

EXAMINING THE MACROECONOMIC IMPACTS OF A CHANGING CLIMATE

HEARING BEFORE THE SUBCOMMITTEE ON NATIONAL SECURITY, INTERNATIONAL DEVELOPMENT AND MONETARY POLICY OF THE COMMITTEE ON FINANCIAL SERVICES U.S. HOUSE OF REPRESENTATIVES ONE HUNDRED SIXTEENTH CONGRESS FIRST SESSION

SEPTEMBER 11, 2019

Printed for the use of the Committee on Financial Services

Serial No. 116–48



U.S. GOVERNMENT PUBLISHING OFFICE

42–316 PDF

WASHINGTON : 2020

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EXAMINING THE MACROECONOMIC IMPACTS OF A CHANGING CLIMATE

Wednesday, September 11, 2019

U.S. HOUSE OF REPRESENTATIVES,
SUBCOMMITTEE ON NATIONAL SECURITY,
INTERNATIONAL DEVELOPMENT
AND MONETARY POLICY,
COMMITTEE ON FINANCIAL SERVICES,
Washington, D.C.

The subcommittee met, pursuant to notice, at 2 p.m., in room 2128, Rayburn House Office Building, Hon. Emanuel Cleaver [chairman of the subcommittee] presiding.

Members present: Representatives Cleaver, Perlmutter, Heck, Vargas, Gottheimer, San Nicolas, Lynch, Garcia of Illinois; Stivers, Lucas, Williams, Hill, Emmer, Gonzalez of Ohio, Rose, and Riggleman.

Ex officio present: Representatives Waters and McHenry.

Also present: Representative Casten.

Chairman CLEAVER. The Subcommittee on National Security, International Development and Monetary Policy will come to order.

Without objection, the Chair is authorized to declare a recess of the subcommittee at any time.

Also, without objection, members of the full Financial Services Committee who are not members of this subcommittee are authorized to participate in today's hearing.

Today's hearing is entitled, "Examining the Macroeconomic Impacts of a Changing Climate." I now recognize myself for 3½ minutes for an opening statement.

I think before I get started on my 3½ minutes, I will do this, because today I think we probably ought to pause to recognize and remember that it was on this day that our nation was attacked. I remember clearly that day, as most of us do. And the thing that happened from that attack that I have some appreciation for was what happened to the American people. All of a sudden, there was a level of unity in the country that I had not seen before, and, tragically and painfully, I have not seen it since.

I was asked to do the opening prayer for the game between the Kansas City Chiefs and the New York Giants on that Sunday afterward. It was one of the most amazing things. The Chiefs lost the game, but nobody was interested in being angry. It was the first time I have ever seen in, Arrowhead, people helping each other. People left their lights on, and people were helping to get other people's cars started. There were no fights.

The firefighters opened up the game with an unplanned running up the steps with American flags. There were 72,000 people in Arrowhead, and probably half of them had teary eyes. I think the tragedy brought us together, and I hope that it doesn't take a 9/11-like tragedy to help us recapture that painful day in September.

But going back to the subject of the day, our defense community has been warning of climate change since the 1980s. The 2019 Worldwide Threat Assessment highlights climate change as a distinct security threat to the country.

Recent news reports are underscoring this point. Arctic ice melting is allowing Russian access to oil and gas fields previously trapped, as well as the capacity buildup of and launch of cruise missiles from the newly opened waters, threatening America's coastline. Around the world, we are seeing the dangers with migration flows and famine.

In response to this, our Federal Government looks to be missing in action. The President withdrew the U.S. from the Paris Agreement and literally refuses to attend international forums related to this subject. There has been an assault on clean-water and clean-air regulations that even some fossil-fuel companies have protested.

CFTC Commissioner Behnam has played a leading role in directly confronting this crisis by creating a subcommittee in July focusing on climate risk. Federal Reserve Chairman Powell noted that the Fed is considering climate risk when it regulates financial institutions. The Federal Reserve Bank of San Francisco is advancing the notion of financial institutions getting extra credit through the Community Reinvestment Act for adapting and preparing for natural disasters.

As financial regulators consider this topic, I have offered a bill before the committee today that calls for the Fed and the SEC to explore the cost of climate change so that we can best confront this crisis.

I look forward to hearing from all of you, and working to confront this issue.

The Chair now recognizes the ranking member of the subcommittee, Mr. Stivers, for 4 minutes for an opening statement.

Mr. STIVERS. Thank you, Chairman Cleaver. And thanks for holding this hearing.

I also want to thank the witnesses for being here. I am looking forward to hearing from you.

And, Mr. Chairman, I think we all wish for the kind of America we saw on September 12, 2001, and we hope it doesn't take a tragedy to get us there.

Climate policy does occasionally come up in this committee, usually with respect to the National Flood Insurance Program and the securities disclosure laws, which are in the jurisdiction of this committee. Today's hearing, I know, will have a broader focus on climate policy, such as the Green New Deal and proposals about how we alter our sourcing of energy.

Over the past decade, America has experienced a clean-energy revolution, which includes the rise of natural gas as well as renewable energy. And, in fact, the United States has cut CO2 emissions enough to exceed the requirements of the Kyoto Accord. And yet,

there is more we can do. I look forward to the exchange with our witnesses today.

Something I do want to stress from the outset is the importance of preserving access to energy that is reliable but also affordable. As policymakers, we should always be mindful of the impact that new laws and regulations have that might be disproportionate among low- and moderate-income Americans.

One of the bills today would require the Federal Reserve to report impacts on climate change to the economy. I think it is a little questionable whether the Fed has the expertise to conduct that analysis. But what they do have expertise in is financial analysis. And they have released a study that said that 44 percent of Americans don't have enough money to cover a \$400 emergency cost.

If we choose policies that make fuel and utility bills more expensive, these individuals will have even less disposable income to cover mortgages, rent, purchase of groceries, and medicine. And one of the ideas put forward today, the Green New Deal, I think would have a disproportionate impact on low- and moderate-income Americans.

I think if we add cost to them, it will add cost to other bills as well, actually. For example, a farmer who is paying more for fuel to operate his tractor will have to pass on additional costs that would raise the cost of food at the grocery store. Strapped with higher energy costs, companies could actually reduce their jobs in America. So there are other impacts of the decisions we make, and I think we need to be mindful of that.

When we talk about the potential damage to the economy, those are the human costs I think of. And so, while many of us—including me—acknowledge that climate change is occurring, we must be smart about how we address it.

Some solutions that I plan to talk to the witnesses about today include negative-emissions technology, expanding research on battery storage that will make our renewables more effective, and incentivizing local communities to establish modern building codes that will go along with the Flood Insurance Program to actually adapt to things while we work to mitigate at the same time.

This combination of mitigation and adaptation strategies, I believe, will be more effective and affordable, and we can get the right environmental balance while ensuring energy is both affordable and reliable.

Again, I want to thank the witnesses for being here.

And I want to yield my final minute to the ranking member of the full Financial Services Committee, Patrick McHenry.

Mr. MCHENRY. Thank you, Mr. Stivers.

And thank you to the panel for being here.

Look, climate change is real, and we have to break free from the established partisan politics of Capitol Hill. We have an aggressive policy called the Green New Deal that wants to reorder society, which further polarizes the discussion about the rational, reasonable solutions that we can take on and make significant changes to ensure that we don't have great long-term negative consequences for our environment and for our people and for our society.

In order to do that, you can't have the same partisan food fight; you have to have innovation. You have to drive clean energy

through innovative policies and innovative solutions that are going to change the footprint, the carbon footprint.

We are cleaner today than Europe in the United States, and that is a positive thing, but it is not enough. We have to work together to ensure that those innovative solutions happen in the private sector and we have a proper risk assessment within our regulators to understand as policymakers the courses of action that we must take.

Thank you, Chairman Cleaver, for holding this hearing.

Chairman CLEAVER. Thank you, Mr. McHenry. I have a bipartisan statement: I like your bow tie.

Mr. McHENRY. That is the most polarizing thing you could possibly say. But, thank you.

Chairman CLEAVER. Today, we welcome seven amazing witnesses.

Our first witness is Marshall Burke. Dr. Burke is an assistant professor in the Department of Earth Systems Science; the deputy director of the Center on Food Security and the Environment at Stanford University; and a research fellow at the National Bureau of Economic Research.

I will introduce the next witness before you speak.

Dr. Burke, you are now recognized for 5 minutes to present your oral statement. And without objection, all of the witnesses' written statements will be made a part of the record.

STATEMENT OF MARSHALL BURKE, ASSISTANT PROFESSOR, EARTH SYSTEMS SCIENCE; AND DEPUTY DIRECTOR, CENTER ON FOOD SECURITY AND THE ENVIRONMENT, STANFORD UNIVERSITY

Mr. BURKE. Thank you very much, Chairman Cleaver, Ranking Member Stivers, and members of the subcommittee, for having me here to speak today.

As the chairman said, my name is Marshall Burke. I am an economist by training, and a professor at Stanford University in earth systems science. I have a Ph.D. in economics, and my research focuses on using data and statistics to understand how changes in climate affect a lot of outcomes we care about in the world: economic outcomes; our livelihoods; and our health.

My goal as an academic economist is not to make political statements; it is really just to make measurements. Just as we use a thermometer to understand whether the temperature is going up or down, we can use statistics to tell us what the impacts of those temperature changes are on a range of things we care about—again, economic output, economic productivity, and our economic livelihoods.

And the measurements that we have taken and that others have taken in the last few years are starting to tell a very clear story about what these temperature changes mean for many things in the world, including many things of direct relevance to the jurisdiction of this committee. So, I would like to make five points about the impacts of climate change on the macroeconomy and related outcomes.

Point number one, and I think most importantly: Climate change is likely to have a fundamental impact and a substantial negative impact on the U.S. economy in coming decades if unmitigated.

Research done by me and my colleagues at Stanford and Berkeley finds that by midcentury, by 2050, unmitigated climate change will cause at least \$5 trillion in damage to our economy, and by the end of the century, will cost tens of trillions of dollars in terms of lost output, so many, many trillions of dollars that we will be throwing away if we don't mitigate climate change.

Point number two, climate change will affect nearly all sectors of the economy.

I think there is a common perception that the main impacts of climate change will be through sea-level rise and effects on agricultural productivity. Now, while those effects will be important, they are actually a very small part of the overall impact picture when we look at the U.S. economy. Evidence from multiple studies shows that output in key sectors, including sectors like financial services and real estate, fall as temperatures rise.

And why is this? We know, again from many studies, that workers are just less productive when it is hot outside. And this, again, has been shown in manufacturing, and this has been shown in service industries. Part of that is because our cognitive function actually declines when it is hot. Now, I think some of us recognize this intuitively. It actually shows up very clearly in the data: Hot temperatures literally make us dumber.

Point number three, climate change will actually worsen security risks, both domestically and abroad.

We can come back to that. I see the ranking member laughing at the data.

Police chiefs in U.S. cities have long recognized that during days or weeks of temperatures that are hotter than normal, you see spikes in many different types of violent crime. We see aggravated assault go up, we see sexual violence go up, we see homicides go up. This is clearly in the data.

And studies that we have conducted also show that hot temperatures increase the risk of suicide around the United States. And, again, we calculate that if we do not mitigate climate change, just this increase in suicide alone could lead to 10,000 to 20,000 excess deaths in the U.S. that would not have occurred otherwise, so a large loss of human life.

Elsewhere in the world, we have documented large increases in civil conflict as temperatures rise and have shown that this conflict actually drives international migration. So, people go from poor countries to rich countries in the face of these climate shocks.

Point number four, climate change is going to exacerbate inequality. We have strong evidence that poor places, both within this country and poor places internationally, will be more affected by a changing climate.

And finally, point number five, and maybe most importantly, doing something about climate change will generate long-run benefits to the economy, the benefits I just mentioned, but crucially, it will also generate immediate benefits in terms of improved air quality and the benefit that those improvements have for human health.

Most of the proposals around what to do about climate change, including investments in clean technology, generally reduce greenhouse gases but they also clean up the air. And studies have suggested that by 2030 alone, this could save hundreds of thousands of lives and generate, again, trillions of dollars of economic benefits for our country.

So, to conclude, this evidence provides, I think, a more robust understanding of how much we should be willing to pay to do something about climate change. Climate change, for me, is not an environmental issue; it is an economic issue. And while policy proposals aimed at reducing climate change might sound like they have a very high cost, we need to compare these costs against the benefits. Focusing exclusively on the costs without considering the benefits is terrible economics and terrible policy.

Thank you very much.

[The prepared statement of Dr. Burke can be found on page 48 of the appendix.]

Chairman CLEAVER. Thank you very much, Dr. Burke.

Let me introduce the General, and then I think I will go ahead and introduce all of you.

I failed to say at the beginning that each witness will have 5 minutes for your presentation. If you run over a little, I will give a gentle tap on this table, and then if you continue to speak, the tap will get louder.

Brigadier General Stephen Cheney (Ret.) is president of the American Security Project and a member of the Department of State's Foreign Affairs Policy Board. He served as a Marine for more than 30 years. Upon retirement, General Cheney became the chief operating officer for Business Executives for National Security, and was president and CEO of the Marine Military Academy in Harlingen, Texas.

Next, Dr. Veronica Eady is the assistant executive officer for environmental justice at the California Air Resources Board. She is the former Chair of the Environmental Protection Agency's National Environmental Justice Advocacy Council. She is also the former vice president and director of the Conservation Law Foundation in Massachusetts.

The next witness is Alexander "Andy" Karsner. Mr. Karsner is a board member of Conservation International, and executive chair of Elemental Labs. From 2006 to 2008, he served as the Department of Energy's Assistant Secretary of Energy for Efficiency and Renewable Energy within the Bush Administration.

Next, is Alicia Seiger. She is the managing director of the Sustainable Finance Initiative at Stanford University. In 2018, she was appointed by the New York Governor, Andrew Cuomo, and Comptroller, Thomas DiNapoli, to serve on the first-ever Decarbonization Advisory Panel for the \$209 billion New York State Common Retirement Fund.

The next witness is John Kotek. He is vice president of policy development and public affairs at the Nuclear Energy Institute. He held several positions with the Department of Energy Office of Nuclear Energy, including the Assistant Secretary, under the Obama Administration.

Our final witness is Richard Powell. Mr. Powell is the executive director at ClearPath. He serves as a member of the 2019 Advisory Committee to the Export-Import Bank of the United States and was previously with McKinney and Company in the sustainability and resource productivity practice.

Thank you all for being here.

And we will proceed now with General Cheney.

**STATEMENT OF BRIGADIER GENERAL STEPHEN CHENEY,
USMC (RET.), PRESIDENT, AMERICAN SECURITY PROJECT**

General CHENEY. Chairman Cleaver, Ranking Member Stivers, and members of the subcommittee, thank you for inviting me to testify here today about the financial threats posed by climate change to our national security.

Thank you for your kind comments about 9/11. That day is particularly poignant to me, as the pilot of American Airlines 77 was my classmate, Navy Captain Chic Burlingame, when it went into the Pentagon. So God bless him, and thank you for your comments.

A quick correction for the record. My tenure on the Foreign Affairs Policy Board expired—as far as I know, the entire board expired in 2017. So, I no longer serve on that board.

I am honored to be here to speak to you about this critical threat. As a nonpartisan nonprofit, the American Security Project (ASP) has worked tirelessly on this issue since our founding in 2006. As president of ASP, I have presented around the world on this specific subject, and spent much of the last 5 years traveling the United States, engaging with local business and community leaders on the risks of climate change.

Today, I am not here to discuss specific legislation or technology solutions, but I am here to explain the national security threats of climate change.

During my 30 years with the Marines, I learned the importance of preparation. In order to achieve the mission, the United States Military must be prepared for any potential threat, particularly foes that are climate- or weather-related.

This should be familiar to those in the financial sector. Risk management is as important for the military as it is for banking. We can't afford to ignore the risk of climate change, just as bankers can't ignore the risks to their business.

Unfortunately, today we are not sufficiently prepared for climate risk and have failed to respond to changes that are already occurring.

Dating back to the George H.W. Bush Administration, in 1992, intelligence and national security professionals warned us that climate change posed a direct threat to U.S. national security.

The impacts of climate change are clear today and threaten our military installations and investments around the globe. The U.S. Department of Defense maintains installations worldwide. Together, that property is worth well over \$1.2 trillion, and is critical to U.S. national security.

This past year's extreme weather has seriously affected our national infrastructure. In September of 2018, Hurricane Florence decimated Camp Lejeune and caused damage to Fort Bragg and military installations all across North Carolina. Just a few weeks

later, Hurricane Michael leveled Tyndall Air Force Base on Florida's panhandle, causing damage to 17 F-22 stealth fighters, and major structural damage throughout the entire base.

Estimates of the cost of these disasters to the military are significant. The Marines have requested \$3.6 billion to rebuild their North Carolina operations, while the Air Force has requested an initial \$5 billion for Tyndall and Offutt.

While climate change by itself did not cause these storms, there is little doubt that it has added to their intensity and frequency.

In addition to extreme weather events, sea-level rise is threatening some of our most vital military installations. Norfolk Naval Station is predicted to see a 2- to 5-foot rise in sea level by 2100, and some say it might be as high as 11 feet. The base has already begun to build double-decker piers to allow maintenance workers to reach critical electrical cables, countering the sinking ground and the rising seas. Each new pier costs \$100 million.

Clearly, the U.S. military will have to invest large sums into rebuilding and recovery at home. The American Security Project is tracking these impacts to our military infrastructure on our new website, www.militarybaseresiliency.org, and I encourage you to review the content and examples that we list there.

Beyond physical damage and financial burdens, climate change will increase global instability. Groups like Boko Haram and Al-Shabaab have leveraged drought and climate-related disasters for recruiting. While climate change may not be the sole cause of instability, it certainly contributes to it.

This instability creates additional demands for U.S. military support. A larger, more expensive military adds financial burdens on the U.S. and its citizens. Climate change is already threatening our military readiness. There needs to be further monitoring of the impacts of climate change and the cost incurred to military infrastructure and personnel.

Further, there needs to be additional investment and allocation of funds towards building back better. Storms and extreme weather are predicted to only intensify, and funds should be allocated to rebuild stronger and more-durable infrastructure.

Finally, we need substantial investment in zero-carbon, clean-energy systems. Without investing in clean energy, all the money spent rebuilding will be for naught as coastal military installations go underwater and stronger storms level our critical infrastructure.

Now is the time to invest in solutions. The United States has the most powerful military in the world. We have the opportunity to maintain that prowess, but only if we invest and prepare for the future that lies ahead.

Thank you for the opportunity to testify today. I look forward to your questions.

[The prepared statement of General Cheney can be found on page 52 of the appendix.]

Chairman CLEAVER. Thank you, General Cheney.

The next witness is Dr. Eady. You have 5 minutes.

STATEMENT OF VERONICA EADY, ASSISTANT EXECUTIVE OFFICER FOR ENVIRONMENTAL JUSTICE, CALIFORNIA AIR RESOURCES BOARD

Ms. EADY. Chairman Cleaver, esteemed members of the subcommittee, it is my great honor to be here today to discuss how California is addressing climate change, and how our programs facilitate investment in the communities most vulnerable to the impacts of climate change.

I am here representing the California Air Resources Board, also known as CARB. It is an agency that is charged with protecting the California public from the harmful effects of air pollution, and developing programs and actions to fight climate change.

From requirements for clean cars and fuels to adopting innovative solutions to reduce greenhouse gas emissions, California has pioneered a range of effective approaches that have set the standard for effective air and climate programs for the nation and the world.

As the assistant executive officer for environmental justice, it is my charge to steer the agency as we promote environmental justice and equity in our programs.

Despite the dramatic progress made in improving air quality in California, there still exists disparities in air pollution exposure, susceptibility, and health, particularly for people of color and low-income communities. This disparity reflects the disproportionate siting of stationary sources and highways in and near disadvantaged communities that were historically intentionally segregated.

And although greenhouse gases are global pollutants that do not, themselves, harm local neighborhoods, the effects of climate change caused by greenhouse gases disproportionately impact low-income communities and communities of color. So, environmental justice is one of our core values and fundamental to achieving our mission.

California has had programs to reduce both criteria pollutants and air toxics and greenhouse gases for decades. As California adopts increasingly ambitious goals for addressing climate change and air quality, it recognizes that the transition to a low-carbon California economy provides an opportunity to create a healthier environment for all Californians, especially those living in our most disadvantaged communities.

Many of our disadvantaged communities disproportionately lack the financial capacity to invest in low-carbon transportation and climate resiliency, so we are pioneering targeted environmental and economic programs to help those most in need.

The proceeds from our cap-and-trade program, which are deposited in the Greenhouse Gas Reduction Fund, also known as the GGRF, facilitate comprehensive and coordinated investments throughout California that further the State's climate goals. In fact, by law, at least 35 percent of those cap-and-trade proceeds have to benefit disadvantaged communities. To date, the legislature has appropriated almost \$12 billion to more than 20 State agencies implementing over 60 unique programs collectively known as California Climate Investments.

Communities where investments occur are realizing a wide range of benefits, including increased affordable housing opportunities; improved mobility options through transit, walking, and biking;

cleaner-air zero-emission vehicles; job creation; energy and water savings; and greener, more vibrant communities.

Many programs funded through California Climate Investments are specifically designed to promote equity. We have clean-vehicle financing assistance for people who want to buy electric vehicles and hybrids. We have rebates, and vouchers with income caps that direct these programs to low-income households. And we have pilot projects that are aimed directly at improving mobility in disadvantaged communities, such as our car-sharing programs targeted toward low-income communities, agricultural worker van pools, and other new mobility options.

Certain programs are also focused on rural communities, such as our Rural School Bus Program, and others, such as affordable-housing programs that have a set-aside for low-income, rural communities.

We also have a handful of targeted investments by regions in the areas most impacted by air pollution, such as communities living near major ports, and freight facilities. And they receive dedicated funding, ranging from heavy-duty vehicle change-outs from diesel to cleaner fuels as well as air-monitoring equipment.

One program to highlight is CARB's new Community Air Protection Program, which was initiated in response to Assembly Bill 617, aimed at reducing air exposure in the State's most impacted communities through air monitoring as well as development of emission-reduction programs.

The legislature has appropriated nearly half-a-billion dollars in incentive funding that is geared in those programs to change out dirtier fuels like diesel to clean or zero-emission vehicles and other near-zero-emission vehicles. In addition, it has appropriated \$25 million, all of this coming out of our cap-and-trade proceeds, for community grants to help communities engage.

We also have another program called Transformative Climate Communities, for which the legislature has appropriated \$150 million to help the communities most impacted from climate change to prepare.

I see that I am almost out of time, so I will just say, California Climate Investments has resulted in, and is required to result in quantifiable reductions in greenhouse gases. In addition to achieving a reduction of almost 40 million metric tons of CO2 equivalent to date, California Climate Investments projects are also achieving additional co-benefits, such as job creation, training, opportunities for small business, and things of that sort. We have achieved—

Chairman CLEAVER. Dr. Eady, your time has expired.

Ms. EADY. Okay. I thank you very much, and I look forward to your questions.

[The prepared statement of Dr. Eady can be found on page 59 of the appendix.]

Chairman CLEAVER. Thank you, Dr. Eady.

Mr. Karsner, you have 5 minutes.

**STATEMENT OF ALEXANDER KARSNER, BOARD MEMBER,
CONSERVATION INTERNATIONAL**

Mr. KARSNER. Thank you, Chairman Cleaver, Ranking Member Stivers, and distinguished members of the subcommittee. Thank

you for having me here on this important day to testify about the confluence of international monetary policy, national security, and climate change.

Your opening remarks, Mr. Chairman, reminded me that the last time I testified in front of Congress, more than 10 years ago as a public servant, was also the day that it was announced that, for the first time in recorded human history, someone had navigated the Northwest Passage. And so, 120 months later, we are facing all the perils in the Arctic of large commercial and military oceangoing vessels that you spoke to in your opening remarks, and it reminds me of the urgency to act.

But of course, we are not in a position today to have the technology to refreeze Greenland. And, therefore, we have to think what it is we can do, beyond mitigation, for preparation and adaptation and resilience of our communities and of our country and how we can achieve this through conservation and through what we call natural capital—that is, the actual value that nature brings beyond the commoditized value of natural resources that we all take for granted.

In my first days as a public servant, I had no government experience. I was encouraged to serve and had an itch to scratch based on 9/11. And the late Samuel Bodman, my then-boss at the Department of Energy, who was a scientist from MIT, encouraged me to go see his friend, the scientist Dr. Jim Mahoney, who led the U.S. Climate Science Program, on my first day. And so, I went to NOAA so that I could understand the magnitude and trajectory of the problem before I was ultimately tasked as a climate negotiator.

But Sam also sent me to visit his wife, Diane, who was a volunteer at Walter Reed Army Hospital, on the next day, so that I could understand the meaning of those things.

And from that time and during that Administration—it exists even to this day—I learned that we cannot separate our national security from our natural security. They are inextricably tied to one another. And they are tied to the fate of all of our communities.

In all of these cases, we understood then, as we do now, that in President Bush's words, we have to face America's addiction to oil. And so, we then launched a clean-energy technology revolution, catalyzing unprecedented capital formation for the commercialization of clean power generation, for efficient electrification of mobility and vehicle drivetrains, for building and industrial efficiency, and, of course, LED lighting and appliance efficiencies that have transformed our energy use and made us more productive.

All of this has grown exponentially in the decades since, but we need much, much more. We need carbon sinks and sequestration. We need the ability to rapidly deeply decarbonize our markets. We need a steady-state circular economy. And we need to get over the notion that we will be able to tithe our way out of this problem or that government expenditure will spend its way out of the problem.

The only way to achieve some progress on this problem is to turn our capital markets and our economy to problem-solving at a speed and scale that is symmetrical to the problem that we seek to solve.

And we have opportunities. Because as we morph from an industrial age into an inexorable information age, data has become the new oil. It is now the driver of all value and growth in our econ-

omy, exceeding the energy economy in ways that were unthinkable a decade ago.

I am not going to talk about the clean-energy technologies. I am happy to respond to any questions about it. But I would rather turn our attention to the revolutions in data science, computational science, and materials science that are collectively giving us an opportunity to band with sensors and do in our natural home that which we already do in our manmade home: have an internet of natural things to care for the comfort and convenience and management in our interactions with nature in ways that we can measure it, manage it, and ultimately monetize it.

These things have to come on to our capital markets and account on our balance sheets. If we have market imperfections to address, the best way to address them is with market-changing rules such as those that you have proposed today on a bipartisan basis.

And I hope that you will go further than asking exclusively for transparency and disclosure; I hope that you will trend into new rules that allow us to integrate the value of nature into our commodity trading systems, into our risk management, by using the revolution in information gain, by being able to have unprecedented insights and analytics and predictability, by forming the indicators based on these information and insights so that we can evolve and innovate new financial instruments that are already burgeoning, whether from Sand Hill Road or from Wall Street or from Main Street across America.

Congress is lagging. The nation is leading. These tools can be employed. And I applaud your efforts to come together to do so.

Finally, let me say, if you will indulge me, sir, that today is my late mother's birthday. And I was with her on 9/11 in her home country, in her home City of Casablanca, Morocco. And, together, we looked at the shore where, when she was a child, General Patton came ashore for the first time with the Third Army, marking America's entry into World War II.

