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NEW EFFICIENCY OPPORTUNITIES PROVIDED BY ADVANCED BUILDING MANAGEMENT AND CONTROL SYSTEMS

HEARING

BEFORE THE

COMMITTEE ON ENERGY AND NATURAL RESOURCES UNITED STATES SENATE

ONE HUNDRED FIFTEENTH CONGRESS

FIRST SESSION

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TUESDAY, OCTOBER 31, 2017

U.S. SENATE,
COMMITTEE ON ENERGY AND NATURAL RESOURCES,
Washington, DC.

The Committee met, pursuant to notice, at 10:03 a.m. in Room SD–366, Dirksen Senate Office Building, Hon. Lisa Murkowski, Chairman of the Committee, presiding.

OPENING STATEMENT OF HON. LISA MURKOWSKI, U.S. SENATOR FROM ALASKA

The CHAIRMAN. Good morning, everyone. The Committee will come to order.

Happy Halloween to you all. I am perhaps in a little more of a Halloween spirit. I like Halloween.

Senator MANCHIN. You scare people.

The CHAIRMAN. I do scare people, sometimes.

[Laughter.]

Boo.

[Laughter.]

Alright, now we are going to get serious. This is a serious subject here this morning.

Last week we had an opportunity to look at a really scary subject, and that was cyber and cybersecurity and the vulnerabilities of our nation's electric grid system. That is clearly going to come up a little bit this morning and a challenge with which we have to contend.

But our primary focus this morning is on what is coming down the pike with building technologies and advanced building management and control systems.

One hears terms like "smart" when it comes to appliances and buildings and cars all the time, but we really have to ask the question as to whether or not we understand the scope of what is possible when we are looking at a whole building.

Smart thermostats and other smart sensing, metering, and control technologies have already had a big impact. No doubt those products are a major reason why new homes here in the country, according to DOE's Building Technology Office, use about 20 percent less energy for space heating than our older homes and why, by DOE's estimate, today's American households are paying roughly $216 less per year than if we did not have energy efficient equipment and appliance standards.

These numbers are dramatically different in my home State of Alaska, where energy costs are exorbitantly high and some of our rural communities live dangerously close to, or are already in, energy insecurity. Some Alaskan families pay thousands of dollars a month, up to half of their household budgets, on energy alone.

The challenges in rural Alaska are unique and that is certainly true when it comes to optimizing the way a building uses energy. That is partly because the puzzle pieces up north are more than just simple math. They are more than just looking at the bottom line on energy bills. Much of the housing in rural Alaska is effectively western-style design, a design that may work in Albuquerque or in Ohio, but just does not work in an Arctic environment.

Mr. Grunau is my expert this morning and I think members of the Committee here will enjoy, or certainly learn a lot from what he has to impart with building energy use from a rural Alaska perspective. I thank you for being here this morning, Bruno.

On the whole, though, the efficiency opportunities our buildings offer are enormous. With around 125 million residential buildings and more than 5 million commercial buildings consuming nearly 75 percent of all the electricity used in the U.S. every year, the volume is obvious. I expect we will hear much more about the sleeping giant those buildings represent as an untapped energy efficiency resource, because most of them do not have any kind of energy management or control system and most of them are nowhere near being optimized when it comes to energy use.

Another thing that we hear, another phrase we use around here a lot is "low-hanging fruit." We may be in the position where we think we have plucked all of that low-hanging fruit, in terms of energy-efficient water heaters and A/C units, but I think we will hear this morning, as we listen to today's witnesses, that there may very well be some pretty ripe, low-hanging fruit that we have yet to go after, and that it is in and with our buildings. So we will look forward to that this morning.

I thank each of the witnesses for being here and, before I introduce each of you, I will ask Senator Cantwell for her comments this morning.

STATEMENT OF HON. MARIA CANTWELL, U.S. SENATOR FROM WASHINGTON

Senator CANTWELL. Thank you, Madam Chair. Thanks for holding this important hearing.

Why is this topic so important? Well, across the United States 2.2 million people work in energy efficiency jobs, including 62,000 in the State of Washington.

This year energy efficiency jobs are expected to grow by nine percent. Buildings in the United States consume 40 percent of our country's energy and only a small fraction of our 130 million buildings we can say are actually smart.

I was glad that the Chair and I were able to tour some of these buildings in the Pacific Northwest and then went to Alaska to hear about how smarter grid technology can help in very rural parts of Alaska.

Advanced controls and inexpensive sensors are the next revolution in how we manage our buildings resulting in energy savings and improved performance for buildings and their occupants.

We made big gains in energy efficiency over the last 40 years, due in large part to DOE's program that focused on research, setting standards for appliances and developing energy codes for buildings. The appliance standard alone will save consumers $2 trillion by 2030 on their energy bills.

So smart buildings are the new frontier. Smart buildings using those building management systems of sensors and advanced controls can save 30 percent more than can be achieved by improving energy efficiency of individual building components.

Lower costs and more competitiveness will help grow our businesses and give them important opportunities, especially in the data-sensitive industries that we host in the State of Washington.

Smart buildings have a potential to make all of our nation's commercial buildings more energy efficient to save owners and tenants money that they can then plug back into their businesses. In fact, we did an analysis that energy efficiency is its own feedback loop—that the savings to businesses go back into helping them create their own technological advances and keep them competitive with other businesses around the globe.

So this is a huge opportunity. The smart building market is expected to be worth $30 billion in five years. And as we hear more about this today, we know that it is part of a modern electricity grid. Buildings provide flexibility for energy storage. They act like distributed mini power plants. Utilities and their consumers get a more resilient grid and avoid having to build costly new power plants and building owners tap into new revenue sources.

So, how do we get there? Well, the bipartisan Senate energy bill was a good start. It included provisions that Senator Murkowski and I introduced as a stand-alone measure, the Smart Building Acceleration Act. This provision of the energy bill would accelerate the use of technologies by evaluating smart building performance and focusing on research and identifying key barriers to adoption. These trends toward smart, integrated systems really are game changers.

Unfortunately R&D challenges persist. At the heart of the smart building revolution is the decreasing size and cost of monitoring controls and computer technology. That is why I am so glad that PNNL is here again, because with the funding from DOE it is leading in the development of cutting-edge controls technologies that can cut a building's energy use by 30 percent.

These are real savings. We must continue to make these investments. We must embrace a future with more smart technologies to improve our economic competitiveness and create jobs. Cutting the DOE's critical research programs in this area by 66 percent as the Trump Administration proposes is not the way to embrace the future.

Last Wednesday, Secretary Perry released DOE's review of so-called regulatory burdens to the American people, calling out reforms to the successful appliance standard program that would, "alleviate or eliminate agency's actions that burden domestic energy development, production and use."

I can't emphasize enough how wrong I think the Secretary got this. In reality, these standards are alleviating the challenges that our businesses face by putting more money into their pockets so that they can be competitive. So I hope they will stop beating up on the energy efficiency programs that we have at DOE and move forward on them.

I so look forward to hearing the testimony and know that there is a lot at stake to make sure that we continue to move forward on energy efficiency.

Thank you, Madam Chair.

The CHAIRMAN. Thank you, Senator Cantwell.

Welcome to each of you. We have a good panel here this morning.

I will ask each of you to try to limit your comments to about five minutes. Your full statements will be included as part of the record. We will hear from each of you, and then the Committee members will have an opportunity to ask questions.

We are joined this morning by Mr. Daniel Simmons, who is the Acting Assistant Secretary of the Office of Energy Efficiency and Renewable Energy, or EERE, over at the U.S. Department of Energy (DOE).

Dr. Jud Virden, as Senator Cantwell mentioned, is with Pacific Northwest National Laboratory (PNNL). He is the Assistant Laboratory Director for Energy and Environment.

I mentioned Mr. Grunau. Bruno Grunau is the Chief Programs Officer for the Cold Climate Housing Research Center. I am going to brag a little bit on this amazing, amazing research and, kind of, living laboratory in Fairbanks, Alaska, just off the campus there at University of Alaska Fairbanks. It is the furthest north, LEED platinum certified building in the world. At first I thought it was just North America, but it is the whole world. So we are very proud of it. We are very proud of the innovation that goes on there and, recognizing that some of the challenges that you have in providing for efficiency in a colder, an Arctic environment, what is being demonstrated there on a daily basis is really quite phenomenal. So I am very pleased that Bruno is with us this morning.

Ms. Tracy West is the Director of End-Use, Power Delivery and Fleet R&D at Southern Company. We welcome you to the Committee.

Mr. John Wallace is with us this morning. He is the Director of Innovation at Emerson Commercial and Residential Solutions. Some neat things coming out of Emerson, so we are pleased that you are with us here this morning.

Mr. Simmons, if you would like to kick the panel off, and we welcome all of you.

STATEMENT OF DANIEL R. SIMMONS, ACTING ASSISTANT SECRETARY, OFFICE OF ENERGY EFFICIENCY AND RENEWABLE ENERGY, U.S. DEPARTMENT OF ENERGY

Mr. SIMMONS. Thank you very much.

Chairman Murkowski, Ranking Member Cantwell and members of the Committee, thank you for inviting the U.S. Department of Energy to testify. My name is Daniel Simmons, and I am the Acting Assistant Secretary for Energy Efficiency and Renewable Energy at the Department of Energy. Efficiency and building management and controls is an important aspect of building efficiency in grid performance, and I am pleased to speak with the Committee today about this important and exciting issue.

As has been mentioned by Senator Murkowski, the U.S. has approximately 125 million buildings consuming about three-quarters of all electricity, taking power from the grid for cooling, for heating, for consumer goods and countless other uses. And as we all know there's been an explosion in the number of internet-connected devices over the past few years. In fact, approximately 200,000 of these devices are connected to the internet every single hour, and the largest market for that is in the United States where it's projected that these devices are—well, it's projected that the world demand for these devices will grow about fourfold in the next few years.

These new and exciting smart and connected technologies are transforming homes, workspaces and other buildings that Americans occupy every day. Quite simply, smart building technology can redirect the way energy is used by buildings, their owners and occupants.

At DOE, we are focusing on the energy opportunities these technologies represent, consistent with our commitment to early stage research and development as well as promoting affordable and reliable energy to enhance economic growth and energy security. To that end we are interested in how these devices can enable families and businesses to save both money and energy and provide valuable grid services.

Just as importantly, we recognize the challenges that a smart and internet-connected building sector brings which is why we are working to promote the interoperability of energy-related technologies so that one, they can work efficiently and more effectively with each other and two, that they can work with the grid.

Furthermore, as part of our smart building efforts, we are working to ensure that these systems are cybersecure from the beginning so that they enhance the grid's reliability and resilience.

The promise of smart buildings represents more than just saving energy and money inside buildings. Increased connectivity for building equipment can also enable buildings to be more responsive to electric grid conditions. This flexibility can help avert system stress and enhance the reliability of the entire electrical grid. Having buildings become more responsive and dispatchable in response to grid needs is a key aspect of our research.

In the rapidly-approaching Grid-interactive Efficient Buildings future, buildings will not only demand power from the grid, but can also adjust their demand up or down, earlier or later, in response to fluctuations on the grid. Our goal is to ensure that families and businesses have the tools to make informed purchasing decisions that meet their individual needs.

EERE's R&D in this area is led by our Building Technology Office who are working very closely with several DOE national labs that you know well, including Oak Ridge National Lab, the National Renewable Energy Lab, Lawrence Berkeley National Lab and, of course, Pacific Northwest National Lab.

Last week, I and others from DOE had the opportunity to spend a couple days at PNNL and much of the conversation was in this space. We had a great time at PNNL.

Our Building Technology Office and other parts of DOE, including the Office of Electricity Delivery and Energy Reliability as well as the Grid Modernization Lab Consortium, are working closely with private and university researchers.

One such example is our work on cybersecure, transaction-based energy systems. We're developing transaction-based controls that inherently value the consumer and utility engagement as a method to help facilitate energy decisions and transactions in grid-interactive efficient buildings.

For example, one such DOE effort done with PNNL and Oak Ridge has been to develop a cybersecure and highly interoperable platform for distributed control and sensing called VOLTTRON, designed to support modern control strategies including the use of agent-based controls. Jud Virden, sitting next to me, obviously knows this work very well. EERE will continue our early stage R&D and other efforts on these key opportunities, challenge and research priorities for grid-interactive, efficient buildings.

Chairman Murkowski, Ranking Member Cantwell, I respectfully request that my full written statement be submitted for the record and thank you very much for the opportunity to testify. I look forward to answering your questions.

[The prepared statement of Mr. Simmons follows:]

Testimony of Acting Assistant Secretary Daniel R Simmons

Office of Energy Efficiency and Renewable Energy

U.S. Department of Energy

Before the

Committee on Energy and Natural Resources

United States Senate

October 31, 2017

Good morning Chairman Murkowski, Ranking Member Cantwell, and members of the Committee. Thank you for inviting the Department of Energy to testify. My name is Daniel Simmons, and I am the acting Assistant Secretary for Energy Efficiency and Renewable Energy at the U.S. Department of Energy. Smart buildings are an important aspect of building efficiency and grid performance, and I am pleased to speak with the Committee today about this important issue.

The United States's approximately 125 million buildings consume three-quarters (74%) of all electricity, taking power from the grid for cooling, heating, lighting, consumer goods and countless other uses and benefits they need.[1] And as we all know, there has been an explosion in the number of Internet-connected devices and smart technologies; in fact, *every hour* more than 200,000 devices get newly connected to the Internet globally, and the U.S. market for these devices is the world's biggest by fourfold – and growing 20% annually or more.[2] These new and exciting smart and connected technologies are transforming the homes, workspaces and other buildings that Americans occupy every day. Smart building technology can be described as the connectivity, data collection and processing, and controls that can provide substantial benefits to building owners, homeowners, and tenants. Some of these benefits are not directly energy-related – such as enhanced comfort, productivity and security. But smart technologies also can greatly improve energy performance – both for the building itself and for the broader power grid.

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[1] U.S. Energy Information Administration. Number of buildings from EIA's CBECS and RECS (https://www.eia.gov/consumption/commercial/data/2012/#b6 and http://www.eia.gov/consumption/residential/data/2009/index.cfm#undefined, respectively). Electricity consumption from EIA's EIA Electric Power Monthly; https://www.eia.gov/electricity/monthly/current_month/epm.pdf. Note, 74% represents the 2011-2016 period.

[2] Projected hourly new devices from Gartner, Inc., Nov. 2015; http://www.gartner.com/newsroom/id/3165317. Size of U.S. market from Statista, Inc. "Energy Management Smart Home Revenue in Selected Countries Worldwide in 2015." (2015); http://www.statista.com/statistics/484511/global-comparison-energy-management-smart-home-revenue-digital-market-outlook/. Projected growth in U.S. market Parks Associates and Consumer Electronics Association. "Smart Home Ecosystem: IoT and Consumers." (2014); http://www.parksassociates.com/bento/shop/whitepapers/files/Parks%20Assoc%20CEA%20Smart%20Home%20Ecosystem%20WP.pdf. No Federal source exists for this information; these are considered reliable industry sources.

Quite simply, smart building technology can re-direct the way energy is used by buildings and their owners and occupants in this country.

As these new technologies give building occupants and managers, as well as electric utilities, more choices in when they get power and how much they need to consume, buildings can become more flexible and dispatchable in their power consumption.

The private sector is certainly succeeding at deploying internet-connected devices. At DOE we are focusing on the energy opportunities they represent, consistent with our commitment to early-stage research and development as well as promoting affordable and reliable energy to enhance economic growth and energy security. To that end, we are interested in how these devices can enable families and businesses to save both money and energy, and also to provide valuable new services to the grid. Just as importantly, we recognize the challenges that a smart and internet-connected building sector brings, which is why we are working to promote the interoperability of energy-related technologies so that, one, they can work effectively with each other, and two, they can work with the grid. Furthermore, as part of our smart buildings efforts we are working to ensure these systems are cybersecure and they enhance the grid's reliability and resiliency.

The energy management abilities of smart building technologies focus on using advanced distributed sensors and processing units to more precisely control the energy-consuming equipment in buildings – for example, controlling lighting and ventilation based upon the specific needs of the occupants at a given time. This makes energy use more efficient and reduces peak demand, helping to cut energy bills for consumers. Now new applications of smart but internet-connected technologies allow buildings to interface with the utility system. These abilities allow building owners to provide new services to the grid, including the following:

- Reducing peak electric demand: smart technologies can help reduce peak electric demand by communicating with the grid and determining the best time to cycle off and on high energy-intensive equipment (e.g. HVAC, pool pumps, refrigerators);

- Helping integrate variable renewables: the flexibility offered by smart technologies can help integrate variable renewables like solar and wind by enabling the precise control of electricity use – so that when the wind isn't blowing or a cloud blocks the sun, energy demand can be managed to maintain the balance of energy sources and loads;

- Providing de facto storage capability: smart building technology can offer "virtual storage" which, like traditional batteries but without the same upfront cost, allows building owners, homeowners and tenants to shift their energy use from peak to off-peak times, providing additional resilience and stability to the electric grid; and

- Helping balance power flows: behind-the-meter assets such as home energy management systems or smart inverters can help manage and balance power flows for buildings that have distributed renewables installed on-site – by shifting energy consumption on the building's side of the meter, these systems reduce any need for distributed resources to "back feed" onto the grid.

In other words, giving American households and business consumers new opportunities to use energy more efficiently, potentially generating savings for end-users, the utility system, and the national economy.

At EERE, we're conducting early-stage research and development to help allow buildings, and the equipment inside them like appliances, air conditioning, water heaters, lighting and thermostats, to be both smarter and more connected. I'll give an example. In the past, to turn off a light one manually flipped a switch. Then came the widespread use of occupancy sensors that detect when someone enters a room, sending an automatic signal to turn on the lights, and similarly after detecting the room not being in use, automatically turn off the lights to save energy and money. Now, thanks to advances in sensors, inexpensive and miniaturized embedded chips, and low-cost Wi-Fi connected to the Internet, building technologies can not only automatically turn off lights when an office space is vacant but can use that information to turn down the ventilation so it's not being wasted in a vacant office – and along with it wasted money on energy bills. Similarly, connected sensors & controls now under development will be able to detect not only whether an office is occupied but much more, including what the outdoor temperature and humidity are and whether there is a large group of people in the office. This will allow building equipment to automatically increase the air conditioning and ventilation – thus keeping the indoor air sufficiently fresh and healthy and all those hard-working American office workers wide awake. In other words, smart and connected building technologies will be able to reduce energy waste whenever it's not needed and direct its use to whenever it is needed.

We like to call this "Grid-interactive Efficient Buildings". It represents a very exciting vision of technology and practices that will allow American businesses and families to save energy and reduce their utility bills automatically and without impacting comfort or productivity.

The promise of smart buildings represents more than just saving energy and money inside buildings. Increased Internet connections for building equipment can also enable buildings to be more responsive to electric grid conditions. This flexibility helps avert system stress, enhancing the reliability of the entire grid. Grid-interactive water heaters, for example, can turn on or off the electric heating elements to reduce power use during moments when the utility system reaches peak demand, or to shift power consumption to when the utility system has excess capacity.

A future where grid-responsive equipment grows in popularity can help better utilize existing grid infrastructure and thus defer the need to construct expensive new transmission and distribution facilities. This can defer potential spending and thus mitigate rate increases for utilities and their customers, and also introduce new sources of revenue for participating customers. A recent Building Technologies Office-sponsored study from the Lawrence Berkeley National Laboratory found that some of the largest utility benefits from energy efficiency come from the deferral of transmission and distribution system infrastructure upgrades. Which means that *when* electricity is saved is just as important as how much is saved.

Helping buildings become more responsive and dispatchable in response to grid needs is a key aspect of our research. In the rapidly approaching Grid-interactive Efficient Buildings future, buildings will not only demand power from the grid but can also adjust their own demand up or down, earlier or later, in response to fluctuating grid conditions. Our early-stage R&D will support the technologies and practices that enable this two-way interaction between buildings and the electric system.

