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COST REDUCTIONS IN EMERGING ENERGY TECHNOLOGIES WITH A SPECIFIC FOCUS ON HOW RECENT TRENDS MAY AFFECT TODAY'S ENERGY LANDSCAPE

HEARING

BEFORE THE

COMMITTEE ON ENERGY AND NATURAL RESOURCES UNITED STATES SENATE

ONE HUNDRED FIFTEENTH CONGRESS

FIRST SESSION

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COST REDUCTIONS IN EMERGING ENERGY TECHNOLOGIES WITH A SPECIFIC FOCUS ON HOW RECENT TRENDS MAY AFFECT TODAY'S ENERGY LANDSCAPE

THURSDAY, JUNE 8, 2017

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

The Committee met, pursuant to notice, at 10:08 a.m. in Room SD–366, Dirksen Senate Office Building, Hon. Lisa Murkowski, Chairman of the Committee, presiding.

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

The CHAIRMAN. Good morning, everyone. The Committee will come to order. This is an oversight hearing to consider cost trends in emerging energy technologies. I appreciate everyone being here this morning. It is kind of quiet on this side of the dais. I think that if we had suggested that this was the overflow room for the Senate Intelligence Committee, we might have a bigger crowd out there.

[Laughter.]

But I do recognize and appreciate that the conversation that you will have with us this morning is one that I think should generate a level of excitement, an opportunity, particularly for young people, as they think about our energy future and how they can be participants in it. So I appreciate the fact that you are here this morning.

This hearing is meant to provide us with a better understanding of what is happening in the energy marketplace, how federal energy policies may be affecting those changes and what more we can do to keep energy affordable. A stronger grasp of what is happening will help us develop what to expect going forward and the best ways for the Federal Government to be involved as we continue our policymaking efforts.

The big story in recent years has been sustained and historically low prices for electricity rates and consumers at the pump, and this has been driven by technological innovation in the oil and gas industry which has dramatically expanded our nation's energy supply and more recently by decreases in the cost of production.

The cost of renewable energy has also decreased drastically. According to the Department of Energy (DOE), the cost of wind turbines decreased by 27 percent from 2009 to 2015, and the cost of installing solar panels decreased by 60 percent over the past decade. These technologies are challenged because of their intermittent nature, but the cost of energy storage technologies are coming down as well and we recognize the great potential there.

Although much work still needs to be done to commercialize the array of storage options that will be needed for our grid in the future, the decrease in lithium-ion battery prices is a big first step. According to McKinsey and Company, the cost of lithium-ion batteries per kilowatt-hour has dropped by 77 percent since 2010.

That drop is also making new vehicle technologies more competitive. Hybrids and electric vehicles rely on high-capacity lithium-ion batteries to operate, and those batteries need to be less expensive for those vehicles to be directly cost competitive with traditional combustion-powered vehicles. This is occurring right now even as traditional vehicles are increasing efficiency through the adoption of lightweight materials and advanced manufacturing techniques.

Although less well-known, the semiconductor industry might be the most impressive story to date when it comes to decreasing costs. Semiconductors are the base of all of our electronic technologies and costs per transistor have continued to decrease at a rapid rate, including three orders of magnitude over the past decade alone. New devices can now be used in more extreme environments and are more energy efficient, and this has led to drastic decreases in LED prices for consumers, leading to further decreases in energy consumption and costs for consumers.

The innovation taking place right now is good news for our energy future, particularly in my state of Alaska, where we pay far more for electricity than the average U.S. consumer. In some of our smaller, more remote communities, we see as much as $1.00 per kilowatt-hour paid by our families. That is simply not sustainable.

We have dozens of communities that are not connected to the main grid, and actually that is not quite an accurate statement. When you have 80 percent of your communities in the state that are not connected by a road, think about what that means then for any kind of an energy grid. When we talk microgrids in Alaska, they are micro microgrids. We recognize that more often than not, when we are looking at how we power our communities, we rely on diesel generation. That is equally not sustainable. So new and more affordable technologies offer tremendous promise for us.

Today is also a good opportunity for us to consider whether federal policies are keeping up with the changes we are seeing in the energy industry. As you have heard the two of us say here, it has been a full decade now since the last major energy bill was signed into law. We are well overdue to update and modernize so many of our energy policies.

So I intend that this hearing will be the first in a series that we will hold in Congress with a focus on innovation. My hope is that it will both set the stage and serve as a jumping off point so that we can develop meaningful policy that continues to drive cost reductions and promote affordable energy for the American people.

I will note that Senator Cantwell and I will be heading to Senator Cantwell's state tomorrow, where we will have an opportunity to look at some of the high-tech, cutting-edge developments when it comes to efficiencies and to energy. I am really excited about the day tomorrow. On Saturday, we will have a field hearing up in a small fishing community, Cordova, Alaska, where we will have a chance to take a look at how microgrids are helping us with our energy.

I am so proud of the work this Committee is doing and very proud of my partnership with my Ranking Member.

Senator Cantwell, I now turn it over to you.

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

Senator CANTWELL. Thank you, Madam Chair, and thanks for scheduling this hearing. Maybe we are the alternative hearing, both in energy alternatives as well as to other things that are happening here in the Senate today. But it is an important hearing, as you mentioned, to examine how energy technologies and recent trends are helping to change the landscape, and particularly how new technologies are helping us drive down the cost of energy.

