole new cluster of industries could begin to develop throughout the city. New product development would explode in the early 2020s. At first, the major focus of R&D activities would be on processing textiles, plastics, and construction wastes. In 2023, CharM, the city's newly-opened materials lab, a joint project of several of Charlotte's incubators and accelerators, would begin experimenting on how to convert collected organic wastes into new materials – like clothing, furnishings, and biodegradable packaging. The strong need for materials and product innovation because of the city's ambitious circularity goals would also lead University of North Carolina Charlotte to establish a new educational facility, the Charlotte Institute of Circular Design and Engineering (CICDE). The Circular Charlotte brand would help the city consolidate its leading position globally, and cement Charlotte's top position in global rankings such as the Sustainable Cities Index.

CHARLOTTE AS A CITY WITH OPPORTUNITIES FOR ALL

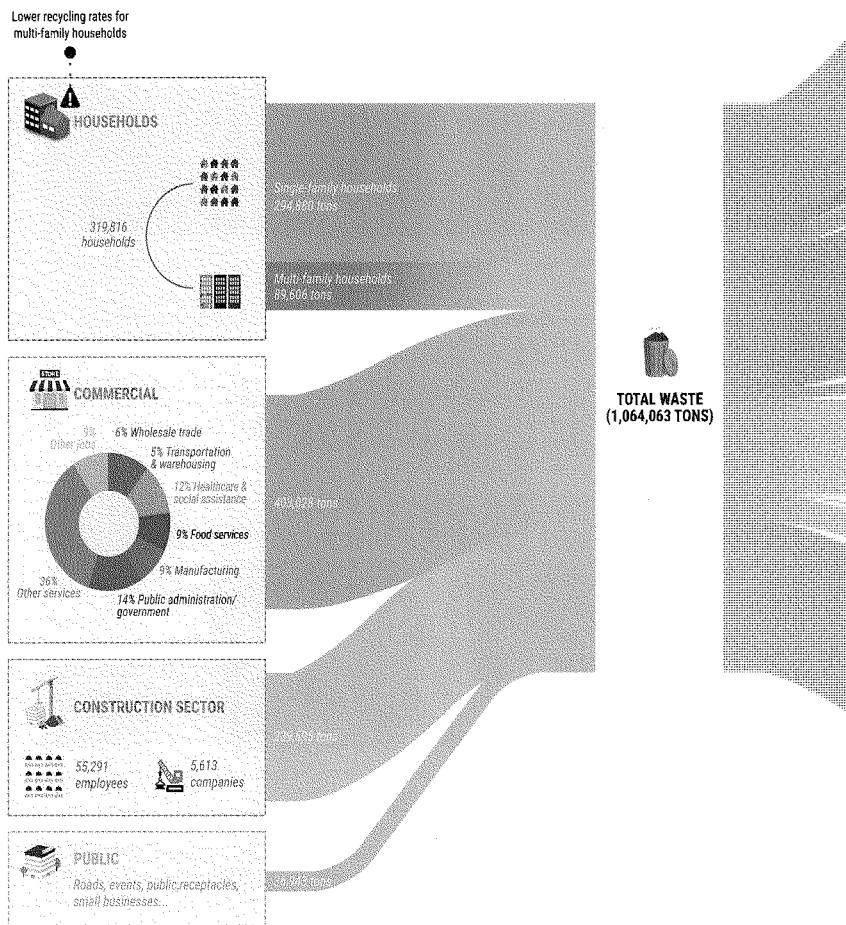


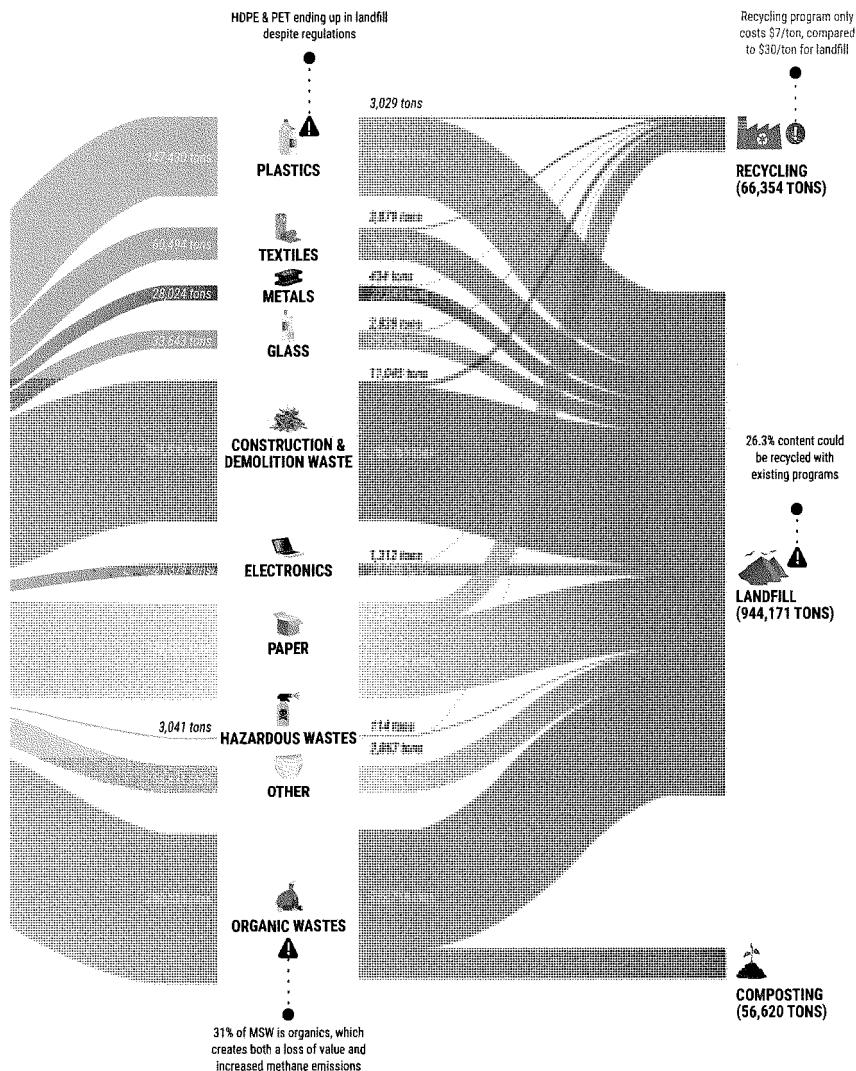
By 2050, Charlotte could have less than 0.5% of its population living in poverty. Initial efforts on establishing circular industry and innovation would be largely focused on skill development, training, and inclusive programs designed to uplift those who are economically disadvantaged. In 2019, the city's solid waste department could establish a test rehabilitation program for the homeless community, providing employment in plastic waste sorting and remanufacturing. Plastic wastes, which are of too low a quality for automated processing at that time, would be sorted, washed, and shredded for the production of small batches of local products like street furniture, waste bins, and trophies for school sporting events. Some of the trainees involved in the pilot program could go on to start their own companies focused on recycling and product manufacturing.

HOW CIRCULAR IS CHARLOTTE TODAY?

This graphic shows the types of wastes generated in Charlotte and where they ultimately end up. Only 11.5% of the materials that currently enter Charlotte's waste system each year are recycled or composted. In order to make Charlotte circular, the city will need to make it convenient and affordable for households and

businesses to recycle and develop products and markets that can accept recycled materials. For example, 16% of the waste that ends up in landfill is food waste, partly because there are no free organic waste recycling programs that provide an alternative to landfill.





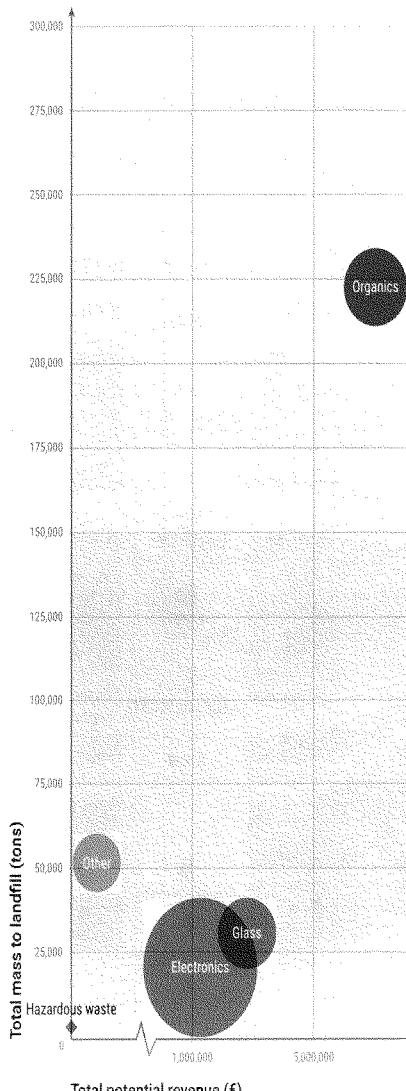
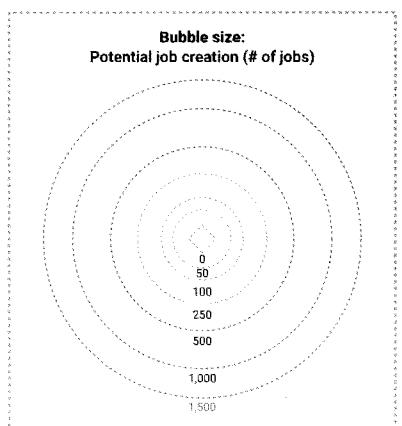
UNCOVERING THE POTENTIAL OF CIRCULARITY

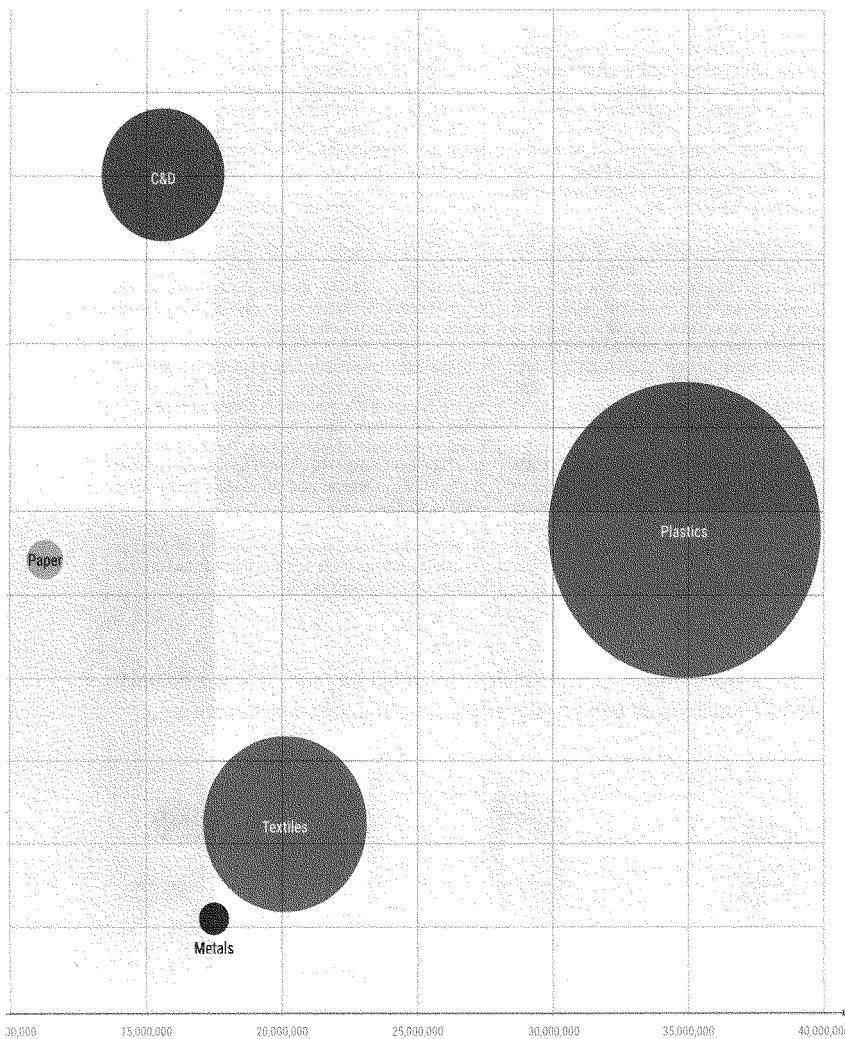
This figure shows the potential mass (y-axis), revenue potential (x-axis), and job creation potential (bubble size) for each of the material categories currently ending up in Charlotte's landfills.

From the graphic, we can see that there is a significant amount of value going literally to waste. In total, we calculate a residual market value of \$111 million in material value and a job creation potential of more than 2,000 new jobs that would be created if these materials were recycled.

It is important to note that here we've only considered the residual scrap value of the materials when they are sold for recycling. When circular business strategies are applied (such as refurbishment, repair, or remanufacturing), more value can be retained than what materials are worth on the scrap market. Design for modularity and disassembly can further increase the value that can be recovered from waste materials, though this also requires participation from parties upstream in the value chain.

This analysis shows the value of all the materials once they have been collected, excluding processing and collection costs. The business cases we developed in Chapter 5 of this report show both the costs and revenues of selected material streams when they are processed in a circular manner.





CIRCULAR OPPORTUNITIES

If done right, a circular economy in Charlotte will create opportunities for local employment, reduce the socio-economic divide in the city, and establish new industries that lead to greater local resilience and economic vitality. Ideally no waste will be going to landfill and all materials flowing through the city will be used as the basis for new circular manufacturing. By definition, training in new skills (such as product repair, remanufacturing, or circular demolition techniques) is required for the transition, creating job potential. In addition to the socioeconomic opportunities that this pathway unlocks, there are a number of other benefits.

Landfilling materials is associated with both financial costs and environmental impacts. Charlotte has recently adopted a low carbon strategy, through which it will strive for a net annual CO₂e emission of less than two tons per person. Reducing the total waste-to-landfill is one way of reducing emissions. Conventional landfilling of municipal solid wastes contributes between 138-601 lbs CO₂e per ton (Manfredi et al., 2009). In total, between 0.08 - 0.34 tons of direct CO₂e emissions per person can be reduced by shifting to a completely zero-waste system.

An additional issue is that sending waste to landfill increases the demand for virgin resources, and can exacerbate impacts upstream associated with material extraction. Recycling materials such as plastic and paper can prevent the need for new production of these materials, while even waste incineration can reduce the need for fossil fuels such as natural gas or

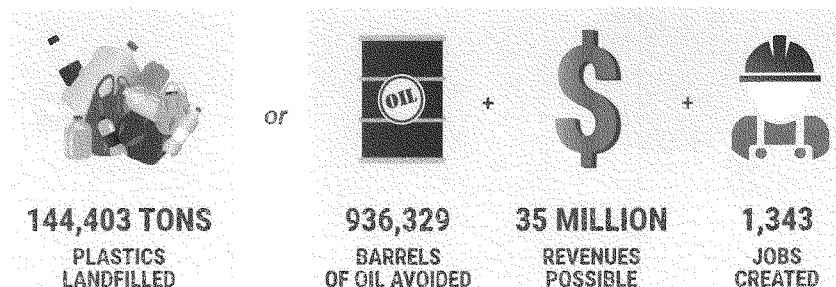
coal in electricity production. As an example, you can consider wood and paper production, which has a large land footprint. To produce the wood and paper that is currently landfilled in Charlotte, you would need an area of nearly 17 square miles. To put this in perspective, you can consider that this is around 5.6% the area of Charlotte or more than 100 times the area of Charlotte's Freedom Park. A large share of this land area could be left unexploited if paper and wood were recycled instead of sent to landfill.

Finally, activities of other stakeholders outside of the scope of Charlotte can have a large impact on how the waste system of Charlotte functions and the opportunities that can be achieved with circularity. One example is China's decision to limit the import of recyclables to those of a high quality, due to environmental and health reasons.

Chinese policy on materials accepted and the quality of recyclates will have a large impact on global markets for recyclables and is expected to have a large negative impact on United States recycling businesses and threaten thousands of jobs (Rosengren, 2017). In some cities in the United States, this ban has already resulted in the refusal of certain types of plastics for recycling (van Fleet, 2017).

By adopting a circular economy strategy, Charlotte can insulate itself from these kinds of impacts and provide local solutions for neighboring counties.

*If all plastics landfilled in Charlotte were recycled instead, this would save
936,329 barrels of oil per year while creating jobs and revenue*



BUSINESS CASES FOR A CIRCULAR CHARLOTTE

Through our analysis, we have shown that the combined residual value of the waste streams currently ending up in Charlotte's landfills amounts to \$111 million per year. The top four opportunities of plastic, textiles, construction and demolition waste (C&D), and organics when taken together can reduce landfill mass by nearly 65%, create just under 2,000 jobs, and generate nearly \$80 million in revenue.

These amounts do not take into account the cost of collection or processing, nor do they take into account the real added value that can be generated if these materials are not sold as scrap, but instead turned into higher-value products.

To delve deeper into the real costs and potential value generated through resource processing and recovery, we explore five business cases for circular business models that fit the regional context, matched with local interest from stakeholders, or addressed some of the most impactful or problematic waste flows.

These five cases include:

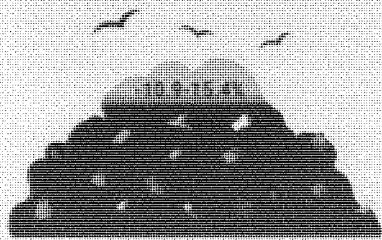
1. Developing a local supply chain manager to organize a closed-loop textiles chain for linens and uniforms used in hotels, hospitals, etc.
2. Scaling up food waste collection and establishing a commercial-scale facility to recycle food waste into larvae for livestock feed.

3. Setting up a Materials Innovation Lab for student entrepreneurs to develop innovations for upcycling specific waste fractions into new products.
4. Setting up a incentivized reverse logistics system to provide households with an incentive to recycle materials at a high quality.
5. Establishing a circular concrete chain in Charlotte and producing new concrete from recycled concrete and post-consumer glass.

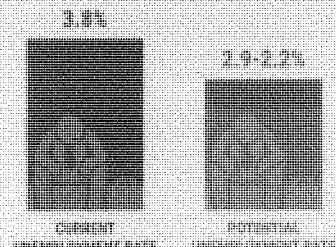
While these business cases cover a relatively small share of the wastes that are going to landfill (around 11-15%), they can result in significant benefits in terms of job creation, CO₂e emissions reduction, and most importantly in terms of building local capacity for circular economy innovation. Out of a set of 29 Key Performance Indicators (KPIs) we propose to measure circularity in the city, each business case can improve between 13-19 indicators.

Taken together, we estimate that these business cases can generate between \$22 and \$34 million in revenue (making more money as they grow over time), and \$6.4 million in profit per year once they are established. Since this is based on only 11-15% of the mass of material going to landfill, it can be seen as in line with (or exceeding) the rough estimates of material value from our revenue assessment.

Together, the business cases can divert 103,000-145,000 tons from the landfill, reducing the total mass by 10.9-15.4%.



The business cases can collectively create 290-492 jobs, reducing the number of unemployed by 24-41%.



DEVELOPING A STRATEGY FOR CHARLOTTE

BARRIERS

The magnitude of the transformation that has to happen in Charlotte to achieve the circularity goals outlined in the strategy will require a coordinated set of actions over a number of years, supported by strong leadership from local government, the private sector, and civil society. There are still some significant barriers to tackle along the way (see page 54).

In conversations with stakeholders, we identified a range of barriers - both real and perceived - that need to be addressed through the city's circular economy strategy.

One key barrier is that there are still some gaps in the physical and technological infrastructure that we need for a transition to a circular economy. For instance, Charlotte currently has no means for recycling styrofoam, plastic dinnerware and cutlery, aluminum or plastic foils and wraps, diapers, ceramics, or any glass that is not used in packaging (glassware, plate glass).

Perhaps more importantly, the majority of products on the market are not designed for high-value reuse and recycling. They are often made of mixed materials, have unknown additives, are assembled with glues making them difficult to take apart, or use problematic dyes and colorants that can contaminate whole recycling streams.

On the social and cultural side, one of the most fundamental challenges that all societal transitions face lies in changing the behavior and mindset of people: their willingness to participate in recycling programs and in the development of new, circular business. The transition to a circular economy will require a great deal of new skills and knowledge: a whole new workforce of people trained to remanufacture products and reuse materials in different ways.

The financial part of change management can sometimes be challenging. Currently, most recyclables have low value - in many cases, because of high levels of contamination among the collected resource streams. A bale of pure PET bottles has much higher value than a bale of mixed plastic, for instance. It is essential to work actively with the market to develop solid business cases for circular resource management.

There are, finally, a number of political and legal barriers. One of these is the solid waste interlocal agreement between Charlotte and Mecklenburg County, which currently dictates how all of Charlotte's waste is handled after collection. On the day-to-day level, existing rules and regulations can hamper how certain waste streams are used and where certain activities (for example, food production) can take place.

ACTIONS

Charlotte's transformation to a circular city clearly cannot take place overnight. Near term actions should focus on building awareness among the city's citizens, business owners, and other key stakeholders on what the circular economy is and the different opportunities it can provide as well as laying the groundwork for tackling some of the barriers we identified.

In addition, it is essential to identify tangible actions, showcases, and circular business cases that can be executed quickly in order to build support for the approach and demonstrate its value. Further steps should include capacity building and efforts geared at longer-term transformation, such as neighborhood action plans, the establishment of new partnerships and institutions, and monitoring programs to track the city's progress on circular economy metrics (i.e., the KPIs presented in Chapter 2). A short, mid, and long-term set of activities that Charlotte should undertake are presented in the roadmap in Chapter 4. We have divided near-term actions that the city should take into several categories:

- Establishing public sector commitment and developing a circular economy strategy
- Launching a communications strategy and developing the Innovation Barn as the city's local circular economy showcase and innovation center
- Building Circular Charlotte's international profile
- Creating circular economy programs for the city and securing long-term staffing and financing
- Building circular infrastructure and resources
- Establishing the basis for data collection and performance monitoring

NEXT STEPS

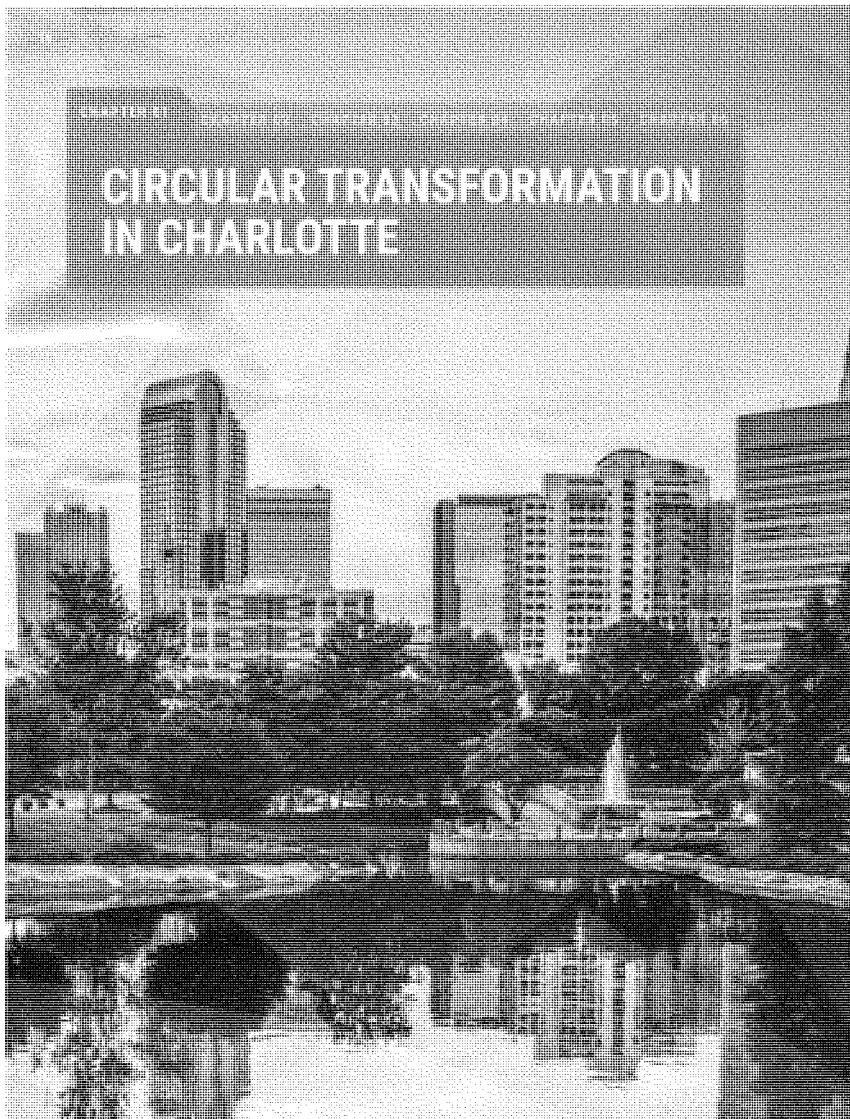
In addition to actions that the city should take in the near term, we have summarized some of the steps that other groups of stakeholders (such as funders, commercial and industrial sectors, NGOs, and knowledge institutes) can take in a coordinated effort towards achieving a circular economy (see Chapter 6).

The initial groundwork for the circular transition, however, should be laid by the government. The city has already demonstrated its public sector commitment to a circular economy. Now this must be communicated to the local community and made tangible. The Innovation Barn can become one of the first meeting places and centers for activity and learning on this topic, kicking off the start of this shared journey.

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CIRCULAR TRANSFORMATION IN CHARLOTTE

INTRODUCTION

Nearly every turn you take as you walk through Charlotte's Uptown greets you with a new construction project of impressive scale. The city is in the middle of a building boom, adding everything from apartments to office buildings and hotels. While Uptown is sprouting expansions to its sleek skyline, neighborhoods like NoDa, a historic district once at the center of the city's textile manufacturing industry, are bursting with the addition of new microbreweries, restaurants, and arts venues.

This expansion of the city points to Charlotte's increasing popularity as a place to live and work. Charlotte is now ranked as one of the fastest growing metropolitan regions in the United States (7th out of 53), having increased in population by 13.9% between 2010 and 2017 (Thomas, 2018). Importantly, Charlotte was recently named the number one city for attracting millennials, demonstrating its position as a place of opportunity for launching a career and building a family (Abadi, 2017).

Beyond changing physically, Charlotte is undergoing a broader transformation in its character, evolving from a banking-focused city with a history of manufacturing and logistics, to a dynamic urban center with unique specialties in the high-tech industry. Though it is currently ranked as a "gamma-minus" city – the lowest tier on the Global Economic Power Index (GEPI, 2015) – these transformations position Charlotte to become more of a force in the international scene over the coming years.

With every new building and enterprise taking root in Charlotte, the city has a chance to reimagine its future and shape the values and principles that will define the next phase of its history. This growth is not only an opportunity to cash in on Charlotte's successes, but also to address challenges – those specific to Charlotte, and those we face as humanity at large. Investment brings with it the opportunity for creativity and innovation – as well as the development of new solutions that can become the basis for Charlotte's next wave of prosperity.

Building an inclusive, zero-waste economy

One of the largest challenges that Charlotte faces was highlighted in a now widely-cited study, published by the Equality of Opportunity Project, which examined economic mobility in America's 50 largest cities. With only 4% of people born into poor families in Charlotte successfully making it out of poverty in their lifetimes, Charlotte's performance was ranked last out of the cities evaluated (Chetty, 2017). Though the problem of low economic mobility is clearly severe in Charlotte, it is a challenge that many cities and countries around the world face.

The city's current phase of growth must therefore not only improve overall wealth: it must provide pathways for decreasing income inequality and increasing access to opportunity for all.

Devising structural solutions to these problems will not only benefit Charlotte, but potentially serve as an example to other parts of the world facing similar struggles.

This period of development also gives Charlotte space to take action on another key opportunity and moral imperative: the transition from a linear to a circular economy. The vast majority of our economic system can currently be defined as linear. We extract resources, use great amounts of labor, energy, and money to transform these into products, and then, soon after their use, these products get thrown away. Every time a product that we have crafted and manufactured with care ends up in a landfill, we lose its "embodied value." McKinsey estimated that up to 630 billion dollars a year are lost in Europe through the loss of materials in the linear economy (EMF & McKinsey, 2011).

This linear system is not only generating an enormous amount of waste and loss of value: it is also putting our way of life at risk. Certain critical resources, like the metals used in electronics, are becoming scarcer. The ecosystems that we rely on for essential environmental services (like the production of clean air and water), as well as the supply of goods (from food to building materials), are overexploited and at the point of collapse. As our economy continues to grow, our demand for these already overexploited materials continues to increase, exacerbating these issues. We need to transition to a smarter model of resource management, where instead of getting lost, these valuable materials are kept in perpetual circulation, reducing the need for increasingly scarce or hard-to-extract virgin materials.

Our dominant economic model, though it has historically brought much prosperity, has now reached a point of diminishing returns.

Though it continues to generate value and prosperity, it does so at the expense of an increasing socio-economic divide and contributes to the destruction of natural capital that is essential for its own continuation. The circular economy – a new economic system that is regenerative and waste-free by design – can not only eliminate negative impacts and create new sources of value, but can also be used to bridge the wealth divide and create new pathways for upward mobility in Charlotte.

Within a circular economy, products and materials are circulated at high value for as long as possible, extending the life of products and enabling high-value component and material recovery for reuse or recycling. The systemic transformations involved in a circular economy – from the development of new technologies, to the evolution of new forms of collaboration and new business models – have also been shown to have great potential in generating new employment and skill development opportunities.

Circular Charlotte

Charlotte is the first city in the United States to make a commitment to adopting the circular economy as a public sector strategy. In its circular future, all of the material resources that now end up in landfills will be the basis for Charlotte's next industrial revolution: the foundation for an era of green manufacturing that unlocks new technological advances and increases local resilience and productivity.

This study, commissioned by the city of Charlotte and Envision Charlotte, helps lay the groundwork for the city's transition to circularity. In it, we describe the results of a baseline analysis of Charlotte's current circular economy performance, including the total value of resources wasted in the city. Together with inputs from stakeholders throughout the city, we have drafted a vision statement for what a circular Charlotte could look like, and created a set of metrics – Key Performance Indicators – that can be used to track the city's progress. Lastly, we present an initial roadmap and a selection of high-impact business cases that can already be implemented within the city in order to move towards a circular economy.

The results presented here are just the first step in a long journey. Though the first step is often the hardest, it is also the most important: it signals a commitment to move towards a greener, healthier, and more equitable future for Charlotte and its people.

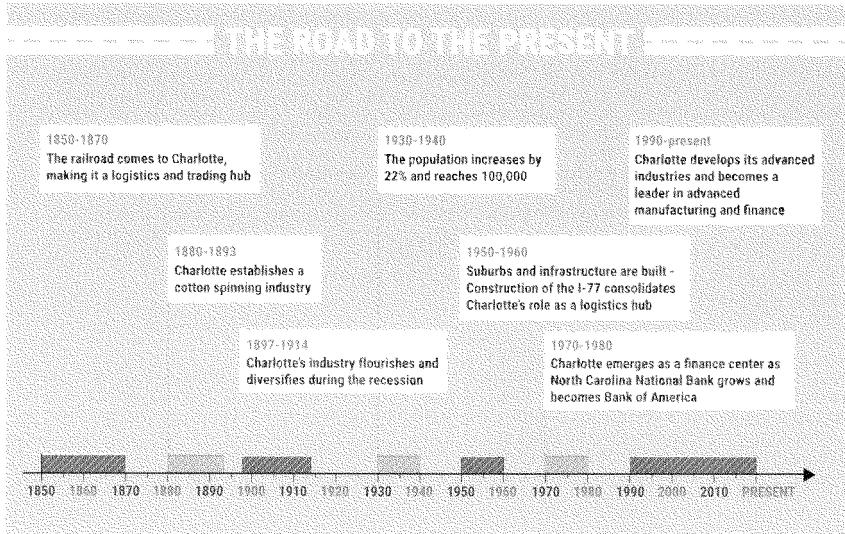


Figure 1. The Road to the Present

THE CITY OF CHARLOTTE

The city of Charlotte, known as the Queen City after its eponymous German princess, Charlotte of Mecklenburg-Strelitz, was incorporated in 1768 and settled by an initial wave of Irish migrants. Though the basic grid network of Charlotte's Uptown was already laid out by surveyors in 1770 in anticipation of further development, at that point the town only consisted of a handful of log houses.

In 1799, gold was struck in nearby Cabarrus County, setting off the first American gold rush and making North Carolina the leading state for gold production until the opening of mines in the western states. As more veins of the precious metal were discovered, the Charlotte Mint was founded to locally melt and coin the gold. Despite these developments, Charlotte remained a relatively small town, and only experienced its first significant growth phase after the Civil War, when a combination of factors led to Charlotte's emergence as one of the South's primary centers of activity.

Financed by prominent Charlotte-area businessmen, the Charlotte and South Carolina Railroad began operating in 1852. This line played a critical role in the emergence of Charlotte's textile boom in the late 19th and early 20th century, when the city became a watershed for cotton produced in North Carolina and neighboring states. Cotton mills sprung up throughout the city and workers flooded in to process the material into new high quality products such as textiles, clothing, and furniture. To support this new boom in commerce, logistical connectivity continued to improve, making Charlotte into one of the most well-connected hubs in the country. In 1910, Charlotte surpassed Wilmington to become the largest city in North Carolina, reaching a population of 34,000.

Pioneering character

Charlotte's prosperity has historically been driven by a spirit of risk-taking and innovation, informed by the acuity of its people in paying attention to the technological trends of the time. While other neighboring towns rejected the idea of having a railroad because it would be too noisy and polluting, Charlotte embraced this leap into the future. The drive to stay on top of the latest trends began with Charlotte's railroad and first cotton mills and continues into today's aerospace and electronics manufacturing industry.

While other cities have struggled, and buckled, under the pressure to outsource their local industries, Charlotte has maintained and diversified its existing capacity and infrastructure. Today, manufacturing represents about 30% of the regional economy and employs 144,000 of Charlotte's citizens (Charlotte Chamber, 2015). With the presence of some of the world's biggest furniture and textile companies, traditional manufacturing is still going strong in Charlotte, but the city has continued to diversify and enhance its capabilities in areas such as energy technology, aerospace technology, precision metrology, and specialty chemicals and plastics.

CHARLOTTE: A GREAT PLACE TO BE

- **Attractive to businesses:** 7th on Forbes list of Places for Business and Career (Forbes, 2018)
- **Job opportunities:** Unemployment below state average at 3.4% (Bureau of Labor Statistics, 2018)
- **Wealthy:** \$53,000 GMP (global metropolitan product) per capita - 61st wealthiest metro (Parilla, 2016)
- **Livable:** 26th most livable city in US (24/7 Wall St, 2017)
- **Hotspot for young people:** Number one choice for millennials in 2015 (Abad, 2017)
- **Clean:** Among the least polluted cities in US (American Lung Association)

THE STRENGTHS OF CHARLOTTE

- **Specialized in advanced industry:** 7th in growth of advanced industry from 2013 to 2015 (Mecklenburg County Community, 2018) - 8.9% of Charlotte's workforce is employed in advanced industries (2014) contributing to 17% of GMP
- **Strong manufacturing sector:** The manufacturing industry represents about 30% of the regional economy and employs 144,000 citizens in Charlotte (Charlotte Chamber, 2015)
- **STEM jobs:** The Charlotte metro has a high demand for STEM occupations, especially in middle-skill jobs, helping maintain attractiveness for workers (Parilla, 2016)
- **Globalized economy:** 14% of GMP in 2014 provided through export (110,000 jobs in Charlotte supported by export) and 6.8% employment at global firms
- **Well connected:** 45 million passengers per year in Charlotte Douglas International Airport, placing it 24th globally. 27,000 miles of rail connects Charlotte with 23 states

Charlotte's industrial success has translated to high levels of prosperity. The city is ranked 7th on Forbes' list of Places For Business And Career, has an average household income of \$56,731 (Forbes, 2018), and an unemployment rate below state average at 3.4% (Bureau of Labor Statistics, 2018 - April). Across various metrics, Charlotte is doing significantly better than other cities in the same weight class.

Partly resulting from this prosperity, Charlotte developed another major role as a prominent banking center in the 1970s and 80s. The city is home to the headquarters of Bank of America, and to the secondary headquarters of other major banks like Wells Fargo, making Charlotte one of the largest centers of banking activity in the United States, second to only New York City (Roberts & Rothacker, 2017).

As evidenced by the current construction boom, Charlotte has become a popular destination for young and highly educated professionals looking for a place to advance their careers (Fahey, 2016), and has been recognized for its high quality of life and livability (Stebbins, Comen, & Sauter, 2017).

Areas for improvement

In the midst of this account of Charlotte's successes, there is another story that until recently remained largely untold. Despite being a wealthy city with a generally high quality of life, Charlotte has more than 148,000 people living in poverty (DATA USA, 2018). In several neighborhoods, more than half of the residents are living below the poverty line (Off, 2016). Looking at a map of Charlotte's average income per neighborhood shows how dominant this social divide is in the city's geography, marking a physical rift across the city. Combined with the recent findings on Charlotte's low social mobility (Deruy & Boschma, 2016), this paints a picture of a city where 13.4% of the population is currently left behind. Tensions resulting from this social divide have justifiably added to local discontentment, and can be linked to events such as the riot of 2016, which put Charlotte in the international media spotlight.

Another barrier to Charlotte's development has to do with demand for highly skilled labor in science, technology, engineering, and mathematics (STEM) fields. There are not enough local graduates with these skills to fill local demand. This makes Charlotte attractive for graduates from other parts of the country, but can also slow down tech development as these hiring needs go unfulfilled for longer periods of time (Parilla, 2016). Potentially

connected to this low number of STEM graduates is the fact that Charlotte is lagging behind on key metrics related to innovation and new business, as highlighted below:

- Lowest social mobility among the 50 biggest cities in the US (Deruy & Boschma, 2016)
- More than 148,000 people living in poverty (DATA USA, 2018)
- Shrinking middle class (Mecklenburg County Community, 2018)
- Low investment in R&D - behind similar cities with a factor 20 or more (Parilla, 2016)
- Patenting is increasing but still below other cities (Parilla, 2016)
- 25th out of 40 in Kauffman Foundation 2015 Startup Activity Index
- Lower amount of venture capital compared to other cities
- Not enough local graduates to support local demand for educated labor - a large share of employment is covered by immigrating graduates (Parilla, 2016)

The path ahead

Charlotte clearly has the wind in its sails and is poised for continued growth. However, to genuinely seize the opportunity to become a more visible participant in the international community of cities, it still needs to tackle some central challenges, among which, we identify:

1. Creating a unique and progressive brand for the city and its business environment to consolidate its position as a city of the future.
2. Improving the resilience and livability of the city to continuously make it a safe and attractive home for its citizens.
3. Closing the social divide and formulating a vision for the city that unites all social groups.
4. Becoming an international example of how economic and industrial development can progress in a sustainable and circular manner.

A pathway forward that can address all of these issues is the transition a circular economy.

THE CIRCULAR ECONOMY

We now live in what has been described as a linear economy, where we extract many biotic (e.g. plant or animal) and abiotic (e.g. mineral or metal) resources, use them, and then send them to a landfill or disperse them into the environment in a way that they are unrecoverable – for example, through incineration, spraying of chemicals, or the use of products like paints that are not designed for recovery. Less than 10% of the materials that pass through our economy each year are recycled (Haas, Krausmann, Wiederhofer & Heinz, 2015).

Moving towards a “circular economy,” which is broadly defined as an economy that is regenerative and waste-free by design, presents vast potential for financial gains made possible through the reuse of all raw materials that are currently lost in the linear “take, make, dispose” system and by extending the value-generating life cycle of products. This transition can be supported through alternative business models and purchasing patterns that will structurally support the recovery of materials, such as leasing models and advanced approaches to extended producer responsibility (systems that make product manufacturers responsible for what they create and sell, even after the products are sold).

Preserving complexity yields more value

One of the principles of the circular economy is to preserve complexity to the greatest extent possible. As illustrated in Figure 2, the value of a product is much higher than the value of its individual parts, and the parts are much more valuable than the base materials they are made of. In an ideally circular system, products are designed for easy repair and refurbishment, so they can go through multiple cycles of use before they need to be taken apart. Once they can no longer be repaired, products should ideally be designed for disassembly, making it possible to harvest their components for high-value resale. Finally, when no more value can be extracted for these elements, all materials should be recycled at high quality (without mixing or downgrading them to lower uses).

A parallel to this value cycle can be seen in the amount of employment generated through circular practices at different levels. The US EPA and the Institute for Local Self Reliance estimate that low-value activities that result in material losses (like incineration and landfilling), only generate a handful of jobs per 10,000 tons of used goods. Recycling generates an order of magnitude more, but reuse and refurbishment are by far the winners, with almost 300 jobs created.



Finished products are worth much more than the raw materials inside them.

Figure 2. Creation and preservation of value along the product chain - adapted from Benton & Hazell, 2013

JOB CREATION POTENTIAL per 10,000 tonnes of used goods

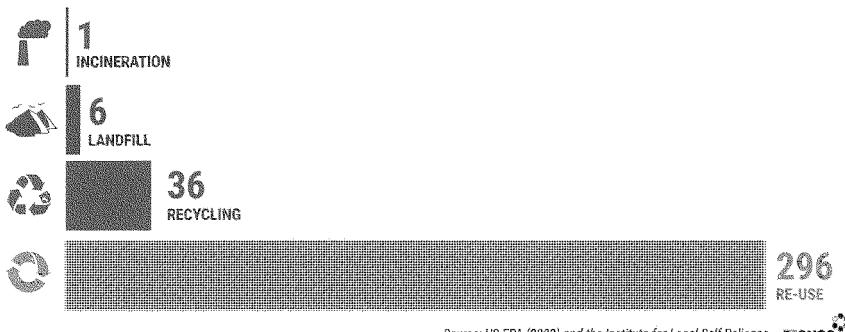


Figure 3. Job Creation through reuse

Implementing a Circular Economy

Though there are many definitions of the circular economy (a recent literature review looked at 114 variations), there are some core traits that most people think of when they hear the phrase. Often, we use analogies with natural systems to explain how such an economy could look: when you're walking through a forest, there is no real "waste" generated. There may be leaves on the ground or fungi feasting on fallen trees, but everything is part of a cycle that reabsorbs these resources back into high-value use. The basic principles of designing an economic system based on this model initially seem straightforward, and include:

- Design all products for easy repair, disassembly, and full recyclability.
- Create the necessary business structures and incentives to get these materials back into the economy at their highest possible value (preferably as whole products or components).
- Strive to use only responsibly-sourced renewable resources for both energy and material provision.
- Avoid the use of toxic substances that may continue to circulate in our environment.

When applying this circular approach our own economy, however, we quickly run into the realization that not all options for closed-cycle resource management result in an optimal outcomes. If we use more oil to recycle plastic bottles than we would use to create new bottles, this is not a circular solution. If we overharvest available natural resources, leading to the destruction

of ecological productivity in our agricultural landscapes, likewise, we have damaged the regenerative basis on which our ideally regenerative circular economy should rest. Furthermore, if our recycling practices are dangerous and lead to health impacts for individuals, then the fundamental point of the system, which is to facilitate a healthy and equitable society for all, is called into question.

Therefore, there are several other parameters we need to consider when aiming for circularity. Yes: we want to manage our resources so that they can cycle infinitely at high value. But: we must do so without undermining our natural capital, creating stresses on Earth systems like the climate, leading to social inequities, or threatening the health and wellbeing of humans and other animals. Therefore, from an integrated perspective, a circular economy is one where we maximize the value generated from resource cycles without undermining the functioning of the biosphere or the integrity of human societies. Activities in the economy should be therefore judged on how well they support this ultimate outcome.

The circular economy is a new economic model for addressing human needs and fairly distributing resources without undermining the functioning of the biosphere or crossing any planetary boundaries.

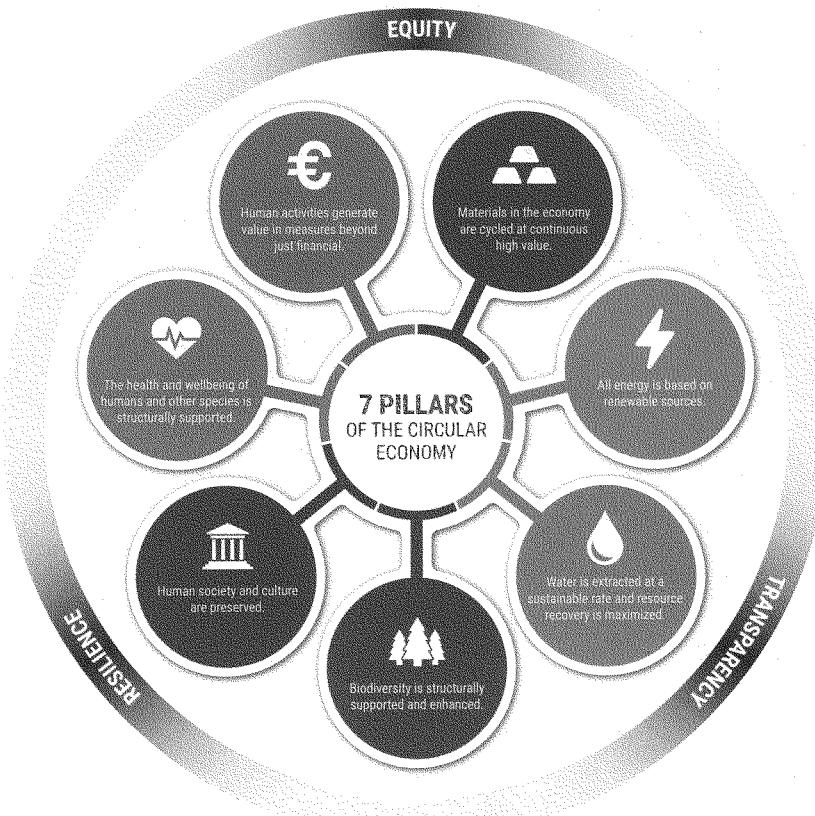
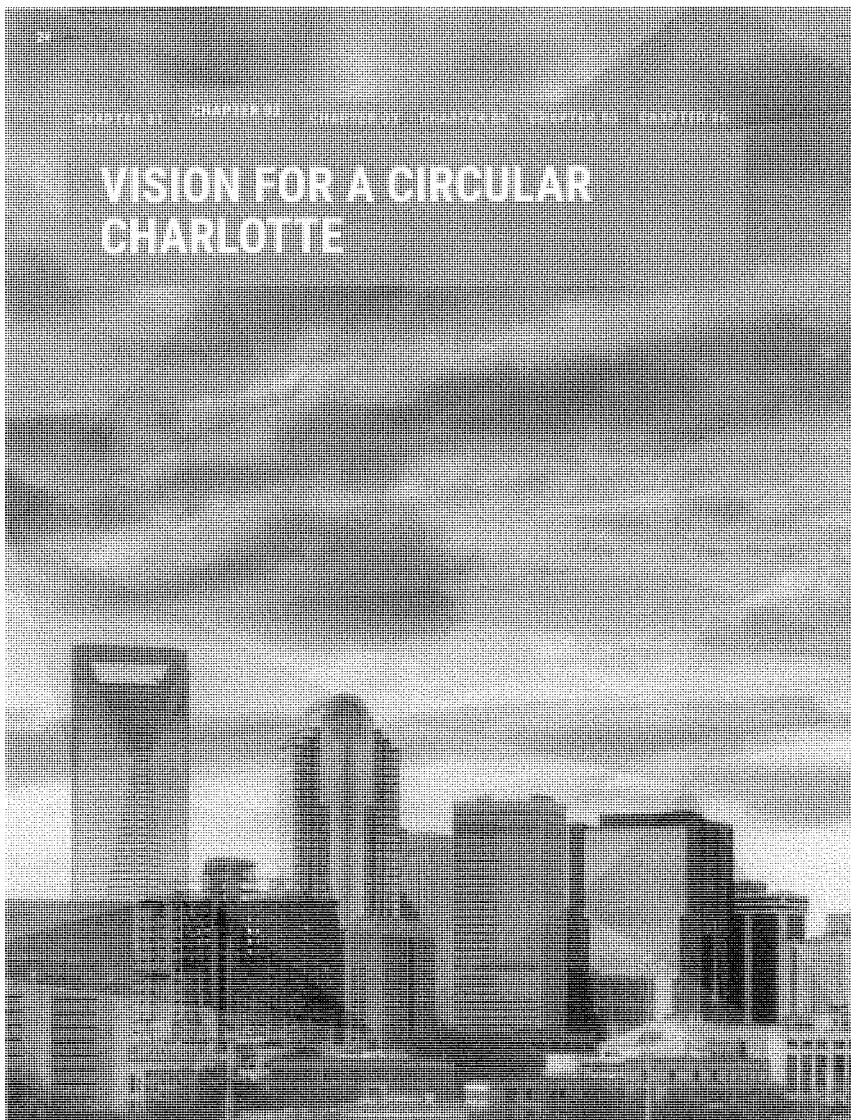


Figure 4. Seven Pillars of the Circular Economy

Seven Pillars of the Circular Economy

Figure 4 illustrates Metabolic's "seven pillars" framework for evaluating circularity. These seven pillars capture the areas that must be simultaneously considered when looking at whether certain activities are genuinely circular. We need to evaluate all of our actions not just on one parameter, but on a complete spectrum. With a holistic set of performance indicators, we can track whether or not circular activities are leading to better results across a broad range of impacts, rather than just optimizing for high value material recovery at the expense of other areas of performance.

To achieve real progress towards a circular economy, it is clear that we need new incentive structures, new business models, and new ways of evaluating our economy to assess whether it is functioning within the safe limits of Earth's carrying capacity. By shifting from the current linear economy to the circular is fundamentally difficult as it challenges many structures and mindsets that are considered common sense but it also holds the potential to unlock formerly wasted value and spark new innovative solutions. Most importantly, the circular economy offers a way to structure the economy in such a way that it can continue to prosper well into the new century as resources are getting scarcer and demands continue to rise.

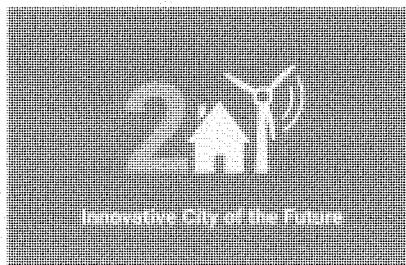


DEVELOPING A CIRCULAR VISION

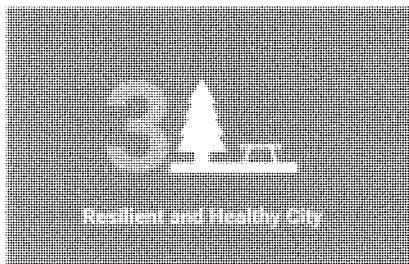
If we take these high level ideas about the circular economy and actually apply them to Charlotte, what might the city actually look like in a circular state? Here we envision some of the changes that might take place within Charlotte if it achieves the full spectrum of a circular economy. We have organized the vision around four thematic areas:



Zero Waste City



Innovative City of the Future



Sustainable and Healthy City



City with Good Governance and Fair Play

Though some of these ideas may seem farther off in the future than others, every plan starts with imagining the reality we aim to achieve. The picture we describe here, from a 2050 perspective, will certainly not be a perfect reflection of what actually transpires, but it can provide a starting narrative and inspiration for the next decades of Charlotte's development.

CHARLOTTE AS A ZERO WASTE CITY



In 2050, Charlotte can proudly call itself a Zero Waste City. Back in 2018, when the Charlotte set off on its transition path, less than 12% of its solid waste was recycled or composted – and many of the recycling methods used at that time would not even qualify as recycling today. The majority of the city's solid resources were put into low-value applications (i.e., downcycled), like cement being used as road-filler.

Today, 98% of all residual materials are separately collected, and only the 5% of waste that is too low quality or hazardous to otherwise process is incinerated for energy recovery. The incineration facility opened in 2029, just a couple of years before Charlotte celebrated the permanent closure of its landfill, which ceased operating because the volumes of waste were too low. The small incinerator has been built to such high emissions standards that the air it releases is even cleaner than the ambient air. The amount of hazardous waste generated in the city is still decreasing each year as old stocks of products are slowly replaced with ones that have been designed based on circular principles.

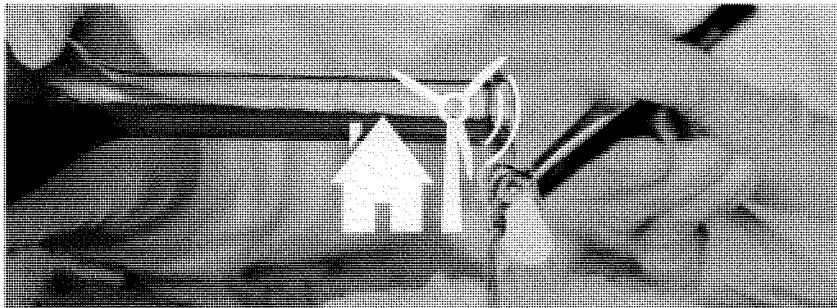
Throughout the city, each household is equipped with smart sorting containers that simplify the process of separating different materials. The containers' built-in technologies tell users if they have sorted something incorrectly. However, the incentive to properly sort resources is already very high: for every pound of correctly sorted waste, residents get Charlotte Coins paid directly into their digital wallets. They can use their earnings for the purchase of local goods branded with the Circular Charlotte label, many of which have been remanufactured or grown from those same residual streams. If they have Charlotte Coins left over, they can

also use them to pay for their – fully renewable – energy bill, or even pay their taxes.

A real-time resource monitoring platform, the Charlotte Circularity Dashboard, continuously reports how much is available of different kinds of residual goods – from citrus peels to old shoes. These resources are automatically diverted to various processing facilities throughout the city, run by large companies and small entrepreneurs alike. The Dashboard keeps a record of orders placed requesting different materials, and ships off materials to the earliest bidders. Because of Charlotte's strong position as a logistics hub, the city also accepts and processes many materials from the nearby counties, adding to the base of resources used for local manufacturing.

But before anything is ever disposed of in Charlotte, it gets the royal treatment of repair and refurbishment, maximizing its usable lifespan. The Innovation Barn, the city's center for circular innovation, is one of the busiest places in the city, with cafes serving food from the building's greenhouses, and with many different stores featuring upcycled products. It is also a center for experimentation and education, with many specialized repair facilities and workshops. New circular ideas are piloted at The Barn, and then scaled up in many other parts of the city. The Barn has also led to a completely different social dynamic than existed in the 2010s, when the main options available for spending time with friends involved eating or drinking at a café or bar. People come to the Barn to learn new skills, but also to socialize while repairing their own clothes or trading their old furniture in for something new.

CHARLOTTE AS AN INNOVATIVE CITY OF THE FUTURE



With Charlotte's innovations in waste collection and sorting, which resulted in the supply of previously-unavailable high-quality and pure resource streams, a whole new cluster of industries began to develop throughout the city. New product development exploded in the early 2020s. At first, the major focus of R&D activities was on processing textiles, plastics, and construction wastes. In 2023, CharM, the city's newly opened materials lab, a joint project of several of Charlotte's incubators and accelerators, began experimenting on how to convert collected bio-wastes into new materials – like clothing, furnishings, and biodegradable packaging.

Later, it became clear that complex consumer goods like household appliances could also generate more value in this new economy. Manufacturers discovered that they could actually claim financial benefits for every pound of materials that was successfully harvested from their products – provided that they included an RFID tag that could be scanned at the automatic sorting and disassembly unit newly installed at the city's Materials Recovery Facility (MRF).

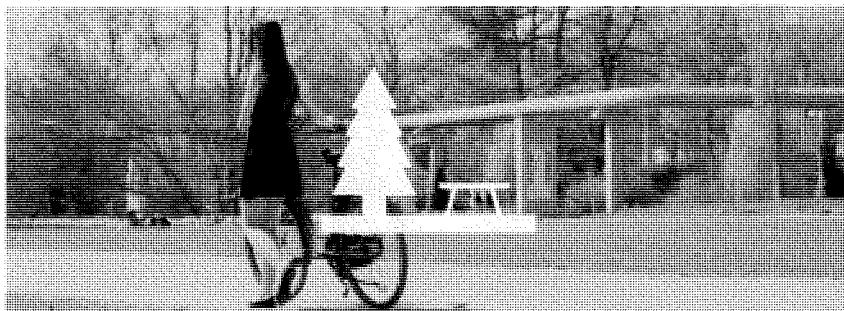
The strong need for materials and product innovation because of the city's ambitious circularity goals also led the University of North Carolina Charlotte to establish

a new educational facility, the Charlotte Institute of Circular Design and Engineering (CICDE). CICDE is now one of the top engineering schools in the world, attracting the brightest minds from throughout the U.S. and abroad. Charlotte is now broadly recognized as one of the world's most innovative design centers, and has pioneered the emergence of circular products that are now dominant in global supply chains.

As engineering and design became a central part of Charlotte's higher education scene, primary and high school curricula were updated to include more experiential learning opportunities and a unique mentorship program that paired up students with researchers. Most high school students now go through an internship at one of the many tech companies in Charlotte's burgeoning startup scene.

These new industries have transformed Charlotte's local economy, creating thousands of new jobs, boosting the city's resilience, and serving as an example for other cities around the world. The Circular Charlotte brand helped the city consolidate its leading position globally, and cemented Charlotte's top position in global rankings such as the Sustainable Cities Index. Barely a week passes without an international delegation coming to visit the city and learn from its successes.

CHARLOTTE AS A RESILIENT AND HEALTHY CITY



Back in 2018, at the start of Charlotte's transition to circularity, North Carolina was importing a net value of 47.4 million dollars' worth of commodities each year. China had just closed its borders to lower-quality recyclables, leaving countries around the world struggling with the challenge of processing huge volumes of unwanted material. The drive for innovating towards circularity was not just a matter of principle: it was equally grounded in economic opportunity and the need for greater local resilience.