Our goal is to ensure that families and businesses have the tools to make informed purchasing decisions that meet their individual needs. Helping make homes and other buildings smarter and better connected is certainly not without challenges. For example, many in the building sector (including owners, managers, and occupants) are either not aware of the energy-savings opportunities from connected devices, or currently believe that the upfront cost is not worth it. And even for those who are aware and would want to make the investment, most do not have electric rates that vary by time, and thus they're not directly financially affected by time-shifting their power use. But with what can be a relatively small investment of effort and/or money, potentially big payoffs can come for building owners and managers who use these energy-saving and utility-connected technologies.

EERE's R&D in this area is led by our Building Technologies Office who are working very closely with several DOE national labs that you know well – including the Oak Ridge National Lab, the National Renewable Energy Lab, Lawrence Berkeley National Lab, and of course the Pacific Northwest National Lab, as evidenced on this very panel by Dr. Jud Virden, who is the Associate Lab Director at PNNL. Our Building Technologies office and other parts of DOE, including the Office of Electricity Delivery and Energy Reliability and the Grid Modernization Lab Consortium, are also working closely with private and university researchers on activities including the following:

Leveraging enhanced data from advancements and cost reductions of sensors and sub-metering – where we're investing in replacing "handcrafted," rule-based building control routines for fault detection and diagnostics and model-predictive control. Our goal is to enable cybersecure, fully autonomous and distributed controls that effectively integrate grid operations with occupant comfort and energy savings.

Enabling interoperability – we're working with stakeholders to develop seamless communication between building devices and systems, regardless of manufacturer, allowing easier control of devices, equipment, and appliances.

Ensuring integration with other distributed energy resources – buildings can increase a utility's ability to host energy storage, electric vehicle charging, and variable renewables such as wind and solar Our Buildings Office and PNNL are examining how buildings and campuses can serve as "virtual storage" – going beyond batteries with transaction-based communicative systems that help balance supply and demand on the grid by shifting the time that power is consumed.

Accurately valuing grid-interactive efficient buildings performance – traditional energy efficiency examines how much energy is saved, but not when. We're analyzing how time and location affect the value of efficiency, as well as the value of connectivity and smartness.
Developing cybersecure transaction-based energy systems – we're developing transaction-based controls (that inherently value the consumer and utility engagement) as a method to help

facilitate energy decisions and transactions in grid-interactive efficient buildings. For example, one DOE effort, done with PNNL and ORNL, has been to develop a cybersecure and highly interoperable platform for distributed control and sensing called VOLTTRON, designed to support modern control strategies, including use of agent-based controls. Dr. Virden, on this panel, knows this work very well if you would like more in depth information about the potential of agent-based controls, cybersecure APIs and VOLTTRON.

Other examples of our work include connected lighting, smart energy analytics, connected appliances, and DOE's broader Grid Modernization Initiative, a comprehensive effort of DOE offices and national laboratories with public and private partners to help shape the future of our nation's grid. The Grid Modernization Initiative is developing new utility architectural concepts and technologies that can better measure, predict, and protect the grid, and identifying the institutional changes needed so American consumers and business can best take advantage of a modernized grid. And let me note that EERE is also quite involved in R&D regarding two other key transformations in the utility sector: the growth in building-sited photovoltaics and the potential demand of electric vehicles that would be plugged into the power grid.

Beyond early-stage R&D, DOE's work in smart and connected buildings includes Federal buildings. The Federal government is overall America's largest single energy consumer and presents an excellent opportunity for early commercial deployment of these emerging grid-interactive efficient technologies, while also improving the energy performance of the Federal buildings.

Our Federal Energy Management Program (FEMP) works closely with other federal agencies in this regard, providing assistance and technical support so that the Federal Government can better incorporate the strategic integration of advanced and smart technologies to promote efficient, resilient and connected facilities. These optimized buildings provide the Government with the opportunity to enhance the efficient operation of the building through active meter and control systems management on a portfolio/enterprise-wide level, and improving energy resiliency and energy security at mission-critical installations. These efforts can enhance the Federal Government's resiliency and strengthen the national energy grids' reliability, while at the same time, with the expanded use of integrated technologies and web connected systems, there lies an increased risk of cyber threats. FEMP is outlining work with Federal agencies to assist with the installation of cybersecurity protocols behind the federal metering system and at the point of grid interface, as well as addressing ongoing energy management challenges that arise from these integrated systems. This includes providing critical collaboration between Federal agencies to foster adoption of best practices for integrated, secure building control systems, and providing technical assistance for guaranteed fixed-price performance contracts to ensure smart building and cybersecurity requirements embedded in enterprise-wide facility planning and implementation efforts.

In Fiscal Year 2018 and beyond, EERE will continue our early-stage R&D and other efforts on these key opportunities, challenges and research priorities for grid-interactive efficient buildings. Thank you for the opportunity to testify today, and I look forward to answering your questions.

The CHAIRMAN. Thank you, Mr. Simmons.
Dr. Virden, welcome.

STATEMENT OF DR. JUD VIRDEN, ASSOCIATE LABORATORY DIRECTOR, ENERGY AND ENVIRONMENT, PACIFIC NORTHWEST NATIONAL LABORATORY

Dr. VIRDEN. Chairman Murkowski, Ranking Member Cantwell and members of the Committee, thank you for the opportunity to testify at today's hearing.

My name is Jud Virden, and I'm the Associate Lab Director for the Energy and Environmental Research at Pacific Northwest National Laboratory. It's PNNL—it's even hard for me to say that sometimes——

[Laughter.]

——in Washington State.

Over the last two decades, PNNL has been at the forefront of research focused on building efficiency, grid operation and buildings-to-grid integration. PNNL research has been supported by DOE's Building Technology Office, the Office of Electricity Delivery and Energy Reliability and the Office of Science. As part of these programs, PNNL collaborates with other national labs, universities and private industry.

As was mentioned, in the U.S. nearly 75 percent of all electricity is consumed in buildings. Eighty-five percent of these commercial buildings do not have automated control systems, and studies estimate that the energy efficiency of commercial buildings could be increased 30 percent with the implementation of automatic control systems. This is the equivalent of the energy use of 15 to 20 million Americans annually. It's a huge opportunity. Managing loads could reduce peak electricity demands 10 to 20 percent which is billions of dollars of energy saved, ultimately.

We believe that we can increase the energy efficiency of buildings and, ultimately, grid reliability and resiliency through the integration of low-cost sensing, measurement devices, computing and advanced control theories.

I'd like to show you one example where PNNL research is being used to optimize buildings' performance. This device, the one I'm holding in my hand, represents about a $10 piece of commercially-available hardware. What makes it unique is we've developed an open-sourced, flexible software platform for distributed control and sensing.

In a building—if we put it in this building, it would integrate data from devices like temperature sensors, thermostats, HVAC systems, perform data analysis and make decisions on building operations to optimize energy use.

You could think of this hardware, kind of, like your smartphone and the software on this device, kind of, like apps on your phone. If an incentive signal was sent to this device from the grid, it could act like an Uber app, where the building could decide if it is willing to offer grid services based on the cost and value of those services, kind of like when we decide if we're willing to pay surge prices with Uber—it can be transactive.

And let me share a couple examples of our research. The first example is a collaboration led by PNNL where we tested 66 rooftop units out in the field. Rooftop units provide heating, cooling, ventilation to buildings. With a device like this and with advanced control algorithms to optimize the performance of the rooftop units and based on measurement temperatures in the buildings, the studies show that on average you could have a 57 percent energy reduction in the rooftop units in a payback period of two to six years, if we can optimize the building and the rooftop units.

In the Olympic Peninsula of Washington State, we led a collaboration to demonstrate that incentive signals sent from the grid could reduce peak loads on a winter-constrained transmission line. An incentive signal was sent to 112 homes with smart technologies, two diesel generators and five municipal water pumps. Over the course of a year, the project resulted in an average 15 percent reduction in peak load and approximately 10 percent energy savings for consumers.

At our own PNNL campus in Richland, Washington, we have installed 9,000 sensors across 12 buildings, and this device helps collect and integrate over 11 million data points per day. Over the course of the experiment we've been running on our campus, that's 34 billion data records over the last 18 months. We installed and are testing advanced algorithms and have shown that we can reduce peak energy consumption by 10 to 20 percent. And now we're teaming with universities across the country using the same approach to optimize energy use on their campus.

We are learning from our research, and what we are learning is that we're pushing the boundaries of big data collection and analysis, data analytics of complex and dynamic systems, and current control theories just don't always work the way we expect them to work.

From a research perspective, we see three important areas of investigation to realize new efficiency opportunities from advanced buildings' management and control systems. And these are: the first one, novel and low-cost approaches for integrating large amounts of data with new advances in analytics, such as machine learning combined with high-performance computing; advanced control theories for complex and dynamic systems; and, finally, stakeholder engagement to establish best practices for interoperability and cybersecurity of smart buildings technologies and systems.

Thank you again for the opportunity to testify on this important subject and I'd be happy to answer any questions you may have.

[The prepared statement of Dr. Virden follows:]

Statement of
Jud Virden, Ph.D.
Associate Laboratory Director,
Energy and Environment
Pacific Northwest National Laboratory

Before the
United States Senate
Committee on Senate Energy and Natural Resources

October 31, 2017

Introduction

Chairman Murkowski, Ranking Member Cantwell, and Members of the Committee, thank you for the opportunity to testify in today's hearing on efficiency in building management and control systems.

My name is Jud Virden and I am the Associate Laboratory Director for Energy and Environmental research at the Pacific Northwest National Laboratory (PNNL) in Washington State. PNNL is a U.S. Department of Energy (DOE) multi-program national laboratory stewarded by the Office of Science.

My comments today will focus on:

1. The importance of advanced building management and control technologies to the U.S. electric sector and economy.

2. PNNL's unique expertise and experience in improving building energy efficiency using building controls and pioneering research exploring the combination of advanced building controls and coordination of building energy assets with the electric grid.

3. Technology gaps and key future research and development (R&D) directions.

Importance of advanced building management and control systems—achieving energy efficiency and grid integration

In the United States there are approximately 125 million homes and more than five million commercial buildings. Nearly 75 percent of all U.S. electricity is consumed within these buildings. Electricity goes to functions such as air conditioning, heating and lighting, but increasingly buildings will also use electricity to charge electric vehicles and will generate and store electricity onsite with resources such as solar photovoltaic arrays and batteries.

The energy resource represented by these commercial and residential buildings is tremendous. PNNL recently completed an analysis for DOE's Building Technologies Office—within the Office of Energy Efficiency and Renewable Energy—which estimates that implementation of advanced building control technologies and related energy efficiency measures could reduce commercial building energy consumption by up to 29 percent. This study also showed that commercial and residential buildings could be operated in ways that would reduce peak electricity demand by 19 percent without disrupting the comfort of building occupants or key building functions, representing a resource that could be used to increase the reliability and resiliency of the electric grid at times of peak electricity demand. [Source: S. Katipamula "Impacts of Commercial Building Controls on Energy Savings and Peak Load Reduction." May 2017.]

However, tapping that resource requires new technology that can automatically operate numerous devices. For example, energy consumption in commercial buildings is associated with space heating (25 percent), space cooling (9 percent), lighting (10 percent), refrigeration (10 percent), ventilation (10 percent) computers and office equipment (8 percent), cooking (7 percent), water heating (7 percent), and other uses (13 percent).

The key is control and optimization of each of these energy-consuming systems within every building, continuous control of multiple buildings, and automatic coordination of large numbers of buildings in response to signals from utilities asking to manage electricity consumption at various times of day throughout the year. This can be accomplished through new technology, and much of that new technology will be made possible by changes that have already revolutionized technology in other fields—low-cost sensing and measurement devices, information technology, and burgeoning connectivity of devices to communication networks and the Internet. In the vehicle industry, for example, the integration of new information technologies and unprecedented computing capabilities is revolutionizing the performance and automation of cars. We need to enable and accelerate this revolution for buildings.

The deployment of sensor and information technology in buildings and the grid—both highly complex systems—will generate large amounts of data. This massive data set must then be converted into useful information allowing us to measure, monitor, and control building energy use, grid operation, and the interaction between buildings and the grid in a secure environment. As such, ***the science and technology challenge for the foreseeable future is***:

> ***Developing novel approaches for integrating large amounts of data with new advances in analytics (such as machine learning), combined with high performance computing, and advanced control theories for extremely complex systems.***

PNNL experience—achieving energy efficiency and buildings-grid integration with advanced building control systems
Over the past 15 years, PNNL has been at the forefront of research focused on buildings, grid operation, and buildings-grid integration, supported by funding from DOE's Buildings Technologies Office, the Office of Electricity Delivery and Energy Reliability, the Office of Science, and other agencies. PNNL has teamed with other national labs—including the National Renewable Energy Laboratory, Oak Ridge National Laboratory, and Lawrence Berkeley National Laboratory—universities, and industry to demonstrate the art of the possible and translate it to practical applications. In the last 10 years, this research has led to 56 copyrights, 38 patents granted, and 68 technology licenses to U.S.-based companies. During the last year alone, PNNL had 219 publications featuring new research in these fields. Moreover, this research has resulted in significant new technologies, including:

- An agent-based distributed sensing and control software platform that enables collection of performance data from various building devices and systems, application of new diagnostic and control methods to optimize building performance, and a secure means of exchanging information between devices, between buildings, and between building and the grid;

- An incentive-based control methodology that combines concepts from economics and the field of control theory to optimize the operation of multiple buildings and coordinate their response to signals received from the electric grid; and

- A suite of software tools for simulation of advanced control approaches involving tens of thousands of buildings over very large geographical areas, integrating and synchronizing independent simulators of the various elements of grid operations (e.g., a feeder, a distribution system consisting of many feeders, and multiple distribution systems, as well as the many buildings connected to them).

Technologies—such as those described above—have enabled PNNL to develop and refine new control strategies and perform a variety of experiments involving building optimization and building-grid integration, including several pioneering field experiments, described below.

Building Energy Efficiency Optimization. *PNNL performed a roof top unit energy saving validation—integrating a PNNL open-source software platform for distributed control and sensing to optimize unit energy use.* Packaged air conditioners and heat pumps—also known as roof top units—are used for 60 percent of all cooled commercial buildings. They serve almost 70 percent of cooled commercial building floor space and represent 15 percent of U.S. commercial building energy consumption. Most roof top units operate with motors and fans that run at a constant speed. With support from DOE's Building Technologies Office, PNNL, Bonneville Power Administration, and Transformative Wave Technologies (located in Kent, Washington) teamed to show the energy savings that could be realized if constant speed fans were replaced with variable speed fans and linked to advanced control algorithms. After testing 66 roof top units on eight different buildings, set in eight different climate zones, the study showed an average 57 percent energy savings. [Source: W. Wang "Advanced Rooftop Control (ARC) Retrofit: Field-Test Results." July 2013.] This technology is particularly important as it addresses the small- and medium-sized commercial buildings that represent 60 percent of the existing building stock and 60 percent of commercial building energy consumption.

Buildings to Grid. *Olympic Peninsula Project—responsive building loads to improve grid reliability and resiliency.* One of PNNL's first experiments that evaluated the benefits of integrating responsive loads to improve grid reliability and resiliency took place in the Olympic Peninsula of Washington State. The primary issue was a 750 kilovolt transmission line that was constrained during winter peak periods, leading to voltage instability and the possibility of collapse. Building a new transmission line or new generation was not a viable option at the time; a non-wires approach was needed. The team, led by PNNL, included Bonneville Power Administration, three local electric power providers, IBM's Watson Research Laboratory, Invensys Controls, and Whirlpool Corporation. The project showed that an incentive signal sent to 112 homes with smart thermostats and appliances, along with two diesel generators—located at commercial building sites—and five municipal water pumps in the region could reduce peak load. The key R&D achievement was accumulating data showing that congestion stresses on a transmission line could be relieved using "smart" loads that respond to an incentive signal from the grid. Over the course of a year, the project resulted in average 15 percent reduction in peak load, up to a 50 percent reduction in total load for short periods, and approximately 10 percent average customer savings. [Source: D. Hammerstrom "Pacific Northwest GridWise™ Testbed Demonstration Projects." October 2007.]

Grid Benefits from Responsive Loads. *Pacific Northwest Smart Grid Demonstration Project—application of interoperable communication and control infrastructure using incentive signals to coordinate a broad range of customer and utility assets.* This project, supported by DOE's Office of Electricity Delivery and Energy Reliability, engaged multiple types of assets across a broad, five-state region and reached from generation through customer delivery. Assets included demand response, distributed generation, energy storage, and distribution automation. The project installed 30,696 smart meters—27,376 residential, 2,961 commercial, 359 industrial—and 12,822 feeder monitors for identifying fault locations, collecting over 350 billion data records over the course of the project. At the end of the project, participating utilities reported that smart meters eliminated 2,714 service calls, saving $235,000 annually. Reliability enhancements included 17 percent fewer outages, 12 percent shorter outages, and 353,336 avoided outage minutes. Fault detection reduced outage time from 119 minutes to just 51 seconds. [source: D. Hammerstrom "Pacific Northwest Smart Grid Demonstration Project Technology Performance Report." June 2015.] In just one community—Fox Island, in Washington State's Puget Sound—the local utility installed modules in 500 homes to help curtail the load of electric water heaters. During this project, one of the two cables providing electricity to the island failed, leaving the local utility with only with only 50 percent of its usual capacity. The utility was able to engage the modules to manage load throughout the winter—its peak demand season. The utility leveraged direct load control to turn water heater controllers on or off, preserving energy and avoiding power failure on the island.

Integration and Optimization of Multiple Buildings. *PNNL Campus Testbeds—integration of low cost sensors with open-source platforms, data analytics, and novel control algorithms to reduce energy across multiple buildings and reduce peak demand charges.* PNNL's Richland, Washington campus uses 94,000 megawatts of electricity at a cost of $4.9 million per year. In any given year, 30 percent of this cost is peak demand charges, reflecting consumption that in some way stresses the grid. With support from DOE's Building Technologies Office, the Office of Electricity Delivery and Energy Reliability, and the Washington State Clean Energy Fund, PNNL is using information from 9,000 sensors deployed in 12 of our buildings in addition to advanced control algorithms that manage how our campus uses energy. The instrumentation on our own campus generates 11 million data records per day, and more than 34 billion in the 18 months over which we've been conducting experiments. Our researchers apply several hundred different diagnostic algorithms to this data to monitor performance, identify and prioritize needed corrections, and initiate control actions that manage energy consumption. To date we have shown that we can reduce peak energy consumption by 10 to 20 percent in several buildings and have identified a number of operational changes to permanently reduce average energy consumption. We have also been developing and testing methods for managing building energy consumption as a response to a grid "service" request (e.g., a request from our utility to reduce load by a given percentage to reduce stress on the grid). We hope PNNL will become a national test bed available to all government agencies and private industry to increase building efficiency and improve grid reliability and resiliency.

In addition, PNNL has partnered with universities to extend the impact of our research. Washington State University is focusing on using on-campus generating and storage assets to provide power to critical City of Pullman, Washington assets—such as the city hall and police station—during sustained outages. The University of Washington in Seattle, Washington, is leveraging advanced data management and cloud-based data analytics to extend the suite of analytic capabilities available to support optimization of building operations. Case Western Reserve University is reviewing PNNL experiments, enhancing models and methods, and is replicating key PNNL experiments for validation. The University of Toledo is applying PNNL-developed control methodologies to coordinate building loads and batteries with a one megawatt photovoltaic array to mitigate stresses to the local grid resulting from variations in solar plant generation.

Technology barriers, research and development directions

I mentioned earlier that future building systems require technology that is low-cost, turn-key, interoperable and cyber-secure. In order to realize this goal, automated data collection, predictive data analytics, and real-time sensing and control solutions are needed. Specifically this entails:

- **Automatic collection of big data needed for optimizing building operations.** Today this is not available in 85 percent of commercial buildings and virtually all residential buildings. This limits the ability to optimize building performance and is a major barrier to providing information about building energy consumption status to the electric grid.

- **Advanced data analytic and machine learning.** New analytic methods are needed to convert building operational data into information that enable new insights about building performance and new, automated control actions.

- **Advance control theories.** The convergence of new sensing technology and much more affordable computing capacity can now support new, advanced control methods that were unimaginable before. Many theories are emerging, with early results suggesting great promise, but the complete suite of methodologies and the underlying theories are not yet adequately developed and have not been experimentally validated.