Obviously, we have seen a revolutionizing way in which consumers consume and how businesses generate energy, and this has affected millions of Americans, certainly in creating new jobs. According to the International Energy Agency, global spending on all renewable resources totaled $313 billion in 2015. And although the investment level has been relatively flat, the annual amount of renewable energy capacity installed has increased 33 percent since 2011, and it is because it costs less to buy more.

So global energy efficiency investment has reached $221 billion, and of that, the amount of energy efficiency investments in the building sector, including appliances, lighting, was $118 billion in 2015. This gives America a leadership and entrepreneurial position on these important sectors.

Renewable electricity investments in the U.S. were nearly $40 billion in 2015. Wind and solar power now account for more new domestic electric generation than any other source, and those investments translate into jobs. The U.S. wind industry supports over 100,000 jobs. The American wind power added jobs nine times faster than the overall economy. So we are where we are today with over 370,000 workers in the solar industry, and one out of every 50 new jobs in the United States in 2016 was created by the solar industry.

So the fact that we have seen such incredible job growth—we are here to discuss this morning what we need to do to make sure we continue that. There are 2.2 million Americans employed in whole or in part in the design, installation and manufacturing of energy efficiency products and services, and these trends are expected to continue. According to the International Energy Agency, global investment in renewable energy will total $4.2 trillion over the period of 2015 to 2030, and around $8 trillion in energy efficiency including $3 trillion in building efficiency. That is why it is so important we look at these issues.

Now, I know I have heard Secretary Pruitt on numerous shows these past few days talking about why we are not committing to further global climate reductions and saying that we will leave it up to the private sector, but I am pretty sure it was not the private sector that did all the R&D that we needed to do on solar chemical equations to help us get a solar industry, nor did they have all the incentives that we passed as far as renewable energy tax credits. I am not sure they would have complied with the fuel efficiency standards that we were also able to pass in a big package giving consumers more fuel-efficient automobiles.

That is what our businesses know. That is why companies like Amazon and Microsoft and REI and so many others wanted to remain part of a climate agreement. That is because they know that these investments in emerging energy technologies help us drive down costs.

Wind capacity has tripled in the United States since 2008 with enough to power 17 million U.S. homes, and that is more homes than in California and Texas combined. That is thanks to the prices reaching all-time lows and power purchase agreements for wind have fallen from rates of up to $0.07 per kilowatt to $0.02 per kilowatt in certain regions.

So these efficiencies are mattering to consumers and to businesses, and the drastic drop in the cost of utility scale solar PV has dropped more than 64 percent since 2008 and has been able to grow sufficient to power 2.1 million American homes. At the same time, a 54 percent reduction in the distributed solar PV cost has resulted in more than one million units being installed in American homes.

So all of these things, Madam Chairman, are important public policies that we have helped to drive, and I am sure today's discussion will help us drive more. I think I am going to stop there and just reiterate what your comments were, and submit the rest of my very detailed statement on statistics about the changes in energy for the record.

But I wanted to reiterate tomorrow we will be at the Bullitt Center in Seattle, which is the most energy-efficient building on the entire planet. Obviously we will have a discussion with those who are driving policies for more types of development like that and to understand how smart buildings and smart grids can help, on a distributed basis, all of our communities to keep moving forward. So we are very excited about that.

Obviously we are going to have a chance to also talk about cybersecurity and making sure that as we get a more distributed grid, how we also protect our consumers and businesses from that as well. So I very much look forward to it. Someone told me that maybe it is the Copper River Salmon Run, but I don't even know that you and I will get to enjoy that, but we will be close by for the Copper River Salmon Run in Cordova.

Thank you.

[The prepared statement of Senator Cantwell follows:]

Cost Reductions of Emerging Technologies – Opening Statement
June 8, 2017

Introduction

Madam Chairman, thank you for scheduling this hearing to examine cost reductions in emerging energy technologies with a specific focus on how recent trends may affect today's energy landscape.

Energy markets have been changing rapidly in the last few years, mostly driven by the declining costs of several technologies.

This has triggered a boom in international investments. It is revolutionizing the way we consume and generate energy, and it has created millions of American jobs.

Energy Investments

According to the International Energy Agency, global spending on all renewable energy sources totaled $313 billion in 2015.

And although the investment level has been relatively flat since 2011, the annual amount of renewable energy ***capacity*** installed has increased 33 percent since 2011. That's because it costs less to buy more.

Global energy efficiency investment reached $221 billion in 2015. Of that amount, energy efficiency investment in the building sector, including appliances and lighting, was $118 billion in 2015.

And given American leadership and entrepreneurship, many of these investments are being made here in the United States.

For example, renewable electricity investments in the U.S. were near $40 billion in 2015. Wind and solar power now account for more new domestic electric generation capacity than any other source.

Clean Energy Jobs

Those investments translate into jobs. The U.S. wind industry now supports over 100 thousand jobs. American wind power added jobs over 9 times faster than the overall economy.

There were over 370 thousand workers in the solar industry in 2016. One out of every 50 new jobs added in the United States in 2016 was created by the solar industry.

In fact, there were more than double as many solar jobs than coal jobs in the United States in 2016

And 2.2 million Americans are employed, in whole or in part, in the design, installation, and manufacture of energy efficiency products and services.