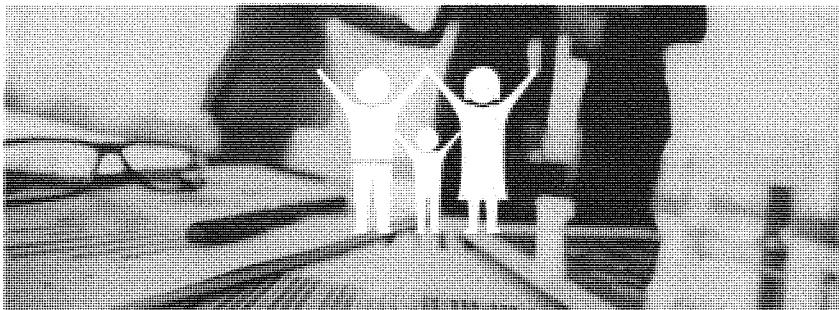
Since circular building standards became the norm, new buildings in Charlotte are designed for complete disassembly. They are demolished by highly trained demolition teams with the help of efficient robots, who scan all individual building components and register them on the Charlotte Circularity Dashboard. The city is now able to harvest a large fraction of the materials needed for new construction projects from within its own demolition cycle, and has in this way eliminated around 30% of the material that used to go to landfills.

As other circular industries developed, Charlotte and its surrounding region became increasingly independent of foreign imports, with almost all material sourced from local cycles. Even local food production has grown immensely, with the advancement of vertical farming technology and the reuse of organic waste streams as fertilizer. Most of Charlotte's schools now also have their own small-scale aquaponics facilities, which are used both for hands-on science education as well as to provide farm fresh produce and fish to the schools' cafeterias. Further efforts to increase the city's health

and resilience have focused on the decentralization of certain utility services. Renewable energy, decentralized battery storage, and smart distribution of energy through the city's smart grid have made Charlotte's energy system highly resistant to the impact of storms or floods, with most damage remaining localized.

Circular Charlotte also became dramatically greener as nature-based solutions became an increasingly central element in the design of buildings and public places. The most dramatic change only happened recently, in 2037, when the municipality finally did away with all personal vehicle transport in the inner city. All the asphalt roads were converted into green boulevards, with walkways meandering among trees and flowers, lined with miles of well-connected bike paths. At the center of each boulevard are rail-lines for the public transport vehicles, which can be ordered on command from any part of the city. They are driverless and each have several seating compartments, allowing people to be picked up and delivered efficiently to their final destination. The parking lots which once dominated Charlotte's Uptown have all been replaced with either public green spaces or new mixed-use developments, further improving the walkability and "human-scale" of this busiest part of the city. People's overall health has improved as a natural result of more walking and biking, not to mention the drastically improved air quality. The city's canopy of trees, which was under threat in 2018 due to increased tree removal relative to new planting, has never been as dense as it is today. Charlotte is one of the greenest cities in the US, known to some as an example of an urban forest.

CHARLOTTE AS A CITY WITH OPPORTUNITIES FOR ALL



Though Charlotte now has less than 0.5% of its population living in poverty, at the start of its journey towards a circular economy, this was far from the case. For this reason, initial efforts on establishing circular industry and innovation were largely focused on skill development, training, and inclusive programs designed to lift up those who were economically disadvantaged.

In 2019, the city's solid waste department established a test rehabilitation program for the homeless community, providing employment in plastic waste sorting and remanufacturing. Plastic wastes, which were of too low a quality for automated processing at that time, were sorted, washed, and shredded for the production of small batches of local products like street furniture, waste bins, and trophies for school sporting events. Some of trainees involved in the pilot program went on to start their own companies focused on recycling and product manufacturing.

In a similar effort, local culinary schools, like the Community Culinary School of Charlotte and the Culinary Program at the Art Institute of Charlotte, collaborated to set up a program focused on the establishment of circular businesses in the food sector. Successful projects resulting from this effort include a 5-star restaurant that uses food salvaged daily from grocery stores to produce gourmet meals, a farm-restaurant hybrid where all food served is produced on site in vertical agriculture systems, and a food processors cooperative making soups, sauces, and jams out of produce rejected at retail stores because it failed to meet aesthetic rather than safety standards.

From the very start of Charlotte's shift towards a circular economy, the Goodwill Opportunity Campus, already a community fixture, has played an essential role in mainstreaming and supporting circularity efforts. In 2019, the Campus, launched a new range of circular training programs focused on repair and

remanufacturing skills, which resulted in a slew of new store openings and services within the city. In addition, the Charlotte Chamber of Commerce launched support services for new entrepreneurs and local makers, giving advice and providing resources for people launching businesses. All local products made or refurbished according to circular principles can be labeled with the Circular Charlotte brand, which has been an important marketing platform for small enterprises in the city, particularly in their early stages.

Another effort towards improving quality of life and increasing access to opportunities, has been the development of circular housing in Charlotte. As part of the housing boom of the 2020s, the city of Charlotte began to encourage inclusive development by giving priority to developers who aimed to include different price levels of housing within individual developments. Not only did this effort increase the social cohesion of neighborhoods, as young couples were able to stay in their neighborhood as their income levels rose, but it also created an equitable manner of providing lower-income housing in prime locations throughout the city.

A uniquely circular feature of many of the new housing developments was the emergence of "full service living" concepts. When you rent or buy a house, you can select from a range of equipment, furniture, and transport packages - like access to cars or bikes, giving you permanent access to the most efficient and up-to-date appliances and equipment. The companies providing this equipment get a steady income stream from the rental of their products, but also have the incentive to design these products for refurbishment and recycling, since they remain responsible for the full lifecycle of their equipment. The new full-service housing concepts have reduced the total amount of large household goods thrown out in the city, and has made moving - especially for students and people starting out their careers - much more carefree.

MEASURING CIRCULARITY

The vision imagined in the previous section shows one of many ways that Charlotte could develop as it progresses towards a circular economy. Regardless of the exact path that the city and its residents choose to travel, there are certain performance outcomes (like eliminating waste sent to landfill) that should ultimately be achieved in a circular model. To help understand these performance outcomes, and make the transition to circularity tangible and actionable, we have translated the vision into concrete goals and key performance indicators (KPIs) that can be used to measure Charlotte's progress towards circularity. As with the vision itself, these must be holistic and cover not only the physical

reality of achieving circularity (resource cycling, impact reduction, etc), but also cover the auxiliary benefits of circular activities (such as employment, innovation, and health) to ensure that the strategy is implemented in a way that also increases value and equity for society.

These goals and KPIs have been developed based largely on inputs from the City of Charlotte and other stakeholders over the course of two stakeholder sessions. They are organized across the same four thematic areas that we have used to define the vision for a Circular Charlotte.

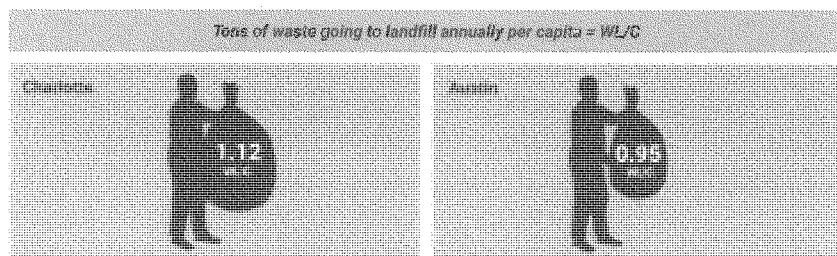


To illustrate the holistic nature of the goals and KPIs, the KPIs are linked to our seven pillars of the circular economy framework (plus three overarching categories), which is described on page 13. The following legend shows the icons used to represent each of the pillars and overarching categories.



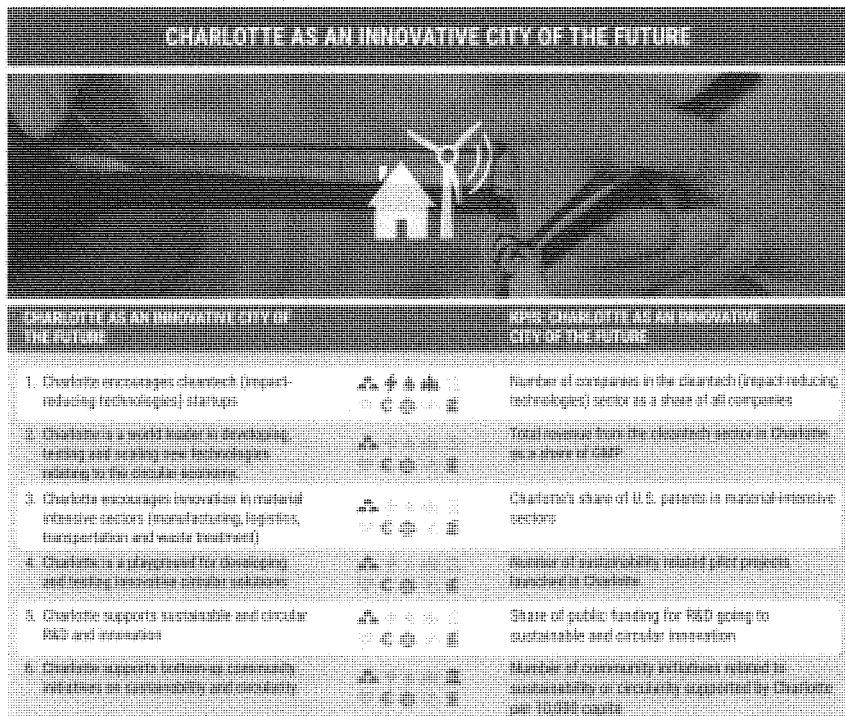
CHARLOTTE AS A ZERO WASTE CITY		
GOALS: CHARLOTTE AS A ZERO WASTE CITY	KPI'S: CHARLOTTE AS A ZERO WASTE CITY	
1. Charlotte terminates all use of landfills by 2040	     	Tons of waste going to landfill annually per capita
2. Charlotte improves its virgin (new) resource efficiency	     	Tons of virgin resources consumed by industry per \$ gross metropolitan product (GMP)
3. Charlotte minimizes annual GHG emissions to 2 tons per person by 2050	     	Tons of CO ₂ equivalent greenhouse gas (GHG) emissions per person
4. Charlotte recovers maximum value from waste streams	     	Average profit per ton of recovered waste
5. Charlotte maintains material quality (complexity) of resources	     	Percentage of resources recycled at the same level of quality/complexity
6. Charlotte ensures that nutrients from all organic wastes are returned to natural cycles	     	Percentage of organic waste processed to recover nutrients and return them to soil
7. Charlotte reduces its reliance on critical (scarce) materials	     	Tons of critical (scarce) materials consumed by industry per \$ GMP
8. Charlotte improves information flows on waste between stakeholders and the City	     	Qualitative assessment of the quality of information flows
9. Circular companies can thrive in Charlotte	     	The number of circular businesses as a share of total businesses

Highlighted KPI

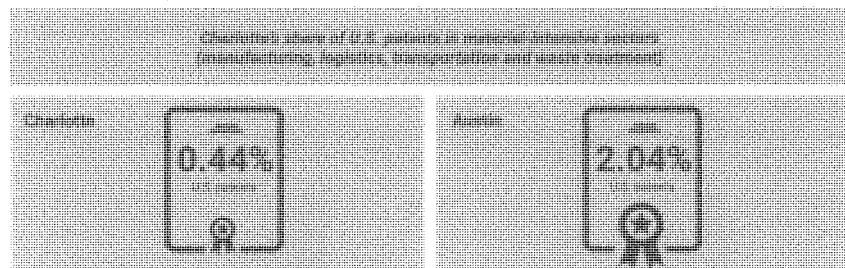


Source: Envision Charlotte, 2017

Source: Austin Resource Recovery Master Plan, 2011



Highlighted KPI



Source: U.S. Cluster Mapping Project, 2015

Calculation: https://docs.google.com/spreadsheets/d/1XeqRWADsz_RJ1_73aUySGtBkBss3Tf_b3aiqEkenT76g/edit#gid=565323749

CHARLOTTE AS A RESILIENT AND HEALTHY CITY



GOALS: CHARLOTTE AS A RESILIENT AND HEALTHY CITY

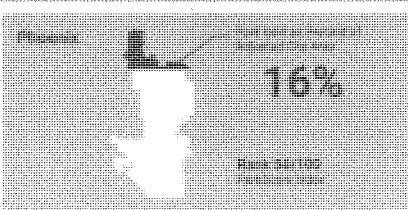
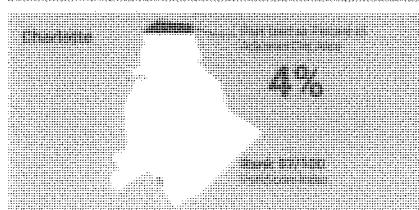
1. Charlotte has clean water and air and a low exposure to pollutants
 2. Charlotte has high quality and extensive green areas
 3. Charlotte provides equal access to green areas for all citizens
 4. Charlotte has resilient systems of provision (food, energy, water, etc.)
 5. Charlotte minimizes flooding risk
 6. Charlotte minimizes the use of toxic substances in industry
 7. Charlotte ensures access to healthy food for all
 8. Charlotte promotes social cohesion and strong communities

KPIs: CHARLOTTE AS A RESILIENT AND HEALTHY CITY

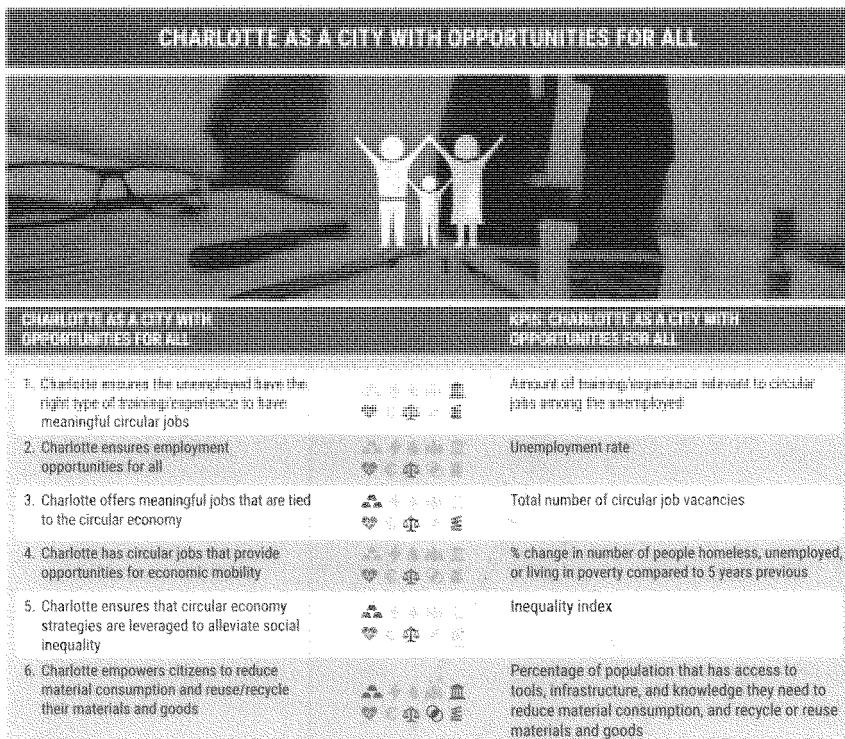
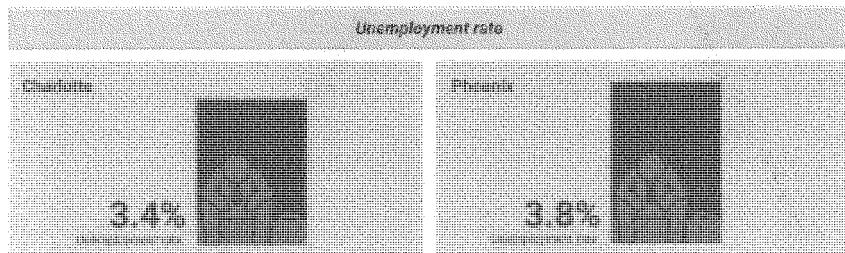
- | |
|--|
| Pollution levels (NO _x , PM ₁₀ , PM _{2.5} , BOD, QALY) |
| Share of area of green spaces in the city of Charlotte |
| Percentage of residents living within 5 min walking distance to green space |
| Self-sufficiency (local production as a share of total consumption of food, energy, water) |
| Flooding risk |
| Use of toxic substances in industry in ton per \$ GMP |
| Percentage of households with food insecurity |
| Share of population attending community events or involved in community organizations |

Highlighted KPI

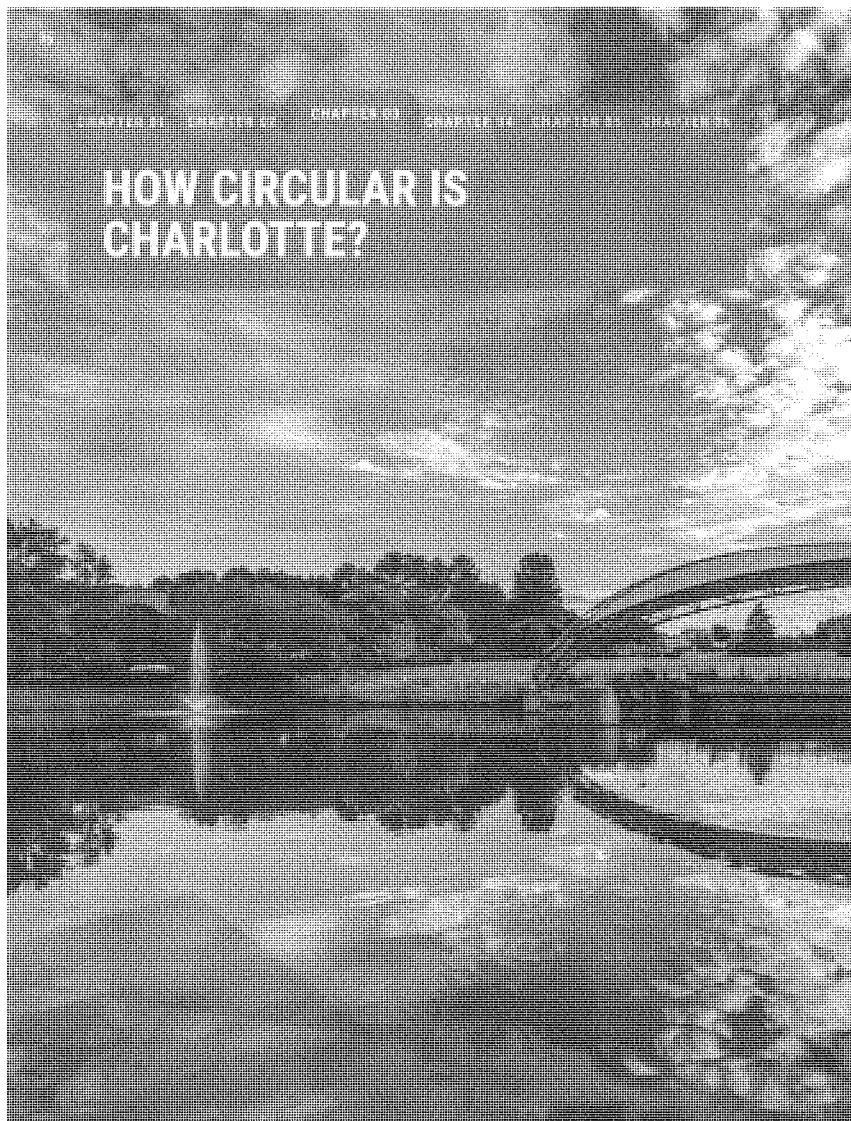
Share of area of green spaces in the city of Charlotte



Source: Trust for Public Land's ParkScore index, 2017

**Highlighted KPI**

Bureau of Labor Statistics (2018) for April 2018



HOW CIRCULAR IS CHARLOTTE?

UNDERSTANDING THE CURRENT STATE

In order to create an effective strategy for Charlotte around the circular economy, we started by first building an understanding of the way things are currently functioning through a baseline assessment of the context, stakeholders, waste flows, and economic and social potential of wastes. This chapter provides an overview of the results from this first baseline assessment as a starting point.

The economic and environmental outcomes we see in Charlotte result from the structures (e.g. social, economic, political, physical) and the actors working in Charlotte. In the first two sections of this chapter, we provide a bit of background on the story of waste in Charlotte, looking at the context and the stakeholders active in the city.

This is followed by a material flow analysis, which provides a big picture view of where a large share of the wastes in Charlotte are coming from, what they consist of, and what is happening to them (e.g. landfill vs. recycling or composting). As we collected data to map out and understand these material flows, we also identified a number of hotspots (or problem areas) and opportunities, which are highlighted in this section.

Finally, we did a quick economic assessment on the material flows that are currently going to landfill. We looked at two basic scenarios: waste incineration with energy recovery and simple recycling material value. For each scenario we looked at the revenue and jobs potential of diverting this waste from landfill.

It is important to note that these options are not yet "circularity strategies", as these only look at the residual market value of the materials themselves. A circular strategy would involve examining the full value chain (e.g. materials should be designed for recovery when they are first produced) and the structural prerequisites required for circularity. Truly circular options offer the possibility of recovering far more value than simply looking at the market value of residual waste streams. Additionally, this is not yet an assessment of profit potential, as we only look at the lost revenue potential heading to landfill (and not the costs). These issues are covered in the following chapters on strategies and specific business cases.

EXPLORING THE CONTEXT

How the waste system functions in Charlotte

For a typical household, involvement in Charlotte's waste system includes weekly curbside pickup of municipal solid waste, biweekly pickup of recyclables, and occasional trips to drop-off centers or other locations to bring types of waste not collected at home. The costs of the program are covered by property tax fees paid to both the city and the county (\$63 dollars in total) as well as other sources, such as special waste fees (for tires, white goods, etc) and the sale of recyclables. These costs are not differentiated by household size, the amount of waste (or recyclables), or income.

In the curbside recycling program, the city collects paper and cardboard (including paper cans and pizza boxes), plastics #1-5 and #7, milk and juice cartons and boxes, aluminum and aerosol cans, and glass bottles and jars in a single container. This system has been in place since 2010; before this, households had to separate paper products from other recyclables. While the new system solves logistical challenges (for example, fewer trucks are required), it also translates to a higher level of contamination and lower-quality recyclables.

Overall, recycling participation rates are low in Charlotte (53%), which is lower than other parts of Mecklenburg County (Mecklenburg County Residential Recycling Behavior 2009 Observation Study, 2009). Since 2009, in the state of North Carolina it has been technically illegal to landfill HDPE and PET (Granger, 2009), though there are no frameworks in place to prevent households from placing these materials in the municipal solid waste bins, resulting in a large share of these materials ending up in the landfill anyway.

If households would like to recycle batteries, light bulbs, textiles, hazardous waste, construction materials, electronics/appliances, oils, or tires, plastic bags, or other metals (like wire hangers, pots and pans), these must be taken to retailers or the county-operated drop-off centers in Charlotte. While the drop-off centers were originally established with the main purpose of collection of household recyclables, the majority of the waste by mass brought to the facility is bulky and construction waste from contractors and cardboard (which can be recycled in curbside programs).

Weekly use across all self-service drop-off centers was estimated to be roughly 800 visitors, of which 88% were households. This means that only 0.2% of the County's households are using the centers each week. For the roughly 19,000 households in Charlotte without a car (Governing the States and Localities, 2016), making a special trip to a drop-off center is practically infeasible, while it is also inconvenient for those with a car. Just the same, drop-off centers have been overcrowded, often with lines. This is due to the fast population growth of Charlotte (+30% over the past decade), resulting in too little capacity in peak hours (DSM Environmental Services Inc., 2017)

The city and county have no means for taking and recycling #6 plastics (including styrofoam), plastic dinnerware/cutlery, aluminum or plastic foils and wraps, non packaging glass (glassware, plate glass), diapers, or ceramics. Therefore, these materials are added to the residual waste bins.

For the majority of companies and other organizations located in Charlotte, the city and county does not provide waste collection and handling services. These organizations must handle waste themselves (for example contractors taking waste directly to landfills or drop-off centers) or establish a contract with a waste hauler. Larger haulers operate their own material recovery facilities for recycled materials or have partnerships with recyclers, making it cheaper to process recycling than general solid waste (with high tipping fees for landfilling). This provides a good incentive for companies and waste haulers to strive for more ambitious recycling rates.

Mecklenburg County is responsible for operating the material recovery facility (MRF) where household recyclables end up. At this facility, recyclables are separated and baled and sold on to third parties. Lately, with the Chinese ban on imports of recyclables of a low quality, finding an appropriate market for these materials has become more challenging, resulting in an accumulation of recyclables.

Charlotte has a large number of recyclers operating in the region, processing everything from plastics to electronics, though much of the material these

companies are processing is post-industrial or imported waste rather than regional post-consumer waste. The main reason for this is that regional post-consumer waste is largely too contaminated, with impurities and other materials mixed into the loads.

With export markets disrupted by the Chinese ban, there may be further incentive now to upgrade the quality of recyclable materials locally (for example through washing and shredding), which could benefit local recyclers and increase employment in the local recycling sector. In North Carolina, it has been shown that increased recycling leads to far more jobs created than lost in industries such as timber harvesting and waste disposal (Institute for Local Self-Reliance, 2002).

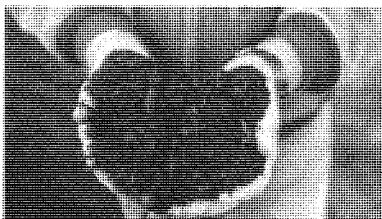
Current initiatives in Charlotte

Though there is a new wave of momentum behind the circular economy, there are already many initiatives in Charlotte that can already be described as circular.

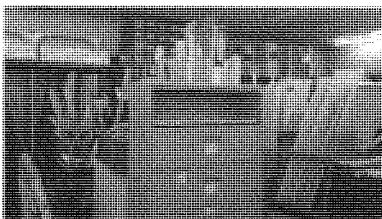
For example, the city established the Healthy Communities program to divert waste from landfill and increase composting and recycling by educating locals. In 2016, around 6,600 citizens were reached through events to provide information on waste separation. In 2017, the city won the Excellence Award for Innovation in Communication, Education and Marketing for the program from the Solid Waste Association of North America. Solid Waste Services is planning on continuing this program to reach more households over the coming years.

As Charlotte strives to become a zero-waste city, there will still be a number of landfills in the region that will need to be remediated. In Mecklenburg County alone, there are eight heavily-polluted landfills that were put into place when environmental regulations were less stringent. There is already precedent in Charlotte for how to make use of these landfills. The Double Oaks landfill was cleaned up with an investment of \$2.1 million and is now a play area and park. In 2016, Charlotte approved a plan to convert another old, polluted landfill site into a solar farm to produce 2-3 MW of electricity (Henderson, 2017).

In addition to these city-level programs and projects, there are a number of entrepreneurs working on interesting initiatives. A few examples, include:



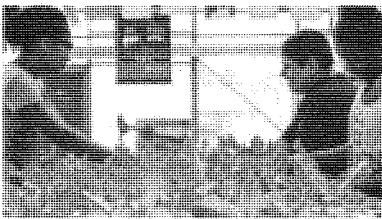
Crown Town Compost - Not everyone in Charlotte has the opportunity for at-home composting and although there were collection programs for yard waste, there was no program to handle the food waste going to landfill from households. Crown Town Compost was established to collect food waste from households and restaurants in a weekly collection program. While this food waste is currently composted with Earth Farm Organics, Crown Town is looking for alternative ways to handle food waste as the program scales up further.



Habitat for Humanity ReStores - Habitat for Humanity is a charity organization that mobilizes volunteers and funding to build houses for families with low incomes who otherwise could not afford to own their own homes. The ReStores are thrift stores for secondhand building and household materials (such as lighting fixtures, cabinetry, furniture, wood, etc). The ReStores divert waste from landfill as well as providing income to fund the Habitat for Humanity program.



Goodwill's Opportunity Campus - A new project established to provide a learning center for teaching people who struggle to find work new skills to get them into the workforce. In addition to the educational programs and two thrift stores on site, the campus also includes a garden for food production. The food is served in the cafe on-site, which also serves to teach people new cooking skills.



100 Gardens - An educational program that aims to teach students about science, technology, business, marketing, and much more through operating aquaponics labs (hydroponic greenhouse production combined with fish production in a symbiotic system). So far, ten labs have been established in Charlotte schools to provide students with a hands-on way of learning about how natural systems function, while also inspiring kids to learn about technology and applied sciences.

How the waste system looks spatially

Charlotte has some areas of the city with extreme poverty and high unemployment rates of up to 50%. We wanted to see if waste collection or processing areas correlated with these areas of economic strife. The southern part of the city, forming a wedge that starts at the center, has a significantly higher median income than the rest of the city. This whole area also only has one recycling center placed on its far southern part and no landfill. At the same time, the lower income areas in the Northern part of the city center have several recycling centers.

This distribution has of course happened organically as the city has developed, but at this point it may form a logistical challenge that makes it more costly to increase the separation capacity because more trucks will have to go back and forth to this wealthier area. For residents in the wealthier areas it may be more cumbersome to visit recycling centers, while residents in low-income areas may experience the noise and air pollution of recycling centers, landfills, or trucks traveling to these as a nuisance in their neighborhood.

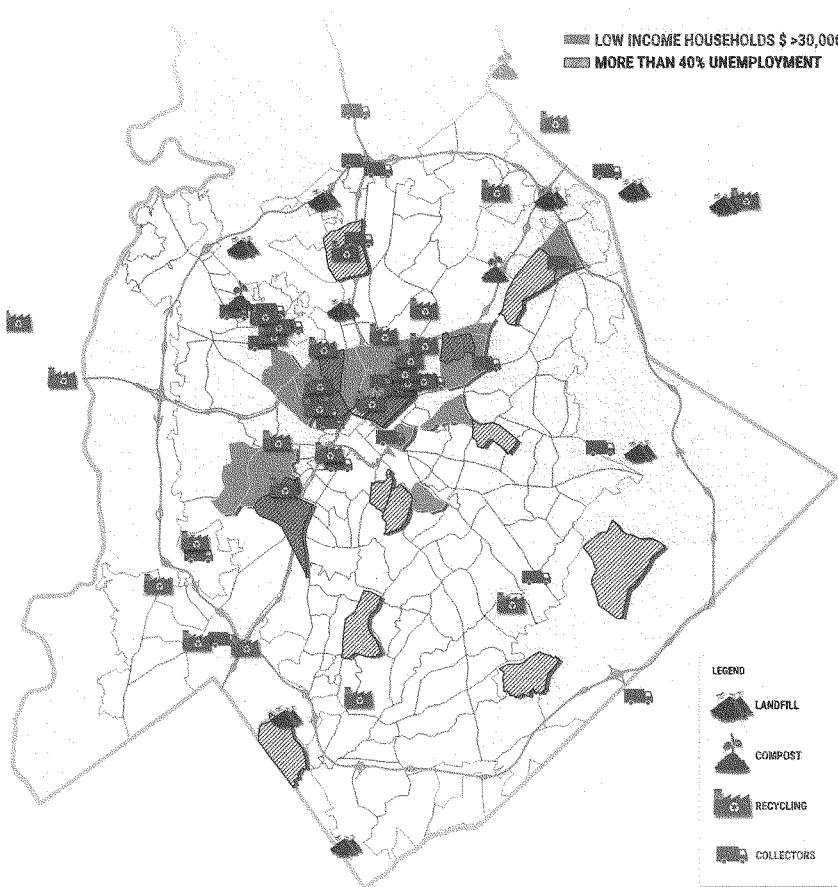


Figure 5. Spatial Aspects of Charlotte's Waste System and Neighborhood Economic Indicators

MAPPING THE STAKEHOLDERS

In Charlotte there are a large number of stakeholders involved in the waste system, including the waste generators (which involves more than 300,000 households and over 60,000 companies and other organizations), waste haulers focused on different client groups, more than fifty waste processors working with specific waste streams, stakeholders that store waste in landfills, companies that use or could use recycled materials, and overarching stakeholders such as the city and county.

The large number of influential and affected stakeholders is one of the main challenges the city faces in achieving circularity. As there is no one party with central oversight over the entire waste system in Charlotte, it makes

it difficult to sketch a complete picture. The city and the county have access to the most complete data on households and small businesses, but as they are responsible for different parts of the waste system, both have gaps in their knowledge. Additionally, data is missing for a large share of the waste system in Charlotte as it bypasses both the city and the county when it goes from private companies to private haulers and processors.

Figure 6 shows the material flows between different stakeholder groups in Charlotte. Thicker lines represent the wastel flows for which the city or county have information, while the other lines are where there is a lack of central oversight on what is happening in the waste system.

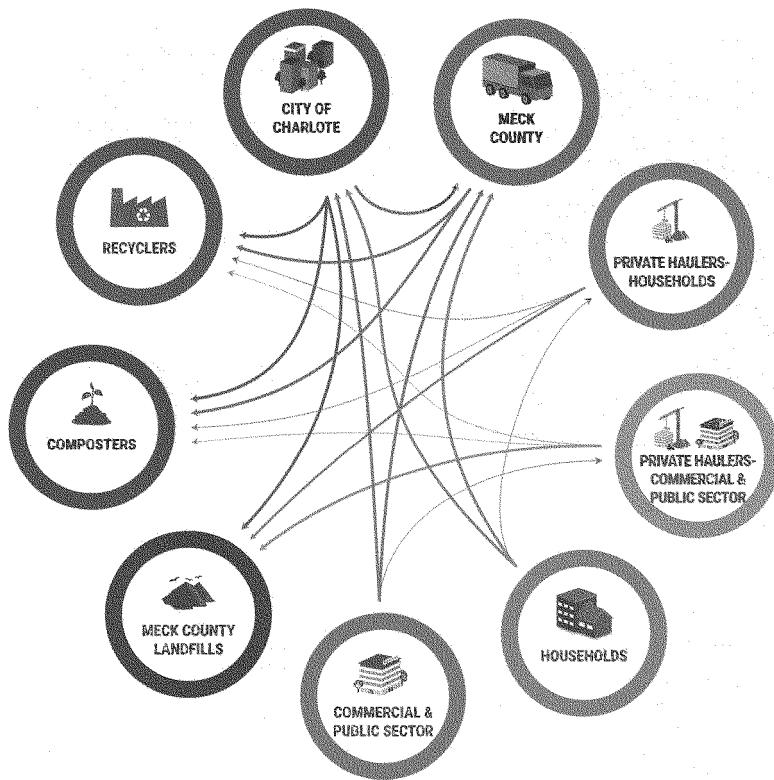


Figure 6. Material Flows between Charlotte Stakeholders

Beyond material and information flows between stakeholders in Charlotte, there are important financial flows to consider, including tipping fees, disposal taxes, special taxes (such as tire taxes or white goods taxes), revenues from recyclables, commercial service costs, etc. The structure of these financial flows is key, as it will determine which stakeholders support or are opposed to certain circularity measures.

For example, the owner of a landfill would presumably be opposed to any measure which reduce the waste to landfill without also resulting in a commensurate benefit in some other way. In this way, we need to take the position and desires of influential stakeholders into account to ensure strategies are feasible. In addition to direct opposition or support of specific measures, stakeholders may see circularity strategies as a way to position themselves in a competitive market. Waste haulers, for example, who compete for contracts, have a strong incentive to support measures which help their position.

One of the most complicated challenges around aligning interests and finding a strategy that works for all is the dynamic between the city and the county. Waste and recycling from households and some small businesses is collected by the City of Charlotte. However, due to a solid waste interlocal agreement with Mecklenburg County (currently in place until 2028), the county is responsible for this waste from this point on.

Outside of the direct financial flows between stakeholders, there are indirect economic issues which affect stakeholders in the region. For the areas in Charlotte where poverty is a major struggle, ensuring that a shift to circularity can provide a means for reducing poverty through workforce development and job opportunities is a prerequisite for adoption. At the same time, the means for achieving circularity should fit within the cultural and social structure of different communities and address additional challenges they face.

Finally, activities of other stakeholders (for example in the market or in policy) outside of the scope of Charlotte can have a large impact on how the waste system of the city functions. One example is China's decision to limit the import of recyclables to those of a high quality, due to environmental and health reasons. In particular, household plastic wastes, unsorted paper, and some textile wastes will no longer be accepted (Prisco, 2017), which poses a challenge as China is the main importer of plastic wastes (Velis, 2014).

Chinese policy on materials accepted and the quality of recyclates will have a large impact on global markets for recyclables and is expected to have a large negative impact on United States recycling businesses, threatening thousands of jobs (Rosengren, 2017). In some cities in the United States, this ban has already resulted in the refusal of certain types of plastics (van Fleet, 2017). The effect of China as an external stakeholder could affect the feasibility of recycling options, provide an incentive to reduce plastic waste production, or present a barrier for preventing plastic wastes to landfill.

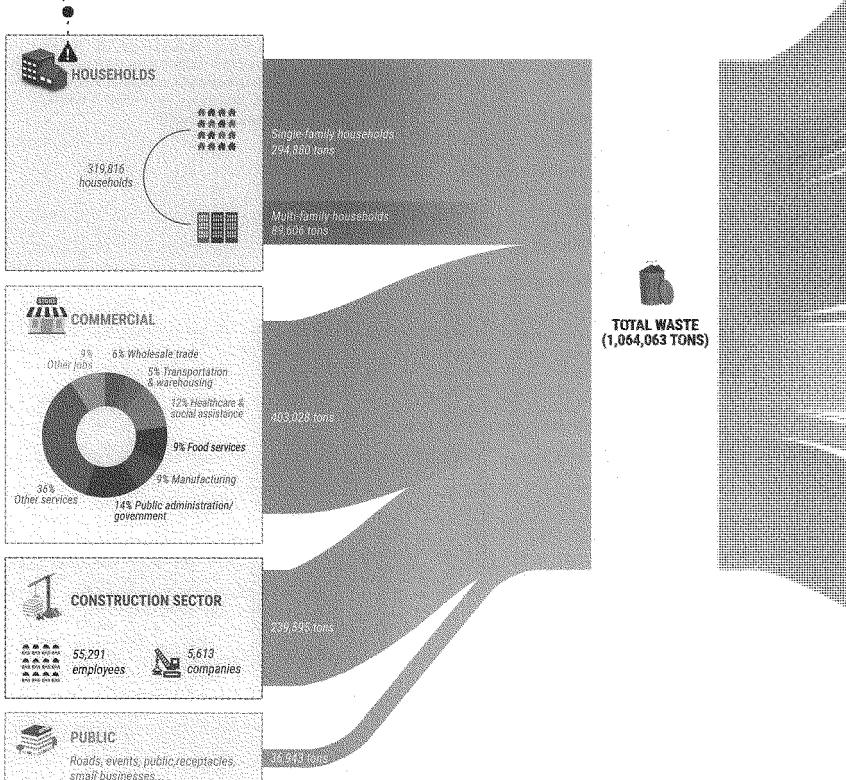
UNDERSTANDING WHAT HAPPENS WITH WASTE IN CHARLOTTE

Based on the data available (mainly from households and small businesses), we put together the big picture of waste flows in Charlotte, looking at where waste is coming from, what the composition of that waste is, and where it is ending up. Overall, we see on the left side that the amount of wastes coming from the commercial sector and households is roughly equal, with construction and demolition (C&D) wastes also contributing a large share. C&D wastes and organic wastes dominate the

total mass of waste flows in Charlotte (showed in the center of the graphic), followed by paper and plastics. On the right side of the graphic, the linear nature of the waste system in Charlotte is evident through the large share of wastes that end up in the landfill compared to what is recycled.

In the graphic we have highlighted a few important issues and opportunities for the waste system of Charlotte. One of these issues is the low recyclable collection rate in Charlotte, which is particularly low among multi-family households.

Lower recycling rates for multi-family households



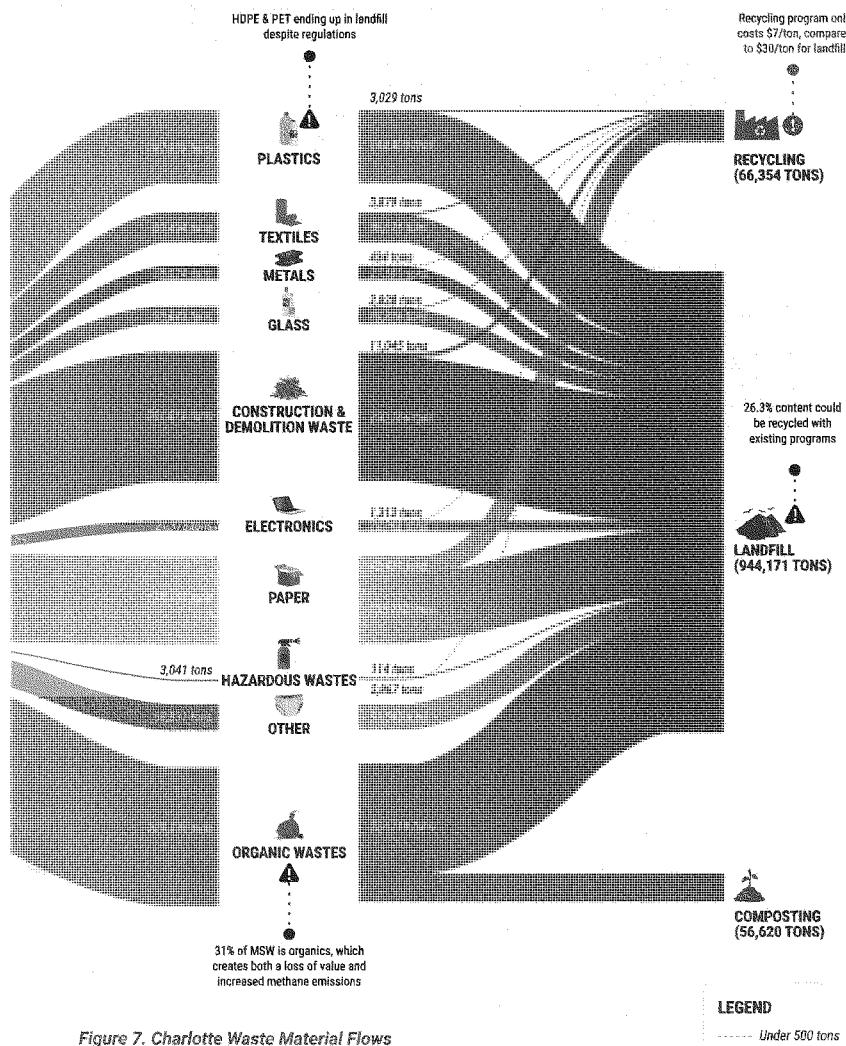


Figure 7. Charlotte Waste Material Flows

Landfilling materials in Charlotte comes at a greater cost than recycling - \$30/ton versus \$7/ton

Sending materials to landfill in Charlotte comes at a greater cost than recycling (\$30/ton versus \$7/ton). This means that even before new circularity strategies are explored, there may be a business case just for expansion of existing recycling programs and increasing recycling participation rates. If around 10% of the materials heading to landfill were recycled instead, this would result in more than \$2 million in savings.

In addition to economic losses, landfilling materials is also associated with environmental impacts. Envision Charlotte is working to establish a low-carbon strategy, which means striving for a net annual CO₂e emission of less than two tons per person. Reducing the total waste to landfill is one way of reducing emissions. Conventional landfilling of municipal solid wastes contributes between 138-601 lbs CO₂e per ton (Manfredi et al., 2009). In total, between 0.08 - 0.34 tons of CO₂e per person can be reduced by shifting to a completely zero-waste system.

Nearly a third of the total mass of materials going to landfill is organic waste. In addition to creating a loss in value and increasing the land requirements for waste storage, organic wastes in landfill produces a large amount of methane emissions during decomposition, which is a greenhouse gas around 25 times stronger than CO₂.

An additional issue is that landfilling wastes increases the demand for virgin resources, and can exacerbate impacts upstream associated with material extraction. Recycling materials such as plastic and paper can prevent the need for new production of these materials, while even waste incineration can reduce the need for fossil fuels such as natural gas or coal in electricity production.

As an example, you can consider wood and paper production, which has a large land footprint. To produce the wood and paper that is currently landfilled in Charlotte, you would need an area of nearly 17 square miles. To put this in perspective, you can consider that this is around 5.6% of the area of Charlotte or more than 100 times the area of the city's Freedom Park. A large share of this land area could be avoided by recycling paper and wood rather than sending it to landfill.

Waste diversion in Charlotte can prevent the need for additional virgin material consumption

Waste to energy can prevent the use of:



168,148 TONS
GAS



116,809 TONS
COAL

Recycling can prevent the use of:



144,403 TONS
PLASTIC



135,732 TONS
PAPER



56,615 TONS
TEXTILES

27,591 TONS
METALS

The land required for the production of wood & paper landfilled in Charlotte is 16.74 mi²/year, which can be avoided with effective recycling



THIS IS EQUAL TO
5.6% OF THE LAND
AREA OF CHARLOTTE



MORE THAN 100
TIMES THE AREA
OF FREEDOM PARK



In Charlotte, nearly 18% of food ends up in the landfill. This food could feed 149,487 people for a year.



Value of food:

\$385
MILLION
AS FOOD

\$5
MILLION
AS RESIDUAL
MATERIAL
(e.g. compost)

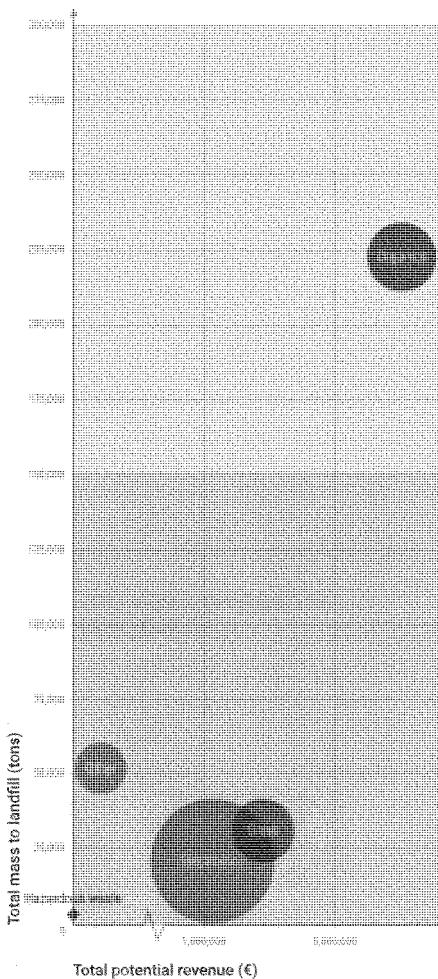
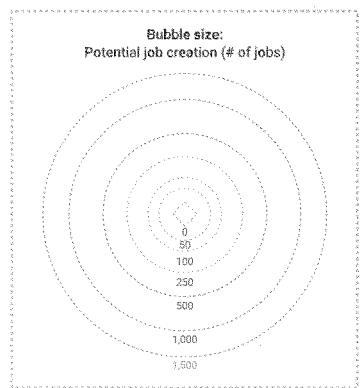
\$0
MILLION
IN A LANDFILL

UNCOVERING THE POTENTIAL OF CIRCULARITY

Circularity is not only about increasing recycling rates, but integrating circularity across the entire value chain and economy. The highest-impact strategies reduce the amount of material throughput and waste entirely.

As one example, consider food waste. In Charlotte, around \$385 million worth of food ends up in landfill, which would have the highest value if it were simply consumed as food. If this food waste was instead diverted to compost, it could be worth up to \$5 million, which is far better than its cost to landfill, but still results in an economic loss of \$380 million in total for Charlotte.

When designing a circular strategy, you should consider measures which make the highest-value use of material wastes possible. Mixed food wastes are of relatively low value, but with the right strategies in place, different fractions of that food waste, such as coffee grounds or fruit peels, could be applied to the production of higher-value products. However, this also requires re-imagining the waste system to enable separate collection or post-collection sorting. Mixed or contaminated material streams will be less economically viable to work with. Understanding these types of tradeoffs requires a much deeper assessment.



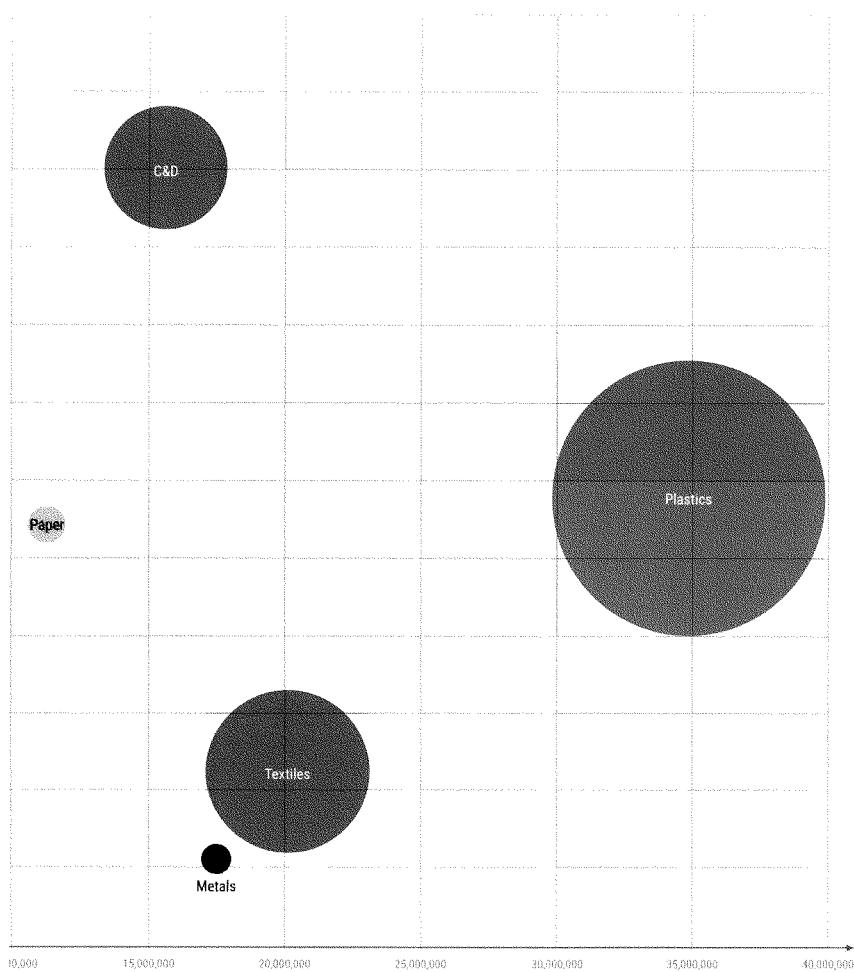


Figure 8. Revenues and Job Potential from Residual Value of Materials Landfilled in Charlotte

Without yet going to this level of detail, we took a first quick look into the potential value of the wastes going to landfill in Charlotte. We evaluated a rough economic potential for the materials, looking only at the residual market value of wastes (e.g. baled PET or waste pallets) and rough number of jobs created by recycling different materials. Figure 8 shows the total mass (y-axis) and total revenue potential (x-axis) as well as the estimated jobs potential (size of bubbles) for different aggregate materials categories. Materials such as plastics have such a high volume that the total potential revenues and job creation from this material stream is much higher in total than that of something like metals or electronics, which have a higher marginal value.

Just based on residual value and potential for job creation alone, the plastics going to landfill is the single most promising waste stream to start with. A total of more than 144,000 tons of plastics end up in Charlotte's landfills. Recycling these materials could create more than 1,000 jobs, bring in \$35 million in revenues, and avoid the consumption of nearly a million barrels of oil a year by avoiding virgin material consumption.

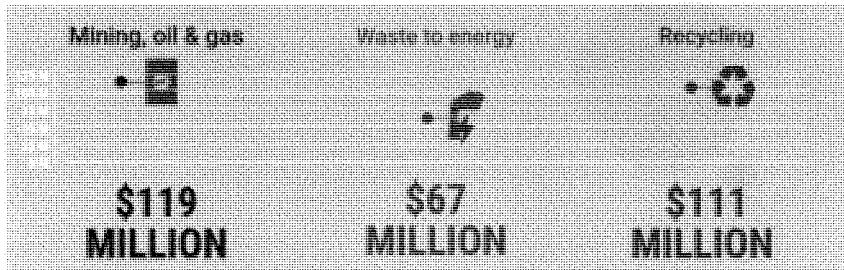
As a comparison, we also consider a scenario for waste incineration with energy recovery. While this would not be recommended as a circular strategy, it has some benefits over landfill, including eliminating the land footprint of waste storage, and generating

revenue from energy production. Waste incineration-to-energy has been widely adopted across Europe as an alternative to landfill. However, many countries that have adopted waste incineration are now locked into costly investments in waste incineration technologies and unable to shift towards higher-value recycling strategies in the short term, even when the potential benefits are clear.

Charlotte has an opportunity for leapfrogging to more truly circular options, but for some wastes where markets do not exist for reuse or recycling it may be more economically viable to explore medium-term options for energy conversion, even on a small scale, for example through biogas production.

As expected, the potential revenues and job creation are much higher for the residual material recovery than for energy production when we compare the scenarios side-by-side. What this does not take into account, however, is the costs of not only investing in logistics and infrastructure (which is trickier with recycling than incineration), but also the social, political, and economic systemic changes that need to take place in society as a whole. In the next chapter we explore how to develop a strategy for a zero-waste Charlotte in more detail, but a large part of the realization of circularity will require not only strong business models, but also paradigm shifts in our way of thinking about supply chains.

Diverting wastes from landfill in Charlotte can result in a comparable amount of additional revenues to those generated by the mining, oil, and gas sector



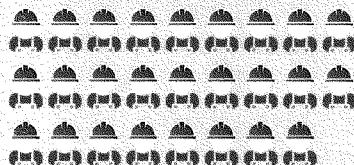
Decreasing the wastes going to landfill in Charlotte would result in additional jobs

Waste to energy



UP TO 102 JOBS

Recycling



UP TO 2,647 JOBS

Circular economy strategies such as recovery of components, refurbishment, or leasing can create even more jobs

If all plastics landfilled in Charlotte were recycled instead, this would save 936,329 barrels of oil per year while creating jobs and revenue



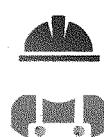
or



+



+



144,403 TONS

PLASTICS
LANDFILLED

936,329

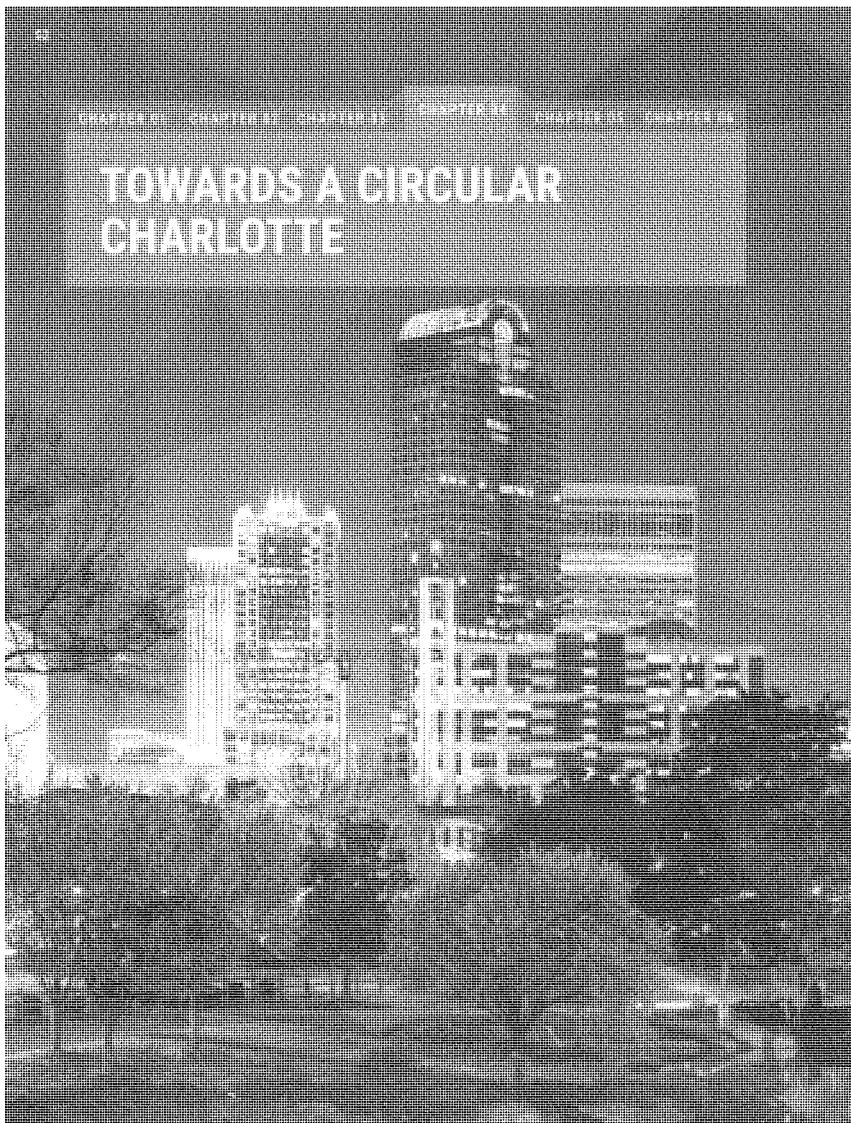
BARRELS
OF OIL AVOIDED

35 MILLION

REVENUES
POSSIBLE

1,343

JOBs
CREATED



DEVELOPING A STRATEGY FOR A CIRCULAR CHARLOTTE

The magnitude of the transformation that has to happen in Charlotte to achieve the circularity goals outlined in Chapter 2 will require a coordinated set of actions over a number of years, supported by strong leadership from local government, the private sector, and civil society. In this chapter, we synthesize the results of our stakeholder workshops, interviews, and research into a recommended plan of action for Charlotte to move towards a circular economy.

We first consider some of the barriers that Charlotte faces on its circular development path. Secondly, we delve into the systemic changes that need to take place to tackle these barriers and take advantage of the opportunities. We then present a draft roadmap of actions that need to be taken over the short, medium, and long-term. Some of these actions require physical changes to Charlotte's infrastructure, some require technical innovation, while others require social mobilization. Above all, success will require the city committing to a long-term transformation trajectory with sufficient financial and human resources dedicated to the process. An essential component of this process will be the development of buy-in from the

city's residents through a communications campaign and a city-wide rebranding as Circular Charlotte. The commitment to a circular economy should become a source of pride and local identity for the city and its residents.