- **Stakeholder engagement.** DOE, national laboratories and industry stakeholder groups should work together to define mechanisms to address two barriers that, if removed, would accelerate innovation. The first is definition and consistent implementation of best practices as "default" control conditions rather than tailored solutions. The second is achieving the level of interoperability necessary to accommodate the anticipated profusion of connected devices that will reside in buildings all of which must be addressed by control and optimization systems.

- **Cybersecurity best practices.** Public-private partnerships should be created to help ensure that cybersecurity is built into all new systems and that appropriate cybersecurity best practices are developed and adopted by industry stakeholder groups. Further, such partnerships could define and implement risk-based approaches that address all aspects of the industry—from product development and integration and operation, to maintenance and "patching" of legacy systems. By considering the complete lifecycle of products, best practices can be used to add cybersecurity awareness, education, training of workforce, and supply chain of building automation products.

Conclusion

More advances in science and technology are required to capitalize on the coming technology and information revolution in buildings. Integrated and coordinated R&D will enable:

- Building systems that will be continually monitored and automatically optimized, a key step toward reduced building operating costs, and long-term energy savings while maintaining occupant comfort;
- Building systems that will be more resilient to off-normal events;
- The integration of large numbers of buildings over wide geographic areas, which in turn enables coordination of building loads with the grid at scale; and
- Security and resilience for all parts of the system.

Thank you again for the opportunity to testify on this important topic. I would be happy to answer any questions you may have.

The CHAIRMAN. Thank you, Dr. Virden.

Sometimes the numbers you are talking about is like it is make believe—it is just that amazing.

So, thank you, I appreciate that.

Mr. Grunau.

STATEMENT OF BRUNO C. GRUNAU, CHIEF PROGRAMS OFFICER, COLD CLIMATE HOUSING RESEARCH CENTER

Mr. GRUNAU. Well, thank you, Chairman Murkowski and thank you, Ranking Member Cantwell and other members of this Committee for the opportunity to talk. Thank you for your searing endorsement too.

It may not be obvious why a small, not-for-profit, research center from Fairbanks may be at the table. Our mission is for resilient, healthy, durable, sustainable homes in the North. We have a reputation for being reputable and relevant, and we're really connected to people. That's really our strength. We also have an extreme environment. We have some of the highest energy costs in the country. It's not evident that we're an oil and gas state, but we fly all of our oil out to these villages or barge them. So it's a great proving ground for energy efficiency and proving all this technology.

We have some of the best housing and some of the worst housing in Alaska, and energy efficiency impacts all of that. In some of the worst housing we have some of the highest upper respiratory rates in the nation, and it all has to do with how people are reacting to high energy costs.

So our focus at the research center is applied research. How quickly can we get this research to the ground, to demonstrate it? Kind of, our philosophy is, if you half—if you cut the demand in half then you're effectively doubling the supply, right?

Cutting the demand doesn't just save money for our families and our businesses, but it reduces the stress on our natural resources. It eases pressure on the grid. It makes us more resilient. It makes our communities more resilient to natural disasters, economic uncertainty. I mean, think about Puerto Rico, right? So building automation absolutely has a piece in this in concert with things like good building envelopes, this is the low-hanging fruit we like to talk about. Good building envelopes, good, efficient heating ventilation and cooling systems.

So how do we get this technology to the market? That's what I want to talk about. In fact, I'd like to give a give a quick example.

Alaska had a home energy rebate program. Great example. It is one of the most cost-effective programs, energy-saving programs in the state's history. It applies to new housing, existing housing, and it created an entire industry and a new economy.

So here's how it works: If you have a home, you're a homeowner, you pay out of your pocket for an energy rater to come in and they grade the energy efficiency of your house. They look at the windows and the insulation, the air tightness and the building automation-type systems and you get a grade on a scale of one to six—one being the worst and six being the best. Then the energy rater gives you a list of things—whether it's add insulation, air tight, increase air tightness, whatever it is. They give the user, the homeowner, the ability to pick and choose and this does a couple of things. They have to pay for it out of their pocket, up front, but it gives the ability of the homeowner to educate themselves on what's the most cost-effective way to go. And then when the rater comes back, you've got a five-star-plus or better, and the state reimburses us up to $10,000 on these costs.

So what's the effect of that? Our retrofit buildings, on average, saved 33 percent on energy use. So they use 33 percent less energy than their next-door neighbor. New housing is even better. New housing is anywhere from 40 to 80 percent less energy.

When the money stopped—of course, you guys know Alaska is in trouble financially—that energy, that program stopped, but the savings continue for the life of the house. Not only that, but it created a demand.

So now our builders—we raised the bar on our builders. And our builders didn't stop making good houses. So we actually have some of the best builders in the country because of this program.

My family and I, personally, took advantage of this when we decided to build our house. And we said, let's build a six-star house. And so, we took it an extra step and said, let's build it without fossil fuels, which is an accomplishment in the subarctic, and we had our paybacks, we had good insulation, good building automation controls and things of that nature.

But I'll tell you, the thing where it really hit most was when we lost power for an entire week a couple years ago. I didn't have to worry about my pipes freezing, my kids getting cold. I mean, there's no amount of money that can account for that level of stress that was alleviated. And that's where the passive systems really were the lowest-hanging fruit.

Quite frankly, if you can do this in Fairbanks, you can do this anywhere. That's pretty much why we did it. And also, we wanted to set an example.

It's not pie in the sky. It's achievable, attainable. The technology is here. It's getting better. And so, our question is how you adopt this in a larger fashion? I see this as the path to energy independence, to self-reliance, to resilient communities and healthy homes. Quite frankly, bottom line—this is preaching to the choir—is investing in energy efficiency has a permanent return on investment.

So I'd like to make the case today that we support research that advances energy efficiency through universities, National Science Foundation, et cetera. Support programs that get the technology adopted into these buildings, like the home energy rebate type of program, like programs that EERE are doing. Great work. And support education. And I don't mean just education, students going to school. I mean, building managers and homeowners. It's really important. Builders support the industry. We need to not just educate how this stuff works, but why is it important—because then you get that buy-in.

I look forward to the discussion, and I hope that our contribution is meaningful and impactful. Thank you.

[The prepared statement of Mr. Grunau follows:]

Written Testimony Prepared For The Senate Energy and Natural Resources Committee

For a Hearing to Examine Opportunities for Efficiency in Building Management and Control Systems

Presented by Bruno C. Grunau, PE, Chief Programs Officer
Cold Climate Housing Research Center
Fairbanks, Alaska

October 31, 2017

Introduction

I would like to thank Chairman Murkowski, Ranking Member Cantwell, and the Members of the Committee on Energy and Natural Resources for the opportunity to address the issue of energy efficient technology and programs.

Alaska presents some of the most extreme and varied environments on earth, from the arctic tundra to the Bering Sea, with hundreds of villages that are inaccessible by road and located far away from energy resources. In this environment, shelter literally means the difference between life and death. Compounding these challenges is the fact that Alaskans face the highest energy costs in the nation. These challenges have helped make Alaska a world leader in energy efficient building and technology. We would like to share several of the lessons that we have learned about building in the world's harshest conditions.

The Cold Climate Housing Research Center (CCHRC) has worked since 1999 to develop efficient, healthy, durable buildings for Alaskans and other northern people. Our housing designs integrate sound building science and advanced technologies to reduce energy costs by 80% over conventional construction while improving health and indoor air quality. Incorporating local and traditional knowledge about climate, architecture, and land use ensures housing meets the cultural as well as economic needs of the people.

Good housing is essential to a safe and healthy life. Yet in Alaska, tens of thousands of homes are cold, under-ventilated, and extremely inefficient. Rather than providing refuge from the elements, a large portion of the housing stock has become a financial burden and an actual health hazard to occupants. Unfortunately, those with the fewest resources are impacted the most, including Alaska Native infants and elderly, who suffer from the highest rates of upper respiratory disease in the country due to unhealthy housing.

CCHRC's deep experience working in both urban and rural Alaska has shown that building healthy, efficient homes is one of the best investments towards healthy, secure, and economically viable communities. Using proven building science and rigorously tested materials, we can dramatically reduce energy use while ensuring healthy indoor air quality for residents, with little additional upfront cost. This applies not only to homes but to commercial buildings and public facilities as well. For instance, CCHRC's facility in Fairbanks is the farthest-north LEED Platinum building on earth. It was designed and built to meet these standards at a cost equivalent to other commercial buildings in the region through close collaboration with the builder, designer and engineering, creating a cohesive team approach.

Lowering our energy demand not only helps families and communities; it also reduces the stress on our natural resources, eases pressure on the electric grid, and makes our communities more resilient to natural disaster and economic uncertainty. This testimony includes four examples of how energy efficiency has benefited Alaska families and businesses and recommendations for how the federal government can further that work:

I. The power of energy efficiency

The U.S. government spends billions of dollars on facilitating oil and gas production every year. The national security, social, and environmental issues stemming from energy production only add to the price tag. It is far more cost-effective and politically popular to address our energy demand. Reducing energy consumption in the built environment is a vast and untapped resource in the United States. In Alaska, we have seen how investing in better buildings has yielded energy savings and reduced greenhouse gas emissions at a very affordable price.

While energy production is vital to our economy, both nationally and in Alaska, investment in energy efficiency has the quickest return on investment. Consider, for instance, the savings of investing in more efficient lighting. On average, upgrading a 60-watt incandescent light bulb to a 10-watt LED will save about 110 kWh in a year. At the national average electricity rate of 10 cents per kWh, that is about $11 in annual savings. Considering that an LED costs about $3, one is looking at an annual return of about 370 percent. For comparison, investing in the oil industry typically produces about a 10 percent annual return for investors. The bottom line is: Investing in the simple energy efficiency upgrade results in reduced stress on natural resources and extraordinary financial benefits at the same time.

The benefits of efficiency can be shared across the spectrum. First, energy efficiency saves money for families. In Fairbanks, for example, the average family spends $8,000 a year to power and heat their home, nearly four times the national average. Investing in energy efficiency retrofits through building better walls, more efficient appliances, and building controls saves more than 30% on energy per year, paying for itself in approximately 8 years (source: Home Energy Rebate Program Outcomes Report, CCHRC and Alaska Housing Finance Corporation, 2012). Investing in energy efficient new construction yields even higher savings with an average of 40% - 80% energy savings over conventional construction. After that, energy savings accumulates over the life of the house.

Energy efficiency also saves money for government. Poor housing is a burden on public budgets. In Alaska, roughly $15 million a year is spent on low-income heating assistance (source: US Department of Health and Human Services, Office of Community Services, 2017) and an additional $31 million a year on power subsidies in rural villages (source: Alaska Department of Treasury). These are costs incurred year after year resulting in no substantive changes. For what is spent annually in subsidies could be used to invest in weatherization and energy retrofits to 7,000 homes. Weatherization not only saves money for government and homeowners, it also improves the useful life of buildings when sound building science is incorporated, creates jobs, and contributes to self reliance .

II. Low-hanging fruit

Of all energy used in the U.S. each year, about 40% is consumed by buildings, according to the Energy Information Administration. The energy usage is divided almost equally between residential and commercial buildings (Source: Annual Energy Review 2016. DOE/EIA-0383) A well-insulated, airtight, and properly ventilated building is the quickest way to reduce this energy consumption. For new construction, this can be done at a low additional cost. When it comes to retrofitting existing buildings, this approach requires upfront capital which, without government support, is only available to building owners with disposable income. Retrofits must be based on vetted building science in order to achieve energy goals and avoid health and durability problems (described in Part IV).

There are many low-cost measures that result in high returns on investment; replacing incandescent or fluorescent lighting with LED lighting can result in 400% returns. Implementing building controls and automation to heating and ventilation systems is another cost-effective way to save energy and lessen the overall demand on the grid. These systems must be installed by qualified technicians but can easily be operated by building managers. Examples include setback controls for HVAC systems and smart thermostats that can sense whether the building is occupied. These features, combined with a super-insulated building envelope, have made CCHRC's building the farthest-north LEED Platinum building in the world and runner-up for Siemens "Smartest Building in America."

III. Energy efficiency creates jobs and investment in our communities

As a state that is built on resource development, we have seen the impact of energy efficiency on the workforce in Alaska. Over the past 10 years, the State of Alaska has spent $716 million making energy efficiency improvements to nearly 20% of occupied homes in Alaska. Our home weatherization and energy rebate programs have saved homeowners 33% on energy bills annually. These long-term energy savings resulted in a 12% return on the state's investment, very competitive in today's economy. At the national level, weatherization programs have yielded about $4 in benefits for every dollar invested, according to the U.S. Department of Energy (Office of Weatherization and Intergovernmental Programs, Weatherization Assistance Program, August 2015).

Investing in energy efficiency creates jobs. In Alaska, the equivalent of 8,600 full-time jobs were created through the state's weatherization and energy rebate programs (nearly 6% of the workforce). In addition to the programs themselves, every $1 million in energy savings added 11 permanent jobs to the economy, according to a report by CCHRC and the University of Alaska Anchorage Institute of Social and Economic Research. That's an estimated 700 jobs. The economic impact would be amplified on a national scale. In 2015, Americans spent 6% of total GDP on energy expenses (including both the residential and commercial sector); that includes billions of dollars that could have otherwise circulated through the U.S. economy.

Throughout Alaska, CCHRC has worked with communities to design and build energy efficient, affordable demonstration homes using local labor and traditional knowledge. Thoughtful design informed by indigenous populations with thousands of years of experience living in this environment helped to significantly reduce the cost of construction. As a result, these homes use 80% less energy than other homes in the same communities, while also being healthier and more durable.

IV. Energy efficiency promotes grid security and resiliency

Energy efficiency lowers the cost of operating a power grid. As more homes and businesses come online, new capacity is required in the form of power plants, hydroelectric dams, or other generation facilities. Making buildings more efficient is far more affordable than building expensive new infrastructure.

In Alaska, the power system is especially vulnerable to wind, storms, icing and earthquakes, and stabilizing the grid requires a reliable backup system. Smaller building energy loads on the grid mean less expensive backup systems. In addition, efficient buildings are less vulnerable to power outages, especially in extreme climates with high heating or cooling loads. Tragedies like the deaths of eight elderly patients in Florida after Hurricane Irma last month may have been prevented if the building envelope had passive qualities that maintained an acceptable temperature, even without power.

V. Energy efficiency promotes health, financial security, and social equality

In general, upper- and middle-class families are the ones who have greater access to energy efficient homes and reap the benefits of lower fuel costs, greater financial security, and improved health. Lower-income households, on the other hand, are most burdened by energy costs and generally cannot afford to make efficiency improvements and investments.

When homeowners start feeling the crunch of energy prices, many take matters into their own hands by tightening the building envelope or adding extra insulation, especially in particularly hot or cold climates. Without a proper understanding of building science, however, these actions can exacerbate health and safety concerns. For instance, tightening up a building envelope without providing balanced ventilation can cause backdrafting of combustion appliances and release gases such as carbon monoxide into the home, resulting in severe sickness or even death. Adding certain amounts of insulation without a proper understanding of moisture dynamics can result in trapped moisture within the building envelope, a common cause of mold. This affects the durability of the house as well as the health of occupants. In these cases, it is essential that homeowners and building managers be educated about these issues or at least have access to professional help.

Unhealthy housing leads to other problems for occupants. Respiratory disease has been directly linked to poor indoor air quality, which could very effectively be addressed through well designed ventilation systems. With simple-to-use controls and homeowner education, these ventilation systems can provide fresh air to homeowners without significantly increasing energy costs, while alleviating the respiratory illness associated with poor air quality.

Access to healthy, efficient, and affordable housing promotes equality. Alaska has a history of inequality in housing. Since western housing was introduced to Native Alaskan communities that was inappropriate for the climate, social and physical health has deteriorated. Rural Alaskans typically do not have the resources or understanding of bureaucracy to create affordable, energy efficient, healthy homes for their villages. While housing authorities have made admirable strides toward meeting this need, they are at capacity and cannot generate the adequate housing to meet critical demand. Lack of housing in villages had led to overcrowding, compromised air quality, and reduced quality of life.

The Cold Climate Housing Research Center has worked intimately with communities to improve rural housing through addressing these systemic problems. A recent example involves a Yupik Eskimo family of 6 living in a 2 bedroom home with extremely poor air quality and no functioning water or sewer system. The majority of the household income was spent on heat and power bills. Because they were unable to obtain financing for a new home, they were forced to choose between their health and leaving their traditional village. Through a collaborative effort involving CCHRC, USDA's Rural Housing program, and the Alaska Native Tribal Health Consortium, the family was able to design and build a new, low-energy home that incorporates clean water and clean air. CCHRC has many other examples of these successes on its website at www.cchrc.org.

VI. CCHRC's Recommendations

New buildings can and should be designed to use much less energy than existing buildings at little additional cost. Attention to siting, building form, window properties and location, material selection and the incorporation of natural heating, cooling, ventilation, and daylighting are among the strategies we are using to achieve this end. After maximizing energy efficiency, a building's energy demand can be met or supplemented by renewable sources such as solar, photovoltaic, wind, biomass, and other viable sources. We recommend specific steps to move in this direction:

Continue funding energy efficiency programs. The federal government, through programs at U.S. Department of Energy, the U.S. Environmental Protection Agency, the National Science Foundation, and the U.S. Department of Housing and Urban Development must initiate and support programs aimed at energy independence. Part of this effort must: (a) target energy use reduction through increased efficiency and conservation in homes and other buildings, and (b) develop environmentally sound energy sources for buildings and communities. Partnerships that involve the private sector, along with universities and state agencies, are particularly well-suited to contribute real solutions. National support for transformative processes are already underway by groups such as the National Association of Home Builders (NAHB) and the many state and local groups focused on green building.

The DOE Weatherization programs provide a significant improvement in the older housing stock, reducing the annual gas heating bills by an average of 32% (see http://www1.eere.energy.gov/office_eere/pdfs/wap_fs.pdf). As CCHRC continues to advance retrofit strategies, the lessons learned by the weatherization agencies across the nation will be increasingly important to incorporate. Improvements in the health of children and adults with asthma and other respiratory conditions can also be made through applying appropriate ventilation and filtration standards.

Continue funding results-based research on building envelopes, heating and ventilation systems. These results are immediately utilized by building managers, homeowners, and builders across the country. Smart controls and building automation systems are part of this integrated approach, but this approach alone may not be suitable for mass implementation. Lower-hanging fruit (insulation, better lighting) will have a much greater impact for mass implementation. At the same time, we need to fund research institutions for advanced control systems so they can be easily integrated with existing systems.

Support education for building managers, homeowners, builders, and building energy technicians. Just because controls are installed does not mean they are used. For instance, the energy lost to ventilation systems in commercial and public buildings that run continuously could easily see 50% savings through setback controls already in place. While homeowners and building owners could also see drastic energy savings by applying setback settings and smart controls for their heating, cooling, and ventilation systems, a lack of understanding of the purpose of these systems often prevents their use.

In a survey conducted on public buildings across Alaska, a large number of buildings had advanced automation and control systems that were deliberately rendered inoperable by facility personnel. Such systems require training and understanding on the part of personnel or they'll just go to waste. It is essential that building managers, homeowners, builders, and building energy technicians are properly educated to understand the impact of energy-saving measures on their budgets and bottom lines.

Encourage public-private partnerships

Cooperative programs involving private-sector partners need increased funding by the federal government. Programs such as the Small Business Innovation Research (SBIR) and the National Science Foundation's Partnerships for Innovation (PFI), Healthy Homes, Weatherization, and others benefit from private-sector partnerships because they have the ability to leverage government funding into projects that address private-sector needs.

Encourage demonstration Projects

Demonstration projects are important to facilitate change in the building community. Even if the technology is well-proven among scientists and engineers, it is still crucial to educate builders and owners about better ways to design and construct buildings. The federal government must vigorously fund and support state and local efforts to demonstrate products and technologies that can make this change happen.