Future Growth

These trends are expected to continue. According to the International Energy Agency, global investment in renewable energy will total $4.2 trillion over the period from 2015 to 2030, and around $8 trillion will be invested in energy efficiency. That includes $3 trillion in building efficiency alone.

But American leadership is necessary to ensure that these investments, opportunities, and jobs continue to come to the United States.

By withdrawing from the Paris Climate Agreement, the President has thrown into question our ability to attract these investments and jobs. He's abandoning the race to become the world's clean energy superpower.

Our business community knows this well. That's why over one thousand of them—including over sixty Fortune 500 companies (including Amazon, Microsoft, Starbucks, and REI in my state)— have called for the United States to remain a part of the agreement.

Fortunately, our states, local communities, and businesses are redoubling their efforts to reduce emissions and find innovative ways to fight climate change.

Not only because it is the right thing to do, but also because it makes good business sense.

Technology Cost Declines

The biggest driver in the growth of emerging energy technologies is declining costs.

Wind capacity has tripled in the United States since 2008 -- enough to power 17 million U.S. homes (or more homes than California and Texas combined). That's thanks to prices reaching all-time lows. Power purchase agreements for wind have fallen from rates of up to 7 cents per kilowatt-hour in 2009 to 2 cents per kilowatt-hour today in certain regions of the country.

The drastic drop in the cost of utility-scale solar PV -- more than 64 percent since 2008 – has enabled growth sufficient to power over 2.1 million American homes. At the same time, a 54 percent reduction in distributed solar PV costs has resulted in more than 1 million units now installed on American homes and businesses.

The National Renewable Energy Laboratory (NREL) has found that electric grids in the West and East can reliably accommodate renewable energy penetration rates of up to 30 percent. The lab also concluded that renewable energy can meet up to 80 percent of our electricity needs by 2050 with a limited set of investments to improve grid flexibility. These are investments we need to make in all cases, to improve the reliability and resilience of the grid.

As of August 2016, nearly half a million electric vehicles were on U.S. streets, making America one of the largest EV markets in the world. The increase in EV sales has been enabled by lower-cost lithium-ion batteries. When mass-produced, these batteries now cost 73 percent less than they did in 2009.

The latest light emitting diode (LED) technology is six to seven times more energy efficient than conventional incandescent lights and can last at least 25 times longer. The most common type of LED installations have grown from 400,000 to more than 200 million since 2008—an increase of 500 percent. At the same time, their costs have dropped by 94 percent.

By 2035, LED installations are projected to save energy equivalent to the total annual consumption of 45 million U.S. homes (or about one-third of total homes in the United States).

The combination of LED cost reductions with sensors and building control technologies are making buildings smarter, saving energy, and improving productivity.

The emerging global market for smart buildings is projected to grow from $7 billion to over $17 billion in the next 4 years. The United States should seize this global market opportunity.

Federal Investment

Across the board, this is a story about American innovation. The cost of each of these technologies has dropped between 41 percent and 94 percent since 2008.

It's a success story built on decades of strategic investments by the Department of Energy—across both Democratic and Republican Administrations—which have identified the need to invest in advanced technologies, and continue to drive down the cost-curve and improve performance. That's what happens when you bring together the best and the brightest from our national laboratories, universities and private industry.

Tomorrow, Senator Murkowski and I will be touring the world's smartest commercial office building in Seattle – the Bullitt Center. This building produces more energy than it uses each year thanks to onsite solar panels and the latest lighting, heating, and cooling technologies. It also uses only 3 percent of the water used in an average office building in Seattle. All for slightly below the median construction costs of other similar commercial office buildings.

It's a leading model for what we can achieve when we put these innovative technologies to work in buildings. And for a sector that consumes over 40 percent of the nation's energy, that's having a real impact.

DOE Budget Cuts

Look at what's possible with commercially available technology today. Consider the promise of continued innovation, which can further lower consumer costs and carbon emissions at the same time. When you put it in that context, President Trump's budget for the Department of Energy looks utterly ridiculous.

For example, the budget proposal cuts the Office of Energy Efficiency and Renewable Energy by a staggering 70 percent. It cuts grid modernization and cyber security funding at a time when attacks on our critical infrastructure are spiking.

The U.S. innovation infrastructure is without parallel in the world—unless President Trump succeeds in dismantling it. And he seems to be pursuing this course at exactly the same moment the rest of the world is opening up global markets to the kinds of technologies American companies are otherwise poised to deliver.

We will have the chance to discuss this budget proposal with Secretary Perry at a hearing in the near future. But it's worth repeating that the Administration's proposed budget would devastate an emerging sector of our economy. It would kill thousands of science and technology jobs all over the country—all in a misguided effort to hold onto the past at the expense of our future.

It's a rhetorical question: but when has the United States and its economy succeeded by trying to stop history in a freeze frame, clinging to obsolete technologies? When have we let the rest of the world pass us by when it comes to the products and services consumers actually want to buy? Since when has that been a strategy to generate jobs and investment? Can you imagine if Steve Jobs had said, "You know what? Forget it. I don't think anything can top the Walkman."

The Department of Energy has a long proud history of acting as an engine for innovation with bipartisan support. That tradition can't end now.