It was the hardest secret, for the longest hours, I ever kept from anybody in my life. And when my mother found out on September 12th what had happened on September 11th, she wasn't mad at me. She simply said, "I will never celebrate my birthday on that day again," that, in exchange, I should have my children always remember what happened so that the country she came to love and immigrated to would always be safe and secure and a beacon.

Thank you for reminding us, and for holding this hearing on this day. And thank you for your bipartisan work.

[The prepared statement of Mr. Karsner can be found on page 64 of the appendix.]

Chairman CLEAVER. Thank you.

Ms. Seiger, you have 5 minutes, please.

**STATEMENT OF ALICIA SEIGER, MANAGING DIRECTOR,
SUSTAINABLE FINANCE INITIATIVE, STANFORD UNIVERSITY**

Ms. SEIGER. Chairman Cleaver, Ranking Member Stivers, and members of the subcommittee, thank you for the opportunity to be here to talk about such an important topic on this significant date.

My name is Alicia Seiger, and I am the managing director of the Sustainable Finance Initiative at Stanford University. I teach

courses on climate finance and mitigation to Stanford business, law, and engineering students. And I serve on the board of directors of Ceres, a nonprofit that works with the world's largest businesses and investors to manage the risks of a changing climate.

The views in my testimony are my own, not necessarily those of Stanford University. I am here today to share my experience and knowledge about the ways in which investors, businesses, and the Federal Government can benefit from measuring the economic risks of a changing climate.

Recently, I worked with the \$210 billion New York State pension plan to help the fund better prepare for climate-related risks and opportunities. Their investment team has taken many leading steps to address climate impacts on their portfolio already, and yet, a lack of transparency into the climate-related impacts of their equity portfolio, which is largely composed of passively managed index funds, remains an unmanageable risk. As we saw with the recent bankruptcy of PG&E, markets are not pricing the impacts of changing temperatures.

New York's pensioners are not alone. This past June, 477 investors with \$34 trillion in assets signed a letter urging world leaders to improve climate-related disclosures in financial filings.

Businesses can benefit from reporting, too. A recent study found that 215 of the world's 500 biggest companies faced roughly \$1 trillion in costs related to climate change unless they prepare. Managers find that reporting catalyzes ingenuity, improves strategic thinking, and increases competitiveness. In other words, reporting improves resilience.

In examining the economic impacts of climate change, it is important to understand that they come in two flavors: physical risks; and transition risks.

Physical risks are those that stem from chronic and acute changes in weather patterns, including storms, sea-level rise, wildfires, and extreme heat. Physical impacts of climate change disrupt supply chains and consumption patterns, threaten real assets, and disturb the health and movement of people.

Transition risks stem from a suite of factors as economies and enterprises transition from low to high resilience and from high to low carbon intensity. Price dislocations can result from misjudging the pace and scale of technology innovation and failing to prepare for abrupt shifts in policy and consumer behavior.

A good deal of information exists about how physical impacts affect workers in communities, national security, and the economy. What is less studied are the impacts from the low-carbon transition. It is important to note that, as Assistant Secretary Karsner has already testified, the low-carbon transition also presents economic opportunity.

It is also important to remember that transition impacts exist irrespective of domestic policy. Highly globalized sectors will feel repercussions from shifts in consumer behavior and regulations oceans away. Major U.S. industries will be affected, including oil and gas, petrochemicals, automotive, and agriculture.

Financial regulators also benefit from reporting in their effort to maintain market efficiency and ensure financial stability. The Network for Greening the Financial System, a group of 36 central

banks and supervisors representing over half of global GHG emissions, said, "Climate-related risks are a source of financial risk, and it falls squarely within the mandate of central banks and supervisors to ensure the financial system is resilient to these risks." Disclosure and reporting were highlighted among the group's six key recommendations to foster a climate-resilient financial system.

Mandated reporting also serves to improve the quality of the current suite of physical and transition risk models. I see this potential at the Sustainable Finance Initiative, where we are working to develop next-generation integrated assessment models. Most of the interest in and data sources for this work are international, and open-source collaboration among U.S. research institutions, powered by a Federal mandate, would lead to more rapid advancement of these models.

I think we can all agree that you manage what you measure, and that management improves performance. Greater SEC oversight of climate-related financial risks, and engaging the Fed in tracking the impacts of climate change will advance the competitiveness of U.S. businesses and investors and will better protect U.S. workers from the impacts of climate change.

I applaud the committee for examining these topics, and I am happy to answer any questions. Thank you.

[The prepared statement of Ms. Seiger can be found on page 91 of the appendix.]

Chairman CLEAVER. Thank you.

Mr. Koteck, you are now recognized for 5 minutes.

STATEMENT OF JOHN KOTEK, VICE PRESIDENT, POLICY DEVELOPMENT AND PUBLIC AFFAIRS, NUCLEAR ENERGY INSTITUTE

Mr. KOTEK. Thank you, sir.

Good afternoon, Chairman Cleaver, Ranking Member Stivers, and members of the subcommittee. I appreciate the invitation to provide testimony on the importance of nuclear energy, one of several low-carbon energy technologies that must be expanded if we are to deeply decarbonize our energy system.

In particular, I will highlight why nuclear power is an essential element of any realistic strategy to mitigate climate change, and steps Congress can take to ensure that nuclear energy can fulfill this role.

Last year, a report from the Intergovernmental Panel on Climate Change called for significant increases in nuclear power under all scenarios aiming to limit global warming to 1.5 degrees C by 2050. The companies and States that have committed to carbon-free electricity by 2050 or sooner are finding that renewable energy technologies can only get them part of the way to their goal. There is a need for firm, dispatchable, carbon-free electricity to complement renewables. Nuclear energy fills this role today and can do even more in the future.

And since the electricity sector emits only about 40 percent of the total carbon entering the atmosphere, effective decarbonization of our wider energy system must extend far beyond electricity production to address transportation, industrial, and residential sectors. Whether alone or integrated with renewables, nuclear energy can

provide essential energy services such as hydrogen production as well as process heat for industrial needs or desalination of water.

Today, nuclear power provides almost one-fifth of U.S. electricity and accounts for more than half of the nation's carbon-free power. The economics of today's nuclear power plants are favorable and improving. The average generation cost for U.S. nuclear plants was about 3.2 cents per kilowatt-hour last year, down from 4.2 cents per kilowatt-hour in 2012.

Yet, despite this impressive economic performance, the U.S. fleet of nuclear plants is under severe pressure. Nuclear energy is contending with very low generation costs from natural-gas-fired plants that don't have to pay to emit carbon. The economics of today's plants are also compromised by Federal and State incentives provided to solar and wind and electricity markets that don't recognize the valuable attributes of nuclear power.

So, if you start from the year 2013, nine nuclear power reactors will have closed by the end of this year, eight more will have announced plants to close by 2025, and several more are under threat. When these plants shut down, they will not reopen, and their outputs will predominantly be replaced by natural gas with resulting increased emissions.

Loss of nuclear resources is a major setback if we are committed to reducing carbon emissions. To enable nuclear energy's role in meeting our climate goals, the U.S. must take steps to preserve the domestic fleet and develop and deploy new nuclear technologies in competing global markets.

First, we must preserve the existing fleet of nuclear plants. Some States have enacted mechanisms to recognize the zero-carbon attributes of nuclear energy and avoid plant closures, but State actions, while important, are insufficient. A Federal solution is needed—options including production or investment tax credits and equal treatment for all clean-energy resources, as through a clean-energy standard, or replacement of renewable energy mandates with clean-energy mandates or some form of price on carbon emissions.

Second, we must develop and deploy the next generation of nuclear technologies. Private companies, including many small startups backed by venture capital, lead the development and commercialization of these designs. We must learn from the success we have had in promoting the growth of wind and solar, and enact policies that give investors confidence that there will be a market for new nuclear technologies.

Innovation must extend beyond the technology developers to the regulators who are tasked with assessing new designs. The successful deployment of these improved designs will require the Nuclear Regulatory Commission to succeed in its efforts to modernize how they assess new nuclear technologies.

And, finally, the U.S. must compete effectively in the large and growing nuclear energy markets overseas. Commercial success in overseas markets is necessary to a healthy U.S. nuclear supply chain, and enables U.S. global leadership on nuclear safety, security, and nonproliferation. Yet, today, two-thirds of the nuclear plants under construction around the world are being led by Russia or China, which don't share U.S. standards.

The U.S. must recognize the new competitive landscape posed by China and Russia, and remedy U.S. policies that are imposing competitive disadvantages on U.S. nuclear energy suppliers.

Notably for this committee, the U.S. must enable export financing to support U.S. nuclear companies. Export credit agency support is a bid requirement for virtually every nuclear energy tender. U.S. competitiveness will be undermined if the charter of the Export-Import Bank is allowed to expire at the end of this month. To be competitive against Russian and Chinese nuclear exports, the U.S. must have a competitive and durable Ex-Im Bank.

In conclusion, thank you for the opportunity to testify. Nuclear energy can play a significant role in meeting our climate goals. We look forward to working with the committee to ensure that nuclear energy remains a major contributor to the nation's and the world's clean-energy portfolio.

[The prepared statement of Mr. Kotek can be found on page 76 of the appendix.]

Chairman CLEAVER. Thank you very much.

Mr. Powell, you now have 5 minutes. Thank you.

**STATEMENT OF RICHARD POWELL, EXECUTIVE DIRECTOR,
CLEARPATH**

Mr. POWELL. Thank you, Chairman Cleaver, and Chairwoman Waters. And thank you, Ranking Members Stivers and McHenry and members of the committee.

My name is Rich Powell. I lead ClearPath, a nonprofit advancing conservative policies that accelerate clean energy globally. We advocate markets over mandates and innovation over regulation. An important note: We receive zero funding from industry.

Given this committee's role in America's climate policy, I will cover a few topics: first, the reality of climate change and its pressure on our economy; second, climate solutions in innovation investments; third, our global realities and challenges; fourth, the role America can play internationally; and fifth and finally, how you can build on last Congress' bipartisan clean-energy record.

First, the elephant in the room: Climate change is real. Industrial activity around the globe is the dominant contributor. And the challenge it poses to society merits significant action at every level of government and the private sector. It is too important to be a partisan punching bag.

For example, the Federal Government insures mortgages through Fannie Mae, Freddie Mac, and the FHA/VA mortgage lending programs, which cover over 60 percent of the outstanding residential mortgage debt in the U.S., totaling \$6.7 trillion. The risks posed to government-sponsored enterprises by climate change are currently unquantified, unmanaged, and increasing as hurricanes and severe weather events increase, creating a potential taxpayer time bomb on top of an already unsustainable National Flood Insurance Program that is over \$20 billion in debt.

So, where to start? Climate change is a huge issue, the United States has a limited budget, and any solution must be global. At ClearPath, we believe the key to the climate challenge is to make it easy for developing countries to choose clean technologies over traditional emitting technologies. This means the solutions we in-

vest in here must focus on making clean energy cheaper, better-performing, and easier to build and buy globally. In short, we must invest in innovation.

Unfortunately, despite some bright spots in ever-cheaper intermittent renewables, existing technologies are not up to this task. The International Energy Agency finds that over the past several decades, global clean development is only just keeping up with economic development. Clean is not gaining ground.

Now, how to make America lead the world in offering better, cheaper alternatives to developing nations? This is the reality of energy innovation: Taxpayers supported all new energy sources in recent decades. Going forward, government should neither command and control a solution nor do nothing and hope. Government should support a wide portfolio of clean innovations and ramp down support as technologies mature.

These investments must be made towards strong objectives. When the Department of Energy has clear goals based on market-relevant cost targets along with strong accountability and steady investment, it produces breakthroughs. The work that enabled the shale gas revolution is a prime example.

As we refine these technologies at home, we must prepare strong support for exports to the developing world. Here, America is at greatest risk of falling behind. China and Russia view the spread of their technology as a means to expand their power, and use their state-owned enterprises to these ends.

China is financing \$36 billion in inefficient coal plants in at least 27 countries. Russia has overtaken the U.S. in nuclear exports, with Rosatom developing 33 reactors in countries like India. China is close behind, increasing nuclear exports with questionable safeguards, under the belief that more nuclear proliferation will make the world more peaceful while supporting their economic goals.

In other words, an American vacuum on clean-energy exports risks severe climate change while also threatening our national security and geopolitical position.

We can reverse this trend. Starting up the International Finance Development Corporation, or IDFC, created by the BUILD Act of 2018 from OPIC, is critical. We must ensure that previous bans on nuclear financing at OPIC do not carry over to IDFC. Similarly, we should work to lift such bans at multilateral organizations where we lead, like the World Bank. As well, continued authorization of the Import-Export Bank and its strategic application in clean-energy exports is vital.

We should also expand bilateral and multilateral engagement. We have been pleased to see this Administration's renewed leadership in the Clean Energy Ministerial, including our new initiatives on carbon capture and nuclear.

Finally, how do we build on your strong bipartisan record of clean innovation? In 2018, the Fiscal Year 2018 and 2019 appropriations bills invested historic sums in clean-energy R&D, and Congress provided new incentives in innovation authorizing programs that rivaled our last major energy legislation when Mr. Karsner served in the Bush Administration. ClearPath applauded your critical investments in advanced nuclear carbon capture, energy storage, and advanced renewables.

Going forward, given the scale of the climate challenge, we must greatly increase ambition. Let's not shy away from clean-energy moonshots. Let's create stronger incentives to commercialize and deploy globally. And let's remove regulatory barriers to rapid scale.

Bipartisan cooperation on climate change is essential under divided government, and is attainable. Indeed, it is the only chance we have to play a significant role in the global solution.

Thank you again for this opportunity, and I look forward to the discussion.

[The prepared statement of Mr. Powell can be found on page 84 of the appendix.]

Chairman CLEAVER. Thank you, Mr. Powell.

And I thank all of you for your testimony.

I am going to begin by giving myself 5 minutes for questions.

Let me begin by just saying that I think Mr. McHenry and I—other than Chairwoman Waters—have been on this committee the longest, a decade and a half, and we have had to deal with the issues of flooding repeatedly and the flood bill. Chairwoman Waters has probably tripled whatever time we put in on it, dealing with the National Flood Insurance Program (NFIP).

According to Marsh, which is one of our largest insurers, they are saying that they have paid out in excess of \$20 billion in claims over the last 20 years. In my State of Missouri, just for the first 5 months of the year, we have had 262 flash floods. And it has been decimating for our farm community.

What I am interested in hearing, Mr. Burke, is, what does climate change have to say to Midwesterners who previously thought, you know, we have a tornado every now and then, but we are not going to have the other big events, but we are having them?

Mr. BURKE. Thanks. That is right, Mr. Chairman. Climate change tells us pretty clearly that we should expect more extreme precipitation. So, the type of flooding that you are talking about will become more likely in the future, and more frequent. So, I think there is clear evidence from climate science there.

On the coasts, what we know from tropical cyclones or hurricanes is, we don't have clear evidence that there will be more or less of them, but we know they will be more powerful and they will move more slowly. And that will also likely dramatically increase the risk of coastal flooding.

So I think flooding—you are hitting the nail on the head here. This is a growing concern.

Chairman CLEAVER. What region do you think will be impacted the most economically if the trends continue and if this issue is not addressed?

Mr. BURKE. Flooding is only one part of the economic impact that we would be worried about from climate change. I think, overall, if you look within the U.S., the southern part of the U.S., which is already warmer, should suffer the largest impacts.

The published estimates suggest that the impacts in the southern U.S. will be 3 to 4 times larger than that in the northern U.S., and that is mainly just a function of the South already being hot.

Chairman CLEAVER. We always have difficulty with flood insurance in this committee. None of us are going to jump up and down to hope we have to deal with that every single year.

But, this year, the Commodity Futures Trading Commission (CFTC) established a Climate-Related Market Risk Subcommittee, under the Market Risk Advisory Committee, to examine financial risk related to climate change. And without objection, I would like to have their report included in the record.

One of the CFTC Commissioners compared the financial risks from climate change to those posed by the mortgage crisis that triggered the 2008 economic collapse in this country.

So I am interested in knowing if any of you or all of you agree with that assessment?

Mr. KARSNER. Yes.

Ms. SEIGER. Mr. Chairman, I agree.

Mr. BURKE. Yes.

Chairman CLEAVER. General?

General CHENEY. Yes.

Mr. KOTEK. Yes.

Chairman CLEAVER. Everybody? This is good.

Mr. KARSNER. Or bad, depending on how you look at it.

Chairman CLEAVER. Well, yes. I don't mean it is good for the country, and we will get tourists. I am just saying it is good that we are coming together. About 97 percent of scientists would agree with the assessment you just gave.

I am going to yield now to the ranking member of the subcommittee, Mr. Stivers.

Mr. STIVERS. Thank you, Mr. Chairman. I appreciate it.

And I really appreciated all of your testimony. Clearly, we have a lot of work to do to try to figure out how to price the cost of climate change into things.

And I am going to start with Mr. Karsner.

Our Flood Insurance Program that the chairman just talked about attempts to try to price risk. And your testimony spoke right to that, about how we can use data and things to price it better.

Can you talk about how 3-D mapping and other data that is available today could make the Flood Insurance Program work better at predicting and then helping us as we figure out how to both adapt and mitigate and understand the cost of the effects of climate change?

Mr. KARSNER. Yes, sir. Thank you.

I think flood insurance is top of the perils with immediacy that we have to face with a linkage to monetary and macro risk. And that was the uniform agreement up here.

Of course, insurance cuts through everything. Everyone has insurance—for home, for business, for transportation. And what I have been told by the executives across the industry is that they cannot have, in a single year, Houston, Miami, and San Juan, Puerto Rico, go down in this way with bleeding balance sheets. So it is imperative to them to develop new tools of risk management, because they are operating on very old modeled inputs and very, I would almost call them ancient at this point, legacy flood maps.

Now, it is an intransigent tug of war to get those maps moved because it affects people's property values, of course. But devoid of that sort of behavioral reality, we have plenty of eyes in the sky—satellites, submersibles, things that float, things that fly—innumerable ways to capture new data with great precision that is far bet-

ter at predictive analytics and visualization of what is happening in our floodplains.

And they reveal something entirely different. It is not only that nature is dynamic and adaptive and evolves, so the maps would be the same even if we were using the same methodology, but with the level of computing that we currently have available, what we know about the inaccuracies is troublesome.

You have some insurers who have to rebuild the same suburban home in a Meyerland suburb of Houston 3 times within a decade, a half-million-dollar home, built in the exact same place. Because the model will say, as a 100-year floodplain, if it floods 3 times, it will be 300 years until the next event. Models actually say this. And our insurance industry actually acts on this.

So, having a much more dynamic, iterative relationship with the available high-performance computing capacity. Machine-learning and modeling is something that we are intensively working on, and it is something that the insurance agencies and the finance industry, for gauging their property asset valuations, are absorbing.

Mr. STIVERS. Great.

Mr. KARSNER. And we would be happy to work with—

Mr. STIVERS. Thank you.

Mr. KARSNER. —the Congress on this.

Mr. STIVERS. And at the risk of embarrassing myself and you, I will ask you, in a 3-D environment, where does water always flow?

Mr. KARSNER. Downhill.

Mr. STIVERS. To the lowest point. So, 3-D maps are very important in making our Flood Insurance Program more effective, and I think it is something that we have to transition to very, very fast.

Mr. Powell, you talked a lot about our renewable energy and the things we have already done and the strides we have taken. Can you talk a little bit about what battery technology can mean, and why the Federal Government should invest—although it is outside the jurisdiction of this committee—in battery storage technology and what it can mean to renewable energy and its ability to actually be more impactful in our power grid?

Mr. POWELL. Sure. First, let me thank you for your leadership in battery storage innovation, with your cosponsorship of the BEST Act as well as the USE IT Act on advanced carbon innovation technology.

Storage is essential to smooth out the intermittency of existing intermittent wind and solar technologies. And, frankly, it is important for other technologies as well. For a baseload technology like nuclear energy that is actually better if it runs all the time, it may be nice to have storage attached to that to add flexibility and improve the economics of that technology.

Today, we have a very competitive technology in lithium ion batteries for short-duration energy storage, but where we struggle is for longer-duration storage, whether that is from one day to another or one week to another or eventually one season to another.

If we think about a grid that is going to have a very high percentage of renewables, 80 percent or more, that would require batteries that might only charge and discharge one time a year, and that would be technologies that we really haven't started to scratch the surface of yet.

Mr. STIVERS. Great.

And one follow-up question for you, Mr. Powell. A lot of people talk about reducing our carbon footprint. I totally agree. Another piece that people don't talk enough about is negative-emissions technology. Negative-emissions technology can be plants, but there are things you could put on plants to make them more effectively pull carbon out of the environment and put oxygen into the environment. How important is that toward a balance?

Mr. POWELL. It is extremely important. I think in the future, we will think about not zero emissions, but net zero emissions.

Mr. STIVERS. I think that is a really important point out of this hearing, and it is something not enough people talk about. It is about a balance; it is about a net. It is not about just going to zero.

Mr. POWELL. Yes.

Mr. STIVERS. I think that is a really important point that I hope we all remember out of this hearing. Thank you very much.

Mr. POWELL. The USE IT legislation establishes an XPRIZE for that technology, which is why it is a very important piece of legislation.

Mr. STIVERS. Thank you.

Thank you, Mr. Chairman. I yield back.

Chairman CLEAVER. Thank you.

The Chair will now recognize the chairwoman of the full Financial Services Committee, Chairwoman Maxine Waters, the gentlewoman from California.

Chairwoman WATERS. Thank you very much, Mr. Chairman. And I am very pleased that you are holding this hearing. The issue of climate change must be addressed in the Congress of the United States, and we must move forward in ways that we have talked about but we have not yet accomplished. But I am very pleased about this hearing today.

I don't have a lot of questions to ask. Obviously, the macro-economic impacts are certainly something that we should all be concerned about, because we can see it unveiling right before our very eyes.

I might just ask the panel if they can help me a little bit, as I am focused on the Bahamas and Grand Bahama and Abaco, and Hurricane Dorian that just lingered over Grand Bahama and the destruction that has caused—over 70,000 people have been impacted by it, and over 50 have been found dead at this point.

And, of course, I am just heartbroken about what is happening in the Amazon. I was raised in school learning about the Amazon and its importance to the world. And I am seeing this destruction, and I am wondering whether or not we are effectively understanding what we can do about all of this.

So anyone who just wants to help me feel a little bit better than I am feeling based on what I have been witnessing in the last few days here, please share your thoughts with me.

General CHENEY. Chairwoman Waters, thank you for coming and joining the testimony we have today.

My experience on the hurricane side of the house is extensive, not the least of which is at Parris Island, South Carolina, which had to evacuate for the second time in 2 years because of Dorian in the past couple of weeks. And then, of course, Dorian moved

north. I think North Carolina got spared, unlike with Florence last year, what that did to Camp Lejeune, North Carolina. It decimated that base. And these are just going to occur on a much more frequent basis.

So I don't think that will make you feel any better about our response to it, other than to raise the alarm that it is impacting our national security and our bases and stations immensely, and that we really do have to get on board and stop this.

Chairwoman WATERS. Thank you.

Anyone else?

Mr. BURKE. Thank you, Madam Chairwoman.

Yes, two things to add about hurricanes: It is hard to stop a hurricane; and what we know from climate science is they are going to get bigger and they are going to get slower. So, Dorian was no surprise, in that sense. It was big and it was really slow, as you said. It sat there for a while, and dumped a lot of rain. And we expect that to happen more often.

So the two things we can do to make that not happen are we can mitigate, we can reduce the amount of future climate change that we are going to see, that we want to see; or we can adapt. And we should probably do some of both.

In terms of adaptation, we should think about how we can help these communities both defend against future hurricanes and then have the safety nets that allow us to rapidly respond. And I think we have seen our ability to rapidly respond in the Caribbean. It is not great and could be dramatically improved.

Chairwoman WATERS. We talk a lot about fossil fuel. Would you consider that high on the list of causes of climate change, the abundance of fossil-fuel use in our country and in the world?

Mr. BURKE. It is the cause, yes. The burning of fossil fuels and the emission of greenhouse gases is exactly the cause. Yes, ma'am.

Chairwoman WATERS. And we talk a lot about how climate change is manmade, for the most part. What other kinds of things should we be doing?

I know you know, and this probably seems redundant to a lot of folks, but I think we need to ask it over and over again: What kind of things should we be doing, besides the elimination of fossil fuels?

Mr. BURKE. That would be a good start, and I think there has been a lot of good discussion about how we might go about that.

Adaptation is the other thing we need to do. Even if we rapidly decarbonize, we will still expect some warming, some climate change, and this will make many of these impacts you are worried about worse. So, we need to figure out how to adapt.

And I think there is a huge role for government in helping communities adapt and understanding what investments can help us adapt. Reforming the Flood Insurance Program would be a good place to start. But governmental investment in communities' ability to adapt to the climate change that we will see.

Chairwoman WATERS. Will there be an elimination of the insurance industry because they cannot afford to calculate the risk anymore, and offer insurance and premiums that would help to renovate and pay for the damage?

Mr. KARSNER. If we fail to act, the insurance industry certainly is in peril. But I don't see that the U.S. economy could do very well

with a significant shock to the insurance industry. So the goal should be to enhance their capacities for risk management and set rules forward that allow them to integrate state-of-the-art technology and predictability and new insurance product innovation.

Chairwoman WATERS. Thank you, Mr. Chairman. I yield back.

Chairman CLEAVER. The gentlelady yields back.

The Chair now recognizes the ranking member of the Full Committee, Mr. McHenry, for 5 minutes.

Mr. MCHENRY. Mr. Powell, I want to continue with what Mr. Stivers talked about, the idea that, instead of just having something that is zero emissions, that we have technology and innovation that could be commercialized, that we are on the cusp of it, in order to not just have zero emissions but to take CO₂ out of the atmosphere. Walk us through that.

Mr. POWELL. Absolutely. This is a very important concept. This is what matters in the climate math. The use or disuse of fossil fuels doesn't matter in the climate math. Net-zero emissions is what matters in the climate math.

So we could continue to use fossil fuels, just so long as we captured those emissions at that point and did something else with them—put them underground, use them to make a product. Or we could continue to use fossil fuels, allow some of those to go into the atmosphere, as long as we were capturing an equivalent amount of carbon dioxide somewhere else. And, in many cases, that might actually be the most economic thing to do, whether—

Mr. MCHENRY. So what can we do to make that happen? Because that seems to be better than adaptation, that we need to just basically walk around in rain boots all the time and batten down the hatches for worse hurricanes, more frequent hurricanes.

Mr. POWELL. There are a couple of major classes of this. The first, as I think as Ranking Member Stivers mentioned, is plant more trees and use natural-based solutions to pull more CO₂ out of the atmosphere.

You can also do things with mechanical solutions. There are a number of companies—one in Europe, two in the United States, and one in Canada—that are using actual mechanical, sort of, large machines to pull it out of the atmosphere.

Occidental Petroleum has just announced that they are going to build one of these machines at very large scale that will eventually sequester millions of tons of CO₂ in the Permian Basin. So they are going to be pulling CO₂—it is a carbon engineering machine, again, from Occidental Petroleum. They are going to be pulling CO₂ out of the atmosphere, they are going to be injecting it underground, and actually using it to spur enhanced oil recovery, so that the oil produced from those wells in the Permian may well be net-negative barrels of oil or even—so they will be fully clean barrels of oil.