As we describe here, there is also an overarching need for Charlotte to maintain accountability for its progress and for achieving the goals it sets. To underpin the other actions presented in this report, it is essential to develop a data collection and monitoring program that details how the city is progressing on improved resource management and inclusive economic development.

The strategy presented here is an initial recommendation that will need further revision and vetting. As more information is uncovered and specific circular business cases for the city are defined, detailed action plans will need to be drafted each year. As such, the strategy here should not be seen as a static document, but rather as a seed from which more concrete action pathways will sprout and be further defined.



OVERCOMING BARRIERS TO ACHIEVING CIRCULARITY

If done right, a circular economy in Charlotte will create opportunities for local employment, reduce the socio-economic divide in the city, and establish new industries that lead to greater local resilience and reduced environmental impacts. Ideally no waste will be going to landfill and all materials flowing through the city will be used as the basis for new circular manufacturing.

Many changes will need to take place within the city to make this possible and initial investments will be needed to unlock the value of circular business opportunities further down the line. As we've described in Chapter 3, around 88% of the waste collected from residents and small businesses in Charlotte is currently ending up in the landfill. The remaining recyclable material that is collected separately, as a single mixed stream, is sorted and baled at the local Materials Recovery Facility (MRF), which is operated by Mecklenburg County.

Up to 15% of the material sorted at the MRF still ends up in the landfill because it was incorrectly identified as recyclable or could not be properly sorted with the automated equipment at the MRF. The decisions that citizens make about what to put into the recycling system have a significant impact on how well these materials can be processed and the quality of the recyclables that are ultimately harvested. Leaving recyclables out in the rain, for example, can result in paper sticking to the plastic and glass, drastically reducing the ability of the automated sorting systems to separate these materials. And though plastic bags were once accepted for recycling in Charlotte, this has not been the case for many years. Putting plastic bags in the recycling, or even throwing out recyclables in a plastic bag, clogs up the sorting machines at the MRF, grinding the whole process to a halt several times a day.

Once the materials are finally sorted and baled at the MRF, they are sold off on the second-hand materials market. Some of these may stay in the Charlotte area, but most (especially prior to the Chinese ban on low-quality recyclables) leave the area. Even when this system is working perfectly, just selling these materials at scrap prices is a missed opportunity. The value of the bales of materials could be much greater - if more local businesses were geared to use them as resource inputs. With good design and effective technology, these base materials can be transformed into products worth hundreds or thousands of times the cost of the original scrap.

Clearly, however, there are a number of challenges to resolve before circular value chains can take root in Charlotte. In shaping a strategy, it is important to have an understanding of both the real and perceived barriers standing in the way of circularity. Once these are mapped out, they can be systematically addressed

through a strategic plan. Below we describe some of the most significant barriers that have emerged throughout our research and in our conversations with stakeholders, grouped across four categories.

Physical and Technological

Though technological advancement is generally far ahead of what is commonly implemented, there are still some gaps in the physical and technological infrastructure that we need for a transition to a circular economy. Collection from multi-family housing remains a challenge. Where over 50% of single family homes participate in recycling, that proportion drops to only 15% of families living in apartment blocks. This is due to a variety of factors such as lack of space for storing separate recyclables, lack of service providers to do in-house collection, and the anonymity of individuals (making it difficult to enforce recycling behavior in line with regulations).

There is also lack of infrastructure in the city more broadly. For instance, Charlotte currently has no means for recycling styrofoam, plastic dinnerware and cutlery, aluminum or plastic foils and wraps, diapers, ceramics, and any glass that is not used in packaging (glassware, plate glass). Additional facilities, such as centralized plastic shredding equipment, have been cited by Engineered Recycling Company, LLC as potentially important pieces of equipment that could allow more smaller recyclers to afford to start businesses in the sector.

Finally, there are some more systemic challenges in this category: perhaps most importantly, the majority of products on the market are not designed for high-value reuse and recycling. They are often made of mixed materials, have unknown additives, are assembled with glues making them difficult to take apart, or use problematic dyes and colorants that can contaminate whole recycling streams. Now that most cities collect mixed stream recyclates, it is also essential to further develop sorting technology using more advanced optical techniques or robotics.

Social and Cultural:

One of the more fundamental challenges that all societal transitions face lies in changing the behavior and mindset of people. Participation in recycling programs is still far from 100%, particularly in multi-family households where physical challenges provide an additional barrier. Moreover, many people are still unaware of sustainability challenges, and therefore do not have as much personal motivation to consume responsibly. On the other side of the issue, the transition to a circular economy will require a great deal of new skills and knowledge: a whole new workforce of people trained to remanufacture products and reuse materials in different ways. To make this transition work, companies from across the value chain will need to collaborate - out of their own intrinsic motivation for change, or through incentives to do so.

Economic and Financial:

In any kind of transition, you need to invest resources to develop new knowledge, technology, and ways of doing things. The financial piece of change management can sometimes be challenging. Currently, most recyclables have low value - partly, in many cases, because of high levels of contamination and lack of purity among the collected resource streams. A bale of pure PET bottles has much higher value than a bale of mixed plastic, for instance. It is essential to work actively with the market to develop solid business cases for circular resource management (some examples of which can be found in the next chapter of this report). There is also the usual challenge of securing money for capital investment: small recyclers often cannot afford the expensive equipment that is needed to get a recycling business started.

More generally, the transition to a circular economy can be hampered by the fact that most environmental impacts (externalities) are not currently priced within day-to-day transactions, there are not sufficient funding vehicles available for projects focused on high social and environmental benefits, and that financial partners tend to be risk averse.

Political and Legal:

There are, finally, a number of political and legal barriers. One of these is the solid waste interlocal agreement between Charlotte and Mecklenburg County, which currently dictates how all of Charlotte's waste is handled after collection (further described on page 43). In general, the process of passing new laws is very slow and frequently involves state involvement, so it can be challenging to get new regulations in place that could advance the circular economy. Aside from this, there is a general aversion to, for example, any kind of taxation, which could be an important policy instrument in pushing for more sustainable material use in products.

On the day-to-day level, existing rules and regulations can hamper how certain waste streams are used and where certain activities (such as food production) can take place. These rules often exist for good reasons, but with changes in technology they become outdated and should be revised. There is also, however, legitimate concern about the health and safety of reusing certain post-consumer materials, which could lead to lawsuits (the fear of which can keep entrepreneurs from entering certain sectors).

KEY BARRIERS TO CIRCULARITY IDENTIFIED IN STAKEHOLDER SESSIONS

Physical and Technological

- Collection from multifamily housing
- Space requirements
- Current capabilities - technology still needs to advance in health and safety of recycled materials
- Added materials in products, lack of design for broader recycling
- Lack of infrastructure for collection and processing

- High cost of waste management - small recyclers can't afford capital investments
- Inadequacy of financial incentive structures (e.g. pricing of externalities)

- Lack of appropriate funding subsidies
- Risk aversion of financial partners (e.g. banks)

Social and Cultural

- Lack of participation from residents
- Lack of training and knowledge
- Consumption patterns
- Lack of creativity and ingenuity
- Lack of recognition for stakeholders who contribute to success
- Difficulty participating in discussions and writing supply chain partners to documents

Political and Legal

- Solid waste interlocal agreement between Charlotte and Mecklenburg County
- Resistance to new legislation / regulation
- Difficulty of passing any local laws without state involvement
- State and national political climate opposed to prioritization of sustainability
- Design and safety of recycled materials (contamination)
- Price of raw materials and cost of labor (i.e., increased visibility)
- Land, water, and energy regulations (i.e., water pollution taxes)
- Regulatory capture and corruption
- Incentives for fossil fuel companies, etc.

Economic and Financial

- Low value of recyclables - finding private circular business cases that work

SYSTEMS CHANGE FOR CIRCULARITY

In this section, we describe some of the actions we believe are necessary for Charlotte to take strides towards circularity in the near-term, mid-term, and long-term (also summarized in the roadmap on pages 66 - 71). As with the vision and KPIs, the actions in the roadmap have been drafted with input from stakeholders across Charlotte. We recommend that this draft be used as the basis for a co-creation process to further refine these plans. Once the roadmap is finalized, it should ideally be revisited on an annual basis to make the activities for the upcoming year more specific and relate them to concrete yearly goals.

SHORT-TERM ACTIONS (0 - 5 YEARS)

Charlotte's transformation to a circular city clearly cannot take place overnight. Near term actions should focus on building awareness among the city's citizens, business owners, and other key stakeholders on what the circular economy is and the different opportunities it can provide as well as laying the groundwork for tackling some of the barriers described in the previous section. In addition, it is essential to identify tangible actions, showcases, and circular business cases that can be executed quickly in order to build support for the approach and demonstrate its value. Further steps should include capacity building and efforts geared at longer-term transformation, such as neighborhood action plans, the establishment of new partnerships and institutions, and monitoring programs to track the city's progress on circular economy metrics (i.e., the KPIs presented in Chapter 2).

Public Sector Commitment and Circular Strategy Development

The activities in this category establish the foundation for Charlotte's transition. As evidenced through this study, some of the first and most important steps are already underway: securing public sector commitment to the circular economy and getting a basic understanding of the opportunities within the city to progress in this direction.

- Establish public sector commitment to the transition to a circular economy.** The city management should have a shared understanding of what the circular economy means and the opportunities it could bring to the city. There should be commitment to allocating resources (both time and money) to making the circular economy a reality in Charlotte.
- Complete baseline assessment on Charlotte's current circularity performance.** City representatives should agree on the metrics used to evaluate Charlotte's circularity performance. A baseline calculation of how Charlotte is currently doing on these metrics should be completed and used to track later progress. A significant part of this baseline assessment has already been completed in this report.

- Develop initial circularity strategy.** The circularity strategy presented in this report should be refined and vetted by the city management and other key stakeholders, ideally resulting in a more specific one-year action plan along with a timeline for reviewing and advancing the strategy on an annual basis.

- Align Charlotte's other strategic goals with circularity.** To ensure alignment between Charlotte's circular economy strategy and other political goals, the city should conduct a review to see how other targets (livability, economic development, climate change objectives, etc.) coincide with the circular economy plan. These should be cross-referenced and integrated for consistency.

Communications Strategy and Development of the Innovation Barn

Once there is clarity and alignment on the basic principles of the circular economy and Charlotte's approach to this transition, the next steps should focus on communicating this commitment to the local, national, and international audiences and developing some tangible showcases. An important part of this visibility is the development of Charlotte's first circular showcase, the Innovation Barn, which Envision Charlotte is already developing.

- Rebranding the city as Circular Charlotte.** Going public with the city's commitment to the circular economy should ideally be coupled with a branding process identifying the city as Circular Charlotte. This should include a recognizable logo and color scheme that can be used to signpost any activities related to the transition plan.



- Communications campaign for Circular Charlotte.** The city should develop a comprehensive communications strategy around the circular economy plan and its other sustainable development commitments. This communications strategy should include a publicity campaign, largely targeted at Charlotte's residents. It should build awareness of the plan and give citizens clear ways that they can get involved and participate.

- **Define plans for the Innovation Barn as the city's first Circular Living Lab.** Already underway, the city should define plans for the Innovation Barn, clearly identifying it as the city's first Circular Living Lab / experimental hub. The Barn should become the physical seat of circular activities in the city, encouraging participation and providing ways of engagement for all of Charlotte's residents. It should include showcases of circular innovations, recreational activities, educational facilities, and workshops that can facilitate pilot projects. The Barn should itself uphold the highest standards of circular economy performance: it should ideally be a zero waste building and designed according to circular building principles.
- **Secure funding and commitment for Charlotte's Innovation Barn.** There needs to be funding for the development of the site, but also sufficient resources for the further maintenance and operations side of the project.

Establishing Circular Programs & Staffing

For this transition to be successful, it is essential for the city to establish longer-term circular economy programs and create support roles within the government to facilitate this process. A lot of effort can also be expected of the business community and civil society, but a fully-fledged adoption of circular practices is not likely to happen on its own without initial leadership and guidance from the city.

- **Appoint Chief Circularity Officer.** To drive the strategy forward, the city should appoint a Chief Circularity Officer. The person in this position should be ultimately responsible for overseeing and implementing the circularity strategy.
- **Set up Circular Charlotte Program.** There should ideally be a Circular Charlotte Program facilitated by the city and overseen by the city's Chief Circularity Officer. This program should provide support functions to the city's entrepreneurs seeking to start circular businesses, it should coordinate stakeholder dialogues to better understand the challenges that companies are facing in moving towards circularity, oversee the city's progress on relevant KPIs, help establish financing mechanisms, convene sectoral dialogues to support the formation of partnerships, host a circular stakeholder network and take other measures in this direction. The different activities under the program should be defined based on the annual circular economy strategy. To ensure long-term commitment on this topic from both the public and private sectors, the program should ideally be funded for at least five years once it is initiated.
- **Work out actionable circular business cases in detail.** In Chapter 5 of this report, we have identified and described a handful of circular business cases that are promising for Charlotte and can be executed within

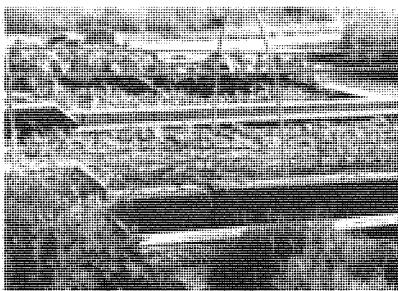
current technological and legal limitations. These and other business cases should be worked out in further detail. Ideally, the city can identify profitable circular activities that it wants to participate in on its own. Revenues from these activities can be earmarked to further finance the circular transition. Business cases not suitable for the city can be co-developed as part of the Circular Charlotte Program and made available on the city's website or in a published handbook.

- **Identify and define circular financing vehicles.** Even if great business cases are identified, no action will take place without appropriate investment. Charlotte could initiate a dialogue with the banking community about establishing a revolving investment fund (or funds) focused on supporting circular businesses and innovation. There are potentially novel constructions possible if the city could provide some financial resources to "de-risk" the investments by taking on the role of a partial co-signer for circular business loans. This is one of many directions for circular financing. Other options include subsidies, tax breaks, grants and fellowships in partnership with philanthropic organizations, etc. The city should take an active role in helping to identify possible funding schemes for supporting circular innovation.
- **Begin discussions on reframing the next interlocal agreement.** Though the current solid waste interlocal agreement between Charlotte and Mecklenburg County does not expire for another decade, it is important to already conceptualize how this agreement could be modified in the future to facilitate circular innovation and understand what kind of outcomes are important to the stakeholders involved.
- **Establish competitions and awards for circular innovation.** The Circular Charlotte Program can host a variety of annual awards for circular innovation focused on different sectors (e.g., hotels, retail, manufacturing) or target groups (students, corporates, start-ups).
- **Develop neighborhood action plans.** To engage the local community in the circular economy, Charlotte should develop neighborhood actions plans together with residents of local communities. These plans should be based on an understanding of the context and specific features of each community and include actions for helping accelerate the circular economy locally. For example, some neighborhoods might want their own repair cafe or facility for sharing tools and appliances, whereas other communities may primarily focus on increasing local recycling rates.

Building Circular Infrastructure and Resources
In parallel to building alignment and commitment to the circular economy, the city should take steps towards creating the physical changes and hands-on programs that will get the movement going. This involves actions ranging from increasing collection and processing

capacity for specific waste streams to developing programs that lead towards circular job creation.

- Set up a revolving fund for community garden establishment.** Community gardens can play an important role in the cycling of local organic waste (in the form of compost). This is one of the lower threshold circular activities that the city could support, which will also provide a range of social and health benefits to communities.



Scale up logistics and processing capacity for high-priority waste streams. We have identified organic (food) waste, plastics, textiles, and concrete as some initial high-priority waste streams for Charlotte to focus on.

Set up task forces for priority waste streams. We recommend that Charlotte set up a task force for each of the high priority waste streams. These task forces should include representatives from the government, private sector, and citizens, and should be asked to identify ways that collection and processing of these target streams can best be scaled up.

Support community centers in setting up centralized recyclable collection capacity. Community centers, including churches and schools, should be encouraged to set up facilities for the collection of recyclable materials. The city should provide guidance on the types of materials that should ideally be collected (for example: food or textile waste), and create an incentive structure for participating groups.

Pilot for homeless employment in circular waste management. The city is already discussing how to establish a rehabilitation program for the homeless by engaging them in activities around circular waste management. This project should ideally start with a specific waste stream (potentially linked to one of the business cases described in the next chapter), that can be processed in a high-value way.

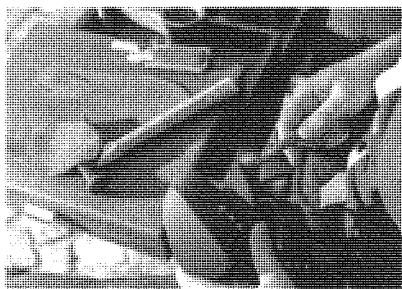
Identify key infrastructure that needs to be invested in. The outcomes of the waste stream task forces

should ideally help identify the kinds of centralized infrastructure that it would most make sense for the city to invest in centrally. One example mentioned in stakeholder interviews is equipment for the pre-shredding of plastic, which would facilitate the ability of small recycling companies to develop.

- Campaign for food waste reduction.** Though waste materials can be processed into high-value products, waste is best avoided to begin with. This is especially true when it comes to food. The city can set up a campaign for food waste reduction, making people aware of tools and apps available for avoiding food waste and by facilitating new enterprises that address food waste challenges.



- Set up repair cafes.** The city should encourage the development of repair cafes, especially in underserved communities. This can provide a training opportunity for the development of new skills around the repair of specific products like clothing, furniture, or electronics.



Establish the Basis for Circular Monitoring

A final category of actions in this near-term phase is to establish the necessary tools to collect and evaluate data on how the city is progressing towards its goals on circularity. Without this insight, it's impossible to

understand which of the approaches described here are working and resulting in the greatest progress.

- **Establish new data collection protocol for material inputs and outputs for the city of Charlotte.** To be able to continuously monitor progress towards circularity, the city needs to establish a new data collection and monitoring protocol for material flow data as well as the other metrics that have been defined in the KPIs chapter. Ideally, the collection of this data would be largely automated and the results continuously displayed in a city dashboard. Different neighborhoods can also be monitored on their contribution to the city's overall score, helping define focus for where different actions need to be taken.
- **Invest in urban sensing and open data infrastructure.** To facilitate the tracking of data for monitoring circularity performance, the city should invest in sensor systems. These can be used to monitor the total quantity of waste and recyclables disposed throughout Charlotte and help improve waste management logistics.



Build Circular Charlotte's International Profile

As Charlotte makes progress towards its circular economy objectives, the city should make a point of gaining international visibility for its efforts: not only for the direct benefits it will bring in attracting talent and improving the city's international standing, but also as a way of sharing solutions that work. Other cities and regions will be able to learn from Charlotte's successes and failures, helping accelerate the transition to a circular economy worldwide.

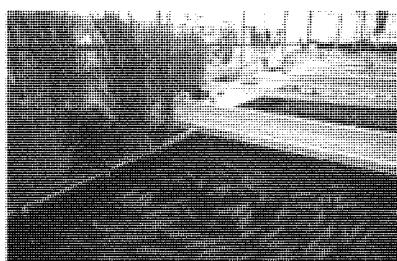
- **International profiling through presentations and speeches.** Representatives from the city of Charlotte should take advantage of opportunities to speak abroad and share the story of Circular Charlotte. Some budget should ideally be set aside for a few international events per year.
- **Set targets around high performance on city rankings.** Charlotte should review the various criteria for different city ranking indices and ensure that they are aligned with its own performance goals.

MEDIUM-TERM ACTIONS

Once the baseline infrastructure for a circular economy in Charlotte is in place, the next phase of activity should build on this foundation. Developing educational and training programs, introducing policies and financing mechanisms, as well as building out Charlotte's innovation ecosystem and circular infrastructure are all important pillars of the medium-term actions we recommend here.

Develop Circular Education Programs

- **Scale-up aquaponics in schools programs for education.** Local initiative 100 Gardens is working to bring aquaponics installations (food production systems that combine fish and plant cultivation) into the city's schools. One of the primary goals behind this project is to create learning experiences for students to understand the interconnectedness of natural systems, add a hands-on aspect to science curricula, and introduce a range of practical skills in areas such as business and marketing. Scaling up this program is a straightforward way of introducing circular thinking in schools with a group that is already active in Charlotte.



- **Adjust school curricula to include circular education.** One of the most commonly mentioned requests by stakeholders is to adjust school curricula in Charlotte to include modules about the circular economy. This is an important step in changing the long-term attitudes of Charlotte's citizens and building the knowledge and skills that are needed to realize a circular economy. Adjusting the curriculum in local schools may be challenging in practice since curricula are defined at the state level. Even so, this is an impactful enough direction that these challenges are worth overcoming.

- **Develop new higher education programs focused on STEM skills and circularity.** Charlotte is currently lacking sufficient higher education programs focused on engineering and technology, which are essential knowledge areas for the circular economy. As we describe in the vision for a circular Charlotte, an important mid-term action would be to establish

new higher education programs focused on circular engineering and design. This would ideally be taken on as an initiative by local universities such as the University of North Carolina Charlotte.

- **Offer free circular construction and deconstruction classes.** Construction and demolition (C&D) waste is the largest single waste stream making it into landfill - not only in Charlotte, but in most cities. Circular construction techniques ensure that buildings are designed for disassembly and reuse, which will lead to the reduction of future C&D waste flows. Even with existing buildings that have not been designed or constructed in a circular manner, proper deconstruction practices can result in much higher quality material for reuse or recycling in new construction projects. Local NGOs, like the Goodwill Opportunities Center, could provide training on circular construction and deconstruction practices. Additionally, the city could sponsor training programs at relevant companies in the construction sector.
- **Start circular mentorship program for high school students.** The Equality of Opportunity Project, in addition to identifying Charlotte's lagging status on economic mobility, has shown the clear link between income and innovation. High potential students from low-income families risk becoming "Lost Einsteins": would-be innovators who were never able to realize their potential. One possible solution to this problem has been identified: providing high-potential students with access to mentorship and exposure to the way of thinking and skills that are needed in order to become innovators. A high school mentorship program would ideally connect students with companies and startups focused on the circular economy.



- **Establish trade skills training center for the Circular Charlotte brand.** Trade skills like carpentry, sewing, and shoe repair are important for artisanal-scale local manufacturing and product reuse. The Circular Charlotte brand, mentioned later in the roadmap, is a product label for all new products and goods made in the city following circular principles. A training center could teach individuals of all ages the necessary skills

to make new products while also giving them the knowledge they need to do this in a truly circular way.

- **Culinary schools establish program for entrepreneurs in circular cuisine.** There are several well-known culinary establishments in Charlotte which could play a strong role in changes practices in the restaurant and food service sector towards reducing food waste. Chefs can be taught how to run more circular kitchens - with a focus on resource efficiency and waste reduction. These programs can also shine light on the many possibilities of new circular business models in food service: using food grown on-site, salvaging produce rejected for aesthetic reasons from farms or retailers, and creating haute cuisine from excess food purchased by retail stores.

Establish Circular Incentives and Policies

Some of the most important systemic shifts towards circularity involve changes in incentives and policy structures. When the "rules of the game" are designed to favor circular behavior, then this will take place much more naturally. Some of these actions may be quite challenging to implement and may require many years of discussion and lobbying, so it is important to look to other parts of the U.S. and the world where these kinds of measures have been successfully put in place and to get started on this path as quickly as possible.

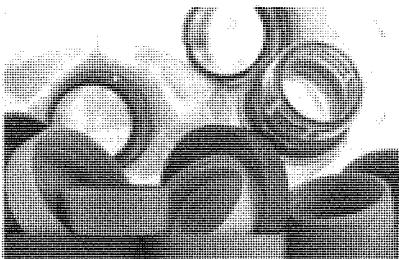
- **Implement "untax" incentive system for citizens to recycle.** In Charlotte, and North Carolina more broadly, there is a strong aversion to new forms of taxation. Ultimately, however, taxes are an important policy instrument that could support the transition to circularity. A lower-threshold initial mechanism that can be tried is "untaxation": providing refunds or credits to incentivize recycling behavior. For example, citizens could get credits for every bag of recycling they deliver to a designated drop-off point. The feasibility of this approach, and its exact mechanism, would need to be further explored.

- **Ban food wastes in restaurants.** Banning food waste in the restaurant and hospitality sector refers to making it illegal for these establishments to throw food or organic waste into the trash. All edible food would ideally be used as food: donated to homeless shelters or otherwise processed into products like soups, sauces, and preserves (potentially by a third party). All organic waste would be composted, biodigested, or processed into materials.

- **Develop circular procurement guidelines for retail stores.** One of the biggest sources of municipal solid waste is food and product packaging. The city could develop and disseminate circular procurement guidelines, encouraging stores to push their suppliers toward buying products with less packaging. This could lead towards a push up the supply chain for changes in product packaging. To encourage the adoption of

these circular procurement standards, the city can later host an annual award recognizing the retailers who have managed to reduce their waste flows most significantly.

- **Define circular building standards for Charlotte.** This measure is particularly important if Charlotte continues to grow at its current pace. All new buildings should eventually adhere to circular building standards, simplifying the process of extracting high-value materials once buildings are ready for renovation or demolition.
- **Abolish sales taxes on circular activities** (repair, refurbishment, etc). One measure that can be taken to incentivize the refurbishment and sale of second-hand goods is to remove the sales tax for all related products and services. This approach is currently being implemented in Sweden.
- **Develop circular procurement criteria for the city's own purchasing.** City governments are an important player in the local economy, buying a significant amount of local products and services. By only buying "circular" products and services, the city of Charlotte can help build the local market for these kinds of solutions while further raising awareness about the transition.
- **Ban on single-use plastics.** Though it may now sound controversial, a growing number of municipalities and even countries are implementing bans on single-use plastics. Within 10 years time, this will likely be a more acceptable action to take in Charlotte, and will also drive people and businesses to move towards more circular solutions.



- **Reward tiered pricing housing development.** An important part of circular development that should not go unrecognized is the importance of maintaining a diverse population through inclusive urban design. It is essential to have city centers where artists and makers can live alongside tradesmen, service workers, and professionals. To facilitate this, the city should consider policies that preferentially award development rights to projects that provide diverse types of housing alongside space for facilities like workshops and studios.

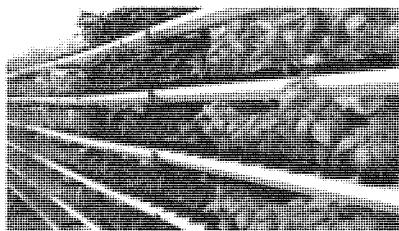
• **Revisit zoning regulations and land allocation to support circular activities.** The city should take a look at where zoning regulations may be hampering the development of circular initiatives by, for example, preventing the establishment of urban farms or clean, small-scale manufacturing activities. The zoning code should ideally be revised with the consideration of new technologies and how they might fit into the urban fabric differently than past options.

• **Stricter enforcement and fines.** Even today, it is technically illegal to landfill PET and HDPE plastics, but this is still broadly happening throughout Charlotte. The city should take a stronger stance on enforcement of existing laws as well as any new policies that are put in place to support the circular transition.

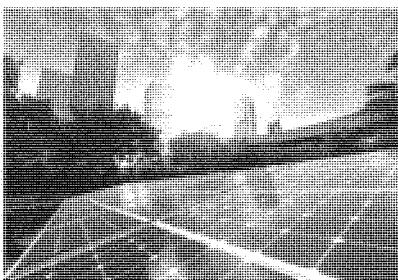
Further Develop Financial Support for Circular Economy

Financing is often one of the most significant stumbling blocks towards innovation. Here we suggest a small selection of topics and mechanisms to focus on with targeted circular finance vehicles.

- **Establish fund for setting up vertical farming projects in Charlotte.** Local food production in landless vertical farming systems can lead to multiple social benefits. If done properly, it can also reduce the environmental footprint of food production and serve as a means of recycling organic waste (as compost and liquid compost derivatives) within city limits. The city should consider setting up a dedicated fund for these types of projects.



- **Establish a loan program for local small recyclers to start up or scale up.** Small recycling companies will initially be at the core of Charlotte's circular transition and should be supported in starting and scaling up.
- **Establish a revolving fund for small-scale renewable energy and battery storage projects.** The circular economy ultimately needs to be powered using renewable energy. Projects on decentralized energy production and storage are an essential part of this transition and should ideally be financed by a city-wide revolving fund.



Build Innovation Ecosystem

An innovation ecosystem refers to the labs, accelerators, communities of startups, and the groups of entrepreneurs that will need to drive a large part of the development of a circular economy in Charlotte.

- **Establish innovation labs and accelerators.** Though Charlotte already has a number of accelerators and innovation labs, these should ideally expand their focus to specifically support circular economy initiatives, or dedicated innovation labs should be set up for this purpose.
- **Replicate the Innovation Barn model in other Circular Living Labs.** The Innovation Barn is going to be one of the most important visible showcases for the circular economy in Charlotte. The most successful aspects of this project can be replicated in other circular living labs that potentially focus on scaling up circular projects, or that are dedicated to handling specific waste streams, like organic waste or plastics.
- **Set up an entrepreneur helpdesk with support services for launching new businesses.** Starting a new business can be challenging - particularly if you do not have a lot of the basic knowledge about the legal, financial, and managerial aspects of running a company. The city could support would-be entrepreneurs with basic training on setting up a business, and launch a helpdesk to assist new companies with some of their administrative and legal questions.
- **Identify locations for circular industry park.** A circular industry park could be an important hub for new manufacturing activities. By co-locating different businesses in one place, you can also facilitate the trading of different material streams (through industrial symbiosis). The city should, in this mid-term phase, investigate what locations might be suitable for setting up such a park.

Further Develop Circular Infrastructure

Alongside all the regulatory and knowledge-centered efforts that need to take place to move towards a circular

economy, there will continue to be many necessary changes to Charlotte's physical infrastructure to help bring about the transition to a circular model.

- **Begin investing in R&D in plastics, textiles, and construction waste processing.** The city should ideally set aside some of its own R&D funding for the recycling and processing of selected high-impact waste streams. This investment should ultimately yield profits that can offset its original cost.
 - **Develop reverse logistics and storage to facilitate urban mining.** It is clear that additional sorting and storage facilities will be needed to, for example, stockpile components from buildings for later reuse. The city should ideally identify locations for these kinds of material hubs, considering where the optimal spots might be based in proximity to waste streams or new projects.
-
- **Invest in central infrastructure to increase quantity and quality of materials processed** (e.g. a plastic shredder, optical sorting, disassembly robots). As discussed in the barriers section, there are still some pieces of central recycling infrastructure that are not at a sufficient level of development for efficient material separation. At the same time, private businesses are often not able to afford this equipment. Charlotte can give all of these players a boost by investing in the centralized technologies that would be most collectively useful.
 - **Introduce new collection systems to increase volumes** (e.g. bins with technologies or incentivized takeback systems). As technologies in waste collection advance, the city should look at implementing systems with tracking, or built-in incentive systems that reward people for depositing correctly sorted recyclables. The city can run pilots with several technologies before settling on a direction to see which approach is most successful at increasing collection volumes and material purity.
 - **Build circular marketplaces** (including an upcycle mall). To drive the growth of a circular economy,

there also needs to be a growing demand for circular products. Setting up marketplaces for products made in a circular way or for products that have been refurbished or remanufactured is one way to achieve this. One possible concept is an "upcycle mall": a shopping mall where every store sells only refurbished or second-hand goods.

City-Wide Innovation Projects

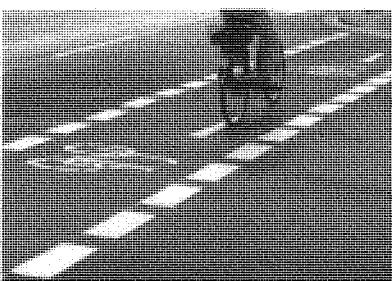
Aside from broad support in the development of circular infrastructure, Charlotte should ideally take on a few iconic projects that advance the city's progress towards a circular economy in highly visible ways.

- **Begin a pilot of Charlotte Coins.** The idea of the Charlotte Coin, as described in the vision section of this report, is to have a complementary currency that can be used to reward participation in recycling schemes and be traded in for discounts on circular products or services. The city can host a pilot of this concept, or find a suitable NGO or other organization to support in this effort. **Fully establish the Circular Charlotte brand for products.** Having a brand with clear standards that can only be applied to local products that are also made in a circular way is something that can benefit the city by boosting the local economy and increasing outside visibility.
- **Address wastewater nutrient and materials recovery.** Wastewater contains many different valuable resources like nitrogen, phosphorus, heat, fiber, and even metals. These should ideally be harvested and reprocessed into valuable products. Alternative sanitation projects around the world are currently experimenting with resource extraction from wastewater. To become truly circular, Charlotte should eventually also address this important (and sizeable) resource flow.



• **Begin the first Charlotte smart grid pilot.** A pillar of the circular economy is to maximize the amount of renewable resources used in the system, including renewable energy. A smart grid can facilitate efficient use of energy and the management of many individual sources of power generation (such as household photovoltaic arrays). Charlotte should support larger-scale transitions in the city's utility infrastructure.

• **Start to develop protected bike lane routes throughout the city.** Carbon-neutral mobility will be much easier to achieve in Charlotte if bicycle travel is made safer and easier. The city should lay the groundwork in terms of urban planning as early as possible to prepare for the construction of a city-wide network of bike lanes.



Further Develop Circular Monitoring Capabilities

After Charlotte's circular economy performance has already been monitored for several years, it will become clearer as to which metrics are most useful and which ones need additional refinement. With data collection infrastructure in place, the city should aim to further automate its monitoring capabilities and make the information more easily accessible to the city's residents through a public Circular City Dashboard.

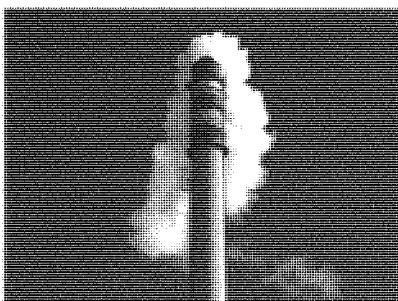
- **Develop a Circular City Dashboard.** Ideally, Charlotte's Circular City Dashboard should be a publicly accessible portal containing all available information on the city's circular economy performance. Residents should be able to see the relative performance of their own neighborhoods, find circular marketplaces and resources, and connect with local initiatives. The Dashboard would also play an essential role for city officials, providing feedback on which policies and incentives are working effectively.

LONG-TERM ACTIONS

The further we look into the future, the more speculative our recommendations naturally become since it is impossible to predict how technologies will develop and how society will change over time. Even so, there are some actions that we imagine Charlotte taking on that we think will become relevant a decade or more from now. Some of these are briefly described here.

New Technologies

- A small-scale incinerator with energy recovery for remaining non-recyclables.** It is unlikely to become possible to ever fully recycle 100% of all materials. Some waste streams will remain that are hazardous, degraded, or highly contaminated. Yet burning these materials for energy is still preferable to landfilling. For these reasons, it would eventually be a good idea for Charlotte to investigate installing a small-scale incinerator or gasification unit, which could handle the remainder of the materials that cannot be used at high value. This incineration process should result in air quality that is equal to or better than the ambient air.



- Smart sorting containers at neighborhood level.** As Internet of Things (IoT) technologies advance, trash collection units will become increasingly smart: they will be able to report how full they are and predict when they will need to be emptied. They may even be able to pre-sort or reject inappropriate content deposited by citizens. Charlotte should implement these kinds of technologies as they become available and financially feasible to use. They will increase the quality of recyclables and improve the efficiency of collection logistics. They can also be paired with Circular Charlotte Coins, giving households rewards for recycling.

- Advanced scanning and sorting technologies for recyclables.** Artificial intelligence, machine learning, and robotics are advancing rapidly. These technologies will make it possible to sort post-consumer wastes

much more effectively and safely. Charlotte should conduct tests and support R&D in this area, and ultimately move to adopt these technologies as they become available.

- Pilot for an on-demand self-driving public transport system.** A large part of the environmental and health impact in cities comes from the thousands of cars that emit air pollutants, take up space when parked, and lead to significant amounts of waste when they are disposed of at the end of their useful lives. By adopting a public transport system with on-demand self-driving vehicles, Charlotte can provide citizens with the flexibility of traveling when and where they want, while also reducing the total vehicle stock in the city.

Continued Innovation

- Charlotte starts developing circular industry park.** Fully scaling up circular activities will eventually require larger-scale industry. Charlotte should make space for the development of new, circular manufacturing by opening up a circular industry park, which should itself be designed as a zero waste facility.

- Emergence of full-service living concepts.** Full service living concepts are apartments or homes where appliances, furniture, and even transportation or food delivery services are provided as part of a package deal. This can help extend the useful lifespan of different products, encouraging companies to design and select equipment that can easily be maintained and upgraded, ultimately reducing waste. It would also increase convenience for residents. As these concepts emerge, this is one pathway that can be explored by Charlotte.



- Establish a new engineering school at UNCC focused on circular design.** Ultimately it is essential for Charlotte to develop a stronger basis in STEM education and attract more science and engineering students to the area. To achieve this, UNCC or another local university should work towards establishing an engineering and design school with a strong circular economy focus.

- **Launch a revolving fund for waste-to-products companies.** Funding new initiatives will remain an essential prerequisite for innovation. Charlotte should continue to provide long-term financial resources for this purpose, ideally in the form of a revolving fund.

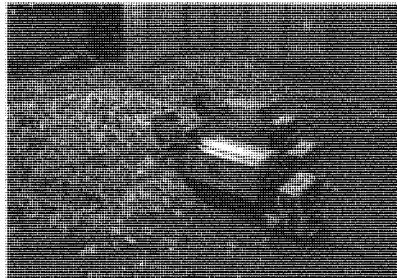


Advances in Circular Policy

- **Adopt circular procurement criteria for all purchasing.** City government is one of the driving forces in any urban economy - largely through its purchasing power. If every dollar spent by the city helps build the demand for circular goods and services, Charlotte's advances toward circularity will rapidly accelerate. The city should define and phase in purchasing guidelines for all products and projects (e.g., construction of new buildings or infrastructure).
- **Require new buildings be built to circular standards.** With circular construction and demolition knowledge becoming more widespread throughout the city, Charlotte should move to require all new buildings to be built to circular standards.
- **Increase waste collection fees (pay-as-you-throw).** As waste collection, sorting, and processing infrastructure becomes more convenient to use, the city should dial up the incentives for all citizens to participate in circular resource management. Pay-as-you-throw schemes have been criticized by some, but also shown to be broadly effective in increasing participation rates in recycling programs.

Circular Milestones

- **City of Charlotte handles all recyclables locally.** With advances in collection, sorting, and remanufacturing, Charlotte can process and recover all value from recyclables locally.
- **Charlotte begins taking and processing recyclables from nearby counties.** Once Charlotte has the infrastructure to effectively process all of its own waste materials in a circular and high-value way, it can start to provide this service to neighboring cities and potentially counties beyond Mecklenburg.
- **Landfills are closed and redeveloped.** If all of the strategies described here are implemented and working, the city and county should eventually no longer have the need for landfills. All residual wastes should be processed in some way, and at the very least used for clean energy generation.

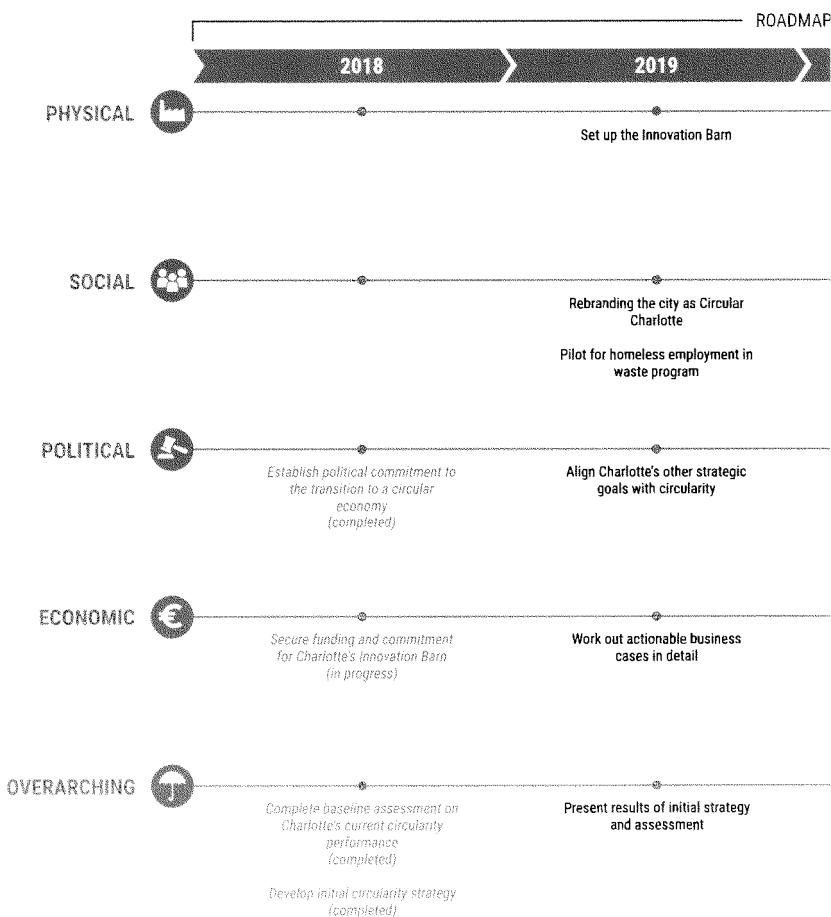


- **Charlotte develops new ten-year circularity strategy.** Even while updating annual action plans, it will eventually be time for Charlotte to take a step back, evaluate its progress, and develop a new 10-year strategy for progressing towards a circular economy. This process should likely be repeated every 10 years or so.

SHORT-TERM ROADMAP

Charlotte's transformation to a circular city clearly cannot take place overnight. Short-term actions should focus on building awareness among the city's citizens, business owners, and other key stakeholders on what the circular

economy is and the different opportunities it can provide, as well as laying the groundwork for tackling some of the barriers described in the previous section. In addition, it is essential to identify tangible actions, showcases, and



circular business cases that can be executed quickly in order to build support for the approach and demonstrate its value. Further steps should include capacity building and efforts geared at longer-term transformation, such

as neighborhood action plans, the establishment of new partnerships and institutions, and monitoring programs to track the city's progress on circular economy metrics (i.e., the KPIs presented in Chapter 2).

SHORT-TERM (0-5 YEARS)

2020

2021

2022

Set up repair cafes

Replicate the Innovation Barn model in other Circular Living Labs

Identify key infrastructure that needs to be invested in

Scale up logistics and capacity of high-priority waste streams

Invest in urban sensing and open data infrastructure

Communications campaign for Circular Charlotte

Social campaign

Circular Charlotte Program

Campaign for food waste reduction

Establish circular stakeholder network

Support community centers in setting up centralized recyclable collection capacity

Identify Chief Circularity Officer for the city

Neighborhood action plans

Setting up task force on priority waste streams (e.g. food waste)

Begin discussions on reframing next interlocal agreement

Define circular investment vehicles

Set up revolving fund for community garden establishment

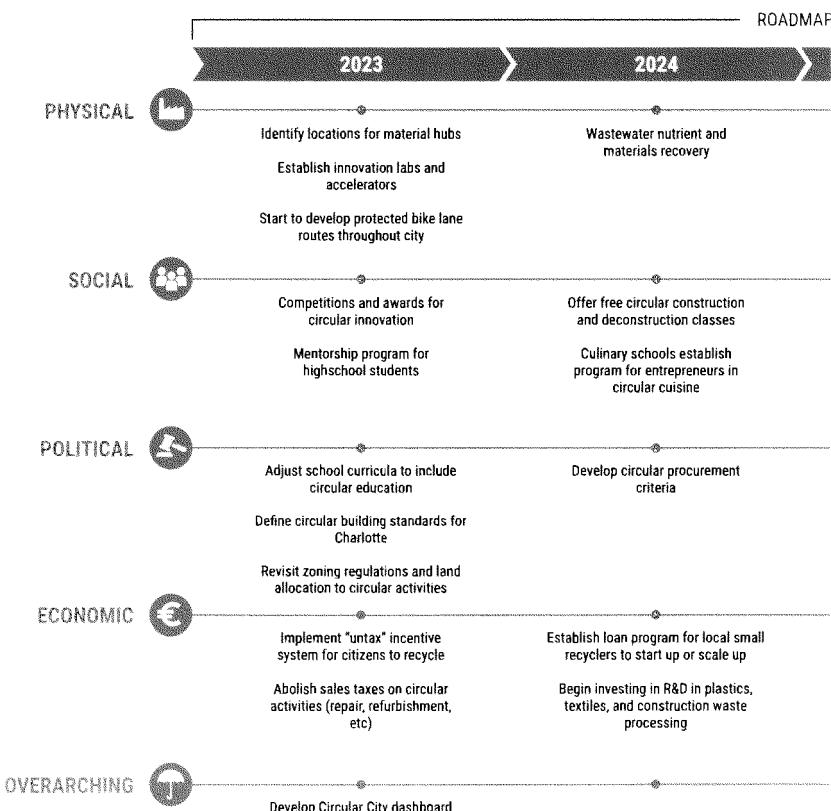
New data collection protocol for material inputs and outputs for the city of Charlotte

International profiling through presentations and speeches

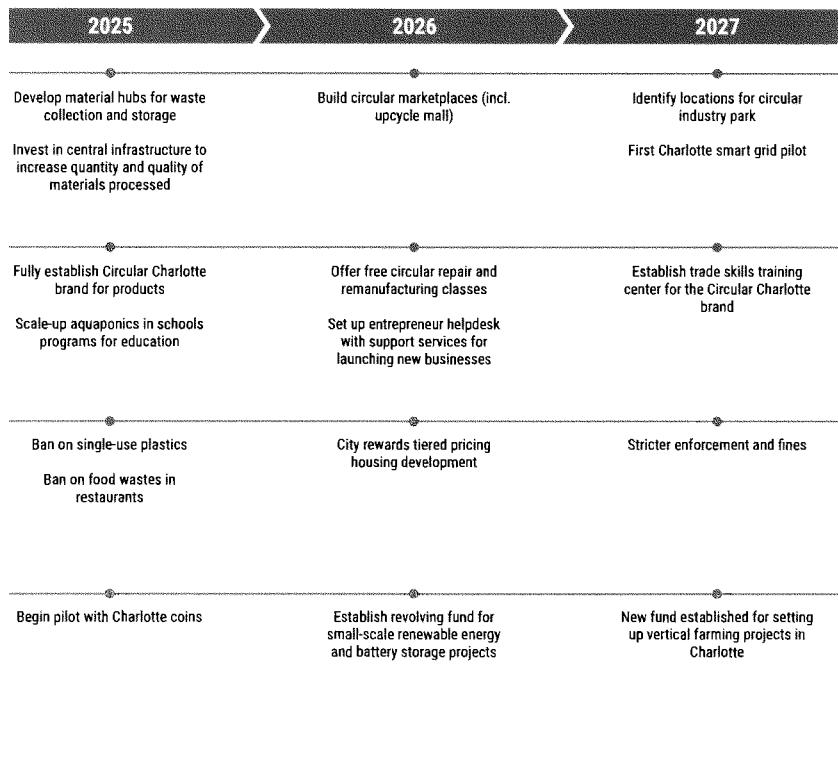
MEDIUM-TERM ROADMAP

Once the baseline infrastructure for a circular economy in Charlotte is in place, the next phase of activity should focus on building on this foundation. Developing education, training programs, introducing policies and

financing mechanisms, as well as building out Charlotte's innovation ecosystem and circular infrastructure are all important pillars of the medium-term actions we recommend here.



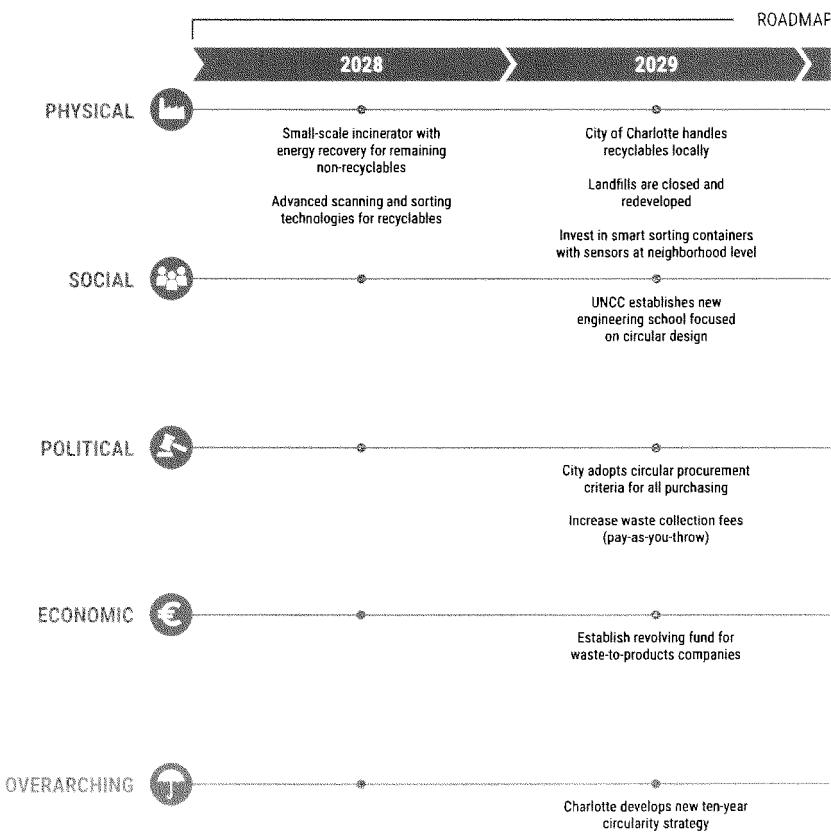
MEDIUM-TERM (5-10 YEARS)



LONG-TERM ROADMAP

The further we look into the future, the more speculative our recommendations naturally become since it is impossible to predict how technologies will develop and how society will change over time. Even so, there

are some actions we imagine Charlotte undertaking that we think will become relevant a decade or more from now. This is also the period in which some important milestones can be met.



LONG-TERM (10-15 YEARS)

2030**2031****2032**

Start developing circular industry park

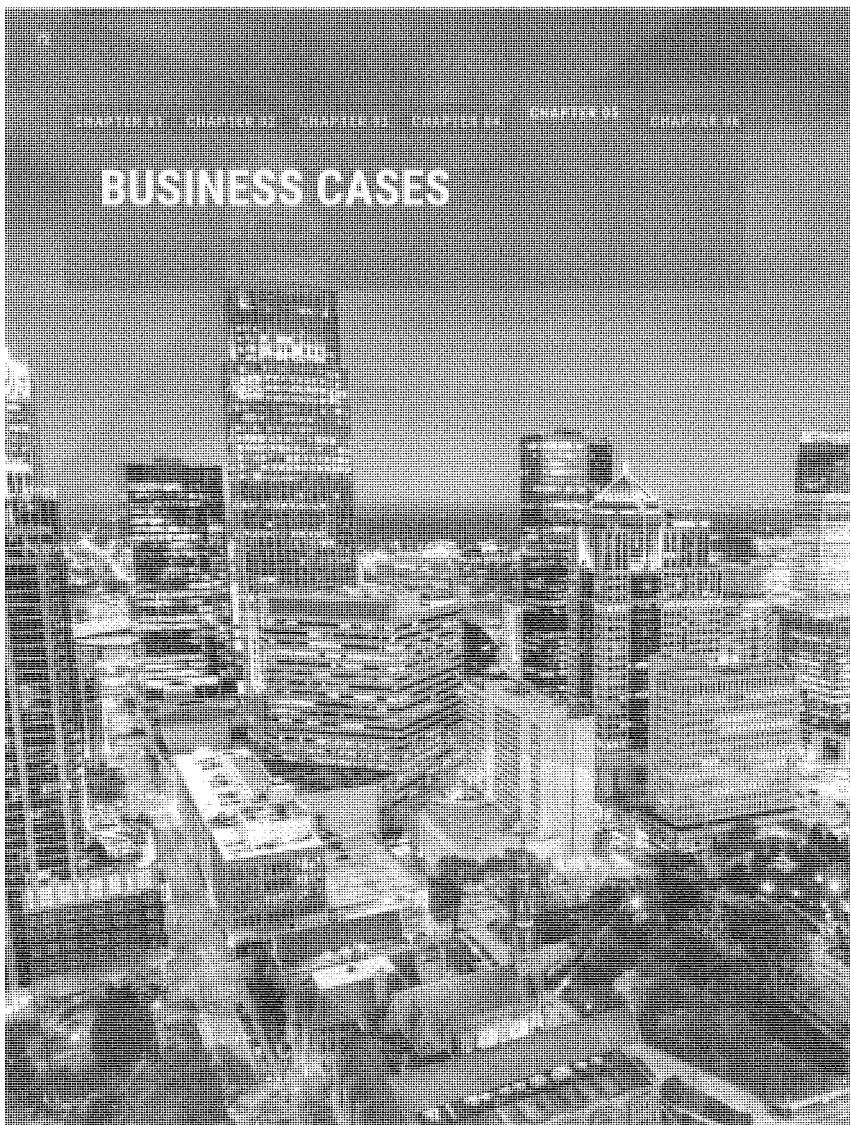
Begin taking and processing recyclables from nearby counties

Emergence of full-service living concepts

Pilot for on-demand self-driving public transport system

Require new buildings be built to circular standards

International profiling through presentations and speeches



DEVELOPING BUSINESS CASES FOR CHARLOTTE

Until now, we have considered the shift to circularity from a high level, by asking ourselves questions such as:

- Which **materials** are ending up in the landfill and why?
- How much material **value** is ending up in the landfill each year?
- How many **jobs** could we create if **all** of this material was recycled into new products?
- What **systemic changes** are needed to enable circularity in Charlotte, for example in policy, education, and infrastructure?

While this high-level thinking is necessary for the city to change the environment into one which can structurally support circularity, local entrepreneurs and communities will be the ones who actually implement circular activities in the city. For this reason, it is necessary to dive deeper into the costs and benefits of specific activities and supply chains.

In this chapter, we present a small selection of business cases, covering just a small share of the material flows of the city. The selection of these cases was made to address some of the most impactful or problematic material flows and on the basis of interest from local stakeholders in specific supply chains that came out of interviews and the workshops hosted as part of this strategy work.

For each business case we:

- Describe the current context and the new scenario we envision
- Present a few examples of similar cases being implemented in other regions
- Explore some of the barriers to implementation and how these can be overcome (for example with structural interventions)
- Describe how we see the case functioning and the benefits each could bring for society and the environment

These are meant to give an indication of the order of magnitude of costs and benefits that each scenario can deliver in order to stimulate local government and entrepreneurs to take action on promising activities. However, in order to actually implement them in the city, they will need to be worked out in further detail with all relevant partners actively participating in giving them form.

BUSINESS CASE: CLOSED-LOOP TEXTILES CHAIN

DESCRIPTION

Charlotte has been an important part of the historical development of the textiles industry in the United States. Today, it is still an important sector for the region; Charlotte ranks 2nd in U.S. cities for employment in the textiles sector (U.S. Cluster Mapping, 2018). Becoming a frontrunner in circular textiles can be one of the most promising ways for Charlotte to take the first steps towards being recognized as a leader in circularity.

Around 57,000 tons of textiles disposed of in Charlotte end up in the landfill each year. Of this amount, 43% is reusable and should ideally end up in secondhand markets. For the textiles that are worn, stained, and damaged, however, there should be a pathway for recycling them into new textiles. To make this possible, there are some barriers to textile recycling that need to be overcome:

- Collection from a large number of households, where volumes are so small and irregular that logistics would be inefficient.
- Identifying and separating the types of textiles after collection. The technologies to properly sort textile types using sensors is still under development, while hand sorting is imperfect in the absence of labels.
- Technology availability for textiles recycling beyond

pure fiber types. While technologies exist for separating polyester and cotton, the most common blend, these are not yet at commercial scale (see HKRITA, Chalmers university, IONCELL-F). For other blends, the technologies are even more limited.

For these reasons, a first step for Charlotte could be a limited circular model for sources of textiles that are easily tracked, standardized, concentrated for collection, and can be of single material types. The best options are textiles used in hotels, medical facilities, and uniforms (public employees, sports clubs, hospitality, etc.). Therefore, two value chains can be established: one around pure cotton streams, which are commonly used in linens and towels, and one around polyester textiles, mainly uniforms.

On the longer term, as technologies for separation and recycling advance, further product types can be added to the circular value chain. This case offers an opportunity to set into place the logistics model for tracking and collecting materials in a way that is scalable, and establishing partnerships between textile users, recyclers, producers, and logistics. Producing and reprocessing textiles locally instead of importing linens and apparel, and exporting textile waste, offers new opportunities for increasing local employment.

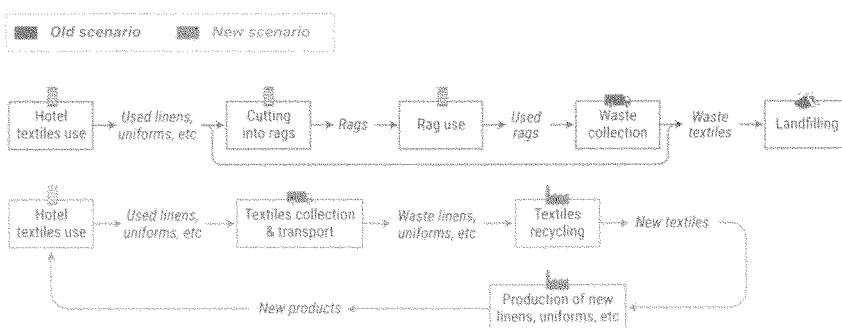


Figure 9. Overview of the Closed-Loop Textiles Chain Case

EXAMPLE CASES

Dutch Awearness is a "chain manager" in the Netherlands, designing circular workwear made from 100% polyester, which is essentially leased, rather than sold, and recovered at the end of life to be recycled into new workwear. To track products, Dutch Awearness has designed a supply chain management process and tool called the Circular Content Management System (CCMS), which uses unique barcodes to track material, impact, and location data.