So once again, I thank the Chair for holding this hearing. And I look forward to the testimony of our witnesses to hear how the cost reductions of these emerging technologies are impacting energy markets here in the United States and around the world.

The CHAIRMAN. Thank you, Senator Cantwell. I am very much looking forward to both parts of our energy tour tomorrow.

I thank you all for being here this morning. I appreciate your contributions at different levels, and this morning we will hear from each of you. I would ask that you try to limit your comments to about five minutes. Your full statements will be incorporated as part of the record, but then I hope we will have a good opportunity for dialogue after the conclusion of your initial remarks.

We will begin this morning with Ms. Lily Donge, who is the Principal at the Business Renewables Center for the Rocky Mountain Institute.

Mr. David Greeson is with us this morning. He is the Project Lead at Petra Nova and the Vice President of Development at NRG Energy.

Mr. Greg Merritt is with us, and he is the Vice President of Marketing and Public Affairs for Cree, Incorporated. Welcome.

Mr. Steve Simonton is the Vice President for Drilling and Completion at Cimarex Energy Company. Welcome.

Mr. Russell Vare is the Manager for Business Development at Mercedes-Benz Energy Americas.

Finally, Mr. Kevin Yates is also with us, and he is the President for Energy Management at Siemens USA.

Again, welcome to each of you.

Ms. Donge, if you want to begin with your comments, then we will just proceed down the line after that.

STATEMENT OF LILY DONGE, PRINCIPAL, BUSINESS RENEWABLES CENTER, ROCKY MOUNTAIN INSTITUTE

Ms. DONGE. Thank you. Good morning, Chairman Murkowski, Ranking Member Cantwell, and members of the Committee. Thank you for inviting me to share the views of the Rocky Mountain Institute and its Business Renewables Center.

My name is Lily Donge, and I am Principal at the Rocky Mountain Institute where I help lead the Business Renewables Center (BRC). The BRC is a membership-based organization that helps streamline and accelerate corporate purchasing of large large-scale offsite wind and solar energy. The BRC currently works with over 200 companies both on the buyer and the developer side. BRC's corporate membership includes companies like Amazon, Walmart, Owens Corning, FedEx, and GM.

The BRC provides an independent collaborative platform for companies to come together to understand and improve the market for purchasing renewable energy. We keep track of these deals, nearly 40 companies announcing transactions for over 7.5 gigawatts of wind and solar projects across North America since 2012. BRC members account for about 93 percent of this.

Corporate renewable procurement is a big trend and here to stay. The new business reality is that corporate America wants to take back control of its electricity supply. They are asking for choice of technology, cost-competitive economics, transparency, and new renewable projects to be added to the grid.

According to what we hear from market participants, we know a lot more is on the way this year. As we track these deals in North America, three things to note. First, 2017 is already outpacing 2016, and we're at one gigawatt. Second, the Fortune 500 dominate these deals; they represent two-thirds of the companies, three-fourths of the deals and the megawatts. The third trend is the newcomers. Since January 2016, 11 of the 18 companies are first-time buyers, like Lockheed Martin, Anheuser-Busch InBev, and Johnson & Johnson.

Diversification also extends to the supply side. During the same timeframe, out of 21 developers we have welcomed 10 developers closing in on their first major corporate deal. We also have dozens of financiers, law firms and consulting firms creating an intermediary network and a transactioning market like never before.

Sustainability commitments is a major driver for these buyers. Sixty-six percent of Fortune 100 and 40 percent of Fortune 500 have public sustainability commitments. In conversations with BRC members, it is also clear that most of these companies would not seriously consider renewable energy investment if costs were not competitive.

It is not just a matter of cost, it is also a matter of speed of delivery. Energy efficiency is more cost effective, but it takes longer to deliver on climate goals, which are necessary and urgent for these companies.

Large-scale renewable deals allow companies to make material progress on their sustainability targets quickly. It is a combination both of speed and reasonable affordability. We are finding out that power purchase agreements in wind are in the low twenties and solar in the south in the low thirties and high twenties in the dollar-per-megawatt-hours range.

Because companies care about economics and cost, my team is rolling out a fair-value tool next week so that companies can understand the economics of a wind and solar project at over 4,300 grid connection nodes across seven electricity markets. With projects in 19 different states, BRC companies are making decisions based on market opportunity. In fact, for companies that want power operations in your states with clean energy, open-market conditions are a key factor in their decision-making process of where to purchase. They care about transparency, where they can create new and additional jobs and community impacts.

Now what is true in these market and state levels is true at the country level. If the policy environment is unfavorable, multinational companies will not choose to procure complex renewable deals.

As President Trump moves to exit the Paris Climate Agreement, the United States faces fewer leadership opportunities in the clean energy industry that has seen much more demand, not less, from the most significant multinational companies around the world. The cost curves for renewable technologies continue to point downwards, and without the United States' leadership, companies will naturally seek out more vibrant and growing markets.

For us at the Rocky Mountain Institute, the next frontier are batteries, as Senator Cantwell had noted, high-voltage lines, IT for DER (distributed energy resources), smart buildings, EVs, and we even have an effort to link blockchains to the Ultra-C [ph] system to track electrons.

All of these moving forces will need the right market conditions, but also the right policy conditions. We look forward to a Senate that supports market forces to create a clean, prosperous and secure future. Again, I would like to thank the Committee for the opportunity to testify here today.