These critical research, development, and demonstration projects usually involve, in one way or another, the donation of equipment, materials, and labor from private-sector partners. This important private-sector contribution should be encouraged by offering tax incentives. Congress should consider tax incentives that encourage investment in projects that shift away from fossil fuels to clean energy sources. By engaging private-sector partners in this way, the burden of developing and expanding critical research in efficiency programs is not shouldered by industry or government alone.

A strong federal and state partnership can drive the development of new energy-saving, energy-generation and transmission technologies. Such an investment would not only benefit the U.S. population but also help develop a market for American technologies by inviting the developing world to see how America is solving its energy needs in rural and remote regions. Alaska could easily become the nation's showcase for distributed power generating technologies.

The CHAIRMAN. Thank you, Mr. Grunau.
Ms. West, welcome.

STATEMENT OF TRACY WEST, DIRECTOR, END USE, POWER DELIVERY AND FLEET R&D, SOUTHERN COMPANY

Ms. WEST. Thank you.

Thank you, Chairman Murkowski, Ranking Member Cantwell and members of the Committee. My name is Tracy West, and I'm a Director in Research and Development at Southern Company. I'm going to take you to the other side of the country, the hot, humid Southeast and talk about our projects today. We're just as enthusiastic, in a different way. So thank you for the opportunity to speak today.

Southern Company has operations in 19 states, serving over nine million gas and electric customers. Our assets include 44,000 megawatts of generating capacity, 200,000 miles of power lines, 80,000 miles of natural gas pipeline and 190 BCF of natural gas storage. Our mission is to provide clean, safe, reliable and affordable energy.

The R&D program at Southern Company includes developing the next generation of energy resources, modernizing our grid for resiliency and security, and creating new products, both in front of and behind the meter to benefit our customers. It is our job in R&D to paint a vision of what the future could hold 10, 20, 30 years out from a technology standpoint. We also take a shorter view by hardening these technologies in our research centers and our test beds, like the projects I'm going to talk about this morning.

We believe that buildings-to-grid integration can bolster the relationship between and the interaction between the customers and the utility. It allows us to meet our load with fewer peaking resources and cycling our online assets while increasing resiliency and flexibility of our grid.

Our Smart Neighborhood projects are an important part of our buildings-to-grid research portfolio. In 2014, we were discussing what a utility might look like in the future and what the customer of the future would expect from their utility. Some envision rapidly-advancing technology and changing economics driving the industry toward microgrids and distributed energy resources (DER), and from this distribution-driven model, the Smart Neighborhood concept was born. These Smart Neighborhoods simulate two scenarios for residential customers in a world where DERs and microgrids become key to powering the country. These projects consist of three main pillars: high performance homes; distributed energy resources; and buildings-to-grid integration.

The Smart Neighborhood project in Birmingham is the first large-scale project of its kind integrating connected technologies with DER assets to explore how these independently tested technologies can benefit both the customers and the grid. This neighborhood consists of 62 single-family homes with a community-scale microgrid owned and operated by Alabama Power. Next generation, high-efficiency heat pumps for HVAC are used. Heat pump water heaters will be used. There will be smart appliances connected to the home's energy management system. Home construction upgrades include items like triple-paned windows, smart outlets, LED lighting, high insulation. These homes will also include smart security features and connectivity.

This project aims to understand these high-performance homes and how to build them, determine programs and services for new energy solutions for our customers, evaluate community-scale microgrids, explore buildings-to-grid opportunities for load shaping and build relationships with the homeowners for real-world feedback.

The community microgrid is located nearby, and is comprised of solar panels, gas generators and battery backup. We will be able to island the community for a few hours or supply the grid. There's a lot of excitement around this project. Nearly all of the homes are sold and the first homeowner will move in before Thanksgiving of this year. The homeowners have signed a two-year agreement with Alabama Power for us to perform research on behalf of our stakeholders.

The second project is in Atlanta, and it's comprised of 46 townhomes that make up the first phase of a larger community build out. Each townhome will be equipped with rooftop solar, battery energy storage, connected heat pump water heaters and thermostats. This project is also customer-owned, behind-the-meter DERs and will be managed on behalf of the homeowner to reduce energy costs, improve comfort and supply energy to the grid as a resource. The goals are similar but also include understanding the impacts of rooftop solar battery storage, understanding the impacts of customer supplying energy back onto the grid, developing new methods to integrate rooftop solar battery storage and controllable devices. And this project should be fully developed in 2018; groundbreaking has just occurred.

I want to stress that these projects would not be possible without our partnerships with key stakeholders like Oak Ridge National Lab. The value of the Alabama project has been strengthened by working across the unit lines at DOE with both the Buildings Technology Office and the Office of Electricity. Smart Neighborhood also includes important collaborations with vendors, builders, EPRI and our customers—our homeowners.

Successes and obstacles from these projects will be applicable across the entire country as the Southeast sets the stage for future Smart Neighborhoods. As these programs develop and energy landscapes shift, Southern Company intends to lead the change to serve our customers and build the future of energy. We have the ability to study the integration and interaction all the way from the control center down to the water heater with these projects, and we are anxious to see what we learn.

Thank you for the opportunity to testify today. I'm looking forward to your questions.

[The prepared statement of Ms. West follows:]

Buildings-to-Grid Oversight Hearing for U.S. Senate Committee on Energy and Natural Resources

Written Testimony of Tracy West, Director, End Use, Power Delivery and Fleet R&D
Southern Company, 600 North 18th Street, Birmingham, AL 35203
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Chairman Murkowski, Ranking Member Cantwell and distinguished members of the Senate Committee on Energy and Natural Resources, my name is Tracy West, and I am a director in research and development (R&D) at Southern Company, overseeing the power delivery and end-use research programs. I would like to thank the Committee for the opportunity to speak with you today as we discuss buildings-to-grid integration and how these technologies can bolster the relationship and interaction between customers and their utility.

As you know, the U.S. energy industry is rapidly changing. Drivers include:

- Evolving customer expectations and choices
- New technologies
- Slow economic growth and reduced demand
- Reduced cost and growth of renewables, storage and other distributed infrastructure
- Changes in regulatory policy
- Stakeholder pressure
- New market competitors

Southern Company recognizes that accelerating technology development is more important than ever in this challenging environment. Since the 1960s, Southern Company has managed over $2.3 billion in R&D investment and remains the industry leader in the U.S. in research, development and deployment of innovative energy technologies. Over the past decade, Southern Company's leveraged R&D investment of $436 million has returned benefits exceeding $3.4 billion.

At Southern Company, we put our 9 million customers at the center of everything we do. From operations and maintenance to R&D, America's premier energy company provides 46,000 megawatts of generating capacity, 200,000 miles of power lines and 1,500 million cubic feet of combined natural gas consumption and throughput volume. And through a joint venture, Southern Company and Kinder Morgan share ownership of the 7,000-mile Southern Natural Gas pipeline system and are exploring future infrastructure development opportunities. Southern Company provides clean, safe, reliable and affordable energy through electric operating companies in four states, natural gas distribution companies in seven states, a competitive generation company serving wholesale customers across America and a nationally recognized provider of customized energy solutions.

Through an industry-leading commitment to innovation, Southern Company and its subsidiaries are inventing America's energy future by developing the full portfolio of energy resources, modernizing the grid for resiliency and security, and creating new products and services to benefit our customers.

Today I'm here to share with you Southern Company's buildings-to-grid efforts, and how we're building the future of energy through our diverse, innovative research, development and demonstration portfolio.

Buildings-to-grid communication and integration technologies could revolutionize the way we make, move and sell energy. So what exactly does it mean? Buildings-to-grid communication allows the utility to actively engage with end-use assets scattered across a geographic area, enabling utilities to meet customer demand while employing fewer peaking generation assets or cycling our assets and increasing the resiliency and flexibility of the grid.

I'd like to discuss a handful of our R&D projects currently underway in the buildings-to-grid space. I'm going to start with and spend the most time describing our newest buildings-to-grid initiative – the Smart Neighborhood projects.

Back in 2014, we were having conversations about what the utility industry might look like in the future. These conversations were bracketed by disparate views. On one hand, people thought the industry would remain the same with a focus on centralized power as the low-cost provider. Others recognized rapidly advancing technology and changing economics could drive the industry toward microgrids and distributed energy resources (DER).

As a result, the Smart Neighborhood concept was born.

Two Smart Neighborhoods were proposed to proactively simulate two scenarios for residential customers in a world where DER and microgrids become key to powering the country. The first focuses on a community-scale microgrid, where resources are shared and managed at the neighborhood level to provide cost savings through economies of scale. The second focuses on customer-owned, behind-the-meter DERs that are managed on behalf of the homeowner to reduce energy costs, improve comfort and supply energy to the grid as a resource. By implementing these projects now, we prepare ourselves to remain the energy experts and adapt to maintain our competitive advantage in the utility space. These projects consist of three main pillars:

1. **High-Performance Homes:** Building codes and appliance standards continue to drive energy efficiency changes throughout the country. In anticipation for these changes, these projects include technologies and building practices that are much higher than the

minimum of today. These high-efficiency construction techniques will model the energy performance of homes that will be the norm 20 years from now.

2. **Distributed Energy Resources:** DER assets on both residential and community-scales are a key component to these two projects. As DER costs continue to decrease, these projects allow us to study the impacts of solar panels, natural gas generators and batteries at the edge of our grid, while developing new strategies to integrate them seamlessly into real-time grid operations.
3. **Buildings-to-Grid Communication:** The third pillar is a way to integrate customer resources onto the grid by using their energy flexibility and thermal energy storage (in heat pump water heaters). This integration capability is enabled by the proliferation of low-cost and robust communications, as well as the widespread adoption of the Internet of Things. Shifting toward a utility that can actively engage with assets scattered across a large geographic area will enable us to meet customer demand while employing fewer peaking generation assets and increasing the flexibility and resiliency of the grid.

To continue providing value-driven solutions for our customers, we must understand the challenges and opportunities currently unfolding in the industry and how it impacts them. With that, these Smart Neighborhood projects are the first large-scale projects of their kind, integrating connected technologies with DER assets to explore how these independently-tested technologies can benefit both customers and the grid.

Alabama Power's Smart Neighborhood in Birmingham, Alabama, consists of 62 single-family dwellings and a community-scale microgrid located nearby. This project aims to:

- Understand high-performance homes and customer experiences
- Determine which programs and services can provide new energy solutions for customers
- Evaluate community-scale microgrids
- Explore buildings-to-grid opportunities for load shaping within a community-scale microgrid
- Build relationships with homeowners to obtain real-world feedback on new home technologies and future utility business cases

Georgia Power's Smart Neighborhood in Atlanta, Georgia, is made up of 46 townhomes that make up the first phase in a larger community buildout of an additional 224 townhomes and commercial facilities over the next several years. Each townhome will be equipped with rooftop solar, battery energy storage, connected heat pump water heaters and thermostats. The goal of this project is to:

- Understand the impacts of behind-the-meter rooftop solar and battery storage
- Understand the impacts of customers supplying energy back onto the grid
- See how highly-efficient townhomes perform
- Develop new methods to integrate rooftop solar, battery storage and controllable devices to benefit the homeowner and the grid
- Investigate how heat pump water heaters can be used for thermal energy storage

- Investigate future rate design models to incorporate new technologies and customer behaviors

Before concluding this discussion about our Smart Neighborhood efforts, I stress that these projects would not be possible without our partnerships with key stakeholders, research organizations and influencers across the industry. Through funding from the Department of Energy (DOE), Oak Ridge National Laboratory (ORNL) has been developing the control systems, VOLTTRON and CSEISMIC, for the Alabama Smart Neighborhood project. VOLTTRON is the home energy management system that will communicate with the water heater and HVAC systems, and CSEISMIC is the microgrid controller that will control the generation assets and communicate with VOLTTRON. The value of the Alabama project has been strengthened by working across unit lines at DOE. The collaboration between the Buildings Technology Office and the Office of Electricity has been key to enabling the success of this multidisciplinary project.

Successes and obstacles from these projects will be applicable across the country, as the Southeast sets the stage for future Smart Neighborhoods. With these projects, we will be able to envision tomorrow's homes, today.

While these Smart Neighborhood projects are gaining national interest, Southern Company is leading additional buildings-to-grid initiatives that include:

- **Sustainable and Holistic Integration of Energy Storage and Solar PV (SHINES):** This Electric Power Research Institute-led, DOE-funded project is integrating solar PV systems, advanced solar forecasting techniques, load management and energy storage with the power delivery network at three test sites across the country. Southern Company R&D and Gulf Power are performing a residential demonstration at two side-by-side Pensacola homes to better understand the capabilities of residential appliances to respond to grid and solar PV signals.
- **ORNL Grid Modernization Lab Call:** *Unified Control of Connected Loads to Provide Grid Services, Novel Energy Management and Improved Energy Efficiency.* This project looks at a way to upgrade the controls within small commercial convenience stores to use the flexibility and thermal storage capability of refrigeration for non-perishable items (soft drinks, etc.). Southern Company is working with ORNL and Emerson Climate Controls to develop, test and implement this control strategy within our footprint.
- **Integration of Responsive Residential Loads into Distribution Management Systems (IDMS):** In a partnership between ORNL, EPRI and other utilities across the southeast, Southern Company is investigating how a fully open standard-based technology framework can be integrated into our distribution management system. This project will allow us to understand different value streams that connected buildings can offer to the

grid and the appropriate internal function of control and hierarchy of priorities to gain the most beneficial implementation.

- **Water Heaters as Thermal Energy Storage:** We are deploying a small number of grid-interactive water heaters across our service territory to integrate them with our daily grid operations. The work will include open protocols for integration and may be expanded to proprietary algorithms and information exchanges to extract the most value from the water heaters as possible.

At the forefront of technology development for making, moving and selling electricity, Southern Company actively collaborates with other utilities, universities, U.S. government, national labs and vendors. Our leadership and vision helps invent real solutions for America's energy future. We are focused on meeting customers' energy needs today and building the future of energy as we anticipate tomorrow. With these buildings-to-grid projects, Southern Company will remain energy experts and adapt to maintain our competitive advantage in the utility space. As these programs develop and the energy landscape shifts, we intend to lead the change to serve our customers with clean, safe, reliable and affordable energy.

Thank you for the opportunity to testify today – I am looking forward to answering any questions you may have.

The CHAIRMAN. Thank you.
Mr. Wallace, welcome.

STATEMENT OF JOHN WALLACE, DIRECTOR INNOVATION, EMERSON COMMERCIAL AND RESIDENTIAL SOLUTIONS

Mr. WALLACE. Good morning, Chair Murkowski, Ranking Member Cantwell and distinguished members of the Committee. Thank you for the opportunity to appear before you and provide testimony related to smart building technologies.

My name is John Wallace, and I'm the Director of Innovation for Emerson Commercial and Residential Solutions located in Kennesaw, Georgia. Emerson is a $14.5 billion, global manufacturing and technology company founded in the United States 127 years ago. Emerson has over 80,000 employees and operations in more than 150 countries. Emerson's commercial and residential solutions business provides products and services for commercial and residential buildings including automation systems which manage HVAC, refrigeration and lighting, as well as other infrastructure within the buildings. Emerson's customers use our products and services to manage and optimize their operations including over $7 billion in energy cost and over $2 billion in food inventory, monitored and safeguarded every year.

HVAC, refrigeration and lighting systems account for most of the energy consumption in a typical retail building. Providing effective optimization and management of these systems is critical to the success of building operators, particularly for our retail operators facing thin margins and increasing competition.

Our multi-site retail customers face many challenges, including providing a safe, comfortable environment for shoppers, ensuring the safety of perishable food and minimizing their energy and maintenance costs across a broad portfolio of buildings. While more efficient equipment can be incorporated into new buildings, providing an easy way to lower energy cost, newer buildings are typically a very small part of a multi-site operator's overall portfolio.

To have the most impact, technologies must be developed that can easily be applied into existing buildings and provide an acceptable payback based upon energy, maintenance or other savings. Through the development of smart buildings, Emerson is working with our customers to lower operating cost while improving sustainability. The following strategies are being implemented to improve the viability of smart buildings: incorporating CO2 and other natural, environmentally friendly refrigerants in refrigeration systems; constructing, or planning to construct, buildings that leave clients with a net-zero, or near net-zero, energy bill as a test or learning prototype; installing onsite electric generation as well as energy storage methods to provide the ability to shift electric demand to non-peak hours; incorporating remote monitoring strategies using data analytics and diagnostics to identify issues; and utilizing internet, cloud-based services to ensure that perishable food is being kept at the proper temperatures throughout the supply chain.

Increasingly, various building equipment is being integrated into building automation systems that can optimize energy use as well as operational characteristics across the equipment within the building. The building automation system serves as the gateway that can coordinate various equipment within the building as well as provide a pathway to access remote services for the equipment from outside the building. For example, Emerson's building automation system, trade named Site Supervisor, integrates the equipment control, provides sensors to monitor key metrics within the building and uses IoT technologies to connect buildings to cloud-based services.

With the introduction of new technologies such as IoT, remote services and machine learning, new possibilities are emerging that enable smart buildings to not only optimize the operations of the equipment within the building, but also to react to and coordinate with other services outside of the buildings. Examples of these types of services include the Demand Response programs which provide some type of incentive to a building operator in exchange for the ability to lower instantaneous or peak demand for electricity.

Some of the challenges to the broader adoption of these types of programs include the mismatch between the load a typical building can shed versus the minimum shed amount typically established by utilities as a threshold to participate. Additionally, building operators typically must maintain normal operations during a shed event, thus choosing which equipment to turn off can be a difficult task. Newer technologies that provide building operators the ability to autonomously aggregate peak demand reductions across a portfolio of buildings, as well as shifting demand peaks, can provide smarter buildings and facilitate broader adoption of these types of programs.

The availability of newer technologies will increasingly enable our buildings to be managed in a smarter and more sustainable manner. Providing the ability for smart buildings to be connected with outside services offers new ways to optimize buildings and respond not just to the conditions within the building, but also to outside conditions and other conditions as well. As an industry, we look to incorporate these new technologies and we need to ensure that we maintain the appropriate balance between the local control of a building equipment and the external services that can optimize operations, not only of an individual building, but of a portfolio of buildings.

Emerson has shown a commitment to industry stewardship and will continue to work with our customers, national labs, universities and others to successfully develop and maintain smart buildings.

Thank you for providing me this opportunity to testify before you today. I will be happy to answer any questions you may have.

[The prepared statement of Mr. Wallace follows:]

Testimony of John Wallace

Director Innovation, Emerson Commercial and Residential Solutions

Before the Senate Committee on Energy & Natural Resources

Hearing to:
"Examine Opportunities for Efficiency in Building Management and Control Systems"

October 31st, 2017 at 10:00 AM

Good morning Chair Murkowski, Ranking member Cantwell, and distinguished members of the committee. Thank you for the opportunity to appear before you and provide testimony related to smart building technologies.

My name is John Wallace, and I am the Director Innovation for Emerson Commercial and Residential Solutions located in Kennesaw, GA.

I also serve as the Chair for the Air Conditioning, Heating and Refrigeration Institute (AHRI) Electronic Controls Section, the North American Food Equipment Manufacturers (NAFEM) Data Protocol Standardization Committee, and am a member of the American Society of Heating, Refrigeration and Air Conditioning Engineers (ASHRAE). In all, I have been involved in the development of technologies related to building equipment and systems (HVAC, Refrigeration, Lighting) for over 20 years.

Emerson background
Emerson is a $14.5 billion global manufacturing and technology company founded in the United States 127 years ago. Emerson has over 80,000 employees and operations in more than 150 countries. We pride ourselves on providing innovative products and solutions for customers in industrial, commercial and residential markets. Emerson's Automation Solutions business helps manufacturers maximize production and protect personnel and the environment, while optimizing their energy and operating costs. Emerson's Commercial and Residential Solutions business helps ensure human comfort and health, protects food quality and safety, advances energy efficiency and creates sustainable infrastructure.

We also provide products and services for commercial buildings, including automation systems which manage HVAC, Refrigeration, Lighting (HVAC/R/L), compression, and control technologies, as well as other infrastructure within buildings. Emerson's customers use our products and services to manage and optimize their operations, including $7 Billion in energy costs and $2 Billion in food inventory monitored and safeguarded every year.