Econyl is a company making 100% recycled nylon fibers for apparel and carpets, designed for recyclability at the end of life. Raw materials for the products come from post-consumer sources, including nylon nets fished out of landfills and the ocean. Econyl fabrics have ended up in apparel by H&M and carpets by Desso.

Repreve is a polyester textile brand by the fiber producer Unifi. This fabric is made using recycled post-industrial and post-consumer PET waste. Repreve offers a range of textiles made from polyester and is currently working with dozens of apparel producers to deliver high-performance fabrics.

Key stats

- Saves up to 95% of the water and prevents up to 63% of the CO₂e emissions
- Can be recycled up to 8 times and produces nearly zero waste

Key stats

- Saves 7 barrels of oil and 5.7 tons of CO₂e emissions per ton of recycled fiber
- Reduces global warming impact by 80% compared to virgin nylon

Key stats

- 80% of polyester comes from post-industrial waste, 20% from post-consumer waste
- Unifi has recycled more than 10 billion PET bottles
- Energy saved is enough to power 95,000 homes for a year



CONTEXTUAL ASPECTS

Charlotte and its surrounding areas are home to companies active in the recycling of post-industrial polyester and cotton fibers. These fibers are then converted into new yarns which are upcycled by regional manufacturers into new products. The existence of these companies points to the infrastructure that is currently available to process future recovered textiles, however increased capacity may be needed once scaled production takes hold.

The barriers that remain relate to establishing partnerships and logistics (including tracking materials) that allow for creating a truly circular model. A logistics model needs to be established that can ultimately prove attractive for all partners in the chain by:

- Reducing waste management costs for organizations in addition to advancing a new sustainable initiative for Charlotte and the surrounding region.
- Ensuring higher supply and demand of high-value post-consumer fibers for textile-recycling companies. Ideally, these are designed for easier disassembly and processing.
- Providing reliable and affordable secondary inputs to textiles manufacturers and providing an incentive to source recycled fibers and design new products for material recovery at the end of life.

IMPLEMENTATION IN CHARLOTTE

Charlotte already has all the pieces in place that are necessary for creating circular textile value chains. The main thing that is missing is a strong "chain manager" that can work with parties from procurement, to waste logistics, to recycling, and producing new products.

A full supply chain approach is necessary to tackle the challenge of making textiles circular. They should be designed in a way that makes it possible to easily recycle, for example by avoiding blended fabrics for which recycling technologies are not at the right scale, or treatments that impact recyclability. They should be collected in high enough volumes that logistics is not cost-prohibitive and that makes it attractive for a continued partnership with recyclers and producers of the textile products.

We think that for a new recycling business, or "chain manager", starting with a few good partnerships would be the best starting point as it simplifies logistics. Examples of partnerships could include large textile users such as the City of Charlotte (uniforms for public service employees) or hotels and hospitals (towels, linens, and uniforms).

We calculated a scenario where 20% of the yearly wastes from hotel and hospital linens and towels are collected, as well as 20% of the uniform wastes from construction, police officers, manufacturing, hospitality, and health

Table 1: Closed-Loop Textiles Costs and Benefits

COST	VALUE	REVENUE	VALUE
Investment costs	\$10,000	Revenue from collection	\$29,000
Rent	\$30,000	Revenue from product sales	\$5,400,000
Personnel	\$112,000	Total	\$5,429,000
Fuel and utilities	\$9,000		
Payments to 3rd parties	\$3,260,000	Return on investment	
Total	\$3,411,000	Payback period	

care. In this scenario, a total of 210,000 lbs per year could be collected for processing, including 9 tons of towels, 8 tons of bed linens, and 88 tons of uniforms.

If a maximum of 10,000 lbs are held at a time, then the space requirement will be approximately 1000 ft², with a rent cost estimated at \$12,000–\$18,000/year. Utility costs are estimated at around \$1,700/year.

If the collected towels and linens were sold as scrap, the value would only be around \$11,000, which would not be enough to cover even the running costs of collection and storage. However, most linens and towels are discarded when they are still usable materials and reselling these may be the best option. If 50% is sold at 40% of the original selling price, this would return \$29,000 in revenues.

For the uniforms, the best option is fully recycling these into new polyester uniforms. If they sell again at the original sale price, the value would end up being \$10.5 million in revenue. The recycling business could outsource part or all of this processing, or purchase equipment and hire additional staff. This part of the business case requires further investigation.

OPPORTUNITIES

If a textiles recycling chain manager starts small with collecting, processing, and reselling around 100 tons/year as in this business case, this will already result in immediate environmental benefits by diverting waste from landfill and avoiding the embodied impacts of virgin textiles production. Additionally, it would create a small number of jobs directly (and indirectly through outsourcing textiles processing).

By reusing cotton towels and bed linens, 150 tons of CO₂e, more than 275,000 gallons of water, and 79 acres of land use can be averted upstream by avoiding new virgin textile production. Recycling polyester instead of producing virgin polyester fabrics saves more than 1,000 tons of CO₂e and 70,000 gallons of water per year.

However, the real benefit lies in the learning opportunity that this business case provides. It could be the starting point for expansion into other textile recovery programs, for example collecting post-consumer textile waste rejected as secondhand clothing. It also provides a platform for engaging in conversation with parties producing textiles to strategically design products with a regenerative life-cycle in mind, ensuring the reuse or recyclability at the end of life.

Table 2: Closed-Loop Textiles Opportunities

OPPORTUNITY	VALUE
Total waste diverted from landfill (lbs./year)	210,000 lbs./year
Potential profits from case (\$/year)	\$201,800
Total jobs created (#)	9
CO ₂ e emissions saved (tons)	1,226
Water use avoided (gallons)	345,341
Land use prevented (acres)	79

BUSINESS CASE: UPCYCLING FOOD WASTE INTO FEED

DESCRIPTION

Every year, nearly 150,000 tons of food waste from Charlotte households and small businesses ends up in landfill, with additional waste coming from other commercial entities and organizations. This is an enormous problem in terms of environmental impact, as decaying waste in the landfill results in high amounts of methane emissions, which is a greenhouse gas 25 times more potent than CO₂.

Additionally, nutrients in this food waste are no longer recoverable once they enter landfill. The loss of phosphorus in particular is problematic from an economic standpoint as this essential nutrient is mined from limited stocks globally and will come up against scarcity issues in the medium term (global stocks are expected to last another 50-100 years, Cordell et al. (2009)). From a circular economy perspective, all food wastes should ideally make it back into cycles for food production.

Composting has been implemented in Charlotte with initiatives to increase household composting and public composting projects, for example at schools.

Additionally, companies like Earth Farm Organics are processing large amounts of compost from households and commercial organizations, while Crown Town Compost has established household and small business food waste collection programs. While these programs should be structurally supported and scaled up, other higher-value products besides compost will need to be developed in order to fully close nutrient cycles and provide a strong incentive for organic waste separation.

An alternative application for food waste is its use as feed for insects called black soldier flies. Black soldier fly larvae eat any kind of food waste and grow quickly to the prepupae stage where they consist of about 42% crude protein and 29% fat (Wang & Shelomi, 2017). These larvae are an excellent source of feed for animals like, pigs, poultry, and fish (Veldkamp et al., 2012). If Charlotte diverted waste to black soldier fly larvae production for feed it could result in significant impact reductions, in addition to creating new employment opportunities and providing a higher revenue to justify expansion of existing food waste collection programs.

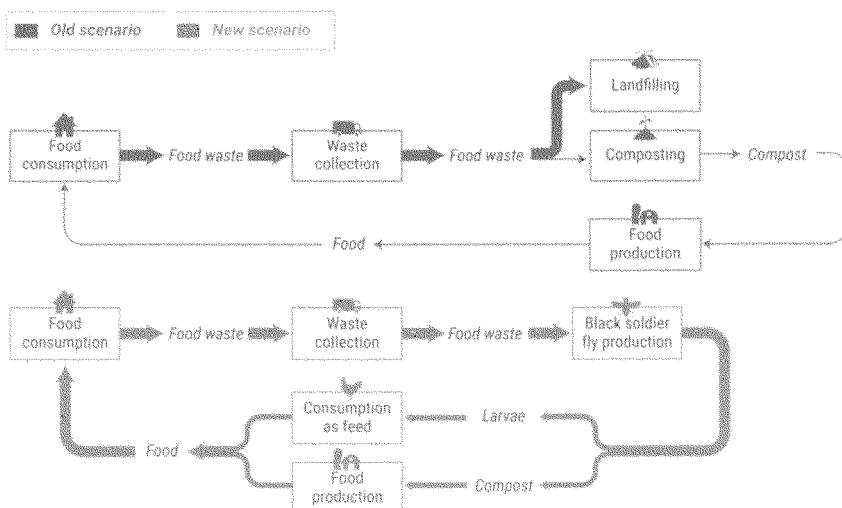


Figure 10. Overview of the Upcycling Food Waste into Feed Case

EXAMPLE CASES

Protix has been working on the breeding and application of black soldier fly larvae and upgrading into products since 2009. In 2017, they acquired \$50.5 million in funding, which is the largest investment in this sector (Burwood-Taylor, 2017). Increasingly, they are collaborating with research institutes to find more high-value applications for black soldier fly larvae, eg. in meat substitutes and textile coatings (Protix, 2018).

EnviroFlight was founded by Glen Courtright in Ohio, US in 2010. EnviroFlight started out by selling larvae as specialty feed for backyard chickens and exotic pets at \$20,000 per ton (Warner, 2014), partly because it could still not be sold as regular feed for livestock. Now they sell larvae as feed for both livestock and pets. On the long-term they want to facilitate the use of the technology by selling consulting and hardware (Warner, 2014).

Enterra is a Canadian company that was founded in 2007 by Brad Marchant after a conversation with environmentalist David Suzuki about problems with conventional aquaculture (Tossel, 2013). In 2014, they secured \$5 million in funding to start a commercial scale pilot facility which can handle up to 54,000 tons of food waste. Recently the company acquired permission to sell products in Canada, the U.S., and Europe.

Key stats

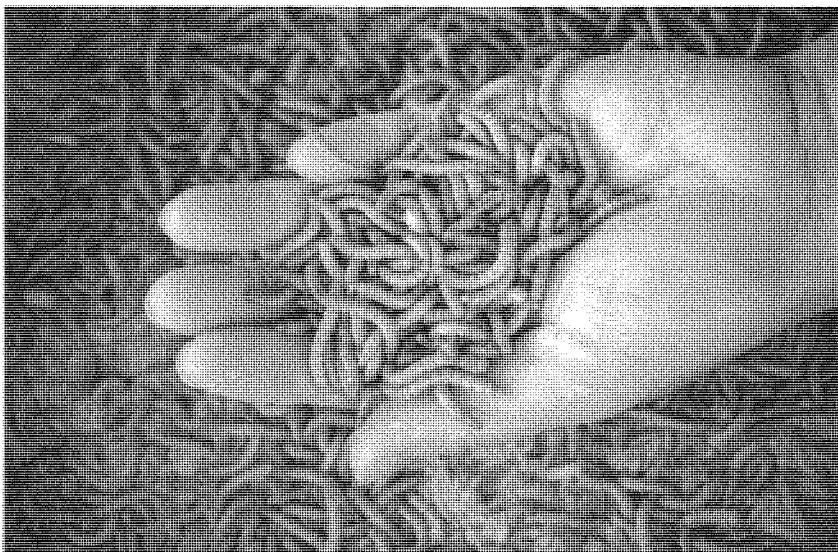
- Protix sells feed products in over 12 countries
- Protix produces 1,600 tons of larvae annually at their location in Dongen (*Salmon Business*, 2017) using around 8000 tons of biomass.
- In their new location, Protix will grow insects on 15,000 m², with 80 employees (*Salmon Business*, 2017)

Key stats

- Opening the first commercial scale facility in 2018
- Using post-industrial food waste from breweries and food processors
- Expects the price for larvae-based feed to reach around \$1300/ton once the market has adapted (Pryer, 2015)

Key stats

- In 2015, Enterra was diverting nearly 40,000 tons of food waste from the landfill (Colvin, 2015)
- Enterra can convert 40,000 tons of food waste into nearly 2,000 tons of meal product, 1,100 tons of food oil, and 3,300 tons of fertilizer (Tossel, 2013)



CONTEXTUAL ASPECTS

Over the last eight years, innovative companies have been working hard to find the right technology for facilitating larvae production, which has resulted in the development of commercial-scale operations. The main technical challenge remaining is making sure the feedstock given to larvae can ensure consistency in nutritional characteristics (such as protein content). Without this assurance, it will be difficult to get farmers to adopt black soldier fly larvae as feed (Ford, 2018).

The main barrier to successfully implementing this business case is regulatory. Companies have been lobbying for regulatory change that would make it possible to sell larvae products in different applications using different production models, and have largely been successful in other countries. However, there are still challenges remaining to ensure the larvae are safe as feed, for example ensuring they do not accumulate heavy metals (through the substrate they are grown on), or develop infections (through plant hygienic conditions).

In the United States, the Food and Drug Administration (FDA) has only approved the use of larvae as a feed for salmon and can only be fed on feed-grade substrates (Wang & Shelomi, 2017). This limits the opportunities for producing and selling black soldier fly larvae and also creates a bottleneck in terms of meeting regulatory requirements for production. In the short term, two options are possible:

- Only using pre-consumer waste (for example from food processors), or
- Using the larvae in other applications, but not selling it on the market as feed

Depending on which pathway is taken, different types of infrastructure would need to be established. If post-

consumer food waste is used, logistics for collection need to be expanded, while the business case for the larvae is not as strong. In this case, local regulatory measures, such as requiring restaurants and cafes to separate food waste (as Austin has done as part of the zero-waste program), could be necessary.

If pre-consumer waste is used, the logistics are easier (collection from a smaller number of entities) and the business case is stronger (larvae can be sold as feed on the market), but the scope and impact reduction potential are drastically reduced.

IMPLEMENTATION IN CHARLOTTE

The business case involves the construction of breeding facilities, with a starting capacity of 55,000 tons of food waste per year (around a third of the food waste currently ending up in the landfill). The facility can produce 11,000 tons of wet larvae or around 3,000 tons of dry larvae per year and employ around 150-250 people (Protix, 2018). As EnviroFlight is producing about 12 tons larvae/ft²/year (Warner, 2014), in total this would require a space of around 132,000 square feet.

The investment for the facility is estimated to be around \$2,000,000 - \$6,000,000 and can generate revenues of \$4,000,000 - \$7,000,000 per year, depending on what products are produced (Protix, 2018). Operational costs are estimated at around \$4,800,000 per year. The best option is to work with an existing technology and process such as EnviroFlight or Protix.

It is important to ensure a steady stream of food waste to keep the production running at a steady pace. Crown Town Compost and Earth Farm Organics may be good partners, as these companies are already handling food waste from households and small businesses (Crown

Table 3: Food Waste to Feed Costs and Benefits

COST	VALUE	REVENUE	VALUE
Investment costs	\$2,000,000 - \$6,000,000	Revenue from collection	\$667,000
Rent	-	Revenue from product sales	\$4,000,000 - \$7,000,000
Personnel	\$3,700,000 - \$4,500,000	Total	\$4.7 - 7.7 mln
Fuel and utilities	\$724,400		
Payments to 3rd parties	-		
Total	\$2.6 mln + \$4.4-5.2 mln yearly	Return on Investment (10 yrs)	114%*
		Payback period	6 years*

* Based on a cautious financial projection using mid-range values for the parameters in the table.

Town) and larger companies and organizations (Earth Farm).

Currently these companies get revenue from collection fees (which accounts for the largest share of revenues) and from sale of the compost produced. If their share in revenues from black soldier fly larvae is high enough to reduce collection costs for companies and households, then participation may increase. Otherwise, policy measures may need to be put into place to incentivize participation.

If a process using pre-consumer waste (from food processing) is put into place, companies like supermarkets, Snyder's Lance, Coca Cola, or Walmart might be good partners to include. In this case, one partner may be sufficient for a pilot stage.

The larvae can be used live or dried and used as feed or can be pressed to extrude fats and concentrate the protein in pellet form (producing a set of higher-value products). The two main outlets for products are as feed for poultry or aquaculture as a replacement for fish meal. Fish meal costs around \$1,500-\$2,000 per ton. However, producers may be hesitant to switch to black soldier fly larvae unless it also presents a clear cost saving. It may be more reasonable to assume a price of around \$1,300/ton.

The poultry industry is the strongest agricultural industry in North Carolina and partnering with North Carolina Poultry Federation might be a good starting point to establish a strong connection to the customer segment.

Aquaculture is a second interesting partnership direction to pursue. Unlike pigs and poultry, fish cannot obtain the protein they need from soy and cereal grains (Burtle et al. 2012). Aquaculture is also increasing in popularity

and the link with the aquaponics project planned for the Innovation Barn and projects such as 100 Gardens (which is using aquaponics to teach school programs about science, math, and more) makes it a more interesting case.

Finally, other markets could include pet stores (for the larvae), farms (fertilizers), cosmetics producers (fats), and pharmaceuticals (Omega 3, 6, and 9 fatty acids).

OPPORTUNITIES

If 50,000 tons of food waste is diverted to black soldier fly larvae production, this will reduce the amount of waste going to landfill by 5.3% and save the municipality \$1.65 million in tipping fees. At an emissions intensity of 1.792 tons CO₂e/ton food waste (World Resources Institute, 2015), this means that nearly 90,000 tons of CO₂e emissions can be prevented per year through diversion from landfill.

An additional 7,000 tons of CO₂e is saved from the 6,800 tons of poultry feed that can be replaced by black soldier fly larvae. The replacement of poultry feed also saves about 41,000 gallons of water per year and 3,200 acres of land.

In total, this could generate \$200k - \$2.5m in profits per year and create 150-250 new jobs in production, as well as an estimated 83 additional jobs created in food waste collection.

It should be noted that while this business case involves large-scale processing, it only covers a third of local food waste and will need to be implemented alongside other initiatives to fully close local nutrient cycles.

Table 4: Food Waste to Feed Opportunities

OPPORTUNITY	VALUE
Total waste diverted from landfill (tons/year)	100 million
Potential profits from case (\$/year)	1,200,000
Total jobs created (#)	233-333
CO ₂ e emissions saved (tons)	97,000
Water use avoided (gallons)	41,000
Land use prevented (acres)	3,200

BUSINESS CASE: MATERIALS INNOVATION LAB

DESCRIPTION

The Charlotte Materials Innovation Lab (MIL) is a concept for a university-affiliated student-startup incubator program focused on new value propositions around organic waste fractions. The aim is to reduce the total amount of organic waste by generating and supporting innovative local initiatives for high-value upcycling of specific organic waste fractions.

In the past few years, the number of startups using organic waste streams to produce new products or resources has exploded, and Charlotte can tap into this trend by stimulating the entrepreneurial spirit of the city. Because such Food Tech initiatives often require a lot of upfront research and innovation, we propose that the city establish a centralized Materials Innovation

Lab that would have all the equipment needed for experimentation and testing, potentially located at The Innovation Barn development.

There are two stakeholders that will be crucial to success. Firstly, the Charlotte MIL would require a strong partnership with one or more nearby universities, as the MIL is meant to support student entrepreneurs in the city, and professors and teachers can provide entrepreneurs with technical guidance during the product development phase. Secondly, a consortium of organisations that have an interest in organic waste would be required to partly fund the program, and provide the startups with the necessary networks, expertise and commercial feedback.

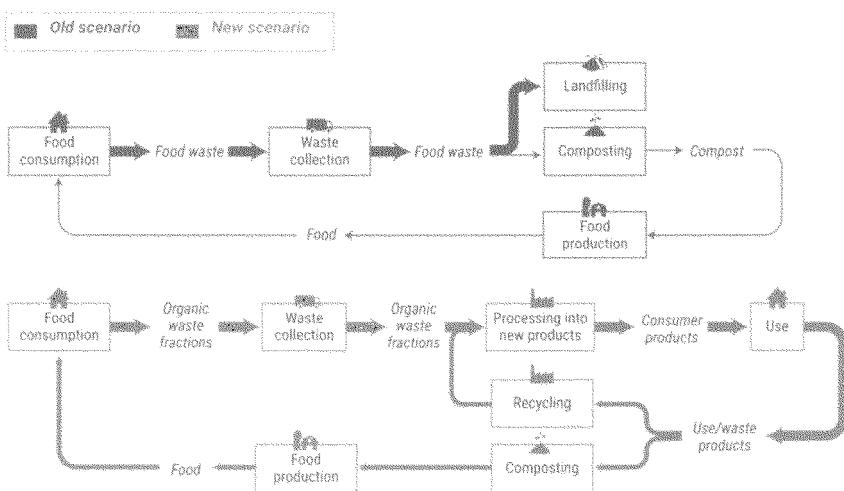


Figure 11. Overview of the Materials Innovation Lab Case

EXAMPLE CASES

The Erasmus Centre for Entrepreneurship is a not-for-profit incubator that helps student entrepreneurs during the validation phase of their business idea. Startups are guided through a multi-week accelerator program and given access to a network of industry players and investors. They have multiple running programs, including specialized tracks focused on key sectors of the Rotterdam economy. Apart from the incubation programs, ECE also organises executive education programs, MBAs focused on entrepreneurship, and other events.

Fruitleather Rotterdam produces leather-like material from fruit waste. Though still in the startup and product development phase, they provide a good example of the type of startup that could be housed in the ML. Due to the high costs of production, their clients are limited to high-end luxury fashion brands, though they expect to be able to compete with real leather. Their main supplier is the harbour of Rotterdam, which is able to supply them with millions of kilograms of fruit waste.

Ecor is a biobased material that serves as an alternative to particle board, cardboard, and other materials. The company was founded in 2014 as a partnership between the company Noble Environmental Technologies and the United States Department of Agriculture. The material is made from cellulosic wastes including cardboard, newspaper, and agricultural fiber, only requiring the addition of heat and water for its production.

Venn Reactor based in Hong Kong, is an innovation supply-chain accelerator that provides research, design, engineering, and sourcing to global premium brands. Venn Reactor specializes in the design-to-manufacture of specialty products that combine hard materials (plastic, metals, meshes), soft materials (textiles, vinyl, or leather), and smart digital systems.

Key stats

- Over a hundred budding entrepreneurs start their company each year through the program
- Has a pool of around 60 academic and industry experts available for coaching and mentorship, as well as close ties to commercial businesses

Key stats

- For every square meter (about 10 ft²) of 'leather' they produce, they require around six kilograms of fruit puree
- The price per square meter is currently around €400, but they hope to reduce the costs to compete with real leather
- They can process 1000 kg of fruit an hour

Key stats

- ECOR's can convert 1,250 tons of wastes per year, with another 37,500 ton capacity planned for new facilities
- Wastes cost \$0-236/ton, Panels sells for \$1,700/ton
- Together, the four facilities will prevent the use of over 600,000 trees and 112,500 yd³/year

Key stats

- One of their most innovative products is a moldable plastic-like material that is made of a combination of orange peel and cornstarch epoxy which is suitable for making lamps, phone cases, etc.



CONTEXTUAL ASPECTS

The main potential barriers to implementation of a materials innovation lab in Charlotte include developing the right partnerships (with universities and the private sector), securing funding, and motivating students to take part in an incubator program. For this last issue, we have heard that it is difficult to get students engaged in Charlotte, even in entrepreneurial activities, so the program has to be attractive to participate in. To make sure this barrier is overcome, the innovation lab could introduce competition for participation in the incubator with awards and other recognition for entrepreneurial students.

UNC Charlotte is already planning to participate in the Innovation Barn project and could be a key partner for the program, though ideally the incubator program would include partners and students from other universities and colleges of Charlotte to encourage multi-disciplinary entrepreneurship in the circular economy.

IMPLEMENTATION IN CHARLOTTE

The Charlotte MIL could be based on the model of ECE in Rotterdam. With a rolling accelerator program of around 15 teams, with an average 1-2 founders per team, the facility would require at least 1,000 ft² of office space, and preferably more for product prototyping. Space at the Innovation Barn is provided by the city for a period of five years after completion, though on the long term it can be expected that continued use of the space will require rent of an estimated \$0-\$28,800/year for the use of 1,600 ft². Utility costs are estimated at around \$2,720/year.

One of the most important resources that the MIL can offer budding entrepreneurs is availability to the necessary

tools and machinery for developing their product. At the very least, such a lab would include a fruit pulping machine, automatic composting machine, and organic waste de-watering screw press, which together would cost an expected \$20,000-30,000 dollars. Furnishing the space with desks as well as basic prototyping equipment would require an additional investment of around .

Operationally, the program would need at least two full time staff, as well as a pool of around 15-20 academic and industry experts to guide the student entrepreneurs. The initiative will require collaboration between many stakeholders. The most important are the university, including the professors, academics, and teaching assistants who will assist in the Lab's incubator program, the local student community, and businesses and industry experts who will provide the startups with market feedback. ECE Rotterdam offers dedicated validation programs that help set up programs like this, and Charlotte could potentially partner with them for the MIL.

Altogether, setting up the university-affiliated Charlotte Materials Innovation Lab would require an initial investment of around \$61,000, and an annual budget of around \$218,000 to cover salaries, marketing, and overheads, and optionally \$600,000 in annual seed investments for the approximately 60 startups. Given that the incubation center will be affiliated with local universities, we expect most of the funding to come from the university itself. However, the MIL could be partly funded through corporate sponsorships of the incubation program, or executive training programs. Most accelerator programs take a small equity stake in the participating startups in exchange for guidance and a small seed investment.

Table 5: Materials Innovation Lab Costs and Benefits

COST	VALUE	REVENUE	VALUE
Investment costs	\$61,000	Revenue from shares	\$214,286 (in year 3)
Rent	\$0 - \$28,800	Other revenue*	\$69,000
Personnel	\$180,000	Total	\$283,286
Fuel and utilities	\$2,720	Return on investment	N/A
Annual Seed Investments	\$600,000	Payback period	N/A
Total	\$61,000 investment + \$182,700 - \$217,280		

*Assumed additional revenues from events, conferences, and executive trainings

OPPORTUNITIES

In the end, 90% of startups fail, and this is unlikely to be any different for the Charlotte MIL. Nevertheless, even if just 10% of the startups that enroll in the program achieve commercial success, that would mean six new companies per year would be successful, creating an average of 14 - 21 new jobs directly every year (Empson, 2012).

While most of these would likely be smaller niche companies like FruitLeather (each diverting around 7 tons of waste per year), the occasional scalable business, like Ecor (diverting 1,250 tons/year) could add much more significantly to the waste diversion potential. If we assume one out of ten successful business is scalable, then overall this incubator could result in a diversion potential of around 1,285 tons/year (accumulating each year as more companies find success).

Over a ten year period, this would account for a share of around 1.4% of the total waste to landfill and a CO₂e emissions reduction potential of 23,000 tons over the period. The main benefit of the Materials Innovation Lab is less direct - education of students in a practical way through experience with entrepreneurship, new innovations and patents in Charlotte, indirect employment through activities adjacent to the work start-ups are doing, attractiveness of Charlotte to STEM students and graduates, etc.

It will be hard for the MIL to be financially sustainable. We expect the program to require significant funding in the first few years of its existence, and our estimates indicate that the returns on its seed investments will be relatively low. However, there are a number of other revenue models that the MIL can adopt to supplement this income, such as executive training programs or hosting events, which we believe could bring in another \$69,000 per year. It is likely that the university will need to fund the remaining budget. However, we believe the indirect benefits to both the university and the city makes this a good investment.

Table 6: Materials Innovation Lab Opportunities

OPPORTUNITY	VALUE
Total waste diverted from landfill (tons/year)	23,000 tons/year
Potential profits from case (\$/year)	N/A
Total jobs created (#)	14-21 jobs/year
CO ₂ e emissions saved (tons)	23,000 tons over ten-year period
Water use avoided (gallons)	Dependent on products produced
Land use prevented (acres)	Dependent on products produced

BUSINESS CASE: INCENTIVIZED REVERSE LOGISTICS SYSTEM FOR MATERIALS

DESCRIPTION

One of the largest problems we need to address for achieving circularity in Charlotte is handling the low recycling participation rates, and even those who do participate are not separating all of their recyclables. For example, we estimate that just over 2% of plastics coming from households are recycled. At the same time, a second problem in the city is that the quality of the recyclables currently produced is not high enough for recyclers in the region (too contaminated and mixed with other materials). We would like to address both of these problems simultaneously through an "incentivized reverse logistics system".

To ensure that recycling participation increases, citizens should be incentivized to participate in recycling, even in the absence of a state deposit system. While there are other options possible that have proven successful (such as pay-as-you-throw programs), there is a lot of political resistance to increasing costs for waste management, and rightly so, as these tend to increase the burden disproportionately for low-income households. An alternative that has been suggested is an "untax" system, where households are rewarded for good behavior, rather than being taxed for not recycling.

The Charlotte incentivized reverse logistics system is a new model we propose for recovering different recyclables in the city. The idea is that citizens are incentivized to recycle by receiving tokens for recyclables that they can exchange at local stores for discounts on or free products or services. The waste streams that are collected are cleaned and processed and then sold on to recycling firms. Eventually, we envision a fully automated take-back system that utilizes the existing return logistics infrastructure for instance supermarkets. This would also improve the efficiency of collection and recycling.

There are many plastics brokers that could use this model to affordably increase their revenues, although it may be more feasible to set up new organization. Establishing an incentivized reverse logistics system will require significant up-front investment. WASTED Lab, a non-profit in Amsterdam which has set up a system that partially resembles the idea proposed for Charlotte, is mostly funded by the municipality of Amsterdam and support from the city will likely be required to establish the system at the start. However, we believe that with the right partnerships and infrastructure a sustainable business model can be built so that the revenues from the sale of recyclables can cover the costs of logistics and pre-processing.

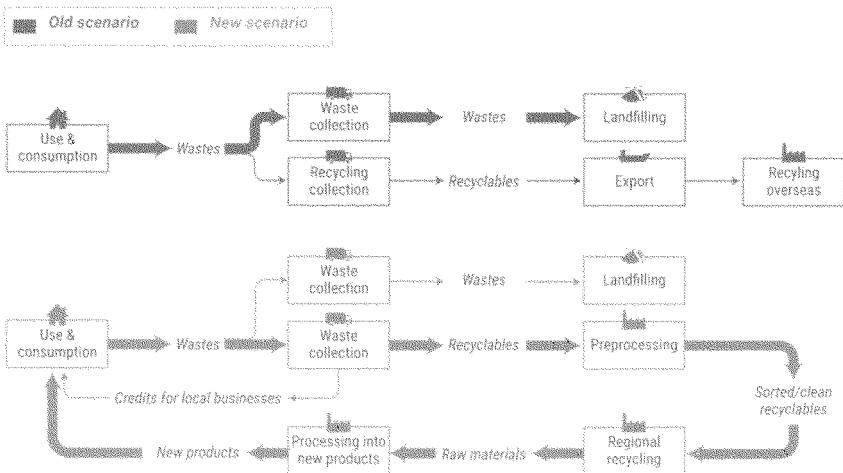


Figure 12. Overview of the Incentivized Reverse Logistics Case

EXAMPLE CASES

RePlanet is a recycling center operator in California that provides the option for getting money back (or donating the money to charities) for bringing clean and dry recyclables. Recyclable materials can be traded in either in staffed centers (payment per pound) or through Automated Recycling Machines (ARM). The recyclables are exchanged for vouchers which customers can deduct from their grocery bill or which they can redeem for cash. Alternatively, the value of the vouchers can be donated to a cause of the person's choice.

WASTED Based in a neighborhood of Amsterdam established a waste collection program, starting with plastics and then branching out to textiles, glass, and paper. While the Netherlands has a deposit system in place for some glass and plastic bottles, the incentive for recycling other materials was low, which led this organization to develop an incentive program for other materials. Participants bring a bag of recyclables to local collection points, scan a QR code sticker and send a picture of the bag, and receive a digital currency (one "coin" per bag of recyclables). The digital currency can be used in local businesses for discounts and free products. The organization's incentive program employs four people and has a budget of €150.000.

Key stats

- RePlanet Automated Recycling Machines (ARM) are available in nearly all major grocery chains
- Locals can return aluminum and bimetal cans, glass bottles, and #1-#7 plastic bottles (only)
- Payments range between 10.5 cents per pound (glass bottles) to \$5.62 (#6 PS plastic bottles)

Key stats

- WASTED has 1,700 participants - almost 5% of the neighborhood's population
- The program has 86 rewards (from 57 businesses) available for tokens, including discounts on groceries and flooring, buy-one-get-one-free beers and movie tickets, and free massages and coffee tasting workshops
- WASTED has collected over 5,391 kgs of plastic since April 2015, and 5,862 kgs of glass, 3,770 kgs of paper, and 1,827 kgs of textiles since June 2017



CONTEXTUAL ASPECTS

In order to successfully implement a program for incentivized reverse logistics, the main challenges are economic (ensuring a good business case for recyclers and local businesses) and logistical (decentralized collection and centralized pre-processing of recyclables), though some social challenges also exist in getting the right type of traction and participants in Charlotte.

For regional recyclers to support this type of system and purchase recyclable materials through it, the materials would need to be relatively clean and free of other materials. High rates of contamination (+30%) are currently quite common. By putting stricter requirements on the recyclables delivered to the program by households and by separating materials, the quality should be higher. As an incentive system allows for tracking bags back to participants, failure to deliver the right quality of recyclables can be addressed by reaching out directly to individual participants.

Logistically, the best option over the longer term is to install reverse vending machines in commonly visited shopping areas (such as grocery store parking lots), which will automatically measure and sort materials which can be collected in central locations. This option makes it easiest for households to participate in such a program. However, in the shorter term, when participation rates are lower, it will likely be more feasible to collect from individual households or central points in neighborhoods (such as community centers).

One of the main social barriers for this program is ensuring the system provides the right type of incentives for participation from low-income households and households who are not already recycling. Partnerships with the right types of local businesses and marketing

the program through the proper channels is key to mitigating the risk of mostly attracting participants that are the usual environmentally-conscious crowd (as experienced with the WASTED program in Amsterdam).

IMPLEMENTATION IN CHARLOTTE

The first step towards implementation is establishing the incentive program for recyclables, which involves creating an app for the program, designing a tracking method, and establishing partnerships with local companies who want to take part in the program. A small team of around four employees will be necessary to design the program, form partnerships, and handle marketing. In addition to the personnel costs, the incentive program will also require a marketing budget, funds for plastic bags and stickers (for example QR code stickers), and other overhead costs.

The overall cost of the incentive program is estimated at around \$164,000/year, which is similar to the funding requirements of the WASTED program in Amsterdam. Over the longer term, as the program finds more success, these overhead costs may double as a larger team is necessary to service a higher number of participants and business partners. Ideally the funding would come originally from the city (to be compensated by lower costs from tipping fees for landfilling), though if the program expands it could operate self-sufficiently from the revenues of material sales.

Over the short-term, we assume that 5% of the households in Charlotte will become participants in the incentive program, recycling 10% of their recyclable paper, textiles, glass, and plastics. These will be brought to local neighborhood collection points and taken to a central facility for sorting, baling, and selling.

Table 7: Incentivized Recycling Costs and Benefits

COST	VALUE	REVENUE	VALUE
Investment costs	ST: \$1.7 mln, LT: \$12.6 mln	Revenue from product sales	ST: \$240,391 - \$589,821, LT: \$5,805,550 - \$14,305,480
Rent	-	Total	ST: \$240,391 - \$589,821, LT: \$5,805,550 - \$14,305,480
Personnel	ST: \$565,000, LT: \$2.1 mln	Return on investment	ST: N/A, LT: 24% after year 5
Other overhead costs	ST: \$142,000, LT: \$724,000	Payback period	ST: N/A, LT: 10.9 years
Payments to 3rd parties			
Total	ST: \$1.7 mln investment + \$707,000/yearly, LT: \$12.6 mln investment + \$2.8 mln yearly		

*ST is short-term, LT is long term

As the program requires source separation and the volumes would be small in the beginning (~1,810 tons/year), relatively small investments in equipment would be necessary (e.g. a truck for collection, balers, conveyor belts) and feasible with only hand sorting and processing. Including the purchase of a warehouse capable of storing a week's worth of recyclables, the total investment costs would be around \$1.7 million. Personnel and other overhead costs would be around \$543,000/year (excluding the incentive program).

On the longer term, if the program scales up to around 50% participation, with participants recycling around 25% of their recyclable material, the total mass recycled would reach 44,100 tons/year. In this case, a larger facility would be necessary, along with automated sorting equipment such as optical sorting machines. For logistics, it would make sense to invest in automated recycling machines (ARM), which could be located at grocery stores (we assume around 50 locations in the city).

In this maximum scenario, the investment costs would reach \$12.6 million. The yearly operational costs for the program would be around \$328,000 and \$2.5 million for the logistics, storage, and processing operations.

OPPORTUNITIES

In the short-term scenario (with 5% participation and 10% recycling), the incentive and recycling program can only deliver a revenue stream of around \$240,000 - \$590,000 and cannot yet function self-sufficiently. However, it should be noted that this scenario results in a reduction of landfill tipping fees of around \$55,000 and much of the cost of the program (logistics, processing) replaces existing costs for the same in the current waste system.

The break-even point for profitability is at around a 10% participation rate or a 5% participation rate with high recycling rates (20% of recyclable paper, plastic, glass, and textiles). It may be possible to create an even lower break-even point if good partnerships can be established with recyclers who are willing to pay more for material with lower contamination rates. Another possibility is to carefully model which materials should be accepted in the program to provide the best scenario. For example, glass is heavy and expensive for logistics, but also very low value. Which materials are accepted could be determined by which favorable partnerships can be established.

If the ambitious, long-term scenario can be achieved, then the financial benefits are quite high: around \$5.8 - \$14.3 million in revenues for material sales versus around \$2.8 million in costs. This is in addition to the savings from landfilling tipping fees (\$1.3 million). If the program reaches this scale, it could make sense to offer direct financial incentives to participants households for recycling, instead of only coupons for local businesses.

In addition to direct financial benefits and employment through the program (35-130 new jobs), regional recyclers would be able to scale up operations. For example, a local HDPE recycler (Engineered Recycling Company, LLC) estimated they would be able to scale up recycling by 30% with existing equipment and space (which is more than even the long-term scenario would produce) by adding personnel, and they currently have too little recycled material to meet the full demand.

Finally, by increasing the amount of material recycled (reducing demand for virgin inputs), this program could have a considerable indirect effect on the embodied impacts of material consumption.

Table 8: Incentivized Recycling Opportunities

OPPORTUNITY	VALUE *
Total waste diverted from landfill (ton/year)	ST: 3.6 mil tons, LT: 5.1 mil tons
Potential profits from case (\$/year)	ST: N/A, LT: min. 3 mil per year
Total jobs created (#)	ST: 35, LT: 130
CO ₂ e emissions saved (tons)	ST: 10,310, LT: 237,003
Water use avoided (gallons)	ST: 675 mil gallons, LT: 18 bln gallons
Land use prevented (acres)	ST: 1,317 acres, LT: 34,404 acres

*ST is short-term, LT is long term

BUSINESS CASE: CONCRETE RECYCLING CHAIN

DESCRIPTION

Charlotte is a fast-growing city and its stock of building materials is growing along with it. Currently, around 12,000 new apartments are being built in the city (Portillo, 2017) and the construction sector is responsible for more than 55,000 jobs in Charlotte (over 5% of employment). At the end of life, buildings are demolished to make way for new buildings, resulting in one of our largest waste streams. Overall, building materials are responsible for around 30% of all material use (OECD, 2015) and 10-15% of all waste streams (Modak, 2011).

One of the main building materials is concrete, accounting for around 70% of all building waste materials (Statista, 2014). In Charlotte, much of the concrete waste from demolition is crushed and downcycled to lower value uses (e.g. as backfill). Even so, around 50,000 tons of concrete ends up in landfill each year, accounting for 6% of the total mass that goes to landfill, representing a loss in terms of economic value and resulting in increased impacts.

Concrete is made of 15-20% water, 60-75% aggregate (e.g. sand, gravel), and 10-15% cement. Concrete is a highly impactful material accounting for 5% of CO₂e emissions globally (Crow, 2008), mainly due to the cement in the mixture. Due to the high impacts of this material, cement recycling should be a top priority. Even the sand in concrete may be a key resource to prioritize recycling locally, as recent sand shortages in certain parts of the world (Torres et al., 2017) remind us that due to the high costs of transportation, sand is mostly a local (not global) resource. This aspect of transportation is also an important issue economically, as it is expensive to transport such a heavy material over long distances.

We propose establishing ambitious targets and a supply chain around concrete recycling to guarantee that 100% of concrete removed during demolition makes its way back into new concrete. Additionally, other waste materials (namely glass) can also be recycled into new concrete. While this business case requires changes at every step of the building life cycle, ensuring that no concrete ends up in the landfill can reduce tipping fees and transportation costs in addition to making large impact reductions.

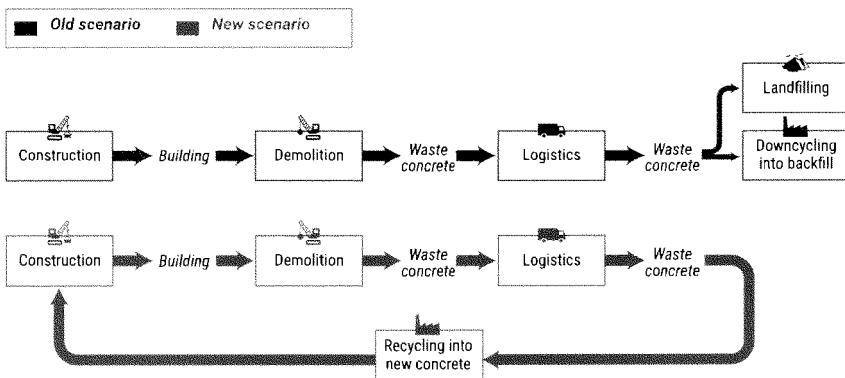


Figure 13. Overview of the Concrete Recycling Chain Case

EXAMPLE CASES

The "Beton Akkoord" or concrete agreement is a joint initiative between public and private parties in the Netherlands to make the concrete chain more sustainable through innovation, knowledge sharing, and collaboration. To date, more than fifty construction companies have signed the agreement. The goals are to reduce CO₂e emissions, support biodiversity and society, and promote circularity.

The Cement Sustainability Initiative (CSI) is a global effort by cement companies to enable sustainable development. One of their goals is to raise awareness of concrete recycling to increase the rates of recovery. The initiative suggests that government and stakeholders increase data transparency on demolition waste, develop economic incentives and legislation to encourage concrete recycling, and set targets for recycled concrete use.

Cherry Companies is a recycling and demolition company headquartered in Houston, which recycles different construction materials including concrete (which can be used in ready-mix concrete). Recycled concrete and asphalt materials are used primarily in road and highway projects.

Key stats

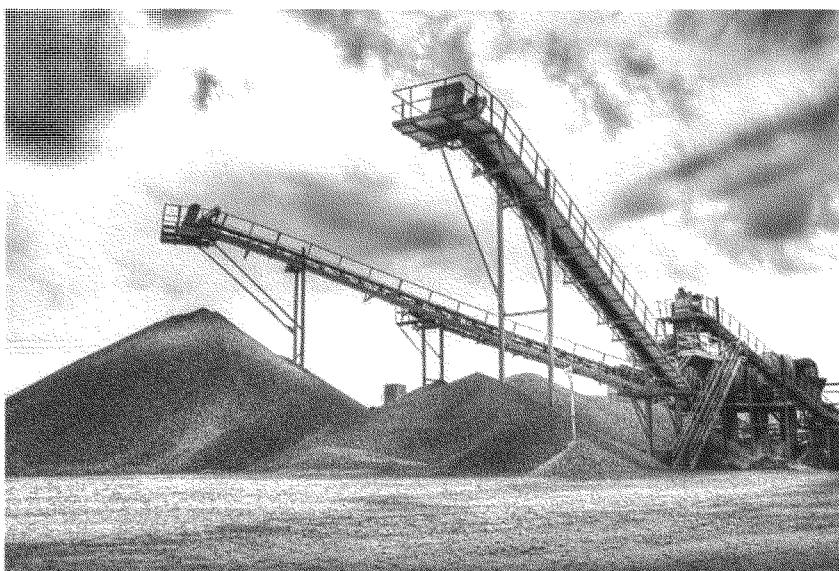
- The program aims for 100% recovery of all concrete waste material in the chain and 100% reuse of reusable concrete components
- Design for reusable components is a major cornerstone of the agreement

Key stats

- 24 major cement producers active in more than 100 countries are participants
- Collectively, these companies account for 30% of global cement production

Key stats

- The company recycles more than 2 million tons of concrete and asphalt every year
- The company produces 99.6% recycled materials



CONTEXTUAL ASPECTS

The main barriers to realizing a circular concrete chain are related to the physical infrastructure and storage capacity of Charlotte to handle concrete recycling. While technologies exist to recycle concrete into new concrete on-site, it is not always the case that demolition and construction happen simultaneously. This means that storage capacity for demolition wastes should be established, but the heavy weight of these types of materials means that storage and processing should be located near the construction and demolition sites. Combined with the intermittency of supply and demand of recycled concrete, this poses a major logistical challenge.

One possibility is the establishment of temporary decentralized material hubs. Identifying suitable locations for these sites requires knowledge on when materials will become available or be in demand. Thus, a prerequisite for implementation is urban mining maps, which can be used to optimize for temporary hub locations. This is a valuable exercise to enable optimal reuse of other building materials, and material hubs can be used to store other types of materials beyond concrete from demolition projects.

An additional barrier to concrete recycling is the common misconception that recycled materials are lower quality than virgin materials. In many countries, there are limits on the maximum amount of recycled aggregates that can be used in new concrete, for example 20% in the UK, Switzerland, and the Netherlands (MPA, 2013; Kuosa, 2012; McNeil, et. al., 2013). 20% recycled aggregate will likely be the maximum attainable share in the short-term and this will only be attainable with education for aggregate and concrete producers on the quality and benefits of recycled materials.

Finally, as Charlotte already has access to nearby sources of virgin concrete aggregate (e.g. from the Martin Marietta quarries in Charlotte), this may be a barrier to incentivizing local concrete recycling. Offering tax credits for the use of recycled aggregates over virgin materials or providing some other financial incentive may be necessary to encourage selection of recycled concrete.

IMPLEMENTATION IN CHARLOTTE

To implement this business case in Charlotte would require demolition companies or haulers, C&D waste processing companies, and concrete producers to work together, but there are clear benefits to each of these parties in concrete and glass recycling. Haulers would need to take concrete to a recycler (instead of a landfill), but this saves them costs in tipping fees. A C&D recycler would need to process waste concrete and glass into inputs for new concrete, though it could provide them with a nice new revenue stream. Concrete producers would need to accept recycled materials, but should save significantly in material input costs.

In North Carolina, 18.6 million tons of concrete are produced per year. The estimated share of this produced in Charlotte is around 1.5 million tons per year. If 20% of the aggregate was replaced with recycled concrete and 20% of the cement was replaced with recycled glass, this would mean 212,049 tons of recycled concrete and 38,814 tons of glass could be used to make all of the new concrete produced in Charlotte contain 16.4% recycled material.

Table 9: Concrete Recycling Chain Costs and Benefits

COST	VALUE	REVENUE	VALUE
Investment costs	\$300,000	Revenue from collection	-
Rent	-	Revenue from product sales	\$6.14 million
Personnel	\$80,000	Total	\$6.14 million
Fuel and utilities	\$175,604		
Glass purchasing	\$3.9 million	Return on investment	3,389%
Total	\$300,000 investment + \$4.14 mln in yearly costs	Payback period	1.5 years

In the region of Charlotte there are already companies crushing and recycling concrete into backfill and other uses. One large company doing this is C&M Recycling, who was recycling almost 400,000 tons of concrete in 2006. As these companies already have the equipment for crushing concrete into an appropriate size for use as aggregate, an additional investment would only need to be made for a high-capacity fine glass crusher (around \$300,000). Extra personnel to process the additional material would be necessary, which we estimate at less than five FTE/year.

The marginal maintenance and fuel costs are estimated at \$0.70/ton, for a total of \$175,604. While the input of demolished concrete is considered free (demolition companies or haulers save money by not having to pay \$5-\$39/ton in tipping fees), sourcing the glass is estimated at a cost of \$100/ton. This forms the highest cost at a total of \$3.9 million. It should be noted that this is the price for premium packaging glass, and as the county is having difficulty finding a market for recycled glass, the price could be much lower.

While there is a small advantage in terms of a final product made from recycled materials (for example in LEED point qualifications), it is unlikely that concrete producers are going to adopt recycled aggregate and glass in their product unless it also represents a cost benefit. This means that the recycled aggregate needs to have a cost that is lower than the virgin materials. We assume that the crushed glass powder and recycled aggregate can be sold to concrete producers at 80% of the price of virgin materials, which results in a yearly revenue of \$6.14 million.

OPPORTUNITIES

Beyond bringing financial benefits to all parties in the concrete recycling chain, this business case can also bring environmental impacts. Recycling all of the concrete currently going to landfill can reduce the total mass to landfill by a considerable 5.3%. Combined with a strategy to increase glass recycling by households (with a potential market for valuable recycling locally), this could reach as high as 8.5%.

In terms of concrete production, the recycled glass powder can reduce CO₂e emissions by 19% and water use by 14% (Jiang et al., 2014). In total, this means savings of almost 42,000 tons of CO₂e and 183 million gallons of water. While the aggregate recycling has a negligible effect on CO₂e emissions, it can reduce the overall land footprint by 30% (Braunschweig et al., 2011).

In addition, this business case alleviates a current problem in finding a suitable market for recycled glass in the Charlotte region. If prices for this material can be lowered, it would prove to be an even more profitable business case.

Table 10: Concrete Recycling Chain Opportunities

OPPORTUNITY	VALUE
Total waste diverted from landfill (tons/year)	100 million lbs
Potential profits from case (\$/year)	\$2 million after first year
Total jobs created (#)	5
CO ₂ e emissions saved (tons)	41,186
Water use avoided (gallons)	183 million
Land use prevented (acres)	Unknown

KEY TAKEAWAYS

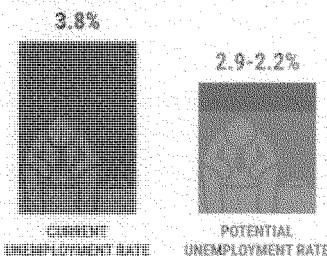
Together, each of the cases looks promising for Charlotte, although some are less feasible in the short term than others. For example, the food waste-to-feed production chain may still be hindered by the legal status of feed produced from food waste for the coming period, at least at this scale. The incentivized recycling collection system, while it should be implemented on the short term, will take years to result in the optimal level of participation and impact.

When implemented, the cases can have a significantly positive impact. This includes diverting a large share of the waste currently going to landfill, reducing CO₂e emissions by up to 379,000 tons/year (through reduced landfill and upstream production emissions), making considerable reductions to the embodied land and water footprints from producing virgin materials, and creating new employment opportunities for the city).

Together, the business cases can divert 103,000-145,000 tons from landfill, reducing the total mass by 10.9-15.4%.



The business cases can collectively create 290-492 jobs, reducing the number of unemployed by 24-41%.



Out of the 29 indicators we proposed in Chapter 2 for measuring circularity holistically in the city, each business case improves between 13-19 of the Key Performance Indicators (KPIs). As shown in the following tables, not all of the indicators are addressed with these business cases, however. Some indicators are more structural, for example providing access to high-quality green space in the city or improving information flows on waste materials. While the business cases may have an impact on these indirectly, such as reducing landfill space required improving land availability for green space, for the most part these will have to be addressed directly.

Other indicators, such as alleviating social inequality, can be addressed with the new business cases, but only if they are established in the right way. Any one of these initiatives can be formulated to provide jobs to people with difficulty accessing the labor market or to provide high-pay work with the opportunity for training, advancement,

and a sense of self-determination. However, this also isn't necessarily the case, which is why we have not considered these as impacted in the business cases. More work has to be done to ensure new initiatives advance society as well as the economy and environment. A circular economy, which should value social capital and labor over the value of materials, is a good opportunity for designing supply chains that are good for society. Nevertheless, it also involves a fundamental change in thinking at its core.

Beyond the benefits that each case can bring when implemented separately, combining different cases can result in additional benefits through symbiosis. In particular, establishing a materials innovation lab (which we have framed as based on biobased innovation, but could be expanded to other types of materials) and the incentivized collection system can interact with other initiatives we explored (as well as many more possible cases we did not explore).

Table 11: Effect of cases on "Charlotte as a Zero Waste City" KPIs

CHARLOTTE AS A ZERO WASTE CITY	CIRCULAR TEXTILES	FOOD WASTE TO FEED	MATERIALS INNOVATION LAB	TOKENIZED RECYCLING	CIRCULAR CONCRETE
1. Charlotte minimizes all use of landfills by 2040	+	++	+	++	++
2. Charlotte improves its virgin resource efficiency	+	++	+	++	++
3. Charlotte minimizes annual GHG emissions to 2 tons per person by 2050	+	++	+	++	++
4. Charlotte recovers maximum value from waste streams	+	+	+	0	+
5. Charlotte maintains material quality (complexity) of non-biotic resources	+	+	+	+	+
6. Charlotte ensures that nutrients from all biotic wastes are returned to natural cycles	0	+	+	0	0
7. Charlotte reduces its reliance on critical (scarce) materials	0	0	0	+	+
8. Charlotte improves information flows on waste between stakeholders and the City	0	0	0	0	0
9. Circular companies can thrive in Charlotte	+	+	++	+	+

Table 12: Effect of cases on "Charlotte as a Innovative City of the Future" KPIs

CHARLOTTE AS AN INNOVATIVE CITY OF THE FUTURE	CIRCULAR TEXTILES	FOOD WASTE TO FEED	MATERIALS INNOVATION LAB	TOKENIZED RECYCLING	CIRCULAR CONCRETE
1. Charlotte encourages circular design (reducing landfilled material waste)	+	+	++	+	+
2. Charlotte is a world leader in developing, testing and scaling new technologies relating to the circular economy	+	+	+	+	+
3. Charlotte encourages innovation in material intensive sectors (manufacturing, logistics, transportation and waste treatment)	0	0	+	0	0
4. Charlotte is a playground for developing and testing innovative circular solutions	+	+	+	+	+
5. Charlotte supports sustainable and circular R&D and innovation	0	0	+	0	0
6. Charlotte supports bottom-up community initiatives on sustainability and circularity	0	0	+	0	0

Table 13: Effect of cases on "Charlotte as a Resilient and Healthy City" KPIs

CHARLOTTE AS A RESILIENT AND HEALTHY CITY	CIRCULAR TEXTILES	FOOD WASTE TO FEED	MATERIALS INNOVATION LAB	TOKENIZED RECYCLING	CIRCULAR CONCRETE
1. Charlotte has clean water and air and a low exposure to pollutants	0	0	0	0	+
2. Charlotte has high quality and extensive green areas	0	0	0	0	0
3. Charlotte provides equal access to green areas for all citizens	0	0	0	0	0
4. Charlotte has resilient systems of provision (food, energy, water, etc.)	+	+	+	+	+
5. Charlotte minimizes flooding risk	0	0	0	0	0
6. Charlotte minimizes the use of toxic substances in industry	0	0	0	0	0
7. Charlotte ensures access to healthy food for all	0	0	0	0	0
8. Charlotte promotes social cohesion and strong communities	0	0	0	+	0

Table 13: Effect of cases on "Charlotte as a City with Opportunities for All" KPIs

CHARLOTTE AS A CITY WITH OPPORTUNITIES FOR ALL	CIRCULAR TEXTILES	FOOD WASTE TO FEED	MATERIALS INNOVATION LAB	TOKENIZED RECYCLING	CIRCULAR CONCRETE
1. Charlotte ensures the unemployed have the right type of training/experience to have meaningful circular jobs	0	+	+	0	0
2. Charlotte ensures employment opportunities for all	+	++	+	++	+
3. Charlotte offers meaningful jobs that are tied to the circular economy	+	++	*	++	+
4. Charlotte has circular jobs that provide opportunities for economic mobility	+	+	+	+	+
5. Charlotte ensures that circular economy strategies are leveraged to alleviate social inequality	0	0	0	0	0
6. Charlotte empowers citizens to reduce material consumption and reuse/recycle their materials and goods	0	0	+	+	0

While all five business cases can offer unique benefits to the city if they are implemented, there are remaining barriers and questions which still need to be addressed to ensure that the businesses can be successful.

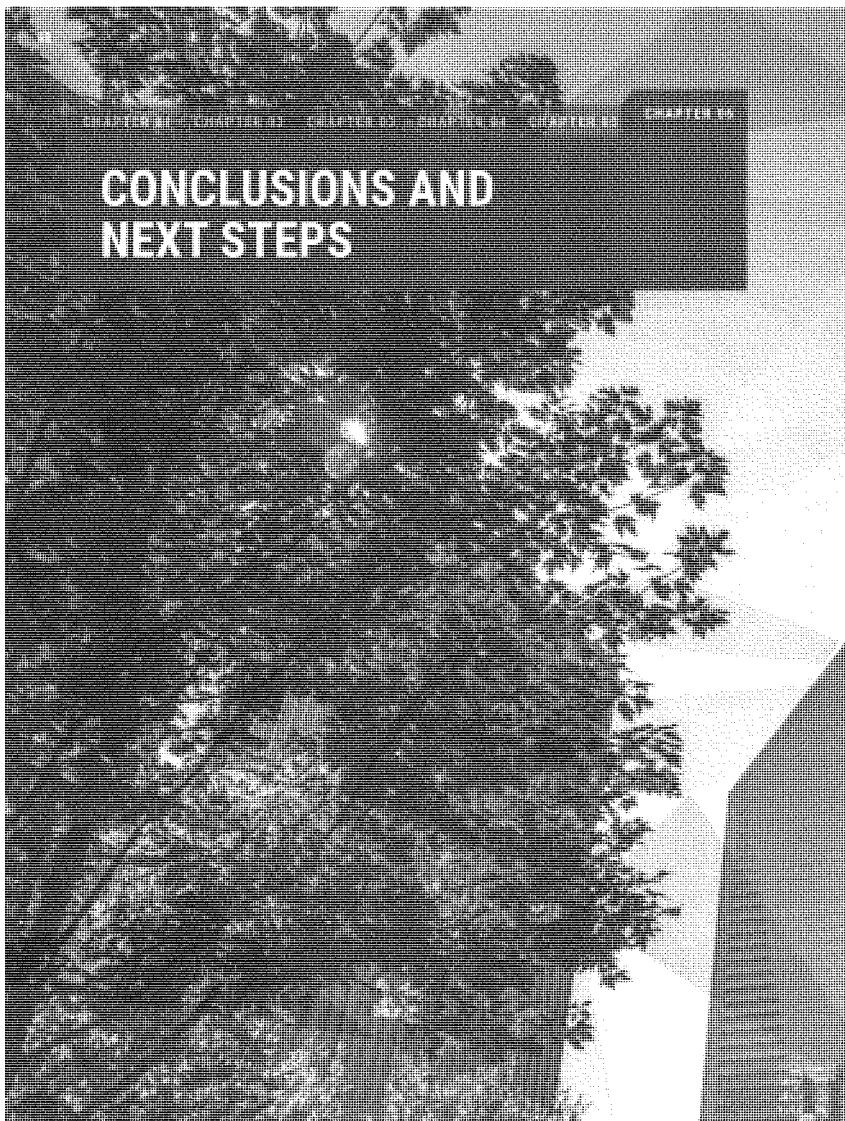
One familiar barrier is the willingness of waste producers (households and organizations) to make the effort to recycle materials. While the reverse logistics business case aims to address this by providing an incentive framework for households to take action, there are remaining structural challenges which also need to be tackled.