[The prepared statement of Ms. Donge follows:]

Written Testimony Of
Lily Donge
Principal, Business Renewables Center
Rocky Mountain Institute
before the
U.S. Energy and Natural Resources Committee

June 8, 2017

Good morning Chairman Murkowski, Ranking Member Cantwell, and members of the Committee. Thank you for inviting me to share the views of Rocky Mountain Institute and its Business Renewables Center on the state of corporate procurement of renewable energy, cost reductions across the energy markets, and the longer-term implications for energy development in the United States.

My name is Lily Donge and I am a principal at the Rocky Mountain Institute, where I help lead the Business Renewables Center. The BRC is a membership-based organization that helps streamline and accelerate corporate purchasing of off-site, large-scale wind and solar energy.

The BRC currently works with over 200 members on both the buyer and developer side, and BRC's corporate membership includes companies like Amazon, Walmart, Owens Corning and FedEx. The BRC provides member education, software platforms for market analysis and transactional support, and consulting-based solutions for companies investing in renewable energy products. To date, nearly 40 companies have transacted for over 7.5 gigawatts (GW) of wind and solar projects across the United States – with BRC members accounting for 93 percent of all corporate renewable energy deals.

I am here today to discuss the falling costs of renewable energy technologies like wind and solar power, and how those reductions are leading to increased procurement by some of the largest and most influential American businesses.

The rise of corporate purchasing of renewable energy is dramatic and indicative of broader trends in the energy markets. 2015 was a breakout year, as corporate purchasers led by companies like Google, Kaiser Permanente and General Motors completed 3.25 GW of renewable energy deals, more than double 2014's figures. Last year was the second strongest year on record, with just under 1.5 GW of build, and 2017 is already outpacing 2016 through May of this year.

Large companies decide purchase wind or solar for a variety of reasons: cost advantages for renewables exist today in various places around the country. Many companies want to lock in low wind and solar prices as a hedge against rising fossil fuel costs. And sustainability is becoming a major motivating factor for business leadership. As of this year, 66 percent of Fortune 100 and 40 percent of Fortune 500 companies have public sustainability commitments. And 96 companies have committed specifically to achieving 100 percent renewable energy.[1]

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[1] http://there100.org/companies

Corporate interest in renewables has scaled quickly. In 2012, there was only one renewable energy transaction – a 50 MW wind deal done by Google. In contrast, 2017 has seen six transactions in the first six months so far, totaling one gigawatt of energy. And the primary force driving this expansion has been technology cost reductions, as installed wind and solar costs have fallen 40 percent and 64 percent since 2008, respectively, per the Department of Energy (DOE)[2]

To underscore this point – in conversations with BRC members, it is very clear that most of these companies would not seriously consider a renewable energy investment if the costs were not competitive with fossil fuels. Lawrence Berkeley National Laboratory found that the average PPA price for wind power in the U.S. interior in 2015 was in the $20/MWh range, down from $55/MWh in 2009.[3]

Because companies care about economics and cost, my team is rolling out a fair value tool so that companies can understand the economics of a wind or solar project at over 4,300 grid connection nodes across seven electricity markets.

With projects in 19 different states, BRC companies are making decisions based on market opportunity and in areas where they have a vested interest in the local community regardless of politics. In fact, for the large companies that want to power their operations in your states with clean energy, open market conditions are a key enabling factor in their decision-making process on where to purchase.

As President Trump moves to exit the Paris Climate Agreement, the United States faces fewer leadership opportunities in a clean energy industry that is seeing more demand – not less – from the most significant multinational companies around the world. The cost curves for renewable technologies continue to point downwards, and without the United States' leadership, companies and investors will naturally seek out more vibrant and growing markets.

We would look forward to a Senate that supports market forces, gives consumers more choice, and supports new technologies to ensure a strong and flexible grid.

Again, I would like to thank the Committee for the opportunity to testify here today.

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[2] https://www.energy.gov/sites/prod/files/2016/09/f33/Revolutiona%CC%82%E2%82%ACNow%202016%20Report_2.pdf

[3] https://emp.lbl.gov/sites/all/files/2015-windtechreport.final_.pdf

The CHAIRMAN. Thank you, Ms. Donge.
Mr. Greeson.

STATEMENT OF DAVID GREESON, VICE PRESIDENT, DEVELOPMENT, NRG ENERGY, INC.

Mr. GREESON. Thank you, Chairman Murkowski and Ranking Member Cantwell and Committee members. My name is David Greeson. I am Vice President of Development for NRG Energy. As you may know, NRG is a Fortune 250 company dual headquartered in both Princeton, New Jersey, and Houston, Texas.

We are one of the largest power generators in the United States with almost 50,000 megawatts of conventional natural gas, coal and nuclear power, and in renewables we're one of the largest owner-operators of solar technologies in the United States, and we have wind generation in 13 states.

We also directly serve about three million retail customers. I am based in our Houston office, where I have spent the last seven years developing and bringing online the world's largest carbon capture system attached to a power plant. The project is called Petra Nova, and I'm happy to report that it came in on time and on budget.