Mr. MCHENRY. So, focus on R&D for us to have the public sector working with the private sector to ensure we have next-generation technology to directionally change the course of our emissions?

Mr. POWELL. Absolutely. And bills like the USE IT Act, which, again, does an XPRIZE for this negative-emissions technology; bills like the LEADING Act, which is, again, a bipartisan bill that focuses on zero-emission natural-gas-fired power plants; or bills like

the Veasey-McKinley Fossil Energy R&D Act, which does the same for coal technology—all would use the resources of the Department of Energy and the National Labs complex, and help really bring down the cost of these—

Mr. MCHENRY. Innovation.

Mr. POWELL. —technologies. Innovation.

Mr. KARSNER. If I may, sir—

Mr. MCHENRY. So, Mr. Kotek—

Mr. KARSNER. Sir—

Mr. MCHENRY. I will get to you. Don't worry.

Mr. Kotek, so, nuclear, how many nuclear power plants do we have in the United States?

Mr. KOTEK. We have 97 operating today, although, unfortunately—

Mr. MCHENRY. Okay. So what does that mean in terms of production?

Mr. KOTEK. A little less than 20 percent of U.S. generation.

Mr. MCHENRY. A little less. So, in terms of carbon emissions, just for the record?

Mr. KOTEK. Yes, sir. More than half of the U.S. carbon-free generation comes from nuclear.

Mr. MCHENRY. So, 20 percent/more than half.

Mr. KOTEK. Yes.

Mr. MCHENRY. All right. So we take you offline, we implement the Green New Deal, take nuclear out of the mix. How do we replace your generation?

Mr. KOTEK. Well, what would happen today is you would build a bunch of gas, by and large.

Mr. MCHENRY. So, we would follow the Germans and stop nuclear power plants, and then go to more CO2 emissions as a result of it.

Mr. KOTEK. Certainly, the German experience has not led to the emissions-reduction promise.

Mr. MCHENRY. Okay. So more emissions, more expensive power. Okay. I just wanted to get that for the record.

Mr. Burke, you talked about data. So, let's talk data. Is the Federal Government doing a good job when it comes to giving you the data you need, making sure that we have open-source data for you to use and analyze? Are we doing a good job or a bad job? What kind of grade would you give us?

Mr. BURKE. On economic data, doing a great job. A lot of data we can use. The data is pretty up to date—

Mr. MCHENRY. But I mean risk data. For instance, where is the risk? We have the National Flood Insurance Program. Where are these properties? What do they look like? What is their elevation? Go through that basic set of data.

We have Fannie Mae and Freddie Mac, the largest holders of mortgages in the world. Where are those properties? Right?

So, would additional data like that be useful for your ability to analyze the risk?

Mr. BURKE. Absolutely. Yes.

Mr. MCHENRY. Is that something, as policymakers, regardless of our view on climate or what to do about it, would that be useful data?

Mr. BURKE. Absolutely.

Mr. MCHENRY. Okay.

Mr. Karsner, in your experience, is that, likewise, something that we need to be pushing for, is greater data, greater transparency of that data, so that we could have better assessments of our risk—taxpayer risk?

Mr. KARSNER. Absolutely indispensable, sir.

Mr. MCHENRY. Okay.

Thank you all. And thank you all for letting me cover quite a broad base here.

And thanks, Mr. Powell, for leaning in on the innovation. I think that is the key for us to conquer this issue.

Mr. CLEAVER. Thank you.

The gentleman from Colorado, Mr. Perlmutter, is recognized for 5 minutes.

Mr. PERLMUTTER. Thanks, Mr. Chairman.

On the 9/11 thing—kind of, this is environmental and 9/11—I remember we were at the construction of what was the Freedom Tower, also known as One World Trade Center. And I was thinking to myself as the construction was underway—they had just started it—I said, I wonder what sea-level rise might do to this construction project and the island of Manhattan. That is just a thought. But it really rang true.

And, Mr. Chairman, I was at the Broncos versus Giants game the night before, on Monday Night Football, September 10, 2001. And I certainly can remember that, and then the next morning.

Mr. Karsner, it is good to see you, sir. And I just want to thank you for your service to the country, and for working with me on a couple of items involving the National Renewable Energy Lab. Thank you for that.

And then you also helped me—and Mr. McHenry just reminded me of this—we had a bill called the GREEN Act, you may recall, that dealt with a lot of construction, mortgage, renewable energy, and energy-efficiency techniques. And it actually passed out of the House a couple of times to the Senate. A number of the proposals in that bill were accepted, in effect, by the Bush Administration and also by the Obama Administration to really try to reduce carbon in the whole construction/real estate sphere. So, I want to thank you for that.

I wanted to ask you a question about how you think policy-makers can accelerate the development of something you call the “Earth Dashboard.” And can you explain what the heck you mean by that?

Mr. KARSNER. Yes, sir. And it is good to see you too, Congressman. Of course, your district in Colorado is one of the great epicenters of innovation, precisely working on the type of R&D that we just heard about.

An Earth Dashboard is moving from the idea that I, as a climate negotiator, would have people talk about the air bars on climate-risk modeling 10 years ago, 20 years ago, even 5 years ago, but the reality, with the amount of big data meeting cloud, high-performance computing, meeting sensors in the internet of things, means that we are collecting such an exponent at a high volume of data that we can move away from long-term projection modeling and

into a real-time, current performance assessment of how the Earth is operating.

Now, that is a mind-boggling concept, and something I couldn't have thought about 10 years ago, but we didn't have this level of computing 10 years ago. But today, we have the capacity to crunch data for enumerable things—for my daughter accidentally holding the photo thing down and having it go to five different data centers across the country to suck up electrons.

But if we actually direct and harness that computing for the sensors and data that measure, quantify, monitor, and ultimately manage our ecosystem services, then not only will we have technological solutions for sequestration, we can begin to value ecosystem services for sequestration. We can understand with great precision why a mahogany tree breathes at 20 times the rate, and absorbs 20 times the carbon than a fir tree in the same forest.

So we need to bring that thinking into—

Mr. PERLMUTTER. In Colorado, we are more likely to have fir than mahogany. That I would say. So, no, I appreciate that.

One of the things that climate scientists in Colorado—we have seen—and the chairwoman talked about it—is that the weather systems just sort of come and sit. It might be a dry system, or it might be a wet system like we have seen in the Midwest most of this summer; a hurricane languishes, sort of sitting out there in the Pacific.

So, General, where do you see the real trouble spots coming unless we really get ahead of this climate change and these kinds of intense, long-lasting climate episodes, instances?

General CHENEY. Congressman, on the military side, our number-one poster child is the Norfolk Naval Base. It is literally sinking, and then seawater is coming up, and it is going underwater. They know it, they understand it, and they are working on it. In their case, it is adaptation, as the doctor pointed out. They are into heavy adaptation here. Long-term mitigation to stop climate change is what the solution is, but that ship has already left the port, as far as they are concerned, because they are going underwater.

All of our bases and stations on the coast are threatened. I mentioned that Parris Island floods routinely now. They had to evacuate for the last hurricane. We look at Tyndall Air Force Base, which is no more. So, all of those from the hurricane perspective.

But it is not just sea-level rise; it is also heat. Many of our bases and stations—I will give an example. Fort Bragg in North Carolina has to shut down more often because of black-flag conditions.

Mr. PERLMUTTER. My time has expired, and I hope somebody else asks you the same question so that you can discuss those other things. Thank you.

And thanks to the panel.

Mr. CLEAVER. I thank the gentleman.

The gentleman from Oklahoma, Mr. Lucas, is now recognized for 5 minutes.

Mr. LUCAS. Thank you, Mr. Chairman.

I think most of my colleagues are aware that in the real world, I am a farmer by trade. And in my farming program with my wife

in rural western Oklahoma, I see the weather patterns changing. It is obvious; it is going on.

But I am also aware that in my part of the world, where weather records date back to the land run in 1892, that we are kind of in a challenging place on the east side of the Rockies in the Southern Plains. We had a drought from the 1890s—the infamous drought through the 1930s, the drought of the 1950s, and in the first 4 years of this decade, maybe the most vicious drought of all.

So I am very sensitive about not just present weather patterns changing, but just the nature of the part of the world I live in. That brings me around to the thought about the progress we have made in this country trying to address clean-energy technologies and how we fit in with the rest of the planet in addressing this issue.

I want to turn to you, Mr. Powell. Could you speak for a moment on how the United States can ensure that our clean-energy technologies are competitive in world markets and how we can help the rest of the world address their problems too? We have competitors, like the Chinese, out there on this matter. Can you touch on that for a moment?

Mr. POWELL. Absolutely. And, first, thank you for your leadership on the Science Committee. Thank you for your sponsorship of the LEADING Act on natural gas CCS (carbon capture and storage) technologies.

This is the key point in climate: This is a global problem. The atmosphere does not care whether a molecule of CO₂ is emitted here in the United States or around the rest of the world. We are now only 15 percent of global CO₂ emissions. So, historical responsibility aside, the climate math is simple. Unless we get the rest of the world to develop on a very different course and emit far less in rapidly developing countries, the problem of climate change cannot be solved.

So the key is, how do we make technologies that are very competitive for a rapidly developing country—a Nigeria, an Indonesia—someone who is first and foremost focused on electrifying their populations and spurring economic growth to meet all kinds of different needs, and secondarily perhaps thinking about clean energy? How do we make that an easy choice for them?

The reality is, today, they are very often looking at an older-technology, unmitigated coal plant, often financed and offered turnkey by the Chinese, often as part of their Belt and Road Initiative. And until we have a really compelling substitute for that, something that can be built on a small amount of land in a few months at relatively reasonable costs using fuel that is available around the world, it is going to be very difficult to change that trajectory. And that is the bogey that we need to be shooting for.

Mr. LUCAS. Well, along that very line, as you have noted correctly, the growing demand for fossil fuels around the world, let's talk more specifically about how we can work with the private sector to utilize and advance the things that the government has already started here in the United States. We have spent a lot of money on research.

Mr. POWELL. Indeed, we have.

There is no better explanation or no better example of that than the shale gas revolution. In the United States, in the 1980s and

1990s, the Office of Fossil Energy at the Department of Energy (DOE) spent somewhere around half-a-billion dollars on basic and applied research. It was a public-private partnership with Mitchell Energy—George Mitchell, a great pioneer in energy technology in Texas.

They unlocked the shale gas revolution—hydraulic fracturing, horizontal drilling, 3-D imaging, diamond-headed drill bits, combined-cycle natural gas turbines. And that is a world-beating technology. If you didn't care about CO2 emissions, it is perfect, right? It is very, very cheap and quick to build. It is extremely flexible. We have a virtually unlimited supply of natural gas in the United States. And it is cheaper than most of the alternatives.

And so, there has been sort of a market-based decarbonization. We are down one-third in power-sector emissions. Two-thirds of that is from natural gas.

Mr. LUCAS. Let me conclude by noting that I have spent a good part of my career in Congress trying to mitigate the effects of weather, whether it is making sure that crop insurance works in an effective way so that producers have the ability to sustain their productive capacity, or things like the Upstream Flood Control Dam Program at USDA, where, in addition to the big flood control projects done by the Army Corps of Engineers, we attempt to use earthen dams, interlocking, to try and slow, to mitigate the effect of these sudden downpours.

But it requires more than just that. I acknowledge that. And that is why I asked my questions about the research that we do at the Department of Energy, and how we make sure the rest of the world can access that, and that we have the ability to sell and work with and service those products.

With that, Mr. Chairman, thank you very much for the hearing. And in my part of Oklahoma, rarely do we pray for dry weather, but I am told that occurs in some other parts of the country.

Mr. CLEAVER. Yes.

Mr. LUCAS. It is a most amazing concept.

Mr. CLEAVER. Yes, we do.

Mr. LUCAS. Thank you, Mr. Chairman.

Mr. CLEAVER. Absolutely.

The gentleman from Washington, Mr. Heck, is now recognized for 5 minutes.

Mr. HECK. Thank you, Mr. Chairman. Thank you for holding this hearing.

And thank you to all of the panelists for your excellent presentations this afternoon. Mr. Kotek, Mr. Powell, by the way, thanks very much for calling out the Export-Import Bank, another issue on which I am very involved.

I have the honor and privilege to serve on the House Permanent Select Committee on Intelligence, so I think about this issue a lot through the filter of national security.

I would like to begin by asking each of you, if at all possible in a yes/no-type response, just because I don't want to assume anything, if you think it is worthwhile to dedicate time and resources to collecting and analyzing data as it relates to the national security implications of climate change. And do you think, to the degree

possible, that ought to be coordinated across the various branches of the Armed Services?

Mr. Burke?

Mr. BURKE. Absolutely.

General CHENEY. Of course, it ought to be.

Ms. EADY. Agreed.

Mr. KARSNER. Yes. Knowledge is power.

Ms. SEIGER. Yes, Congressman.

Mr. KOTEK. Yes, sir.

Mr. POWELL. Yes.

Mr. HECK. 7-. Thank you for your implicit endorsement of my bill, H.R. 3110, the Climate Security Intelligence Act, which would set up a climate security intelligence center at the Office of the Director of National Intelligence to do exactly what you just said you support. I promise I will not use your name in explicit endorsement without talking to you first.

And the good news is that a variation on H.R. 3110 was included in the Intelligence Authorization Act, which passed the House by a large, bipartisan majority.

General, as I want to plumb a little bit more the national security thing, I do want to pick up, and had intended to do so even before he asked this question, on the issue of where our vulnerabilities are, especially with respect to military installations.

We have those that have already been damaged—Tyndall, Offutt, Lejeune, Bragg. You mentioned and added to that any seaport that is subject to sea rise. I would ask you to take that next step and identify, if you could, where you are particularly concerned about vulnerability, whether it is with respect to sea rise or weather damage or shortage of water, which I understand is a potentially significant compromising factor for some bases or camps that don't have an adequate water supply.

Where else would you cite, sir?

General CHENEY. Thanks for the question.

When you look at Alaska, we have a NORAD base that is sinking through the permafrost, I mean, literally sinking. It has to be moved. That's a dramatic impact on our national security.

We have a Marine brigade's worth of equipment on Diego Garcia in the Indian Ocean. Diego Garcia will go underwater. We will have to move that brigade's worth of equipment somewhere.

By the way, this is all on the ASP's website. We have it listed base by base, not just in the continental United States but worldwide.

I mentioned our bases and stations in the United States. Camp Pendleton in California routinely would have fires—I have been stationed there for many, many years—but not like the last 2 years' worth. And, of course, you all on the West Coast are very familiar with the fires that are occurring now fairly routinely, which are impacting our bases and stations. And, oh, by the way, we are deploying military members to fight these forest fires as well. So, it is a dual problem for them.

The sad part about all this, Congressman, is when you look at the documents coming out of the White House and the Pentagon—the National Security Strategy, the National Defense Strategy, and the National Military Strategy—not a single one of them mentions

the two words, “climate change.” They did in the past, but they don’t anymore.

And I think the role of Congress in this can be to, either through the NDAA or other legislation, tell them that they have to consider this as the critical threat that it is to our—

Mr. HECK. H.R. 3110.

Let me ask the parallel question as it relates to geographic spots on the globe where you might be particularly concerned about increased instability.

General CHENEY. I could spend an hour on this, but I will try to put it down to a minute.

Mr. HECK. I have 40 seconds—

General CHENEY. Yes.

Mr. HECK. —and another point I want to make.

General CHENEY. You can start with sub-Saharan Africa where, as the climate changes because the heat is increasing, they predict it is probably going to be up to 140-plus degrees Fahrenheit in a couple of years. People can’t live there. You are going to have millions—

Mr. HECK. Would that be your number one, General?

General CHENEY. No. I think number one would probably be Southeast Asia, with the sea-level rise in Bangladesh. We are going to have 30 million climate refugees who are going to have to leave because their land is being encompassed by sea-level rise.

Then, you look throughout the Mideast now as it heats up and there is continued drought, which was a big contributor to the Arab Spring and what happened in Syria.

I would say Bangladesh, number one; Middle East, number two; Africa, number three; and then our bases and stations here in the continental United States.

Mr. HECK. Well, my time is up, but I cannot help but conclude, sir, by saying that the Marine Corps is very, very special in my family. I honor your service greatly. I thank you for it. Semper fi.

General CHENEY. Well, semper fi, Congressman. Thank you.

Mr. CLEAVER. The gentleman from Texas, Mr. Williams, is recognized for 5 minutes.

Mr. WILLIAMS. Thank you, Mr. Chairman.

In early August, electricity prices in Texas surpassed the \$9,000 price cap that forced our State’s grid operator to declare an emergency.

A Bloomberg News article about the incident said this: “This week’s price spikes also underscore how dependent the region’s power grid has become on wind farms, which now make up about a quarter of the generation capacity in Texas. Lackluster breezes contributed to the higher prices.”

This seems like one of the many flaws of rushing to implement green technologies when they are not an economically viable solution.

So, Mr. Powell, what do you believe is the best way to balance implementing clean technologies without shifting this cost burden to hardworking Americans?

Mr. POWELL. Well, it was an interesting summer in Texas with some of those power prices. I do wish I was connected to the grid

and able to capture some of those on some of those days. You could have made a lot of money.

I think this is a perfect illustration of why flexibility is absolutely key when we think about clean-energy technology. We spend a lot of time on intermittent renewables, and those are great and the prices are coming down, but without the flexibility, they can occasionally help contribute to some of these incidents where power prices, such as in that instance, spiked very high.

So if you had something paired with that that was a highly flexible zero-emission technology, like a grid-scale battery or something like the zero-emission fossil power plant that is being developed in Texas, the NET Power plant, that could have responded to that moment, kept prices down, and actually done it continuously with zero-emission power.

And, going forward, this is going to become a larger and larger issue as we have more and more of these other intermittent renewables in other parts of the country.

Mr. WILLIAMS. Okay.

For full disclosure, all of you need to know that I am a capitalist, I am from Texas, I am a car dealer, and I have a nuclear plant in my district.

So, I think that innovation will play a key role in reducing emissions. And it won't be a government mandate; it won't be increased regulations; and it won't be banning people from eating meat that will solve this issue. It will be the private sector and increased research and development that will bring these more efficient technologies to market.

So, Mr. Powell, again, I know that there are some success stories of innovation that has greatly reduced emissions over the years, one of which occurred in Texas. And you touched on Mitchell Energy during Mr. Lucas's question before me, but I think it is really an important point that you once again elaborate on how good public policy allowed for Mitchell Energy's innovation.

Mr. POWELL. Absolutely. I agree it is worth restating. It was a combination of policies and a public-private partnership.

You had a significant tax incentive, the alternative production credit, through the 1980s and 1990s, which was sort of the gold ring that he was chasing there.

You had a public-private partnership between Mitchell Energy and the Office of Fossil Energy at DOE, which enabled lots of basic research, and applied testing in wells on a number of their properties and lease areas.

And then, you also had voluntary work from the gas industry. The Gas Research Institute, in a voluntary way, put \$100 million from private industry towards helping scale that up.

And all of those things came together to spur that breakthrough.

Mr. WILLIAMS. Okay.

Energy independence is a national security issue, we all agree. As long as oil and gas are some of the most important global commodities, the United States cannot afford to simply ban all fossil fuels and sit on the sidelines.

So, again, Mr. Powell, what do you think the effect would be on the economy and our global influence if we banned all mineral leases and oil exploration activities on public lands?

Mr. POWELL. It obviously would have a disastrous effect on the economy to do all of that in that very rapid way.

And, again, we shouldn't think about any need to ban fossil fuels. We should be working on lowering emissions. Emissions are the problem, right? If you could continue using fossil fuels well into the future but do it with very low or no emissions or offset those emissions entirely with other technologies, why wouldn't you keep using fossil fuels into the future if those were the least expensive way to go forward?

Mr. WILLIAMS. As I said, I have Comanche Peak Nuclear Plant in my district in Texas. And we know nuclear power accounts for 20 percent of the power production in the United States and produces zero emissions. Expanding nuclear seems like a logical and realistic way to obtain sustainable, low-emission energy. However, nuclear remains heavily criticized by many Democrats, even as they talk about their lofty emission-reduction goals.

So, Mr. Kotek, do you think it is possible to achieve a goal of zero emissions without the use of nuclear power?

Mr. KOTEK. When you look at the system today, you need what nuclear delivers. You need flexible, firm, zero-emission generation. Right now, nuclear is far and away the leading source.

So what we are advocating is developing next-generation nuclear systems that can address some of the challenges, particularly around cost, and ensure that nuclear is available to complement the other technologies we have heard about today.

Mr. WILLIAMS. Okay.

Thank you all for being here today, and thank you for calling this hearing, Mr. Chairman. I yield back.

Mr. CLEAVER. Thank you.

The gentleman from Guam, Mr. San Nicolas, who is also the Vice Chair of the Full Committee, is recognized for 5 minutes.

Mr. SAN NICOLAS. Thank you, Mr. Chairman. And thank you so much for affording me the opportunity to serve on this subcommittee.

As the Representative from Guam, I bring to the committee the unique perspective of having the only district that is actually an island. And we are in the South Pacific.

General Cheney, I really appreciate your perspective, because we have significant military assets on the island, as well as significant military assets to our allies in the south, particularly the Republic of the Marshall Islands, on Kwajalein Atoll, that is just a few feet above sea level. And so, these climate change concerns are absolutely national security concerns.

In listening to the conversation, however, I just get very disenchanted. When we hear, for example, that the U.S. represents 15 percent of global emissions, as you mentioned, Mr. Powell, and that if we don't have the rest of the world on board, even if we went 100 percent zero emissions, we still wouldn't solve the problem, that is a huge concern.

Because the reality is that we are getting outspent in Africa by the Chinese, \$10 to \$1. And those about \$60 billion of state-owned enterprise investments going on in Africa aren't in the clean-energy sphere. They are also able to leverage those dollars to construct a

lot of inexpensive, high-emissions facilities in areas that we are coming up short.

And as I listen to all of this, I ask myself, what can we really do at the end-game scenario? Even if we got it right 100 percent of the way, even if we fully recognized the national security concern and we dedicated more defense dollars to this actual national security threat, without addressing the fact that the rest of the world is going to continue to drag us down, I just ask myself, how can we actually overcome this?

And so, I am listening to the conversation when we talk about adaptation, Mr. Burke, and we also talk about trying to stem the tide of these high-emissions facilities being built in developing countries.

Mr. Karsner, is there any study that weighs the opportunity cost of adaptation investment versus international, developing nation investment and trying to stem that tide?

Because at the end of the day, we have to weigh issues like homelessness and trying to solve that in this committee; we have to weigh issues like student loans and trying to solve that in this committee. And then we talk about climate change and the real threat that presents, and at the end of the day, we only have so many resources.

We can invest in adaptation, we can invest in trying to bring new technologies to developing countries, but are we actually studying where is the most effective use of the limited dollars that we have right now?

Mr. KARSNER. I am confident that there are many, and I would invite any of my academic friends on the panel to share some if they have it, and I would be happy to get back to you for the record, sir, on that.

I would say, as a former climate negotiator, that there is great sensitivity amongst those who believe there should be a balanced approach to adaptation and mitigation versus another school of thought that says, the more you are talking about adaptation, the more you are abandoning the probability or possibility of mitigation.

And so that has led people, in my personal judgment, to not be as dispassionately objective with the integrity of such research. And I think we are in need of continuously working on mitigation and never abandoning that, but at the same time, moving with the kind of urgency that most of the panel has talked about on adaptation, preparation, resilience.

Because I think we probably have underperformed those things over the past decade, and I think that we have a serious need to catch up, particularly in low-lying islands across the Pacific, which by population may not represent the same problems of migration and human crisis, but when we think of whole populations, like Kiribati or the Solomons, that are contemplating relocation—or now I would say Abacos and other islands, to go back to Chairwoman Waters' question—I think amongst the things we can do is be far more humane in recognizing that we are not going to be able to rebuild everywhere. We are not going to have populations that have enough funding for gray concrete and seawalls, like Manhattan or Amsterdam, for 500 years.

And so, when you talk about the Bangladeshi and Nigerian deltas and the low-lying islands of the Pacific, we need to be much more direct in our planning and the kind of studies that you have asked about.

Mr. SAN NICOLAS. To close, Mr. Chairman, the reason why I feel like we really need to get all this data crunched and have these concrete things set before us is because at the end of the day, we have to decide, are we going to invest \$3 billion on a seawall or are we going to invest \$3 billion on cleaner energy in a developing nation to help stem the emissions issues that are creeping up there? And at the end of the day, without the data, without the studies, we are flying blind.

Mr. KARSNER. And the data can also characterize the value of green infrastructure and how green seawalls full of mangroves, and wetlands and prairies can absorb some of that and let nature act as an ally as much as a threat, in some cases.

Mr. CLEAVER. Thank you.

The gentleman from Arkansas, Mr. Hill, is recognized for 5 minutes.

Mr. HILL. Thank you, Mr. Chairman. I appreciate it.

And I thank the panel for your time this afternoon. I appreciate all your contributions to this important topic, and I am grateful for these views.

I am thinking that I have enjoyed the conversation so far, particularly in the area of innovation and in the discussion about mitigation and the data necessary to plan that mitigation in the right way. Because for 30 years, where this climate change was just an unformed topic, people have been building more and more expensive infrastructure in places that they probably shouldn't have built it anyway, regardless of climate change.

I think we have way overbuilt coastal islands and ravines and suburban L.A., and not smart building. But that is what county commissioners and cities wanted for tax revenue, and so they made some bad decisions. I think that has compounded this mitigation challenge that we face, and I hope that local governments are thinking about that as well.

But in the innovation issue, I was so intrigued by the discussion. I live in Arkansas, where about 19½ percent of our energy is generated by nuclear through Entergy, which is a publicly traded company, one of the few companies that has its own goal to meet. It is cutting its carbon emissions over 50 percent by 2030. And they have done that by relying on nuclear as a big part of their strategy, not to the extent of some utilities. But I am concerned they won't replace it because of lack of innovation, regulatory cost, lack of regulatory innovation, just the general expense of nuclear. And I think that would be a shame. They were one of the first companies—Arkansas Power and Light and Mississippi Power and Light—to innovate in nuclear.

So I hope that we can have a strategy that includes robust nuclear energy, and that America returns to a leadership role there. And we have all of these National Labs who had a little hand in inventing nuclear energy. It would be nice if they could help us roll out a low-cost nuclear reactor component for the Third World.

Would you comment on that, Mr. Powell?

Mr. POWELL. Sure.

Mr. HILL. And then, I would also like to turn it over to Mr. Kotek.

Mr. POWELL. This is absolutely vital. Today's nuclear reactors are terrific machines. They are operating, as Mr. Kotek mentioned, at historically low cost, and at extremely high reliability. And yet, given all the benefits of the shale gas revolution that we discussed earlier, and given the subsidies we have given to intermittent renewable energy, power prices are now so low in so many parts of the country that they are no longer economic to continue operating. In some cases, it would be cheaper for a utility to shut it down because some of its other attributes aren't being compensated for.