For example, households need education on the circular economy that is engaging and relevant to them personally. From companies, we have heard that it is often more expensive to implement recycling programs than just to send all waste to landfill, even though recycling should generate profits, while landfilling only results in costs for waste haulers. Perverse incentives like this need to be addressed by ensuring waste companies have sufficient information, access to markets, and support in investing in recycling and logistics infrastructure.

Another common thread is the potential reluctance of some companies to adopt recycled materials as an input to their production processes, even when the price can be lower than with virgin materials. While this can be addressed partially through education, more support may be needed, for example in testing the quality of recycled materials to prove they are suitable and safe, or even by doing new research in development of processing technologies.

Beyond these issues, there are many more structural barriers and issues in Charlotte that need to be addressed to ensure that these business cases and other initiatives in the city can be successful. These business cases can be an excellent starting point for building the right type of capacity, partnerships, and knowledge to take on more ambitious projects in the future, but they cannot stand alone without addressing the underlying issues that result in a linear economy. There is still much work to be done!





CONCLUSIONS AND NEXT STEPS

REFLECTION ON A CIRCULAR CHARLOTTE

The small selection of business cases explored in this report highlights the fact that a Circular Charlotte can bring a lot of direct benefits to the residents of the city. While the direct benefits on employment and landfill reductions are important, the most valuable benefits are less direct: effects on innovation, entrepreneurship, social cohesion, and the resilience of the local economy and community. Circularity is an important way for Charlotte to stand out and cement its position as a leading global city.

However, Charlotte still has a long way to go to become a circular city

In Charlotte, only 11.5% of materials that end up in the waste system each year are recycled or composted. This indicates that Charlotte is currently still a very linear city. While Charlotte aims to achieve ambitious circularity objectives in order to improve the strength and resilience of the city, our assessment reveals that there are still many barriers standing in the way. Without intervention, Charlotte is unlikely to move away from a linear system.

The city must make it convenient and affordable to recycle

One of the main issues that needs to be addressed is simply ensuring that materials make it back into new cycles of use. Charlotte has low recycling participation rates overall and even those who recycle only do so for a small share of materials. The first thing that needs to change is addressing the barriers that prevent households and companies from recycling. Despite the fact that recycling generates revenues while landfilling only represents an additional cost, we have discovered that it

is far more expensive and inconvenient for citizens and companies to recycle than to throw materials in the trash.

A pertinent example of this is food waste. Around 16% of all of the waste ending up in the landfill each year is food waste, for which there are no free programs for recycling. For many other materials, such as textiles and electronics, the inconvenience of taking these materials far away by car to have the option to recycle them discourages recycling participation. Textiles alone account for almost 6% of the waste sent to landfill. Policy, economic incentives, and infrastructure will need to be adapted to ensure recycling rates increase.

The city needs to create new products and markets for recyclable materials

In order to increase the materials diverted from landfill, Charlotte needs to create high-value outlets for material cycling at the same time. However, Charlotte's recycled materials have a relatively high contamination rate, which make them difficult to sell for recycling in regional markets, while export is becoming increasingly difficult for the same reason. This threatens the existing recycling system at a time when city wants to shift towards a more circular model.

Previously, baling mixed plastics or paper and selling this on the market was considered a sufficient recycling business model for the city and county. However, to extract significant value from materials and to ensure the city can become circular, new innovations, partnerships, and business models will need to be developed to process specific materials into high-value products that truly bring benefits to the city.





Over the longer-term, more fundamental issues need to be addressed to achieve circularity

While these first issues can be mostly addressed by simply setting into place better infrastructure for collection, separation, and processing of recyclables, over the longer term a shift to circularity requires more fundamental changes. Extending product life cycles for as long as possible, for example through maintenance, repair, and refurbishment, provides the highest societal value. At the end of life of a product, cascading materials into new products that maintain as much complexity as possible is ideal. For example, cotton should be used as cotton again, but when that is no longer possible, the cellulose can be used in paper production.

Oftentimes, this requires a change from the very beginning of the design process, to ensure that products are designed for longevity and can be effectively disassembled into usable parts, components, and materials. This goes far beyond the end-of-pipe solutions of recycling and is an area where Charlotte, as a historical manufacturing hub, can lead the way in developing truly circular products from the start.

Charlotte is already home to innovative initiatives that are paving the way for circularity

Local stakeholders are already undertaking circular initiatives or setting ambitious sustainability or circularity targets. While we highlighted a small number of initiatives we had contact with, there are many more interesting developments taking place, and new ideas brewing among entrepreneurs in Charlotte. What is already happening in Charlotte is inspiring and provides

evidence that the motivation and drive to make the city circular already is in place.

The overall vision of these organizations is much larger than what they are currently able to do with the resources they have at hand. One of the main tasks of the city should be to identify how to really upscale these initiatives and bring together different stakeholders to look for symbiotic opportunities. Finally, local awareness of these initiatives should be increased to get more people inspired and involved in supporting the shift towards circularity.

Beyond economic and environmental benefits, a circular Charlotte should also support society

In the current state assessment of Charlotte, we made a rough assessment of the number of jobs associated with recycling materials, which we further worked out in the business cases for specific scenarios. Based on this assessment, we estimated that at least 25% of the currently unemployed people in Charlotte could find jobs in these five new initiatives, even though these only cover around 11-15% of the wastes currently heading to landfill. However, job creation is not the only end goal. These jobs should also be formulated to provide rewarding work with opportunities for personal advancement.

Beyond these business cases, an important part of the overarching circularity strategy should be to provide education and entrepreneurship opportunities for local citizens that support a structural shift to circularity. With these types of activities in place, it will be possible to create meaningful, long-lasting change in Charlotte and to position the city as a frontrunner in circularity and innovation.

NEXT STEPS

In Chapter 4, we presented a strategic roadmap for how Charlotte can take action towards a circular future, focusing primarily on the steps that Charlotte's government can take. Here we summarize some of the most urgent actions and describe what additional steps other stakeholders can take to get involved in the transition.

Key actions local government can take include:

- Taking the lead on improving information flows on waste within the city to provide entrepreneurs and communities with the information they need to evaluate and establish new initiatives
- Measuring and reporting on circularity to identify areas of poor performance for strategic prioritization and to keep the public informed on the progress the city is making
- Identifying and alleviating key local policy barriers to the circular economy (e.g. zoning barriers, waste regulations) and lobbying for state or national policy change to address higher-level barriers
- Establishing stakeholder groups to work together on new cross-sectoral circularity initiatives
- Funding initiatives that will reduce costs for the city over the long term, increase innovation or entrepreneurship, or support underserved communities
- Appoint a Chief Circularity Officer to oversee strategy and track progress towards achieving goals
- Begin discussions on reframing the next interlocal agreement to ensure waste management agreements strongly support circularity

The commercial and industrial sectors can support circularity by:

- Developing comprehensive and ambitious circularity strategies internally and educating and empowering employees to take initiative in making the company more circular
- Establishing procurement protocols that prioritize recycled and low-impact materials
- Designing their own products and processes to ensure that material value can be recovered at the end of life and that the impacts along the entire life cycle of products are minimized
- Taking part in stakeholder discussions with other companies to actively look for industrial symbiosis opportunities
- Setting up internal material reduction and waste recovery processes
- Arranging partnerships with waste management companies who can help them meet ambitious recycling targets

Non-profit organizations can support the community in achieving circularity through:

- Establishing more neighborhood repair hubs to help citizens extend product lifespans and learn repair skills
- Expanding community gardening projects, especially in underserved communities, to empower people to produce their own food
- Setting up open community spaces that function as innovation centers and makerspaces for locals to learn new skills and develop new products
- Providing education on circularity and engaging the community in local recycling initiatives
- Giving support to local entrepreneurs in basic business skills (e.g. website creation, navigating business establishment procedures)

Local funders and financial institutions can create exponential growth in circularity by:

- Establishing revolving funds and microfinancing for initiatives such as green energy, urban farming, small-scale material processing, and refurbishment
- Supporting local accelerators by providing financial advice and investing in promising local start-ups
- Investing in pilot projects for remanufacturing, recycling, or upcycling materials in Charlotte

Educational institutions can structurally support a shift in mindset through:

- Providing comprehensive education on circularity and sustainability at every level
- Making hands-on learning and experimentation accessible to all students, e.g. through 100 Gardens aquaponics, materials innovation labs, or makerspaces
- Increasing student engagement through contests that provide strong incentives for participation by students
- Setting ambitious circularity and sustainability targets internally, examining procurement protocols, and informing and involving students in initiatives

Critical action can be taken by local citizens to increase circularity, such as:

- Reducing their own consumption of single-use and disposable products
- Consciously purchasing goods that will have a longer lifespan, maintaining products, and repairing instead of disposing of them
- Seeking out information about proper recycling and making an effort to recycle as much as possible
- Volunteering with local community organizations to make Charlotte more circular, fair, and healthy
- Petitioning local policymakers and companies to take on ambitious circularity initiatives

BIBLIOGRAPHY

- 3XN DEPA.** (2016). Building A Circular Future, 284. Retrieved from <https://issuu.com/3xnarchitects/docs/buildingacircularfuture>
- Abadi, M.** (2017, November 28). Forget New York – millennials are flocking to these 11 US cities in droves. Business Insider. Retrieved from <https://www.businessinsider.nl/cities-millennials-are-moving-to-2017-11/?internation-al=true&r=US#seattle-washington-2>
- Alexandra Freitas, Guoping Zhang, & Ruth Mathews.** (2017). Water Footprint Assessment of Polyester and viscose. Retrieved from http://waterfootprint.org/media/downloads/WFA_Polyester_and_Viscose_2017.pdf
- Alibaba.** (2018). Alibaba. Retrieved January 14, 2018, from https://www.alibaba.com/product-detail/Pet-bottle-scrap_50035463485.html?spm=a2700.7724838.2017115.3.72b79e5cU7y3m9
- Aluminum Association.** (n.d.). Recycling | The Aluminum Association. Retrieved March 28, 2018, from <http://www.aluminum.org/industries/production/recycling>
- American Chemistry Council.** (2016). United States National Postconsumer Plastic Bottle Recycling Report. Retrieved from www.plasticsrecycling.org
- Antonopoulos, I. S., Karagiannidis, A., & Kalogirou, E.** (2010). Estimation of Municipal Solid Waste heating Value in Greece in the Frame of Formulating Appropriate Scenarios on Waste Treatment. Third International Symposium on Energy from Biomass and Waste, (November 2010), 8. <https://doi.org/10.4236/eng.201062430>
- Association of Plastic Recyclers.** (2018). Plastic Film Recycling FAQs. Retrieved March 26, 2018, from <http://www.plasticsrecycling.org/education/faqs/plastic-film-recycling>
- Auburn Aggregates.** (2018). Pricing & Calculator. Retrieved June 19, 2018, from <http://auburnagg.com/buy/>
- Axion Consulting.** (2009). A financial assessment of recycling mixed plastics in the UK Financial modelling and assessment of mixed plastics separation and reprocessing on a commercial scale in the UK A financial assessment of recycling mixed plastics in the UK 1. Retrieved from <http://www.wrap.org.uk/sites/files/wrap/WRAP A financial assessment of recycling mixed plastics in the UK.pdf>
- Baker, A.** (2015). Fly farming: How it could feed the world | Time. Retrieved June 10, 2018, from <http://time.com/3825158/farming-flies-south-africa/>
- Bakker, M., Hu, M., Nusselder, S., Maqbool, A. S., Deen, R., Blake, G., ... Faizi, R. T.** (2015). Closed-loop economy: Case of concrete in the Netherlands. <https://doi.org/10.1007/s13398-014-0173-7.2>
- Bell, N. C., Lee, P., Riley, K., & Slater, S.** (2018). TACKLING PROBLEMATIc TEXTILE WASTE STREAMS. Retrieved from <http://resyntex.eu/downloads>
- Bernardo, C. A., Simões, C. L., & Pinto, L. M. C.** (2016). Environmental and economic life cycle analysis of plastic waste management options. A review, 10(123), 140001–20053. <https://doi.org/10.1063/1.4958429>
- Block, D. G.** (2017, November). 2017: A Mixed Bag for Recycled Plastics Pricing So Far. Plastics Technology. Retrieved from <https://www.ptonline.com/articles/2017-a-mixed-bag-for-recycled-plastics-pricing-so-far>
- Boboltz, S.** (2017, December). We Buy an Obscene Amount Of Clothes. Here's What It's Doing To Secondhand Stores. HuffPost. Retrieved from https://www.huffingtonpost.com/2014/11/20/fast-fashion-thrift-stores_n_5798612.html
- Brandon Jones.** (n.d.). Is recycling glass worth the cost? | News | kdhnews.com. Retrieved March 26, 2018, from http://kdhnews.com/news/is-recycling-glass-worth-the-cost/article_8e2dd0e6-d956-11e2-ab95-0019bb30f31a.html
- Bureau of Labor Statistics.** (2018). Unemployment Rates for Metropolitan Areas. Retrieved June 6, 2018, from <https://www.bls.gov/web/metro/laummrk.htm>
- Burwood-Taylor, L.** (2017, June). Protix Raises \$50m in Largest Insect Farming Investment on Record - AGfunderNews. AGfunder News. Retrieved from <https://agfundernews.com/protix-raises-50m-in-largest-insect-farming-investment-on-record.html>
- Calt, E. A.** (2008). Converting Organic Waste to Money 02-07-13, (March), 1–16.
- Can Pac Recycling.** (2018). Can Pac Recycling. Retrieved January 14, 2018, from <http://www.canpacrecycling.com/pricing.html>
- Canter, L.** (2015, July 4). Nappies: which are best – disposables or reusable? | Money | The Guardian. The Guardian. Retrieved from <https://www.theguardian.com/money/2015/jul/04/nappies-which-best-disposables-reusables-cost-ethics>
- Cavalline, T., Assistant, P. E., & Charlotte, U.** (2017). Environmental Considerations in Concrete Recycling. Retrieved from <http://www.cptechcenter.org/webinars/documents/RCA Environmental Considerations 03-29-2017.pdf>
- Charlotte Business Journal.** (2018). More proof that Charlotte is a boomtown. Retrieved January 14, 2018, from <https://www.bizjournals.com/charlotte/news/2015/03/05/more-proof-that-charlotte-is-a-boomtown.html>
- Charlotte Chamber.** (2017). Mecklenburg County Economy Quarterly: A New and Expanded Report 3rd Quarter 2017.
- Charlotte Chamber.** (2017). Go Green: A guide to Sustainability in Charlotte. Retrieved from https://charlottechamber.com/clientuploads/GreenWorks/Sustainable_Business.pdf
- Charlotte Chamber of Commerce.** (2015). Charlotte's Major Employers.

- Charlotte Fire Department.** (2018). About Us > Home. Retrieved June 12, 2018, from <http://charlottenc.gov/Fire/about-us/Pages/default.aspx>
- Charlotte Water.** (2018). Charlotte Water Commercial Rates. Retrieved June 20, 2018, from <http://charlottenc.gov/Water/Pages/CommercialRates.aspx>
- Charlottechamber.** (2017). International Business. Charlotte NC.
- Charlottechamber.** (2017). Advanced Manufacturing. Charlotte NC.
- Charlottechamber.** (2016). Charlotte's Energy Sector: Leading the charge. Charlotte NC.
- Charlottechamber.** (2017). Information Technology. Charlotte NC.
- Charlottechamber.** (2015). Charlotte's Manufacturing Industry. Charlotte NC. Retrieved from https://charlottechamber.com/clientuploads/Economic_pdfs/Manufacturers_Directory.pdf
- CHARLOTTE-MECKLENBURG POLICE DEPARTMENT.** (2018). Our Organization > Home. Retrieved June 12, 2018, from <http://charlottenc.gov/cmpd/organization/Pages/default.aspx>
- Chetty, R., & Hendren, N.** (2016). The Impacts of Neighborhoods on Intergenerational Mobility II: County-Level Estimates, (December). <https://doi.org/10.3386/w23002>
- Circle Economy.** (2016). Circle Case study, G-Star RAW close the loop denim: Business case and environmental impact analysis, 301–316. <https://doi.org/10.1002/dir.10048>
- City of Austin.** (2011). Austin Resource Recovery Master Plan. Austin EcoNetwork. Retrieved from https://austintexas.gov/sites/default/files/files/Trash_and_Recycling/MasterPlan_Final_12.30.pdf
- Clark & Chase Research.** (2009). Mecklenburg County Residential Recycling Behavior - 2009 Observation Study.
- CMC Recycling.** (2018). CMC Recycling Burlington. Retrieved January 15, 2018, from <https://www.cmcrecyclingburlington.com/current-pricing/>
- Colvin, P.** (2015). 24 Hours Vancouver – Langley bugs turn food waste into feed – Enterra. Retrieved June 10, 2018, from <http://www.enterrafeed.com/24-hours-vancouver-langley-bugs-turn-food-waste-into-feed/>
- Cordell, D., Drangert, J.-O., & White, S.** (2009). The story of phosphorus: Global food security and food for thought. *Global Environmental Change*, 19(2), 292–305. <https://doi.org/10.1016/J.GLOENVCHA.2008.10.009>
- Cotton Incorporated.** (2012). Life Cycle Assessment of Cotton Fiber & Fabric, 156. Retrieved from http://cottontoday.cottoninc.com/wp-content/uploads/2014/07/LCA_Full_Report.pdf
- Crow, J. M.** (2008). The concrete conundrum. *Chemistry World*, (March), 62–66.
- Crozier, T.** (2017). CHARLOTTE LODGING OVERVIEW. Retrieved from http://www.cushwakehospitality.com/wp-content/uploads/2017/10/Hospitality_Charlotte-Lodging-Overview_Mar2017_FINAL.pdf
- Denison, R. A.** (1996). ENVIRONMENTAL LIFE-CYCLE COMPARISONS OF RECYCLING, LANDFILLING, AND INCINERATION: A Review of Recent Studies. *Annual Review Energy Environment*, 21, 191–237. Retrieved from https://grist.files.wordpress.com/2006/01/1340_denison.pdf
- Depken, C. A., & Stephenson, E. F.** (2016). Hotel Demand Before, During, and After: Evidence from Charlotte, North Carolina, (September).
- DipTerra LLC.** (2014). On the Road to Commercial Production of BSFL [Sorting Out the Chaff : The Life and Times of BSF (Black Soldier Flies)]. Retrieved June 10, 2018, from <http://www.dipterra.com/blog.html?entry=on-the-road-to-commercial>
- DSM Environmental Services Inc.** (2017). Utilization Assessment of County Full-Service and Self-Service Waste and Recycling Drop-off Facilities.
- Duke Energy Renewables.** (2017). Solar Power Projects. Retrieved from <https://www.duke-energy.com/our-company/about-us/businesses/renewable-energy/solar-energy>
- Dunham, J., & Associates.** (2016). The Poultry Industry Creates Jobs in North Carolina. Retrieved from <http://www.bls.gov/bls/unemployment.htm>.
- Ecofys.** (2017). Circular Economy and Environmental Priorities for Business, 1–23. <https://doi.org/10.1038/531435a>
- Ellen MacArthur Foundation.** (2017). A New Textiles Economy: Redesigning Fashion's Future. Retrieved from https://www.ellenmacarthurfoundation.org/assets/downloads/publications/A-New-Textiles-Economy_Full-Report_Update_1-12-17.pdf
- Empson, R.** (2012). Economic Impact Of Startup Accelerators: \$1.6B+ Raised, 4,800+ Jobs Created, 2,000 Startups Funded | TechCrunch. Retrieved June 11, 2018, from <https://techcrunch.com/2012/11/27/economic-impact-of-startup-accelerators-1-6b-raised-4800-jobs-created-2000-startups-funded/?guccounter=2>
- Environmental and Energy Study Institute.** (2015). Fact Sheet - Jobs in Renewable Energy and Energy Efficiency. Retrieved January 25, 2018, from <http://www.eesi.org/papers/view/fact-sheet-jobs-in-renewable-energy-and-energy-efficiency-2015>
- Envision Charlotte.** (2014). The Waste Problem. Retrieved January 15, 2018, from <http://envisioncharlotte.com/water-waste-air/waste/>
- European Commission.** (2017). Price development and volume trade of plastic waste EU-28. Retrieved from <http://ec.europa.eu/eurostat/documents/342366/351919/web-sheet-plastic.pdf>

- Fahey, A.** (2016). Strong growth in rates, occupancy driving new hotels in Charlotte — CAHA. Retrieved June 1, 2018, from <http://www.charlotteareahotels.com/news/2017/1/13/strong-growth-in-rates-occupancy-driving-new-hotels-in-charlotte>
- Farzana Mohamed, Laura Sandler, Cesar Ramirez, & Jason C. Wong.** (1996). Take Back Laws on Industries of the European Community. Retrieved from <http://web.mit.edu/course/3/3s32/www/mohamed.html>
- Foolmaun, R. K., & Ramjeawon, T.** (2008). Life Cycle Assessment (LCA) of PET bottles and comparative LCA of three disposal options in Mauritius. International Journal of Environment and Waste Management, 2(1/2), 125. <https://doi.org/10.1504/IJEW.M.2008.016997>
- Ford, R. L.** (2018). Questions about poultry feed in North Carolina - thomasthorin@metabolic.nl - Metabolic Mail. Retrieved June 8, 2018, from <https://mail.google.com/mail/u/0/#inbox/163d5a2fa8239cef>
- Franklin Associates.** (2011). Life Cycle Inventory of 100% Postconsumer HDPE and PET Recycled Resin from Postconsumer Containers and Packaging.
- Freeman S.** (n.d.). The world is running out of sand — and you'd be surprised how significant that is | Financial Post. Retrieved June 10, 2018, from <http://business.financialpost.com/commodities/alarm-bells-ringing-globally-as-world-begins-running-out-of-sand>
- Gary J. Burtle, Larry Newton, & D. Craig Sheppard.** (2012). Black Soldier Fly Pupae for Aquaculture Diets. Engormix - Aquaculture. Retrieved from <https://en.engormix.com/aquaculture/articles/black-soldier-fly-pupae-aquaculture-diets-i35244.htm>
- Gary Liss & Associates.** (2008). Austin Zero Waste Strategic Plan. Retrieved from https://austinxtexas.gov/sites/default/files/files/Trash_and_Recycling/Zero_Waste_Plan_-_full_version_-_Council_Adopted_w-resolution.pdf
- GaWC.** (2017). The World According to GaWC 2016. Retrieved January 8, 2018, from <http://www.lboro.ac.uk/gawc/world2016t.html>
- GBB.** (2016). Solid Waste Characterization Study Fall 2015. Charlotte NC.
- Gershman, Brickner & Bratton, I.** (2007). Strategic Review of Quantities Generated, Processing and Disposal Capacities, and Recycling Market Attributes. Retrieved from www.gbbinc.com
- Global Recycling Network.** (2018). Global Recycling Network. Retrieved January 14, 2018, from <http://www.grn.com/a/view/1206.html>
- Governing the States and Localities.** (2016). Car Ownership in U.S. Cities Data and Map. Retrieved June 6, 2018, from <http://www.governing.com/gov-data/car-ownership-numbers-of-vehicles-by-city-map.html>
- Granger, T.** (2009). North Carolina Law to Ban Plastic Bottles from Landfills | recycler, a new way to recycle online! Retrieved June 6, 2018, from <http://recycler.com/2009/10/05/north-carolina-law-to-ban-plastic-bottles/>
- GrantThornton.** (2018). North Carolina's Top 100 Private Companies, 63–67.
- Green Seal Environmental Inc., & Sovereign Consulting Inc.** (2015). Construction and Demolition Waste Characterization and Market Analysis.
- Hainault, T., Smith, D., Cauchi, D., Thompson, D., Fisher, M., & Hetzel, C.** (2001). Recycling Used Electronics - Report on Minnesota's Demonstration Project.
- Hanchett, T. W.** (2018). THE GROWTH OF CHARLOTTE: A HISTORY. Retrieved May 16, 2018, from <http://www.cmhp.org/educhargrowth.htm>
- He, K., Tan, Q., Zheng, L., & Li, J.** (2018). Adapting to new policy environment – past pattern and future trend in us-sino waste plastic trade flow. International Journal of Sustainable Development & World Ecology, 1–10. <https://doi.org/10.1080/13504509.2018.1437845>
- Henderson, B.** (2017). A solar farm may be built on Charlotte's old Statesville Road landfill north of uptown | Charlotte Observer. Retrieved January 23, 2018, from <http://www.charlotteobserver.com/news/local/article124113469.html>
- ICIS (Independent Chemical Information Service).** (2015). US east coast R-PET bottle bale prices continue fall. Retrieved January 14, 2018, from <https://www.icis.com/resources/news/2015/11/19/9945745/us-east-coast-r-pet-bottle-bale-prices-continue-fall/#>
- Institute for Local Self-Reliance.** (2002). Recycling Means Business. Retrieved January 23, 2018, from <https://ilsr.org/recycling-means-business/>
- Islam, G. M. S., Rahman, M. H., & Kazi, N.** (2017). Waste glass powder as partial replacement of cement for sustainable concrete practice. International Journal of Sustainable Built Environment, 6(1), 37–44. <https://doi.org/10.1016/J.IJSBE.2016.10.005>
- Jacopo Prisco.** (n.d.). China to U.S.: Please stop sending us your junk - Sep. 11, 2017. Retrieved February 26, 2018, from <http://money.cnn.com/2017/09/11/news/china-scrap-ban-us-recycling/index.html>
- Jiang, M., Chen, X., Rajabipour, F., & Hendrickson, C. T.** (2014). Comparative Life Cycle Assessment of Conventional, Glass Powder, and Alkali-Activated Slag Concrete and Mortar. Journal of Infrastructure Systems, 20(4), 04014020. [https://doi.org/10.1061/\(ASCE\)IS.1943-555X.000021](https://doi.org/10.1061/(ASCE)IS.1943-555X.000021)
- Jin, R., & Chen, Q.** (2015). Investigation of Concrete Recycling in the U.S. Construction Industry. Procedia Engineering, 118, 894–901. <https://doi.org/10.1016/j.proeng.2015.08.528>
- Johnson, V. O., & Jackson, D.** (2017). Healthy Communities - SWANA 2017 Excellence Award Entry Charlotte.
- Kelley Stoklosa.** (n.d.). New Life for Glass - Recycling Today. Retrieved March 26, 2018, from <http://www.recyclingtoday.com/article/r10112-processing-glass-recycling/>
- Kim, T., Tae, S., & Chae, C. U.** (2016). Analysis of environmental impact for concrete using LCA by varying the recycling

- components, the compressive strength and the admixture material mixing. *Sustainability (Switzerland)*, 8(4), 1–14. <https://doi.org/10.3390/su8040389>
- Kinsella, S.** (2012). Paperwork : Comparing Recycled to Virgin Paper. Royal Society of Chemistry, 3(April), 1–13. Retrieved from Retrieved from conservetree.org/learn/WhitePaper_Why_Recycled.pdf [Accessed on 25 July 2016]
- Kuosa, H.** (n.d.). Reuse of recycled aggregates and other C&D wastes. Retrieved from <https://www.vtt.fi/inf/julkaisut/muut/2012/VTT-R-0598-12.pdf>
- Kuzhiyil, N., & Kong, S.-C.** (2009). Energy Recovery from Waste Plastics by Using Blends of Biodiesel and Polystyrene in Diesel Engines. *Energy & Fuels*, 23(6), 3246–3253. <https://doi.org/10.1021/ef801110j>
- Leung, V.** (2018). News Release – Enterra receives new approvals to sell sustainable insect ingredients for animal feed in USA, Canada and EU – Enterra. Retrieved June 7, 2018, from <http://www.enterrafeed.com/news-release-enterra-receives-new-approvals-to-sell-sustainable-insect-ingredients-for-animal-feed-in-usa-canada-and-eu/>
- Leung, V.** (2016, July). News Release – New insect protein gains approval for use in animal feed – Enterra. Enterra. Retrieved from <http://www.enterrafeed.com/news-release-new-insect-protein-gains-approval-for-use-in-animal-feed/>
- Mae Israel.** (n.d.). Why you can't toss these into your recycling bin | UNC Charlotte Urban Institute. Retrieved April 10, 2018, from <https://ui.uncc.edu/story/why-you-cant-toss-these-your-recycling-bin>
- Manfredi, S., Tonini, D., Christensen, T. H., & Schaffert, H.** (2009). Waste Management & Research gases and global warming contributions. *Waste Management & Research*, (October), 825–836. <https://doi.org/10.1177/0734242X09348529>
- McNeil, K., & Kang, T. H. K.** (2013). Recycled Concrete Aggregates: A Review. *International Journal of Concrete Structures and Materials*, 7(1), 61–69. <https://doi.org/10.1007/s40069-013-0032-5>
- Mecklenburg County.** (2018). Construction and Demolition Debris Landfills. Retrieved June 19, 2018, from <https://www.meccknc.gov/LUESA/SolidWaste/ConstructionRecycling/Pages/cd.aspx>
- Mecklenburg County.** (2017). Disposal & Recycling Convenience Centers: July 2017–June 2018 Fees & Information, (July 2017).
- Michaelbluejay.com.** (2017). How much fuel is required to produce electricity. Retrieved January 26, 2018, from <http://michaelbluejay.com/electricity/fuel.html>
- Micks, A.** (2012). The Costs of Recycling. Retrieved June 18, 2018, from <http://large.stanford.edu/courses/2012/ph240/micks2/>
- Mid Atlantic Solid Waste Consultants.** (2008). Construction and Demolition Debris Composition Study. Mswconsultants, (September), 1–59. <https://doi.org/10.1080/1475382862000363139>
- Miljögiraff.** (2016). 75 report LCA on Rec Cotton Miljögiraff HM, (August), 70. <https://doi.org/10.13140/RG.2.2.22598.57927>
- Miller, H.** (2012). Dirtytech: They Obsessively Sort and Recycle What You Dump | San Francisco Public Press. Retrieved June 18, 2018, from <https://sfpublicpress.org/news/2012-12/dirtytech-they-obsessively-sort-and-recycle-what-you-dump>
- Montgomery Scrap Corporation.** (2018). Montgomery Scrap Corp Pricing. Retrieved January 14, 2018, from <http://www.scrapmsc.com/our-pricing/>
- Morris, J.** (2016). Oregon Recycling Markets Price Cycles and Trends: A Statistical Search for Significant Economic Causes. Retrieved from <http://www.oregon.gov/deq/FilterDocs/RecyclingPriceAnalysis.pdf>
- MPA Cement, & Mineral Products Association.** (n.d.). Use of recycled aggregates in concrete. Retrieved from http://cement.mineralproducts.org/documents/FS_6_Use_of_recycled_aggs_in_concrete.pdf
- National Asphalt Pavement Association.** (2016). Asphalt Pavement Industry Survey on Recycled Materials and Warm-Mix Asphalt Usage.
- Neidel, T. L., & Jakobsen, J. B.** (2013). Report on initial assessment of relevant recycling technologies. Plastic ZERO - Public Private Cooperations for Avoiding Plastic as a Waste, (September), 1–33.
- Nordic Council of Ministers.** (2017). Greener Textiles.
- Northeast Michigan Council of Governments, Michigan Department of Environmental Quality, Resource Recycling Systems, & Public Sector Consultants.** (2016). Recycling in Michigan: Successful Recycling Programs, Best Practices, and Diversion Potential.
- OECD.** (2015). Material Resources, Productivity and the Environment. <https://doi.org/10.1787/9789264190504-en>
- Office of Planning, & The District Department of the Environment.** (2012). Sustainable DC Plan. Retrieved from https://sustainable.dc.gov/sites/default/files/dc/sites/sustainable/page_content/attachments/DCS-008_Report_508.3j.pdf
- Paper Recycling Online.** (2017). Paper Recycling Online. Retrieved January 14, 2018, from <http://www.recycle.cc/freepaper.htm>
- Parilla, J.** (2016). Greater Charlotte in the global economy: Benchmarking the region's global competitive assets. Washington D.C. Retrieved from [https://www.slideshare.net/owashburn/greater-charlotte-in-the-global-economy-benchmarking-the-regions-global-competi](https://www.slideshare.net/owashburn/greater-charlotte-in-the-global-economy-benchmarking-the-regions-global-competitiveness-assets?ref=https://www.brookings.edu/on-the-record/greater-charlotte-in-the-global-economy-benchmarking-the-regions-global-competi)
- Patagonia.** (2009). Closing the Loop – A Report on Patagonia's Common Threads Garment Recycling Program – The Cleanest Line. Retrieved June 9, 2018, from <https://www.patagonia.com/blog/2009/03/closing-the-loop-a-report-on-patagonias-common-threads-garment-recycling-program/>

- PCA Portand Cement Association.** (n.d.). North Carolina Cement Industry, Building the Foundation of North Carolina's Economy. Retrieved from http://www.cement.org/docs/default-source/market-economics-pdfs/cement-industry-by-state/nc-statefacst-17-d2.pdf?sfvrsn=b78e6bf_2
- Pelletier, N.** (2008). Environmental performance in the US broiler poultry sector: Life cycle energy use and greenhouse gas, ozone depleting, acidifying and eutrophying emissions. Agricultural Systems, 98(2), 67–73. <https://doi.org/10.1016/j.agsy.2008.03.007>
- Petru, A.** (2014, November). What's in Store for Clothes Too Worn to Sell? Triple Pundit. Retrieved from <https://www.triplepundit.com/special/sustainable-fashion-2014/thrift-store-happens-donated-clothes/>
- Pierce, L. M.** (2017). How to increase recycling of flexible packaging | Packaging Digest. Retrieved March 21, 2018, from <http://www.packagingdigest.com/flexible-packaging/how-to-increase-recycling-of-flexible-packaging-2017-03-15>
- Plastics Recycling Update.** (2016). PetroChem Wire: Recycled HDPE price softens. Retrieved January 14, 2018, from <https://resource-recycling.com/plastics/2016/07/19/petrochem-wire-recycled-hdpe-price-softens/>
- Portillo, E.** (2015, May 24). Uptown's hotel building boom: How many rooms are enough? | Charlotte Observer. The Charlotte Observer. Retrieved from <http://www.charlotteobserver.com/news/business/biz-columns-blogs/development/article21688650.html>
- Portillo, E.** (2017, May 26). This number shows why developers aren't worried they're building too many apartments in Charlotte. Charlotte Observer. Retrieved from <http://www.charlotteobserver.com/news/business/biz-columns-blogs/development/article152694539.html>
- Premier Recycling.** (2018). Mississauga Scrap Metal Pricing. Retrieved January 20, 2018, from <http://www.premierrecycling.ca/contact/premier-recycling-mississauga-ltd/pricing/>
- Protix.** (2018). Partners | Protix. Retrieved June 7, 2018, from <https://protix.eu/partners/>
- R.J. Grondin & Sons.** (2017). LOADED AGGREGATE PRICING 2017.
- Rachel Stone.** (n.d.). Charlotte recycling business sees green in discarded e-devices | Charlotte Observer. Retrieved April 6, 2018, from <http://www.charlotteobserver.com/news/business/small-business/article82516842.html>
- Rajiv Joarder.** (n.d.). Recycled Glass Price Increases 40% in 3 years - Spend Matters. Retrieved March 26, 2018, from <http://spendmatters.com/2015/04/20/recycled-glass-price-increases-40-in-3-years/>
- RCBC.** (2018). Recycling Council of British Columbia. Retrieved January 14, 2018, from <https://www.rcbc.ca/resources/faqs/misc1>
- Recyclebank.** (n.d.). Because You Asked: Is Aluminum Foil Recyclable? - Live Green - Recyclebank. Retrieved March 28, 2018, from <https://livergreen.recyclebank.com/because-you-asked-is-aluminum-foil-recyclable>
- Recycler's World.** (2018). Recycler's World. Retrieved January 20, 2018, from <http://www.recycle.net/>
- Recycler's World.** (2018). Recycler's World. Retrieved January 17, 2018, from <http://www.recycle.net/exchange/>
- RecycleXchange.** (2018). RecycleXchange. Retrieved January 24, 2018, from <http://www.recyclexchange.com/exchange/>
- Recycling Today.** (2018). Recycling Today. Retrieved January 14, 2018, from <http://www.recyclingtoday.com/rmdas/>
- Recycling Today.** (2016). Recycling Today "Off-the-Charts." Retrieved January 14, 2018, from <http://www.recyclingtoday.com/article/off-the-charts-september-2016/>
- Recycling Today.** (2014). Recycling Today "Clear Options." Retrieved January 14, 2018, from <http://www.recyclingtoday.com/article/r11114-recycled-glass-commodity/>
- Resource Recycling.** (2013). Growth Trends and New Drivers for Recycling of Non-Bottle Mixed Rigid Plastics. Retrieved from www.resource-recycling.com
- RREUSE (The Reuse and Recycling EU Social Enterprises network).** (2015). Briefing on job creation potential in the reuse sector. Retrieved from <http://www.rreuse.org/wp-content/uploads/Final-briefing-on-reuse-jobs-website-2.pdf>
- Salmon Business.** (2017). Protix seeks new location for expansion of farvae production | SalmonBusiness. Retrieved June 9, 2018, from <http://salmonbusiness.com/protix-looking-for-new-location/>
- Salvage-Exchange.** (2018). Salvage-Exchange. Retrieved January 24, 2018, from <http://www.salvage-exchange.net/>
- Scott Mouw.** (n.d.). NC State Perspective On Glass Recycling. Retrieved from <http://gmic.org/wp-content/uploads/2016/06/2011GOMD-Mouw.pdf>
- Scrap Register.** (2017). United States electronic scrap Prices, China electronic scrap Prices, India electronic scrap Prices. Retrieved January 20, 2018, from <https://www.scrapregister.com/metal-price/electronic-scrap/80>
- Sheets, B.** (2014). At recycling center, workers sort 550 tons of trash a day | HeraldNet.com. Retrieved June 18, 2018, from <https://www.heraldn.com/news/at-recycling-center-workers-sort-550-tons-of-trash-a-day/>
- Shui, S., & Plastina, A.** (2013). WORLD APPAREL FIBER CONSUMPTION SURVEY WORLD APPAREL FIBRE CONSUMPTION SURVEY 2013 Effects of the Great Recession on Apparel Fibre Consumption. Retrieved from https://www.icac.org/cotton_info/publications/statistics/world-apparel-survey/FAO-ICAC-Survey-2013-Update-and-2011-Text.pdf
- Spend Matters.** (2015). Recycled Glass Price Increases 40% in 3 years. Retrieved January 14, 2018, from <http://spendmatters.com/2015/04/20/recycled-glass-price-increases-40-in-3-years/>
- Statista.** (n.d.). U.S. cement prices 2017 | Statista. Retrieved June 20, 2018, from <https://www.statista.com/statistics/219339/us-prices-of-cement/>

- Statista.** (2014). Share of U.S. construction & demolition waste by material 2014 | Statistic. Retrieved June 12, 2018, from <https://www.statista.com/statistics/504126/share-of-construction-demolition-waste-generation-in-us-by-material/>
- Statista.** (2016). Price of sand and gravel United States 2016. Retrieved January 25, 2018, from <https://www.statista.com/statistics/219381/sand-and-gravel-prices-in-the-us/>
- Street, N. T., & Consulting, K.** (2012). MECKLENBURG COUNTY NC FOOD WASTE DIVERSION STUDY FINAL REPORT MARCH 2012 Prepared for : Mecklenburg County Solid Waste Waste Reduction / Composting Prepared by : innovative waste solutions, (March).
- Swinehart, A.** (2014). Is 100% recyclable flexible packaging possible? | Packaging Digest. Retrieved March 21, 2018, from <http://www.packagingdigest.com/flexible-packaging/is-100-recyclable-flexible-packaging-possible140807>
- Tam, V.** (2008). Economic comparison of concrete recycling : a case study approach.
- Tellus Institute, & Sound Resource Management.** (2013). More jobs, less pollution: Growing the Recycling Economy in the U.S. New Economy, 2(3), 157–162. <https://doi.org/10.1111/j.1468-0041.1995.tb00074.x>
- The Balance.** (2017). Get Current Scrap Metal Prices in the U.S. Retrieved January 14, 2018, from <https://www.thebalance.com/current-scrap-metal-prices-2877937>
- The Ellen MacArthur Foundation.** (2016). The Circular Economy and the Promise of Glass in Concrete. Retrieved from <https://www.ellenmacarthurfoundation.org/assets/downloads/circular-economy/The-Circular-Economy-and-the-Promise-of-Glass-in-Concrete.pdf>
- The Guardian.** (2016). Billions of dirty nappies can be turned into pet litter, insulation and compost. Retrieved January 14, 2018, from <https://www.theguardian.com/sustainable-business/2016/sep/06/billions-dirty-nappies-diapers-recycled-pet-litter-insulation-compost-waste-landfill>
- The Recycling Partnership.** (2016). State of Recycling. Retrieved from <https://therecyclingpartnership.app.box.com/s/i0wvano7hi3dr3ivqxv689y4zz0583l2>
- Themelis, N. J., & Mussche, C.** (2014). 2014 Energy and Economic Value of Municipal Solid Waste (MSW), Including Non-Recycled plastics (NRP), Currently Landfilled in the Fifty States. Columbia University. Retrieved from <http://www.americanchemistry.com/Policy/Energy/Energy-Recovery/2014-Update-of-Potential-for-Energy-Recovery-from-Municipal-Solid-Waste-and-Non-Recycled-Plastics.pdf>
- Thomas, S.** (2018). How Charlotte's massive growth compares to other U.S. metros (SLIDESHOW) - Charlotte Business Journal. Retrieved June 8, 2018, from <https://www.bizjournals.com/charlotte/news/2018/03/23/how-charlottes-massive-growth-stacks-up-to-other-u.html>
- Thompson, P., & Willis, P.** (2013). A review of commercial textile fibre recycling technologies A study to identify commercially viable textile fibre recycling technologies, to inform the development of a sustainable market within the UK for recycled fibres, including a high level business case for their operation in the UK. Retrieved from http://www.wrap.org.uk/system/files/private/Commercial_textile_fibre_recycling_technologies_report.pdf
- Toby van Vleet.** (n.d.). Local recyclers scramble after China curbs recycling imports | Metro. Retrieved February 26, 2018, from <https://www.oregonmetro.gov/news/local-recyclers-scramble-after-china-curbs-recycling-imports>
- Torres, A., Brandt, J., Lear, K., & Liu, J.** (2017). A looming tragedy of the sand commons. *Science* (New York, N.Y.), 357(6355), 970–971. <https://doi.org/10.1126/science.aoa0503>
- Tossei, I.** (2013). Conversation with David Suzuki leads to maggot-based animal feed - The Globe and Mail. Retrieved June 10, 2018, from <https://www.theglobeandmail.com/report-on-business/small-business/startups/conversation-with-david-suzuki-leads-to-maggot-based-animal-feed/article15114182/>
- Trans-American Trading Co.** (2018). Trans-American Trading Co. Recycling. Retrieved January 17, 2018, from <http://trancio.com/sellers/recycling-faqs/>
- U.S. Census Bureau.** (n.d.). North Carolina State Imports. Retrieved from <https://www.census.gov/foreign-trade/statistics/state/data/imports/nc.html>
- U.S. Cluster Mapping.** (2018). Regional Dashboard: Cluster Portfolio - Charlotte, NC Economic Area. Retrieved June 9, 2018, from https://clustermapping.us/region/economic/charlotte_gastonia_salisbury_nc_sc/cluster-portfolio#employment
- U.S. Environmental Protection Agency (EPA).** (2010). U.S. Environmental Protection Agency Office of Resource Conservation and Recovery, (February), 1–70. Retrieved from https://www.epa.gov/sites/production/files/2016-03/documents/warm_v14_containers_packaging_non-durable_goods_mateials.pdf
- Ulubeyli, S., Kazaz, A., & Arslan, V.** (2017). Construction and Demolition Waste Recycling Plants Revisited: Management Issues. *Procedia Engineering*, 172, 1190–1197. <https://doi.org/10.1016/j.proeng.2017.02.139>
- US EPA.** (2018). Resource Conservation and Recovery Act (RCRA) Overview. Retrieved March 28, 2018, from <https://www.epa.gov/rcra/resource-conservation-and-recovery-act-rcra-overview>
- US EPA, OSWER, O.** (n.d.). Best Practices for Reducing, Reusing, and Recycling Construction and Demolition Materials. Retrieved June 10, 2018, from <https://www.epa.gov/smm/best-practices-reducing-reusing-and-recycling-construction-and-demolition-materials#design>
- Veldkamp, T., Van Duinkerken, G., Van Huis, A., Lakemond, C. M. M., Ottewanger, E., Bosch, G., & Van Boekel, M. A. J. S.** (2012). Wageningen UR Livestock Research Partner in livestock innovations Insects as a sustainable feed ingredient in pig and poultry diets - a feasibility study Title Insects as a sustainable feed ingredient in pig and poultry diets - a feasibility study. Retrieved from <http://www.livestockresearch.wur.nl>

- Velis, C.** (2014). A report from the ISWA Task Force on Globalisation and Waste Management Global recycling markets: plastic waste A story for one player ~ China. Retrieved from https://www.iswa.org/fileadmin/galleries/Task_Forces/TF-GWM_Report_GRM_Plastic_China_LR.pdf
- Wang, Y.-S., & Shelomi, M.** (2017). Review of Black Soldier Fly (*Hermetia illucens*) as Animal Feed and Human Food. Foods (Basel, Switzerland), 6(10). <https://doi.org/10.3390/foods6100091>
- Warner, B.** (2014, October). The Next Big Thing in the Food Industry: Flies | Inc.com. INC. Magazine. Retrieved from <https://www.inc.com/magazine/201406/bernhard-warner/envirofly-ght-turns-black-soldier-fly-larvae-into-food.html>
- Waste 360.** (1993). Reflections On Refuse Collection Management | Waste360. Retrieved June 18, 2018, from http://www.waste360.com/mag/waste_reflections_refuse_collection
- Waste 360.** (2015). PET, Aluminum Can Prices Drop, Colored HDPE Values Rise in Latest Readings. Retrieved January 14, 2018, from <http://www.waste360.com/commodities-pricing/pet-aluminum-can-prices-drop-colored-hdpe-values-rise-latest-readings>
- Waste Management World.** (2017). Dirty Diaper Recycling Project Brings Nappies into the Circular Economy. Retrieved January 14, 2018, from <https://waste-management-world.com/a/dirty-diaper-recycling-project-brings-nappies-in-to-the-circular-economy>
- Watkins, E., Gionfra, S., Schweitzer, J.-P., Pantzar, M., Janssens, C., & Ten Brink, P.** (2017). EPR in the EU Plastics Strategy and the Circular Economy: A focus on plastic packaging. Retrieved from https://ieep.eu/uploads/articles/attachments/95369718-a733-473b-aa6b-153c1341f581/EPR_and_plastics_report_IEEP_9_Nov_2017_final.pdf?v=63677462324
- Watson, D., Charlotte Gylliing, A., Andersson, T., Elander, M., & Heikkilä, P.** (2017). Textile-to-textile recycling - Ten Nordic Brands that are Leading the Way. Retrieved from <http://dx.doi.org/10.6027/>
- Wikipedia.** (2018). Charlotte, North Carolina. Retrieved January 17, 2018, from https://en.wikipedia.org/wiki/Charlotte,_North_Carolina#Demographics
- Wipe Out Waste.** (2006). Waste Reduction and Recycling Resource Guide- Construction and Demolition, 03, 15–16.
- World Population Review.** (2018). World Population Review. Retrieved January 17, 2018, from <http://worldpopulationreview.com/us-cities/charlotte-population/>
- World Resources Institute (WRI).** (2015). Policy and Action Standard - Waste Sector Guidance, (May).
- WRAP.** (2012). A review of commercial textile fibre recycling technologies A study to identify commercially viable textile fibre recycling technologies, to inform the development of a sustainable market within the UK for recycled fibres, including a high level business case for their operation in the UK. Retrieved from http://www.wrap.org.uk/system/files/private/Commercial_textile_fibre_recycling_technologies_report.pdf
- WRAP.** (2017). Market Snapshot - October 2017. Retrieved from http://www.wrap.org.uk/sites/files/wrap/Market_Snapshot_October_2017_0.pdf
- WRAP.** (2018). Waste Electrical and Electronic Equipment Collection Guide Robust services in WEEE collection. Retrieved from http://www.wrap.org.uk/sites/files/wrap/WRAP_WEEE_Collection_Guide.pdf
- WRAP.** (2018). Realising the Reuse Value of Household WEEE. Retrieved from www.wrap.org.uk/eproducts
- WRAP, & Green Alliance.** (2015). Employment and the circular economy Job creation in a more resource efficient Britain, 28. <https://doi.org/10.13140/RG.2.1.1026.5049>
- Yin, Y., Yao, D., Wang, C., & Wang, Y.** (2014). Removal of spandex from nylon/spandex blended fabrics by selective polymer degradation. *Textile Research Journal*, 84(1), 16–27. <https://doi.org/10.1177/0040517513487790>
- Zamani, B.** (2011). Carbon footprint and energy use of textile recycling techniques. Master's Thesis - Chalmers Institute. Retrieved from <http://publications.lib.chalmers.se/records/fulltext/146872.pdf>
- Slimme puinbreker spaart beton en CO₂ | De Ingenieur.** (2018). Retrieved June 10, 2018, from <https://www.deingenieur.nl/artikel/slimme-puinbreker-spaart-beton-en-co2>
- Sand, rarer than one thinks.** (2014). Environmental Development, 11, 208–218. <https://doi.org/10.1016/J.ENVDEV.2014.04.001>

Ms. LYLES. You know, this benefits us because we are looking at our landfills and our highways, and we need to do something about it. We are excited to leverage our State University, UNC Charlotte, and the many entrepreneurs that are growing from that University's research section.

But we know that real change requires everything of everyone, that we have to look at what we are currently doing and we have to try to change. And we started doing that.

We have taken immediate action, now completing energy audits for over a million square feet, including and starting with our cultural facilities, some of the best in our country I hope. And we want to determine retrofits that would reduce building energy usage.

We are embedding sustainability into our comprehensive land use plan that we call the Charlotte of the Future in 2040. We are launching a Green Workforce Development Program to train individuals in building efficiency, solar energy, and other emerging technologies.

We are investing our public transportation network and electrical vehicles for our city fleet, and our airport had just invested in five electric buses.

We are particularly proud of our work with the private sector, and being accepted into the Duke Energy Green Source Advantage Program, a renewable energy program for North Carolina customers who want to support renewable resources. We think that if we can work with this program, that it will equate to moving 12,000 passenger vehicles from the roads annually in our city.

We know that 61 percent of our greenhouse gas emissions come from transportation and buildings, so if you really want to help us do better, here are some of the things that we need. So, I second many of those that the Chair has mentioned.

We need more money and research for renewable energies. We need money to retrofit our existing facilities. We need funding for electric vehicles, especially for our buses. We need infrastructure money to make choices that we can have that will a difference. We need support for mass transit. And we need support for our light rail system.

Last week, Greta Thunberg came to our city, and she spoke on our Government Center Plaza, energizing thousands of young people to address climate change. Well, that is great, but we need to address it now. Our young people are holding us accountable, and we should be accountable. Charlotte is a great city and it is a livable city, but we must make changes to make it a city that everyone can continue to see.

You know, cars generate 36 percent of our bad air. We have to have mass transit. We have to have a better bus system. All of those things are essential to us continuing to be a city that we would all like to see. Thank you so much for having me, and I appreciate the opportunity to talk about my city, my representative, and all of our governing officials to represent Charlotte. Thank you.

[The information follows:]



I greatly appreciate your invitation and the opportunity to provide testimony to the committee to highlight challenges associated with addressing climate change, and the actions we're taking to make the City of Charlotte a resilient city and model for environmental sustainability.

Charlotte's population has more than doubled to almost 900,000 residents and is now the 16th largest city in the United States. Every day, we welcome more than 100 new residents and this city is expected to add almost 400,000 people over the next 20 years. Our Charlotte region is home to more than 2.5 million people and is one of the top five fastest growing large cities.

Charlotte is an international gateway, home to nearly 1,000 foreign-owned firms. We have added more than 14,800 jobs in the last year, and another 12,700 this year. Charlotte has become a hub for entrepreneurs and the booming tech industry, and we are also the 2nd largest banking city in the U.S. Here are a few of the objective ratings:

Charlotte is ...

- #2 metro in the U.S. for economic growth potential (Business Facilities, 2017)
- #1 TechTown in the U.S. (CompTIA 2018)
- #1 fastest growing tech-talent market in country (CBRE, 2018 & 2019)
- #1 city in America for female-owned business growth (American Express 2018)
- #3 city in America for STEM job growth (Forbes)
- 6th best large city to start a business in the U.S. (Wallethub 2019)
- "Top Ten Rising Cities for Start-ups" (2018 Forbes / Revolution)

Charlotte is also the #1 city where millennials are moving. Additionally, SmartAsset projected Charlotte to have the highest rate of millennial growth in the nation. Yelp rated Charlotte #1 - Up & Coming City in 2018. All this momentum, in conjunction with the 27 nationally ranked universities within 200 miles of Charlotte, helps us generate a pipeline of future talent.

One reason people are moving here is our geographic location. That prime location puts our city at a significant risk for a catastrophic event and our explosive growth puts an even larger number of people at risk. Our state and region is directly feeling the consequences of extreme weather patterns. Hurricane Dorian was the latest example of a major weather event to batter the state, making landfall just a week shy of Hurricane Florence's one-year anniversary. Our increasing population density will further strain infrastructure already threatened by higher temperatures and increased precipitation intensity and frequency.



This growth will also lead to increases in respiratory and heat-related illnesses associated with emissions from power plants and vehicles and increasing temperatures. These changes put our critical regional resources increasingly at risk. Ultimately this will have dramatic effects on the vibrancy and viability of our metropolitan area that so many are proud to call home.

We have two choices:

- 1) Embrace the reality that long-term plans are needed to change the way we consume energy; or
- 2) Keep doing what we are doing and pass this issue on to the next generation where it will be too late to do anything.

The choice we made has changed the course of Charlotte history.

As a signatory to the Global Covenant of Mayors (2015), Charlotte has joined thousands of cities and regions in a commitment to accelerate ambitious, measurable climate and energy initiatives that lead to an inclusive, equitable, low-emission and climate resilient future.

Our Charlotte City Council voted unanimously in support of the *Sustainable and Resilient Charlotte by 2050 resolution*, in June 2018. This directive provides a vision towards a low-carbon path, and city leadership are committed to achieving our community's aspirations. The resolution states that Charlotte will strive to source 100% of City's energy use in its buildings and fleet from zero carbon sources, become a low carbon city by 2050, spanning all sectors, and bring citywide greenhouse gas emissions to below two tons CO₂e per person annually.

City Council also unanimously adopted the City's first *Strategic Energy Action Plan* (SEAP) in December of 2018, which sets a framework to guide Charlotte's transition to a low-carbon future. At the same time, Bloomberg Philanthropies named Charlotte a winner in Bloomberg American Cities Challenge. As one of twenty-five cities selected, Bloomberg Philanthropies provides funding and resources to work with Charlotte to accelerate and deepen climate solutions where we will have the most impact and showcase the benefits – good jobs, cleaner air, and cost savings.

Charlotte has also launched a bold and innovative vision, Circular Charlotte, to become a zero-waste city by transforming \$111 million worth of annual waste and reclaiming it to boost our economy and create jobs. This program would benefit Charlotte by reducing impact to our landfill and removing CO₂ emissions equivalent to 75,000 vehicles each year.



Our plan for environmental sustainability provides solutions for reducing our carbon emissions that will also make Charlotte a more attractive place to live and work and be globally competitive. Achieving a low-carbon future for Charlotte will require a transformational change in the way we consume and generate energy and how we manage our waste stream. We know that this will be challenging and require new and innovative ideas, research, projects and collaborations. It will require government agencies, companies and organizations to look at their role, as well as residents to look at how they are using energy each day. For example:

- We commented on and affirmed North Carolina Governor Roy Cooper's Executive Order 80 which contains firm, but necessary goals that will need to be met to combat climate change, including reducing statewide GHG emissions.
- We support our utility, Duke Energy, who recently set a 2050 net zero carbon goal.

As a city we are also doing our part to take **immediate action** by:

- Completing energy audits of over a million square feet, starting with of our cultural facilities, so we can best determine retrofits that will reduce energy consumption.
- Embedding sustainability and resilience into our Comprehensive Plan, CharlotteFuture2040, which will guide land use ordinance updates for years to come.
- Launching a green workforce development program where we will begin to train individuals in building efficiency, solar energy, and other emerging technologies. This year, we have a goal to enroll 100 students in related workforce areas.
- Investing in expanding our public transportation network and in electric and hybrid-electric vehicles in our city fleet. Our airport has just invested in five e-buses.
- We are particularly proud of applying and getting accepted into the Duke Energy Green Source Advantage program, a renewable energy program for large North Carolina customers who want to support development of renewable resources. If our Council votes to move forward with the agreement, this will make us a leader among local governments in NC in renewable energy and will equate to removing 12,000 passenger vehicles from the road annually. It will also get us a quarter of the way to our Strategic Energy Action Plan goal.