As I appear before you today, the project is online and capturing 5,000 tons of CO2 per day that is being injected into an oilfield. That same oilfield before Petra Nova was nearly played out and was producing less than 300 barrels per day. I'm pleased to announce to you today that with only five months of injecting CO2, this oilfield is now producing 3,400 barrels per day, a more than 10X increase in production.

It's important to have some context into how we had to think about this project. NRG is a competitive company, not a utility. That means that the Petra Nova project, like all NRG assets, needs to be profitable in a competitive energy market. We don't rely on rate base, where customers are locked into paying the costs no matter what. Rather, NRG bears the risk of a successful project. So for the Petra Nova project, we not only had to design the carbon capture system to be profitable, but we also had to ensure that the host coal unit that the carbon capture system is attached to did not increase the cost of electricity or change the way it's dispatched in the market so that it could remain competitive.

We accomplished these goals with a lot of creative thinking. For example, instead of taking steam and electricity from the power plant to run the carbon capture system, we installed a combined heat and power system that was tailored just for our needs, and therefore was a lot more efficient than extraction steam and power. In the end, these creative solutions and others allowed us to simultaneously reduce the carbon emissions of the coal plant while preserving the cost competitiveness of that unit in the market, and all of this was at no risk to electric consumers in Texas.

But with that as a backdrop, I'd like to talk about the specifics of the finances. The Petra Nova project was a $1 billion project funded 55 percent by private capital contributions, 25 percent from loans by Japanese government export agencies and a 20 percent grant from the U.S. Government under the Clean Coal Power Initiative managed by DOE's National Energy Technology Laboratory in Morgantown, West Virginia.

I'd like to say thank you to you and the members of Congress for this grant. I can't tell you how important this grant was to the success of this project. Especially early on in the project, even though the dollars weren't big, they're the riskiest dollars you spend on any endeavor like this, and so I just wanted to say thanks.

My written testimony has more details about the project, and I'll refer you to those for a more in-depth explanation.

So why do this at all? Well, consider the fact that because of the Petra Nova project, we did two really good things. First, we've reduced the emissions of a coal-fired power plant to be the same as a gas-fired power plant. Second, we're producing U.S. crude to supply domestic demand.

In the near-term, carbon capture economics will continue to be challenging. The volatility of the price of oil and the upfront capital costs are the two biggest challenges. That's why I'd like to thank the members of this Committee who have supported the 45Q CCS tax credit. This program, if extended, would help the Petra Nova project and future CCS projects through those two tough challenges. The industry is working on bringing down costs. The government support of this low carbon domestic energy source, just like wind and solar, is essential for success.

There are new technologies on the horizon. Membranes show a lot of promise, and there are more effective formulations of aiming scrubbing systems that are now moving out of the laboratory and into field tests. So with your continued support, carbon capture can be on a trajectory for being competitive on its own.

Thank you, and I look forward to answering your questions.

[The prepared statement of Mr. Greeson follows:]

Testimony of David Greeson
NRG Energy
Petra Nova project

Written Testimony of:

David Greeson
Vice President, Development
NRG Energy, Inc.
1000 Main Street
Houston, Texas 77002

My name is David Greeson, Vice President of Development for NRG Energy, Inc. I have 36 years of experience in the electric power industry in both regulated utilities and independent power companies. I have developed 5 major power projects in the US that total more than $3 billion of investment and includes the $1 billion Petra Nova Carbon Capture and Enhance Oil Recovery project that I'll be speaking about today.

The Petra Nova project began as an initiative by NRG to find a way to de-carbonize our coal-fired generation fleet and do it without increasing the cost of electricity. At NRG everything we do is subject to competition. We are not a utility with captive customers, but rather win each customer by providing a better value than their other choices. In 2009 when we began this project, there were good reasons to believe that policies were coming that would make it difficult for coal-fired power plants to continue to deliver low-cost, reliable power, a value that our customers and shareholders had come to expect.

The final design of the project was guided by two constraints:

- The project could not impact the cost to produce electricity from the host coal unit or negatively impact its ability to participate in the Texas electric market.
- The project would include enhanced oil recovery since it was (and is still today) the only know way to simultaneously (a) handle significant volumes of CO2 and (2) in the absence of a price on carbon emissions, create a revenue stream that had a chance of off-setting the cost of building and operating carbon capture.

Today, after seven years of diligent work by all stakeholders, the plant is on-line capturing 5,000 tons per day of CO2. Thanks to a lot of planning, preparation, and persistence I'm proud to report that the project was on-time and on-budget which is an amazing accomplishment for a first of its kind deployment of a technology at full commercial scale. The plant is operating as designed, which means that we now have a coal-fired power plant that has the same carbon footprint as a natural gas-fired unit.

As you can see from slide 5 in the attachment to this testimony, the project is really five projects in one:

1. Design to interface with the host coal-fired plant in a way that did not impact its cost or its operations.
2. Install a carbon capture technology that had never been built at this scale before and had many design improvements that were not in the one-tenth scale unit built several years earlier.
3. Design and build an 81-mile CO2 pipeline without the power to condemn or expropriate private property.
4. Prepare a large oil field that had been in production since the 1930s by finding and plugging to today's standards virtually all the existing wells, drill over 200 new modern wells, and install a large processing plant on the surface to handle the new oil production.