Current State
HVAC/R/L systems account for most of the energy consumption for a typical retail building. Depending on the type of facility, refrigeration is typically 30 to 40% of the energy used while HVAC generally accounts for 20 to 30% and lighting 15 to 20%. Providing effective optimization and management of these systems is critical to the success of building operators, particularly for retail operators facing thin operating margins and increasing competition. Our multi-site retail customers face many challenges including providing a safe, comfortable environment for shoppers, ensuring the safety of perishable food, and minimizing their energy and maintenance cost across a broad portfolio of buildings. Through further development of smart buildings, Emerson is addressing these issues in a comprehensive strategic plan I will highlight shortly.

While more efficient equipment can be incorporated into new buildings - providing an easy way to lower energy costs - newer buildings are typically a very small part of a multi-site operators' overall portfolio. To have the most impact, technologies must be developed that can easily be applied into existing buildings, and provide an acceptable payback based on energy, maintenance or other savings. Additionally, smaller commercial buildings (10,000-20,000 square feet and below) typically have lower overall energy costs, which makes creating a payback based on energy savings alone very difficult.

Key Challenges in the Market
There is a growing expectation in industry that buildings should be operated in a more sustainable manner. Nearly every member of this committee has stated that they are looking to improve efficiency and lower energy costs for their constituents, and Emerson shares these concerns. Through the development of smart buildings, Emerson is working with customers to lower operating costs, while improving sustainability. The following strategies are being implemented to improve the viability of smart buildings:

a) Incorporating CO2 and other natural, environmentally friendly refrigerants in refrigeration systems,
b) Constructing (or planning to construct) buildings that leave clients with a net-zero or near net-zero energy bill as a test or learning prototype. These buildings are known as "net-zero" buildings,
c) Installing on-site electric generation as well as energy storage methods to provide the ability to shift electric demand to non-peak hours,
d) Incorporating remote monitoring strategies using data analytics and diagnostics to identify issues or malfunctions quickly before they materially impact operations,
e) Applying variable speed technologies to more closely match operation of HVAC systems to the actual conditions, and
f) Utilizing internet, cloud-based services to ensure that perishable food is being kept at the proper temperatures.

Increasingly, various building equipment (including HVAC/R/L) is being integrated into a building automation system (BAS) that can optimize energy use as well as other operational characteristics across equipment. The BAS serves as a "gateway" that can coordinate operation of various equipment *within* the building, as well as provide a pathway to access *remote* services for the equipment from *outside the building*. For example, Emerson's BAS (trade named Site Supervisor) integrates the equipment control, provides sensors to monitor key metrics within the building (such as energy consumption, food temperatures, HVAC/R performance, etc.) and utilizes Internet of Things (IoT) technologies to connect buildings to cloud based services.

Key needs related to smart buildings
Traditional equipment control approaches have tended to focus on optimization of the control algorithms that determine the operation of buildings systems (for example, a better control algorithm that would operate an HVAC system in a more efficient manner). With the introduction of new technologies such as IoT, cloud-based remote services, and machine learning, new possibilities are emerging that enable smart buildings to not only optimize operations within the building but also react to and coordinate with other services outside the building. Examples of these types of services include Demand Response (DR) programs, typically implemented by utilities, which provide some type of incentive to a building operator in exchange for the ability to lower the instantaneous "peak" demand for electricity. While DR programs have existed for many years, adoption of these programs (especially in the retail) has been somewhat limited.

Some of the challenges to broader adoption include the mismatch between the load a typical building can shed (as measured in Kilowatts, or KW) (i.e. by temporarily turning off lights, HVAC, etc.) versus the minimum shed amount (measured in Megawatts, or MW) established by utilities as a threshold to participate in these programs. Additionally, building operators typically must maintain normal operations during a shed event, thus choosing which equipment to turn off can be a difficult task. Newer technologies that provide building operators the ability to autonomously aggregate peak demand reductions across multiple buildings, as well as shifting demand peaks, can provide smarter buildings and more intelligence on the way these types of programs are implemented.
These technologies, coupled with proper incentives for the building operator, could help with the adoption of DR and other smart grid programs, and lead to a more efficient way to manage buildings as well as facilitate the incorporation of renewables and on-site generation capabilities. Emerson has participated in research programs with both Pacific Northwest National Lab (PNNL) and Oak Ridge National Lab (ORNL) to help research and test some of these new technologies -- generally referred to as transactive control.

Conclusion
The availability of new technologies as noted above will increasingly enable our buildings to be managed in a smarter, and more sustainable manner. Providing the ability for smart buildings to be "connected" with outside services offers new, potentially more effective ways to optimize buildings and respond not just to the conditions within the building but other conditions (such as real-time utility pricing) as well. As an industry, we look to incorporate these new technologies, and we need to ensure that we maintain the appropriate balance between local control of the building equipment and the external services that can optimize operations - not only of an individual building, but of a portfolio of buildings.

As noted above, Emerson's partnerships with the national labs help to ensure that the technologies are developed in a manner that makes deployment possible to existing as well as new building stock and meets the changing needs of the markets we serve. Emerson has shown a commitment to industry stewardship, and will continue to work with customers, national labs, universities, and others to successfully develop and maintain smart buildings. I believe new technologies are key to meeting market needs, and helping the nation's buildings become more efficient and sustainable.

Thank you for providing me this opportunity to testify before you today. I will be happy to answer any questions you may have.

The CHAIRMAN. Thank you, Mr. Wallace.

And thank you, each of you, for your contributions this morning.

I want to thank you, Mr. Grunau, for the discussion about the energy audits and the rebates that have allowed for, I think, some significant differences not only in people's homes but when we think about the audits for some of our public buildings.

I had an opportunity at AFN this year to focus on some of the ways that we are pioneering with some of the efficiencies, and I mentioned little things like an energy audit that Hoonah underwent. They realized that by changing out the lights on the docks at their little public swimming pool, they could save tens of thousands of dollars. At Craig, they did a simple walk-through of the little hotel there and the savings that they then realized. When you think about communities like that that are really operating on the margin, $10,000 means a lot to them and particularly a small little hotel that may be somewhat seasonal. So I think about the advantages that gives.

You mentioned healthy homes, and I think that this is something that—well, we are focused on cost savings that efficiency brings. We have been talking a lot in this building this year about health care and health care costs and some of the drivers. There was a study that came out not too many months back about health statistics with Alaska children, and you mentioned respiratory disease amongst young children, particularly in our villages. We have the highest rate of infant pneumonia, and so much of this is attributable back to the home and the fact that you have homes that are not adequately ventilated that in an effort to stop the leakage of the heat escaping, you plug every exit and thus you trap in just the bad stuff.

If you are living in a small house where you have a couple bedrooms and eight people living in the home, ten people living in the home, it is also the garage. So you might have somebody working on the outboard engine in the living room and you have fumes that are coming off. It is a reality that we face that we do not think about.

So I want you to just speak, just a moment here, to this aspect of healthy homes because, again, I think we do not understand how efficiency can actually allow the homes to be healthier for our families.

Mr. GRUNAU. Well, thank you for the question.

I'd like to add to your example. It's not just energy efficiency. It's energy efficiency based on sound building science.

So after the pipeline boom, a lot of the folks who came up here from the pipeline came from the Midwest and they built houses like they knew in the Midwest, right? Two-by-four type construction. When the price of energy was inexpensive it wasn't a big deal, but when the price of energy went up, then people started really feeling the crunch. And so, people kind of took matters into their own hands and would take maybe one or two inches of foam and put it on the outside of the house. Now what happens is that any moisture that's generated in the house no longer has an escape path—now it's trapped in the walls. So now you're generating mold, allowing mold to grow. It creates rot, and mold also inhibits our health, so there's that part.

Ventilation and overcrowding is just a key issue that, I think, can be addressed when people understand the importance of ventilation, importance of these systems, importance of building properly, making these energy retrofits properly. So the example you gave with regard to the plugging up the holes—I mean, if you're paying $8.00 a gallon for heating oil, you're going to save money any way you can. When people feel cold air coming in they're just going to plug it in. They think that's what's helping them.

With things that can happen, of course, is if someone turns on the dryer, now you're depressurizing the house. You can pull in exhaust gases from your boiler, now you've got carbon monoxide issues. Now you end up with some headline about this family that ends up in the hospital or worse.

How do we address it? The first thing we do is we try to go and inform the public, but we go to each of these projects, and just have this conversation with them. The resources are here and they're available, and for us it's a matter of outreach and having these communications.

The CHAIRMAN. A lot of education.

Let me go to, I think Senator Manchin was up first. I think, who is after Manchin? Senator Hirono is gone. Senator Franken? Oh wait, Senator Cortez Masto, you were first. Sorry about that. Please.

Senator CORTEZ MASTO. Thank you, I appreciate that.

Thank you for this conversation. I am very excited. I think this is our future—smart communities, smart buildings. The technology is going to be there for the future.

I support the Chairwoman and Ranking Member's Smart Building Acceleration Act. Senator Burr and I introduced in Commerce the Moving First Act, which is similarly focused on technological innovation, mobility and transportation for our communities and smart cities.

I am curious though, and I am going to open it up to all of you—what are our barriers? I appreciate, Mr. Grunau, the conversation about how do we get new technology to market, because I think that is going to be key to all of this and the affordability. What are our barriers? What do we need to be looking at to address this, to make sure we are moving in that direction?

Ms. WEST. I would say for Southern Company, the barrier is cost-effectiveness. Our rates are fairly competitive, at or below national average, and the paybacks are just not what you're going to get when you're in Alaska or California or the Northeast.

Senator CORTEZ MASTO. Anyone else? Same barrier?

Mr. GRUNAU. I'd like to just add to that.

It's often not just the payback, it's just the upfront cost. I mean, someone has got to pull it out of their pocket to do that. And if you're struggling to make rent, the last thing you're going to do is think about how to put in a smart thermostat.

Senator CORTEZ MASTO. So what can we do? Incentives? Grant programs? Programs for innovation to help supplement some of that cost? Is that what we should be looking at here in Congress?

Mr. GRUNAU. I think that's incentives, and the other thing is that when people start to see it and they start to embrace it and if your neighbor has it, then you have it. So, I think, just getting it out there and demonstrating it is a key solution.

Senator CORTEZ MASTO. Dr. Virden, did you have a comment?

Dr. VIRDEN. Yeah, Senator, I would add cost for sure, but it was 85 percent of the buildings that don't have automated control systems, you know, they really need it and they're not aggregated so it will take companies like Southern and others to aggregate those buildings so they can get the cost down so they can get the return on investment and consumers can see that return on investment.

So we have a disaggregated market and you really need turnkey solutions for this vision of a smart building where it's automated, as was said earlier. So it's turnkey, it's put in, it can do all the things that you want and it keeps the environment, the built environment, healthy and eventually both the utilities or others can see the value added and the consumer can see the value added.

Senator CORTEZ MASTO. Okay, thank you.

Dr. VIRDEN. And it gets more complicated the more you put more buildings together responding to a dynamic grid.

Senator CORTEZ MASTO. Well, no, and I appreciate the conversation that there needs to be this collaboration and it is not just government, it is private sector, it is builders, it is everybody coming together to really create these communities. And it is going to be a different type of collaboration, correct?

Dr. VIRDEN. Correct.

Senator CORTEZ MASTO. Yes.

Ms. WEST. Can I elaborate on that?

Because we are in the process of building and we are having to work extremely closely with these builders who don't understand how to build such a tight envelope. And so, we are there every day explaining and helping them, and then the vendors are also there, as well as the building company. All the subs have had to be brought up to speed, all of the vendors, I mean, this is a learning process for everybody.

Senator CORTEZ MASTO. Right.

Then can you talk about how you incorporate the cybersecurity piece in this because I imagine you are thinking about that as the interconnectivity of things——

Ms. WEST. Yes.

Senator CORTEZ MASTO. ——and how that can address, or the concerns with respect to it?

Ms. WEST. Yes, Senator Cortez Masto.

We are working through Oak Ridge, who is actually using VOLTTRON as the platform, and developing some software called CSEISMIC and that software will incorporate cybersecurity constraints because it is talking back to Southern Company's distribution grid. So we are trying to pull all of these components back together and the houses will have, well, they won't necessarily have cybersecurity, but they will have security components built on them as well.

Dr. VIRDEN. Yeah, I would add, VOLTTRON is the open-sourced software that's put on this device and it's the kind of name you get when you let a bunch of engineers choose a name.

[Laughter.]

This one has volts and Tron and there's actually a suit people wear.

But the point is, from a cybersecurity perspective, it's—we've got to raise the entire community and its best practices around cyber, its best practices in the vendor communities that supply all the, you know, the technologies. It's the cybersecurity of the systems, not just the technology, so there's a hardware, there's an IT portion and there's a controls portion. We're going to have to work through consumer groups and professional societies in partnerships to raise that cybersecurity best practices.

Senator CORTEZ MASTO. I appreciate that. Thank you.

Mr. WALLACE. Could I add too?

From the cyber perspective on a commercial side it is obviously top of the line for us as well as our partners.

I serve on a number of industry committees—AHRI, ASHRAE and others—and those committees are all looking at cyber and how we should be at the forefront of incorporating that into our products. I would echo it's really the whole ecosystem from the products themselves to how they're configured in the buildings and then how they're ultimately used. You have to take a very broad view of that.

Senator CORTEZ MASTO. Thank you.

Thank you, Madam Chair.

The CHAIRMAN. Thank you.

Senator Gardner.

Senator GARDNER. Thank you, Madam Chair. And thanks to the witnesses today for your testimony and time with us today.

Senator Warner and I have introduced legislation relating to the purchase of IoT devices when it comes to the Federal Government, the federal procurement process when it comes to any device. Our legislation would require that the device: one, disclose any known vulnerabilities, so if you are buying an IoT device we ought to know what those vulnerabilities are; two, there can be no hard-coated credentials like a pre-set, unchangeable password like the camera on your laptop being password 0-0-0-0; three, must use industry standard protocols, things like segmentation firewalls; and four, devices must be updatable, they must be patchable. It is pretty commonsense things. I don't think anything there really exceeds beyond, sort of, current cyber hygiene practices.

Does such a standard exist in the private sector, Dr. Virden? Ms. West?

Ms. WEST. I am unaware of a standard in the private sector right now, but we are putting in devices that are all up to whatever code that they're appropriate for, so——

Senator GARDNER. Dr. Virden?

Dr. VIRDEN. I'm not aware either. I think it's best practices at this point and, you know, we led through many of the smart grid demos, evaluating all the cybersecurity of federal proposals. So I really applaud you on that approach because I think that's what we need to do is keep raising the bar with our industry partners to get that, kind of, best practices.

Senator GARDNER. Dr. Virden, I just wanted to ask you, along those same lines, are we putting IoT devices that are, as you said, I think, automated control systems that are not patchable? Are we using IoT devices within our IoT devices, or automated control systems, excuse me, that are not patchable? Would you say that we are?

Dr. VIRDEN. Boy, I don't know of every automated system that's out there whether they're patchable, maybe some of my colleagues know that. And that's another area though where you need best practices so everybody understands the vulnerabilities and how to deal with them.

Senator GARDNER. Perhaps we can get to that question later. I just think those are some standard things that are very important that, again, they don't reinvent or dramatically refine or redefine what we are doing, pretty commonsense stuff.

Mr. Simmons, thank you. Welcome to the Committee. I have been active in promoting Energy Savings Performance Contracts (ESPCs). President Bush was very active in ESPCs, and President Obama had set a $2 billion goal of savings achieved through performance contracting. I believe they later expanded it to $4 or $5 billion.

I just want to talk to you about the role that DOE plays for performance contracting. What can be done to expand such energy efficiency measures and what kind of goals the Administration may be pursuing?

Mr. SIMMONS. Sure.

The very first thing I did, actually, when I became the Acting Assistant Secretary was to participate in the announcement of the new indefinite delivery, indefinite quantity, ESPC contract that authorizes up to $55 billion in ESPC contracts. There is not an Administration position on a goal going forward currently that I know of for ESPCs. There's obviously a lot of work that could be done.

In the past five years, I believe, there was $4 billion of work on ESPCs and that is fantastic. There was an LBNL report that said there was between, I think, $10 to $15 billion of possible federal work. So there are definitely opportunities going forward for ESPCs, and we will definitely continue to work with those in the future.

Senator GARDNER. I think when we talk about $55 billion worth of contracts, that is $55 billion of private sector dollars. That is not an expense to the Federal Government.

Mr. SIMMONS. Correct. Correct.

Senator GARDNER. That is actually taken up by the private sector creating private sector jobs and then the energy efficiency, in terms of gains to the taxpayers, that's $55 billion value-add to the U.S. taxpayers.

It is a pretty incredible opportunity for us, and I would encourage the Administration to continue your partnership in performance contracting.

Dr. Virden, just quickly. Puerto Rico, where the network has— if you had a Puerto Rico where the network had been built with smart meters, building efficiency, advanced building controls, control centers of operational viability . . . if we had a modern system based on what we have now, how different would the recovery process look going forward as to what it looks like today?

Dr. VIRDEN. Boy, I'm not close to the ground. If the infrastructure had survived, if you had all of those things, it would be faster. You'd have better situational awareness. You would understand where you were down and you'd be able to recover quicker from it. But it has to survive.

Senator GARDNER. Thank you.

One of the things I think is important in automated control systems, in the top we have energy efficiency.

We had a situation in Colorado where a company was designing efficient lighting but they were not replacing the whole light fixture. They could go in and actually retrofit existing fixtures and put an LED light or other type of light system within it. However, we had to work for some time getting that defined or getting that approach to fit within the Energy Star guidelines and guidances.

How much of the efficiency work that we carry out faces obstacles like that? We eventually did get that Energy Star certification, or qualification, but it was some time before that happened. How much of a challenge can, sort of, the regulatory obstacles be when it comes to getting a new energy efficiency product to fit within a program like Energy Star or perhaps other efficiency programs?

Ms. WEST. We have multiple mechanisms for assessing energy efficiency and then bringing them in front of our public service commissions. So it's a pretty rigorous process to get things approved. Could it be faster? Probably. Is it robust and well vetted? Yes.

I think as we have more and more options, we're going to have to find ways to streamline the process and remove some hurdles to accelerate this.

Senator GARDNER. Great. I would love to continue, but my time is expired.

Thanks, Madam Chair.

The CHAIRMAN. Thank you, Senator Gardner.

Senator Franken.

Senator FRANKEN. Thank you, Madam Chair, for holding this hearing.

You know, this is all win-win. It helps the homeowner or the building owner. Buildings use 40 percent of our energy, I think 75 percent of our electricity.

And there are a couple things here that I have been interested in for quite a long time. I am glad that Senator Gardner brought up Energy Savings Performance Contracts because there is, part of their financing——

[Laughter.]

Okay, a little physical humor from the Senator from Colorado.

But, you know, sometimes the financing of that is done by the energy service provider paying the new bill and you don't—there is no money up front, I mean, this is creative financing, but it works.

It seems like part of what is holding us back is the willingness to do this. One, we see a cut by this Administration for the Office of Energy Efficiency and Renewable Energy by 70 percent. That includes cutting the Building Technologies Office by 66 percent.

Mr. Simmons, your testimony focused on the important role of your office for the research and development of smart building technologies and the significant impact they have on healthcare—on energy savings. But the proposed budget would severely limit technological innovation and threaten the incredible research being done at the national labs. How can you reconcile these cuts?

Mr. SIMMONS. The budget is really focused on—the President's proposed budget is really focused on redirecting as much effort as possible on early-stage research and development where, you know, the Administration believes that that is the most appropriate federal role, that there is a lot of research to be done on that most basic research. But one important thing about the budget is that we really want to work with these people on the panel, for example, to take up the later-stage research and development, even if it's things that we're not funding, for things like demonstrations. So that is the, you know, that's what the theory of the budget is, is to focus our efforts on the early stage.

Senator FRANKEN. Yes, well, it seems harder to spend more money on the early stages if you are cutting the budget by 70 percent and then leaving nothing for this, which I started off by saying this is a win-win, and it seems like we need your office to be part of that. By cutting the budget for something that is so beneficial and so, sort of, common sense by 70 percent, that seems very counterintuitive to me.