Ultimately, as we continue to seek opportunities to address climate change, we understand the enormity of the challenge before us and understand that research and development in this area is critical.



Together we can meet this challenge, not only with ambitious goals, like those the City of Charlotte set last year, but with additional investment in energy innovation and the development of new cost-effective technologies.

As a local government with responsibility to our residents, we face real challenges in balancing our goals with the resources and technology to meet them. We know 61% of our greenhouse gas emissions come from transportation and buildings, so if you want to help cities like Charlotte, here are some things that we need:

- Funding and research for renewable energy, and for retrofits for our existing facilities.
- Funding for electric buses, and infrastructure, to make electric buses a real choice.
- Support for our mass transit and light rail system.
- More research providing guidance and direction on the most cost-effective means to accelerate environmental sustainability.

Thank you for giving me the time to share the excitement I have for Charlotte as well as the challenges and actions we are taking to make our community a resilient city.

Ms. KAPTUR. Thank you so very much, Mayor Lyles, and also, congratulations on your reelection. And I want to thank Congresswoman Adams for making special efforts to be here today and to accompany you today.

We will now move to Mr. Keefe, if you could begin your testimony.

Mr. KEEFE. Thank you, Madam Chair, and members of the committee. I really appreciate you letting me be here with you and this august group on this side of the table.

I am Bob Keefe. I am the executive director of E2, Environmental Entrepreneurs. We are a national nonpartisan group of business owners, investors, and others, who advocate for policies that are good for our economy and good for our environment. E2's more than 7,000 members and supporters have founded or funded more than 2,500 companies, created about 600,000 jobs, and collectively control about 100 billion in private and venture equity capital. And those members, by the way, include executives, founders, and funders of clean energy companies that are making energy cleaner, more abundant, and less expensive in America. And in doing so, they are helping our country reduce greenhouse gas emissions that worsen the impacts, including the economic impacts, by the way, of climate change.

Now, they are also driving economic growth, and they are creating millions of good paying jobs, which you can see on the screen right there, that cannot be outsourced or shipped overseas. We know this because E2 for years now, in connection with EFI and other partners, have been tracking clean energy job growth all across the country down to the state, city, county, congressional, legislative, district levels.

Our most recent Clean Jobs America Report, which I have submitted for the record, shows us that more than 3.3 million Americans work in clean energy today and, as the chairwoman mentioned, nearly 2.3 million of those are in energy efficiency, and many of those jobs rely on energy efficiency standards, other programs from DOE. For a frame of reference, 3.3 million jobs, as the chair mentioned, is more than there are waiters and waitresses in America. It is more than there are people in real estate. It is more than there are people in agriculture in our country. It is more than the people in investment banking. And, by the way, it is more than double the number of Americans who now work in fossil fuels.

What we also know is that many of these jobs, and the climate and environmental benefits that come with them, simply would not exist without crucial DOE programs. Let me give you a couple of examples.

A few weeks ago, I was fortunate to be in the chair's home state of Ohio, visiting the headquarters of an E2 member, Steve Melink. Steve's 100 employee company designs and supplies clean energy solutions, solar, energy efficiency, big range hoods, things like that, geothermal, to companies like hotel chains and restaurant chains that you would recognize, and factories all across America.

Now, Steve is an expert in this stuff, and he tells me that geothermal HVAC systems are the most energy-efficient heating and cooling systems known to exist. I would ask Dr. Moniz if that is true or not, but that is what I heard. The—

Mr. MONIZ. I bought one last year.

Mr. KEEFE. Oh, great. The other thing I understand is that they are pretty expensive, at least initially, and they are hard to install. But thanks to a Department of Energy Small Business Innovation Research Grant, a SBIR Grant, Melink Corporation is about to introduce new technology that could dramatically reduce the costs, substantially increase the adoption of geothermal in our country, saving money for those big users that I have mentioned, while also reducing there and our country's carbon emissions.

Steve's company is already growing. He is—when I was there a couple weeks ago, he is building a brand-new headquarters building and expects to hire a bunch of new employees as this comes to market.

Let me give you another example. We have an E2 member named Michael Rucker, who started two clean energy companies, in the past 5 years. He is a wind energy exec. He has created about 250 jobs across the country. Michael's current company, Scout Clean Energy, is developing major wind projects in over a dozen states. In Washington State, for example, I think, in Congressman Newhouse's district, Scout is building the Horse Haven Project, which is expected to generate 500 megawatts of power by 2020—excuse me, 2022. But behind every one of those wind turbines that Michael's company is erecting is some of the most advanced wind energy technology available, technology that probably would not exist, by the way, without DOE clean energy programs.

Scout now is planning to install storage systems, aka batteries, with its wind projects that will allow it to produce and distribute clean, emissions-free, renewable energy, even when the wind is not blowing, kind of the holy grail in the wind industry. And that would not be possible without the technology and the companies that exist, in part, because of DOE programs.

Lastly, I want to mention to you the companies and the jobs of America's future. You will find them at clean tech incubators and within the portfolios of clean tech investment groups in all of your states and many others. You will find them working and emerging from places like the Idaho National Labs and the Oakridge National Labs.

Not long ago, a group of clean tech incubator CEOs and I met with members of Congress, like you all, including some of you all, I think, to talk about the consequences of cutting DOE funding, the same issue that we are addressing here today.

What they said was this: Without DOE programs, hundreds of promising companies and their incubators developing the next generation of energy technology in America simply would not exist, nor would the jobs, the climate, the environmental benefits that come with that.

So, in summary, DOE clean energy programs, they are vital to innovation. They are vital to investment. They are vital to competitiveness and they are vital to jobs in America. They are also a critical tool we can use and that we desperately need in the fight against climate change. E2 and its members strongly encourage you to continue the leadership this panel has shown in aggressively funding DOE's applied science offices and programs, and we strong-

ly encourage you to do that, not just for the good of our environment, but for the good of our economy. Thank you very much.

[The information follows:]



Good for the Economy.
Good for the Environment.

Nov 20, 2019.

**Energy and Water Development and Related Agencies House Appropriations
Subcommittee on:
“The Department of Energy’s Role in Addressing Climate Change”**

Oral Testimony of Bob Keefe, Executive Director of E2

Madam Chair, ranking member Simpson, members of the Committee, thank you for having me.

I am Bob Keefe, executive director of E2 (Environmental Entrepreneurs), a national, nonpartisan group of business owners, investors and other professionals who advocate for policies that are good for our economy and good for our environment.

E2’s more than 7,000 members and supporters have founded or funded more than 2,500 companies, created more than 600,000 jobs and control about \$100 billion in private and venture equity capital.

Our members include executives, founders and funders of clean energy companies that are making energy cleaner, more abundant and less expensive in America. In doing so, they are helping our country reduce greenhouse gas emissions that worsen the impacts – including the economic impacts - of climate change. They’re also driving economic growth and creating millions of good-paying jobs that can’t be outsourced or shipped overseas.

We know this because E2 for years now has been tracking clean energy job growth down to the state, city, county, congressional and legislative district levels. Our most recent Clean Jobs America report, which I have submitted for the record, found that more than 3.3 million Americans now work in clean energy. Nearly 2.3 million of those jobs are in energy efficiency, and many of those rely on energy efficiency standards and other programs from DOE. For reference, 3.2 million jobs are more jobs than there are in real estate; in agriculture; in

investment banking. And it's more than double the number of Americans who work in fossil fuels.

What we also know is that many of these jobs and the environmental benefits that come with them wouldn't exist without crucial Department of Energy programs.

Let me give you a few examples.

A few weeks ago, I was fortunate to visit the Ohio headquarters of E2 member Steve Melink, whose company designs and supplies clean energy solutions – solar, energy efficiency, geothermal – to big companies like hotel and restaurant chains and factories. Steve tells me that geothermal HVAC systems are the most energy-efficient heating/cooling systems known to exist. Thanks to a Department of Energy Small Business Innovation Research (SBIR) grant, Melink Corp. is about to introduce new technology could dramatically reduce the cost and substantially increase the adoption of geothermal energy in our country – saving money for big users of energy while reducing their - and our country's - carbon emissions. Steve's company currently employs over 100 people, and is growing fast. He's currently building a new second headquarters building near Cincinnati – which by the way is creating scores of new construction jobs in the area as well.

Here's another example. E2 member Michael Rucker has started two clean energy companies in the past five years that created more than 250 jobs. Michael's current company, Scout Clean Energy, is developing major wind projects in over a dozen states. In Washington state, for example, Scout is building the Horse Heaven project in Congressman Newhouse's district which is expected to generate 500MW of power by 2022. Behind every wind turbine that Michael's company erects is some of the most advanced wind energy technology available – technology that probably wouldn't exist without DOE clean energy programs. Scout is now planning to install energy storage systems – batteries - with its wind projects that will allow it to produce and distribute clean, emissions-free, renewable energy even when the wind isn't blowing. That wouldn't be possible without

technology and companies that exist in part because of Department of Energy programs.

Lastly, I want to mention the companies and jobs of America's future. You'll find them at places like cleantech incubator Greentown Labs in Boston, or in the portfolios of cleantech investment groups like Element 8 in Seattle, both of which are led by E2 members. You'll find them working with and growing from places like the Idaho National Labs and Oak Ridge National Lab.

Not long ago, a group of cleantech incubator CEOs and I met with members of Congress to talk about the consequences of cutting DOE funding. What those CEOs uniformly and unequivocally said was this: Without DOE programs, hundreds of promising start-up companies developing the next-generation of energy technology in America simply would not exist – nor would the domestic jobs, economic potential and environmental and climate change benefits they're producing and will produce in years to come.

In summary, DOE clean energy programs are vital to innovation, vital to investment, vital to competitiveness - and vital to jobs in America. They're also a critical tool we can use and desperately need in the fight against climate change.

E2 and its members strongly encourage you to continue the leadership this panel has shown in aggressively funding DOE's applied science offices and programs – for the good of our economy and our environment.

Thank you again for having me, and for your leadership.

Links to Jobs Reports:

Clean Jobs America 2019:

<https://www.e2.org/reports/clean-jobs-america-2019/>

Energy Efficiency Jobs in America 2019 (with links to all 50 states):

<https://www.e2.org/reports/energy-efficiency-jobs-in-america-2019/>

3.3 Million Clean Energy Jobs in America

www.e2.org/reports/clean-jobs-America-2019

State/local examples:

Ohio: 112,500 clean energy jobs

- * US House District 9: 4,800 jobs

Indiana: 86,000 clean energy jobs

- * US House District 1: 9,100 jobs

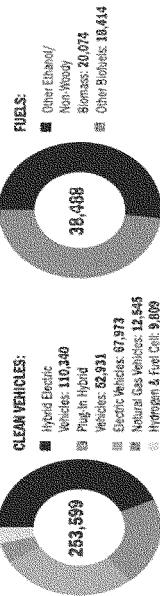
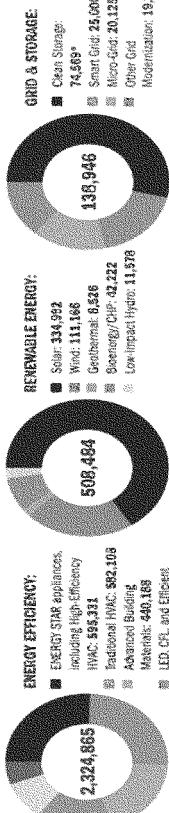
California: 513,000 clean energy jobs

- * US House District 42: 5,700 jobs

Washington: 82,900 clean energy jobs

- * US House District 4: 6,000 jobs

INDUSTRIALIZATION OF JOBS



Good for the Economy.
Good for the Environment.



EZ



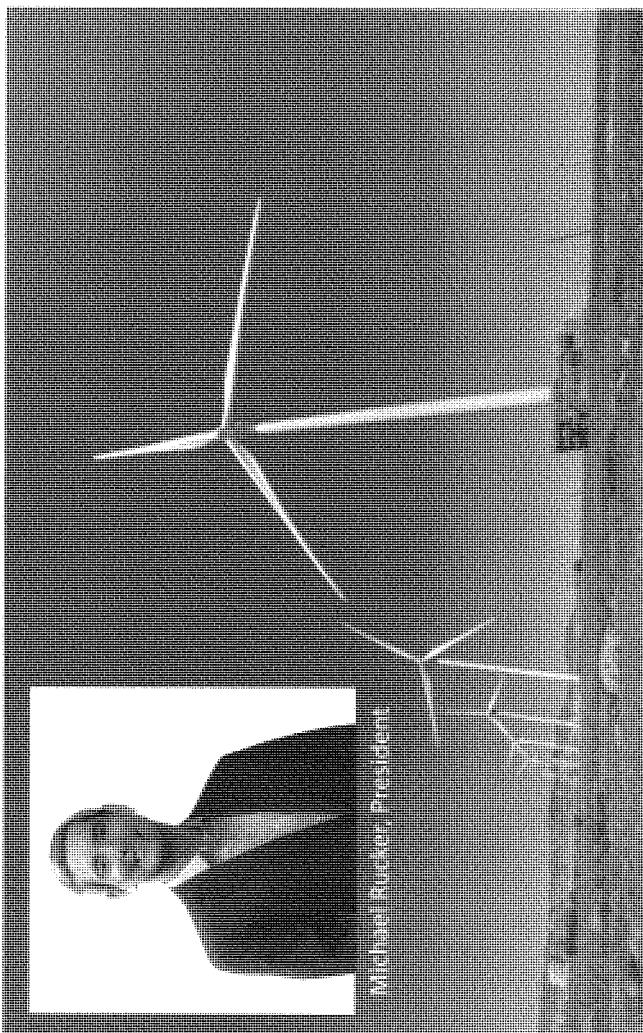
Employees: 100+

Headquarters: Cincinnati, OH

Business: Solar, geothermal,
energy efficiency, commercial
kitchen ventilation controls

Project: Super-hybrid
commercial geothermal HVAC
systems; DOE SBIR grant in
2018

Good for the Economy
Good for the Environment



E2



Employees: 250+

Headquarters: Colorado

States: 12, including
Washington, Indiana, Texas,

Business: Wind energy,
storage

Good for the Economy.
Good for the Environment.

Ms. KAPTUR. Thank you very much, Mr. Keefe. It is not every day that Americans get to work on embracing the future, and I think this is such a positive panel. And thank you all for what you are devoting your lives to.

Mr. Powell, we are going to turn to you now. Please begin.

Mr. POWELL. Good morning, Chairwoman Kaptur, Ranking Member Simpson, and members of the committee. My name is Rich Powell. I lead ClearPath, a nonprofit advancing conservative policies that accelerate clean energy globally. ClearPath, I am proud to say, was founded in Charlotte, and we are proud sponsors of the Clean America Jobs Act. One note, we accept no funding from industry.

First, congratulations on your remarkable bipartisan accomplishments in clean innovation over the past 2 fiscal years. The new resources this committee injected into the world's greatest peacetime R&D engine, the Department of Energy, are catalyzing breakthroughs. The fiscal year 2020 bills continue this momentum. This committee's efforts do not garner the attention and deep appreciation they merit. Your work is essential to tackling this global problem quickly and affordably.

Given this committee's vital role in American climate policy, a few topics today. First, how the global nature of the climate challenge requires an innovation-focused policy; second, how scaling up America's innovations means more spending—more investing than spending; and third, how we might modernize our innovation engine towards the climate challenge.

At the outset, the elephant in the room. Climate change is a wicked problem caused by global industrial activity. From the harmful algae blooms in Lake Erie to the pine beetle infestations in Idaho, the increasingly painful costs make it clear. Climate change merits significant action at every level of government and the private sector.

On DOE's role, we must first acknowledge the global nature of this challenge. An American molecule of CO₂ has the same effect as a molecule emitted in Nigeria. Even if the U.S. eliminated all greenhouse gas emissions tomorrow, the growth in CO₂ through 2050 by developing Asian countries alone would exceed our cuts.

I do not make this point to minimize the American role in the global solution or argue that aggressive domestic action is unnecessary, just the opposite. We must develop the U.S. as a test bed for globally relevant clean solutions, using U.S. climate policy to help developing nations easily choose clean energy.

As this chart shows, the share of global energy supplied by clean sources has not increased over decades. Despite significant renewables deployment, clean is not gaining ground. Emissions continue increasing. Technologies available today are simply not up to the task of global decarbonization.

The great philosopher Stephen Cave offers us the clearest path to solving tough problems. Begin with the end in mind. On climate change our end ought to be changing this story for developing countries. We need more clean, affordable, reliable, exportable offerings, so developing nations consistently choose them over higher emitting options. Leveraging our world-class national labs, America is uniquely suited to seize this immense economic opportunity.

How? We must reorient our climate policy mindset from spending to investing. We cannot spend our way to this end. The global energy system is too large, our budget too small. Rather, we must invest scarce tax dollars into clean innovations the global economy chooses on their economic merits.

The DOE has successfully invested when it has clearly articulated goals, and aligned management and funding all the way from the Secretary's desk to the scientist's bench. See DOE success in unlocking shale gas and radically reducing the cost of photovoltaic solar.

This committee and DOE leadership have provided fresh proof points. You urged DOE to launch a moonshot on energy storage. Earlier this year, they commenced the Advanced Energy Storage Initiative, with key technology and performance cost objectives. In fiscal year 2018, you urged DOE to plan for multiple advanced reactor demonstrations within a decade. This year's Senate committee purported bill proposes an advanced reactor demonstration program to launch two prototypes by 2025. This committee's funding for the National Reactor Innovation Center will help make the demonstration program a success.

These are examples of investing, not just spending. They leverage the precious Federal funds into globally relevant solutions. Such wise investments are the very definition of a market-based solution to climate change, enlisting markets themselves to distribute clean energy.

Lastly, I encourage the committee to think well beyond fiscal year 2020. The precursors of DOE were created in a time of national emergency, with the Manhattan Project sites evolving into the First National Laboratories. Over the following decades, the labs were reimaged to solve national energy scarcity. Such daunting endeavors are now in DOE's DNA.

Today, we confront a very different opportunity, how to make all of our increasingly abundant energy options clean. To seize this, I urge you to reimagine the mission and structure of the Department towards making all energy clean. A modern Department should expand and reorient it to cover all emitting sectors.

We have made enormous strides on reducing power emissions, but lag far behind on transportation, industry, and buildings. A future DOE might build offices for each. Beyond DOE's structure, we have learned a great deal about how to attract, retain, organize, and motivate world-class innovation talent from ARPA-E. A future DOE might expand the innovative APRA-E people model.

There is no question that these structural changes are difficult, but the climate challenge requires that we explore every possible option and take bold action. Thank you, again, for the opportunity to testify and for your bipartisan leadership. ClearPath is eager to assist the committee in your important work.

[The information follows:]

CLEARPATH

**Testimony of Richard J. Powell
Executive Director, ClearPath Inc.**

**House Appropriations Subcommittee on Energy and Water Hearing
“The Department of Energy’s Role in Addressing Climate Change”
Wednesday, November 20, 2019**

Good morning Chairwoman Kaptur, Ranking Member Simpson and Members of the committee. My name is Rich Powell, and I am the Executive Director of ClearPath.

ClearPath is a 501(c)3 organization focused on conservative policies that accelerate clean energy deployment in the power sector. We support solutions that advance the wide array of clean energy technologies, including next-generation nuclear, hydropower, cleaner fossil fuel technologies and grid-scale storage solutions that improve grid efficiency, in part by integrating additional renewable sources. Our core mission advocates markets over mandates and bolstering technological innovation rather than implementing stifling regulation. ClearPath provides education and analysis to policymakers, collaborates with relevant industry partners to inform our independent research and policy development, and supports mission-aligned grantees. An important note: we receive zero funding from industry.

I would like to start by thanking the Members of this Committee for your work, and congratulating you on your remarkable, bipartisan track record in clean energy innovation over the past two fiscal years. The significant resources this Committee has injected into the world's most advanced peacetime research and development engine -- the Department of Energy and its 17 world class national laboratories, alongside American institutions of higher education and private-sector entrepreneurs -- is catalyzing a new generation of zero emission technologies.

The House and Senate's fiscal year 2020 bills continue the momentum of the past two fiscal years, and we look forward to seeing the outcome of the appropriations process. The annual appropriations efforts do not garner the attention they merit. We realize the innovation this vital process enables is essential to tackling this global problem as quickly and affordably as possible.

As we look at the Department's vital role in America's response to the global climate challenge, I will underscore three key points:

1. The significant threat to the U.S. economy posed by climate change is global in nature, which requires continued and aggressive focus at driving down the cost of clean technologies as quickly as possible.
2. Turbo-charging the American innovation engine means more than just spending additional resources. Given national budget constraints, any successful strategy must have targeted goals that bring real breakthroughs to market and produce tangible economic and environmental benefits for the globe.
3. Modernizing the innovation engine around the energy and environmental challenges facing the globe today -- rather than specific technology stove pipes -- would yield a more impactful technology incubator.

America's Role as a Global Clean Technology Provider:

It's always important to address the elephant in the room first. Climate change is real and industrial activity around the globe is the dominant contributor to it. The impacts of a changing climate are clear. From the harmful algae blooms in Lake Erie to the pine beetle infestations in Idaho, the increasingly tangible costs make clear that the challenge climate change poses to society merits significant action at every level of government and in the private sector.

These consequences are just in the U.S., but climate change is obviously a global problem. A molecule of CO₂ emitted on the other side of the world has the same impact as one released here. For example, the projected emissions growth from developing Asian countries alone would offset a complete decarbonization of the U.S. economy by mid-century.¹

I do not make this point to minimize the American role in the global solution or argue aggressive domestic action is unnecessary -- actually just the opposite.

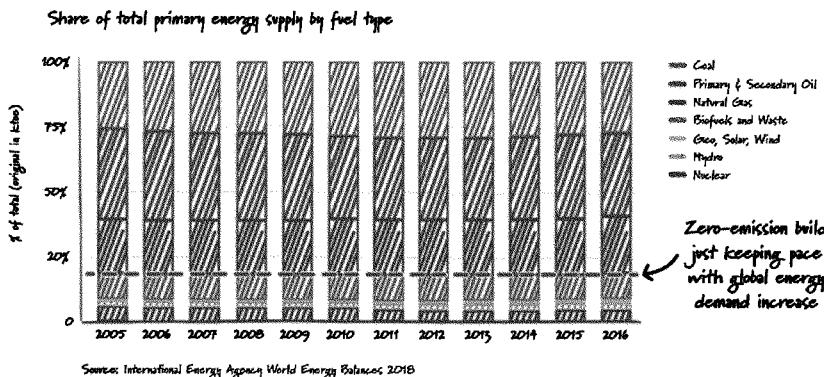
While the U.S. represents roughly 16 percent of global greenhouse emissions today, in cumulative terms (i.e. historical terms), the United States also owns this problem more than any other country. Given that such is the case, it is imperative that we tackle American emission reductions as quickly as possible and help find a solution that will allow developing nations to easily choose clean energy. To do this, it is essential to prioritize investments that accelerate the U.S. as a clean technology provider. Just as we were the great arsenal of Democracy in the second world war, we must become the workshop and driver of the global clean energy transition. The American innovation engine can lead the world, which is precisely why the U.S. Department of Energy is so important.

¹<https://www.eia.gov/outlooks/aeo/data/browser/#/?id=10-IEO2017®ion=0-0&cases=Reference&start=2010&end=2050&f=A&linechart=Reference-d082317.3-10-IEO2017~~~~~Reference-d082317.17-10-I-EO2017&map=&ctype=linechart&sourcekey=0>

As the Committee looks towards “the Department of Energy’s role in addressing climate change,” we must look at how we make programs and policies effective at making clean energy cheaper.

Why? By and large, the share of global energy supplied by clean sources has not increased over the past decades. Despite significant renewables deployment globally, emissions continue to rise. Renewables are an important part of the solution, and no doubt we need more of them. But the math is simple -- clean energy deployment is only just keeping up with economic development. Clean energy is not gaining ground, and the technologies available today are simply not up to the task of global decarbonization.

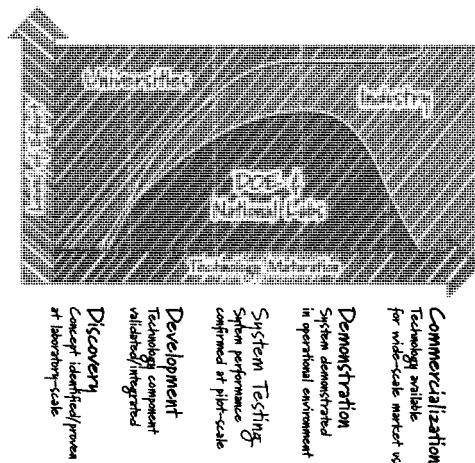
Humanity is not yet transitioning to a zero-emission energy system



Our clean technology offerings must represent a better, affordable alternative so developing nations will consistently choose them over higher-emitting options. The United States is uniquely suited to seize this immense economic opportunity while leading on global climate action.

Our Department of Energy and national lab system is the leading technology incubator of the world. It has catalyzed such life-altering creations such as nuclear power, the internal combustion engine, and sequencing the human genome; and is uniquely suited to bring the technological solutions needed to tackle climate change to the global marketplace. So how can best capitalize on this immense economic opportunity?

**DOE National Laboratories Relationship to Universities
and Industry in the Energy Innovation System**



Source: [Annual Report on the Status of the National Labs](#)

Investment Goals Need Clear Outcomes:

Too often, we think of the DOE's role in terms of dollars spent on priority topics. We too rarely ask "to what end?" President John F. Kennedy's original MoonShot concept, proven more than half a century ago, has withstood the test of time. The DOE has found success emulating the MoonShot model by clearly articulating goals and aligning management and funding of those goals all the way from the Secretary's desk to the scientist's bench.

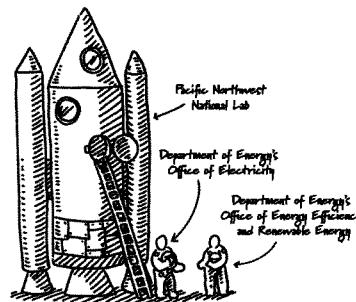
The Office of Fossil Energy's work on unlocking shale gas, the Energy Efficiency and Renewable Energy Office's work on SunShot to radically decrease the cost of photovoltaic solar, and the Joint Bioenergy Initiative on lignocellulosic biofuels at the Lawrence Berkeley Laboratory are all recent examples. When DOE has clear, well understood and shared goals, combined with a strong focus on innovation that aligns leadership and creates clear organizational accountability, coupled with the steady investments supporting those goals over multiple administrations, the Department produces breakthrough results.

The DOE should set ambitious technology development goals to support private sector commercialization across technologies that touch each sector of the economy. These goals must

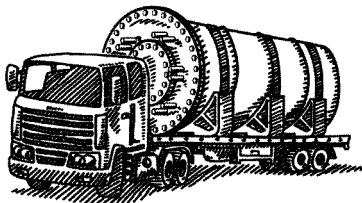
be accompanied by deep private sector engagement to ensure that the research priorities and other DOE activities are well aligned with the needs of the innovators, and most importantly the users of the technologies. These goals need to be properly funded, but flexible enough to empower researchers to take on key scientific and engineering challenges. These goals should also be regularly reviewed to ensure accountability and measurable progress (and reevaluated or discontinued when milestones are not achieved).

There are some more recent examples of this approach, in large part due to the advocacy of this committee and current Department leadership:

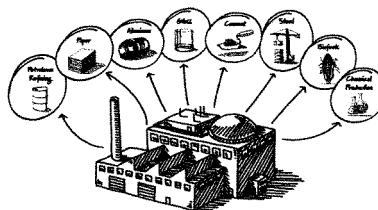
- **Advanced Energy Storage Initiative (AESI):** Energy storage technologies have the potential to transform the U.S. electricity system by bolstering grid reliability, reducing electricity market prices, and improving the integration of intermittent renewable energy resources like wind and solar. Until recently, federal energy storage RD&D lacked the organizational accountability usually needed for breakthrough success. These programs are spread across the DOE in four offices: from Electricity to EERE to Science and to the Advanced Research Project Agency-Energy (ARPA-E). Many of these offices primarily focus on transportation rather than grid-scale storage. This Committee has urged the Department to better coordinate grid-scale technology efforts, and the Administration recently took a major step in the right direction by coalescing these programs around key technology performance and cost objectives, the AESI. Concurrently, they've proposed a "launchpad" hosted at the Pacific Northwest National Lab (PNNL) focused on developing, testing, and evaluating battery (and potentially other) materials and systems for grid applications. AESI should expand into goals for long-duration storage and seasonal storage solutions, as suggested by this Committee's FY20 bill and bipartisan bicameral legislation, the Better Energy Storage (BEST) Act ([H.R.2986/S.1602](#)).
- **Advanced Reactor Demonstration Program:** This year's Senate Committee-reported bill proposes an Advanced Reactor Demonstration Program to accelerate the demonstration of two advanced reactor designs by 2025, and multiple subsequent designs by 2035. This moonshot RD&D initiative mirrors the program laid out in the bicameral bipartisan Nuclear Energy Leadership Act (H.R.3306) and drives federal resources



towards commercializing American reactor designs that have the attributes needed to be cost-competitive (<\$60/MWh leveled cost of electricity) and constructed by the private sector. This is consistent with the direction this Committee provided the Department in FY18 to develop a plan to demonstrate multiple reactor designs within a decade. In addition to the demonstration program, I commend this Committee for including specific direction on hybrid energy systems and the development of advanced materials. These research initiatives benefit the industry as a whole as innovation aims to increase the technologies' economic competitiveness. It is important that these provisions make it in any FY20 bill, because the United States is losing ground. Other countries, specifically China and Russia, are actively building these new reactor designs. These countries know that in order to deploy these technologies both domestically and internationally, they need to be able to actually build them. If the United States does not support the near term deployment of these technologies, then it will lose ground internationally and miss an opportunity to reduce emissions globally.



- **Maximizing Carbon Capture Utilization and Storage Potential:** Commercializing low-cost American carbon capture technologies is essential to tackling global emission reductions. In 2018, global demand for all fuels rose, with fossil fuels meeting nearly 70% of the growth for the second year running. Carbon capture and sequestration is one of the few technologies that can address emissions from both power plants like coal and natural gas, and industrial processes like the production of steel, cement, and chemicals. In FY18, the Committee wisely provided the Department resources and guidance which resulted in over \$53 million aimed at building gas or coal carbon capture project in the next 5 to 8 years. This year, both bills aptly direct the Department to bolster a gas centric carbon capture research program and map out industrial technology pathways. It is also important to note that bipartisan bicameral RD&D goals bills for gas capture (the LEADING Act - H.R.3828) and nonpower industrial sector decarbonization (the Clean



Industrial Technology Act - H.R.3978) have also advanced this year in the relevant authorizing Committee.

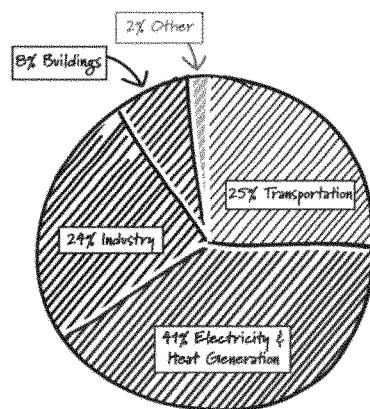
It is important to remember that we cannot spend our way to a solution -- the global energy economy and the demands of rising populations around the world are too much even for the mighty U.S. budget to facilitate these decisions around the world. Rather, we need to invest in a set of better mousetraps - ones that will leverage the scarce dollars of U.S. taxpayers into solutions that the global economy will pick up on their own merits. These kinds of smart investment is the very definition of a market-based solution to climate change, one that makes markets themselves the force for change in distributing clean energy instead of the force we work against.

Big Changes for a Daunting Challenge:

Lastly, I want to share some thoughts for the Committee to consider beyond the fiscal year 2020 appropriations cycle. Remember, the Department of Energy and its laboratories were created in a time of national emergency. During World War II, the Manhattan project was conducted by the first iteration of our national laboratories. Over the decades that followed, the labs were reimaged to help solve our national energy scarcity challenges. Thanks to their work and the innovations that resulted, the U.S. moved from a position of energy scarcity to one of abundance. Daunting challenges are part of the Department's DNA.

We now confront a very different and daunting challenge -- how to make all of the abundant energy options clean. In order to meet this challenge, I urge you to think seriously about reimagining the structure and function of the Department to reorient its programs toward the goal of making energy clean. Traditionally, calls to reorganize the Department have come from those concerned with the "stove-pipe" structure which artificially separates different fuel sources in the power sector. A more modern Department would take on that challenge, and more. First, that approach would much better align the Department's focus and resources with the various emitting sectors of the economy. We've made enormous strides on reducing power sector emissions, but lag far behind on transportation,

CO₂ Emissions from Fuel Combustion (2017)



industrial, and direct emissions from buildings. A future Department might have dedicated structures to deal with each of those challenges.

Beyond the structure of the organization, we have learned a great deal about how to attract, retain, organize, and motivate the world class talent at the labs from our experiences at ARPA-E. A future DOE might also seek to use tools from the innovative ARPA-E people model.

There is no question that these structural changes are extremely difficult to achieve, but the challenge we face requires that we explore every possible option and take bold action.

Thank you again for the opportunity to provide remarks. ClearPath is eager to assist the Committee in developing innovative policies, identifying opportunities for investing, tracking successful outcomes around the new moonshot energy technology goals outlined above, and building on the recent bipartisan success. We applaud the Committee for taking on this important task to help ensure the appropriate investments can be made to modernize and facilitate the research, development, and demonstration of cutting-edge energy technologies in the service of a stable global climate.

Ms. KAPTUR. Thank you so very much for your very constructive proposals, Mr. Powell.

And we are now going to move to Secretary Moniz. Please begin.

Mr. MONIZ. Thank you, Chairwoman Kaptur and Ranking Member Simpson, members of the committee, for the opportunity to join you—thank you—to join you today about the role of DOE in addressing climate change. Let me deliver the punchline up front. The scale and pace needed for the low-carbon energy transition which is underway have come to be understood as much greater than was put forward just 4 years ago at the Paris COP21 meeting, and DOE stands at the center of the energy, science, and technology innovation solutions that will position the U.S. for economic, environmental, and security success in that transition.

My testimony will draw heavily from the data and analysis-based work at the Energy Futures Initiative, or EFI, that I established with two colleagues in mid-2017. We believe it is possible to build a secure, affordable, low-carbon energy future through the power of clean energy innovation and policies based on independent, unbiased, fact-based energy analysis. We do not indulge in magical thinking about either the problem or the solutions.

Our approach is framed by what we termed the Green Real Deal up on—there is a slide up there on that. The Green Real Deal offers a pragmatic approach to reaching deep decarbonization, while addressing social equity as fast as is technically, socially, and politically feasible.

There are five broad principles. Technology business model and policy innovation are essential. Broad and inclusive coalitions must be built. Social equity is essential for success. All greenhouse gas emitting sectors must be addressed in climate solutions, not just electricity. Optionality and flexibility are needed for technologies, policies, and investments.

We then organize around eight work elements. I will just mention two of them: the need to understand and develop a workforce for the clean energy future, and the importance of looking at low-carbon pathways in the city, state, and regional context since low-carbon solutions will look very different locationally within our country and in other countries.

With regard to workforce, with two of our partners to my left, as well as NASEO, two well-regarded surveys of energy jobs in the United States, following on two earlier DOE surveys, have come out. We believe this is an important foundation for policymaking and should be institutionalized within the government, that is understanding the workforce in energy.

With regard to a regional perspective, a study of California's low-carbon pathways carried out at EFI is illustrative. The figure shows 33 technology pathways, do not try to read them all, across all sectors. This reinforces Mr. Powell's point. We must address all sectors if we are to reach goals, and that certainly is true for California. The numbers you see are the millions of tons of CO₂-equivalent emissions that we concluded could be eliminated for each of these pathways by 2030, when California has a statutory economy-wide 40 percent reduction requirement. And this kind of analysis can guide solutions.

For example, just looking at this in more detail, we can see that success, again, depends upon success in multiple sectors, including some that are very hard to decarbonize. Secondly, one sees here that pathways, like auto efficiency, actually is the biggest single opportunity for California. Third, somewhat to our surprise in carrying out the analysis, we found that carbon capture and sequestration, CCS, from both NGCC plants and from industrial facilities together can get the state to nearly 20 percent of its goal.

However, regrettably, there is very little progress, frankly, being made in California on CCS. And yet, there is a time urgency to take advantage of the 45Q tax credits passed by Congress in bipartisan fashion. So, an all-of-the-above approach is needed, and this is a California and a national imperative.

The California study also pointed out the importance of data for planning. Sometimes data is inconvenient, but it really deserves being looked at. For an example, in 2017, looking hour by hour across the entire year, we found that a quarter of the days in that year in California, there was little to no wind statewide, and as many as 10 days in a row without appreciable wind. And the picture, by the way, is very similar in Texas, for example.

Solar and wind production in California were also double in the summer compared to the winter. These facts illustrate a system based heavily on these resources will require large-scale storage at all time scales, from hours to seasons, and that will not be accomplished by batteries. It is just one example of the need for a strong emphasis on a broad innovation program. We simply cannot get to net zero by midcentury without breakthroughs in our innovation approach.

Another high priority breakthrough example not often discussed is carbon dioxide removal from the atmosphere and perhaps the oceans. This can be done naturally, like planting trees; technologically, like direct air capture; and through technologically enhanced natural processes, like accelerated mineralization. Basalt, by the way, in the Northwest and the Southeast are good examples, deep-rooted plants, so changing plants, et cetera. At EFI, we developed a extensive RD&D portfolio for multiple pathways in carbon dioxide removal with resource needs of about \$10.7 billion over 10 years, including \$2 billion towards cost-shared demonstration projects. DOE, under this committee's responsibility, would be responsible, we estimate, for 55 percent of the R&D agenda with USDA, NOAA, and NSF playing lesser but still major roles.

So, such an investment could easily make the difference between success and failure in reaching our 2050 net zero goals and the committee can provide leadership in this domain, given the critical role of DOE in that program, which takes us to more extensively DOE's role.

In my last year as Secretary, we determined that DOE was responsible for about three-quarters of the entire Federal Government's clean energy innovation program. So, DOE is central, but it is also central, we want to emphasize in closing, across the entire clean energy innovation system from basic research to deployment.

First, it is sometimes overlooked that DOE provides an unparalleled array of cutting-edge experimental and computational facilities available to the entire American research community through

its extraordinary system of 17 national labs, at last count serving about 30,000 American scientists and engineers. For energy researchers, for an example, the national lab light sources and neutron sources are absolutely essential for discovering new materials that can drive energy technology breakthroughs. For nuclear energy, the Idaho reactors and associated facilities allow development of new fuels, for example, with enhanced safety. Plant genomics facilities in the national labs, critical for biofuels and much more.

So, these are foundational capabilities for an enormous range of energy science. But then, of course, there is a set of programs and facilities and early stage companies targeted specifically for energy innovation. For example, the Energy Frontier Research Centers, 36 in 34 states and DC, each attacking a fundamental science challenge critical for advanced energy technology. And I might say without detail, an excellent example of crossing administrations, where the Bush administration really provided the structure and the Obama administration provided the implementation with an ARRA kick-start. But the number of EFRCs, despite their success, has actually gone down since the beginning of the program.

Taking a step further along the innovation chain, ARPA-E, next slide please, helping in the precarious high-risk transition from lab to company. Since 2009, around \$2 billion over 10 years on around 800 projects, producing 76 companies, 346 patents with 145 projects attracting about \$3 billion of private funding. A great success. But the National Academy of Science has called for a billion-dollar program and we are not close to that yet.

Taking another big step along the innovation chain, the DOE loan program, by any private sector metric, a highly successful program to move technologies over the last hurdle towards deployment. A tremendous ratio of capital deployed to success at this stage with singular successes such as seeding the utility scale PV industry and then appropriately leaving the scene in favor of private investors.

Forty billion dollars of remaining authority, let us use it to pursue the energy infrastructure developments that the President and most of us agree upon and leverage that into maybe \$100 billion of energy infrastructure investment. So, support across the innovation chain is happening, it is successful, we should support it.

In conclusion, Congress has been committed to advancing the American Energy Innovation Agenda over the last several years, but I ask that the pace be picked up further through, of course, appropriations and other mechanisms that could be supplementary. Our climate needs it, our economy needs it, our security needs it, and I look forward to discussions with the committee. Thank you.

[The information follows:]



Statement of the Honorable Ernest J. Moniz
Secretary of Energy (2013-2017)
Founder and CEO
Energy Futures Initiative, Inc.

before the
U.S. House Energy and Water Development Appropriations Subcommittee
on
The Role of the U.S. Department of Energy in Addressing Climate Change
November 20, 2019

Chairwoman Kaptur, Ranking Member Simpson and Members of the House Appropriations Subcommittee on Energy and Water Development, thank you for the opportunity to appear before you today to discuss the imperatives of climate change and the importance of clean energy innovation. When I was Secretary, I very much appreciated the opportunity to work with you in a bipartisan fashion to advance DOE's important missions. And I take this opportunity to once again congratulate the Chairwoman for being the longest-serving woman in the history of the U.S. House of Representatives and thank Congressman Simpson's for his support of the Idaho National Laboratory, the nation's lead lab for nuclear energy research and development.

Let me deliver the punch line up front: the scale and pace needed for the low-carbon energy transition have come to be understood as even greater than was put forward just four short years ago at the Paris COP21 meeting, and DOE stands at the center of the energy science and technology innovation *solutions* that will position the United States for economic, environmental and security success in that transition.

The Energy Futures Initiative

My testimony will draw heavily from the data- and analysis-based work of the Energy Futures Initiative (EFI). In June 2017, I launched EFI together with my former colleagues at the U.S. Department of Energy: Melanie Kenderdine, founding Director of the Office of Energy Policy and Systems Analysis; and Joseph Hezir, the former Chief Financial Officer. EFI is dedicated to harnessing the power of innovation – both in technology and policy – to create clean energy jobs, grow the economy, enhance national and global energy security, and address the imperatives of climate change. We believe it is possible to build a secure, affordable, low-carbon energy future through the power of clean energy innovation and policies based on independent, unbiased, fact-based energy analysis.

To fulfill this mission, EFI produces rigorous analytical reports that offer new insights into emerging energy issues and recommendations for policymakers, and by leading stakeholder engagements that focus on elucidating the important technical, policy, economic, social and financial considerations for the energy sector. EFI seeks to achieve the maximum impact by identifying solutions that are effective, realistic and



sufficiently robust for adoption in these uncertain times. In just over two years, we have published 11 reports:

1. *The U.S. Nuclear Energy Enterprise: A Key National Security Enabler* (August 2017)
2. *Leveraging the DOE Loan Programs: Using \$39 Billion in Existing Authority to Help Modernize the Nation's Energy Infrastructure* (March 2018)
3. *The 2018 and 2019 U.S. Energy and Employment Reports* (March 2019 & June 2018), with the National Association of State Energy Officials
4. *Promising Blockchain Applications for Energy: Separating the Signal from the Noise* (July 2018)
5. *Advancing Large Scale Carbon Management: Expansion of the 45Q Tax Credit* (May 2018)
6. *Investing in Natural Gas for Africans: Doing Good and Doing Well* (November 2018)
7. *Advancing the Landscape of Clean Energy Innovation* (February 2019), with IHS Markit
8. *More Funding Needed for Carbon Removal Technologies* (April 2019), with the Bipartisan Policy Center
9. *Optionality, Flexibility & Innovation: Pathways for Deep Decarbonization in California* (May 2019)
10. *The Green Real Deal: A Framework for Achieving a Deeply Decarbonized Economy* (August 2019)
11. *Clearing the Air: A Federal RD&D Initiative and Management Plan for Carbon Dioxide Removal Technologies* (September 2019)

A twelfth report on regional innovation systems should be published next month. The analysis and conclusions of our reports solely those of EFI. All EFI reports are available to the public at no charge at: <https://energyfuturesinitiative.org/efi-reports>.

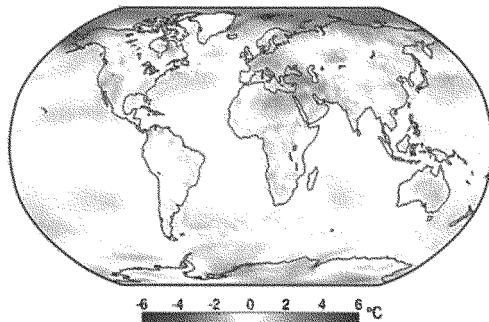
The Urgency of the Climate Issue and Need for Action

The threats posed by climate change to the world, our nation, and our way of life present an unprecedented and urgent challenge. The evolving climate science indicates the need to move toward a more stringent temperature limit of 1.5°C rather than 2°C. Yet as of 2018, two-thirds of the major carbon-emitting countries were not on track to meet the Paris target of 2°C,¹ and even if fully implemented, the Nationally Determined Contributions (NDCs) would achieve only one-third of the needed emissions reductions for a least cost pathway to 2°C.² Meanwhile, global carbon dioxide (CO₂) emissions rose 1.6 percent in 2017.³ Preliminary estimates for 2018 suggest that global CO₂ emissions rose again at a rate of more than 2 percent.⁴ The U.S. is no exception. In 2018, its CO₂ emissions from fossil fuel combustion rose 2.7 percent while economywide emissions likely increased by 1.5 to 2.5 percent.⁵

The United Nation's 2019 Climate Action Summit brief noted that “[t]he last four years were the four hottest on record, and winter temperatures in the Arctic have risen by 3°C since 1990”. Arctic sea ice volumes in September 2018 compared to 1979 have declined by 75 percent.⁶ Climate scientists have also expressed growing concerns about climate “tipping points”—irreversible changes in the climate system with uncertain triggers—after record-high global emissions in 2018.



Temperature Differences Between 2018 and 1980-2010 Average



2015-2018 were the four hottest years on record. Orange shaded locations were above average overall in 2018 and blue shaded areas were below average. Source: The Weather Channel, 2018

The growing intensity and frequency of floods, hurricanes and droughts across the country and around the world have underscored both the ferocity and costs of a changing climate. The recent wildfires in California offer a case in point: 12 of the state's 15 largest wildfires have occurred since 2000 and estimates of the costs of a single fire—the 2018 Camp Fire—are as high as \$16.5 billion.⁷ While Earth has seen major climate variation over its history, the pace of change today is well beyond that attributable to natural phenomena and is driven by human activity, especially from fossil energy production and use. These trends are consistent with decades of forecasts and predictions.

A warning on the costs of prolonged inaction is found in the Fourth National Climate Assessment, whose contributors include representatives from eleven Cabinet-level agencies, NASA, USAID and the National Science Foundation. The Assessment highlights the extremely high cost of inaction on climate change to the U.S. economy⁸:

[R]ising temperatures, sea level rise, and changes in extreme events are expected to increasingly disrupt and damage critical infrastructure and property, labor productivity, and the vitality of our communities. Regional economies and industries that depend on natural resources and favorable climate conditions, such as agriculture, tourism, and fisheries, are vulnerable to the growing impacts of climate change...continued warming...without substantial and sustained reductions in global greenhouse gas emissions is expected to cause substantial net damage to the U.S. economy throughout this century...annual losses in some economic sectors are projected to reach hundreds of billions of dollars by the end of the century—more than the current gross domestic product (GDP) of many U.S. states.



The Assessment indirectly underscores the social equity dimension of climate change: the high costs of inaction are disproportionately borne by those who can least afford them. These costs should be considered in the context of the Paris Agreement's targets of a 2°C increase in global temperatures by 2050, as well as its more desirable target of 1.5°C increase. The difference between the two targets presents very significant consequences. According to the European Geosciences Union, "the additional 0.5°C would mean a 10-cm-higher global sea-level rise by 2100, longer heat waves, and would result in virtually all tropical coral reefs being at risk."⁹

In short, *every tenth of a degree matters* in the fight against global warming, no matter where we are in our progress to limit the rise of global temperatures. Concerns about tipping points also reinforce the need for an additional focus on the "tenth of a degree" solutions and contributions: any and all incremental carbon reductions, whether above or below the multinational targets, reduce the risks of the most catastrophic impacts from global warming caused by Earth's feedback loops.¹⁰ Clearly, we are in a climate crisis.

The energy transition must also respect issues of social equity and allow for truly common but differentiated responsibilities for the developed and developing world. In many regions of the world, energy access is fundamentally a human rights issue that must be addressed on the path to decarbonization.

The U.S. withdrawal from the Paris Agreement is the latest step in the abandonment of American leadership to address the climate crisis. While efforts to curtail emissions continue in states and cities, and many companies are reducing emissions and building their strategic plans around the coming energy transition, the world needs the federal government to play the key role in building broad coalitions and creating actionable frameworks to transition to a low-carbon global economy. It must also continue and indeed expand its role in energy RD&D innovation.

Advances in science and observed environmental changes in the short time since Paris have, however, caused a reevaluation of the stringency of the targets. A 40 percent economywide emissions reduction target by 2030 and *net-zero* greenhouse gas emissions by 2050 are increasingly seen as the needed objectives. The net-zero requirement suggests the importance of major negative carbon technology deployment by mid-century, such as carbon dioxide removal (CDR) from the atmosphere and possibly from the oceans. CDR systems can help address CO₂ already emitted in the environment and could greatly reduce the level of difficulty in reaching net zero by avoiding the requirements of a zero-emissions energy system.

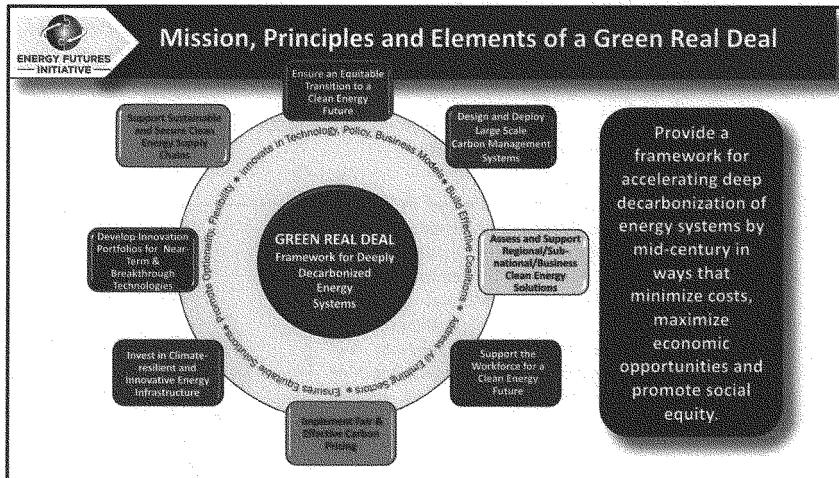
The Green Real Deal: A Framework for Achieving a Deeply Decarbonized Economy

The Green New Deal has focused attention on the urgent need to act on climate change. It is, however, aspirational and includes many provisions that are not energy or climate specific. Its core principles for the energy transition are the need for deep decarbonization and the importance of addressing social equity during the transition. A wise and just transition to a low-carbon economy, moving as fast as is technically and socially possible, must minimize stranded physical assets as well as stranded workers and communities. It must be based on practicality, not ideology. The need for urgency and the serious impacts



of inaction underscore the dangers of magical thinking—the deniers and the prescribers—at either extreme.

To translate the aspirations of the Green New Deal into practical and timely actions, EFI has developed the *Green Real Deal (GRD)*, a framework for a strategy for deep decarbonization of U.S. energy systems by mid-century in ways that minimize costs, maximize economic opportunities and promote social equity.



The Green Real Deal Principles are represented in the inner blue ring. Its Elements are represented by the outer ring. Source: EFI, 2019.

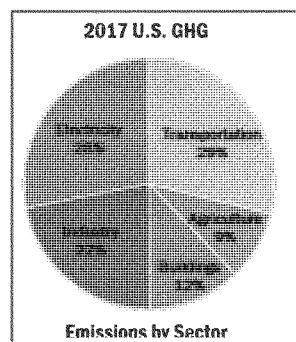
Principles and Elements of the Green Real Deal

The Green Real Deal rests on five fundamental principles: a strong, ongoing commitment to and reliance on innovation; the need to attract and build strong and inclusive coalitions; a commitment to social equity in all deep decarbonization policies; economywide solutions to the climate challenge that are both sector specific and crosscutting; and technology and regional innovation options and flexibility supported by policies that enable each. Above all, the GRD is pragmatic in aiming for deep decarbonization as rapidly as is possible while preserving adequate, reliable and resilient energy systems.

- ✓ **Technology, Business Model, and Policy Innovations Are Essential.** Innovations in technology, business models, and policy are essential for meeting deep decarbonization targets by midcentury. Incremental and breakthrough innovations must be developed to meet the challenges of deep decarbonization, including the rising marginal costs of GHG abatement.



- ✓ **Broad and Inclusive Coalitions Must Be Built.** Solutions for addressing the climate challenge cut across all portions of the economy and require participation of businesses, consumers, workers, governments and advocacy groups. Finding common cause, proactively addressing conflict and ensuring all members of society benefit from a transformation to a low-carbon economy will put wind in the sails of meaningful action.
- ✓ **Social Equity Is Essential for Success.** The transformation of energy and associated systems must also improve lives, grow public acceptance of the widespread change required to address climate change, and provide meaningful, well-paying jobs. The GRD subscribes to the National Academy of Public Administration's definition of social equity: "The fair, just and equitable management of all institutions serving the public directly or by contract, and the fair, just and equitable distribution of public services, and implementation of public policy, and the commitment to promote fairness, justice, and equity in the formation of public policy."
- ✓ **All GHG Emitting Sectors Must be Addressed in Climate Solutions.** Much of the academic and policy carbon abatement work to-date has focused on the electricity sector. Electricity produces, however, only 28 percent of U.S. emissions and is arguably the easiest to decarbonize. Sectoral analyses—electricity, transportation, industry, buildings and agriculture—will be central to identifying solutions and advancing innovation and net zero emissions targets. Reaching economywide emissions reductions targets will require progress in every sector of the economy, including those that are difficult to decarbonize due technical, cost and performance barriers.
- ✓ **Optionality and Flexibility are Needed for Technologies, Policies, and Investments.** There are no clear “silver bullet” solutions to decarbonization at the present time. Multiple clean energy technology options are needed for each sector of the economy and region of the country—this requires technology and policy options and flexibility. Optionality in the energy space is best described as “thinking through the various scenarios that might follow a decision, not just Plan A, and placing appropriate value on possibilities opened-up or shut down by each path... Optionality allows a company to embrace new opportunities first at the margin, but eventually at the heart of operations.”¹¹ An all-of-the-above approach to deep decarbonization is inherent in an approach with maximum optionality and flexibility.



The five core principles of the GRD inform its eight key elements. These include:

- ✓ **National Technology, Policy, and Business Model Innovation Program Portfolios.** Innovation is at the core of the Green Real Deal. Technology innovation opens new doors to new cost effective decarbonization options, enabling greater ambition and creativity in policymaking. Meeting the decarbonization goals of the GRD requires acceleration of current public and private sector energy



innovation programs. The focus of these efforts should be to further reduce the cost of current technologies as well as to pursue aggressive programs focused on technology areas with breakthrough potential to transform the nation's energy systems.

- ✓ **Subnational and Corporate Decarbonization Strategies.** Many states, cities and businesses are developing strategies and action plans to implement their "We are still in" commitments. These efforts could benefit from information-sharing on common issues, such as baseline definition and best practices, as well as external expert reviews to help identify new and creative approaches. This element focuses on techno-economic and policy assessments of the bottom-up multi-sectoral pathways needed to meet challenging decarbonization objectives in the 2030 to 2050 timeframe. This approach builds upon the previous work conducted by EFI on the California Decarbonization study as well as current on-going work.
- ✓ **Social Equity in the Distribution of the Costs and Benefits of Deep Decarbonization.** Transformation of the energy economy will incur cost, but these costs can be minimized through innovation combined with effective policy measures that enhance social equity. Families at lower income levels typically pay a higher proportion of their household budgets on energy than those at higher levels. Innovation in wind and solar energy have led to significant cost reductions, and many energy efficiency measures reduce consumer costs, but many decarbonization measures currently have higher costs, exacerbating the regressive impacts of energy costs. Environmental justice issues also arise in the consideration of the location of new energy infrastructures or the repurposing of existing assets.
- ✓ **Fair and Effective Carbon Pricing** Economywide carbon charges have been advocated by economists as the most cost-effective approach for achieving deep decarbonization. An economywide charge will mobilize market forces to pursue least cost solutions, and also will motivate innovators to develop and provide new solutions. In the near term, it is unlikely that policy makers will support carbon pricing regimes at levels that will induce technology-shifting across all sectors of the economy. This means other policy measures, such as CAFE and low-carbon fuel standards, industrial decarbonization, and CO₂ sequestration tax credits will need to be continued as companion policies. Carbon pricing can work in concert with other policy measures. For example, some states currently have carbon cap-and-trade programs (a form of shadow carbon pricing) in addition to sector specific mandates and incentives. Also, many private sector entities already have included carbon shadow prices in their analysis of long-term investments. While there have been a number of modeling studies on the impact of carbon pricing on decarbonization, several important elements require further examination.
- ✓ **Workforce for a Clean Energy Future** Clean energy innovation, including deployment, has also been important for the creation of U.S. jobs. The U.S. Energy and Employment (USEER) report from January 2019, produced by EFI in partnership with NASEO and BW Research, indicated that in 2018 there were nearly two million workers directly employed in Electric Power Generation and Fuels technologies; 800,000 of them were working in low-carbon emission generation technologies, including renewables, nuclear, and advanced/low-emission natural gas. The greatest increases in this category were in advanced/low-emissions natural gas, wind, and CHP generation jobs, which grew by 7 percent, 3.5 percent, and 7.4 percent, respectively. Energy efficiency jobs, which include design, installation and manufacture of energy efficiency products and services, increased 3.4 percent from 2017 to 2018



with over 2.35 million total jobs in 2018. The transformation of the energy economy will require new workforce skills. To ensure policymakers are doing everything possible and the right things, these trends in job growth need to be understood and analyzed from the perspective of needs, requirements, and the necessary innovation infrastructure to support jobs.