So, we can do two routes to that. One is we can continue innovation on the existing nuclear fleet, and we should. There is a terrific program at the National Labs complex on increasingly lowering the cost of those and making sure that we can do second life extensions to those reactors so that we can extend their life all the way out to 80 years.

And when, inevitably, some of them need to be replaced, we need to make sure that we have a more economical solution to replace them with. And that is why efforts like the Nuclear Energy Leadership Act (NELA) that Representative Rigglesman is leading on, which set a moonshot program at the Department of Energy to develop new advanced nuclear reactors which would be smaller, cheaper, and more flexible than the existing generation—

Mr. HILL. Thank you.

Mr. POWELL. That is why that legislation is so important.

Mr. HILL. Thank you.

Mr. Kotek?

Mr. KOTEK. Excellent point, and thank you, sir, for making it.

Part of the reason we started the Gateway for Accelerated Innovation in Nuclear at DOE during my time there was to try to bring the resources of the National Laboratories more to bear in assisting private-sector companies in developing new nuclear technologies and getting them to market.

The challenges that those innovators are facing now largely stem from just the large capital requirement to get a new technology through the licensing process and then through to demonstration. So laws like NELA will help greatly in making that a reality. Of course, then we will need the appropriations necessary to sort of hold up the public-sector side of a public-private partnership to demonstrate those technologies.

We also need to provide a demand signal that the carbon-free generation from nuclear is going to be valued equally with that from, say, wind—

Mr. HILL. Yes.

Mr. KOTEK. —and solar, right?

Mr. HILL. You made that point. Thank you for that.

Mr. KOTEK. Thank you.

Mr. HILL. Well, I appreciate Entergy's leadership and Arkansas Electric Cooperatives. Both have been leaders also in the solar arena, and both have put in plants now in Arkansas that have significant battery storage, which is a new scene institutionally in our State, to have large solar arrays but have the storage. Because that

is one of the biggest detriments to renewables, is we don't have the storage. And I appreciate DOE's significant \$60 million a year of research in batteries.

Thank you, Mr. Chairman. I yield back.

Mr. CLEAVER. The gentleman from California, Mr. Vargas, is recognized for 5 minutes.

Mr. VARGAS. Mr. Chairman, thank you very much. And thank you very much for holding this hearing.

I think this might be a banner day. I think this is the first time that I have ever sat in a committee, with both Republicans and Democrats, where no one has disagreed that climate change exists.

Mr. Chairman, you asked the question to the panel, and I think the panel, each and every one, answered that climate change is real, and it exists. I haven't heard one of my Republican colleagues, so far, say that that is not true. This is the first time.

I am from California. We have been dealing with this issue for many, many years. Usually, you get ridicule from the other side, that it is a Chinese fake, that it doesn't exist, sometimes are snowballs thrown, and a whole bunch of other things.

I think this is the first time—and we still have a few friends over here. I don't want to presume that—but it could be. That is why I am saying it could be a banner day, the first time ever that there haven't been howls from the other side on the notion that climate change exists and that it is real. I hope that is the case. And I do sense that there is a change, not only in my friends on the other side but I think, in society, that we are coming to this realization because of what we see.

Someone talked about insurance earlier. There will always be insurance, because there is never a bad risk; there is only a bad price. That is what they say in insurance. But the reality is that insurance takes a look at events. And these large weather events are normally measuring 50-year, 100-year, 250-year, 500-year, and 1,000-year events. These events are happening much sooner and with much more intensity. A 250-year event is happening every 100 years now. And it is getting harder and harder to price the risk, because, in fact, you don't know what it is because the climate is changing so quickly.

But I do just want to take a moment to say that I am very excited. This is literally the first time—and I have sat in hundreds of hearings—that climate change has been brought up and there hasn't been ridicule about it, that, in fact, we have all taken it seriously, and that we are all trying to do something about it.

There are different approaches here, and I appreciate that, and I think it is terrific. Mr. Powell, I think you have had significant contributions here today, and Mr. Kotek and everybody else, trying to figure out what perspective do we attack this on, but not the notion that it doesn't exist. I think that should be something that we take note of. I think that is very, very important.

That being said, I do want to talk about all-of-the-above. Geothermal hasn't been talked about today. And, Mr. Powell, I did want to ask you about geothermal, what your views are on that, because we have geothermal in my district. I represent Imperial County. We do have wind there. We also have solar and geothermal. What are your views on geothermal?

Mr. POWELL. There is literally enormous untapped opportunity in the United States, especially if you think about some of the new technologies in geothermal.

We have actually been taking a look, at ClearPath, at enhanced geothermal. And this would be actually using a lot of the same technology from the shale gas revolution and applying that to just tapping deep, hot rocks that don't have a lot of water already and sort of introducing water down there.

There may be 500 gigawatts of potential for that technology across the country. It is clean, it is baseload, it is flexible. It could be a huge part of the solution. And we think that more innovation in that space is absolutely vital, both in the private sector and in the National Labs.

Mr. VARGAS. One of the things you didn't mention that I think is important—because you mentioned it earlier—is the notion, also, of batteries and how important it is to store energy. In my district, they pull a lot of lithium out of there too, but they don't know what to do with it. They put it right back into the ground.

So we also, I think, have a way to take a look at these rare minerals that are necessary. And you do reach them with geothermal.

Mr. POWELL. Absolutely. Certainly, in a more general way, finding new sources for rare-earth minerals like lithium and cobalt, in large part because the supply chains we currently rely on for those, from places like the Democratic Republic of the Congo and China, are fraught, right? So finding new places to find those things, new sources like bringing it up out of the ground sort of incidentally in geothermal is very important.

Mr. VARGAS. Yes. And I think I will stop when I am ahead and just say, Hallelujah, Amen. And I will yield back.

Mr. CLEAVER. The gentleman from Ohio, Mr. Gonzalez, is recognized for 5 minutes.

Mr. GONZALEZ OF OHIO. First off, I want to thank everybody for the testimony. I really appreciate the time and energy that everybody put into it.

Mr. Powell, as a once-aspiring McKinsey consultant—I did a summer there—I appreciate the sober, data-driven analysis and solutions that you are offering. I think one person that I talked to about this earlier in the year was a lady named Sally Benson, whom some of the folks at Stanford may know. And we had a great conversation, and she said, look, we need sober, rational thinking to lead the way here. And I couldn't agree more.

Mr. Powell, you cited the fact that this is in fact a global issue. We are at 15 percent of emissions. Even if we cut to zero today, if global development patterns continued the way that they are, without the innovations that you are talking about, we don't really get anywhere. And that is just a fact. So, innovation must lead the way, if for no other reason, so that we can continue to be energy exporters in this country.

And I think, with respect to this hearing, the macroeconomic effects of climate change, I want to talk about the macroeconomic effects, briefly, of bad policy, frankly. And so, while we agree there is an issue, I think we do need to be clear on what the solutions are.

So, as I mentioned, we are energy exporters. The Green New Deal, which is the most comprehensive and, I would argue, laughable proposal I have ever seen, wants to rely exclusively on wind, solar, and battery. Using existing technologies today, is that even possible to get to zero emissions?

Mr. POWELL. Well, first, let me thank you for your leadership on the Science Committee. Thank you for your leadership on storage innovation and the BEST Act.

I do think that there have been multiple studies of studies of all of the different takes on how we would get to a zero-emission grid, and none of those studies that have taken cost as any kind of a factor into account find that we can do everything with existing technology today.

Mr. GONZALEZ OF OHIO. Right.

Mr. POWELL. They all find that we need—

Mr. GONZALEZ OF OHIO. And as Mr. McHenry noted, Germany has tried something similar; I call it “Green New Deal Lite.” They spent tens of billions of dollars, have the highest energy prices in the EU, and have not reduced emissions on a net basis, which I fear is where we were going.

Striking on that again, we are energy exporters today. If we were to go down the solar and wind turbine path, would we be exporters or importers, net?

Mr. POWELL. We would be importers. We import virtually—

Mr. GONZALEZ OF OHIO. From where?

Mr. POWELL. —all of our solar panels, in particular from China.

Mr. GONZALEZ OF OHIO. Thank you.

The other big proposal in there is to transition every single building, single family buildings, apartment buildings, there are roughly 100 million of these in the country today. To do it over 12 years—I did the math on that, and it is 4,000 buildings an hour for 12 years—4,000 buildings an hour.

Again, we all seem to agree, and I agree with Mr. Vargas, that this is happening, but we have to be realistic in what we are doing. That doesn't mean that we think small or we don't try to solve it, but it means we actually spend our dollars in smart ways.

And, with that, I want to turn to the innovation side. You have talked a bit about carbon capture. Tell me more, if you could, about bioengineering and grid reliability and how we can innovate in those sectors?

Mr. POWELL. Bioengineering, meaning changing plants to—

Mr. GONZALEZ OF OHIO. Yes.

Mr. POWELL. —maybe sequester?

Mr. GONZALEZ OF OHIO. Yes.

Mr. POWELL. Well, one thing we could do with bioengineering is—well, we could do two things, really. One is to change plants to sequester more CO₂ and soils to sequester more CO₂. And there is currently activity in several parts of the National Labs complex and ARPA-E on that very topic that we should continue to support, and ideally expand over time.

We could also do a lot with bioengineering to create better feedstocks for biofuels for transportation and biomass power, sort of the holy grail in climate modeling is a negative-emission power plant, so something that would take biomass power, take CO₂ out of the

air to make that feedstock, run it in effectively a fossil power plant, a biomass power plant, and then sequester those emissions. So, we would actually have negative emissions that was also producing power.

Right now, it is a little difficult to do that with any of our existing feedstocks. You could imagine using bioengineering to do that.

Mr. GONZALEZ OF OHIO. And then you talked about the public-private modeling from fracking, which I think is a great parallel to what we should be thinking about here. What set of technologies do you think provide the most promise today with respect to having a similar outcome in energy?

Mr. POWELL. We would certainly say that the suite of zero-emission, flexible technologies—so advanced nuclear; fossils with carbon capture, both gas and coal; grid-scale storage technology; and geothermal technology—right now seem to be the ones that have private companies that you could actually feasibly partner with, that could respond to incentives and that could be part of those partnerships.

Mr. GONZALEZ OF OHIO. Fantastic. Thanks again.

And I yield back.

Mr. CLEAVER. The gentleman yields back.

The gentleman from Illinois, Mr. Garcia, is recognized for 5 minutes.

Mr. GARCIA OF ILLINOIS. Thank you, Mr. Chairman.

And thanks to all of the great presenters here this afternoon.

I would like to begin with Ms. Seiger. You served on an advisory panel that was tasked with identifying investment risks and opportunities related to climate change, which found that the New York State Common Retirement Fund took a loss of approximately \$22 billion by not divesting from fossil fuels a decade ago.

I am very concerned that large State pension funds, like the fossil-fuel and financial industry as a whole, are simply not doing the math on climate change. In Illinois, for example, the Teachers' Retirement System of the State of Illinois' fourth-largest holding is in Shell. Its sixth-largest holding is in BP. It also has significant investments in NGP Natural Resources, EIF, and Energy Capital Partners—natural gas firms that have shown serious signs of volatility in recent months.

As more and more energy analysts begin to forecast a negative performance outlook for the fossil-fuel industry, how can State pension systems protect themselves?

Ms. SEIGER. Thank you for the question, Congressman.

This is a challenge for pension plans. Many of them have the majority of their listed equities managed under passive indexes, where they aren't actively controlling what is in and what is out. And as a result, when sectors decline in value because they are perhaps mispriced, perhaps because risks haven't been fully disclosed, they just own those losses.

So, more reporting transparency and disclosure would help protect pension funds by creating more efficient market pricing of those listed equities.

You also mentioned some private equity firms that have exposure to the fossil-fuel industry. In the case of New York Common, they have a very rigorous screening process about the environmental,

social, and governance components of the assets that they hold. So, in that case, they can actively manage that risk. But when it comes to listed equities, they are passive takers on those bad bets.

Thank you.

Mr. GARCIA OF ILLINOIS. Staying in the financial vein of things, looking back at the past decade of bankruptcies in the coal industry, many have predicted a similar path for oil and gas companies in the coming years as the world transitions to clean-energy sources.

However, fossil-fuel companies continue to invest in new production, and financial institutions continue to invest in this unsustainable expansion. Do you believe that this could lead to U.S. investors and the economy facing significant risk of stranded assets?

Ms. SEIGER. Congressman, I think that is a risk, and I think greater reporting and transparency would help us understand the extent of that risk and the magnitude and prepare for it.

And that is why I mentioned the point about transition risks. We have talked a lot about physical risks, which are very real and more well-documented. The transition risk is a much more complex set of factors to understand, and it gets to your question. And so, better modeling and information would help us to better prepare for that risk.

Mr. GARCIA OF ILLINOIS. And as for retired teachers, what do you think the implications are?

Ms. SEIGER. It threatens their nest eggs.

Mr. GARCIA OF ILLINOIS. That is what I thought.

Thank you.

Mr. CLEAVER. The gentleman yields back.

The gentleman from Tennessee, Mr. Rose, is recognized for 5 minutes.

Mr. ROSE. Thank you, Mr. Chairman.

Economic security and national security go hand-in-hand. You can't have one without the other.

The Green New Deal, as proposed in House Resolution 109, would upend our economy. As the American Enterprise Institute notes in an April 2019 report, believing that the Green New Deal would increase national wealth and employment follows the broken-window fallacy, that the destruction of resources increases national wealth.

One such resource I have heard criticized recently is nuclear energy. For more than 60 years, the United States has used nuclear power to produce reliable, low-carbon energy. In fact, my home State of Tennessee is home to the most diverse nuclear research lab in terms of competencies in the country, the Oak Ridge National Laboratory. Tennessee is, in fact, the birthplace of nuclear power.

Despite the fact that the United States invented nuclear power, a couple of leading 2020 Presidential candidates have stated that we should not build any new nuclear power plants and that we shouldn't even renew licenses of existing ones.

Without continued U.S. leadership, Russia and China are filling the void, creating a major security vulnerability for the United States. The Atlantic Council reported in 2018 that nearly two-

thirds of the new reactors under construction worldwide use designs from China and Russia.

General Cheney, in June 2018 you signed on to a letter to Secretary Perry, urging him to recognize the importance of U.S. nuclear energy to our nation's security.

Mr. Chairman, I ask unanimous consent that the letter be entered into the record.

Mr. CLEAVER. Without objection, it is so ordered.

Mr. ROSE. General Cheney, briefly, can you explain why nuclear energy is so important to our national security and to our military?

General CHENEY. Congressman, it is a great question.

As you probably noticed, nuclear power started with the United States Department of Defense. And today, I am a big proponent of small modular reactors (SMRs), which are the next cusp on nuclear energy. We have 60 or 70 of them running today in the United States Navy, and they have run safely, by the way, with a 100-percent safety record for the last 60 or 70 years.

So we at the American Security Project are big proponents of nuclear energy. We just think it has priced itself out of the market, that it needs help, that we need to be advanced, and we need to invest in technology. And to take this one step further, we are investing also in fusion energy, which we believe is the long-term solution to this.

But we are big proponents of nuclear energy. And, indeed, we must invest in the nuclear energy that our military is heavily dependent upon, particularly the United States Navy, for nuclear reactors for their ships, and they are vitally important to national security.

Mr. ROSE. Thank you.

Mr. Kotek, earlier this year, DOD's Strategic Capabilities Office put out a request for information about small nuclear reactors, or microreactors, that could be useful for future military use. Are there future civilian applications for a capability like this?

Mr. KOTEK. Thank you, Congressman.

Absolutely. If you think about some of the remote locations, whether Alaska, Canada, or other parts of the world where it is very difficult to get access to the forms of electricity or energy we use now, you can absolutely see where you could replace those forms of energy with a very small nuclear reactor.

Mr. ROSE. As I mentioned earlier, in my home State of Tennessee, 40 percent of the electricity produced is supplied by nuclear energy.

I am also very proud of the fact that Tennessee is home to Oak Ridge. A particular project at Oak Ridge is the Transformational Challenge Reactor project, or TCR. One of the major goals of the TCR project is lowering the cost of nuclear energy.

Mr. Powell, is nuclear energy clean energy?

Mr. POWELL. Of course.

Mr. ROSE. What can Congress do to help reduce the cost of nuclear energy specifically?

Mr. POWELL. I think that programs like the Transformational Challenge Reactor Demonstration Program at Oak Ridge, which is an amazing program at an equally amazing facility, can go a long

way. They could do for nuclear what all our work on shale gas did for natural gas power.

With the Transformational Challenge Reactor, they are looking at very advanced technologies—artificial intelligence, 3-D printing, advanced sensors—to completely rethink how you would design and operate a nuclear reactor.

And that is the kind of thinking that we need if small modular reactors and microreactors are going to be a reality and if they are actually going to be competitive with other sources of energy like natural gas.

Mr. ROSE. Thank you.

I yield back.

Mr. CLEAVER. The gentleman yields back.

Mr. Casten is next. The bell just signaled that votes are being called, so you two will be the final questioners. And if you wanted to cut it short, we wouldn't object.

Mr. CASTEN. Thank you, Mr. Chairman, for recognizing me. I will try to be quick.

I am a newly elected, freshman Member. I spent 20 years in the clean-energy industry before I got here. That was 2 decades that I spent being frustrated by how little I felt Washington really understood the economics of the clean-energy world. And I would love to tell you that I am not frustrated anymore, but let's move on.

My great frustration is that we far too often talk about the economics of clean energy in ways that wouldn't pass muster in a freshman capital budgeting class. Operating expenses and capital expenses are two totally separate things. And when you deploy clean energy, you don't raise the cost of energy, you lower the cost of energy.

If you operate a coal plant, every night before you go to bed, you look at what the power price is going to be the next day, and try to figure out whether you can afford to run. If you have a solar panel, if you have a geothermal plant, in Mr. Vargas' district, you stay up, you have a beer, you watch TV. You don't have to worry about it, because it is always going to be economic to run that.

And, in fact, as we have deployed clean energy, the price of energy has fallen, and that has made the real challenge much harder—and it is the reason I asked to be on the Financial Services Committee—which is, how do we deploy the capital that is always going to out-compete the dirty-energy sources?

Respectfully, Mr. Powell, do not build carbon capture on the back of coal plants. All it does is raise their operating costs, and make it harder for them to run. It will be great for the environment because it will shut the coal plants down faster, but it is going to be lousy for the economy.

Now, we can learn something from the private sector, because if we are going to lower the cost of capital—the second-biggest electricity consumer in the country is Walmart, and Walmart made a decision to preferentially buy all their energy from clean sources, which gave clean-energy developers a very high credit offtake agreement, which lowered their cost of debt, lowered their cost of equity, and brought that forward.

The biggest purchaser of electricity in the country is the Department of Defense. And as General Cheney points out, across the

globe, the U.S. military has installations that are threatened by rising sea levels, intense weather, and other climate-related risks. We need a defense infrastructure that is resilient to those changes but that also has to be reliable and resistant, which means better infrastructure, higher efficiencies, and distributed resources that minimize their reliance on disruptable fuel supplies.

And that is a heck of an opportunity. It is depressing that we are still having this conversation 20 years later, but it is an opportunity. And it is why I am working on a bill, which I expect to introduce later this fall, that will ask the Department of Defense to embrace a cleaner future, and set clear goals for the Department to preferentially purchase clean energy, while still allowing the Department the flexibility required to keep our nation safe and reliable. Just like Walmart didn't decide to be less reliable, but they also want cheaper, less volatile energy.

The bill also includes goals for improving base efficiency, lowering water use, and reducing waste at the facilities. All of this is good stuff. We will be bringing it out soon.

General Cheney, Assistant Secretary of Defense for Sustainment Bob McMahon has said that DOD, "should continue to invest in energy-efficient technologies to improve energy resilience and provide for mission assurance." Meanwhile, he has also said, "Investments in renewable energy and energy-efficiency measures help insulate our critical infrastructure from the fragility of the commercial power grid."

Do you agree with those statements?

General CHENEY. Yes.

Mr. CASTEN. Do you agree that investments in energy efficiency and renewable energy can help with mission assurance?

General CHENEY. I do.

Mr. CASTEN. In your testimony, you discussed the need for substantial investment in zero-carbon, clean-energy systems alongside the need to invest in base resiliency. Can you explain how investments in distributed clean energy and energy storage at bases could help ensure our military's readiness in a changing climate while also combating the climate crisis?

General CHENEY. Yes. Congressman, thanks for the question. I will give you an example. When I was Commanding General at Parris Island, which totally depended on the local grid for electricity, any big thunderstorm shut it down, and we had an alternate oil-fired power plant that we would incorporate to use for our power. Today, they are putting up a new solar panel array, which will hopefully make the base maybe a net-zero.

There is a net-zero program in the Army and the Air Force. There are a number of bases where the intent is to produce more power than they consume. If you go out to Davis-Monthan or Nellis Air Force Base, there are huge solar arrays.

It does a couple of things. The Base Commander is not dependent on the local grid. He has a fairly dependable source of power. And it is fairly cost-free, so to speak, so that is a huge efficiency for our bases and stations.

I will close on one other comment here. It was General Mattis, in Iraq, who said, "Please get me off this tether of fossil fuels", the point being that we have lost over 1,000 soldiers, sailors, airmen,

and Marines defending fossil-fuel convoys in both Afghanistan and Iraq. And his point being, of course, can we not have another source of energy so that we are not totally dependent on these fuel convoys?

So there have been great efforts made in DOD to get to biofuels or get to alternative energies. Unfortunately, we have seen that grind to a halt over about the last 2 years. So, those programs need to be reinstated and reinvigorated.

Mr. CASTEN. Thank you.

I yield back.

Chairman CLEAVER. The gentleman from Virginia, Mr. Rigglesman, is recognized for 5 minutes.

Mr. RIGGLESMAN. Thank you, Mr. Chairman.

And I find it amazing—I wish more people were here, Mr. Chairman, but I think this is the first time ever in a climate-change debate that I never heard the other side of the aisle say anything positive about the Green New Deal either. So, I think this is a really good day.

This meeting was called by the Subcommittee on National Security, International Development and Monetary Policy.

I want to thank the General for his service, and all of your service, honestly. But I am a veteran of 9/11, and I was hoping today that we could actually discuss H.R. 2514, the Coordinating Oversight, Upgrading and Innovating Technology, and Examiner Reform Act of 2019 (the COUNTER Act), where we are talking about terrorist financing.

I want to thank the chairman for his leadership on H.R. 2514. And I also want to thank the chairman for his hard work and I look forward to continuing to work with him on that issue.

I was reading an article this morning that made an interesting point: Many college freshmen hadn't been born before 9/11, and that means an entire generation of young Americans have no idea what it was like—the confusion, panic, and ultimately horrific realization that the homeland's safety should not be taken for granted.

And, as a result, what we often see in today's world is comparisons that climate change is this generation's World War II or that the world could end in 12 years if Congress fails to act now. And this is what I find refreshing here today. We had a comic in our hearing yesterday, and I appreciated that, and I had hoped that we could be more serious than methane-capture devices on the back-sides of cows.

So where does that leave those of us who take climate change seriously, but understand that as legislators, we need a commonsense and realistic approach? Speaking for myself, I believe there is ample opportunity for free markets to work symbiotically to reduce man's effect on the environment.

Before coming to Congress—and that is why I appreciate the General—I was in military intelligence for 20 years, and I understand the threat assessments. I also make whiskey. And I had the only geothermal distillery in the country, because we thought we could combine business and green technology to make something that everybody enjoys.

Since coming to Congress—and thank you, Mr. Powell, for mentioning this—I have introduced a bill with my colleague, Elaine

Luria, which is the Nuclear Energy Leadership Act. And listening to the General talking about SMRs, I got a little excited. I was geeking out a little bit on it. It may not be the holistic solution, but it is a step in the right direction.

To me, the answer is not, as we saw yesterday in the student loan hearing, a socialist government takeover of markets or products, but free markets and entrepreneurs working to come up with realistic solutions that work for Americans, like some of my colleagues have actually mentioned on the other side. Congress cannot continue to give Americans cheap talking points to drive up Twitter likes or Instagram followers. We need to get to work.

This is the question, since we are on the National Security Subcommittee. And it is a serious question I want to ask the General. I ask a simple question: If the Green New Deal were signed into law today as it is written, what would be the effects on the economy and on national security?

General CHENEY. Congressman, I am not going to sit here and comment on future legislation nor the Green New Deal. What we are in favor of at my organization is things that bring up the topic of climate change, and I leave it to you to figure out what the solution is going to be to it.

Mr. RIGGLEMAN. That is actually the answer I was expecting. And thank you, sir. Because, at this point, what we are talking about here is a common-sense solution to this without, sort of, fabricated solutions or things that just don't make sense.

I think it is fair to say today that the legislation we have been discussing, and some of the other Members, is far less drastic and something I could potentially support if we are talking about private-public partnerships, like NELA, which—I worked in the Federal Acquisition Regulation space virtually my entire life. It is just not that out-there to do these types of things.

However, I do have a few concerns, mostly that individual Members of Congress, with no statutory authority to do so, will use economic climate change for other types of regulations, sort of on the Operation Choke Point model, especially on certain industries that are vital to the American economy. And, again, we heard that today from both sides of the aisle.

That being said, I appreciate the chairman's efforts and I look forward to working with him on this legislation and many others. I do appreciate that, Mr. Chairman.

Mr. Powell, can you tell me where Congress has failed the most with climate-change legislation? And if you have time, can you tell me where the Federal Government has failed the most in dealing with climate change?

Mr. POWELL. I think where Congress has failed the most, with all due respect, is that in the past decade, this has become an extremely partisan issue.

The last great energy policy Acts passed in 2005 and 2007 were broad, bipartisan Acts. They were big-tent solutions, and there was something for virtually everyone in every industry in those. I would argue that we need to get back to a bipartisan orientation in energy and climate policymaking.

Mr. RIGGLEMAN. And looking at this, does anybody else want to answer this? I have 27 seconds, which would give you plenty of time, I am sure, in this day and age.

But I think—and, again, talking to the General, hearing these things and hearing everybody's, really, assessment today, it sounded to me—and I am not trying to be too rosy here—like we can come up with a bipartisan solution to move forward using private-public partnerships, common-sense legislation, but also realizing that we actually have a problem.

That is why I appreciate all of you here today. And I hope you have a great day going back. And, again, thank you for being here today.

Chairman CLEAVER. Thank you.

I would like to thank our witnesses for their testimony.

The Chair notes that some Members may have additional questions for this panel, which they may wish to submit in writing. Without objection, the hearing record will remain open for 5 legislative days for Members to submit written questions to these witnesses and to place their responses in the record. Also, without objection, Members will have 5 legislative days to submit extraneous materials to the Chair for inclusion in the record.

If there is nothing else to be said, this hearing is adjourned.

[Whereupon, at 4:14 p.m., the hearing was adjourned.]

A P P E N D I X

September 11, 2019

**Written Testimony of Marshall Burke
Assistant Professor of Earth System Science
Stanford University**

**Hearing on “Examining the Macroeconomic Impacts of a Changing Climate”
United States House Subcommittee on National Security, International Development, and
Monetary Policy**

Thank you Chairman Cleaver, Ranking Member Stivers, and members of the Committee for inviting me to speak today.