I tried to push an energy efficiency resource standard, a national one. We do that in Minnesota, about half the states in the Union do it—every one of them has exceeded their goals. In Minnesota, utilities have to make sure their customers are using their electricity—what is it, 0.75 percent a year improvement? It is 1.5 percent in Minnesota. But I wanted to do this.

Anybody here, how do you think that would be helpful? Because what we have done is, in Minnesota, we have met those goals and it has increased retrofitting. It means the utility helps the target retrofits and does exactly the kind of work you all have been talking about. Anybody have an opinion?

Mr. GRUNAU. I'd support that, I mean, I like the concept of it.

There's—that talk happens in Alaska and there's always push back from people who say well, we're, you know, builders, for instance, having to live up to the standard. And there's also the enforcing it. We're just such a dispersed state. There were arguments against that, just from the government side, of paying for the cost of enforcing that out in the bush.

To me, personally, I think it makes sense to have a standard. I mean, in a way, the Home Energy Rebate Program I talked——

Senator FRANKEN. Let me just—I've got—I'm over.

Mr. GRUNAU. Sure.

Senator FRANKEN. Can I ask about weatherization?

The CHAIRMAN. Yes.

Senator FRANKEN. Why would we be cutting weatherization? The Weatherization Assistance Program helps low-income families make their homes more efficient and reduce energy costs, but the Trump Administration is proposing eliminating the Weatherization Assistance Program which is, Mr. Simmons, part of the office that you lead. How do you justify eliminating this when it helps low-income families save money on their energy bills and supports thousands of jobs?

Mr. SIMMONS. Sure. With that program, the theory is that that is money that is best for the states to take that role. It is state decisions in how that money gets allocated. It's money that comes from the Federal Government, goes through the states. Now, obviously, Congress has a different perspective on that program and that program has been funded and we will carry out, you know, obviously we will fund the program as we are appropriated money. The budget, the proposed budget is a proposal, but we are going to carry out Congress'—you know, how you appropriate money, we're going to carry that out.

Senator FRANKEN. Okay, thank you.

The CHAIRMAN. I think you will get the message loud and clear from this appropriator that we think weatherization funds are absolutely necessary, not just from the cold states, but from the warm states as well.

Senator Heinrich.

Senator HEINRICH. Thank you, Madam Chair, I could not agree more. I want to thank Senator Franken for bringing up efficiency standards and raise a related issue.

Mr. Simmons, as you know, last week Secretary Perry released the results of the President's required review of hurdles to domestic energy development. Now, as someone who comes from a state that produces a great deal of energy—oil and gas, wind, solar, you name it—I understand that we can argue about permitting and regulation and we argue about those things regularly on this Committee. But I find it somewhat incredible that this Department of Energy concluded that efficient appliance standards are somehow a burden on energy producers. Can you explain the logic behind this DOE conclusion that using less energy and saving consumers money in their appliances through these standards is somehow a burden on domestic energy production?

Mr. SIMMONS. Sure.

First of all, that statement, I believe, has to be read in the context of our statutory requirements, as in, in the context of the EPCA, the Energy Policy and Conservation Act. Under that, that is the Act that creates the Appliance Standards Program. Under that Act we are not, you know, we set appliance standards. As in we, the Department of Energy, sets appliance standards for——

Senator HEINRICH. Correct.

Mr. SIMMONS. ——refrigerators, microwaves, you know, many other things. And we, once those standards are set, we cannot backslide. We cannot reduce those standards.

So there is nothing in that memo that should be, like, implicating or suggesting that we are reducing, you know, reducing what those public standards are.

Senator HEINRICH. How is that a burden on producers?

We produce a lot of energy in New Mexico. Some of it goes into the transportation sector, but much of it goes into generation through natural gas generators, through putting clean, solar electrons onto the grid through wind generation. For any of those businesses, I do not understand how that is a burden.

Mr. SIMMONS. It isn't necessarily a burden for domestic energy production. It is, would, you know, there are some possible burdens on, you know, for—there are possible burdens on the American public that are looking to buy certain types of appliances. That's where the burdens would be, not necessarily on production.

Senator HEINRICH. Well, I think before we change statute, we should probably find actual burdens as opposed to possible burdens.

Shifting gears a little bit to those of you in the private sector. Mr. Grunau, Ms. West, as a general rule from your professional experience, is it cheaper today to achieve in the market a megawatt of reduced demand through energy efficiency or is it cheaper to bring on another megawatt or any other increment of additional generation?

Mr. GRUNAU. I mean it's, from the numbers we've done, energy efficiency is the quicker route to energy——

Senator HEINRICH. The cheaper route as well?

Mr. GRUNAU. Cheaper route, yes, cheaper route.

Senator HEINRICH. Do you have any numbers you want to share on that off the top of your head?

Mr. GRUNAU. I don't have any off the top of my head.

And if I could correct, I misspoke when I was saying—Alaska does have an energy standard, we just don't have an energy code.

Senator HEINRICH. Okay.

Mr. GRUNAU. My fault.

Senator HEINRICH. Ms. West?

Ms. WEST. I'm not sure we can agree on that.

Our power rates are pretty competitive and I think right now that we are still struggling from getting comparable cost from energy efficiency, but we will be happy to provide numbers for you.

Senator HEINRICH. It seems like the biggest issue here, at least from my experience in New Mexico and doing quite a bit of energy efficiency work when I was on the City Council there, where we had financed a number of issues like replacing lighting with LED lighting, with more efficient, up-to-date appliances and actually saving money as a result.

A lot of the challenge here, as I think it was alluded to by Senator Franken as well, is not that we cannot save money, it is finding an innovative, financial model to actually have that work for the individual consumer.

So if you are a utility you can aggregate a lot of things, and oftentimes that works to your advantage. But, if you just go back 10 years, when I put solar on my house in 2004 I happened to be refinancing my house, so I was able to make that work. I traded a bill, my monthly electric bill, for a small increment, cheaper increment, on my mortgage and was able to basically go net-zero in terms of production at my house.

But for a lot of people if they could trade $100 off their energy bill for paying some third party $80 a month or $50 a month or $75 a month, that would be a net gain for them. But there is not an easy way to do that, at least at the consumer level. The solar industry seems to have figured that out, in large part. How come we haven't been able to figure out that question of just innovative models, when the numbers do pencil out in a positive direction?

Ms. WEST. Part of it is our regulatory structure precludes us from being able to deal with that; however, we offer rooftop solar rates and we're just not finding the penetration. People just aren't signing up for them, because they're not finding it competitive in our service territory.

Senator HEINRICH. I am talking about energy efficiency. So if somebody can—a higher SEER number, you know, cooling system, more insulation, et cetera. Why isn't it easier to find a contractor who will basically trade a benefit on your electric bill for their paying for things that clearly reduce demand for the consumer?

It seems like those benefits are easy if you are a big company, but if you are an individual consumer nobody has cracked that market from a financial point of view.

Ms. WEST. Yeah, that's out of my wheelhouse.

Mr. GRUNAU. I'd love to find an answer for that for you. I have the same question myself. We don't see that up where we are either. Good point.

The CHAIRMAN. Thank you, Senator Heinrich.

Senator Hirono.

Senator HIRONO. Thank you, Madam Chair.

Mr. Virden, your testimony called for the creation of public-private partnerships to ensure that cybersecurity is built into all new building control systems and adopted by the building industry. Can you elaborate briefly on what you hope the partnerships would achieve that is not already happening?

Then in your view, is the Federal Government investing enough resources to address the cyber threat and are utilities and the smart buildings industry doing enough to address continuously evolving cyber threats?

Dr. VIRDEN. Well, thank you for the question.

As I mentioned in my written testimony, I think from an industry standpoint, when you start talking about smart buildings and linking buildings to the grid there's a lot of stakeholders who need to be engaged from a cybersecurity perspective. And perhaps, the grid is moving faster than the smart buildings, is relative to associations and stakeholders moving to cyber best practices.

But what I think needs to be done is we need to raise the cyber best practices in public-private partnerships with industries, the vendors community—it is a complicated ecosystem so you will need some convening power.

ASHRAE and others, I think, I believe have a subcommittee now that is looking at cybersecurity. So it's starting to move forward from a technology point of view. It also needs to move forward from a systems point of view and how hardware and technologies come together.

And I think DOE can play a fantastic role in helping to convene and drive this whole cyber agenda forward both in buildings and the grid and between the two.

Senator HIRONO. Is the DOE stepping forward to do that, especially in an environment where their budget is being cut?

Dr. VIRDEN. At least in the programs I am involved in, there are cybersecurity best practices being developed and there are partnerships being developed.

Senator HIRONO. So do you think that in terms of the best practices, though, should there be some government standards that would lay the framework for what should be happening or should we rely on something developing in the private sector or voluntary standards?

Dr. VIRDEN. Boy, standards are out of my area of expertise, but I do really believe that public-private partnership needs to elevate and we need to test and validate that our cybersecurity best practices are working. I think that's why and it's very important that you have that public-private partnership.

Senator HIRONO. I noticed some heads nodding. Are there other people on the panel who are more focused on the standards and the need for standards—especially in an ever-evolving scenario—because cyber doesn't stand still?

Ms. WEST. Exactly, Senator Hirono. I agree with everything Jud is saying.

I feel like, from an engineering perspective, we like our standards and think we know better than folks how to make the standards, but with cybersecurity, this is a different animal and we feel like we've got to have these private and public collaborations together to make it safe for everybody. So in this case, everybody needs to be working together to come up with these standards.

Senator HIRONO. So at some point we should have standards, but how long do you think that is going to take in an ever-changing environment?

Mr. WALLACE. Well, as I mentioned a few minutes ago, the industry committees that I serve on, the awareness is certainly there which is, to me, the first step. And there is a lot of activity now with ASHRAE and AHR and others to produce those standards and best practices.

I think the good news is that work is already happening. I think our, the customers that we serve are also aware of that and demanding that we pay attention to those kinds of issues to make sure that we're providing the proper responses and standards. But I think the industry committees are working and fully aware of the need to do that and are very close to having those kind of standards out.

Senator HIRONO. When you talk about the consumers that you work with, are you talking about the corporations or—we are not really focusing on individual homeowners are we?

Mr. WALLACE. My comments are related to the commercial, big companies that you would know and they're obviously aware. They have entire departments that are set up to address those things. So it's a little bit different than individual homeowners, certainly.

Senator HIRONO. So are we mainly focused on those kinds of corporate buildings, in terms of what we need to do because it is hard to envision, aside from things like energy efficiency appliances, that would be helpful to homeowners that in this kind of, you know, where you are talking about thousands of entities in the private sector.

Dr. VIRDEN. Well, I think yes, but it goes beyond that in that every technology we could put in our home that is smart, you have to work through the vendor chain that every IT or OT system that we would have in a building, information technology or operational, you know, technology, we would need to have best practices and industry standards.

So I think it's broad. And consumer products, you have some very smart consumer products, you know, plugging into your house as well. So it's got to be a broad group of stakeholders and we have to raise all practices so if someone comes into any of our houses and plugs in a bunch of new technology and software, we have confidence that, collectively, it's cybersecure.

Senator HIRONO. It's a daunting task.

Dr. VIRDEN. We can do it.

Senator HIRONO. Oh, good to know.

[Laughter.]

Thank you, Madam Chair.

The CHAIRMAN. Yes, it is good to know.

Thank you, Senator Hirono.

You know, when we talk about all of the smart technology, I think, we are also reminded that sometimes the weakest link here is us, the operators. Mr. Grunau, you mentioned in your written testimony that in a survey on many of the public buildings in Alaska, a large number of the buildings actually had advanced or control systems that were deliberately rendered inoperable by facility personnel. Talk to me a little bit about the human factor here.

I think we recognize that oftentimes we do have some pretty decent systems that could help us, but because we want to override that system because sometimes we do not understand the full benefits that that system can provide, that many times in Alaska, I think, we have folks coming in from the outside, installing something, leaving it without the appropriate training to the local people. Share a little bit with the Committee here—because it is not just in Alaska, it is all over—where we have systems that can allow us to do better, but we are just not as smart as our systems. Talk to me a little bit about the situation.

Mr. GRUNAU. Thank you for the question.

I think that this applies, not just to about building automation systems in schools and big buildings, but also, we've walked into plenty of homes where the ventilation systems are disabled because people just don't understand it.

A lot of times the decisions, at least on public buildings, the decisions to incorporate and adopt these building automation systems come from the top and the message and the importance of it doesn't always trickle down to the person who is actually having to push the buttons and monitor and maintain it. In many cases, those folks are there for a job and maintaining the building automation system is just a small part of what they have to do. And so, if it's—if they don't really understand the importance of it then they're going to prioritize it at a lesser level. In some cases we did see where they've just completely disabled, in that survey from 2012.

And again, in homes it's the same thing. Ventilation systems are often just unplugged, and it has to do with people just not understanding why they're there.

The CHAIRMAN. So how do we do a better job? How do we make sure that either as the homeowner you know and understand what it is that you have in your home or from a broader systems perspective that the training is more than adequate?

Mr. GRUNAU. Wow, I mean, that's a big question.

I mean in the communities our approach is to go to the communities first and say, hey, here's this project we're doing. We want your buy-in, we want your feedback, we want your input.

And so, for us to, you know, give a chance to incorporate traditional wisdom with 21st century technology, that is one of the ways we're able to do this in the villages.

When it comes to just building automation systems on the bigger scale and the commercial scale, it's just a matter of, I think, really training and having exposure for the people who are operating those systems and getting that, maybe it's through continuing education, maybe it's through, I mean, I don't know what the directions or the answers are for getting them that information but it needs to be addressed. It needs to be addressed.

The CHAIRMAN. Let me ask you, Ms. West, because you are trying to do this in a community or neighborhood there in Birmingham. What are the hardships here just in terms of the education or the training? What are you encountering?

Ms. WEST. I think it's everything that Bruno is saying, but I think that with the research we're about to undertake where we will have control of the water heaters and can use them as energy storage devices with the customers being able to override. We're trying to figure out how much interaction the utility should play to optimize, and can the utility have a role in trying to optimize at least the larger—the HVAC and the water heaters in homes and then let the homeowners deal with a lot of the other things. So maybe that's a direction——

The CHAIRMAN. Well, how difficult is that because I like to be able to control my thermostat——

Ms. WEST. And you should be able to.

The CHAIRMAN. ——and I do not want somebody to tell me what the temperature of my hot water is going to be particularly if I think that somebody is doing it downtown.

As a societal thing, is this just something that we are going to have to get over in order to gain these efficiencies? I will ask Mr. Wallace to join the conversation here, too, because from a big commercial perspective—one of the things that drives me crazy here, it gets so cold in this Committee room and we cannot control it.

Ms. WEST. So I'll just continue.

We will always allow the customer to have the last choice——

The CHAIRMAN. Okay, I like that.

Ms. WEST. ——if they want to override it. We will offer them cost incentives to let us do that and so we might preheat your hot water—so you still have hot water, it's just we might shift it, shift the peak for everybody and heat it early, so——

The CHAIRMAN. Mr. Emerson or Mr. Wallace?

Mr. WALLACE. I would agree. I think one of the challenges—I think you have a very good point about that.

We've seen and many times people install building automation systems and they tune them and get them really optimized when they are first installed, but over time as work needs to be done or technicians are in adjusting things, they don't really, necessarily, understand the impact of the overall system. So it can degrade over time.

We have programs where we've saved one of our clients over $7 million in energy savings over three years by remotely checking and monitoring and making sure that those erosions are not happening on that.

So I think there's really a couple parts to it. One of them is taking advantage of the new technologies, IoT or remote monitoring services, as well as really, as a manufacturer, making sure that we're designing products that are simple to use, they're not really complicated because I think that's a large part of it as well. The usability of that system shouldn't be complicated and somebody shouldn't need to have to worry about a lot of things in order to use the system itself.

The CHAIRMAN. Senator Hirono, did you have any more questions that you wanted to field?

Senator HIRONO. I am with you, Mr. Wallace, in terms of if the system is too complicated then there will be erosion and even in our own homes. I mean, I have an HVAC thing. I don't even touch it, it is like something bad might happen or—I think you have a lot of customers like that, Mr. Wallace, who once the system is turned on—my hot water, I also don't touch that thermostat either. It's like, it's there, it's working. That is all I care about. If anything goes wrong, I have no idea. We are living in an age where the user-friendliness of all of these products is very critical, I would say.

Thank you.

The CHAIRMAN. Just a couple last questions here and this one is directed to you, Mr. Wallace.

I was a little bit surprised when you stated in your written testimony that refrigeration accounts for a bigger chunk of a typical retail building's energy consumption than either HVAC or lighting. That one surprised me.

Given that, what are the issues that you are dealing with, with R&D, energy technology innovation, the building automation systems in general as it relates to the refrigeration piece?

Mr. WALLACE. Thank you very much for the question.

And yes, refrigeration, it is a surprise but depending on the type of building, refrigeration can be the largest part of it and the other part of it, as well, is refrigeration is a baseload. So refrigeration needs to be on to keep your food at the proper temperatures regardless of the time of day. We've invested a lot of R&D, in terms of how to build more efficient refrigeration systems from compression technologies to smarter control algorithms that are able to use advanced sensors to look at the actual conditions now and adjust the capacity of the system as well.

Those are all from an equipment level standpoint too, but we've also noticed and I think it's a fact that in many installations there could be some mechanical problem that is causing a degradation of the equipment itself. So, in other words, it's still keeping, you know, if you go to your local grocery store it's still keeping the food cold, but there's something that's just not right in that system and it's operating inefficiently, but it's being masked because of that.

So one of the areas that we're focused on is using new sensors, new technologies, many things, as Dr. Virden has talked about as well, to pull that data out and to run analytics and machine learning on top of that data to understand, is that system really operating as efficiently as it should be? It was installed one way. Is it really operating that way?

And I think those, combining those pieces together are part of the key going forward in terms of managing those systems more efficiently and understanding when something really has a problem and addressing it.

The CHAIRMAN. Mr. Simmons, did you want to jump in there?

Mr. SIMMONS. Sure.

One of, I think, the kind of exciting pieces of research that the Department of Energy has been working on, especially with Oak Ridge, is on essentially solid-state refrigeration. That's, obviously, essentially sci-fi, but then again, LED lights could be seen as, kind of, something out there and yet, here they are, lighting this room. But that type of next-generation technologies for refrigeration is something, is some of the research that we're doing and it's particularly happening at Oak Ridge. Just wanted to put that in.

Dr. VIRDEN. If I could add on to that, Senator?

The CHAIRMAN. Dr. Virden.

Dr. VIRDEN. I think it's so important about the automation and the simplicity and the transparency of technologies and the system of technologies that would go into buildings and the workforce that can install these systems and adequately train all of us to be able to operate them.

And the analogy I think about where I hope we'll get to with buildings, is our vehicles. So our vehicles are, you know, have a lot of computational horsepower, a lot of sensors on them. They're GPS tracked, soon they'll drive themselves, and we're all going to be very comfortable with that. I hope they're cybersecure. They're going to be the most expensive 20 square foot, you know, room that you could find. And we can do all the temperature control, but when we walk into our car each day, it's turnkey and we expect it to work. And when something goes wrong it comes up and then we take it to somebody to maintain it, if we don't change the oil.

We need to get our buildings to that point where it's automated, it's turnkey—problems, diagnostics are run. They either fix themselves or the right maintenance crew comes in and they're optimized so a room like this isn't cold.

The CHAIRMAN. Well, you have given me a good segway to my last question which was the role that electronic vehicles can play connecting with the issue of smart buildings.

We are going to be at that point where we are going to see an increased need for charging at night when everyone is at home and as you look to the variable loads, the variable supplies, the smart controllers that are going to be aiding our buildings to be more efficient.

How do you see electronic vehicles or electric vehicles playing into all this? How long before these vehicles really are viewed as our mobile storage devices? It sounds like you think there is a very key and a very integrated role here, but I am curious to know from the others as well.

Go ahead, Dr. Virden.

Dr. VIRDEN. Well, I don't know exactly when they're going to be ubiquitous, but their growth is happening. Battery costs are coming down. They're becoming more affordable so there's going to be more and more electric vehicles that are going to come out into the market.