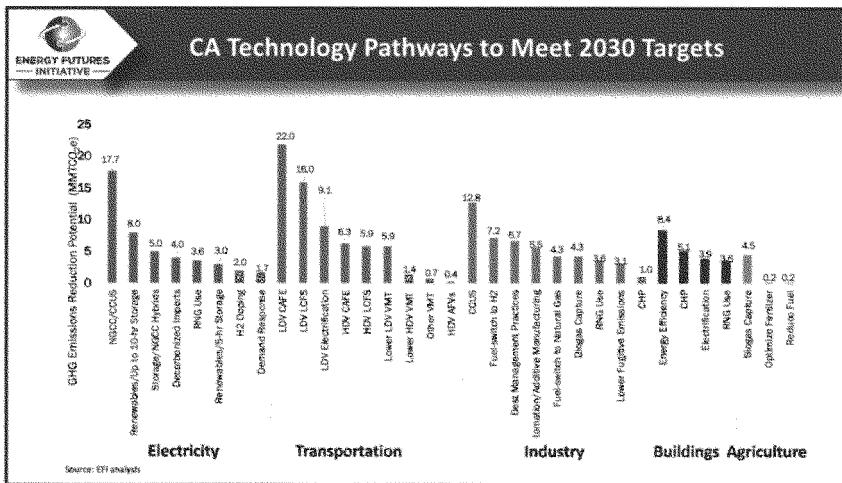
- ✓ **Large-Scale Carbon Management Systems.** The urgent need for action and the transition to a deeply decarbonized economy will likely require the ongoing use of some fossil fuels. Natural gas, in particular, will continue to play for some time an important role in providing dispatchable electric power generation and high-temperature industrial process heat—applications that are not readily amenable to non-fossil fuel options. Carbon capture, utilization and storage (CCUS) opportunities will be needed to enable continued use of natural gas and for high efficiency coal-fired power generation, as well as decarbonizing a number of industrial facilities. CCUS technology solutions are available today, but implementation is limited due to constrained financial incentives under the current 45Q tax credit and long-term uncertainty of compliance with regulatory requirements for carbon sequestration. Climate science is providing increasing evidence for the need to achieve carbon neutrality, which will require measures with negative CO₂ emissions. These pathways for carbon dioxide removal (CDR) will involve new technological approaches to remove carbon already in the atmosphere and oceans. There have been several recent studies identifying research needs for CDR, including large scale biological sequestration, and these need to be translated into functional RD&D programs that will be an important element of the technology innovation agenda. The recent EFI report on CDR does this.
- ✓ **Modernized, Innovative and Climate Resilient Energy Infrastructures.** Numerous studies have documented the significant investment needs for modernization of energy and energy-related publicly and privately-owned infrastructures. These estimates primarily focus on the need to replace aging infrastructure while managing the influx of “smart” and connected devices. These requirements are compounded by the need to make energy infrastructure more reliable and more climate resilient. Deployment of new clean energy technologies, such as battery and fuel cell zero-emission vehicles, will require entirely new energy infrastructures for charging and fueling. Widespread deployment of smart and distributed electricity generation and storage systems also will require new infrastructure investment in transactive transmission and distribution systems enabled by digital control systems, and sophisticated energy management systems supported by broadband communication capabilities. Finally, the impact of climate change will require that new infrastructures have enhanced resiliency. Meeting these needs will require substantial increases in investment as well as innovation in the architecture of infrastructure systems.
- ✓ **Sustainable and Secure Clean Energy Technology Supply Chains.** Widespread deployment of clean energy technology solutions will require that those technologies be supported by sustainable and secure supply chains. Critical materials supply chains for new clean energy technologies are emerging as the energy security challenge of the coming decades. Many clean energy technologies, for example, rely upon new or critical materials that may not be readily sourced domestically. According to the World Bank, “Global demand for strategic minerals” such as lithium, graphite and nickel will skyrocket by 965 percent, 383 percent, and 108 percent respectively by 2050.” A 2017 World Bank study of the mineral and metals needed for wind, solar and battery technologies concluded that: “Simply put, a



green technology future is [materials] intensive and, if not properly managed, could bely the efforts and policies of supplying countries to meet their objectives of meeting climate and related Sustainable Development Goals."

EFI's California Study Underscores Key Principles and Elements of the Green Real Deal

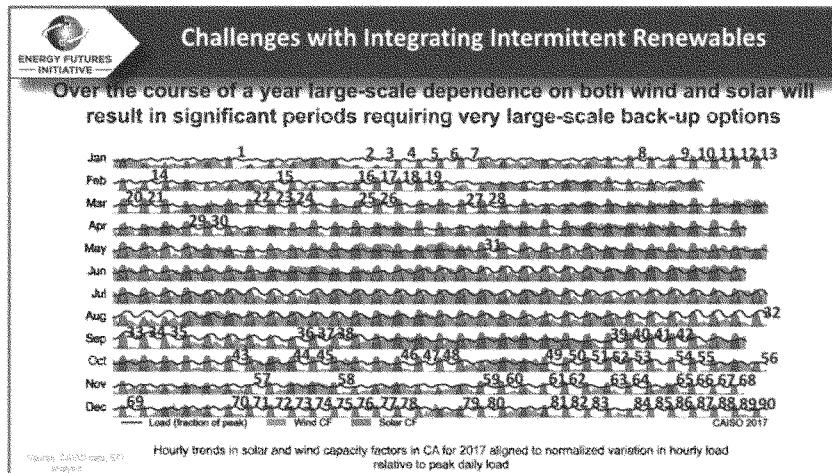
In June 2019, EFI published a study, *Optionality, Flexibility, and Innovation: Pathways for Deep Decarbonization in California*. The study is not a policy analysis; it assumes California's key policy targets for 2030 and mid-century and, where possible, identifies technology pathways to achieve those targets. Its title underscores key objectives and elements of the Green Real Deal – optionality, flexibility and innovation are all essential for a deeply decarbonized economy.



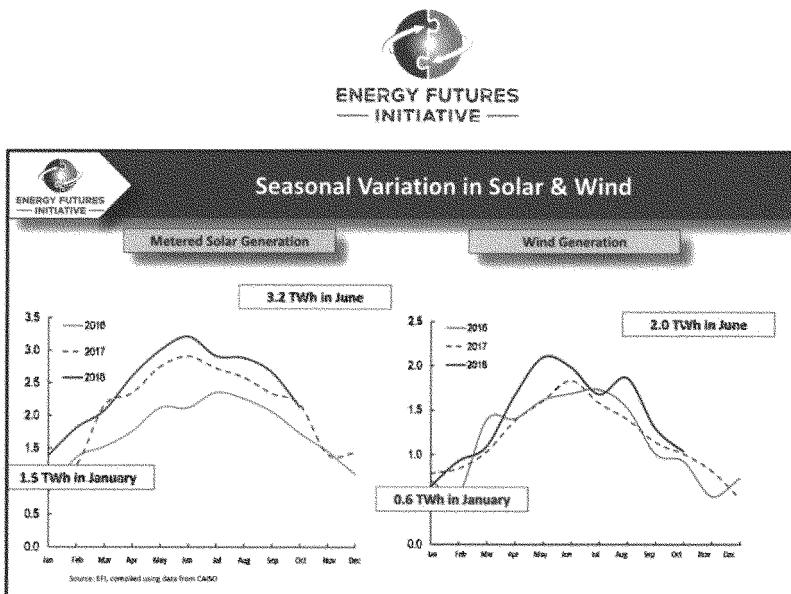
For the 2030 targets (40 percent economywide CO₂e reductions and 60 percent renewable electricity), a comprehensive, sectoral analysis was performed that identified a portfolio of 33 clean energy technology pathways. For context, the 40 percent economywide target calls for a reduction of over 160 million tons of CO₂-equivalent; the figure notes reduction potential in millions of tons. The high-level conclusion is that the target can be reached but only if there is success pretty much across the board. The analysis demonstrates the importance of developing technology options optionality and ensuring sufficient policy flexibility to enable the broadest use of the available options. The single largest pathway for all sectors was CAFÉ standards for light duty vehicles, but the future of these state standards is the subject of a sharp disagreement with the Administration. Certain pathways, such as carbon capture, utilization and storage offer surprisingly large emissions reduction potential in the decadal time frame (roughly 30 million tons) but is not sufficiently supported today in California to be deployed at this scale and pace. To pursue this reduction potential will require prompt action in order to capitalize on the 45Q tax credits.



Analysis concluded that managing and operating a deeply decarbonized electricity system based largely on variable renewables is technically very difficult. A detailed review of the state's regional attributes found that managing California's electric grid even at current levels of intermittent renewables is especially challenging. In 2017, there was a total of 90 days with little-to-no wind and periods where there were 5-10 days in a row with little to no wind generation. Current battery storage technologies are generally for a few hours duration.



In addition, seasonal variation of both solar and wind results in roughly a factor of two greater resource in the summer compared with the winter. Consequently, if the system becomes dominated by these variable renewables, the problem of practical and economic seasonal storage will need to be addressed. Current energy storage technologies are inadequate to address these weather-related phenomena.



Meeting California's long-term decarbonization targets—including an 80 percent GHG reduction or net-zero by 2050 and carbon-free electricity by 2045—is not possible without breakthrough innovations. In addition to the 33 technology pathways to help meet 2030 targets, the study identified eleven potential breakthrough technologies needed to meet 2050 targets, based on resources, energy system and market needs, and other distinct regional features that help position California as a technological first mover and global leader. The technology priorities identified for California (these will vary by state or region) include hydrogen production from electrolysis, seasonal storage, advanced nuclear, green cement, floating offshore wind, smart cities, and direct air capture, among others. These technologies, and many others with breakthrough potential, must be developed and deployed at scale by midcentury, with investments in innovation that must start today. In particular, a large scale low- to no-carbon hydrogen economy to complement zero-carbon electricity offers a possible solution, but major challenges of cost and infrastructure development will need to be solved. This would be alleviated considerably if CDR can be implemented at scale, as will be discussed below.

The Importance of Energy Innovation

For the past seven decades, the United States has been the global leader in technology and energy innovation. Central to U.S. leadership in innovation is our unparalleled innovation ecosystem, which includes the Federal, state, local and tribal governments; national laboratories; research universities; the private sector; nonprofits and philanthropies. Our ability to innovate is at the heart of American economic success and optimism. Innovation drives job creation, contributes to national security, addresses complex societal challenges and improves our quality of life. U.S. innovation has led not only to new products but also to entirely new industries. The challenges to our leadership in technology innovation are considerable, especially from China, where huge markets present an advantage.

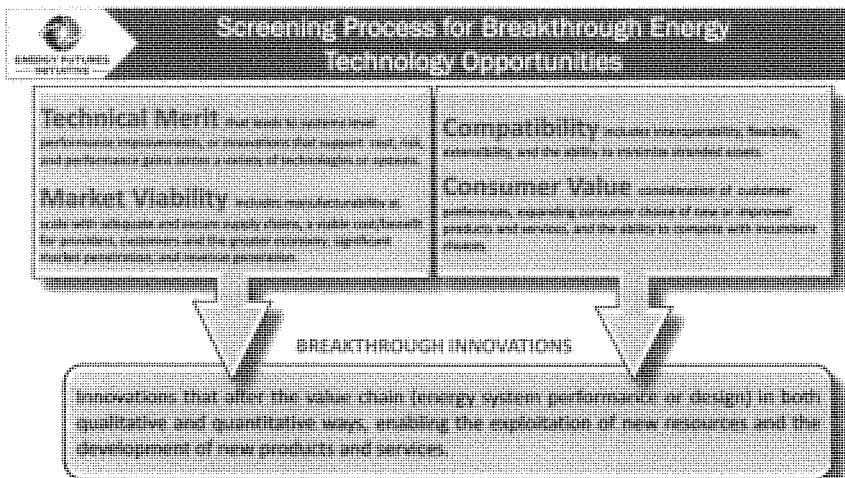


Key Green Real Deal elements are reinforced by the results of another EFI analysis (carried out with IHS Markit), *Advancing the Landscape of Clean Energy Innovation*, which emphasized the need to effectively navigate the technical, economic, regional and social realities of decarbonizing the energy system: the energy system must provide essential services reliably at all times; energy delivery infrastructure must be available, reliable and secure as the system transforms; affordable negative emissions technologies will be important at large-scale for deep decarbonization; and success will require aligning the interests and commitment of a range of key stakeholders. These boundary conditions shaped each clean energy pathway, revealing both opportunities and gaps for future efforts.

A key finding in *Advancing the Landscape of Clean Energy Innovation* was the emergence of new technologies outside the energy arena that can enable further innovation in energy applications. Technological developments in digitalization, big data analytics, advanced computing, smart systems, additive manufacturing and robotics have opened the door to a potential new wave of innovation in the energy economy. Combined with socio-economic trends in urbanization and flattening of energy demand, they point to new opportunities for energy innovation, for the emergence of new companies and whole new industries in the energy sector, creation of new and better jobs, new consumer services, more cost-effective energy use and a deeply decarbonized 21st century energy economy.

Why More Investment Is Needed

Another key finding of *Advancing the Landscape of Clean Energy Innovation*: the need for increased, and better targeted, public and private sector investment in energy innovation across all stages of the innovation spectrum from fundamental research through commercial scale demonstrations. The report examined more than 100 cutting edge energy technologies, focusing on the candidates with significant breakthrough potential, including: advanced energy storage technologies; advanced nuclear reactor technologies; new approaches to decarbonization of industrial processes; electricity systems modernization with a focus on the role of grid modernization in enabling smart communities; and large scale carbon dioxide utilization and management, including new approaches for carbon dioxide removal from the environment where emissions are not otherwise averted or mitigated.



Concerns about the inadequacy of collective emissions mitigation efforts, a growing body of scientific evidence and current emissions trajectories are reflected in the actions of many foreign governments, including many U.S. states and cities, in their movement towards “net-zero” emissions targets to balance GHG emissions with an equivalent amount of carbon removal and sequestration. The growing number of national, state and subnational entities that have committed to net-zero emissions puts additional pressure on innovators to develop a range of technologies that go beyond the scope of conventional mitigation options, including net negative carbon technology. Such technologies will also make possible, in the long term, a reversal of ever increasing GHG concentrations in the atmosphere, thereby reducing the impact of past actions.

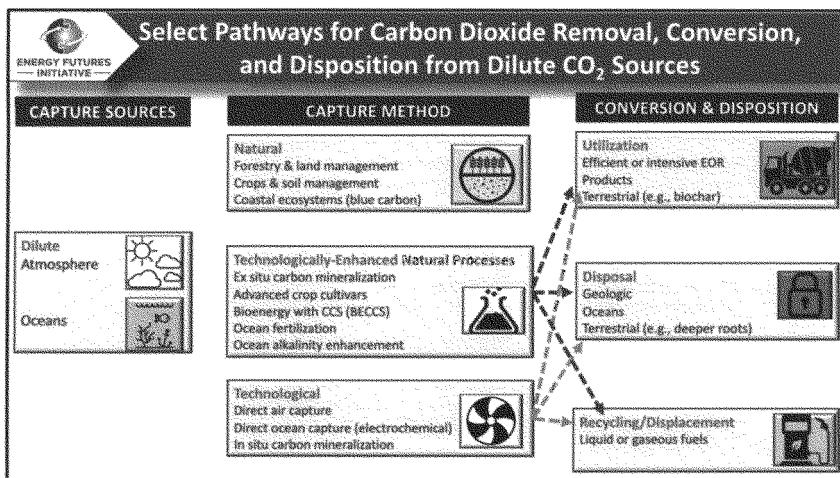


Illustrative Energy Technologies with Breakthrough Potential

- ✓ Applications for the Difficult-to-Decarbonize Sectors [Industry, Buildings]
 - Hydrogen and Clean Fuels
 - Advanced Manufacturing Technologies
 - Building Energy Technologies
- ✓ Electricity Systems and Smart Cities
 - Electric Grid Modernization, Communications, IT and Smart Cities
 - Transportation Electrification, Clean Fuels and Systems
 - Energy Storage and Battery Technologies
 - Advanced Nuclear Reactors
- ✓ Deep Decarbonization: Large Scale Carbon Management
 - Carbon Capture, Use, and Storage (CCUS) at Scale
 - Biological Conversion (Sunlight to Fuels) and Sequestration
 - Carbon Dioxide Removal (CDR)

EFI's most recent report, *Clearing the Air: A Federal RD&D Initiative and Management Plan for Carbon Dioxide Removal Technologies*, is an excellent example of how the U.S., particularly the U.S. Department of Energy, can successfully establish an expanded federal research, development, and demonstration (RD&D) program to address climate change. The report provides a set of recommendations and detailed implementation plans for a comprehensive, 10-year, \$10.7 billion RD&D initiative in the United States to bring new pathways for technological (including technology-enhanced natural) CDR to commercial readiness. Natural CDR processes, such as tree planting, can also make a substantial impact.

The CDR RD&D initiative encompasses a broad range of technological pathways and technologically-enhanced natural processes that can remove CO₂ from the environment including direct air capture (DAC); technologically-enhanced carbon uptake in trees, plants, and soils; capture and isolation of CO₂ in coastal and deep ocean waters; and carbon mineralization in surface and subsurface rock formations. Geologic sequestration and CO₂ utilization will also be included in the CDR RD&D initiative to provide CO₂ disposition options for CDR pathways such as DAC and bioenergy with carbon capture and sequestration (BECCS).



The wide range of scientific challenges requires a whole-of-government approach that reaches the mission responsibilities and research expertise of 12 federal departments and agencies, with DOE, the Department of Agriculture, and the National Oceanic and Atmospheric Administration playing key roles. The planning, budgeting, execution and performance aspects of the CDR RD&D initiative will require effective coordination led by the Office of Science and Technology Policy and the Office of Management and Budget within the Executive Office of the President. A practical appropriations strategy could be to start with the DOE and USDA portfolios for atmospheric CDR, since these will have the largest resource needs, and then building out the rest of the portfolio over a couple of years.



Overview of CDR RD&D Initiative

Goal	Comprehensive 10-year RD&D initiative focused on multiple CDR technology pathways Capable of gigaton-scale deployment, at technology-specific cost targets, with minimal ecological impact
Organization	Federal Committee on Large-Scale Carbon Management 12-agency, whole-of-government effort involving planning, budgeting, and coordination
Proposed Funding	\$10.7B over 10 years, with \$325M in the first full year Funding distributed among 10 agencies in six separate appropriations bills
RD&D Portfolio	

*The CDR RD&D initiative is proposed to span 10 years and involve multi-agency collaboration and coordination.
Source: EFI, 2019.*

At an international level, the CDR RD&D initiative should seek to collaborate with similar efforts in other countries under an expanded Mission Innovation initiative, which was launched at COP21 in 2015.

DOE's Role in Addressing Climate Change

The DOE is the largest single funder of energy R&D and viewed as the steward of the nation's energy technology innovation portfolio. For example, in FY 2016, the Department of Energy administered three-quarters of Federal investment in clean energy innovation.

During my tenure as Secretary from 2013-2017, I advanced clean energy innovation as the cornerstone of our national energy policy. We combined the science and applied energy R&D portfolios under a single Under Secretary for Science and Energy to enable more seamless translation of fundamental science into new energy technologies.

We incorporated innovation into the two installments of the Quadrennial Energy Review, a government-wide effort that integrated the energy-related interests of 22 federal agencies. Congressional action on many of the energy infrastructure recommendations demonstrated the broad appeal of analytically grounded policy development. We also updated the Quadrennial Technology Review into a comprehensive look at the innovation opportunities for guiding and accelerating the energy transition.

We placed particular focus on the role of the DOE National Laboratory system. We created a Laboratory Policy Council to engage the Laboratories in a stronger strategic relationship with Departmental policies and programs, established a Laboratory Operations Board to promote more efficient and effective laboratory operations, created the Office of Technology Transitions to accelerate the transfer of new technologies to the private sector and produced the first State of the National Laboratories report. We



analyzed the importance of regional innovation systems and our last budget request sought funding for regional structures. The Undersecretary for Science and Energy had 13 of the 17 national labs under his responsibility; with the cooperation of the Undersecretaries for Nuclear Security (three labs) and for Management and Performance (one lab), he was able to steward cooperation and collaboration across the entire national lab system.

On the international side, DOE led efforts to revamp and modernize the G-7 and European Union Energy Security Principles, which emphasized energy security as a collective responsibility and provided a focus on the importance of clean energy to energy security. It also promoted the role of functioning markets and extensive infrastructure as a key to energy security.

DOE also was in the forefront of the establishment of Mission Innovation, a global initiative started at the 2015 Paris COP21 with leaders of twenty countries committing to double the level of public investment in energy technology innovation over five years. Today, Mission Innovation has 24 countries and the EU. The establishment of Mission Innovation put clean energy technology innovation at the center of global climate solutions.

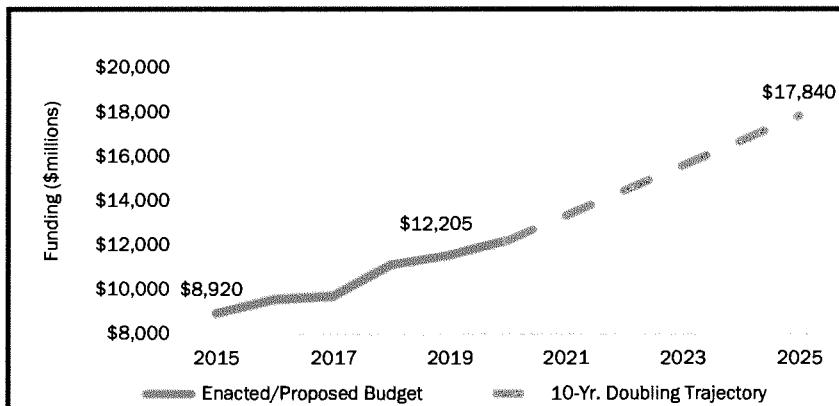
Another important feature of the Mission Innovation launch was that Bill Gates represented a coalition of wealthy international investors who pledged to invest significant resources in clean energy commercialization, taking advantage of the increased public investments in earlier stage RD&D. The resulting Breakthrough fund has been realized as a parallel activity to Mission Innovation.

Congress has been supportive of increased investment in energy R&D but at a slower pace. Congressional appropriations for the total DOE science and energy R&D program portfolio have increased by 30 percent over the past 5 years, putting the DOE budget on a track to nearly double over 10 years. Achieving the larger step-change in funding to support an accelerated energy innovation program may require augmentation of the current federal annual appropriations process with dedicated funding from new funding sources.

The idea of doubling or tripling the clean energy innovation budget goes back almost a decade. In 2010, the American Energy Innovation Council, composed of prominent CEO's in the US, called for a three-fold increase in its "Business Plan for America's Future". Later that year, the President's Council of Advisors in Science and Technology (PCAST) issued its "Report to the President on Accelerating the Pace of Change in Energy Technologies through an Integrated Federal Energy Policy" reached a similar conclusion. The latter report offered a top-down rationale for the scale of the increase but also emphasized that the innovation portfolio would need to be built bottom up. However, the scale is important for constructing the portfolio. For example, when I was Secretary, the Secretary of Energy Advisory Board (SEAB) analyzed the needs for a DOE program that could properly take an innovative Generation IV nuclear technology through all stages to deployment. They concluded that roughly a billion dollars a year would be needed, an amount that cannot be credibly expended within the current nuclear energy budget but could be with a doubled budget. So that portfolio could look quite different if long range planning to a significantly increased budget could go forward responsibly.



Doubling the DOE Science and Energy R&D Budget



DOE science and energy budget could be on a 10-year doubling trajectory by 2025. Source: EFI, 2019.

As highlighted in *Advancing the Landscape of Clean Energy Innovation*, the process of annual appropriations introduces large uncertainties into the process of planning and executing the energy innovation portfolio, due to the uncertainties and delays associated with annual budget cap negotiations and the resulting dependence on stop-gap and sometimes longer Continuing Resolutions. Large swings in year-on-year President's budget requests and funding—evidencing an underlying lack of a consensus on innovation policy—is also a significant factor leading to inefficiencies in the way Federal energy R&D funds are deployed. Continuing Resolutions inherently impede innovation portfolio development.

While Congress likely will continue to rely on the annual appropriations process to fund energy innovation, there are alternative funding models that can supplement this process to increase the pace of investment in energy innovation and achieve better innovation performance than likely would have been attained if funded through annual appropriations alone.

One approach is to supplement annual appropriations with advance appropriations to provide funding certainty for large, multi-year projects. The DOE Clean Coal Technology Program in the 1980s and 1990s, for example, was funded through advance appropriations that automatically became available in future fiscal years. This led to greater certainty in cost-sharing arrangements and more successful demonstration project outcomes. The practice of advanced appropriations has since been prohibited by Congress, except in a few grandfathered circumstances.

Another approach is to earmark specific revenue streams as an offset to appropriations, so that the net appropriation is not scored against appropriation caps. In 2015, Congress authorized a special funding mechanism for modernization of the Strategic Petroleum Reserve (SPR). The Bipartisan Budget Act of 2015 authorized annual appropriations totaling \$2 billion for SPR modernization, offset by the sale of SPR oil.



While annual funding levels are set in appropriations acts, the use of a dedicated offset isolates the program from the uncertainties and constraints of the non-defense discretionary caps. This mechanism has been successfully implemented over the past three years, and I note that it is again included in the pending FY 2020 appropriations bills.

A similar mechanism was authorized by Congress in 2005 for The Ultra Deepwater and Unconventional Natural Gas and Other Petroleum Fund. This fund was not only financed solely from a set aside of federal oil and natural gas royalties, it also was not subject to annual appropriations, although Congress exercised oversight through review of the annual program plan. Because the research program was intended to provide new technologies to expand natural gas and petroleum production from Federal lands, it offered the possibility to eventually become self-sustaining.

Another approach is for Congress to authorize appropriations outside of the discretionary spending caps. In 2016, Congress enacted the 21st Century Cures Act, which sought to increase funding for NIH research programs by authorizing an increment of annual appropriations totaling \$4.8 billion over 10 years, outside of the discretionary spending caps. The funds were intended to increase the level of annual funding normally appropriated to NIH. To comply with budget scoring rules, the new funding (outside the cap) was offset by the sale of oil from the SPR.

Finally, Congress may wish to consider providing a stable source of funding to supplement annual appropriations through the establishment of new user charge. One possible approach would be to institute a national public benefits charge on electricity, implemented through some form of "wires charge" or upstream charge on fuels for electricity. Several states currently use public benefits charges as a mechanism to accelerate deployment of innovative technologies. Another model that could be considered would be a non-governmental entity to manage the R&D program or a "all-of-the-above" demonstration project program but funded through a governmentally controlled charge. The Gas Research Institute (GRI) and the Electric Power Research Institute (EPRI) provide examples of R&D funding approved by Federal and state regulators, respectively:

- GRI was a non-profit, non-governmental entity established by the natural gas industry in 1976. It was funded by a mandatory surcharge placed by the Federal Energy Regulatory Commission on natural gas volumes in interstate commerce. At its peak annual funding level in the early 1990s, the GRI annual budget was more than \$200 million, financed by a surcharge of about 1.5 cents per thousand cubic feet of gas transported by interstate pipeline companies. The mandatory surcharge was phased out over a seven-year period by FERC beginning in 1998. The Gas Technology Institute (GTI) is the successor organization to GRI and is currently funded from voluntary contributions from natural gas utilities. GTI revenues totaled \$103 million in 2016.
- EPRI is a non-profit, non-governmental entity established by the electric power industry in 1973. It was originally funded through a voluntary charge placed on sales revenues and approved by state public utility commissions. The suggested charge was 0.1 mills per kilowatt-hour (kWh) of electricity. EPRI restructured its program around 2000 to a business model that was project-based, with voluntary cost sharing from interested companies on a project-by-project basis. Revenues in 2015 totaled approximately \$407 million. Based on the prior charge regime, in 2016



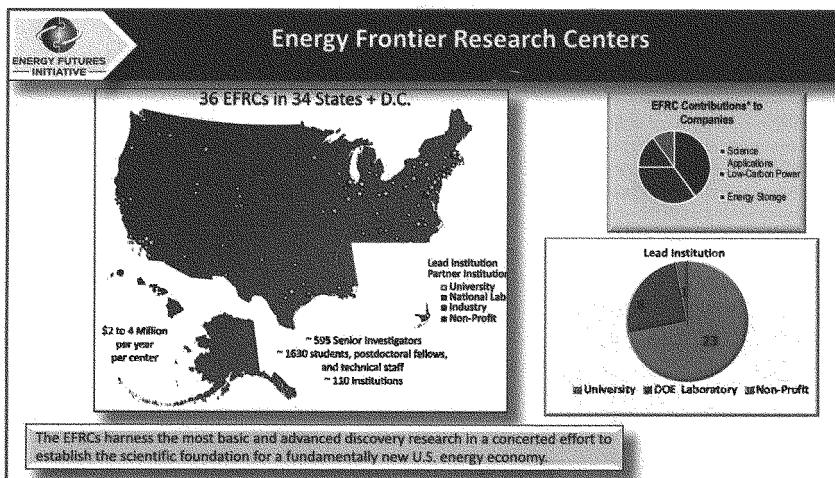
EPRI's budget would have been \$3.76 billion, if 0.1 mills had been collected for every kWh consumed at retail nationwide.

Movement toward a more assured funding structure for energy innovation could provide a significant boost to the pace and effectiveness of the innovation process. Such a structure could supplement current annual appropriations to accelerate the pace of energy innovation investment, while retaining a comparable degree of Congressional oversight. Much work would need to be done to develop a new funding mechanism that would be supported by stakeholders and acceptable under current budget scoring rules.

Energy Innovation Investments Have Reduced the Costs of Clean Energy Technologies

Breakthrough innovations generally take decades of support from multiple stakeholders along the innovation chain. The DOE has long sponsored R&D of breakthrough technologies, such as solar photovoltaics and hydraulic fracturing of oil and gas resources.

Hydraulic fracturing technology also began with decades of R&D linked to DOE. In 1975, a DOE-industry joint venture drilled the first Appalachian Basin directional wells to tap shale gas. Between 1978 and 1992, DOE invested about \$137 million in the Eastern Gas Shale Program to help demonstrate and commercialize many of the technologies in use today, including directional drilling, micro-seismic monitoring and hydraulic fracturing treatments, and modeling.¹² GRI, working with companies, carried out essential demonstration projects, and Congress supported the effort through a time-limited tax incentive. Years of sharing knowledge and resources along the energy innovation chain made the "shale revolution" possible.



DOE continues to have impact along the innovation chain. At the basic research level, in addition to providing key tools for the American research community (such as synchrotron light sources and neutron sources for advanced materials research), the Department established a set of Energy Research Frontier Centers (EFRC). These are typically \$2-4M/year, multi-investigator centers focused on one of the breakthrough science challenges that need to be met for innovative energy technology development. The challenges were defined through an exemplary community process organized by the DOE Basic Energy Sciences office during the George W. Bush administration, and then the program was implemented early in the Obama administration. The majority of the 36 centers (in 34 states and DC) are at universities. Budget constraints have decreased the number of EFRC's since their establishment, since about a third of the original funding was from the one-time American Recovery and Reinvestment Act of 2009. The scale of the program deserves revisiting.





Advanced Research Projects Agency-Energy (ARPA-E)

ARPA-E focuses on promoting transformational technologies with high risk, high payoff characteristics that may fall outside the path of conventional technology roadmaps

U.S. National Academy of Sciences recommended a funding priority for an additional \$1 billion from ARPA-E

Since 2009 ARPA-E has provided **\$2 billion** in R&D funding to more than 200 projects

76 companies formed by ARPA-E projects



131 projects have partnered with other government agencies for further development



145 Projects have attracted more than **\$2.9 billion** in private-sector follow-on funding



2,489 peer-reviewed journal articles from ARPA-E projects



346 patents issued by U.S. Patent and Trademark Office



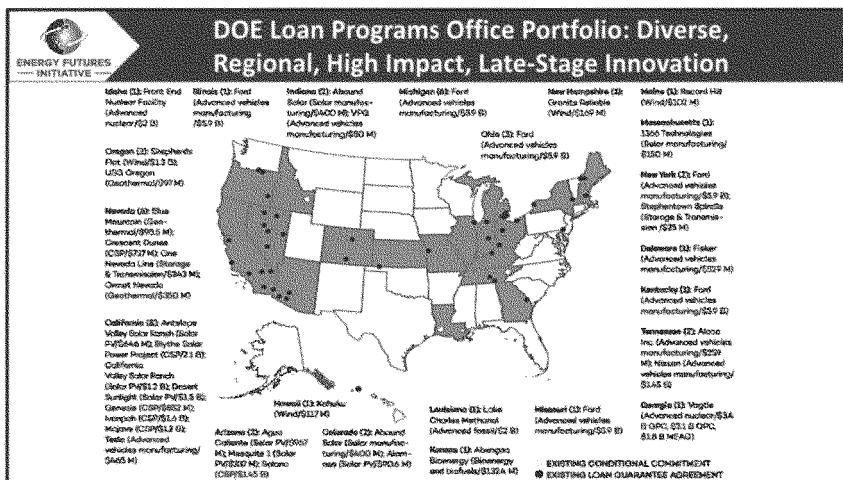
Source: ARPA-E, U.S. Department of Energy, 2019

09 March 2019

The Energy Advanced Research Projects Agency (ARPA-E) focuses on promoting transformational technologies with high risk, high payoff characteristics that often fall outside the path of conventional technology roadmaps, bridging the gap between the university and national lab work on basic science and DOE's programs that support pilot and commercial scale projects. Between 2009 and 2017, ARPA-E supported technologies have set global efficiency records and raised substantial private investor funding for startup companies. In 2017, the National Academies of Sciences, Engineering and Medicine conducted an assessment¹³ of ARPA-E, noting that:

ARPA-E is in many cases successfully enhancing the economic and energy security of the United States by funding transformational activities, white space (technology areas that are novel or underexplored and unlikely to be addressed by the private sector or by other federal research programs), and feasibility studies to open up new technological directions and evaluate the technical merit of potential directions.¹⁴

The DOE Loan Programs address the opposite end of the technology innovation roadmap—late stage innovation.



As noted in *Advancing the Landscape of Clean Energy Innovation*, the Loan Programs Office (LPO) was instrumental in seeding the U.S. utility scale photovoltaic (PV) market. In 2009, there were only 22 megawatts (MW) of installed utility-scale PV capacity domestically, and the U.S. Energy Information Administration (EIA) forecast only 126 MW of total utility-scale PV solar capacity to be installed by 2015. Solar developers were unable to secure the necessary financing for construction of large projects, even with firm offtake contracts and substantial equity in hand.

In 2011, LPO provided more than \$4.6 billion in loan guarantees to support the first five utility-scale solar PV facilities larger than 100 MW.¹⁵ Since then, the private sector has taken over, financing 590 new utility-scale PV projects by the end of 2017.¹⁶ By the end of 2018 there were over 30,400 MW of solar PV capacity installed at utility scale, an increase of more than 1,900% since 2011.¹⁷ Many of the banks that financed these projects, such as John Hancock, Bank of America, and Citigroup, were banks that worked with LPO through the Financial Institution Partnership Program (FIPP) in financing the first five utility-scale PV projects.¹⁸ The launch of the domestic utility-scale PV industry demonstrates the critical role LPO plays in reducing risk for innovative technologies and creating a financing model that can be adopted by the private sector.

Again, the key point is that DOE has and does play a very important role in the entire U.S. energy science and technology innovation system. A multiplier effect is the large number of students and young researchers and entrepreneurs who got their start through DOE programs and have gone on to be the backbone of the American innovation enterprise.



Conclusion

The threats posed by climate change, and the resulting need to decarbonize the economy, create even more urgency for the U.S. to rapidly expand and accelerate its efforts in clean energy innovation. The growing intensity and frequency of floods, hurricanes, and droughts across the country and world have underscored the moral, economic, social and environmental imperatives of addressing climate change. As such, the country is becoming increasingly aligned on the need for action, especially as global greenhouse gas emissions continue to increase. Economywide decarbonization will likely depend on multiple technology breakthroughs that address key issues in the energy sector. The time is here and now for the U.S. to step up as the global leader in clean energy innovation by leveraging the full potential of its innovation ecosystem.

Chairwoman Kaptur, Ranking Member Simpson and Members of the House Appropriations Subcommittee on Energy and Water Development, thank you for the opportunity to appear before you today to discuss the imperatives of climate change and the importance of clean energy innovation. I look forward to your questions.

¹ <https://www.pbl.nl/node/65210>

² <https://www.unenvironment.org/resources/emissions-gap-report-2017>

³ https://www.globalcarbonproject.org/carbonbudget/18/files/Norway_CICERO_GCPBudget2018.pdf

⁴ https://www.globalcarbonproject.org/carbonbudget/18/files/Norway_CICERO_GCPBudget2018.pdf

⁵ <https://fhg.com/research/initial-us-emissions-estimates-for-2018/>

⁶ Chris Mooney, "The Arctic Ocean has lost 95 percent of its oldest ice — a startling sign of what's to come," *The Washington Post*, December 11, 2018, https://www.washingtonpost.com/energy-environment/2018/12/11/arctic-is-even-worse-shape-than-you-realize/?utm_term=.4f243d86b0c8

⁷ "Extreme storms, wildfires and droughts cause heavy nat cat losses in 2018," *Munich RE*, January 8, 2019, <https://www.munichre.com/en/media-relations/publications/press-releases/2019/2019-01-08-press-release/index.html?ref=Twitter&id=%23Natcat2018%20year%20End%20Report>

⁸ David Reidmiller et al., "Summary Findings," *Fourth National Climate Assessment* (U.S. Global Change Research Program, 2018), <https://nca2018.globalchange.gov/>

⁹ "1.5 C vs 2 C global warming: New study shows why half a degree matters," *Science Daily*, April 21, 2016, <https://www.sciencedaily.com/releases/2016/04/160421085218.htm>

¹⁰ Johan Rockstrom, "Climate tipping points," *Global Challenges Foundation*, <https://www.globalchallenges.org/en/our-work/annual-report/climate-tipping-points>

¹¹ Michael Liebreich, "The new energy ROI: Resilience, Optionality, Intelligence," *Get Resilient*, March 15, 2013, <http://getresilient.com/2013/03/15/the-new-energy-roi-resilience-optionality-intelligence/>

¹² https://www.energy.gov/science-innovation/all-gas-research/share_gas_id

¹³ National Academies of Sciences, Engineering, and Medicine. 2017. *An Assessment of ARPA-E*. Washington, DC: The National Academies Press. <https://doi.org/10.17226/24778>.

¹⁴ Press Release, June 13, 2017. <http://www8.nationalacademies.org/onpinews/newsitem.aspx?RecordID=24778>

¹⁵ https://energy.gov/sites/prod/files/2015/02/f19/DOE_LPO_Utility-Scale_PV_Solar_Markets_February2015.pdf

¹⁶ https://emp.lbl.gov/sites/default/files/lbnl_utility_scale_solar_2018_edition_report.pdf, page 11

¹⁷ https://www.eia.gov/electricity/annual/html/epa_04_03.html

¹⁸ https://energy.gov/sites/prod/files/2015/02/f19/DOE_LPO_Utility-Scale_PV_Solar_Markets_February2015.pdf

<https://www.greentechmedia.com/articles/read/financing-utility-scale-solar-in-the-years-ahead>

<https://www.solarpowerworldonline.com/2019/01/john-hancock-pine-gate-renewables-solar-portfolio/>

Ms. KAPTUR. Thank you very much, Mr. Secretary, and thanks to all of you. I want to thank all of the members who have come today. What a tremendous turnout with respect to you, but also to the issue we are discussing.

Since it has been a little while since our last hearing, I just wanted to remind members about our hearing rules. For those members present in the room when I gaveled in at the beginning of the hearing, I will recognize you for questions in order of seniority alternating between majority and minority until all who arrived prior to the gavel have asked questions. And for those who arrived after the hearing started, I will recognize those members solely in order of arrival, again alternating between majority and minority. Lastly, I intend to observe the 5-minute rule for questions, if we can, and answers as well.

We will now begin with questioning under our normal rules. I will ask one question to allow other members to ask, but I will ask the panelists to remain for a while afterwards so we can get all questions in.

I want to start with Mayor Lyles. Can you discuss the impacts Charlotte expects to see from climate change and how that has affected the programmatic implementation you discussed this morning? I also wanted to ask if you could provide for the record the resolution and summary plan you mentioned, and also the zero waste proposal. Would you be able to make that available for our record?

Ms. LYLES. Yes, thank you so much for asking and we would be able to do that, yes.

Ms. KAPTUR. Thank you very much. Could you please discuss the impacts that Charlotte expects to see or is already seeing from climate change? And also, how that has influenced what you are doing in Charlotte.

Ms. LYLES. Thank you for the question, Madam Chair. You know, the impact of climate change, I think, really hits us at home. When we talk about the health of our residents, allergies, asthma, all of those things are very real when we have air problems, especially in the times. Because Charlotte, often during the summer, with lots of cars and lots of trucking equipment and things like that, that truly makes a difference. And we have had days where we have had to suggest that people stay inside their homes. Now that is just not acceptable.

The other thing that we see as we continue to grow, we are a southern city so we tended to grow with a great deal of sprawl. And as we have had that great deal of sprawl, it has been beautiful because it gives people, our residents, choices about where they want to live. But when they have those choices, we have then got to react with giving them the ability to move around our city. And that means that we have to have a bus system that works and a rail system that works. Otherwise, we are just going to have cars clogging roads.

And I have to agree with the Secretary. When we think about this, it cannot just be about one thing. It has to overlay every aspect of what we do. So, if we agree that we are going to have development, then we have to agree that we are going to have a dif-

ferent way of funding transportation. And so, those are the kinds of tradeoffs we have to make.

But we are working really hard on maintaining and growing a tree canopy. We are putting that in our development plans. We are actually having to work with developers to say we will save our trees because we know that that is a part of what we have to do.

We are also embarking on a new 26-mile rail system. And when we are doing that, we are creating zoning districts that allow for more density around that so that we can have people have choices that they will not have to get into a car. If I could wave a magic wand in our city, I would actually reduce the number of cars that we have because traffic congestion means greenhouse gasses. And it means that we will have bad air for all of our children and that creates public health issues.

So, that is what we really understand, that it is not just the responsibility of one area of work, it is where we plan on transportation, how we plan development, and how do we ensure that the quality of life continues for everyone.

Ms. KAPTUR. Thank you very much.

Ms. LYLES. Thank you.

Ms. KAPTUR. Ranking Member Simpson.

Mr. SIMPSON. Thank you all for being here and for your testimony. It almost seems like an overwhelming problem that we are trying to address. And I do not know that there is anybody here or I have never met anybody in Congress anyway that denies the fact that climate is changing and that there is an impact that we need to address.

Government certainly has a role in it, private sector certainly has a role in this, and trying to pair those two together is sometimes difficult. And what we do here in this committee is fund a little bit of everything, I guess. And I have wondered in the past what the results of that is and if there is a better way to address our funding of these various programs that are out there and how do we involve the private sector in that.

Mr. Powell, in your testimony, you mentioned a moonshot strategy to demonstrate multiple new American reactor concepts in the next decade. And as you know, the Idaho National Laboratory recently launched the National Reactor Innovation Center, or NRIC, which will provide private sector technology developers support to accelerate the testing and demonstration of new nuclear systems for eventual licensing and commercialization.

How would the advanced reactor demonstration program that you mentioned in your testimony complement the work at NRIC? And how can NRIC help amplify the impact of a demonstration program in commercializing the next generation of advanced reactors?

And along that same line, for you and Secretary Moniz, our national labs play a significant role in U.S. leadership and clean energy R&D, and especially when they work collaboratively with the private sector. Are there specific suggestions on how we can—we might make our national laboratories even more accessible to private sector development? Because there has always been kind of a break there for some reason, it is called “the valley of death,” and how do we address that?

Mr. POWELL. Sure. Well, first, thank you so much for your leadership on nuclear innovation. INL is an amazing center of excellence in the global nuclear industry. And so much of the global breakthroughs on the civilian nuclear power have come through that remarkable facility.

So, I think that the two programs you mentioned are perfect examples of different and complementary approaches to working with the private sector on scaling up really difficult, new, clean energy technologies. So, the NRIC, I think, can somewhat crudely be thought of as a WeWork for nuclear energy, right.

It is very difficult if you are a young nuclear entrepreneur with an idea for a new reactor or a new design. That is not the kind of thing you can scale up in a garage. None of us want that to be scaled up in a garage, right? You need a specialized facility with specialized equipment, like the versatile test reactor which you have already started to fund and to start plan and design—to build at the NRIC.

You need a center where nuclear innovators can come test their designs, use all of the facilities of the labs, to your second question. But at some point, we also need to decide to go further with some of those designs, right? It is very, very difficult on something as large scale as a new nuclear reactor to even using all of the facilities of the labs go all the way to demonstration with private capital alone. There is so much risk, right?

Take a look at, you know, Bill Gates nuclear startup TerraPower. Even with all of their resources, they have said repeatedly that they would need some government co-investment in it in order to scale up that technology. And that is, I think, where the moonshot goals come in. At some point, we need a mechanism, a rational mechanism, not only applied to nuclear, we think applied to many different energy technologies which would select not just one, but a few designs, and use a dedicated program of basic and applied research and cost shares with private industry in order to make real targets and demonstrate those technologies.

So, I think that, you know, the case of the advanced reactor demonstration goals, right, let us get two of these things up and running by 2025, a very aggressive kind of a moonshot, but, realistically, the sort of timeline we need to be hitting if advanced reactors are going to play a role in decarbonizing a large part of the power grid by the 2050s. You know, they will be demonstrated in the middle of the 2020s, scaled up and starting deployment in the middle of the 2030s, and then these things usually take 10 to 15 years to scale up meaningfully around the world. So, we need to be setting those kinds of aggressive milestones.

Mr. SIMPSON. Secretary Moniz.

Mr. MONIZ. Let me just add a few points to what Rich just said. First of all, on nuclear specifically, I think we take a step back and say that we have never seen so much innovation in the nuclear sector as we are seeing today with literally tens of companies out there with private funds moving along advanced concepts actually in both fission and fusion in the nuclear sphere.

But as you said, we have not, let us say, found the right key to getting these concepts over the finish line to demonstration. And if we cannot demonstrate some number of particularly the small mod-

ular reactors, then, of course, we will never know if the dog hunts in terms of the ability to scale up. So, that is absolutely critical.

I believe that cannot happen without a direct or indirect role of the government in a private partner—private sector—private-public partnership approach, and some of those mechanisms have been discussed. I would be happy to come back and talk about it more.

But I would like to go, again, to reinforce a point I made in the testimony that sometimes we forget the very foundation of all of these big, unique, cutting-edge user facilities that are in the national labs across the Nation. And, I think, we need to look at, for example, taking lessons from something like the Cyclotron Road approach at the Berkeley laboratory in terms of making the laboratories in the private sector work in service of the private sector innovation system.

We need, I believe, I mentioned earlier how regional solutions are so important. I think we need to do more and part of it would be an authorization, part of it might be an appropriation. We need to see the laboratories used as hubs for regional innovation systems. Frankly, it was not so many years ago when that was not viewed as part of their mission. I believe we have to recognize it as part of their mission to develop these regional innovation systems.

I would just say that in my last year as Secretary of the Department, we did have some funding there to get ideas on the table for specific regional innovation funding. Regrettably, I do not believe that those projects have moved forward and I think that is an example of something that should be reexamined.

Finally, and I know this is tough, but, you know, we can go back essentially 10 years to where a group like the American Energy Innovation Council reinforced by others said, you know, we really are underspending in this innovation budget by factors of two or three. The Congress, frankly, in the face of unrealistic administration budget proposals, has really put us on a track of maybe doubling over 10 years, especially if you look carefully at the trajectory, and that is important.

Let me say why it is important and I will end by going back to nuclear as an example. It is much broader than that.

As Secretary, I charged my advisory group, C-AB, to look at the question, what would it take of Federal resources, investments to really move to getting a generation for technology actually deployed? They came back with a number, let us call it in round numbers, like a billion dollars a year. Realistically, you cannot do that with the current budget. If you had—if you were talking about doubling the budget, now a program can plan for a long-term effort to get over that finish line and get it out.

So, there are these many different aspects together with this kind of a system view. We could do a lot more in terms of regional innovation and private sector progress towards deployment.

Ms. KAPTUR. Thank you very much. Mr. Pocan.

Mr. POCAN. Thank you very much, Madam Chair. And thank you to all of you for being here. So, I feel like there is this big disconnect between this town and the rest of the country when it comes to this issue. And, you know, when you come from a swing state, you look at a lot of swing state polling. And so, I have looked

at a lot of Wisconsin, Michigan polling lately and they asked a bunch of Independents top issue, ran a bunch of issues, two-thirds support for the Green New Deal.

Now, I do not know if they know the particulars of the Green New Deal, but what they know is there is a problem that we have to deal with in climate change. And then when I got on this sub-committee, I noticed that we spend three times more money on research for NASA than we do for energy, and that just seems to be part of that disconnect.

We put on 8.5 kilowatts of solar on our house 3 years ago and there is nothing like a March or April bill of \$7 for your monthly utility bill to, you know, make a big smile on your face. But one of the things was we did not get the battery storage because the cost was still prohibitive, it was not quite there.

So, my question kind of goes right after what the Secretary was saying, but it is for everyone, which is on the research dollar side, what are the most promising innovations that if they had some research boosts, because they need some research boost, could show some potential? I think sometimes it is easier for us rather than just talking about a dollar amount, what would the money actually be going to that is promising that shows this is something that, with a little push, could get us across a finish line of having some real growth in this area? Open it up to everyone actually.

Mr. POWELL. Sure. I am curious to know how my list compares to the Secretary's in particular. I would say, I will put a few that I think are sort of—lots of things could use more resources, a few that are sort of tragically underfunded and could really be doing a lot more.

So energy storage technologies, you all have done an amazing—you virtually doubled support for energy storage technologies in the past 2 fiscal years. We still spend about a fifth that we do on energy storage as we do on researching new wind technologies, for example. And that seems really quite out of whack given that wind is already, in some sense, the cheapest new source of energy in the country, and energy storage is far behind. But we know it is necessary to continue wind moving along. That is one that I would really target.

I think in the solar space, perovskite solar cells, which are the next generation facilities to come online that could radically reduce the cost of solar energy even further. Or there is one that is tragically underfunded, I think the most recent mark maybe brings it up to sort of 10 million or so, but that is compared to a solar budget of more than 200 million, when this is pretty well acknowledged is the thing to really move solar along.

And then I think in the fossil energy space, and this is changing, but I think it is pretty clear we have been underinvesting in both industrial carbon capture and in carbon capture on gas-fired power plants. We have traditionally thought of CCS, carbon capture technology, for coal plants, and that is absolutely vital to continue that funding. But there is a lot of other sources of CO₂ out there that we could be also focusing more time and energy on controlling. That would be my quick list. Thank you.

Mr. MONIZ. I would just add to that. And first of all, we would be happy to supply to your office a report from the spring of this

year called, ‘Looking at the Energy Innovation Landscape.’ So a lot will be in there. But let me—I would be happy to, of course. Yes. It is measured in kilograms however, but anyway.

But in terms of specific areas, first of all, let me start with the storage again. Just to reemphasize, we should not equate storage to batteries. Batteries are very important for both grid and transportation. But as I said, with those data, for example from California, batteries do not make a system with reliability and resilience if we have a large dependence on wind and solar.

Now, an example of storage, it is often not thought of as storage, but, for example, big innovation required, but if we had a system with a large dependence on hydrogen, clean hydrogen, hydrogen could serve all of those sectors and could be a storage medium, for example. So we have got to think of storage in a different way for time scales, even up to seasonal.

One of my slides, and I am sure everyone can read every one as they went through, does have a list of some innovation areas. Advanced nuclear reactors was another one. But things like hydrogen advanced manufacturing technologies very important. We are only scratching the surface on the integration of what we call platform technologies, big data, AI, additive manufacturing, et cetera, into the energy system. And particularly for the urban environments that will be important in new services.

And I will just end by reinforcing again the issue of large-scale carbon management, including this carbon dioxide removal agenda. I only gave a couple of examples going through it, but in our report we have 27 different portfolio elements that we are just not making progress on. And that is a game changer. If we can make this a significant carbon management approach, let us say atmospheric carbon dioxide removal, it just changes the whole game for getting to very, very low carbon.

So we will supply a longer list, but that is a good example, I think.

Mr. KEEFE. Congressman, I appreciate the question. If I may, I would add building efficiency into that. That is a simple one. Right now buildings emit about 34 percent of the greenhouse gas emissions in this country. DOE funding for research and development is around 10 percent for building efficiency. And this can be simple stuff, it can be more complex stuff. There is a company in California, for instance, called Carbon Lighthouse, that uses sensors and other equipment to essentially monitor a building real-time, like you would monitor a patient in a hospital, if you will. And can adjust the energy usage in that building real-time using that system.

Another area, and to build on the Secretary’s idea, I think, a little bit is pumped hydro. I was in Montana a couple of months ago and met with a company that is putting up a pump hydro project in connection with a giant wind farm. I can’t begin to explain to you how it works, but it is a great storage system.

Mr. MONIZ. It is called gravity.

Mr. KEEFE. It is called gravity. But it is in addition to the storage that we typically think of as batteries.

Mr. MONIZ. May I just add as a factoid because maybe it is worth putting in context, follows on what was just said, that this issue

of multiple sectors, we love to talk about decarbonizing electricity, and that is very important, but electricity emissions in the United States are about 27 percent. We got to keep our eye on the 73 percent as well, so transportation and not just autos, class A trucks, air travel, et cetera; very high heat requirements for industry; the building sector. Can we electrify that entire sector, et cetera? Agriculture, very, very tough. So those are areas I think where we need a lot more focus. Thank you.

Ms. KAPTUR. I just have to say this is such an exciting panel.

Congressman Calvert, who knows a whole lot about this, not just in his capacity serving on this Subcommittee, but obviously on Interior and his excellent work on Defense.

Mr. CALVERT. Translation, I have been here a long time. Thank you.

Speaking of transportation sector emissions, and I agree that that is the most profound change we need to make, but thanks to advancements in it, in efficiency and the shale gas revolution, emissions from the electric power sector have declined significantly since the early 2000s.

For the first time, emissions from transportation have eclipsed emissions from the electric power sector. In my previous role as chairman of the Interior Subcommittee, I focused heavily on ways to reduce emissions from transportation through programs like diesel emissions reduction and target air-shared grants.

As noted in several witness testimonies, the path to decarbonization in the transportation sector, especially freight and maritime transportation, is less clear than for power generation or light-duty vehicles.

Mr. Powell, how would a 100 percent renewable strategy impact efforts to reduce emissions in hard-to-abate sectors like transportation and industry?

Mr. POWELL. Well, first, let me thank you for your long leadership on this very important topic, both here on this committee and in Interior for your cosponsorship of the BEST Act, which takes on this broader storage question. And to build on the Secretary's point, goes well beyond just batteries and thinks about storage across many different time horizons, including day to day, week to week, month to month, right, 24/7, 365 storage. So thank you for your leadership in all that.

I think it is fair to say that, you know, a renewable's only strategy in the power sector would do very little to take on some of these much tougher challenges, especially in heavy transportation.

First, and to build on the Secretary's point, when we are thinking about storage, that is true not just in the power sector, but also in the transportation sector, we have got to remember it is not just about batteries and transportation either. So electric vehicles appear to be making great strides for light-duty passenger vehicles, but it is very difficult to imagine electric vehicles for heavy-duty freight, for trains, for aviation, for the I believe 20 percent of global emissions which comes from the global shipping fleet.

We are going to have to be thinking about an entirely new set of either extremely energy-dense liquid fuels, like some combination of hydrogen or renewable fuels and biodiesel, or, you know,

methanol or ammonia. There are lots of different approaches for that.

In the heavy shipping space there may even be a role for advanced small nuclear reactors to power heavy shipping in the same way that it powers so much of the carrier and the submarine fleet. And there are companies actively working on that in shipyards around the world, thinking about whether that could be an option.

So we are going to need a whole suite of technologies to take on that challenge, maybe even more so than in power. And I couldn't agree more that trying to think about that as a renewables only approach is just the wrong place to start.

Mr. CALVERT. And we need to get DOE to focus on innovation to reduce emissions, especially as it relates to transportation and trucks.

And I know there are a number of technologies on the horizon with the potential to transform this, and a lot of those companies are in California. I know Elon Musk wants to do this electric truck; he mentioned it is not quite there yet because of the heavy grades. You know, let's face it, diesel is a very efficient fuel. So if there is a way to clean that up and make it more effective, that would certainly, in the short term, have a lot of effect.

Speaking of going down the path of moving too soon on unproven technologies, Germany spent the equivalent of \$222 billion in renewable energy subsidies and their emissions are basically stuck at 2009 levels, so it didn't succeed. They spent all that money, all that effort, and it didn't work.

So what did we learn from this example of Germany's energy policy? I think the whole panel can answer that.

Mr. MONIZ. Well, first of all, we have always advocated, and when I was Secretary strongly advocated, what we call the all-of-the-above approach. Germany chose not to follow that direction. And I think that is a major part of the issue there.

Indeed, as you well know, to make up for the loss, particularly of their nuclear capacity, they have actually introduced additional coal capacity. So I think to me the answer is we need to look broadly at this whole set of options, all of the above. And that will allow regional choices to be made that are fit for purpose.

If I may just make one comment back to your first question on transportation. And if one studies that figure on the California pathways, it is in there. For one thing, first of all, this may sound shocking, but emissions in California are 39 percent transportation. So if you are Willy Sutton, you know where you want to look for the carbon reductions. And one big piece is efficiency, vehicle efficiency, where there is a long way to go yet. Another big piece is electrification, as much as one can. And I would say, by the way, light-duty vehicles may be up to Class 6, actually a lot of progress is being made. Class 8 is a tougher nut to crack there.

But the piece which we often forget about and is essential for California, and I think much more broadly, is the focus on low-carbon liquid fuels. And that is something that needs really a bigger kick-start.

For example, there has been a lot of work being done in terms of drop-in biofuels. It has not made a lot of progress in the kinds

of cost reduction that we would need. So there is another example of a game-changing innovation if we can crack that nut.