My name is Marshall Burke, and I am a professor of Earth System Science at Stanford University. I have a PhD in economics, and my research focuses on using data and statistics to understand how climate change impacts our economy and our livelihoods.

My job as an academic economist is not to make policy recommendations, but to provide information on the likely costs and benefits of a particular policy choice – or in this case, of failing to take policy action. And we have increasing amounts of evidence on what those costs and benefits might look like with regard to climate change.

Data can now tell us what happens to our economy when temperatures warm or when rainfall patterns change. Just as we use thermometers to tell us whether the temperature is going up or down, we can use data and statistics to tell us what happens to different sectors of the economy, or the economy as a whole, when the temperature changes. Again, my goal as a scientist is to simply make measurements, not political statements. And these measurements are starting to tell a very clear story.

Importantly, this climate story touches directly on all three of the jurisdictional areas of this subcommittee: national security, international development, and monetary policy. I would like to make six points about how a changing climate will affect these important areas.

First, **climate change is likely to have a substantial negative impact on the US economy.** Numerous studies using recent historical data on the US economy show that economic output falls in hot years as compared to cooler years¹. When combined with projections of future temperature change from climate scientists, these data allow researchers to estimate what the likely loss in future economic output could be if warming continues unimpeded.

Research done by myself and colleagues at Berkeley and Stanford finds that, by 2050, unmitigated climate change will have cost the US economy roughly \$5 trillion². By the end of

¹ Burke, Marshall, Solomon M. Hsiang, and Edward Miguel. "Global non-linear effect of temperature on economic production." *Nature* 527. (2015): 235; Burke, Marshall, and Vincent Tanutama. *Climatic Constraints on Aggregate Economic Output*. No. w25779. National Bureau of Economic Research, 2019; Deryugina, Tatyana, and Solomon Hsiang. *The marginal product of climate*. No. w24072. National Bureau of Economic Research, 2017; Kahn, Matthew E., et al. *Long-term macroeconomic effects of climate change: A cross-country analysis*. No. w26167. National Bureau of Economic Research, 2019.

² Burke, Marshall, Solomon M. Hsiang, and Edward Miguel. "Global non-linear effect of temperature on economic production." *Nature* 527. (2015): 235; Burke, Marshall, W. Matthew Davis, and Noah S. Diffenbaugh. "Large

the century, these damages could rise to tens of trillions of dollars in present value, just for the US economy alone. In other research, we find that the roughly +1C of temperature increase due to climate change that we've already experienced in the US has already cost the US economy over \$1 trillion.³

Second, **climate change will affect nearly all sectors of the economy.** For many people, climate impacts are most closely associated with rising seas and declining crop yields. These impacts are certainly important, but in fact are likely to only be a small part of the overall economic consequences in the US. Many other sectors and many other outcomes will be affected by a warming climate.⁴ We have strong evidence that workers in all industries are less productive when it's hot.⁵ We also have clear evidence that our cognitive function declines when it's hot: people perform office tasks less effectively⁶, and kids learn less and score worse on standardized tests⁷. These impacts will have economy-wide effects on economic performance.

Given these widespread economic impacts, it's no surprise that the insurance industry is already labeling climate change *the* top global risk – more worrisome than financial instability, cyber warfare, or terrorism.⁸

The third thing we know is that **climate change will worsen security risks, both domestically and abroad.** Police chiefs in US cities have recognized for decades that crime spikes during heat waves. The statistics bear this out very clearly: violent assault, sexual violence, and homicide all increase on days or months where temperatures are above normal⁹. Hot temperatures also increase suicide risk, and in recent research we calculate that future warming could lead to tens

potential reduction in economic damages under UN mitigation targets." *Nature* 557 (2018): 549; Deryugina, Tatyana, and Solomon Hsiang. *The marginal product of climate*. No. w24072. National Bureau of Economic Research, 2017. See <http://web.stanford.edu/~mburke/climate/> for country data.

³ Burke, Marshall, and Vincent Tanutama. *Climatic Constraints on Aggregate Economic Output*. No. w25779. National Bureau of Economic Research, 2019.

⁴ Hsiang, Solomon, et al. "Estimating economic damage from climate change in the United States." *Science* 356.6345 (2017): 1362-1369.

⁵ Seppanen, Olli, William J. Fisk, and David Faulkner. "Control of temperature for health and productivity in offices." *ASHRAE transactions* 111.LBNL-55448 (2004); Seppanen, Olli, William J. Fisk, and Q. H. Lei. *Effect of temperature on task performance in office environment*. No. LBNL-60946. Ernest Orlando Lawrence Berkeley National Laboratory, Berkeley, CA (US), 2006; Cachon, Gerard P., Santiago Gallino, and Marcelo Olivares. "Severe weather and automobile assembly productivity." *Columbia Business School Research Paper* 12/37 (2012).

⁶ Seppanen, Olli, William J. Fisk, and Q. H. Lei. *Effect of temperature on task performance in office environment*. No. LBNL-60946. Ernest Orlando Lawrence Berkeley National Laboratory, Berkeley, CA (US), 2006.

⁷ Goodman, Joshua, et al. "Heat and learning." (2018), forthcoming *American Economic Journal – Economic Policy*; Graff Zivin, Joshua, Solomon M. Hsiang, and Matthew Neidell. "Temperature and human capital in the short and long run." *Journal of the Association of Environmental and Resource Economists* 5.1 (2018): 77-105.

⁸ <https://grist.org/article/insurance-experts-rank-climate-change-as-top-risk-for-2019/>, <https://www.soa.org/globalassets/assets/files/resources/research-report/2019/12th-emerging-risk-survey.pdf>, <https://group.axa.com/en/spotlight/story/emerging-risks-survey-2018>

⁹ Ranson, Matthew. "Crime, weather, and climate change." *Journal of Environmental Economics and Management* 67.3 (2014): 274-302; Jacob, Brian, Lars Lefgren, and Enrico Moretti. "The dynamics of criminal behavior evidence from weather shocks." *Journal of Human resources* 42.3 (2007): 489-527; Heilmann, Kilian, and Matthew E. Kahn. *The Urban Crime and Heat Gradient in High and Low Poverty Areas*. No. w25961. National Bureau of Economic Research, 2019.

of thousands of additional suicides in the US by mid-century¹⁰. Elsewhere in the world, we have documented large increases in civil conflict and organized crime as temperatures rise¹¹. Colleagues from Columbia University have in turn shown that this conflict drives substantial international migration into wealthier countries¹².

Fourth, climate change is going to exacerbate economic inequality, both domestically and abroad. Poorer people in this country, and poorer people around the world, tend to live in environments that are already hot. As these regions get even hotter, most economic impacts will be amplified. Country-level estimates that I have published with colleagues at Stanford and Berkeley suggest that poorer countries will suffer two or three times more economic harm than many wealthier countries in coming decades.¹³ A recent study in the US also found that economic damages from climate change will be many times higher in poorer counties as compared to wealthier counties.¹⁴

Fifth, adaptation is possible, but will be costly. Adaptation to climate change requires devoting resources to adaptation projects. For instance, we can spend money to build sea walls, to air condition every building, or to treat extra people at the doctor when they get sick. These investments will reduce the damage caused by climate change. But these investments also have a clear “opportunity cost” – they could have been spent on something else, such as on investments that improve future productivity rather than just keeping it from declining.

Similarly, while future innovation will likely reduce the cost of adapting to climate change, it is risky to simply assume these innovations will occur on their own. In many key areas such as agriculture, we don’t have clear evidence that farmers – and the public and private entities that support them – are adapting to the substantial climate change that’s already occurring.¹⁵ If anything, the negative impact of higher temperatures on crop yields appear to be growing larger¹⁶, likely due to a combination of changing management practices and disincentives

¹⁰ Burke, Marshall, et al. "Higher temperatures increase suicide rates in the United States and Mexico." *Nature climate change* 8(8) (2018): 723.

¹¹ Burke, Marshall B., et al. "Warming increases the risk of civil war in Africa." *Proceedings of the national Academy of sciences* 106.49 (2009): 20670-20674; Hsiang, Solomon M., Kyle C. Meng, and Mark A. Cane. "Civil conflicts are associated with the global climate." *Nature* 476,7361 (2011): 438; Hsiang, Solomon M., Marshall Burke, and Edward Miguel. "Quantifying the influence of climate on human conflict." *Science* 341.6151 (2013): 1235367; Burke, Marshall, Solomon M. Hsiang, and Edward Miguel. "Climate and conflict." *Annual Rev. Econ.* 7(1) (2015): 577-617; Baysan, Ceren, et al. *Economic and non-economic factors in violence: Evidence from organized crime, suicides and climate in Mexico*. No. w24897. National Bureau of Economic Research, 2018.

¹² Missirian, Anouch, and Wolfram Schlenker. "Asylum applications respond to temperature fluctuations." *Science* 358 (6370) (2017): 1610-1614.

¹³ Diffenbaugh, Noah S., and Marshall Burke. "Global warming has increased global economic inequality." *Proceedings of the National Academy of Sciences* 116.20 (2019): 9808-9813; Burke, Marshall, W. Matthew Davis, and Noah S. Diffenbaugh. "Large potential reduction in economic damages under UN mitigation targets." *Nature* 557 (2018): 549; Burke, Marshall, Solomon M. Hsiang, and Edward Miguel. "Global non-linear effect of temperature on economic production." *Nature* 527 (2015): 235.

¹⁴ Hsiang, Solomon, et al. "Estimating economic damage from climate change in the United States." *Science* 356 (2017): 1362-1369.

¹⁵ Burke, Marshall, and Kyle Emerick. "Adaptation to climate change: Evidence from US agriculture." *American Economic Journal: Economic Policy* 8 3 (2016): 106-40.

¹⁶ Lobell, David B., et al. "Greater sensitivity to drought accompanies maize yield increase in the US Midwest." *Science* 344 6183 (2014): 516-519; Ortiz-Bobea, Ariel, Erwin Knippenberg, and Robert G. Chambers.

provided by subsidized crop insurance programs¹⁷. Similarly, while the widespread adoption of air conditioning in the US reduced many types of mortality¹⁸, it has not reduced suicide- or homicide-related mortality¹⁹, nor has it reduced the impact of hot temperatures on overall economic output in the US²⁰.

Sixth, **most policies that mitigate climate change will generate immediate benefits**, in the form of improved air quality as we transition away from dirty sources of power in the energy and transportation sectors. Estimates suggest that the health and economic benefits of this improved air quality could be massive. For instance, were the US to adopt clean energy and clean transportation policies consistent with our prior emissions reductions commitments under the Paris Accords, these policies would lead to air quality improvements that would save roughly 300,000 premature deaths by 2030 in the US alone.²¹ This reduced mortality would be valued in the trillions of dollars in the US²², which is roughly on par with the economic benefit of reduced warming by mid-century. Improved air quality would also have positive effects on worker productivity²³ and cognition²⁴, further amplifying these economic benefits. Crucially, however, unlike the long-run benefits of climate mitigation, these air quality benefits accrue immediately after a polluting power plant is turned off or a polluting car is taken off the road.

Taken together, this evidence helps provide a more robust understanding of how much we should be willing to pay to reduce climate change. Focusing exclusively on the costs of action without considering these very large costs of inaction is terrible economics and bad policy. If we are able to substantially slow the future temperature increases expected under climate change, this will generate tens of trillions of dollars in economic benefits for the US economy and its citizens over the coming decades – and even larger benefits globally. These benefits should be weighed against the costs of proposed climate policies. Policies that can put a big dent in climate change that cost less than tens of trillions of dollars to implement are policies that make economic sense.

Thank you.

"Growing climatic sensitivity of US agriculture linked to technological change and regional specialization." *Science Advances* 4.12 (2018): eaat4343.

¹⁷ Annan, Francis, and Wolfram Schlenker. "Federal crop insurance and the disincentive to adapt to extreme heat." *American Economic Review* 105.5 (2015): 262-66.

¹⁸ Barreca, Alan, et al. "Adapting to climate change: The remarkable decline in the US temperature-mortality relationship over the twentieth century." *Journal of Political Economy* 124.1 (2016): 105-159.

¹⁹ Burke, Marshall, et al. "Higher temperatures increase suicide rates in the United States and Mexico." *Nature Climate Change* 8(8) (2018): 723; Ranson, Matthew. "Crime, weather, and climate change." *Journal of Environmental Economics and Management* 67(3) (2014): 274-302

²⁰ Deryugina, Tatyana, and Solomon Hsiang. *The marginal product of climate*. No. w24072. National Bureau of Economic Research, 2017.

²¹ Shindell, Drew T., Yunha Lee, and Greg Faluvegi. "Climate and health impacts of US emissions reductions consistent with 2 C." *Nature Climate Change* 6.5 (2016): 503.

²² Shindell, Drew T., Yunha Lee, and Greg Faluvegi. "Climate and health impacts of US emissions reductions consistent with 2 C." *Nature Climate Change* 6.5 (2016): 503.

²³ Graff Zivin, Joshua, and Matthew Neidell. "The impact of pollution on worker productivity." *American Economic Review* 102.7 (2012): 3652-73; Chang, Tom, et al. "Particulate pollution and the productivity of pear packers." *American Economic Journal: Economic Policy* 8.3 (2016): 141-69.

²⁴ Ebenstein, Avraham, Victor Lavy, and Sefi Roth. "The long-run economic consequences of high-stakes examinations: Evidence from transitory variation in pollution." *American Economic Journal: Applied Economics* 8.4 (2016): 36-65.



WRITTEN TESTIMONY OF STEPHEN A. CHENEY to U.S. House Committee on
Financial Services; Subcommittee on National Security, International
Development and Monetary Policy
RETIRED BRIGADIER GENERAL, UNITED STATES MARINE CORPS
PRESIDENT, AMERICAN SECURITY PROJECT
SEPTEMBER 11, 2019

Chairman Cleaver, Ranking Member Stivers, members of the Committee, thank you for inviting me to testify about the financial threats posed by climate change to our national security.

I'm honored to provide testimony about this critical threat. A non-partisan, non-profit, the American Security Project has worked tirelessly on this issue since our founding in 2006. As President of ASP, I have presented around the world on this subject and spent much of the last 5 years traveling the United States, everywhere from Ohio to Virginia to Washington state, engaging with local business, and community leaders on the risk of climate change. I often call on my experience in the Marine Corps to illustrate the threat climate change poses to our military and national security around the globe. Today, I am not here to discuss specific legislation or technology solutions, I am here to explain the national security threats of climate change.

Through my 30-year long career in the United States Marine Corps, I learned the importance of preparation. In order to achieve the mission, the United States

military must be prepared for all potential threats, whether its terrorism, near-peer states, or climate and weather-related. In regard to climate in particular, the military cannot afford to delay planning. As retired U.S. Army General Gordon Sullivan once commented, “We never have 100 percent certainty. We never have it. If you wait until you have 100 percent certainty, something bad is going to happen on the battlefield.”

This should be familiar in the financial sector. Risk management is as important for the military as it is for banking. We can’t afford to ignore the risk of climate change, just as bankers can’t ignore risks to their business. Unfortunately, today we are not sufficiently prepared for climate risk and have failed to respond to changes already occurring.

Dating back to the George H.W. Bush Administration in 1992, intelligence and national security professionals warned us that climate change posed a direct threat to U.S. national security. This work has been informed by U.S. scientists telling us that a melting Arctic, more frequent droughts and floods, and extreme weather are all examples of the changing climate in the United States and the world.

We don't need to wait for more sophisticated climate models to project the security consequences of climate change. The impacts of climate change are clear today and threaten our military installations and investments around the globe.

As members on this committee know, the U.S. Department of Defense (DoD) maintains installations worldwide; together that property is worth over \$1.2 trillion and critical to U.S. national security. Extreme weather, rising sea levels, and increasing global instability are all consequences of climate change and each threatens national and financial security.

This past year's extreme weather has seriously affected our military readiness and national security. In September 2018, Hurricane Florence decimated Camp Lejeune and caused damage to Fort Bragg and military installations across North Carolina.

A few weeks later, Hurricane Michael leveled Tyndall Air Force Base on Florida's Panhandle, causing damage to 17 F-22 stealth fighters and major structural damage throughout the base.

Estimates of the cost of these disasters to the military are significant. The Marines have requested \$3.6 billion to rebuild their North Carolina operations, while the Air Force has requested an initial \$5 billion for Tyndall and Offutt.

While the bases may rebuild over time, the loss of training and readiness cannot be recovered. In a February letter to the Secretary of the Navy, General Neller, Commandant of the Marine Corps, wrote that because of the damage from the storms, “The combat readiness of Marine Expeditionary Force – 1/3 the combat power of the Marine Corps – is degraded and will continue to degrade.” He specifically noted that he was forced to curtail or cancel several training exercises to free up funds for hurricane repair.

In addition to extreme weather events, sea level rise is threatening some of our most vital military installations. Norfolk Naval Station is predicted to see 2-5 feet of sea level rise by 2100, maybe up to 11 feet. Even 5 feet of sea level rise would completely submerge the Navy’s piers and significant sections of runway at neighboring Langley Air Force Base. The base has already begun to build new, double decker piers to allow maintenance workers to reach electrical cables, countering the sinking ground and rising seas. Each new pier costs over \$100 million.

Similarly, in the Arctic, Cape Lisburne in Point Hope, Alaska is home to the Long Range Radar program which detects foreign aircraft entering U.S. airspace. Coastal erosion is expected to have a significant impact on infrastructure by 2040. The station is already investing in fortifying its runway.

Clearly, the U.S. military will have to invest large sums into rebuilding and recovery at home. ASP is tracking these impacts to our military infrastructure on our new website www.militarybaseresiliency.org. I encourage you to review the content and examples there.

Beyond physical damage and financial burdens to military infrastructure, climate change will increase global instability. A common example of this is the Lake Chad Basin in Africa. Following year-after-year of devastating drought, driven in part by climate change, the lake has decreased dramatically. Previously the main source of water and livelihood, the drying of the lake has forced communities to search for alternative occupations. Boko Haram has leveraged the sudden influx in unemployed individuals for recruiting. Climate change may not have been the sole cause of instability, but it certainly contributed to it.

Growing instability creates additional demand for U.S. military support. This will require more troops and more deployments. A larger, more expensive military adds financial burdens on the U.S. and its citizens.

Climate change will also undermine the global economy as instability makes continuing business as usual challenging. While important to model the potential economic impacts of climate change, I would note that there are some impacts that are not quantifiable by models. The difference between war and peace may not show up in an equation, but it affects people's ability to survive. What would economic models have predicted for Syria's future over the last decade? Stability and security may not be fully quantifiable but both are valuable on their own right.

The massive cost of recovering from extreme weather every year and persistent degrading of installations undermines our ability to respond and compromises our readiness. In a time of increasing competition and aggression by both Russia and China, the U.S. cannot afford to ignore this threat. If the United States hopes to seriously combat the influence of bad actors around the globe, we must begin by investing in resiliency and recovery at our military installations and in our communities.

Climate change is already impacting our military readiness and we need additional investment to combat this risk. There needs to be further monitoring of the impacts of climate change and the cost incurred by military infrastructure and

personnel. Tracking the cost will aid in developing plans to build resiliency against future disasters.

Further, there needs to be additional investment and allocation of funds towards “building back better.” Current levels of investment will not be enough to rebuild after disasters. The U.S. Air Force went into a \$4 billion deficit this past year in part due to costs of recovery at Tyndall Air Force Base after Hurricane Matthew and at Offutt Air Force Base in Nebraska after severe flooding. Storms and extreme weather are predicted to only intensify, and funds should be allocated to rebuild stronger and more durable infrastructure.

Finally, we need substantial investment in zero-carbon, clean energy systems. Without investing in clean energy, all of the money spent rebuilding will be for naught as coastal military installations go underwater and stronger storms level our critical infrastructure.

Now is the time to invest in solutions. The United States has the most powerful military in the world. We have the opportunity to maintain that prowess but only if we invest and prepare for the future that lies ahead.

Thank you for the opportunity to testify today. I look forward to your questions.



Gavin Newsom, Governor
 Jared Blumenfeld, CalEPA Secretary
 Mary D. Nichols, Chair

September 11, 2019

Testimony of Veronica Eady
 Assistant Executive Officer
 California Air Resources Board

Before the U.S. House of Representatives
 Committee on Financial Services
 Subcommittee on National Security, International Development, and Monetary Policy
Examining the Macroeconomic Impacts of a Changing Climate

Chair Waters, Subcommittee chair Cleaver, esteemed members of the House Financial Services Committee:

It is my great honor to be here today to discuss how California is addressing climate change, and how our programs facilitate investment in communities most vulnerable to the impacts of climate change.

I am here representing the California Air Resources Board. The California Air Resources Board (CARB) is charged with protecting the public from the harmful effects of air pollution and developing programs and actions to fight climate change. From requirements for clean cars and fuels to adopting innovative solutions to reduce greenhouse gas (GHG) emissions, California has pioneered a range of effective approaches that have set the standard for effective air and climate programs for the nation, and the world.

As part of the California Environmental Protection Agency (CalEPA), CARB works closely with its sister agencies in the implementation of its climate programs, while CalEPA plays a key role in leveraging the work of its agencies, facilitating cross-agency work, and achieving the California's climate goals, broadly.

As CARB's Assistant Executive Officer for Environmental Justice, I provide advice to CARB leadership on how our programs can address environmental justice issues and eliminate the disproportionate air pollution and climate change burdens facing California's low-income communities and communities of color.

Environmental Justice at CARB

Despite the dramatic progress made in improving air quality in California, there still exists disparities in air pollution exposure, susceptibility, and health, particularly for people of color and low-income communities. This disparity reflects the disproportionate siting of stationary sources and highways in and near their communities, some which were historically and intentionally segregated. Although greenhouse gases are global pollutants that do not themselves harm local neighborhoods that host sources of greenhouse gases, the effects of climate change caused by greenhouse gases disproportionately impact low-income communities and communities of color.

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Furthermore, sources of greenhouse gases often emit criteria pollutants and toxic air contaminants, which can impact the health of residents who live, work, and go to school near these sources.

State law defines environmental justice as the fair treatment of people of all races, cultures, and incomes with respect to the development, adoption, implementation, and enforcement of environmental laws, regulations, and policies. Government Code, section 65040.12, subdivision (c). Environmental justice calls for transparency, inclusivity, and systemic change.

Environmental justice is one of CARB's core values and fundamental to achieving its mission. The Board approved its Environmental Justice Policies and Actions on December 13, 2001, to establish a framework for incorporating environmental justice into ARB's programs consistent with the directives of State law (ARB 2001). Since then, CARB has prioritized environmental justice when adopting, implementing, and enforcing regulations, when providing technical support, and when allocating funding. CARB strives for equity in the implementation of all its programs.

California's Climate Goals

California has had programs to reduce both criteria and toxics and GHG emissions for decades. The historic passage of the California Global Warming Solutions Act of 2006 – established the first statewide GHG emissions reduction target of returning to 1990 levels by 2020. Today, California is on track to exceed its AB 32 climate targets, with an early start to achieve its SB 32 target of 40 percent below 1990 levels by 2030, and we are laying the groundwork to meet a 2050 target of 80 percent below 1990 levels and achieve carbon neutrality by mid-century.

California's 2017 Climate Change Scoping Plan (2017 Scoping Plan) lays out a cost-effective and technically feasible path to achieve our 2030 GHG target. From the beginning, each version of the Scoping Plan has included a mix of incentives, regulations, and market policies to help the State reduce its GHG emissions. This approach provides California with the greatest certainty in meeting the 2030 GHG target at the lowest cost while also improving public health, supporting investments and equity in disadvantaged and low-income communities, protecting consumers, and supporting economic growth, jobs and energy diversity.

As California adopts increasingly ambitious goals for addressing climate change and air quality, it recognizes that the transition to a low carbon California economy provides an opportunity to create a healthier environment for all Californians, especially those living in the state's most disadvantaged communities, which will likely be the first impacted and hardest hit by the effects of climate change.

California Climate Investments

Many of California's disadvantaged communities disproportionately lack the financial capacity to invest in low-carbon practices, transportation, or climate resiliency. California is pioneering targeted environmental and economic development programs to help those most in need. Proceeds from the Cap-and-Trade Program, which are deposited into the Greenhouse Gas Reduction Fund (GGRF), facilitate comprehensive and coordinated investments throughout California that further the State's climate goals. These investments support programs and projects that reduce GHG emissions in the State and also deliver major economic,

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environmental, and public health benefits for Californians, including meaningful benefits to the most disadvantaged communities. At least 35 percent of Cap-an-Trade proceeds must benefit “disadvantaged communities,” as defined by Senate Bill 535 through California’s pollution mapping tool, California Environmental Screen. To date, the California legislature has appropriated approximately \$11.9 billion to more than 20 state agencies implementing over 60 unique programs collectively known as California Climate Investments.

Communities where investments occur are realizing a wide range of benefits, including: increased affordable housing opportunities; improved mobility options through transit, walking, and biking; cleaner air through zero-emission vehicles; job creation, energy and water savings; and greener, more vibrant communities.

Advancing Climate Equity in California

Many programs funded through California Climate Investments are specifically designed to promote equity. We have clean vehicle financing assistance, rebates, and vouchers that have income caps to direct funding to low-income households. Pilot projects aimed directly at improving mobility in disadvantaged communities has funded car sharing, agricultural workers van pools, and other new mobility options.

Certain programs, such as CARB’s Rural School Bus Program, specifically targets all funds in rural areas. Others, such as an Affordable Housing program, have established a funding set-aside for rural areas. This approach is particularly effective for this program where projects are ranked based on reductions in vehicle miles traveled, which is largely dependent on density, making rural projects inherently less competitive.

We also have a handful of targeted investments in the areas most impacted by air pollution. These communities, sometimes located next to major ports or freight facilities, are receiving dedicated funding ranging from heavy duty vehicle change outs and air monitoring equipment.

One program to highlight is CARB’s new Community Air Protection program was initiated in response to Assembly Bill 617, a landmark piece of legislation aimed at reducing air pollution exposure in the state’s most impacted areas. AB 617 was a companion bill to AB 398, which extends California’s Cap-and-Trade program to 2030. Its main object is to reduce criteria pollutants and toxic air contaminants in communities with the

Examples: CCI Projects

- A 44-unit affordable housing development in Tulare County with integrated vanpooling service and discount transit passes is among more than 1,600 housing units funded statewide.
- The Cecchini Farm in Contra Costa County, whose fifth-generation owners decided not to sell after they were approved for a conservation easement, is among more than 250,000 acres of land statewide that will be preserved, from coastal watersheds and wetlands to mountain meadows.
- Los Angeles County’s Foothill Transit is purchasing 15 zero-emission electric buses to advance the agency’s goal to go all-electric by 2030 to reduce GHG emissions and improve air quality in the inland communities it serves.
- In California’s forests, California Climate Investments are protecting more than 1.4 million acres, funding projects to reduce fire risk, limit loss of life and property damage, and lower the cost of fighting wildfires. More than 14,000 trees have been planted to provide shade and limit the heat island effect in urban areas from Oakland and Stockton to San Bernardino and Los Angeles counties.
- Grants to farmers, businesses and individuals for more water-efficient technology will not only cut greenhouse gas (GHG) emissions but save more than 370 billion gallons of water throughout the state. And more than 150,000 rebates for zero-emission and plug-in hybrid cars are expected to reduce over 5,000 tons of criteria and toxic air pollutants in addition to GHG emissions.