But what's, for me, is really interesting when you think about smart buildings is our buildings may be generating power, you know, through PV. They may be storing power through vehicles plugged in at night or other energy storage technologies. They're going to be responding, you know, to grid signals to reduce loads.

So the entire operation of a building is going to change and the electric vehicles—it's going to be really interesting when you link it back to the grid. We did a study about 10 years ago of how many electric vehicles could you put on the transmission infrastructure of the grid. In some parts of the country you could put 100 percent of the light-duty vehicle fleet on the grid. And that's a good thing from an electric vehicle point of view.

Now your grids, running 90, 95 percent all the time as it provides, you know, that electricity to the vehicles that are charging in the middle. And on the West Coast it's a much smaller amount because we have a lot more renewables and hydros.

So the bottom line, it's going to change the dynamics of it considerably when electric vehicles start plugging into buildings or homes and we start managing that in large numbers.

The CHAIRMAN. Mr. Simmons.

Mr. SIMMONS. And there is, obviously, this is a very important area of research and we are working with a number of the national labs on this, with Idaho National Lab, Oak Ridge, PNNL, because not only are you talking about possible two-way flows from the, you know, from the residents into the cars and back again, but with the research that we're doing on extreme fast charging to be able to charge those cars very quickly. That uses an incredible amount of electricity in a short period of time.

I think, don't quote me on this, I thought from like, if I remembered the numbers correctly for just three vehicles, they'd be drawing one megawatt for a short period of time. That is a lot of electricity which, you know, this is some of the important work that we're doing in trying to figure out how to make that work, number one, for the vehicles themselves, for the batteries so that we can recharge batteries quickly. But then, to look at from an overall perspective, what does this mean for the grid and to try to look at what those implications are. So there's a lot of research going on, obviously, because of the massive changes we're seeing in vehicles and the energy space right now.

The CHAIRMAN. Ms. West, are you factoring EVs into your Smart Neighborhoods?

Ms. WEST. In this phase, we're not. But we fully intend, in future phases, we'd love to see EVs. And it's a very important part of our research program so, another piece of the equation.

The CHAIRMAN. And as far as Alaska goes, I always say, places like Juneau—island, operating off of hydro; Sitka—hydro, island; perfect for EVs. We just need to get more of them up there.

Mr. GRUNAU. Agreed.

The CHAIRMAN. Yes.

Mr. Wallace, care to comment?

Mr. WALLACE. No, that's really outside my area of expertise just a bit, but I do believe that that does play into the overall idea of how you manage the grid and how that the building loads can be shifted up and down based upon some of the changes to the grid from EVs and other areas as well.

The CHAIRMAN. Good. Very interesting.

Well, thank you all for your testimony this morning, your contributions in many different ways. It has been interesting, and I think we recognize that when it comes to efficiency opportunities we have a great deal within our buildings and our homes.

So thank you for your time this morning.

With that, we stand adjourned.

[Whereupon, at 11:33 a.m. the hearing was adjourned.]

APPENDIX MATERIAL SUBMITTED

Department of Energy
Washington, DC 20585

November 21, 2017

The Honorable Lisa Murkowski
Chairman
Committee on Energy and Natural Resources
United States Senate
Washington, DC 20510

Dear Madam Chairman:

On October 31, 2017, Acting Assistant Secretary Daniel R Simmons testified regarding new efficiency opportunities provided by advanced building management and control systems.

Enclosed are answers to questions submitted by Senators Ron Wyden, Debbie Stabenow and you.

If you need any additional information or further assistance, please contact me or Fahiye Yusuf, Office of Congressional and Intergovernmental Affairs at (202) 586-5450.

Sincerely,

Jennifer A. Loraine
Deputy Assistant Secretary for Senate Affairs
Congressional and Intergovernmental Affairs

Enclosures

cc: The Honorable Maria Cantwell
Ranking Member

QUESTION FROM CHAIRMAN MURKOWSKI

Q1. The vision of American businesses and families being able to save energy and reduce their energy bills automatically, and without negatively impacting comfort or productivity, is an exciting one. Where then, specifically, does EERE see its commitment to early-stage R&D fitting in with pursuing a Grid-interactive Efficient Buildings future? And how should cybersecurity concerns be addressed?

A1. The President's Budget Request supports early stage R&D around building sensors, controls, and modeling. These are critical to achieving a Grid-interactive Efficient Buildings future. Major research thrusts include the exploration of foundational materials fabrication approaches and communications algorithms of wireless sensor networks, as well as physics-based and data-driven models to develop algorithms for the next generation of distributed and autonomous control technologies and analytics. This early stage R&D provides the key building blocks for affordable, energy efficient buildings that are also secure and resilient.

As we pursue this R&D agenda, we share the concern about the cybersecurity of "smart devices" and thus are helping ensure that cybersecurity is fully incorporated in our work by closely collaborating with the Office of Electricity Delivery and Energy Reliability (OE) and other federal and private sector partners working in this space. This strategy allows us to leverage R&D investments and help ensure that cybersecurity approaches are integrated and aligned throughout the energy sector.

QUESTIONS FROM SENATOR WYDEN

Q1. American homes and offices are increasingly becoming "smart" through internet-connected thermostats, cameras, lights, home security systems and other devices. While this technology can improve our lives, these devices can also create serious problems, if they are not adequately secured. For example, in 2016, cyber-criminals launched massive denial-of-service attacks through a botnet, which was largely made up of vulnerable cameras and home routers that had been infected by hackers. Vulnerable devices in smart homes threaten the security and privacy of those who live in the home and others on the system.

Q1a. Mr. Simmons, how concerned are you about the security of "smart" devices sold to American consumers and businesses?

A1a. As our society becomes increasingly digitized, protecting American consumers and businesses from cyber-attacks and incidents is a top priority of this Administration. The Department is concerned about the security of smart devices and therefore is engaged in research with industry to understand the threat better and develop better levels of protection as industry brings to market new cyber physically secure, resilient systems.

Q1b. What, if anything, is DOE doing to ensure that smart devices, which can be a key enabling technology for systems-level energy efficiency gains, are not leaving American consumers and businesses vulnerable to cyber-attacks?

A1b. Energy Efficiency and Renewable Energy (EERE)'s offices contribute to cyber security solutions in their areas of responsibility and expertise. Within the Building Technologies Office, for example, the program has adapted to the building sector the Office of Electricity Delivery and Energy Reliability's Electricity Subsector Cybersecurity Capability Maturity Model (ES-C2M2), which was established to help the electricity subsector better understand their cybersecurity posture and make informed decisions to improve their cybersecurity capabilities. Those tools help raise the awareness and educate a business on its buildings' cybersecurity readiness, preparedness, and resiliency. Additionally, the Building Technologies Office has worked with trade groups and manufacturers to develop cyber security solutions for connected equipment that could one day find itself in products.

The National Labs also take steps to understand and address cyber security challenges. Working with industry, the National Labs developed solutions to help ensure that connected equipment maintains the features that consumers demand while helping ensure that devices could not be maliciously coordinated to cause utility disruptions or infrastructure damage.

Q2. With this year's series of devastating hurricanes, there is a renewed discussion about the role of energy efficiency and deploying distributed resources to improve local and overall grid resiliency.

Q2a. Mr. Simmons, how does the resiliency of our grid benefit from the extensive deployment of energy efficiency in residential and commercial buildings?

A2a. There are many opportunities to utilize more traditional building energy efficiency technologies to improve grid resilience. For example, well-insulated buildings will be able to maintain comfortable and safe conditions during a temporary grid outage for a longer period of time than buildings with poor thermal performance. Looking forward, in order to realize a vision of Grid-interactive, Efficient Buildings at scale not only requires systems to integrate buildings with grid operation and planning, but also new component technologies that can provide fundamentally greater flexibility and resilience. These next-generation technologies include water heater thermal storage, micro combined heat and power, and multi-function fuel-fired heat pumps, among many others.

Q2B. What role does energy efficiency have in recovery efforts after disasters such as Hurricanes Harvey, Irma, and Maria?

A2b. The repair, replacement, and rehabilitation of building envelope and mechanical systems damaged or destroyed during a disaster can offer opportunities to improve building energy efficiency, reducing future energy consumption and building operating costs. Materials and technologies that enhance a building's energy efficiency can also make the building more durable and resilient in the future. During a disaster, key components of the building envelope and mechanical systems may be damaged or destroyed, requiring repair, replacement or rehabilitation of the structure. After a disaster situation is sufficiently stabilized and people are safe, energy efficiency can reduce the operating cost of buildings by lowering energy consumption, and materials and technologies that enhance buildings' energy efficiency can also make buildings more durable and resilient in the future.

Energy efficiency can also enhance the ability of homes and businesses to withstand severe weather events, by reducing vulnerability to extreme temperatures. For example, homes that have been air sealed to reduce infiltration, air leakage, and are properly insulated have reduced heating and cooling loads. Reducing the building load lowers the demand for electricity and fuel supplies, which may be compromised after a disaster.

The Department of Energy (DOE) conducts research and has supported states and communities with post-disaster recovery. DOE also engages in pre-disaster planning to increase resiliency of homes and businesses. The National Renewable Energy Laboratory (NREL) provides support resources and services to assist federal, state and local entities with pre-disaster preparedness and planning, and post-disaster recovery and rebuilding, including opportunities to incorporate energy efficiency and distributed resources into disaster recovery efforts.[1] DOE's Building Technologies Office's (BTO) Building America program has sponsored research on installation methods and materials to provide flood-resistant materials and assemblies, such as wall and floor systems, that can improve energy efficiency while reducing impacts of water damage for homes and properties located in flood-prone areas.[2]

Q3. This hearing has explored the cutting edge in "smart" building technologies. This represents great progress in how we think about energy consumption in the building sector. But we ought not to lose sight of the importance of traditional energy efficiency programs such as building envelopes and individual components, products, and equipment.

Mr. Simmons, what role, if any, does DOE have in advancing energy efficiency in building energy codes and the appliance and equipment standards program?

[1] https://www.nrel.gov/tech_deployment/tech_assistance_disaster_resilience.html
[2] See: Building Science Corporation, 2007. Building a Durable and Energy Efficient Home in Post-Katrina New Orleans. Research Report -0704. https://www1.eere.energy.gov/buildings/publications/pdfs/building_america/building_post_katrina.pdf

A3. There are two major voluntary model building energy codes developed and updated periodically by consensus-based standards organizations: the American Society of Heating, Refrigerating, and Air-Conditioning Engineers (ASHRAE) Standard 90.1 applicable to commercial buildings and the International Energy Conservation Code (IECC) for residential buildings. Each time these codes are updated, DOE is obligated by the Energy Conservation and Production Act to make a determination, not later than 12 months after such revision, whether the revised code would improve energy efficiency in commercial or residential buildings, respectively, and must publish notice of such determination in the Federal Register. (42 U.S.C. 6833 (a)(5)(A) and (b)(2)(A)) DOE also provides technical assistance to States to improve and implement State residential and commercial building energy efficiency codes and to promote the design and construction of energy efficient buildings. (42 USC 6833(d)).

With respect to residential appliances and commercial equipment, DOE has authority under the Energy Policy and Conservation Act to establish and revise minimum energy efficiency or maximum energy or water use standards and test procedures applicable to covered products. Any new or amended energy efficiency or energy or water use standard must be designed to achieve the maximum improvement in energy efficiency or energy or water use that the DOE determines is technologically feasible and economically justified. (42 U.S.C. 6291 et seq.)

Q4. I understand there is a large potential for direct current (DC) technologies such as lighting and heat pumps to increase energy efficiency. DOE identified DC-driven HVAC systems as an R&D priority, but has not yet allocated resources to address this opportunity. These are huge opportunities for savings.

Mr. Simmons, what is DOE doing to help the federal government and private industry realize these savings?

A4. The Buildings Technology Office (BTO) has identified the potential of direct current (DC) technologies in its HVAC roadmap, stating that if successfully developed, DC-enabled HVAC systems could facilitate greater integration of distributed energy resources, including renewable generating sources, and reduce transmission, distribution, and conversion losses throughout the current electricity infrastructure. The Department has done several things in the past to capture this potential. This technology was included as a research focus in the HVAC roadmap and several technical reports. The Department has also targeted this topic area with several funding opportunity announcements (FOAs), Buildings Energy Efficiency Frontiers and Innovation Technologies (BENEFIT) 2015 and BENEFIT 2017. Several of these alternatives to vapor-compression technology in residential and commercial HVAC applications funded by DOE are potentially DC-driven solutions, e.g., electrocaloric heat pumps and electrochemical compression (ECC). This topic area in general and DC-driven HVAC systems as outlined in the HVAC roadmap continue to be highlighted as potential FOA topics. In addition, BTO is currently funding two projects to measure, characterize and validate the energy savings impact of DC technologies across building end uses with the National Renewable Energy Laboratory and the Lawrence Berkeley National Laboratory.

DOE's Advanced Manufacturing Office (AMO) Program supports early-stage R&D efforts in DC technologies through the Next Generation Electric Machines (NGEM) program. The NGEM program is an early-stage R&D effort leveraging recent technology advancements in power electronics and electric motors to develop a new generation of energy efficient, high power density, high speed, integrated medium voltage (MV) drive systems for a wide variety of critical energy applications. The NGEM program will facilitate a step-change that enables more efficient use of electricity, as well as reduced drive system size and weight, developing lasting capabilities for motor material development and design that will reduce industry's energy footprint while supporting U.S. global competitiveness.

QUESTION FROM SENATOR STABENOW

Q1. According to the U.S. Energy Information Administration, the industrial sector accounts for approximately 32% of the energy used in the United States, just shy of the 40% of energy consumed by residential and commercial buildings.

What research is the Department conducting to enhance the efficiency of our nation's industrial and manufacturing sectors? How would these efforts be impacted by the $1.4 billion in cuts that the Administration has proposed in FY2018 to the Office of Energy Efficiency and Renewable Energy?

A1. The Fiscal Year 2018 (FY18) request reflects the Administration's focus on early-stage research and development The Department of Energy (DOE)'s Advanced Manufacturing Office (AMO) Program works on early-stage research with universities, laboratories, companies (for-profit and not-for profit), state/local governments, or consortia groups through merit-based peer-reviewed R&D activities for manufacturing process, information, and materials technologies essential to the efficient and competitive domestic manufacturing of energy products and to support energy productivity across the entire U.S. manufacturing sector. AMO's early-stage applied R&D technology areas are organized around a set of major, high potential impact focus areas that have scientific knowledge gaps applicable to manufacturing and energy. The program supports early-stage research on manufacturing technologies through three different modes: individual R&D projects, collaborative R&D consortia, and technology partnerships that inform subsequent research activities as well as provide a vehicle for field verification research, knowledge dissemination, and transfer of novel manufacturing technologies.

AMO technical focus areas target early-stage research needs that, when adopted by industry for further development, will improve energy efficiency and productivity of manufacturing process, information and materials technologies. Examples include Critical Materials, Novel Sensors and Process Controls, Grid and Resource Integration in Manufacturing, Sustainable Manufacturing, and Advanced Materials. American ingenuity combined with free-market capitalism have driven, and will continue to drive, tremendous technological breakthroughs. In spurring future advances, Federal funding of research and development programs and research infrastructure can play a crucial supporting role.

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Questions from Chairman Lisa Murkowski

<u>Question 1</u>: You have talked about – and submitted in your written testimony – the concept of "optimizing" building operations. Not just designing a building that is capable of doing things in an energy efficient way, but actively optimizing its operations.

- Please elaborate briefly on the concept of building optimization and give us a sense of the scope of efficiency gains that might be attainable through optimizing buildings as they are right now?

  <u>Answer:</u> Operation of various devices and systems could be significantly improved using monitoring data to provide information about their state of operations, applying diagnostic algorithms to assess how to improve operation, and using integrated control strategies that optimize the building as a system. Based upon analyses and field experience, we would expect efficiency gains of as much as 30 percent, along with reduced operating and maintenance costs and improved building comfort for occupants.

- How can we overcome the barriers limiting our ability to optimize building performance? For example, if automatic data collection is not available or a legitimate concern for cyber security delay market penetration?

  <u>Answer:</u> The cost of sensors and computing have declined significantly in recent years, enabling researchers to consider control and optimization strategies that were previously not cost-effective. A concerted research effort is needed to fully develop these optimization strategies, including leveraging state-of-the-art analytic methods such as machine learning. Then these concepts must be translated into operational technology and be extensively tested and evaluated in real-world buildings so that the efficiency, economic and comfort benefits can be validated. This must also include addressing the security of these new control technologies.

<u>Question 2</u>: The story of VOLTTRON is ongoing, but would you please share with us the VOLTTRON story from its inception through today, the importance of open-source in its development, and what is coming next for it?

<u>Answer:</u> VOLTTRON began as an internal Pacific Northwest National Laboratory (PNNL) research project, originally intended to provide a platform for conducting new kinds of control experiments using large numbers of devices, known as "agent-based methods for distributed control" in the laboratory. The potential benefit of using this method of control in buildings became clear about three years ago and the Department of Energy (DOE) began investing in development of the VOLTTRON platform at PNNL. The open-source approach enabled a wider research community to simultaneously contribute to its development, which accelerated the pace

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of innovation and enabled many organizations to take advantage of it capabilities. With recent release of VOLTTRON Version 5.0 the plan is to transition VOLTTRON from the DOE research environment to a non-profit open-source entity to ensure the long-term support and maintenance of a commercial version of VOLTTRON.

Questions from Senator Ron Wyden

Question 1: DOE estimates that miscellaneous electric loads (MELs) -- which includes things like power adapters, pool pumps, computer equipment, and televisions -- account for roughly 30-36% of primary energy use in residential and commercial buildings. And MELs are projected to grow rapidly.

Dr. Virden, what is the state of the industry when it comes to addressing this portion of our building energy consumption?

Answer: Monitoring, managing and optimizing the energy consumed by MELs is not economically possible with current technology. There is increasing awareness of the importance of MELs and emerging research interest in this field.

What role can a systems approach and the use of systems-integrated energy efficiency technologies play in controlling and managing these electric loads?

Answer: Developing technologies that enable monitoring and management of all systems within a building, including plug loads, has significant potential to better manage these loads, and provide monetary savings. However, targeted research to improve the energy efficiency of many of these MELs devices is also important, particularly consumer products that have high stand-by energy consumption or that are equipped with constant-drive electric motors.

Question 2: There is increasing discussion about the ability of grid-interconnected buildings to increase energy efficiency at the systems-level.

What technology advances and policies are needed to realize these energy savings?

Answer: Future building systems require technology that is low-cost, turn-key, interoperable and cyber-secure. In order to realize this goal, automated data collection, predictive data analytics, and real-time sensing and control solutions are needed that can be easily deployed in existing buildings. Further, we need new technology capable of coordinating large numbers of devices, even large numbers of buildings, with the grid in a cost-effective way. We are currently working on some of these technologies and evaluating them in buildings on the Pacific Northwest National Laboratory (PNNL) campus.

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Questions from Chairman Lisa Murkowski

Question 1: It would seem that customer preferences are changing along with the energy industry. From your company's perspective, what drives the changes in your approach to buildings and their energy use going forward? How far ahead do you try to look and prepare for? Is building energy use maturing to the point where the government intervention will be less of a factor?

Our approach to buildings and energy use is driven by a few key factors:

Advancement in technology: As technology develops for heating, cooling, and ventilation systems, building envelopes, building automation, lighting, and appliances, so to do the recommendations for best practices for buildings and their energy use.
Industry: Our approach is also driven by feedback from the building industry and their willingness to embrace building energy codes and sound building practices.
Physical health of occupants: Buildings can directly affect the physical health of their occupants. For instance, aging occupants or people with respiratory issues will want healthy indoor air; people with high health costs need stable energy costs; those with mobility issues require age-in-place housing; carbon monoxide death may spur legislation to mandate detectors.
Energy Costs: As far as the market is concerned, energy costs generally drive the demand for energy efficiency.

From a practical standpoint, our organization evaluates technology that is either currently available or no more than 5 years out - and that is technology that looks extremely promising or has high return on investment. We focus on technologies with payback periods within 10-15 years or less. With climate change, we are trying to anticipate issues that may affect buildings (such as thawing permafrost) in the decades to come.