Testimony of David Greeson
NRG Energy
Petra Nova project

5. Re-establish a pipeline link to the crude oil market since the previous facilities had been abandoned years ago.

The carbon capture system starts by pre-treating the flue gas by cooling and removing any remaining trace amounts of sulfur in a vessel called the quencher. Next treated flue gas is blown through the 340' tall absorber tower where CO2 comes into contact with a liquid solvent and dissolves into the liquid. Now laden with CO2 the solvent is pumped to a closed vessel where it is heated by steam which causes the CO2 to come out of solution as a gas again. Now segregated, CO2 is compressed and shipped down an 81-mile pipeline where it is injected into the oil field. I've included a picture of the Petra Nova CCS facility in the attachment.

Please keep in mind that NRG's power plant does not pay for any of the carbon capture and enhanced oil recovery project. Even the steam and power needed by the carbon capture system is provided by Petra Nova's captive cogeneration system.

Once CO2 arrives at the oil field it is injected into the oil-bearing formation where CO2 acts as a solvent, dissolving into the oil and thereby lowering the viscosity. This allows stubborn oil that is clinging to the surface of the rock in the reservoir to flow freely to wells to be recovered. Once at the surface the oil-water-CO2 mixture is separated and the oil is sold to the market. The produced water is re-injected into the oil formation and the CO2 is recompress and likewise re-injected. With each cycle of injecting and producing the CO2 some is permanently lost and therefore sequestered in the oil formation.

NRG considers itself very fortunate to have the partners in this project, beginning with the US DOE when we finalized the grant agreement in 2010. The State of Texas establishing meaningful incentives in 2009-11. Hilcorp joined the project in 2011 as our oil field operator and designer/operator of the enhanced oil recovery system. JX Nippon Oil and Gas Exploration, who is the largest oil company in Japan, became NRG's 50-50 partner in 2014 after a year and a half of working on the project pro bono. And finally the Japanese Government through its Japanese Bank for International Cooperation and Nippon Export and Investment Insurance agencies made a limited recourse loan to the project to complete the capital requirements.

The project has been in full commercial operations for 5 months now. I am pleased to report that all systems are working well and oil production is rising sharply. In December of 2016 just 5 months ago this oil field was producing less than 300 barrels of oil per day. Today, it is producing 3,400 barrels per day and climbing. It is currently estimated that an incremental 60 million barrels will be produced from this field.

I look expectantly to the future of CCS in the US and then to the rest of the world. The US is blessed with plenty of oil fields that will respond well to CO2 and our coal-fired generation fleet is still young enough to warrant the investment needed for coal to take its place in the sustainable energy future. But upfront capital costs remain the hurdle and federal subsidies to wind and solar further stack the deck against clean coal. Yet there is reason for optimism. Congress is considering measures to bring parity to low carbon technologies. Also, reductions in the cost to build amine systems like the Petra Nova project will happen. New innovations in membranes are now out of the lab and are being tested in small field trials. New formulations of solvents may be commercially ready in 3-5 years that could significantly reduce the size of the capture system and thereby reduce the cost.

Thank you.