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highest exposure burdens as prioritized by local residents, regional air districts, and ultimately voted upon and designated by the CARB board.

A first of its kind program, AB 617 builds partnerships with local communities to address neighborhood-scale pollution, through local air monitoring and development of community emission reduction programs.

Casa Familiar - Project Highlight

- Community-based organization, Casa Familiar, in border community of San Ysidro
- Sustain and expand a current network of community-operated air monitors
- Help identify, evaluate, and ultimately reduce exposure to harmful emissions
- Empower community members to participate in the AB 617 process



The legislature has thus far appropriated \$25 million from the GGRF for an AB 617 grants program to support local community-based organizations participation in the implementation of AB 617. Besides developing school curricula focused on air quality, performing local outreach and building awareness, several

grantees have established their own community-run air quality networks that provide real-time air quality conditions to residents who can access the data through an internet portal.

Another program receiving funding from the GGRF is California's Transformative Climate Communities Program, an initiative that empowers the communities most impacted by pollution to choose their own goals, strategies, and projects to reduce greenhouse gas emissions and local air pollution. The legislature has appropriated a total of \$150 million from the GGRF to support this program that takes a unique approach to addressing community needs by implemented places-based projects that are community-driven.

Watts Rising - Project Highlight

- Community-led projects
- 6 workshops attended by 400 residents
- Set goals, GHG strategies, and voted to prioritize projects
- Components include:
 - 216 new affordable homes
 - 10 new battery-electric buses
 - 5 miles of new bike paths
 - 300+ construction and permanent jobs created



Tracking Outcomes

California Climate Investments must result in quantifiable greenhouse gas reductions. In addition to achieving a reduction of almost 40 million metrics tons of CO₂e to date, California Climate Investments projects are also achieving additional important co-benefits.

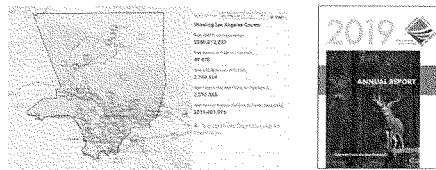
We've seen investments foster job creation; improve air quality; provide opportunities for small businesses and other community institutions; and lessen the impacts and effects of climate change. Over half of the on-the-ground projects to date are benefiting the most vulnerable of California's communities.

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CARB reports on CCI funding and attendant impacts annually, in an annual report. Over 80 percent of the funds support investments in the transportation, the largest source of greenhouse gases in California, and sustainable communities sector, including:

- Electric vehicles;
- Provision of cleaner and more buses and trains;
- Help for riders to save money through fare reductions;
- More bike paths;
- Support for compact infill development that brings affordable housing and jobs closer together;
- Protection of agricultural lands from sprawl development.

Accountability and Transparency



CARB's climate programs have a global profile and have achieved an array of important benchmarks. We reached our 2020 target of ratcheting down greenhouse gases to 1990 levels back in 2016. With that goal now behind us, we are fully immersed in efforts to reach our 2030 targets of 40 percent below 1990 levels. Our Cap-and-Trade program and California Climate Investments will continue to play an integral role in reaching that goal.

Conclusion

These are some highlights of how California's climate programs and helping us reach our greenhouse gas reduction targets, while bolstering our economy – now the fifth largest in the world. The success of our climate program depends heavily on the public that we serve. To that end, CARB has knitted principles of environmental justice and climate equity throughout our climate and air pollution programs.

I'm available for questions.

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STATEMENT OF

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BEFORE THE

SUBCOMMITTEE ON NATIONAL SECURITY,
INTERNATIONAL DEVELOPMENT AND MONETARY POLICY
UNITED STATES HOUSE OF REPRESENTATIVES

September 11, 2019

Chair Cleaver, Ranking Member Stivers, Distinguished Members of the Committee;

Thank you for the invitation to contribute to your time-sensitive deliberation on this time-honored day, when we memorialize the victims of the worst foreign attack in our country's history, and vow never to find the American people ill-prepared and exposed to knowable risks that threaten our lives, communities, and the commerce that thrives between us.

Like so many of us who will always remember the awful shock, terrifying images, and the sinking, suffering feeling that was etched into the soul of our nation on this fateful day eighteen years ago, I remain inspired by the collective determination of a generation to honor the memories of 9/11, and renew our country's collective resolve to imbue meaning in the phrase: "never again".

Never again should our government fail to protect America's citizens from life-threatening perils and economic upheaval that we can reasonably and proactively predict, through intelligence, analytics and insight. Never again shall we neglect an obvious "gathering storm", finding ourselves passive victims, having failed to ensure our safety and security through adequate planning. Never again should our fellow citizens pay the ultimate price in blood and treasure, when sound, cost-effective policy can shift the probabilities from sacrifice to safety. Honorable Members, I ask that we consider the significant lessons of this day, and our collective resolve, as the context for Congress's compelling need to act to ensure America's security, economic, and environmental well-being.

I was honored to be asked to serve the President and our nation in the aftermath of 9/11, to urgently address "America's addiction to oil". My mission was to galvanize the capacities of our incredible National Laboratories and the federal applied science programs at the Department of Energy, to stimulate our country's innovation and entrepreneurship at unprecedented speed and scale, in the middle of a war and an energy crisis, with the highest oil prices ever recorded. I am honored to be invited back to testify before this Congress, and I am grateful to be still be engaged in the mission of accelerating technology innovations to market for greater impact. I have increasingly focused on data science technologies with powerful applications for nature. This has the potential to durably establish the value of natural capital¹ as a source of strength for humanity, bolstering our preparedness and adaptive resilience in the face of disaster. In other words, I have focused on the tools, technologies, and business models that undergird our natural security and enhance our economic prosperity.

As today's hearing suggests, recurring destructive threats from rapidly changing climate conditions are endangering the lives and property of many Americans. As catastrophic peril threatens our shores and communities, we are obligated to do our utmost to ensure adequate preparation and agile responsiveness. Knowingly doing less, when our country is scientifically and technological capable of doing more, risks our children contemptuously accusing the 9/11

¹ Natural capital is defined by various organizations as the country's or world's stocks of natural assets, including geology, soil, air, water, and all living things. Natural capital is the Nation's stock of biophysical capacity and supply capability, an asset which could be included as a component of the country's evaluation of national economic performance or GDP.

generation of failing in its duty to protect and preserve all we cherish most. We must not have history consider us so confused by “alternative facts”, that even as we resolved to prevent and subdue global terrorism, we were blind to the catastrophic threat climate change poses to our communities.

This hearing is a timely reminder that we can still act with intention, in our enlightened self-interest, to design systems solutions to our most pressing problems. Our greatest national and natural security threats are less from rogue foreign terrorists, and certainly less from the columns of Red Army tanks we once invested trillions to defend against. Instead, our most dire and urgent threats are from the relentless rise of nature’s fury, recurring with unprecedented harm, frequency, and severity.

We have all witnessed the shocking rise in record numbers of multi-billion-dollar natural catastrophes, with devastating economic and human tolls. From hurricanes and flooding to wildfires, droughts and heat waves, we are living in an age of accelerations, experiencing fluctuations in healthy habitats, loss of species and biodiversity and seeing the effects of climate change across geographies, communities, and economic sectors.

This week alone, the death and destruction from Hurricane Dorian arrived unwelcome in the Carolinas after devastating our neighbors in the Bahamas, with many people missing and 70,000 left homeless. In 2017 and 2018, the US experienced at least thirty natural disasters that resulted in excess of \$1 billion in damages each.² The costs of climate-related disasters are steadily increasing, exceeding \$450 billion between 2016 and 2018 alone, an average of \$150 billion per year.³

Who pays? Who, if anyone, benefits from a collective failure to account for, plan, and allocate costs to smooth the impact of these shocks to our communities? We have the capacity to enable markets to operate far more effectively and intelligently, sharing risks more evenly and equitably. We can avoid scenarios where the weakest amongst us chronically suffer worst and first, due to vulnerabilities and volatility we have the power to minimize.

Although there are many facets of environmental degradation and destruction – from the deforestation and burning of the Amazon, to pollution of our oceans with plastics and our waterways with agricultural runoff, to the cascading, poorly understood effects of catastrophic climate change – the essential problem is the same. Current market systems are premised on the outdated assumption that natural resources are inexhaustible and can be exploited without impact. That nature will be tamed or conquered, rather than stewarded and conserved. This has encouraged market participants to asymmetrically privatize gains and socialize risks, imposing the risks on families, citizens, and taxpayers when we need our corporate actors most incentivized to align with societal interests. We are not accounting for the costs of these actions, and we are socializing their risks, leading ourselves to react to environmental threats by default when we should be investing proactively, fortifying our security and economy with intention.

² Hurricane Irma property damage at up to \$65B: CoreLogic (Sept 20, 2017).

<https://www.intelligentinsurer.com/news/hurricane-irma-property-damage-at-up-to-65bn-corelogic-13220>

³ NOAA National Centers for Environmental Information (NCEI), U.S. Billion-Dollar Weather and Climate Disasters (2019). <https://www.ncdc.noaa.gov/billions/>

We have historically lacked the tools necessary to accurately and cost-effectively measure and meter natural resources, beyond the commodity markets of exploitable or extracted goods. Due to the complex and dynamic physical properties of nature, traditional cost-benefit analyses have not justified measuring and metering access to natural capital, resulting in unchecked extraction and unmeasured externalities. Price discovery requires objective quantitative rigor, and the incumbent market rationale has been that the market clearing price of natural capital is zero. That is to say, according to our present market economy's parameters, the forests, prairies, and wetlands that clean our water, that sustain our food, that buffer us from storms have zero value beyond that of the goods we take.

Ironically, we give greater value to perceptions of scarcity, and often end up incentivizing greater destruction in pursuit of the rarity of what remains. The carcasses of sharks litter beaches, slaughtered for their fins to ensure prized soups make the menus in Shanghai. Of course, we know from our own history – returning from the brink with America's wild salmon and bison herds – that we can recover through deliberate intention and design. This same thinking and theory of change that has been embedded in America's conservation practices applies to the market integration and accounting of natural capital.

Extractive systems have scaled exponentially throughout the industrial age, degrading the reliability and resilience of our fragile, dynamic, complex, adaptive life support systems. This tragedy of the commons is deeply interwoven with challenges of equity and justice, public health, and wealth and income inequality – all of which are compounded by unprecedented natural disasters and ecosystem shocks.

There are those who may consider markets to have failed us because of this and other “tragedy of the commons” conundrums. I am not such a person. I have personally experienced the power of free markets to lift people out of poverty and fill the public purse; to incentivize enormous leaps of innovation and prosperity. I am steadfast in the conviction that, when equitable and accessible in opportunities for a good society, market economics enabling free enterprise can be the most powerful and prolific source of transformation and social mobility. But one must sanction economic theory with practical and technical realities: markets themselves don't originate or implement strategy. Market mechanisms demand good governance and good operating parameters to guide good outcomes, including indispensable outcomes such as our national and natural security.

That's why humility, rather than ideology, must prevail when assessing the role of markets. We the people designed our markets, and we the people can and should update and redesign them, especially to integrate the benefits of innovation. This is as true for the birth of the aerospace industry as it has been for automobiles replacing horses and buggies, and digital optics replacing chemical films. All innovation has somehow, at some time, catalyzed Congress to shape outcomes for safety, health, and equitable benefits of growth and prosperity. This is no less true of the exponential technological surges in Silicon Valley and elsewhere, which have enabled unprecedented American growth in nano-materials manufacturing, high performance computing, data science, and other areas.

Due to their scaling function, properly designed markets can serve as an equally powerful corrective force. Advances in artificial intelligence, machine learning, and data processing have enabled us to cost-effectively collect and process data about the performance and health of nature. By harnessing these advances to accurately quantify the value of natural capital and internalize these values in financial transactions, we could fill a key information gap and enable markets to operate more efficiently. This informational advantage could be a major driver of differentiation and arbitrage opportunity for market participants. It would provide a competitive advantage to those who accurately measure and manage climate change risk, and monetize opportunities stemming from more accurate risk pricing.

Our present climate conundrum breeds opportunity as well as risk. We need to enable risk management through enhanced monetary policy, to shift capital formation and direct it toward solutions that exceed the pace of mounting problems. This alignment of incentives would reorient markets to maximize profitability in a sustainable way, reversing the tide of environmental destruction at a speed and scale commensurate with the challenge we face.

The systematic deficiency to account for nature's actual value has been accompanied by underutilization of nature's capacities to support our infrastructure and resilience. As the environmental, economic, and human costs of extreme weather and shifting climate patterns continue to rise, they are accompanied by infrastructure failures and turnover. This must be addressed with urgency, especially to protect our most vulnerable communities. This includes the tens of millions of Americans who live and work along coastlines, inland lakes and rivers, behind levees, and in other areas susceptible to natural catastrophes, sea level rise, and flooding.

Rapid replacement and retirement of carbon-intensive infrastructure is an opportunity to attract the next generation of investment in sustainable assets and supply chains. This includes significant investment in natural infrastructure / nature-based solutions: restoration, conservation of nature, and nature-based systems. Accurately pricing climate change-related risks and opportunities is the fastest pathway to designing a sustainable transition toward a low-carbon economy that maximizes the benefits of green infrastructure.

Global markets are at an inflection point, where the direction and application of these technologies will determine long-term outcomes for markets and societies. There is growing marketplace momentum behind technological applications to measure and monitor natural capital, along with recognition of the threat posed by mispriced climate change-related risk. Technological advances in our ability to measure and monitor natural systems are ready to be widely deployed, and there is a need for good governance to guide these technologies toward the highest-value applications that align markets and nature.

The ultimate intended outcome of convergent alignment would be the acceleration of investments and infrastructure turnover that:

- (1) Reduces net emissions at the fastest mathematically feasible rate, and
- (2) Accurately aligns prices and risks to recalibrate the economics of solutions that restore and protect our healthy human habitats and communities.

Fundamentally, the failure to understand and account for natural capital is nothing more than a market imperfection. This design flaw externalizes the measurable value of things most vital to our longevity and excludes such considerations from our balance sheets, investment and return considerations. Congress should pose a paramount question and encourage action with its urgent answer: how shall we, as a society, responsibly draw upon the interest of our natural capital endowment, while preserving and even growing its principal for the inheritance of the next generation?

ECONOMIC IMPACTS OF CLIMATE CHANGE

The economic effects of climate change may likely become far more severe and far-reaching over time, with three broad categories of risk facing businesses:

- *Physical risks* can include non-linear impacts, such as multi-annual occurrence of historically rare events, resulting in unexpectedly high insurance claims burdens, supply chain disruptions, and other direct effects.
- *Transition risks* are more indirect and may be significantly affected by policy guidance and intervention to ensure a smooth and sustainable transition. These result from systemic disruptions in the transition to a low-carbon economy, including policy changes, market dynamics, technological innovation, and social shifts.
- *Liability risks* might include climate-related claims under liability policies, direct claims against insurers for failing to manage climate risks, or liability for inadequate disclosure of current and future risks.

Approximately \$100 trillion of global infrastructure is estimated to be at risk due to inadequate insurance and risk management,⁴ while almost 1.9 million homes worth a combined \$882 billion are at risk of being underwater by 2100.⁵ Yet present actuarial and other risk assessment models are woefully inadequate to predict these risks, due to overreliance on less accurate historical data and the inherent uncertainty involved in climate modeling. The world's top insurers and reinsurers, such as Swiss Re, Munich Re, Lloyd's, AXA XL, and RenaissanceRe are aware of these risks and expanding their in-house climate science efforts and teams to build better models and assessment tools to estimate these impacts.⁶ This trend is not limited to the insurance sector, as demonstrated by Moody's acquisition of a majority stake in Four Twenty Seven, a leading provider of data, intelligence, and analysis related to physical climate risks.

The danger of mispriced risk is exemplified by the National Flood Insurance Program (NFIP), which provides the bulk of flood insurance coverage in the U.S. Through highly subsidized rates, the program has now borrowed over \$40 billion from U.S. taxpayers. Although it provides critical coverage, the NFIP masks rates and risk, making it difficult for people vulnerable to

⁴ Jupiter. (2018, February 12). Jupiter Launches Climate Data, Analytics and Technology Platform to Predict and Manage Weather and Climate Change Risks. Retrieved from <https://www.globenewswire.com/news-release/2018/02/12/1339285/0/en/Jupiter-Launches-Climate-Data-Analytics-and-Technology-Platform-to-Predict-and-Manage-Weather-and-Climate-Change-Risks.html>

⁵ Zillow Research. (2017, June 2). Climate Change and Housing: Will a Rising Tide Sink All Homes? Retrieved from <https://www.zillow.com/research/climate-change-underwater-homes-12890/>

⁶ (2018, October 2). Climate Change Is Forcing the Insurance Industry to Recalculate. *Wall Street Journal*. Retrieved from <https://www.wsj.com/graphics/climate-change-forcing-insurance-industry-recalculate/>

floods to understand or plan for known risks. This program has provided the lion's share of national flood coverage for decades without charging risk-based rates. FEMA itself has found that subsidized rates can promote poor decision-making by property owners and political representatives, while removing the incentive to undertake mitigation efforts and passing the costs on to taxpayers and society.⁷ These subsidized rates largely do not end up benefiting low-income homeowners; only five percent of subsidized NFIP properties are located in counties with the lowest home values.⁸ A parallel problem is underinsurance in the most vulnerable areas and a large protection gap in critical insurance coverage: only 40% of global losses from natural disasters in 2018 were covered by insurance, while only approximately one third of the \$15 billion in losses resulting from Hurricane Michael were covered by insurance.⁹

Meanwhile, private companies are writing flood coverage, often at more reasonable rates, and providing tailored mitigation incentives. A large portion of insured risk is covered by reinsurers, who in turn spread these risks into the capital markets and beyond the US. We need the insurance and reinsurance industry to smooth shocks and remain healthy and stable through newfound volatility, which requires sensible collaboration in risk sharing and risk management to cover communities and people more economically.

In addition to the risks climate change poses to homeowners and business, these trends are giving rise to significant fiscal risk to the federal government and the greater economy. For example, according to the Trump Administration's landmark November 2018 National Climate Assessment report, the continued increase in the frequency and extent of high-tide flooding due to sea level rise threatens America's trillion-dollar coastal property market and public infrastructure, with cascading impacts to the larger economy.

New climate threats are no less asymmetrical to our military and civil defenses than conventional or historic ones. Both our Department of Defense and Department of Homeland Security have made clear the compelling need to address the looming consequences of a warming world. As first responders and uniformed services become stretched, along with budgets and agency balance sheets, it's imperative that we catalyze market forces, monetary policy, and good governance to strengthen transparency and disclosure as the indispensable characteristics of sound risk management and price discovery.

MEASURE THE TREASURE TECHNOLOGIES

Cost-effective technologies exist and are being deployed to gather accurate, reliable, verifiable collection of real-time data about ecosystem health. These include sensors, satellites and other remote imaging techniques, artificial intelligence, machine learning, connected devices / the Internet of Things (IoT), new applications of robotics, high performance computing, and open

⁷ Oliver Wyman. Flood Insurance Risk Study: "Options for Privatizing the NFIP. P52 Available at: http://www.floods.org/ace-files/documentlibrary/2012_NFIP_Reform/Reinsuring_NFIP_Insurance_Risk_and_Options_for_Privatizing_the_NFIP_Report.pdf

⁸ Government Accountability Office, Flood Insurance: More Information Needed on Subsidized Properties (2013).

⁹ Aon, Weather, Climate & Catastrophe Insight, 2018 Annual Report. <http://thoughtleadership.aonbenfield.com/Documents/20190122-ab-if-annual-weather-climate-report-2018.pdf>

source data ecosystems. These can collect data about real-time ecosystem attributes, and process complex data streams to rapidly respond to shifts in risk.

How much oxygen does a particular poplar tree produce? How much carbon precisely does a pine forest absorb each minute? How much soil moisture is equitably allocated to healthy and efficient crops at this hour? How many wild Pacific fisheries are reproducing at a greater rate than they are being depleted this week by the distant commercial fleet of a growing Asian economy? These have all become knowable as never before.

In a dynamic, adaptive world with computational power amplified by artificial intelligence and machine learning, we will be harvesting natural capital data that takes humanity well beyond conventional natural resource utilization and commodity supply chains, and into a more symbiotic relationship of precision accounting for the true value of ecosystem services. This hearing and the important legislative work of this committee and Congress must be informed by our rapidly evolving capacity to enable a universal and ultimately ubiquitous “Internet of Natural Things”. This would be a truly World Wide Web that goes beyond connected man-made devices that inform, with accuracy and detail, not only models and projections of climate conditions, but also the real-time performance of our planet.

Such technologies are already disrupting and/or influencing best practices for the insurance and financial industries, where behaviors and products are projected to shift from “detect and repair” to “prevent and predict”. Examples include faster and more automated purchase of insurance, more granular and sophisticated risk identification, behaviorally tailored and dynamic usage-based products, rapid underwriting and pricing innovation, and greater incorporation of sensors and other data capture technologies.¹⁰ Insurance providers are already oriented toward the importance of rapidly integrating this data into risk assessment in order to maintain a competitive advantage.

These technologies can enable new capabilities to measure, monitor, manage, and monetize the same dynamic, elusive stocks and flows of natural capital that are currently assigned no value in most markets. Private actors pursuing environmental projects, companies seeking to strengthen their environmental and social governance (ESG) scoring, risk managers charged with fortifying balance sheets, as well as jurisdictions seeking performance and compliance are all desperately in need of clearer, more usable and easily translatable standards to justify and verify investments.

The foundational technologies exist for a real-time “Earth Dashboard” that could serve as an open-source, credible, and verifiable real-time digital data platform to aggregate and distill information about nature’s health and performance, quantified in a way that is applicable to general accounting systems. These technology breakthroughs are fundamental to a new era of natural capital accounting with far greater, real-time transparency and disclosure. This, in turn, supports the redesign of antiquated risk management models and fosters restorative economic growth. This would be a game-changing introduction to markets, eliminating existing

¹⁰ McKinsey, Insurance 2030 – The impact of AI on the future of insurance, April 2018.
<https://www.mckinsey.com/industries/financial-services/our-insights/insurance-2030-the-impact-of-ai-on-the-future-of-insurance>

inefficiencies, enabling price discovery, and ultimately creating a virtuous cycle that heals the relationship between markets and nature while unlocking new sources of value.

While the technology and financial communities develop the products and platforms to collect and translate this wealth of data, policy can have a vital role in shaping their application. One option would be through direct acceleration of relevant technologies and methodologies. Significant work remains to develop and validate methodologies for natural capital accounting. This work could be led by NIST, the National Academies, or the National Laboratories. Additionally, legislation could require a few federal agencies – BOR, BLM, FS, NPS – to test and implement natural capital valuation approaches, providing a public accounting of natural capital stewardship on public lands under their jurisdiction. Piloting at the federal level could help drive private sector development. Such efforts could lead to more comprehensive and granular, real-time public maps, communicating risks and trends related to floods, as well as storms, wildfire, and other climate-related risks. This could drive risk-based insurance rates as well as investment in mitigation measures.

Federal leadership could also be prioritized to focus on dissemination of best practices for natural capital protection to state and local decision-makers. Providing actionable, real-time, place-based guidance to develop localized projects – either through the National Labs or land-grant universities & county extension offices – would enable community-led efforts to harness the power of nature at a much higher rate and speed.

Another critical policy role is to catalyze markets that create demand pull for these innovations and applications. For example, allowing businesses to reduce their financial burden by purchasing international forest-based offsets would help accelerate the development of credible, verifiable, unitized offsets. Offsets are payments made by emitters to compensate landholders for preserving the land under their control. Under this nature-based-solution, governments and local communities benefit financially from maintaining their land, and businesses can “offset” or reduce the cost of complying with environmental and regulatory regimes, as well as global use cases for standards related to forest carbon credits and carbon emissions, fisheries and aquaculture, ocean health, air quality, and water. Across all of these, well designed offsets enable achieving environmental goals far cheaper and faster.

Carbon offset methodology development and implementation within existing markets has significantly contributed to the development thus far of practices, technologies, metrics, accounting and verification, and other components of market development. However, current verification requirements for carbon markets are onerous and expensive, and there is room for government-supported evolution of market-based approaches that value and monetize ecosystem services.

To manage and integrate the value of natural capital, we know we must measure it – not qualitatively and theoretically, but quantitatively and precisely. We can only truly manage what we can measure, and emerging for the first time in human history is the capacity to truly measure everything in our physical world. If we can measure and manage, then we also have the potential to continuously monitor and ultimately monetize the value of nature’s ecosystem services. This

would enable the ultimate achievement: internalization of environmental externalities, and transparency for the systems that secure our health and well-being.

NATURE-BASED SOLUTIONS

The ultimate outcome of these technology applications and market reforms is large-scale capital formation to sharply decelerate net emissions, and enhance community resilience to climate change. Nature-based solutions will be a critical part of this reorientation, and government should seek to maximize the cost-effectiveness of federal infrastructure investments within such parameters. Nature-based solutions have been consistently found to be more effective than their “grey” counterparts, with scientific findings that nature can supply up to approximately 30% of the carbon abatement necessary to stabilize global temperatures by 2030.

It is clear that “natural systems such as wetlands, dunes, and riparian forests provide valuable protection to nearby communities from the impacts of floods and hurricanes by capturing and absorbing stormwater and buffering shorelines from waves and erosion.”¹¹ A robust, economically sound response to climate related risk would pursue enhancement of these benefits. Some economists already estimate the United States benefits from as much as \$23.2 billion worth of “green” storm protection services in the United States each year. Investing in and enhancing these critical American resources could yield cost effective results, and be particularly fit for purpose in rural or low density areas where significant new grey infrastructure may not be warranted.

Infrastructure development that reflects natural capital as a value can take many forms, such as use of low-carbon materials in construction, carbon capture and mineralization into cements, development of CO2 pipelines, and development of parks and green spaces in low-income areas. Natural capital infrastructure projects to date have often been pilot or demonstration-scale – using federal tax or bond policy to encourage systematic planning at a large spatial scale would have a much larger impact. Examples might include:

- *Agricultural management:* Biological sequestration involves using and managing land in ways that enhance the natural absorption of atmospheric carbon by vegetation and soil. Strategic agricultural practices—including conservation tillage, crop-mixture, grazing and grassland management—can augment the sector. A funding avenue could be pursued through farm subsidies policy; USDA currently has programs that could be modified or expanded.
- *Forest management:* Afforestation, reforestation, and reduced deforestation activities can maintain and increase the carbon potential of U.S. forests.
- *Federal land management:* It is fundamental to have improved federal land management to reduce wildfire risk. Similarly, legislative language could be enacted to require federal agencies (BLM, FS, NPS) to manage lands in a way that maximizes biological

¹¹ Glick, Kostyack, Pittmann, Briceno and Wahlund, “Natural Defenses from Hurricanes and Floods” 2014, <https://www.nwf.org/-/media/PDFs/Global-Warming/2014/Natural-Defenses-Final-Embargoed-Until-102114-10amET.pdf>

sequestration. Federal agencies could be required to quantify and then report, in real-time to the public and annually to Congress, on the amount of carbon sequestered on federal lands. Legislation could also require an annual increase of biological sequestration on managed federal lands.