Mr. CALVERT. We spent a lot of money in California and when I left California last week, I paid \$4.25 a gallon for regular gasoline line.

Mr. SIMPSON. That is why you are all coming to Idaho.

Mr. CALVERT. Yeah.

Mr. MONIZ. Which is why efficiency would be very good.

Mr. CALVERT. Yes, efficiency would be very good or at least where we can get our price of gasoline down.

But if you do buy an electric vehicle in California you only pay \$100 a year registration fee versus paying 4.25 for a gallon of gasoline line. Thank you.

Ms. KAPTUR. Thank you. I wanted to just put a comment on the record. I can remember when Senator Lugar from the state that adjoins Ohio to the west was here. And he said "So the 20th century was all about the hydrocarbon molecule. We are now moving into the 21st and it's going to be all about unwinding the carbohydrate molecule." That was a good way to explain it to the public; we are at the very dawn of that age.

So when you talk about drop-in fuels, for example, I completely agree that the Department of Agriculture has to be an essential element in any future, along with the finest scientists that we have and all the labs across the country. Because we don't really understand, even in terms of plants, what produces the most BTUs, usable BTUs, for BTU input into the soil. And so we have a ways to go there.

I am not going to ask a question at this point because I am going to turn to Congresswoman Frankel, who is such a faithful attendee at all of these meetings. Thank you so much for being here.

Ms. FRANKEL. Thank you, Madam Chair. I am listening to all this and I am optimistic and I am pessimistic. I am not sure how to feel about this whole thing.

But thank you all for being here. I was a mayor, also; I appreciate the mayor being here.

So my first question is what, if anything, do any of you think is the effect of our leaving the Paris Agreement?

Mr. MONIZ. Well, I think it is a mixed issue. First of all, the impact, to date at least, has been somewhat mitigated by the stepping up to the plate of mayors, governors, and business executives. And let me just focus on the business executives as an example. Thousands, literally, have more or less said we are still in because they are responsible for making decisions with long-term implications, long-term capital outlays, for example. And they can see quite clearly, we are going to a low-carbon economy. So that has really helped.

State leadership, of course, has been very important. But where the withdrawal from Paris certainly comes in, and I won't even go into the broader issues of, frankly, reliability of the United States in a whole variety of agreements, but just in the climate area, American leadership, as in so many other areas, is absolutely essential. It is not being provided, and the withdrawal from the Paris Agreement, of course, is the most obvious indictor of that.

Ms. FRANKEL. Anybody else want to comment?

Ms. LYLES. Well, as mayor I would like to say thank you for the recognition. In Charlotte, when that happened, it just heightened our awareness and our need to move more aggressively towards our own plan. And it is something that our citizens wanted us to do. And that is why the impact of it is likely to be something that we won't deal with, but I want to say the impact of withdrawal made it actually more imperative at the local level for us to begin to do this work.

Ms. FRANKEL. Thank you for that. So if anybody knows, what actions is our Department of Energy taking in this area of climate change? Yes, sir.

Mr. POWELL. Well, first, thank you for the question and your attention to these issues. Let me first say that I think the broad swath of what is happening at the Department of Energy is actually largely continued apace from the previous administration. So all of these programs working on deep decarbonizing technologies have, you know, proceeded. And as I mentioned earlier, new programs are being launched on things like grid scale energy storage, advanced nuclear gas for carbon capture.

And then in the international space this Department has not only reinvigorated—well, it has after a year or two recommitted to U.S. participation in the Clean Energy Ministerial. So if you think of the UNCCC as sort of the international body that focuses on the problem, the Clean Energy Ministerial is what focuses on the solution.

And this administration has argued for the launch of two new programs. Actually I think one was launched under Secretary Moniz and has sort of really just gotten started, which is a focus on carbon capture at the Clean Energy Ministerial. And then this administration has launched an advanced nuclear focus at the Clean Energy Ministerial as well. So there is continuing cooperation on deployment of clean energy technologies coming out of this Department.

Ms. FRANKEL. That is very good to know.

Mr. MONIZ. If I could add.

Ms. FRANKEL. Sorry, go ahead.

Mr. MONIZ. Oh, I am sorry. May I add to that?

Ms. FRANKEL. Yes, please, of course.

Mr. MONIZ. I mean, I agree with what Mr. Powell has said. Although on the international front I do want to emphasize the mission innovation initiative started wherein there is the CCS, but there are other things that need to be followed up on. For example, Mexico took the initiative to host, along with the United States and Canada, a very interesting project looking at advanced materials production in a novel way. So that is going on.

However, I have to say that there are other areas where we need to see perhaps the new Secretary, if he is confirmed, pick up the pace and pick up the ball. For example, in the previous administration the energy efficiency standards that would put forth in an accelerated way are a really big deal. The standards put forward just then are projected to 2030 to account for 30 gigatons of carbon emissions reduction, and over a half a trillion dollars of reduced consumer bills from the more efficient appliances as they come in, up to 2030. Unfortunately, that program is just not going at, shall

we say, anything like the same pace. So, there are—so, on the one hand, many of the innovation areas, as Rich said, are moving forward, but other areas really need some attention.

Ms. FRANKEL. Well, like, what about the cars in California, that issue?

Mr. MONIZ. Well, and in our study, frankly, the biggest single impact that we found for California meeting its 2030 targets would be the existing cafe standards for efficiency, especially of the light-duty fleet, because the reality is, again, data matters. Today, California has about 30 million light-duty vehicles. In 2030, we gave them credit for reaching their goal of 5 million light-duty EVs on the road. However, the projection for the number of light-duty vehicles in 2030 is 35 million. So, it is the same 30 million internal combustion engine vehicles, which is why the efficiency gains would be so important. That is a very, very critical issue in terms of their capacity to meet their goals.

Ms. FRANKEL. Thank you, Madam Chair.

Ms. KAPTUR. Thank you. Congressman Newhouse.

Mr. NEWHOUSE. Thank you, Madam Chair, and, like you, I am finding this discussion quite interesting. So, thank you all for being here. Madam Mayor, pleasure to have you here. Good to see you again, Mr. Secretary. I am glad to see you are doing well, and welcome to our other two panelists for being here this morning. It truly is an important discussion, and fraught with—it brings up a lot of good ideas.

I had the privilege of going to Houston, Texas, and seeing, I think, the largest CO₂ sequestration project in the world, which really I suggest all of you go to see that. It is really a fascinating—it just opens your eyes to all kinds of possibilities.

And then, being a farmer, I cannot let the agricultural industry take all the brunt for all of our issues. I think we are part of the solution. There is a lot of opportunities in the agricultural industry, as well. So, I am looking forward to working with you guys on that.

But, certainly, as we discuss the role of the Department of Energy in addressing climate change, I think, humbly, I would say that any serious discussion has to include nuclear power. And Mr. Pocan has left. He referenced the Green New Deal. Unfortunately, that does not even mention nuclear power, but coming from my part of the world, it is certainly a big part of the way of moving forward.

Mr. Powell, your testimony, which I was particularly interested in hearing, and I have just got two questions I will ask real quickly, and let you take off. But you highlight the Advanced Reactor Demonstration Program, and the need to ensure the near-term deployment of advanced reactor designs, and I would agree with that.

In Central Washington, in my district, which Mr. Moniz—Dr. Moniz, you have been to, it—many times, yeah. In Tri-Cities, it is a nuclear hub, it truly is. We have got a long history of innovation rooted in the Hanford site. We have got the only nuclear plant in that nine-state area, the Columbia Generating Station. We have got a flourishing and diverse set of nuclear companies and startups building off the work of the scientific and energy pillars, such as the Pacific Northwest National Laboratory, which we are all proud

of, but those include Framatome, as well as New Scale, and many, many others.

So, in many ways, I think the Tri-Cities is the ideal site for a small nuclear reactor unit. So, you piqued my attention when you brought that up. And so, the question is, keeping with the theme of today, does the Department of Energy have the tools and the authority that it truly needs to assist reactors that are approaching commercialization? And, if not, what can we do to support those efforts?

And then, if I could just switch gears and keep that thought, I also appreciate you highlighting the grid storage launch pad at PNNL, which is, again, is in my district, in your testimony. We are excited to see the lab, and really the Tri-Cities play a leading role in this, which brought up, several times, this crucial technology in helping to address climate and energy challenges. This grid storage is one of those huge challenges we face.

So, as you talked about the importance of U.S. leadership in the terms of economic opportunity for the country, could you expand on both how this effort can accelerate commercialization of grid scales, technologies, as well as what the Federal investments like the launch pad mean to local economies, such as the Tri-Cities? So, thank you.

Mr. POWELL. Well, first, thank you for your leadership on this. PNNL and the Tri-Cities are one of the real jewels in the American innovation system.

Mr. NEWHOUSE. That is my line. I use that all the time.

Mr. POWELL. Well, I will echo your line, and the wine is not bad right there at the river, either.

Mr. NEWHOUSE. Well, thank you for that. Okay.

Mr. POWELL. So, first and foremost, on demonstrating advanced reactors in your region, I just last week actually had the privilege of sitting down with the CEO of Energy Northwest, who, as you know, runs the Columbia Generating Station in your neck of the woods, who is going to run the New Scale first demonstration plant down at the Idaho National Lab, and is very enthusiastic about using the Columbia Generating Station site, which, as folks may recall, was initially conceived of not as a spot to run sort of one big reactor, but actually to run at least five big reactors.

Mr. NEWHOUSE. Right.

Mr. POWELL. And so, there is a huge amount of infrastructure already there in place. And it makes it, in many ways, an ideal place for, you know, perhaps New Scale Unit 2, after the first one demonstrated at INL. Who knows? Perhaps even ahead of the first one demonstrated at INL. So, I think you have got an enthusiastic—

Mr. NEWHOUSE. Don't say that.

Mr. POWELL. Oh, sure. Yep. Well, I think a little friendly competition can be good sometimes, you know, but it really is an ideal site for that. It has a community that is enthusiastic about nuclear energy, in terms of the tools to actually do that and make that happen. Well, I think that the idea of both the launch pad, the NRIC launch pad, at INL will be very helpful in that. The demonstration that is already underway, and the DOE's decision to buy some of the power for that first New Scale reactor sets a really interesting precedent. Right? Both the Hanford site and PNNL, more broadly,

also consume a lot of electricity, and they could be early purchasers to take some of the units from an SMR that could be sited there. And then new ideas, like the NELA proposal that has been floated now, it has been, now, actually passed out of Senate, Energy and Natural Resources, and introduced in the House, as well, would expand those PPA authorities, so that DOE could do 40-year PPAs, which would go a long way to help license those, and it could also, in some cases, for first plants, do them at slightly above market rates. Different committee jurisdiction, I think that would be—end up in OGR here in the House, but I think another really important tool.

And then, lastly, having a demonstration program, such as been proposed in the Senate, Mark, you know, a really aggressive demonstration program, two reactors by 2025, PNNL, Hanford, Columbia Generating Station, something in that region would be at a very good spot to site one of the reactors—

Mr. NEWHOUSE. Right.

Mr. POWELL [continuing]. For that program, and, as you know, there is quite a few nuclear innovators—

Mr. NEWHOUSE. Yes.

Mr. POWELL [continuing]. You know, more broadly, in your state that I think would be, you know, enthusiastic about siting something like that there.

On your second question, on storage, I think, you know, we are thrilled that PNNL will serve as the launch pad for the Advanced Energy Storage Initiative. PNNL, obviously, has this amazing track record, and thinking of storage beyond just traditional lithium ion batteries. You have made, you know, the great breakthroughs in vanadium flow batteries there, for example. But I think, crucially, so many of those technologies that have been innovated at PNNL have struggled actually to survive in the marketplace because we sort of got them right up to early applied research, but then there wasn't a good public-private partnership to bring them the rest of the way and really demonstrate them.

And so, an example of one of the technologies that has come out of that, the UET Company, attempting to commercialize those vanadium flow batteries, struggled to find a marketplace here in the U.S. China is actively watching our innovation engine. They have got no problem with demonstration and applied research and public-private partnerships. And so, they have actually invested in UET, and they are going to be building the first large-scale installations of that in China as opposed to in the United States, which seems, to me, to be a bit of a tragedy when we are thinking about, you know, trying to capture the economic benefits for these technologies here, and then for us to be the ones selling it to the rest of the world as opposed to China being the ones to leverage our R&D and sell it to the rest of the world.

Mr. MONIZ. May I add a—Madam Chair?

Ms. KAPTUR. Yes.

Mr. MONIZ. I have got two points. One is going back to the nuclear issue. I want to, first of all, endorse what Rich said, in particular about having multiple tools, including purchase power agreements and purchase power agreements with greater authority is very important, but I want to up the ante.

So, the word “aggressive” was used with regard to the Senate Bill of two reactors by 2025. And from where we are today, perhaps the word “aggressive” is appropriate. The reality, however, is that I believe that the value proposition, the cost proposition, for small modular reactors needs more. It doesn’t need just one or two deployed. It needs enough to have an order book where the investment in tooling and production line investment can be made. So, whether that is 5 or 10, we can argue, but I think we need to think bigger in terms of getting out there, so that the manufacturability can be understood and the learning curve of manufacturing can be brought into play, the stable workforce.

Right now, for example, with the reactors being built in Georgia, the large reactors in Georgia, which are almost a factor of too over-budget, well, you try getting 7,000, 8,000 craftworkers, for a 7-year project in rural Georgia. So, we need to think in that system view what does it mean to really have an industry built?

Secondly, if you will allow me, twice I have heard the words “Green New Deal” mentioned. I would just like to point out, number one, we should not confuse the words put out for Green New Deal with some of the statements made peripherally about what it might mean. In particular, for the energy and climate agenda, so, I am not talking—there are many, many agendas in there, but on this agenda item, what we say—there seem to be only two things that are said. One, we should go to low carbon; and two, in going to low carbon, we should have social justice concerns in the foreground. I agree with that completely.

Now, the question is what is an actual implementable program that respects those principles and moves forward? That is what we called the Green Real Deal that was in my first slide. So, that is our way of saying, look, here is how you build a program that respects those two principles, and let us move on with it.

Ms. KAPTUR. Thank you. Congresswoman Kirkpatrick.

Mrs. KIRKPATRICK. Thank you, Madam Secretary. First of all, thank you for having this very important hearing. I have been saying for about 25 years we should have a national energy strategy to convert over to renewables. I, now, after coming back from China, think that there has to be an international strategy along with that, because this really is an international problem.

And, you know, it was interesting and disappointing when I was in China to hear from their leaders that they don’t feel like our country is taking the lead in infrastructure and renewables, and they see themselves as more taking the lead in that.

And so, my question is—I have got a couple questions, but my first question is for you, Mr. Secretary. Are you aware of any work right now in developing a national and international energy strategy to convert to renewables?

Mr. MONIZ. Well, first of all, I would say the innovation strategy as we have been discussing it today is certainly part of that comprehensive strategy, but it is also—it is necessary, but not sufficient. And there, I think, is where we need to complement the innovation agenda with various policies.

For example, some form of carbon pricing would make enormous difference; whether it is direct or indirect, one can discuss. And, for example, actually maybe it is worth mentioning the well known

Baker-Shultz proposal, which is a carbon price of around \$40 to start per ton emitted with the proceeds, the collections not staying with the government, but going back as a uniform dividend to the population. I mention that because that combination actually addresses those principles of low carbon and social equity because the dividend approach favors those with—lower on the income distribution. So, that is an example.

However, if you want a comprehensive strategy, you really need to go to their next statement. It is with a carbon price, what do we then eliminate in terms of certain regulations and incentives? And there I say, okay, now it is time to have the real discussion because \$40, for example, would be a technology shifting price for the electricity sector, but probably not for the transportation or industrial sectors. So, we will still need to complement carbon prices in that level with a discussion with the Congress about the statutory basis for other policies and regulations. And on that, I have to say, frankly, that discussion has not really begun and needs to.

Mrs. KIRKPATRICK. And that is disappointing. You know, it is an existential threat, internationally and nationally. The Department of Defense says it identified it as our top security problem, and yet, here we sit with not much really, really happening.

I think we have got a real opportunity in my district to work across the border with Mexico because we share that border, and if they are not starting to use innovation and renewables, for my district it does not matter. The air doesn't follow borders. You know, it just comes over, so we are seeing all of the effects of that.

Yeah, Mr. Powell, can you address that?

Mr. POWELL. Sure. Just generally, I think we spend far too little time thinking about all of the energy development in other countries, which are, at this point, the vast majority of the emissions, and all of the tools that are actually at our disposal. Right? So, in the last Congress, the BUILD Act, a big, broad, bipartisan bill, right, which converted OPIC, the Overseas Private Investment Corporation, to the New International Development Finance Corporation, that authorizes \$60 billion in authorities, much of which could be used to, you know, do smart either lending or equity investments—

Mrs. KIRKPATRICK. Right.

Mr. POWELL [continuing]. And clean energy development, right, around the rest of the world. Also, we have got to address the problem in OPIC, which is that it uses the World Bank's restriction on financing new nuclear plants in much of the rest of the world. That might be a really viable, clean, zero-emission new source that we should be building. We should be fixing that at World Bank. We should be making sure that that is part of the IDFC portfolio, and I think that Axiom could play a significant role in that, as well.

Mrs. KIRKPATRICK. I—

Mr. MONIZ. Can I supplement that?

Mrs. KIRKPATRICK. Yes, go ahead. Go ahead.

Mr. MONIZ. To build on that, what Rich said, because I know how—and I certainly agree with it, but I also, going back to your statement about, for example, the Department of Defense concerns about this, we are not taking an integrated view not only about, let us say, energy innovation and energy policy, but national secu-

rity policy, foreign policy. For example, we like to complain and wring our hands about China's Belt and Road Initiative, which includes, especially in Southeast Asia, the construction of lots and lots of coal plants. Well, instead of wringing our hands, why don't we just compete? Which is what Rich is saying. And it could be nuclear, it could be renewables, it could be natural gas, which is certainly better than coal. So, but we can't compete without those kinds of mechanisms in place.

So, obviously, this committee has a particular jurisdiction, but as members of Congress, more broadly, I think integrating those issues is absolutely essential.

Mrs. KIRKPATRICK. I couldn't agree more. You know, we have a nuclear power plant in Arizona. The utility would like to expand it, but they have run into so much public resistance, people are still afraid of nuclear. And so, so much of this policy has to be educating people about how important this is and how we can do it right now.

Mr. MONIZ. And, by the way, many of the new plants that are being designed really have extraordinary safety features.

Mrs. KIRKPATRICK. I think the—yes, go ahead.

Mr. KEEFE. Congresswoman—

Mrs. KIRKPATRICK. Yeah.

Mr. KEEFE [continuing]. If I may, to your original question about an international strategy, frankly, I think we did have the foundation of an international strategy in the Paris Agreement.

And to Congresswoman Frankel's point, the good news is we are not out of it yet. And thanks to the leadership here in Congress and the resolution you all passed earlier this year in the House, we have shown the world that we are still committed to that. We just need to figure out how to stay in that. And that, I think, is a good foundation for the type of international strategy that you are talking about.

Mrs. KIRKPATRICK. Thank you for that comment. I couldn't agree more. I think we can still move ahead in a very meaningful way. And, like I said, time is of the essence. So, I yield back.

Ms. KAPTUR. Thank you, Congresswoman Kirkpatrick. And now, Congressman Kilmer.

Mr. KILMER. Thank you, Madam Chair, and thank you for holding a hearing on what I think is one of the most important topics that we will cover. I wanted to start with a question for Mr. Keefe.

I chair the New Democrat Coalition. We, earlier this year, put out a set of principles that were focused on really providing a roadmap for big, bold, ambitious action to meet the scientifically mandated goal of an economy-wide net zero greenhouse gas emissions by 2050 at the latest. And I want to recognize the valuable role of the research and policy work that you all have done in helping to shape that.

One of the core ideas that we have focused on is workers and how do we make sure that they have the skills that they need to succeed in a cleaner energy economy? And I know that E2 put out a clean jobs report. And I highlighted that two-thirds of the current jobs in the U.S. clean energy industry are in construction and manufacturing and are largely the same skill sets as other traditional construction and manufacturing sectors.

But we have a sense that not all jobs in the clean energy economy can be filled with existing skill sets. So, I want to get a sense from you of where do you see opportunities for the existing skilled workforce to transition into clean energy jobs? Where do you see need for potential rescaling or upscaling of existing workers? And give us a little guidance from a public policy standpoint. What should the Federal Government be doing both for current workers and for that future workforce to make sure that they can succeed in a clean energy economy?

Mr. KEEFE. Thank you for the question, Congressman. First of all, I will say the good news is that clean energy jobs run the spectrum. They run from the Secretary of the Department of Energy to the folks that are putting insulation in your attic, right, and it is a wide variety of skill sets, which means that it is—these jobs are available to people of all stripes and in all states across the country.

As part of our work tracking clean energy jobs and the work that EFI and NASEO has done with the user report, I think we surveyed something like 35,000 businesses across the country, not just in clean energy, but in things like electricians and roofing companies and appliance makers and things like that which also work in energy efficiency fields, for instance. And what we found over and over again is that these employers are saying the biggest problem that they have is hiring enough employees.

If you talk to people in the wind industry, our friend, Mr. Rucker, Michael Rucker, one of our members out in Colorado, he can't hire enough people because they are not scaled up enough. If you look in the solar industry, particularly in certain states, the availability of solar workers is just not there.

I think that one solution to that is investment, obviously, in training, and one good place to do that is in community colleges around the country. We are starting to see community colleges and other secondary education institutions start to realize the opportunities here, but they are slow to move. And I do not know what it was like when you were in high school, but we were still learning how to fix lawnmowers. Well, maybe we should be teaching kids how to fix solar panels now instead.

Mr. KILMER. Thank you, thanks.

Mr. MONIZ. May I just add to that? I certainly agree on the training and the community colleges aspect and at DOE, we did quite a bit of that. But I would like to also say that we should really think hard about the role of organized labor here. Organized labor knows how to train people to do their jobs. So, I think a combination of creating the job opportunities and working with organized labor can also be a very, very effective way to fill those needs.

Mr. KILMER. Thank you. And, Mr. Secretary, I wanted to direct a question your way as well. So, I am proud, like Mr. Newhouse, to have a Pacific Northwest National Lab in my district. They support the DOE's only marine lab in my district. And I am excited to see that the DOE is investing in some of these initiatives, like the HydroNEXT and the Wave Energy Prize competition, to really tries to catalyze some of the development in this next generation of marine energy technologies.

There is considerable interest from the DOE and from private industry and growing investment in marine energy sources: renewables, marine hydrokinetic energy, biofuels from algae. There is increased public and agency recognition of the critical value that our oceans play to combat climate change.

And so, with that in mind, I want to get a sense from you of what opportunities do you see for the DOE to increase funding for ocean-based fundamental research and technology development?

Mr. MONIZ. Well, first of all, I would say you have put your finger on a lot of what is being done at, frankly, too low a level today, so I think amplifying that is very important. So, there are the technical solutions like hydrokinetic, et cetera, which still have a long way to go in terms of cost effectiveness.

I would like to, however, also note that you mentioned algae, for example. And in our carbon dioxide removal report, we note that there are major opportunities for coastal carbon dioxide removal. A lot of that involves plants in one way or another, organisms. And so, I think perhaps with NOAA, really picking up on those coastal opportunities, kind of green water stuff, would be a really good place to increase the focus.

Mr. KILMER. Thank you.

Mr. MONIZ. And also, I should mention, and earlier the chair mentioned USDA, which clearly is a big player. But I will note that Department of Energy through its national lab systems has enormous capabilities in terms of plant genomics, for example, and in terms of things like computational chemistry where PNNL was actually a leader. And so, I think one needs to have a big view and bring the system together.

I would also like to say that I sure would like to see more people west of the Cascades know about PNNL.

Mr. KILMER. Yeah, no doubt. Well, I mean, it is a gem. In Sequim, Washington, it is not just doing important research, but providing really important jobs, so thank you. And I yield back.

Ms. KAPTUR. Thank you very much. About 15 years ago, when I was Ranking Member on Agriculture, Senator Tom Harkin was over in the Senate and we cooperated on an amendment in an appropriations bill to try to spawn a biofuels industry out of the Department of Agriculture. And it was the most interesting experience because, at that time, agriculture was known for food. They had the tree Fs: food, fiber and forestry. So, we wanted to give them a fourth leg on the stool, fuel. You cannot imagine the resistance.

And so, today, if you look at the biodiesel industry, if you look at the ethanol industry, now you couldn't take it away from them. But the research in terms of the types of plants, the plant science that we must know in order to be the most efficient at yielding the highest number of BTUs for the number we invest in trying to get the plant to grow, still doesn't exist in the highest science that it should.

But I wanted to put that on the record because the district that I represent sent the first fighter craft into the air using biodiesel and it didn't crash. And as we think about, you know, new fuels, I think Agriculture has a massive role to play in this. And I have heard what you said, Mr. Secretary, about the Department of En-

ergy laboratories. But you would have to be God to get the Department of Agriculture and the Department of Energy to cooperate.

Barbara Lee and I have been trying for well over a decade now to try to get them to invent, work together, impossible, to invent a type of climate-controlled, affordable greenhouse that is energy efficient, so we could roll it into poor neighborhoods across the world. They cannot do it, yet.

But it is just so hard to get these scientists to cooperate across departmental lines, I have found. I just put that out there as a real experience and one where we see the marketplace moving in the direction of new fuels, and we should be able to get it there faster. There is a biodiesel industry, there is an ethanol industry, but our science is still—we are still at gate 1. We are not even at first base. We are not even, in terms of where we are on those carbohydrate-based fuels, but we just cannot move there fast enough.

So, if you could provide me with ideas of how to do more along those lines, I really do think the world would benefit.

Looking at the materials that you have provided for the record, which are extensive and we are very grateful, I think one of the problems with the Department of Energy is that it is extremely right-brained and the ability to communicate to the general public is a stretch. Everyone in this room is an exception. This is something you really understand, this is something you really care about.

But if I look over at NASA, they have managed to get the public to imagine about a Moon/Mars landing. We have the first women walking in space. We have Artemis, we have a name.

I know that we have the Green Real Deal, I heard what you said this morning. But I think maybe working with Mayor Lyles, seems like we don't have clear goals that the American people can feel, in this community, we have to plant 100,000 trees. Here at this research lab we do this.

I think to take additional steps, there needs to be some kind of industrywide goal setting that the every Scout troop can adopt. I think it is hard for the public to, other than purchasing an energy-efficient vehicle, to participate and I think they want to.

So, I am asking for the record if you could give us some suggestions on how to begin to do a better job of setting goals that the public—we had talked about SunShot, I remember, Mr. Secretary, when you were such an able Secretary of Energy. And I thought, that is a name. I take it you want to comment on that. I did not think you could answer the question fast enough. But I do think somehow we have to get these brilliant people to communicate, as Congressman Simpson and Congresswoman Frankel do so well, with ordinary people so they can gravitate to the goal.

Mr. MONIZ. If I may comment and you mentioned SunShot, I would just say we have other—we had other catchy phrases like in the energy efficiency program, "The Fridge to the 21st Century" back in the Clinton years, et cetera. We had, "A mine is a terrible thing to waste." But anyway, we could on with that.

But more seriously, you mentioned NASA and the job it does in terms of kind of public education, et cetera, versus the Department of Energy. There actually is something that could, in principle, be done. The mission of educating the public is part of NASA's found-

ing act. Doing that at the Department of Energy is not part of its authorized set of activities. And I cannot tell you how gingerly we would have to approach some of these programs in terms of education, et cetera.

So, one could assign, I think, there are some staff here in the room, to do maybe like a comparative analysis of what the authorities are on those two cases and see how one might go forward there. So, that might be a concrete suggestion. And we also did some other things, but they are piecemeal because there is not that kind of authority.

For example, here is something that probably nobody knows. That the Department of Energy, and I don't know if it is active, to be honest, today, but it was when I was there because I waved the green flag at a NASCAR race. We have, DOE has an MOU with NASCAR which led to all NASCAR—in all NASCAR races, they require 15 percent ethanol in the fuel. And that has been now in place for quite a few years. But again, they are piecemeal as opposed to something integrated and the ranking member could help us overcome some of those barriers.

Ms. KAPTUR. I thank you very much for those suggestions. And if anyone else wants to think about those and provide replies to the record, we would be most welcome. Mr. Powell.

Mr. POWELL. I would just add, I think that the idea of goal setting is just music to our ears. You know, if you go around the national laboratory complex, again, a remarkable set of facilities, at every one you hear a lot about capabilities. We can do anything here. Too often you do not hear about, well, this is specifically what we are working on producing. And I think for many folks, having those clear goals makes it so much easier to justify, okay, we are putting dollars in because we are going to get this specific thing. We are going to get two nuclear reactors or, you know, three grid scale storage facilities at a particular price point on a particular timeline.

And I think establishing those, I realize that none of these are sexy, like landing on Mars or the Artemis program, but at least they are a step in the right direction of having clarity which can then be shared with everyone working in the Department, with all of the labs. It sort of forces collaboration across the labs, et cetera. I think it is a really good step.

Ms. KAPTUR. I wanted to thank you very much for that. And I wanted to move to hydrogen just for a moment. I had a fascinating discussion with one of our Japanese diplomats recently. And I said, I come from a huge automotive and truck platform production region, probably the largest one in the country, okay? I said, hydrogen. I have a dear brother, my only sibling, he is brilliant on mechanics. He told me long ago, Marcy, hydrogen. Hydrogen is where it is headed, we have just got to get there.

I said to this Japanese diplomat and we have eaten our lunch in the automotive industry for a long time, what about hydrogen in Japan? Which company? I probably should not say it for the record, but the gentleman picked one of the companies in Japan and said that is the one that has the lead. But then he went, but we are not really in the lead. China is on hydrogen and motor vehicles.

So, my question is if we are not in the lead and even if Japan is not in the lead now, how do we catch up and surpass in terms of hydrogen and vehicular transportation?

Mr. MONIZ. I will say a couple things. And, by the way, just to add to the story, I would say that Europe is doing a lot more also in an organized way to develop a hydrogen economy than are we, and in addition to Japan and China's work. I would just say that, and I mentioned hydrogen earlier, I think that what we should be looking at and dramatically increasing our level of effort is hydrogen not just for transportation, but as an economy-wide opportunity.

Sometimes I would refer to hydrogen as carbonless natural gas by which I mean that natural gas today is a fuel that is used really economy-wide. It has got so many flexible uses and hydrogen can be that in a very, very low-carbon world. And I think that is where we should be looking.

Hydrogen applications especially, and I think Rich mentioned earlier, for the heavier transportation fleet, for example, for industry, for process heat, for all kinds of applications. So, I think we need a really broad-based big program on hydrogen. I think it has got enormous potential.

Ms. KAPTUR. Which of the labs has that mandate?

Mr. MONIZ. I do not—to my knowledge, maybe others can correct me, but to my knowledge, there is no specific mandate at any laboratory, and that is an example of what is needed, yeah.

Ms. KAPTUR. That is really very interesting.

Ms. LYLES. Madam Chair, can I just emphasize there?

Ms. KAPTUR. Please do.

Ms. LYLES. We have a small group in Morrisville, North Carolina, close to where the race tracks are. But they have been working on hydrogen for a while and they do all of their work abroad because they have not been able to get traction here in the States. So, I think that it is this idea of getting the ability to know that there is a goal, stating a goal, and then stating an accountability for it. Then those folks would have an easier path than just saying, I have got an idea and they are shopping it across the world now, not just in the States.

So, I really like the idea of Mr. Powell's, you know, focus on a goal and on accountability and have people that are really trying to innovate and do things differently know where they can go, at least to get the audience. It doesn't mean that they have the right method right now, but if we miss out on that opportunity when that right method comes, it is a real loss for our country.

Mr. MONIZ. Can I also just add one point? Sorry, let me just add another point on how broad this challenge is. Because, clearly, for hydrogen economy infrastructure is a really, really big deal. But if you go to Japan, for example, one should not think that in their heads is just the idea that in a hydrogen economy you would be sending it around by pipes. It is a possibility, but I know they are working very heavily also on the idea that you move the hydrogen in a liquid so to make it much easier, and then you release it kind of at the endpoint, et cetera. And if we don't develop the optionality we can get locked in to the wrong direction. So that is why we need

to have a really broad comprehensive program and then, and I agree with the goals, to start getting it out there.

Another thing I will just say is that often in terms of producing hydrogen one thinks—many people think just of electrolysis of water and with innovation, reducing the costs of electrolysis, getting a lot of really low-cost carbon free electricity and heat. Maybe that is going to be absolutely the future. But we shouldn't forget, at least in the transitional mode, today the cheapest way to make hydrogen, of course, is steam reforming of natural gas or methane, and you could add to that carbon capture and sequestration and have low-carbon hydrogen. And in different parts of the country, because of their geography and geology, they might take different solutions to make hydrogen.

So all of these questions remain out there and not really being addressed.

Ms. KAPTUR. Thank you. Ranking Member Simpson.

Mr. SIMPSON. Thank you. When I first got on this committee I read a book called The Hydrogen Economy. And so that has been 16 years ago or 17 years ago. And I was talking to my uncle, who was a research guy out at the Idaho National Laboratory years ago, long since retired. And he said, you know, we worked on that in the 1950s and 1960s. The problem was that we were looking at it for transportation, for automobiles and stuff. The materials for a container were so heavy for hydrogen that it just didn't make sense. He said if you really want to put hydrogen to work, what we got to do is reform the rail industry; mostly runs on diesel now. He said because they can carry their own containers, all that kind of stuff.

I am going to talk for just a minute if that is okay. I agree, we need a transportation system and it is going to be challenging as we are getting more and more fuel-efficient automobiles, as we are getting more and more electric vehicles on the road. How are we going to pay for our transportation system? That is an issue that we are going to have to deal with in Congress, a different way of raising the revenue for our transportation system. And I don't have the answer to that, but it is certainly going to be a challenge for all of us, so I appreciate what you are doing.

But I have been impressed that local communities and states and private companies are actually the ones taking the lead in a lot of these things. Your community, Boise, Idaho, has decided by I think it is 2040 or something like that they are going to be a completely green community or green energy. Idaho Power has said by 2045 they are going to be, you know—and they are mostly hydropower now, but they also have coal-fired plants. They are going to get rid of the coal-fired plants by 2045. That doesn't mean they are not going to do anything until 2045. They are going to be moving in that direction and have it completed by 2045.

But it is really the private sector and local communities and states that are making the main changes that are driving a lot of the changes that are going on. But all of this is dependent on these changes and the things that you have talked about being cost-effective. Because ultimately, the consumer is not going to go out and say, hey, I am willing to pay another 50 bucks for a gallon of gas. I am making that up, whatever. And you mentioned the new bill

that is out there about putting a \$40 or \$50 carbon tax on and then refunding it to citizens, and that addresses the social justice aspect of it. And I talk to these people quite a bit and, you know, I get a little nervous when we institute another government program that can be manipulated and everything else.

The problem is that that tax goes away as the emissions come down. Start taking away that subsidy you are giving to those people as it comes down and you have got a real problem. So there are some challenges with that aspect of it.

But all of this—and we talk about electric automobiles. I just saw on TV last night at the L.A. car show they have the new Mustang, all electric Mustang. And they were real proud, they are saying, hey, this gets 300 miles before a recharge. That is beautiful if I am driving around D.C. If I am driving across Idaho, I am going to have to stop and recharge it and that might take an hour, 2 hours, whatever. They are working on trying to reduce the charging times at the Idaho National Laboratory. They would like to get them down to where it takes about as long as it does to fill up a car. But there are still no charging stations around Idaho. So where am I going to stop halfway between Boise and Idaho Falls and recharge my automobile? So it is different challenges in different parts of the world.

But what I really need to know, and what I need you all to think about, and these are some really neat things that you are talking about, and I have no doubt that we could implement and mandate a lot of these things that would have significant carbon reductions. But at what cost, and at what consumer adaptability or willingness to accept those costs?

Right now we look at our budget, about \$45 billion, seems like a lot of money; it is. About 20 billion of that is in defense. I know, Secretary Moniz, we had discussions when you were Secretary about whether that ought to be there or not, but about 20 billion in defense. That is 7 billion in the Army Corps of Engineers, about 1½ billion in Bureau of Reclamation, throw in another half-billion in other things. We are down to where the Department of Energy that runs 17 national laboratories, does all the research stuff, ARPA-E, et cetera, et cetera, about \$13 billion.

If we doubled our research and development in this, if we could somehow get the Budget Committee and leadership to go, yeah, you guys need 10 more billion dollars if you are going to do this or whatever, or 5, where would we put it where it would make the difference? That is what I—you know, I am not an energy expert. Where would this committee put it where we could see the results that we would need, that we get over this Death Valley that you talked about where we develop these technologies and it gets to a place where it is not yet ready to go to the private sector or nobody is there to accept it and move it on? And what should our role be in that?

I know that is a broad meaningless question, but if you could address that.

Mr. KEEFE. Excuse me, Congressman, if I may. For one thing, I think it would be smart to look at the way that funds are allocated to DOE generally. We have been talking, yes, it is important to look at nuclear; yes, it is important to look at hydrogen. But it is

also important to make transportation a priority. It is also important to make building efficiency, more broadly, a priority and to fund those types of programs that are going to, frankly, get the most bang out of the buck for a lot of those investments.

The other thing I would consider when thinking about costs is that there are two sides of the ledger. And we started this discussion with the “elephant in the room,” which is climate change. The economic costs of climate change are piling up every single day. It is \$17 billion in damage from Hurricane Florence in my home state of North Carolina. It is 50 to 80 billion in fires in California where I live now. It is 10 and 20 billion of flooding in the Midwest. Those are costs that have to be borne somehow as well. And if we can do something on the investment side through DOE programs in these smart areas that are going to reduce carbon and, by the way, also attract more investment, create more jobs, that is a plus on the other side.

I would also suggest that, and Dr. Moniz is more proficient in this than I am, but if you look at the return on the investment from some of DOE’s programs, he mentioned ARPA-E, which I think has invested about 2 billion over 10 years and returned 3 billion, that is a pretty good return. Created 70, 80 companies and attracted billions of dollars in private investment.

If you look at EERE, as I understand it, EERE has invested \$12 billion between ’76 and 2015. In return it has created \$388 billion in net economic benefits. That is a rate of return of something around 27, 28 percent, which is a pretty darn good rate of return.

So I think we need to look at this as an investment in our future and, frankly, in our present because we need to do this now. And we need to consider the costs that we are confronting on the other side of the ledger as well.

Mr. SIMPSON. I don’t disagree with anything you said. With \$13 billion and all of these different things out there, where do you put it? I mean, everybody wants us to fund every different program that they come, and every company comes in and they got an idea and we need a little funding and so forth, and it just is never ending. And so we have limited resources. Where do we put it?

Mr. POWELL. Yeah. Can I just add? I think this cost filter is how you make those decisions. And remember it is not just the cost of deploying it here in the U.S. You know, the Secretary mentioned the China Belt and Road Initiative. A lot of the coal plants that they are building around the world aren’t even the best coal plants that China has to offer. Right? China has an actually ultra-efficient, super-critical coal fleet. In Pakistan, for example, they are building sub-critical coal right now because it is cheaper. All right.

So the developing world, if your priority is electrifying your population as quickly as possible, they are going to go to the low-cost option.

So for better or for worse, that has got to be the filter for our innovation programs. We have to be looking for each of these major emitting sectors, and, of course, nobody has a crystal ball, but we have got some sense. We have got terrific, brilliant people at DOE who do really detailed techno-economic analysis and can at least say, you know, I see some pathway toward this thing getting to cost parity with either here in the U.S. combined-cycle natural gas

in the power sector, which is kind of the thing to be, around the world sub-critical coal, in the transportation sector with, you know, with diesel or in maritime shipping with bunker fuel. You kind of know what the bug is in each of these different sectors. You can have some sense of which technologies have some pathway to get there on a meaningful timeline, and you can use that to set up, you know, at least your first-line filter about what you should fund.

EFI has actually done great work in the breakthrough report earlier this year in sort of taking that and a number of other factors and developing a filter and using that to identify a set of technologies that kind of pass those hurdles. And I really think that the Department, and I would say appropriately the committee as well, ought to be adopting something like that, a really formal filter which is saying, well, these are the things that, you know, that make sense and have some horizon and use it to justify some hard choices. There is stuff happening at the Department, you know, we probably shouldn't keep investing in, right, if it doesn't have that clear pathway, you know, and pick our time horizon, right?

Let us say we are trying to get a fleet of things done in a decade. Right? If things have some chance of getting done in a decade, let us put 80 percent of our resources there. Sure, we should be investing in longer term riskier things as well, but if you take the climate crisis seriously, we don't have much more than a decade to produce the breakthroughs and then get them scaled up globally, you know, by 2050.

Mr. SIMPSON. Well, that is kind of what I like about ARPA-E is that it is you have to demonstrate progress and that kind of stuff.

I know, Secretary, you want to answer this, but one other thing. Could you just explain to me what the hell direct air capture is and how that works?

Mr. MONIZ. Well, that will come at the end of my soliloquy because it will be a natural.

First, let me reinforce something that Bob said about the cost equation. And that, you know, some don't like the words used, but the words that have been coined are "social cost of carbon." And so it is a very imprecise way, a very difficult calculation to make, but kind of in some average sense, the feeling, at least back a few years ago, was some number in the 40s of dollars per ton of CO₂ was an appropriate way of looking at that.

So it gives you some idea that it is not free in many ways to not put in place policies or incentives that push us towards low carbon. The adaptation costs are one major example of that.

And I might say even that we can count up how many tens of billions a hurricane cost or the floods in the Midwest cost, et cetera. But how do we add up, really, here in the United States of America, right now in Northern California, people being told you are not going to have electricity for a week? I mean, it is unbelievable in terms of something that is so central to all of our lives.

So we are paying a cost. In fact, I would add that, in my view, I think that the reason there is so much shift in, I think, the public's recognition of the importance of doing something about this, and this may sound not very, I don't know, complimentary of all of us, but it is because we have stopped thinking of this only as an issue for our children and grandchildren as opposed to as an

issue for us, too. It is right now that we are paying the price in not addressing this, while realizing there is no way to flip a switch and suddenly we have resolved the problem. So we have got to have this decadal view going forward and keep turning the ship as fast as we can.

Now, I am going to disagree slightly with—finally we can disagree—with something Rich said, a little bit. There was the statement that if it can't produce something in 10 years, then we kind of put it out of the portfolio, give it small funding. I would say the opposite if that was the intent in the sense that, again, take—and now I am coming to your last question. So take this carbon dioxide removal agenda. Clearly it is not going to scale up and have a major impact until mid-century. But it ain't going to have any impact in mid-century if we don't make a big push now in that budget.

So it is all how you manage the portfolio to recognize that let us say on a decadal timescale, 2030. The impacts we are going to have in 2030 are the things you see today, but improved. I mean, innovation still matters because that is what will keep driving the costs down, which is very, very important, and was your point.

But we also can't take our eyes off some of the very fundamental problems that we have to address to have scalability by mid-century. And so that is why the portfolio needs—that is why you need \$5 billion more in the budget, or some fraction of that maybe combined with something that is not appropriations, but other mechanisms.

As an example, it is now an expired program; it was in place for 8 years. It was a program looking at unconventional gas, et cetera, in which the Congress said that a certain fraction of oil and gas royalties would be invested in that program and the oversight stayed with the Department and the Congress, the Appropriations, because in many of these kinds of programs it will identify an alternative funding stream, but each year it still had to be appropriated even though it wasn't counted against the budget caps.

So there are creative ways to make up part of that at least. But I do think appropriations need to be increased, as I said earlier to Rick. Now, so I believe one of those areas is this carbon dioxide removal, and we will send you that report as well as the innovation report you asked for earlier.

Among the 27 portfolio elements we have is the issue of direct air capture. And, I mean, at some level it is very similar to carbon capture from the flue gas of a coal plant. It is just that in the flue gas of a coal plant it is 15 percent carbon dioxide, in the atmosphere it is .04 percent CO₂, so you got to move a hell of a lot more air through your system to be able to have a comparable amount of capture rate. So that is where cost reduction is very, very important, getting very low-carbon, low-cost energy to drive the process will be very important.

But by the way, if you are using that direct air capture, congratulations. Let us say you have now captured, globally, 2½ billion tons of CO₂. Great. But now you got to figure out what to do with 2½ billion tons of CO₂.

If you want to put it all underground, there is pour space, but you will be putting as much underground as the entire oil extrac-

tion industry globally today. So you might want to try to find some other things to do with the CO₂ as well. Maybe a hybrid system, like use some of the—or basalt for more mineralization of some of that CO₂. Maybe you can convert it into fuels, a big part of the research agenda, the utilization agenda of the CO₂.

So these are big, big numbers and we got to get on it and have something that is scalable within a minimum of three decades, but hopefully sooner. And so we could go through that, and like the hydrogen, that is another big issue, as I said earlier, with many, many questions.

So there are many areas that deserve expansion, like Bob mentioned quite correctly, the whole building technologies issues. And there are other areas that are the potential for big breakthroughs, as Rich mentioned, that our innovation report will lead you through both criteria for formulating the portfolio, and then what we concluded were the biggest breakthrough opportunities from the application of those criteria.

Mr. SIMPSON. Let me just again thank you all for being here, and tell you, in conclusion, one of my real frustrations with all of this, not with what you said or anything else.

Ever since I was chairman of the Interior Subcommittee, before I became chairman of this committee and then ranking member of this committee, my frustration was that after 9–11 whenever any Federal agency came to see us and they wanted us to do something, or any private company who came to see us and they wanted us to do something, we always had to do it because the key phrase was “homeland security.” If you were going to grow corn in Iowa, we were doing it for homeland security reasons, and that was the key phrase to get additional funding.

Now it is climate change, and nobody can tell me how much money in this Federal Government we are spending on climate change. I am not saying it is too much or too little or anything else, but every agency counts.

The Forest Service gets money to study climate change, so does the Park Service. Even though there ain’t a lot of difference between a park and a forest at the border. So, I mean, it is—I thought about trying to gather up all the money that all agencies spend on climate change and putting it in one budget, so that we weren’t duplicating efforts, duplicating research, duplicating science, everything else. So that if the Forest Service wanted to do a study on the impacts of climate change on our forest, that they went to this agency, and I thought the USGS might be a good place to put it.

But they would—okay, you know, it had been approved by members of scientists and so forth, that is a good study, they would fund it, and then every agency could use those studies and stuff. Somehow we have got to coordinate this is a lot better, in my opinion, not just in the Department of Energy, but throughout the government.

Anyway, thank you all for being here. It is a fascinating discussion, one that could go on for hours and hours, but I know that you have been here for a couple hours already.

Ms. KAPTUR. Thank you, Ranking Member Simpson. In closing today, I have been thinking about the political reality of our coun-

try where there are forces at work to create division among the American people in a whole set of ways, maybe some of it unintentional, but, for example, the ownership of our media, where if you live in a rural area, you listen to different stations than if you live in urban America. And the messages that are carried, the kinds of programming, and so forth, are distinctly different.

And I have been asking myself, how does America unite in common cause? And how do we create a Green Real Deal that people will embrace whether they live in rural Ohio and are involved in dairy farming or if they live in Charlotte and they are involved in the tech industry? So the political question looms large in my mind.

And I think about, so goal setting. Goal setting for urban America, metropolitan America, goal setting for rural America. I agree with what Ranking Member Simpson has said about the confusion in a way of the different agencies taking pieces of this, but, again, the whole that people can gravitate to and make a concrete contribution despite how daunting the challenge seems, we need to make that more clear to the American people, and so that Scout troops know that in Ohio and Michigan, we have to replant minimum 20 million trees. That doesn't even count what farmers have to do to deal with what has happened to our green cover.

Somehow, Mr. Secretary, when you talked about the rural—or the regional innovation offices that were imagined at DOE, but never really implemented, that is kind of important—that is an important thought because both Ranking Member Simpson and I have served on the Interior Committee, where the Department of Interior redrew America's watersheds. And it was trying to create a different arrangement we address regionally, so everyone felt part of the solution.

I am feeling we have to inch our way toward that rather quickly. And I am just stating that for the record so that the energy ideas, the energy innovation ideas, and the implementation of those can be done well. The same way we built the interstate highway system. We just didn't leave it to chance. There were mechanisms set in place, we had to cooperate with the states.

As I listened to Mayor Lyles, I was thinking about one of my key interests in urban America, which is helping our mayors figure out a way to pay the energy costs of the purification of water and the treatment of sewage. It is one of the largest bills that cities pay across the country, yet it is hidden. Mayors know what it is, but it is not an issue with U.S. Conference of Mayors or the National League of Cities. And yet, I think innovation there is desperately needed. We have a lot of old plans, maybe we need to throw them all out. But it becomes increasingly more expensive for cities to operate, and if they are economically challenged cities, like Flint, Michigan, it becomes a crisis.

And somehow regionally, we have to get our arms around this. I think the mayors are very important voices for the country. I think that the U.S. Department of Agriculture and the various organizations that represent farmers are very important.

But right now, we are not organized regionally through the Green Real Deal for people to be able to look at their region that they know best, and really make a concerted effort with certain goals.

So, one of my questions for the record, unless you feel motivated to answer it now, would be, how would we do that? How would we organize the country to think—and I think watersheds have to be an important part of it because of what is happening with rainfall and all. And how do we connect this to meeting the challenges of changes in our whole ecosystem?

The issue of money coming to our labs and to the Department of Energy, I have been amazed at the ability of our labs to be sites where contracts are let, from NOAA, from other departments, to our labs. I don't know if Congressman Simpson knows, I don't know of the number now, but the contracts that come to the Idaho labs from other departments, that is a way of moving money to our labs. If we could think about working with our colleagues on Appropriations and looking at some of the possibilities of adding to the contractual capabilities of DOE, we could meet some of these goals.

But I see a need to somehow create a template that people can buy into at every level, and I am finding that missing. At the same time as we do the longer term research, if you give the American people a goal, whether it is NASCAR or whether it is, blood pressure, whatever it is they will meet the goal, but they have got to be able to get their hands around it.

So, I am struggling with how do we create this Green Real Deal that people can buy into regionally, and how would one define those regions?

And also then, through the Department of Energy and other willing actors, how do we create rewards? For example, for net zero homes, I have been amazed, for instance, at Habitat for Humanity or the work that we do with community gardens. If one person and a group of people create a community garden, within 5 years there will be 100. The American people pick it up like that, but we have got to figure out a way to give them a template they can actualize. And I think the Department of Energy needs help in doing that because they are so brilliant, and they are involved in such high-level research that sometimes you lose touch with the ground.

And so I am struggling with that. I am struggling with how to arm my colleagues. How do members of Congress, how does Congresswoman Adams work with the mayor and really create in whatever you would call the region of Charlotte actual accomplishments that people could help with if they knew what the goal was, if they know what the finish line is, right?

And I think we need really need help there. I am not quite sure how to get there, all I know is we need to do it.

And so I just wanted to put that on the record. If you could think about that, and along the way create public recognition, kind of our net-zero homes or number of trees planted or the Academy Award for the best energy innovation. If they are doing it at DOE, most of America doesn't know about it.

And I heard what you said about education, Mr. Secretary, that, in fact, those authorities don't exist. Oh, my goodness, no wonder we are having so much trouble.

Mr. SIMPSON. I was going to say, Chairwoman Kaptur—

Ms. KAPTUR. Yes, please.

Mr. SIMPSON [continuing]. That I remember during one hearing when I was chairman you were ranking member, I believe you suggested that Secretary Moniz would be good to do like a Mr. Rogers program—

Ms. KAPTUR. Yes. Yes.

Mr. SIMPSON [continuing]. For several things that we ran on TV.

Ms. KAPTUR. Yes. He wouldn't do it.

Mr. SIMPSON. I remember that.

Ms. KAPTUR. He wouldn't do it. Yeah, that was one of my great disappointments, Mr. Secretary.

Mr. MONIZ. I will buy a sweater.

Ms. KAPTUR. Well, this has just been an excellent morning.

Mr. MONIZ. Can I make just one more comment?

Ms. KAPTUR. Yes, please. Please, Mr. Secretary.

Mr. MONIZ. I won't try to answer the question about how to do the regional things, but we would be happy to come in with you, or with you and the ranking member and discuss that because we do have many ideas. But I would just note that I think, again, something that I don't think it would take much prodding to go back and have it actually executed.

Towards the end of our term at DOE, what we did is we put out an RFP for small grants that would come in for ideas as to how to do regional innovation in their region. So rather than dictate it, we asked for some ideas. Unfortunately, I don't think those awards were ever made, but that is an example of a simple thing that could go out, and have different groups.

Often they were university-led groups, for example, putting together some regional assets. And they would come in and say—I don't know what they would have said, but the idea was come in and tell us how you think a regional innovation system would work for your region, using your assets, addressing your problems. So, I think that is an example of a pretty simple step, and doesn't—and not a big money deal.

Ms. KAPTUR. Thank you. Yes, Mayor Lyles.

Ms. LYLES. Yeah, I just wanted to say thank you for so well speaking the issue and the problem, because we can talk about a lot of things, but some of the decisions that you were wrestling with, we are now doing locally. We are trying to figure out how to pay for things that we require to be a quality place to live, and climate change has so much to do with it, storm water, hurricanes, all of these things.

So, I just want to say you have described what we need to do. We need to have a regional approach, because if you can get a region, then you can go statewide; if you can go statewide, you can then go to cover abroad.

But we, right now, are struggling on our own, and our people, our residents and citizens, they understand the struggle, and we are having to make choices and we need to work with you to get halfway there. We need your help to get us there.

So, thank you for the way you have described it and formed it.

I think intuitively people know something is not right, and they don't know how to fix it. And I love the—gentleman, I have learned as much today about what you are doing as anything. So, I am

going to take back a lot of that, but we need to have the ability to share the wealth of information that you have presented today.

So, thank you very much for allowing Charlotte to be a part of it. And I am really proud to represent our city. Thank you very much.

Ms. KAPTUR. Thank you so much, Mayor Lyles. And I know that Congresswoman Adams couldn't spend the morning with us because she had conflicting hearings herself, but I would just say that the work that she does on Agriculture, and the importance of that sector as a major component of the solution is extraordinarily important. And I know when you two put your heads together, you are going to come up with something really magnificent.

So, please share the nature of the hearing she could not hear with her. And we will look for her leadership as well.

Mr. Powell.

Mr. POWELL. I will just say one last thing on this issue of regional innovation. And actually, so Mayor Lyles mentioned in her testimony Duke Energy, headquartered in Charlotte, very important recent goal to go to 100 clean energy, or net-zero energy as they framed it, by 2050. And they are not alone.

Over the last year we have had a wave of our electric utilities around the country, including Idaho Power, make these, you know, deep decarbonization goals. And one of the things that is very common about all of the goals made in the past year, folks have said, you know, we have got a terrific set of technologies today that can get us to, in Duke's case, 50 percent emissions reductions, in Xcel's case out West, where there is just, you know, fabulous wind and solar potential, 80 percent reductions. But we have got a gap, right. And in some sense you could build a regional innovation policy around whatever it is that each of these utilities that have made these big voluntary commitments say they need to fill the gap.

So, Duke calls it ZELFERS, Zero Emission Load Following Energy Resources. Right? Things that don't have any emissions and could ramp up and down fast Right? And so you could go to each of these different regions and say, well, what is it? You have made this, you know, this bold, voluntary pledge to get us to a zero emission electricity sector that we can use to decarbonize the whole economy. What is it that you need, right?

And I think that that would be another really helpful filter, and obviously that would be quite different by region. Right? In the Southeast, it is not going to be all renewables. In Ohio it is not going to be all renewables. Right? It is going to be, you know, very different suites of technology in each place, but you could imagine a program that is built around, you know, helping and supporting big, voluntary commitments from the private sector.

Ms. KAPTUR. Thank you for that contribution. Mr. Keefe.

Mr. KEEFE. Madam Chair and Ranking Member, again, thanks to you all for having us here.

I might suggest in the realm of setting goals, there is already a foundation for that within DOE, and that is the standards. Those are energy efficiency standards. Those are programs like it might not be as catchy as "Fridge to the 21st Century," but a pretty well-known one, Energy Star, the Energy Star program.

I would suggest that it is really important, frankly, for this committee, and the Appropriations committees generally, to protect those types of programs, make sure those standards get out of DOE and get implemented.

So, I don't know about you all, but everybody that I know always wants to compare how far their car can go on a gallon of gas. We are always comparing mileage. And talk to a Tesla guy or somebody with a plug-in, and then you are out of the market if you are not—if you don't have an electric vehicle of some sorts.

But if we could build—first of all, protect those energy efficiency standards, protect programs like Energy Star, and then perhaps figure out ways to consumerize them, maybe the Department of Energy is not the best at consumer marketing, I don't know, no offense, but the standards and the foundation for those types of goals are already in place.

Ms. KAPTUR. All right. We thank you all very much. I just wanted to say since we are being carried, inside Congress today at 5:30 we are going to have a showing of a film called Planet Ocean. And what is so great about this film, in my opinion, I think it was done by the Australians, it wasn't done in this country, but it is so, to me, descriptive of how warming waters impact climate and weather conditions across the entire world. And people can kind of think about what is happening in their regions of the country. We have so many members that have experienced extreme flooding, those that have lived in coastal environments and have just been beaten by hurricanes and big storms, Sandy, Katrina, you name it, and winds. There are these conditions that are occurring now.

We worked in conjunction with the Healing Our Waters Coalition, the Ocean Conservancy, and Congressman Paul Tonko of New York, who is very, very, very involved in climate change issues, is helping to cosponsor this. It will be in Room 2362B of this building, of Rayburn, and it will start at 5:30. It takes about an hour. So, if people want popcorn, and they want to come and just listen, we hope to, again, visually demonstrate some of the work that we do as verified by outside actors. So, again, that is 5:30 today, Planet Ocean, Room 2362B here in Rayburn.

I would like to say that this concludes this morning's hearing. We haven't done that badly in terms of keeping on time.

Again, I would like to thank our witnesses for joining us, and ask the witnesses to please ensure for the hearing record that questions for the record, and any supporting information or ideas you have requested by the Subcommittee are delivered in final form to us no later than 3 weeks from time you receive them.

Members who have additional questions for the record will have until the close of business this Friday, tomorrow, to provide them to the subcommittee office.

This hearing is adjourned.

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