Regarding government intervention, there are a few considerations. Up-to-date building energy codes that support energy efficiency would reduce the need for government incentive programs that are currently in place to encourage energy efficient buildings. If the law mandates minimum building codes, it levels the playing field for builders.

However, research and education are the best way to advance energy efficiency. Research advances technology and sound building practices, ensuring a healthy, durable housing stock in the future. Education is the key to having the building industry adopt new technologies and building practices. Unfortunately, since free market systems almost never support research and

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education, some level of government support is essential to ensure we keep up with emerging technologies.

Government intervention and regulation will continue to be required, as there are several key inefficiencies in the residential building market that need to be addressed:

Building energy use metrics. There is a lack of a transparent, standardized way to compare energy use between buildings for homebuyers. Often energy efficiency is not visible at all in the purchasing process, and consumers can't properly value what they don't know about. For example, while more than 30 percent of occupied homes have received an energy rating that quantifies it's efficiency, generally these ratings are not available in the MLS systems in Alaska. Even in places where high-performance home ratings such as Energy Star are listed on MLS, often they are wrong. A study by the Northwest Energy Efficiency Alliance found up to 90% of the listings that purported to be certified as Energy Star or Earth Advantage homes were erroneous.

Home ownership versus energy efficiency investment. There is a disconnect between the economics of energy efficiency for an individual homebuyer and society. The average home is owned for 5.9 years, whereas the average life of a home is 62 years and has been increasing over time. Thus even efficiency upgrades which have a 10 percent return on investment that will continue for many years will not be implemented in many cases because of the short time span of the economic considerations of consumers.

Existing housing. The replacement rate of housing in the U.S. is fairly slow, so the majority of housing units are existing homes, most of which were built prior to energy efficiency being incorporated in building codes. Retrofitting homes has a high upfront capital cost and would benefit tremendously from government-funded research, financing options, and rebate programs.

Government programs that encourage energy efficiency across new and existing buildings rather than programs that reduce the cost of energy in the short term are the best way to lessen future need for government intervention.

Question 2: Energy efficiency has provided plenty of success stories across our state, but I am interested in your perspective on the unique challenges that your Center faces in its quest to improve the housing stock in rural Alaska. You must consider variables that don't challenge many home builders and designers in the lower 48 probably – issues such as using local labor

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Questions for the Record Submitted to Mr. Bruno C. Grunau

and traditional knowledge, incorporating indigenous populations with thousands of years of experience living in those environments and climates into your designs. Please tell us why and how community and culture are so much at the forefront of your home design considerations.

Community and culture are indeed at the forefront of our building design process. As you know, the development of rural Alaska has largely occurred without adequate input from local communities. For decades, projects have come to rural communities without local hire or community involvement. Big rural projects like power houses, water and wastewater systems, and public buildings have historically been designed by Outside firms that have no relationship to the communities, their values, lifestyle, or visions for the future. These projects have often burdened communities with tremendous maintenance costs and technical failures. If this approach continues, future generations will grow up in a place where nothing works, where people are leaving, where communities depend on government funding and subsidies, and where there is no sense that the community belongs to those who live there.

We want to change that. When projects come to us, we involve the community through every step of the design and construction process. Our first step is to visit the community and learn from them what their needs are, and work with them to develop an appropriate design. This inclusive process continues through construction. Our goal is to merge traditional knowledge about climate and architecture with 21st-century technology. Challenges that may not be evident to an outsider include costliness and maintenance issues involving piped water and sanitation systems in areas with permafrost, homes in thawing permafrost regions, and the need for cold storage space for subsistence foods. Also, it is important to use locally available parts and materials so systems can be repaired quickly and easily, even if that means not using the most technologically advanced, lowest capital cost, or most efficient appliance. Home designs that are best-suited for the wind-driven rain of southwest Alaska may not be suitable for a community on the North Slope with extreme cold (20,000 heating degree days a year). The people and place should inform the design. For instance, we need to consider who will be living in the house and design for aging-in-place or occupants that fall outside the government concept of an immediate family unit.

In our rural work, every project uses local labor to the greatest extent possible, cultivating job skills in carpentry, mechanical systems, and construction management that can add value to the workforce. This also ensures that the community has workers that are capable of performing future maintenance tasks. After every project, we continue to engage with the community to monitor the performance of the home and the occupants' comfort with systems. We have found that local labor and traditional knowledge are key to the long-term success of any housing or infrastructure project.

TO: Senator Lisa Murkowski, Chairman, Senate Committee on Energy and Natural Resources
FROM: Tessie Mernick, 1501 6th St, Boulder, CO 80302
HEARING: Full Committee Hearing to Examine Opportunities for Efficiency in Building Management and Control Systems
SUBJECT: Development of Statewide Building Efficiency Standards Through the Adoption of New Building Code Policies

Dear Senator Murkowski,

I have become invested in the outcome of the Full Committee Hearing to Examine Opportunities for Efficiency in Building Management and Control Systems[1]. While I fully support the implementation of advanced building management and control systems, I argue that much more can be done in the built environment concerning the increase of energy efficiency improvements. I propose new building efficiency standards to be required in every state through the development of new building codes. In order for these types of policies to be fully implemented, support will be needed from all stakeholders involved, including state government, property owners in the real estate industry and local businesses. Proper execution of energy efficiency building codes will create new jobs, decrease overall utility expenditures for the consumer and cut climate-changing pollution[2]. These benefits will help earn the support from the stakeholders required to pass building energy efficiency code legislation.

Mandatory energy efficiency policies will require businesses to lower their annual energy consumption, which is a guaranteed way of decreasing overall utility expenses. Those in opposition of putting building efficiency codes into effect claim that the policies will require the property owner to invest in numerous green infrastructure projects, imposing high costs when the

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[1] *Examine Opportunities for Efficiency in Building Management and Control Systems.*
[2] Carter, Sheryl. "Energy Efficiency Jobs: Nearly 1.9 Million and Growing."

owner may lack the capital to cover those projects[3]. While it is true that energy retrofits typically require a large expense upfront, the return on investment (ROI) pays off in cost savings over time. Additionally, the installation of energy efficiency equipment can substantially improve a property owner's bottom line[4]. According to a report conducted by the Pacific Northwest National Laboratory (PNNL) for the U.S. Department of Energy (DOE), there is a clear correlation between states that currently have to comply with energy disclosure ordinances and a potential for energy savings opportunities[5]. (See Appendix I). PPNL attests that "energy code compliance is crucial to realizing savings potential" and notes that in the first part of their residential building study "states realized more than 100% of expected savings for codes that had been adopted."[6] When more strict energy codes are embraced, the potential for cost saving increases.

In a recent case study, WegoWise, a software company used for tracking and benchmarking energy and water consumption and cost, helped verify 42% energy savings for WinnCompanies, the 5th largest multi-family management company in the US[7]. WinnCompanies invested around $245,000 in an electric retrofit project at one of their properties in 2012[8]. The company installed LED light fixtures, upgraded the buildings heating system and inserted solar panels on the roof. WinnCompanies was able to track the impact of the retrofit project and found a decrease in energy consumption by 42% annually, resulting in $51,557 saved in electric costs per year[9]. The company was able to earn ROI in just five years. It is important to share stories likes these amongst stakeholders to enable them to see how property owners that are

[3] Bloomberg, Michael, and Carl Pope. *Climate of Hope*. Pg. 170
[4] Kramer, Merrill, et al. "Property Owners Increasingly Embracing Energy Efficiency Technologies."
[5] U.S. Energy Efficiency Potential Maps. *Department of Energy*, Pacific Northwest National Laboratory, 2016.
[6] Athalye, RA, et al. *Impacts of Model Building Energy Codes*.
[7] WegoWise. "Case Studies: WinnCompanies."
[8] WegoWise. "Case Studies: WinnCompanies."
[9] WegoWise. "Case Studies: WinnCompanies."

incorporating energy efficiency strategies into their business plans are finding significant cost saving opportunities.

For organizations that lack the capital to make large retrofit investments, there are a growing number of incentive programs to foster energy retrofitting projects. Property Assessed Clean Energy (PACE) allows loans to be taken out by property owners to fund efficiency upgrades[10]. There are also programs that acknowledge organizations that have committed to sustainability like the Fannie Mae Multifamily Green Rewards Program and the Freddie Mac Multifamily Green Advantage Program, which both provide discounted or additional loans to Leadership in Energy and Environmental Design (LEED) certified properties[11]. There is a diverse range of options for property owners to choose from when starting to plan for efficiency upgrades. By creating new policies to impose strict building efficiency codes in states, more organizations will be encouraged to make smart energy retrofit investments that will strengthen their economic growth in the long run.

Compliance with new building efficiency codes will require extra time and effort by the property owner. The task of gathering, submitting and reporting energy data can be accomplished efficiently by creating new jobs in the workforce. Sustainability reporting is a tedious task and having a dedicated staff member will save an organization money and resources. Energy efficiency related careers have already surpassed the number of positions in the oil and gas drilling industry with a whopping 1.9 million US jobs[12]. It is projected that there will be an additional 250,000 jobs related to energy efficiency in the next year[13]. In a National Resource

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[10] Bloomberg, Michael, and Carl Pope. *Climate of Hope. Pg. 113*
[11] U.S. Green Building Council. *Policy Brief - LEED and Multifamily Green Building Financing Incentives.*
[12] Carter, Sheryl. "Energy Efficiency Jobs: Nearly 1.9 Million and Growing."
[13] Carter, Sheryl. "Energy Efficiency Jobs: Nearly 1.9 Million and Growing."

Defense Council article, Sheryl Carter declares that "strengthened local, state and federal efficiency policies…could create many additional energy efficiency jobs, further reduce harmful pollutants from power plant generation, strengthen the electricity grid and lower energy costs for everybody."[14] From Carters statement, I believe building efficiency codes could end in a win-win situation for all stakeholders involved by increasing the American job market with an energy efficiency workforce.

Sustainability reporting is only one of the job opportunities that will come out of new building code policies. Energy waste is an incredibly expensive result of aging infrastructure in buildings. From single paned windows to old boiler systems, upgrades can make a considerable difference to the overall utility spend of an organization. Once organizations start planning energy retrofitting projects, they will need to consult with local construction companies to install upgraded insulation in windows and walls and communicate with factories that manufacture ENERGY STAR certified products[15]. An increase in demand of efficiency and construction services will boost the local economy and grow the market for efficiency related jobs.

Fortunately, the infrastructure is already in place for property owners to submit energy data in order to comply with future efficiency building codes, making the policy easier and more efficient for states to adopt. The Environmental Protection Agency's (EPA) Portfolio Manager is a free online database used for compliance reporting and utility consumption and cost data can be directly entered into the site. A number of states already have ordinances in place requiring public organizations to disclose their energy data to the general public (See Appendix II)[16]. As

[14] Carter, Sheryl. "Energy Efficiency Jobs: Nearly 1.9 Million and Growing."
[15] Carter, Sheryl. "Energy Efficiency Jobs: Nearly 1.9 Million and Growing."
[16] IMT. "Map: U.S. Building Benchmarking and Transparency Policies." *Institute for Market Transformation*, Institute for Market Transformation, 2017, www.imt.org/resources/detail/map-u.s.-building-benchmarking-policies.

one can imagine, the accessibility to energy data can stimulate competition amongst property management companies. This is especially true in the multi-family residential space, where tenants are increasingly determined to live in a "green" building for the added health benefits and for receiving lower utility bills than other inefficient buildings. The account firm Deloitte conducted research to discover why building owners were adopting more energy efficiency technologies and concluded that of the sampled businesses, "79% view reducing electricity costs as critical to maintaining a "competitive advantage."[17] The drive to be one of the top energy efficiency organizations in the US can be energized by compliance with building efficiency codes and disclosure ordinances.

While advanced building management and control systems can certainly be adopted by companies to help them monitor their energy consumption and catch inefficiencies, a higher level of energy efficiency standards can be set if new buildings codes are enacted in each state. DOE has identified that "effective compliance and enforcement unlocks deeper energy savings, reduced costs, higher building resale value and minimized environmental impact."[18] By creating policies that are supported by numerous stakeholders, we can steadily and effectively increase energy efficiency, decrease the bottom line for property owners, and slash carbon emissions in the built environment.

Sincerely,

Tessie Mernick
Graduate Student, Masters of the Environment Program
University of Colorado, Boulder

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[17] Kramer, Merrill, et al. "Property Owners Increasingly Embracing Energy Efficiency Technologies."
[18] "Building Energy Codes Program." *Department of Energy*.

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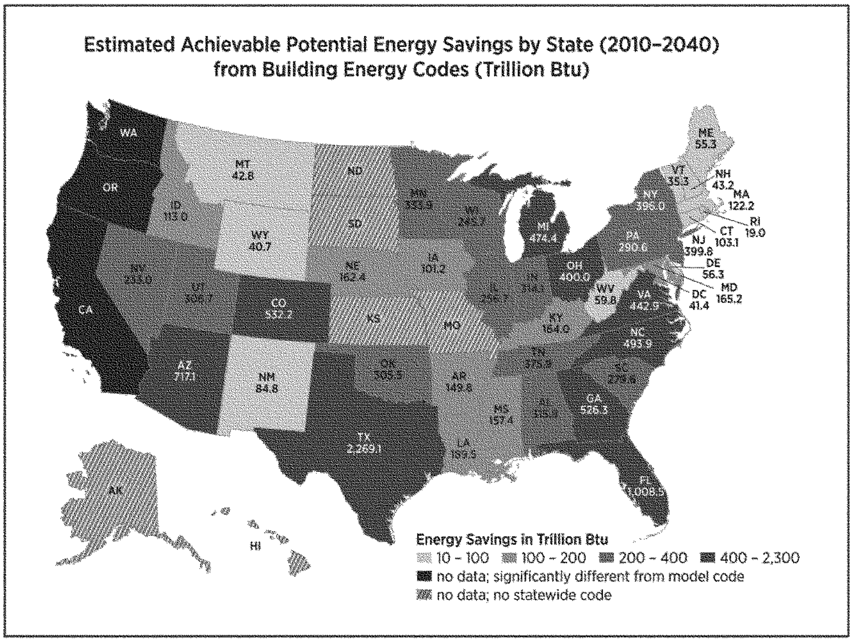
APPENDICES

APPENDIX I – Map generated by the Pacific Northwest National Laboratory (PNNL) for the U.S. Department of Energy in the Impacts of Model Building Energy Codes Report (2016)

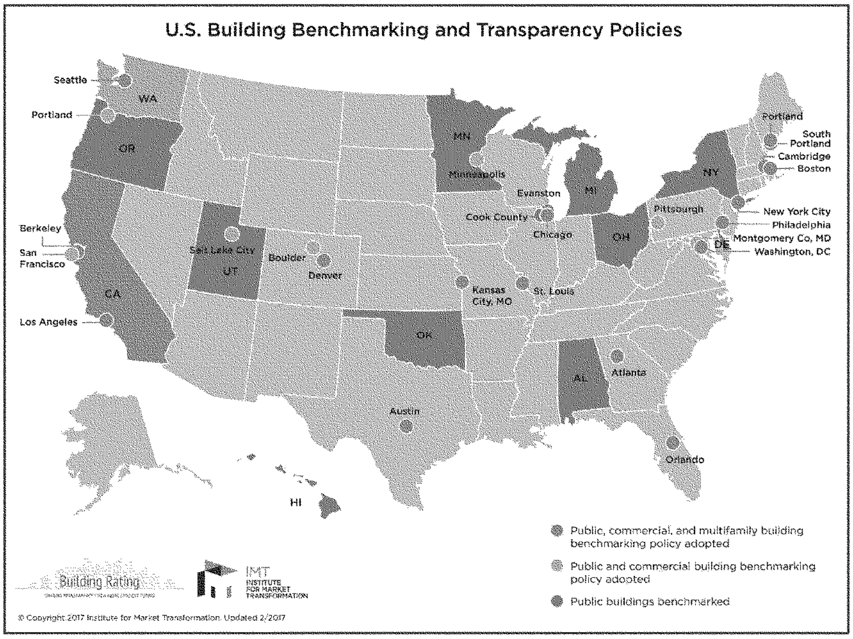


More data from the PNNL Report[19]:

- Total energy savings: 12,824 trillion Btu (2040)
- State-level energy savings: 19 to 2,269 trillion Btu per state in 2040
- Total cost savings: $125.93 billion (2040)
- State-level cost savings: $26 million to $21.87 billion per state in 2040
- Total CO2 reduction: 840.94 million metric tons (MMT) (2040)
- State-level CO2 reduction: 1.27 to 149.33 MMT in 2040

[19] Athalye, RA, et al. *Impacts of Model Building Energy Codes.*

APPENDIX II – Map of the U.S. Building Benchmarking and Transparency Policies, generated by the Institute for Market Transformation[20].



[20] IMT. "Map: U.S. Building Benchmarking and Transparency Policies."

Southern Company

Research & Development

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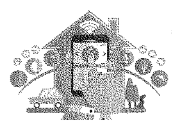

From this project, Southern Company will better understand high-performance homes, smart technology and the interactions between a neighborhood, community-scale microgrid and the existing electric grid.

Smart Neighborhood™

Southern Company is partnering with Alabama Power, Signature Homes, Oak Ridge National Laboratory and technology vendors to develop Smart Neighborhood – a state-of-the-art community of 62 homes in Birmingham, Alabama, featuring high-performance homes, internet-enabled automation, smart devices and a community-scale microgrid.

The energy for this neighborhood will be provided by the existing electric grid and a community-scale microgrid, composed of solar panels, battery storage and backup generation.

Throughout this two-year research project, energy usage and performance data will be collected and analyzed to:

- Understand high-performance homes and how customer experience is improved
- Determine which programs and services can provide new energy solutions for customers
- Evaluate microgrid technology and its interaction with the neighborhood and the existing electric grid
- Build relationships with homeowners to obtain real-world feedback on new home technologies and future utility business cases

Construction will be completed in spring 2018.

Southern Company · Alabama Power · SMART NEIGHBORHOOD · Signature Homes

Oak Ridge National Laboratory · Rheem · Carrier turn to the experts · vivint.SmartHome

PowerSecure · SAMSUNG · AT&T

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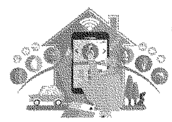
Southern Company

Research & Development

REVOLUTIONIZING THE FUTURE OF ENERGY



From this project, Southern Company will better understand high-performance homes, smart technology and the interactions between neighborhood distributed energy resources and the existing electric grid.

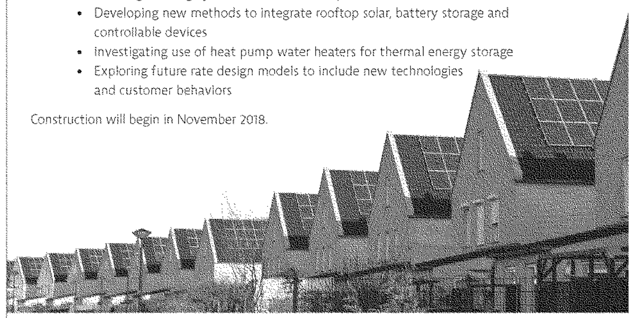
Smart Neighborhood™

Southern Company, Georgia Power and partners are developing Smart Neighborhood – a state-of-the-art community of 46 townhomes in Atlanta, Georgia, featuring high-efficiency construction, distributed energy resources (DERs) and buildings-to-grid communication. Each home will be equipped with rooftop solar, battery energy storage and connected heat pump water heaters and thermostats.

Research will focus on customer-owned, behind-the-meter DERs managed on behalf of the homeowner to reduce energy costs, improve comfort and enable energy management with the grid. Goals of the two-year project include:

- Understanding impacts of behind-the-meter rooftop solar and battery storage
- Evaluating impacts of customers supplying energy back onto the grid
- Learning how highly efficient townhomes perform
- Developing new methods to integrate rooftop solar, battery storage and controllable devices
- Investigating use of heat pump water heaters for thermal energy storage
- Exploring future rate design models to include new technologies and customer behaviors

Construction will begin in November 2018.



Southern Company Georgia Power SMART NEIGHBORHOOD™

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