- *Private sector incentives:* Currently, the U.S. funds a variety of coastal restoration projects, often through fossil fuel royalties or grants. In the private sector, The Nature Conservancy has launched a Blue Bonds for Conservation project, focused on unlocking \$1.6 billion in capital for wetland and coastal preservation. Federal policy proposals in this area could include incentives for private investors to participate in third-party projects like the Blue Bonds, a federal reinvigoration of Brady Bonds to allow highly indebted poor countries to get debt relief in exchange for conservation, or increased local grants for restoration and resiliency projects.
- *Federal procurement policy:* giving preference in bidding to proposals that use natural capital to respond to federal needs.
- *Disaster risk reduction:* The 2018 \$81 billion disaster relief package included a provision that requires rebuilding and recovery efforts to account for future risk. A well-designed infrastructure plan should incorporate the same common-sense provision. Such a program could also foster meaningful innovation and experimentation in “green” and “blue” infrastructure, which a number of studies strongly suggests can play a significant role in reducing disaster risk. A concrete measure put forward by the global disaster risk reduction community is investment in resilient infrastructure, including meadows and forests (green infrastructure), and lakes, swamps and peatlands (blue infrastructure), which can be combined with dykes and seawalls (grey infrastructure) for cost-effectiveness and greater protection.

CONCLUSION

We are faced with an urgent need to modify policy and modernize markets to address catastrophic failures of legacy systems. The core of an effective systems solution is to apply state-of-the-art technological progress to redesign markets and enhance risk management. This will ensure a rapidly scaling realignment of incentives, commensurate with the magnitude and timeframe of the risks posed by our changing climate.

Today we have the tools, technologies and the urgent compelling call to not only conserve nature, but to assess, quantify, and collaborate with its essential value. In doing so, we can strengthen the health and well-being of our populations and fortify our physical defenses against catastrophic risks. The resilience and effectiveness of nature-based solutions may likely exceed that of purely man-made, manufactured infrastructure.

We see an opportunity for policy to accelerate the application and integration of key technological advances, guiding them to meet the challenges posed by climate change risk. Policy can also better equip entrepreneurs and market participants to innovate products and

business models that eliminate inefficient allocations of value in the current system, accelerating capital formation around solutions that understand nature as an ally in addressing climate risks.

The extreme weather events of recent weeks, months, and years are a sobering reminder that Nature's fury does not discern between Republicans and Democrats; red states and blue states. As Mother Nature's fever rises and the vital signs of our vital ecosystems become increasingly ominous, we may recognize once again that the futures of each and every American's security are inextricably linked to one another. Indeed, this can be extrapolated to the whole of humanity. When it comes to the risks of habitat health and ecosystem stability, we are truly a world without borders. And so, it's essential on this historic day, when we honor the fallen and the outsized heroic role of first responders to every community catastrophe, that we broaden our nation's renewed commitment to national security with recognition of an urgent new imperative of natural security.

Testimony of Nuclear Energy Institute

John F. Kotek

Vice President for Policy Development and Public Affairs

**Hearing on Examining the Macroeconomic Impacts of a Changing Climate
Subcommittee on National Security, International Development, and Monetary Policy
Committee on Financial Services**

U.S. House of Representatives

September 11, 2019

Subcommittee Chairman Cleaver, Subcommittee Ranking Member Stivers, and Distinguished Colleagues, it is an honor to participate in this hearing of your Subcommittee on National Security, International Development, and Monetary Policy. The Nuclear Energy Institute (NEI) appreciates the opportunity to provide testimony on the importance of nuclear energy in addressing climate change, in the nation's electricity portfolio, and in national security.

I currently serve as Vice President for Policy Development and Public Affairs for NEI, where I work to raise awareness of the role nuclear energy plays in slowing the changes to our climate by reducing the emission of carbon dioxide and other greenhouse gases from electricity production. Before joining NEI, I ran the U.S. Department of Energy's Office of Nuclear Energy from mid-2015 to early 2017. Prior to that I served in a variety of capacities in the U.S. Department of Energy, at Argonne National Laboratory, as a consultant and as a Congressional fellow.

The Role of Nuclear Power in the United States

Our nuclear power plants represent a vital resource for the nation. Nuclear power provides almost one-fifth of U.S. electricity and is the source of more than half of the nation's carbon-free electricity generation. Nuclear plants are by far the most resilient component of our nation's electrical grid, as has been proven in extreme weather events in the last few years. They provide the highest capacity factors of any generation source, averaging 92.6% in 2018. As DOE Secretary Perry said recently, "I don't know how anybody who cares about the climate can't be for nuclear energy."

When the 18-24-month fuel supply on-site at a nuclear plant is contrasted with the need for continued shipment of coal, operation of gas pipelines to run fossil fuel plants, or dependence on intermittent wind and solar resources, the vital role of nuclear power plants in resilience of the grid is clear. The high capacity factors for nuclear plants provide superb reliability and give confidence to consumers that the plants will be providing power when they need it. They also contributed over \$2B in state taxes and about \$10B in federal taxes. The broader nuclear energy sector in the U.S. supports about 475,000 jobs. Estimates are that the nation's nuclear power plants add about \$60B to the nation's GDP.

Nuclear power demonstrates impressive economics. In 2018, the average generation cost for U.S. nuclear power plants was about 3.2 cents per kWh. That figure results from a continued focus on improved economics. For example, by comparison, in 2012 the average cost for U.S.

nuclear power was 4.2 cents per kWh. Note that individual plant costs are distributed around the average. Smaller and single-unit plants may experience higher than average costs.

While further economies are being sought, the situation remains complicated by the very low generation costs for natural gas and by the fact that intermittent solar and wind operate with zero fuel cost, solar construction costs are reduced by federal investment tax credits, and wind farms (and some solar installations) earn federal production tax credits whenever they operate. In many states, wind and solar also benefit from Renewable Portfolio Standards that exclude nuclear energy. The federal and state incentives provided to solar and wind mean that they can profitably run even when their abundance in some locations and at some times of the day leads to negative electricity prices. But since consumers need electricity when the sun and wind do not cooperate, other sources of power must be standing by to provide power as needed.

Role of Nuclear in Decarbonization Scenarios

As broader carbon reduction goals have been brought to the forefront by the IPCC report, a growing series of analyses have called for the inclusion of nuclear in the portfolio of energy technologies. Noted climate scientist, Dr. James Hansen has noted that “Nuclear will make the difference between the world missing crucial climate targets or achieving them.” And in May, the International Energy Agency noted that “A range of technologies, including nuclear will be needed for clean energy transitions around the world.” Their report also called for an 80% increase in global nuclear power production by 2040.

This realization of the role of nuclear energy in decarbonization represents a shift in academic assessments of the policy framework to reduce emissions.¹ Recent work has emphasized the role that firm, dispatchable nuclear energy can fill in complementing variable sources such as wind and solar.² Massachusetts Institute of Technology released a major study³ that showed including nuclear energy in decarbonization scenarios significantly reduced the cost of energy transition. This finding fit with the conclusions of Jesse Jenkins and Sam Thornstrom whose literature review of academic studies found excluding nuclear increased the cost of decarbonization.⁴

Analysts who have looked at the global evolution needed to address climate change have pointed to the need for nuclear energy. The International Energy Agency calls for an expansion of

¹ Stanford’s Mark Jacobson had received great attention for his analyses that showed all energy needs could be met by wind, solar and hydropower (<https://www.pnas.org/content/112/49/15060>). These findings were refuted by a cadre of researchers that challenged Jacobson’s findings (Clack, *et al.*: <https://www.pnas.org/content/114/26/6722>).

² Nestor Sepulveda, Jesse Jenkins, Fernando de Sisternes and Richard Lester, “The Role of Firm Low-Carbon Electricity Resources in Deep Decarbonization of Power Generation.” *Joule*, Volume 2, Issue 11, November 2018. Available at: <https://doi.org/10.1016/j.joule.2018.08.006>.

³ *The Future of Nuclear Energy in a Carbon-Constrained World: An Interdisciplinary MIT Study*, 2018. Available at: <https://energy.mit.edu/wp-content/uploads/2018/09/The-Future-of-Nuclear-Energy-in-a-Carbon-Constrained-World.pdf>.

⁴ Jesse Jenkins, Max Luke and Samuel Thornstrom, “Getting to Zero Carbon Emissions in the Electric Power Sector,” *Joule*, Volume 2, Issue 12, December 2018. Available at: <https://doi.org/10.1016/j.joule.2018.11.013>.

nuclear as part of their 2DS scenario intended to cap warming at 2 degrees C.⁵ The OECD's Nuclear Energy Agency has released the latest⁶ in a series of reports that estimate the economic burden of increasing reliance on renewables in terms of the costs borne by the rest of the system to integrate variable sources whose generation is concentrated in terms of time and geography (Figure 2). A financial perspective yields a similar conclusion. The analysis done by the Risky Business Project shows that including nuclear energy in the portfolio delivers better results.⁷ The cost of deploying a low-carbon energy system was lower with a more diversified portfolio that has nuclear providing a significant portion of electricity than in scenarios that rely heavily on renewables.

We are seeing companies and states committing to carbon-free electricity by 2050 or sooner. As industry leaders and analysts have really begun to grapple with what it will take to get there they have concluded that they can make quite a bit of progress with the renewable technologies available today, but those only get part of the way to these goals and then they have a problem.

Google is already facing the issue.⁸ They aspired to run all of their operations with renewables. They drove the development of renewable projects and purchased renewable credits to match with the rest of their load. But when they looked at the electricity they were actually using they found that the renewables-only approach fell short. The places where they came closest were areas that already had nuclear or hydro that were available when renewables weren't.

There is a clear need for firm, dispatchable, carbon-free power. Nuclear energy can fill this role.

Action to Preserve Nuclear Plants

Low prices for natural gas, electricity markets that do not recognize nuclear energy's attributes, and renewable energy mandates and tax incentives have impacted the economics of many nuclear plants. Looking at just the past several years, nine nuclear power reactors will have closed by the end of 2019, eight more have announced plans to close by 2025, and several more are facing severe economic pressures. Some states have enacted mechanisms to recognize the zero-carbon attributes of nuclear energy and avoid plant closures. When nuclear plants have closed, their outputs have been predominantly replaced with natural gas with increased emissions. Loss of nuclear resources is a serious setback for reduced carbon emissions.

State actions to preserve their nuclear plants, while important, are insufficient to preserve our total national nuclear resources – a federal solution is needed. Several studies, such as those done by the Idaho National Laboratory⁹ note that while many of the nation's nuclear power units

⁵ International Energy Agency, *Energy Technology Perspectives*, 2017. Available at: <https://www.iea.org/etp2017/summary/>. Nuclear is specifically assessed: <https://www.iea.org/tcep/power/nuclear/>.

⁶ OECD Nuclear Energy Agency, *The Costs of Decarbonisation: System Costs with High Shares of Nuclear and Renewables*, January 2019. Available at: <https://www.oecd-neo.org/ndd/pubs/2019/7299-system-costs.pdf>.

⁷ Risky Business, *From Risk to Return: Investing in a Clean Energy Economy*, Appendix 1: Model, Methodology, Key Results, p. 22-24. Available at: <https://riskybusiness.org/fromrisktoreturn/>.

⁸ Google, *Moving toward 24x7 Carbon-Free Energy at Google Data Centers: Progress and Insights*, October 2018.

⁹ See <https://gain.inl.gov/Shared%20Documents/Economics-Nuclear-Fleet.pdf>

are not profitable today, their negative margins are fairly modest. These shortfalls could be addressed through a range of policy options if preservation of our nuclear energy assets was appropriately valued by the nation. These options could include production or investment tax credits to better value nuclear generation or a more fundamental approach to create equal treatment for all clean energy sources, such as through a clean energy standard, replacement of renewable energy mandates with clean energy mandates, or some form of price on carbon emissions.

Effective Decarbonization of the Economy

Since the electricity sector emits only about 40% of the total carbon entering the atmosphere, effective decarbonization of our overall energy system must extend far beyond the electricity sector. Thus, carbon emissions must be minimized in all economic sectors. Today, only two energy sources offer zero carbon emissions today, renewables and nuclear energy, and hopefully clean fossil sources may become economic soon.

Our nation can be powered with minimal carbon emissions if we transition across all sectors of the economy to a future with only clean energy sources: renewables, fossil fuels with carbon capture or utilization, and nuclear power. There is a great deal of research, both in this country and abroad, now focused on developing paths that best utilize all these clean energy sources for significant decarbonization of the world's energy requirements.

This research shows that the intermittent character of renewables and the baseload operation of nuclear energy are complementary and can be effectively integrated into clean energy options that impact a range of sectors of the economy, not just electricity. Studies are exploring how these integrated systems can be used in the transportation, industrial, and residential sectors through options like production of hydrogen, provision of process heat for industrial needs, or desalination of water.

One example has moved to deployment in France for clean hydrogen production for “decarbonization of industry and mobility using low-carbon electricity from its nuclear and renewable energy fleet.” And, just last month, Exelon and its partners received a grant from the U.S. Department of Energy in response to its proposal to explore the use of nuclear power in hydrogen production. Exelon has stated: “Carbon-free nuclear power is critical to our clean energy future. Just think: One day in Illinois, where nuclear is 90% of the state’s clean energy, existing sites could be used to produce clean hydrogen to further combat climate change.”

One development of immense significance is that the United States, Japan and Canada founded the Nuclear Innovation Clean Energy (NICE) Future Initiative and introduced the Initiative at the 2018 Clean Energy Ministerial. Many countries have joined the NICE Future. NICE Future goals include “address[ing] improved power system integration ...[by] nuclear-renewable systems, combined ..heat and power, hydrogen production, and industrial decarbonization.” This Initiative provides a global framework for decarbonization.

Climate change is a global problem – and if nuclear power is critical to achieving our climate goals in the United States, it is even more vital to the many nations that are expanding their electricity generation capacity. And the United States cannot lead the world toward a low-carbon future without nuclear power. Small and advanced nuclear power technologies, with lower capital cost and smaller generation capacity, could dramatically expand the potential market for nuclear power to nations in Africa, Asia and elsewhere that have never considered developing a large nuclear power plant.

Innovation

Investment is being made in advanced nuclear technologies that promise improvements over the current plants. These designs generally take advantage of physical properties and novel materials to create plants with enhanced safety and operational characteristics. Private companies, including many small startups backed by venture capital, lead the development and commercialization of individual designs, but these efforts are largely supported by federal R&D investments. Direct federal research on cross-cutting scientific questions, often through the national laboratories, as well as funding of public-private partnerships has advanced the state-of-the-art for new reactor designs. In the near-term, small modular reactors could be operational within a decade.

The long timelines to develop nuclear technologies and demonstrate their safety to independent federal regulators have made consistent federal R&D funding an important part of a long-term strategy. Federal investments in developing clean energy technologies, including advanced nuclear designs, need to reflect the urgency of the need to transform the energy system

Innovation must extend beyond the technology developers to the regulators who are tasked with assessing new designs. These new reactor concepts are built upon inherent safety characteristics that should be welcomed by those who seek to ensure public safety. The NRC's expertise, however, is steeped in its deep knowledge of the operating fleet. The successful deployment of these improved designs will require the NRC to modernize how they assess new nuclear technologies. Similarly, the licensing of new designs should efficiently enable their deployment to other nations seeking to deploy non-emitting nuclear energy. Harmonizing international approvals of advanced designs will allow the most modern, most appropriate technologies to reach the markets that need them.

National Security Attributes of Nuclear Energy

The role of nuclear energy in providing reliable, safe, highly resilient, clean power on demand at reasonable costs is of inestimable value to the nation and its security, but it is only one facet of national security to which the nuclear industry contributes.

The national security benefits of our nuclear power plants cannot be understated. I strongly agree with Secretary Perry when he says "Energy security is national security." Certainly, the reliability and resilience contributed by nuclear power to our national grid are fundamental to our energy and national security. But many studies note that our nuclear navy and nuclear weapons

programs are supported by the same infrastructure, including educational institutions, as that of the nation's nuclear power industry. For example, a June 2018 letter to the Secretary of Energy from a group of 77 prominent Americans commended him "for recognizing the important role our civil nuclear energy sector plays in bolstering America's national security," and asked that he "continue to take concrete steps to ensure the national security attributes of U.S. nuclear power plants are properly recognized by policymakers and are valued in U.S. electricity markets." That letter was signed by a host of former leaders: 4 Senators; over 20 top military leaders; several White House officials; a number of Secretaries and other senior leaders from State, Defense, Energy, and Veterans Affairs; two Chairs of the Nuclear Regulatory Commission; 7 directors of national laboratories; and several Ambassadors.

A 2018 Report from the prestigious Center for Strategic and International Studies, "Back from the Brink," discusses the national security implications of a strong domestic nuclear industry. In fact, the sub-title of that Report is "A Threatened Nuclear Energy Industry Compromises National Security." The Report notes that:

- "United States' dominance in nuclear has allowed the U.S. government to ... support our naval propulsion program and nuclear weapons program,"
- "our nuclear navy depends heavily on the health of the broader U.S. nuclear energy industry for fuel, technical support, and knowhow," and
- "U.S. Naval reactors rely on a U.S. nuclear fuel cycle, a healthy U.S. nuclear support community, and staying at the cutting edge of nuclear innovation."

The Report discusses how a decline in the commercial nuclear energy industry would undermine our universities' ability to offer the programs needed for other elements of our national security. In addition, many retirees from the nuclear navy look forward to extending their careers in the commercial nuclear industry, and those retirees are typically in great demand by the industry. All these factors are seriously jeopardized if our commercial nuclear industry continues to wither and will seriously complicate the long-term viability of both the nation's nuclear navy and nuclear weapons programs.

Other studies reach the same conclusion. The August 2017 report of the Energy Futures Initiative, whose President and CEO is Dr. Moniz, titled, "The U.S. Nuclear Energy Enterprise; A Key National Security Enabler," stated that:

- "Meeting national security priorities requires a robust nuclear energy industry,"
- "Nuclear power and a robust associated supply chain (equipment, services, people) are intimately connected with U.S. leadership in global nuclear nonproliferation policy and norms and with the nation's nuclear security capabilities." and
- "The U.S. Nuclear Navy relies on a robust domestic nuclear energy supply chain."

In addition, William Ostendorff, now a Distinguished Visiting Professor of National Security at the U.S. Naval Academy (previously a Commissioner of the Nuclear Regulatory Commission,

Principal Deputy Administrator of the National Nuclear Security Administration, and Staff Director of the House Strategic Forces Subcommittee of the House Armed Services Committee) wrote in November 2018: “There is a vital and deep nexus between the health of the U.S. nuclear industry and national security.”

The International Trade, National Security and the Export of Nuclear Technologies

In years past, the United States was the unquestioned leader in nuclear energy. Our exports of nuclear power provided the foundations for well over half of the nuclear plants around the world. When U.S. companies exported their designs and expertise, they also exported U.S. standards for nuclear safety, security and nonproliferation. In addition, they created long-term, close to a century, relationships between the U.S. and other nations. Yet today, 2/3 of the nuclear plants under construction are being led by Russia or China.

Russia is, by far, the dominant international builder of nuclear power plants today. China, while currently focused on building their own domestic plants, is beginning to explore significant international opportunities and, with high confidence, international construction of nuclear power plants will be dominated by Russia and China in the foreseeable future unless the U.S. nuclear industry is revitalized. If the U.S. loses its ability to compete on the international market, we cede those markets to Russia and China. At the same time, we will be ceding international leadership on nuclear safety, security and nonproliferation to Russia and China and those countries will build a century-long global dependence on their nuclear energy suppliers. Loss of our domestic nuclear power plants seriously undercuts our international competitiveness with dangerous implications for national security.

Preventing countries like Russia and China from partnering with other countries on civil nuclear energy development must be ranked as a top nuclear security and nonproliferation priority for the United States. To be successful, the United States must recognize the new competitive landscape posed by Russia and China and remedy U.S. policies that are imposing competitive disadvantages on U.S. nuclear energy suppliers.

First, the United States must enable export financing to support U.S. nuclear exports. Export credit agency support is a bid requirement for virtually every nuclear energy tender. Earlier this year, the U.S. Export-Import Bank regained a quorum on its board of directors, enabling it to approve transactions over \$10 million for the first time since 2015. This progress will be lost if Congress does not extend the Bank’s charter before its expiration at the end of this month. To be competitive against Russian and Chinese nuclear exports, the United States must have a competitive and durable Ex-Im Bank. Additionally, the U.S. Development Finance Corporation should be enabled to support nuclear energy projects.

Second, the United States must have access to international nuclear energy markets. This requires the bilateral negotiation and implementation of framework agreements for civil nuclear cooperation, also known as Section 123 agreements. With the market potential of small and advanced plants, the United States must pursue bilateral engagement earlier and more broadly.

The Department of State's recently adopted policy to seek Nuclear Cooperation MOUs for this purpose should be applauded.

Third, U.S. industry must also be enabled to engage early in markets. This requires reforming U.S. nuclear export controls, which despite recent improvements continue to pose a competitive disadvantage on U.S. suppliers.

To be sure, other nations still have motivations to cooperate with the U.S. on nuclear energy development, including our regulatory system, the excellent operation of nuclear plants, our university system, and the innovation the U.S. is leading on advanced reactor systems. But for nations that simply want to jump-start their journey in nuclear power, they may be far more interested in seeking quick nuclear energy import opportunities and utilizing low cost loans from countries that underwrite their exports.

Conclusion

Thank you again for the opportunity to testify. Nuclear energy can play a significant role in meeting our climate change, energy, national security, international goals. We look forward to working with the Committee to ensure nuclear energy remains a significant contributor to the nation's and the world's clean energy portfolio.

Testimony of Richard J. Powell
Executive Director, ClearPath
House Committee on Financial Services
Examining the Macroeconomic Impacts of a Changing Climate

Good morning Chairman Cleaver, Ranking Member Stivers and members of the committee. My name is Rich Powell, and I am the Executive Director of ClearPath.

ClearPath is a 501(c)3 organization whose mission is to develop and advance conservative policies that accelerate clean energy innovation. We support solutions that advance the wide array of clean energy technologies - including next-generation nuclear, hydropower, cleaner fossil fuel technologies and grid-scale storage solutions that improve grid efficiency, including the integration of additional renewable sources such as wind and solar. Our core mission advocates markets over mandates and bolstering technological innovation rather than implementing stifling regulation. ClearPath provides education and analysis to policymakers, collaborates with relevant industry partners to inform our independent research and policy development, and supports mission-aligned grantees. An important note: we receive zero funding from industry.

I am excited to see the focus this committee is giving to climate change. We believe that this committee can play a large role in America's response to the global climate challenge. With this in mind, I will discuss a few topics today:

- First, the reality of climate change and its pressure on U.S. national economic policy.
- Second, solutions to the climate issue in targeted innovation investments.
- Third, the realities and challenges we face on the global level due to the appetite for energy of developing countries.
- Fourth, the role America can play internationally to help solve the climate challenge.
- Fifth and finally, the opportunity for this Congress to build on last Congress' bipartisan clean innovation record.

1. Climate change already presents significant risks to the U.S. economy

It's always important to address the elephant in the room first. Climate change is real, industrial activity around the globe is the dominant contributor to it, and the challenge it

poses society merits significant action at every level of government and the private sector. It is too important to be a partisan punching bag. Climate change deserves a pragmatic and technology-inclusive agenda to make the global clean energy transition cheaper and faster.

I commend Chairman Cleaver and Ranking Member Stivers for holding this important hearing and look forward to continuing this dialogue as climate change will continue to challenge programs and issues under this committee's jurisdiction.

For example, analysis from the Risk Center at the Wharton School recently demonstrated how the federal mortgage finance system will face multiple challenges due to climate risks. According to Wharton, mortgage-backed securities insured by the Federal Government through Fannie Mae, Freddie Mac, or FHA/VA programs account for over 60 percent of the outstanding residential mortgage debt in the U.S., totaling \$6.7 trillion.¹ In 2018, NOAA acknowledged 14 individual weather and climate events doing at least \$1 billion in damage, totaling \$93.5 billion in total damages.² Additionally, a 2017 report by the Inspector General found that only 42% of FEMA's flood maps correctly identified flooding risk at this point. The National Flood Insurance Program already finds itself in heavy debt. This trend will likely continue to worsen - as climate-related exposure continues to increase, those impacts will be felt in securities backed by the Federal Government, with higher costs passed on to Americans as a result.

2. An Innovation-Focused Approach to Addressing Climate Change

Before we created ClearPath, I was a business consultant at McKinsey & Company. Of all the business philosophy I read and used to help clients, the simplest and most important came from the great Stephen Covey. His second rule for success was elegant, and all important: Begin with the end in mind.

We know that climate change is a huge issue. We also know that the United States has a limited budget and that any solution that truly solves the climate issue must be global. With these constraints and the end in mind: the solutions we pursue must be scalable and sustainable. This means the solutions we invest in must focus on making clean energy cheaper, better performing and easier to buy and build than current technologies - in short, we must invest in innovation.

¹<https://riskcenter.wharton.upenn.edu/climate-risk-solutions-2/can-the-federal-mortgage-finance-system-help-manage-climate-risk/>

² <https://www.ncdc.noaa.gov/billions/events/US/2018>

This is doubly important when considering the global nature of the issue. Developing countries face many hurdles and will infrequently choose clean energy over traditional energy sources if that choice is painful - if, as today, the traditional technologies are cheaper, easier to build, and better performing than the clean technologies. Some will put policies in place to make those painful decisions. Others will not. At ClearPath, we would argue that our "end" ought to be making that choice easy for developing countries by providing them with better performing, clean alternatives to traditional emitting technologies.

With that end in mind, we need to evaluate our tools. We cannot spend our way to a solution -- the global energy economy and the demands of rising populations around the world are too much even for the mighty U.S. budget to facilitate these decisions. Rather, we must invest in a set of better mousetraps. Such solutions leverage the scarce dollars of U.S. taxpayers into technologies that the global economy will pick up on their own merits because they produce energy - which happens to be clean - more cheaply and efficiently than their competitors. This kind of investment is the very definition of a market-based solution to climate change, one that makes markets themselves the force for change in distributing clean energy, instead of the force we work against.

Achieving this solution must also include effective action by government entities like the Department of Energy, because unfortunately, large scale clean energy solutions are not Uber. These systems cannot be built by two guys in a garage. Energy innovation requires massive scale, sometimes taking decades to get from lab to market.

Where the DOE has been most successful in the past is when it has set long-term, aggressive milestones to develop and stand-up new technologies at price points and performance levels that are meaningful for private markets. The Office of Fossil Energy's work on unlocking shale gas, the Energy Efficiency and Renewable Energy Office's work on SunShot to radically decrease the cost of photovoltaic solar, and the Joint Bioenergy Initiative on lignocellulosic biofuels at the Lawrence Berkeley Laboratory are all strong examples. DOE is set for success when the Department has a clear, well understood and shared goal. Strong innovation leadership and clear accountability where political appointees and career employees own the results of all actions then focus our Federal investments. And, with steady investments against the goal over multiple administrations, the federal government tends to produce breakthrough results. We believe that all DOE programs should follow this method - set goals, hold political and career employees accountable to meet those goals, and provide steady investments that drive resources to those end-goals.

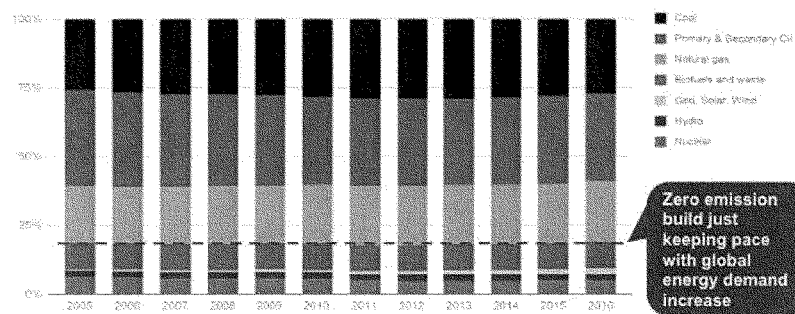
Fine tuning our existing structures to supercharge innovation and finance first-of-a-kind projects, will enable a successful technology-neutral approach that sets the stage for America to lead the world in decarbonization.

3. Global Energy Realities

To have a debate about climate change rooted in political and technical realism, as well as economic competitiveness, we need to understand the needs of the rest of the world. Developing countries have an insatiable energy appetite. As populations and economies grow they are demanding more and more affordable energy options.

Humanity is not yet transitioning to a zero emission energy system

Share of total primary energy supply by fuel type
% of total (originally in ktoe)



Source: International Energy Agency World Energy Balances 2018

The current energy choices available to developing nations are less than desirable for the climate. Despite significant global renewables deployment, emissions continue to rise. In fact, the share of global energy supplied by clean sources has not increased since 2005. In other words, clean development is only just keeping up with economic development; clean is not gaining ground. Clean technology available today is simply not up to the task of global decarbonization. It must represent a better, cheaper alternative so developing nations consistently choose it over higher-emitting options. It's also unlikely that story will change any time soon unless new clean technologies become market competitive. In fact, current expected emissions growth from developing Asian countries alone would offset a complete decarbonization of the U.S. economy by

mid-century.³ China, as part of its Belt and Road initiative is financing \$36 billion dollars' worth of inefficient coal power plants in at least 27 countries, totaling 102 GW of new coal power.⁴

This highlights another important fact. If America does not provide the rest of the world with energy technologies, it isn't going to stop developing countries from gaining the technologies they need to grow. Instead, they are going to turn to our adversaries, partnering with countries like China and Russia who view the spread of their technology as a way to expand their power while weakening the United States. In other words, by failing to develop affordable clean energy sources of all kinds, we not only fail to solve the climate issue at hand but also threaten our own national security and geopolitical position.

China and Russia have gained the upper hand in energy exports by leveraging state owned enterprises to achieve their economic and political interests. The aforementioned Belt and Road initiative that China is pursuing relies heavily on state-owned enterprises to achieve its goals. By project value, as of last October, 70% of Belt and Road projects were contracted to state-owned enterprises. These state owned enterprises seek to achieve the strategic objectives of the initiative: to use economics to promote politics and to combine politics and economics.⁵ They seek to achieve these objectives with more than just financial backing from China. The Chinese government offers policy, performance evaluation, and risk management and analysis to these companies to make them more effective.

As for Russia, they also utilize state-owned enterprises to achieve their goals. Their state-owned nuclear company Rosatom reports that at least 33 plants are currently planned for development. Whereas the United States historically lead the world in peaceful and safe nuclear energy exports, this Russian investment has made them the leading exporter of the technology internationally with over a dozen plants currently being built in countries like Turkey, Bangladesh, India and Hungary.⁶ China is close behind Russia, having increased nuclear exports under the belief that more nuclear energy proliferation will make the world more peaceful while also supporting their economic goals.⁷

³https://www.eia.gov/outlooks/aeo/data/browser/#/?id=10-IEO2017®ion=0-0&cases=Reference&start=2010&end=2050&f=A&linechart=Reference-d082317_3-10-IEO2017~~~~~Reference-d082317_17-10-IEO2017&map=&ctype=linechart&sourcekey=0

⁴ http://ieefa.org/wp-content/uploads/2019/01/China-at-a-Crossroads_January-2019.pdf

⁵ <https://www.lowyinstitute.org/the-interpreter/china-s-belt-and-road-initiative-inside-looking-out>

⁶ <https://www.economist.com/graphic-detail/2018/08/07/russia-leads-the-world-at-nuclear-reactor-exports>

⁷ <https://carnegieendowment.org/2018/05/14/future-of-nuclear-power-in-china-introduction-pub-76312>

These examples illustrate both the economic potential and the pitfalls of inaction present in this debate. The markets America could serve are vast and the trade benefits we can experience are huge, if we are the first to develop truly scalable clean energy solutions and craft a cohesive plan for international deployment assistance. More broadly, continuing an innovation-focused approach to American clean energy dominance will cement our geopolitical gains from the shale revolution, ensuring we continue as the global energy superpower through the 21st century.

4. America's International Role

America has several levers to ensure our technology offerings are competitive with countries who do not share our interests or values. These include engagement with the international community in financing like the International Finance Development Corporation or IDFC -- created by the BUILD Act of 2018 from OPIC -- and the Export Import Bank, along with bilateral and multilateral engagement on clean energy exports and technology transfer in forums like the Clean Energy Ministerial.

In particular, we have been pleased to see the United State's engagement in the Clean Energy Ministerial over the past few years, as well as our push to create new initiatives in coordination with other foreign governments within this framework on carbon capture, utilization, and storage or CCUS, and nuclear innovation. These are two very important initiatives that seek to ensure that all clean resources are on the table as the world seeks to decarbonize. Having attended both the CEM meeting in Copenhagen where these initiatives were launched in 2017, as well as the CEM meeting in Vancouver this past year, it was a great source of hope to see how many countries were engaged and serious about deploying 24/7 clean energy resources.

To help achieve the deployment of these resources, the US International Finance Development Corporation, which was created to expand on the work done previously by OPIC, is key. This organization will be able to help finance the deployment of American energy technologies internationally and is the first step to truly having a competitive offering to the incentives China and Russia are providing when they approach other countries with offers to develop infrastructure and energy domestically. However, to achieve the largest impact possible, we need to ensure that previous restrictions on nuclear energy development imposed by OPIC do not continue to restrict the activities of the new USIDFC. Similarly, America needs to work to ensure that restrictions on clean energy projects do not exist at international organizations we participate in like the

World Bank. Finally, the continued authorization of the Export Import Bank is key to ensuring the export of energy technologies internationally.

One thing is clear, as Russia and China utilize their command and control government owned enterprises to attempt to gain influence internationally, the American government must utilize the tools they have at their disposal to ensure that our companies, our innovators, and our clean energy technologies have the best possible chance to compete internationally. As stated earlier, achieving the maximum amount of impact from these government organizations will allow a market-based solution to climate change, one that makes markets themselves the force for change in distributing clean energy.

5. A Bipartisan Path Forward

The last Congress hasn't received the credit it is due for boosting low-carbon technologies. The broadly bipartisan agenda enhanced critical incentives for carbon capture, renewables, and advanced nuclear; invested in Department of Energy R&D at record levels; and reformed regulations to accelerate the licensing of both advanced nuclear reactors and hydropower. The 45Q tax incentive for carbon capture and storage technology is a perfect example - it was supported by a vast bipartisan coalition from environmental organizations to organized labor to utilities to coal companies. Notably, seven national unions recently collectively re-emphasized the importance of including carbon capture and nuclear in any national clean energy policy. Lastly, as previously mentioned, the creation of the IDFC through the BUILD Act greatly improves the prospects for American clean technologies internationally.

Going forward, given the scale of the climate challenge, we need to greatly increase the pace and ambition of our efforts. Let's not shy away from smart investments in "moonshot" goal programs that deliver low-cost, high-performing clean technology - from basic research all the way through demonstrations. Let's create stronger financing and incentives to commercialize cutting-edge companies and deploy those technologies globally. And let's enact deep regulatory reforms that remove barriers to rapidly scaling clean technology.

Bipartisan cooperation on climate change is essential under divided government - and attainable. In fact, it is the only chance our nation will have if it is going to play a significant role in the global solution. Thank you again for this opportunity, and I look forward to the discussion.

Written Testimony of Alicia Seiger
Managing Director, Stanford Sustainable Finance Initiative

Prepared for the U.S. House of Representatives, Committee on Financial Services,
Subcommittee on National Security, International Development and Monetary Policy

“Examining the Macroeconomic Impacts of a Changing Climate”

September 11, 2019
Rayburn Office Building, Room 2139

Chair Cleaver, Ranking Member Stivers, and Members of the Committee,

Thank you for the opportunity to appear before the Committee today to testify on the macroeconomic impacts of a changing climate and the role of climate-related financial reporting. My name is Alicia Seiger and I am the Managing Director of the Sustainable Finance Initiative at Stanford University’s Precourt Institute for Energy. I also manage the Steyer-Taylor Center for Energy Policy and Finance, a joint initiative of the Stanford Graduate School of Business and Law School, and I teach courses on climate finance and climate mitigation at Stanford Law school.

The macroeconomic impacts of a changing climate are extensive and well documented. Given the areas of expertise among my fellow witnesses, my testimony focuses on how climate change is unique among other structural economic drivers and the role of climate-related financial reporting. My three main points can be summarized as follows: 1) climate change merits special consideration; 2) climate risks can be measured and analyzed but reporting is

only as useful as the quality of the data on which it is sourced; and 3) climate-related financial reporting can form the basis for good policy and market stability.

The stated purpose of this hearing is to examine the “macroeconomic” impacts of climate change. Because the proposed bill refers to both the Fed and the SEC, I also include discussion of private risk (i.e. the micro) and weave the roles of the Fed and the SEC throughout.

The Fed and The SEC – Systemic and Private Risks

The Fed’s purview is to ensure economic growth and price stability and maximize employment. The SEC is primarily concerned with the efficiency and credibility of investment markets, the stock market in particular. The following simplified and fact-based scenario in Florida illustrates the relationship between climate change and the responsibilities of the SEC and the Fed.

Rising sea-level, sunny-day flooding and storm surges impact property values in Miami. As the amount of property damage increases, insurance companies raise premiums and eventually exit the market entirely. Without access to insurance and with frequent damage from storms and flooding, people are less likely to choose to purchase real estate in Miami. The SEC is responsible for protecting investors from the private risk of financial losses by, say, requiring issuers of securities whose value is tied to Miami real estate to properly disclose the economic impact of these physical impacts.

A July 2019 report from the Union of Concerned Scientists predicted that Florida is likely to see temperatures over 100 degrees for four months every year by mid-century.¹ Well before mid-century, prolonged extreme heat is likely to deter the elderly from retiring to the state. With no state income tax, the Florida economy is supported by retirees and a growing housing market.² A reduction in the flow of retirees and the lack of availability of home insurance in the country's fourth largest economy poses systemic risk to the state and the U.S. mortgage market. The Fed, presumably, does not want that set of circumstances to come as a surprise.

Climate-related impacts are unique among other structural changes

The Fed considers many macroeconomic trends affecting the economy and financial system. Climate change however, has four distinctive characteristics that merit special consideration and management.³

1. **Climate change is not an environmental issue, it's an everything issue.** Climate change affects all agents in the economy, across all sectors and geographies.
2. **Climate change is foreseeable.** Climate science models offer businesses, investors and policy-makers a high degree of certainty that physical and transition risks will materialize in the future.
3. **Climate change cannot be reversed.** According to scientists, climate change will have irreversible consequences for our planet.

¹ <https://www.ucsusa.org/press/2019/southeast-region-areas-endure-about-four-months-year-when-feels-temperature-exceeds-105>

² <https://www.forbes.com/sites/adammillsap/2018/06/06/floridas-population-is-booming-but-should-we-worry-about-income-growth/#67351f56134d>

³ https://www.banque-france.fr/sites/default/files/media/2019/08/19/ngfs-report-technical-supplement_final_v2.pdf

4. **Climate is a long-term condition that depends on near-term actions.** Enough global warming is already “baked into the system” to cause significant disruption and impacts to financial assets regardless of the speed and scale of a transition. However, the ultimate magnitude of future impacts and future costs will be determined by actions taken today.⁴

To delay action is itself a decision to enter unprepared into a more volatile economy and increase the likelihood of more abrupt and disorienting market corrections.

To better understand the macroeconomic impacts of a changing climate, it is useful to consider the drivers of risk. There are two primary drivers – physical risk and transition risk.

Physical and Transition Risks

Physical risks stem from chronic and acute changes in weather patterns including storms and floods, droughts, sea-level rise, wildfires, and extreme heat. Physical impacts disrupt supply chains and consumption patterns, threaten real assets (including property and agriculture), and disturb the health and movement of people.

Physical risks can add-up to significant financial losses. In the case of insured losses, insurance and reinsurance firms are impacted by higher claims. If losses are uninsured, the burden

⁴ According to a Harvard meta-analysis, a one-decade delay in addressing climate change would lead to about a 40% increase in the net present value cost of addressing climate change. <https://voxeu.org/article/cost-delaying-action-stem-climate-change-meta-analysis>

ultimately falls on the US taxpayer. Uninsured losses also create uncertainty in federal budgets in the form of large and unexpected disaster relief. Physical risks also threaten asset values and increase credit risk for banks and investors. The frequency and intensity of losses from extreme weather is rising exponentially. Consider this, in the 35-year period prior to 1990, the average number of billion-dollar weather related disasters globally was 5 per year. In 2017, there were 16 separate billion-dollar disaster events in the U.S. alone.⁵

Transition risks rise from a suite of factors as economies and enterprises transition from low to high resilience and from high to low-carbon intensity. Price dislocations can result from misjudging the pace and scale of technology innovation and failing to prepare for abrupt shifts in policy and consumer behavior. Investments in long-lived emissions-intensive assets face the risk of becoming so-called “stranded assets,” retired before the end of their productive lifespan, thereby imposing financial losses. While emphasis has been placed on risks to firms involved in the production and distribution of fossil fuels, transition risk will impact asset values across utilities, heavy industry, petrochemicals, cement, transportation (including aviation and shipping), real estate and agriculture.

The degree to which an economy is impacted by transition risk can depend on where it sits on the spectrum of globalization. Highly globalized economies have less control over the impact of transition risks. For example, the stability of the German automotive sector is highly subject to

⁵ <https://www.climate.gov/news-features/blogs/beyond-data/2017-us-billion-dollar-weather-and-climate-disasters-historic-year>

electric vehicle (EV) policy in the European Union and China. And U.S. investors are subject to policy and technology transitions in countries where their investments are deployed or operate.

Companies and investors also face liability risk as the possibility of claims for damages increase and climate-related losses increase. The increasing sophistication of attribution science (i.e. the likelihood that a particular extreme weather event was caused by climate change) will serve to increase the threat of legal liability.⁶

The value of reporting and disclosure

The value of climate risk reporting is two-fold. First, investors benefit from robust and comparable data when trying to determine how climate risks and opportunities impact companies and projects. And second, businesses and workers often find that climate-related risk reporting catalyzes ingenuity, improves strategic thinking, and increases competitiveness. In sum, you manage what you measure and if you manage it, you can improve performance.

In recognition of the role disclosure can play in preventing financial instability, and following his seminal “Tragedy of the Horizon” speech at Lloyd’s of London in September 2015⁷, Governor of the Bank of England and G20 Financial Stability Board (FSB) Chair Mark Carney established the Task Force on Climate-related Financial Disclosures (TCFD). The final TCFD recommendations,

⁶ <https://www.scientificamerican.com/article/scientists-can-now-blame-individual-natural-disasters-on-climate-change/>

⁷ <https://www.bankofengland.co.uk/speech/2015/breaking-the-tragedy-of-the-horizon-climate-change-and-financial-stability>

issued in 2017, provided a framework for companies to develop more effective climate-related financial disclosures and marked a positive step toward ensuring greater stability of the global financial system.

Investors have repeatedly validated and echoed the intention of the TCFD. In June 2019, 477 investors with \$34 trillion (USD) in assets urged world leaders to step up ambition on climate change. The statement had an emphasis on improving corporate climate risk disclosure in financial filings, including asking governments to improve climate-related financial reporting and commit to implementing the TCFD recommendations.⁸

Companies have also benefited from following the TCFD reporting framework and employing voluntary disclosure reporting such as those provided by the Sustainable Accounting Standards Board (SASB) and CDP (formerly the Carbon Disclosure Project.) Based on analysis of corporate disclosures from 215 of the world's 500 biggest companies, CDP found that these firms faced roughly \$1 trillion in costs related to climate change unless they took proactive steps to prepare.⁹ According to research from Ceres, a sustainability non-profit on whose Board of Directors I serve, companies that disclose climate-related financial risks in annual financial filings are nearly twice as likely to have time-bound commitments to reduce GHG emissions than companies that do not.¹⁰

⁸ <https://theinvestoragenda.org/wp-content/uploads/2019/07/190704-GISGCC-correction-3.pdf>

⁹ <https://www.cdp.net/en/research/global-reports/global-climate-change-report-2018>

¹⁰ <https://www.ceres.org/resources/roadmap-for-sustainability>

In June 2019, the FSB published a TCFD status report that found while disclosure has increased since 2016, it is still insufficient for investors given the lack of specificity and standardization of data. The report also found that mainstreaming climate-related issues requires the involvement of multiple functions within a firm.¹¹ This is also true for governments - mitigating and managing the impacts of climate change is an all-agencies on deck exercise. As the head of the International Monetary Fund Christine Lagarde put it, “any institution has to actually have climate change risk at the core of their understanding of their mission.”¹²

Limits of current risk assessment models

While reporting is valuable, the value of reports depends entirely on the quality of the underlying models, assumptions and data sources. Physical risk is relatively straightforward to analyze because of the robust volume of observations from climate science models. Today, leading companies and investors are using granular models and machine learning techniques to assess physical risk to assets and operations.

Transition risk is more difficult to analyze because assessment models have fewer observations and less certainty than physical risk models. The Network for Greening the Financial System (NGFS) is a group of thirty-six Central Banks and Supervisors, collectively representing five continents and half of global GHG emissions, who voluntarily share experiences and best practices in pursuit of climate risk management. In July 2019, the NGFS published a technical

¹¹ <https://www.fsb.org/2019/06/tcf-d-report-finds-encouraging-progress-on-climate-related-financial-disclosure-but-also-need-for-further-progress-to-consider-financial-risks/>

¹² <https://www.nytimes.com/2019/09/04/business/climate-change-ecb-lagarde.html>

supplement report entitled “Macroeconomic and financial stability: Implications of climate change.” The report identifies limitations of current risk assessment models and charts a course to fill analytical gaps. The report concludes:

Financial stability assessment using modeling approaches necessitates more bottom-up quantitative estimates of risk for individual issuers and borrowers which is currently lacking. There is also a need to better understand how physical and transition risks are interrelated, and the potential for climate-related feedback loops between the economy and financial system.¹³

The recent bankruptcy of my utility, Pacific Gas & Electric, exemplified the lack of prevalence and sophistication with regard to climate-risk modeling, and the relationship between private and systemic risk from climate change. PG&E outperformed its peers on Environment, Social and Governance (ESG) metrics. But ESG ratings do not adequately account for the risk of increased heat and drought, liability risk, shifting land-use patterns, and safety lapses. Passive index investors had no warning, and even few active investors tracked the foreseeable consequences of California’s devastating wildfires on the utility’s share price. In the end, PG&E’s bankruptcy not only caused billions in losses for shareholders, but also losses to insurers, customers, creditors and taxpayers.¹⁴ The path forward for California’s utility, insurance, and housing policies remain unclear.

¹³ https://www.banque-france.fr/sites/default/files/media/2019/08/19/ngfs-report-technical-supplement_final_v2.pdf

¹⁴ <https://www.forbes.com/sites/chunkamui/2019/01/24/pge-is-just-the-first-of-many-climate-change-bankruptcies/#553624887e5f>

Without mandates and standards, that status quo leaves investors to grapple with limited and largely unhelpful information. The current practice of confounding ESG and climate risk and the lack of enforcement of the SEC's current guidance regarding climate change disclosure¹⁵ has pushed the development of next generation Integrated Assessment Models (IAMs) to pioneering entrepreneurs and a small group of NGOs. IAMs are models that combine a climate science module describing how emissions derived from an economic activity impact temperature and an economic module describing how economic outcomes driven by rising temperatures and shifts in technology, policy and consumer behavior. Universities are playing a role in developing next generation IAMs too, including the Stanford Sustainable Finance Initiative. But most of this work is being done either for foreign governments or for niche applications. Mandated reporting requirements will improve and standardize risk models and better protect financial stability and economic growth.

An investor perspective – New York State Common Retirement Fund

The year I spent as an advisor to New York State Comptroller Thomas DiNapoli in his capacity as the sole fiduciary of the \$210 billion New York State Common Retirement Fund (NYCRF) illustrated the challenges investors confront in the face of limited climate-related financial information.

¹⁵<https://www.ceres.org/sites/default/files/Fact%20Sheets%20or%20misc%20files/Ceres%20Investor%20Letter%20SEC%20Concept%20Release%207-20-16.pdf>

Our Decarbonization Advisory Panel's recommendations¹⁶ were well received and within two months, the Comptroller and his staff issued a Climate Action Plan¹⁷ that largely embodied the thrust of our panel's recommendations. But my work with NYCRRF made clear the limitations of current climate-related risk disclosure (e.g. voluntary, limited, and incomparable) and the need for more robust, consistent, comparable and granular climate-risk reporting and analysis by companies, asset managers and consultants.

NYCRRF is a leader among its peers with regard to climate change. Its investment staff have worked with third-party experts to conduct climate risk analyses at the portfolio and asset level and design new low-emission investment products. And yet, despite NYCRRF'S willingness to pursue our panel's recommendations, its proactive posture on investing in climate solutions and engaging companies on climate, and its efforts to practice best-in-class climate-related research and product development, NYCRRF remains highly exposed to climate risk.

Like most large pensions, to limit costs, NYCRRF is heavily invested in passive index funds. In other words, they own the market, along with any mispriced risk or systemic failure. In the absence of high-quality climate-related financial disclosures, NYCRRF is a passive taker on a bet wagered with insufficient information. Not only does this bet increase the risk of financial loss for New York state employee pensioners, but it poses a systemic risk in that a majority of state

¹⁶ https://law.stanford.edu/wp-content/uploads/2019/05/newer.PDF-NYCRRF_DAP_FinalReport_Full.pdf.pdf

¹⁷ <https://osc.state.ny.us/pension/climate-action-plan-2019.pdf>

pensions also rely heavily on passively managed index funds. A shock to the public markets from an abrupt or disorderly transition will smash nest eggs across the country.

A sovereign perspective – the case of South Africa

As the hearing memo and my fellow witnesses have articulated, lots of information exists about the impacts of physical risk on the U.S. economy. What has been less well covered is the impact of transition risk, and the combination of the two. A global example that may be of interest to this committee is a recent report that analyzed the impacts of the low-carbon transition on the South African economy by the data analytics firm Climate Policy Initiative (CPI).

South Africa generates significant revenue from exporting coal (\$4.2 billion in 2017) and more than 100,000 people are employed in the extraction, development and export of this natural resource. In early 2018, Cape Town, the country's second largest city with a population of 4 million, came within days of running out of water. The country faces competing pressures of the physical impacts of climate change and the threat of reduction in demand for coal. Patrick Dlamini, Chief Executive Officer and Managing Director, Development Bank of Southern Africa responded to the CPI analysis this way:

“One of the most striking findings from this report is that South Africa faces “transition risk” approaching R1.8 trillion (\$125 billion) in present value terms if the world achieves a path consistent with the Paris targets. With much of this risk apparently due to fall on the public balance sheet, such transition risk could strain the public finances [and]

jeopardize the sovereign credit rating... It would be irresponsible of us not to investigate these risks more thoroughly.”¹⁸

Several major economic sectors in the U.S. will be affected by the low-carbon transition including the oil and gas, petrochemicals, automotive and agriculture industries. Not enough research has been done to calculate the impacts to companies, workers and the overall economy.

The road ahead

On Sunday June 22, 1969, a spark from a passing train flared into the Cuyahoga river igniting industrial debris floating on the surface of the water. It wasn't the first time the Cuyahoga river caught fire, nor was it the most destructive. But it occurred at a time of increased consciousness about protecting natural resources, and a month later a photo of the fire appeared in Time magazine, igniting national outrage.¹⁹ Then Cleveland Mayor Carl Stokes became deeply committed to greater federal involvement in pollution control. Stokes' advocacy played a part in the passage of the 1972 Clean Water Act, signed by a Republican President.

Sadly, climate is harder than water. For most of the thirty-plus years since climate science was firmly established, carbon pollution couldn't be seen. Nothing was on fire. There was no “Baby

¹⁸ <https://climatepolicyinitiative.org/wp-content/uploads/2019/03/CPI-EF-Understanding-the-impact-of-a-low-carbon-transition-on-South-Africa-2019.pdf>

¹⁹ The 1969 Time Magazine photo was actually from a previous and more devastating Cuyahoga River fire in November 1952.

Jessica” moment for television news crews to focus national attention. In recent years, that has changed. Today, we are seeing the impacts of carbon pollution in the form of devastating storms and wildfires, increased heat and drought, and shifting human migration. Had Congress and the rest of the world tackled climate change thirty years ago, we might not be discussing it in this committee. Instead, the world has emitted as much atmospheric carbon in the last thirty-years as in the previous two centuries of industrialization. As a result, climate change has progressed to the point where it is increasingly necessary to protect investors and financial stability from climate impacts.

Reporting on the economic costs of climate is one way for the Fed and the SEC to better prepare the national government, businesses, workers and investors for a changing climate. In order for those reports to be useful, they must be built upon data gleaned from mandated financial disclosures that benefit from standardization and best-in-class integrated assessment models. And thoughtful attention should be paid between what is disclosed and what the agencies will do with the information.

For example, the Fed could develop a set of key risk indicators (KRIs) to monitor potential risks and use climate reports to inform those KRIs. According to the NGFS, KRIs should include, “insured and non-insured losses due to catastrophe events, residential loans in areas exposed to frequent natural disasters, financial indicators such as equity prices and profitability of

companies in ‘non-green’ sectors, credit exposure to sectors with high GHG intensity and the global carbon price.”²⁰

Armed with reports and KRIs, the Fed can choose among a portfolio of actions. One possibility is to simply measure and report risk. Other possibilities the Fed might consider include: requiring stress testing for financial system exposure to climate risk, introducing standards for how much money banks are permitted to have in certain types of investments, or extending preferable borrowing rates for firms that maintain certain “climate resilient” portfolio standards. The Fed will ultimately need to evaluate the levers it feels are appropriate pull as an independent institution.

Appropriate SEC action appears more straightforward – mandating climate-related financial disclosure.

Conclusion

Mandatory reporting on the economic costs of climate is both possible and beneficial. And regardless, the U.S. legislature must pass comprehensive, science-based climate policy or the Fed and the SEC will not be able to manage what they have measured, no matter how much data is at their fingertips.

²⁰ https://www.banque-france.fr/sites/default/files/media/2019/08/19/ngfs-report-technical-supplement_final_v2.pdf