Testimony of David Greeson
NRG Energy
Petra Nova project

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PETRA NOVA Carbon Capture

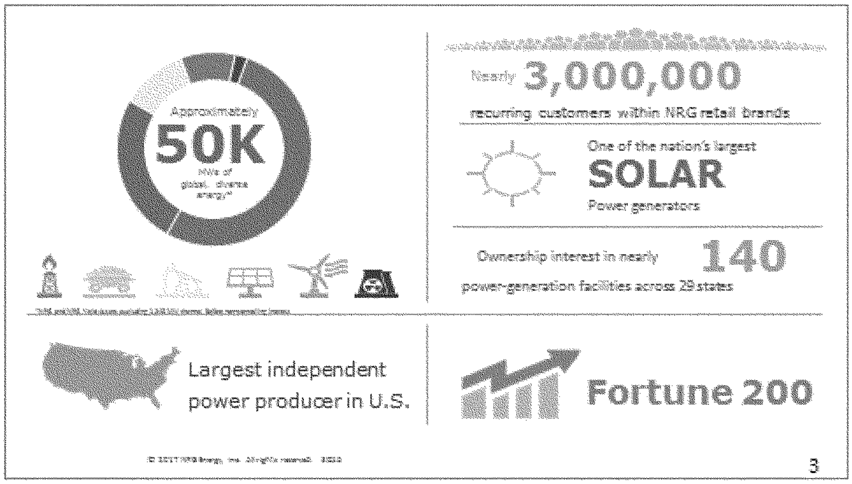
Safe harbor statement

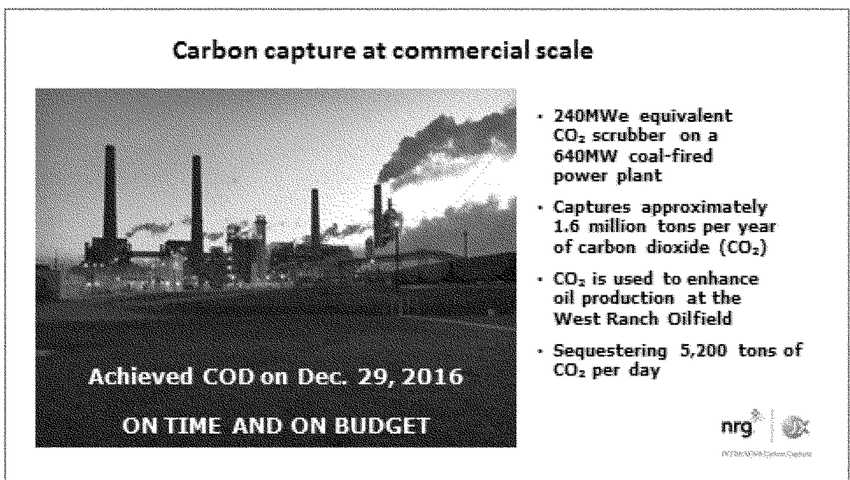
This presentation contains forward-looking statements within the meaning of Section 27A of the Securities Act of 1933 and Section 21E of the Securities Exchange Act of 1934. Forward-looking statements are subject to certain risks, uncertainties and assumptions and typically can be identified by the use of words such as "expect," "estimate," "should," "anticipate," "forecast," "plan," "guidance," "believe" and similar terms. Such forward-looking statements include our future growth and financial performance, Company operations, developments in renewables, and project development. Although NRG believes that its expectations are reasonable, it can give no assurance that these expectations will prove to have been correct, and actual results may vary materially. Factors that could cause actual results to differ materially from those contemplated above include, among others, general economic conditions, hazards customary in the power industry, weather conditions, competition in wholesale and retail power markets, the volatility of energy and fuel prices, failure of customers to perform under contracts, changes in the wholesale and retail power markets, changes in government regulation of markets and of environmental emissions, the condition of capital markets generally, our ability to access capital markets, unanticipated outages at our generation facilities, adverse results in current and future litigation, failure to identify or successfully implement acquisitions and repowerings, the inability to implement value enhancing improvements to plant operations and companywide processes, our ability to realize value through our commercial operations strategy, and our ability maintain successful partnering relationships.

NRG undertakes no obligation to update or revise any forward-looking statements, whether as a result of new information, future events or otherwise, except as required by law. The foregoing review of factors that could cause NRG's actual results to differ materially from those contemplated in the forward-looking statements included in this Investor Presentation should be considered in connection with information regarding risks and uncertainties that may affect NRG's future results included in NRG's filings with the Securities and Exchange Commission at www.sec.gov. Statements made in connection with the exchange offer are not subject to the safe harbor protections provided to forward-looking statements under Private Securities Litigation Reform Act.

2

Testimony of David Greeson
NRG Energy
Petra Nova project





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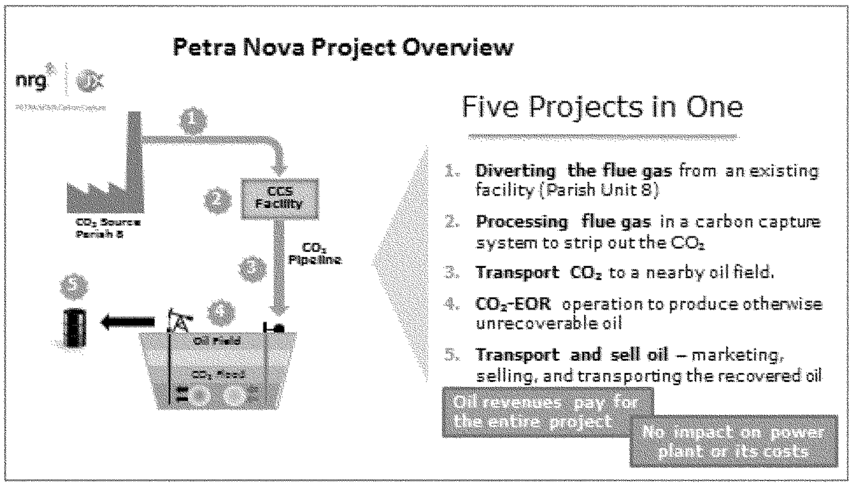

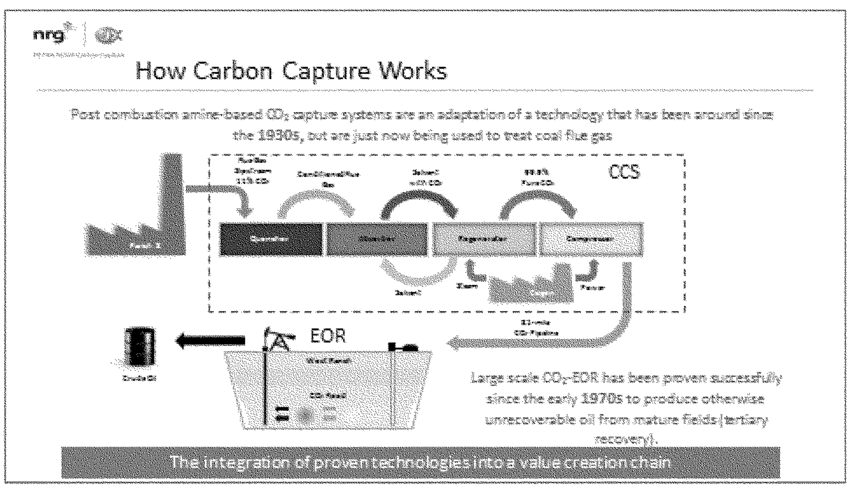

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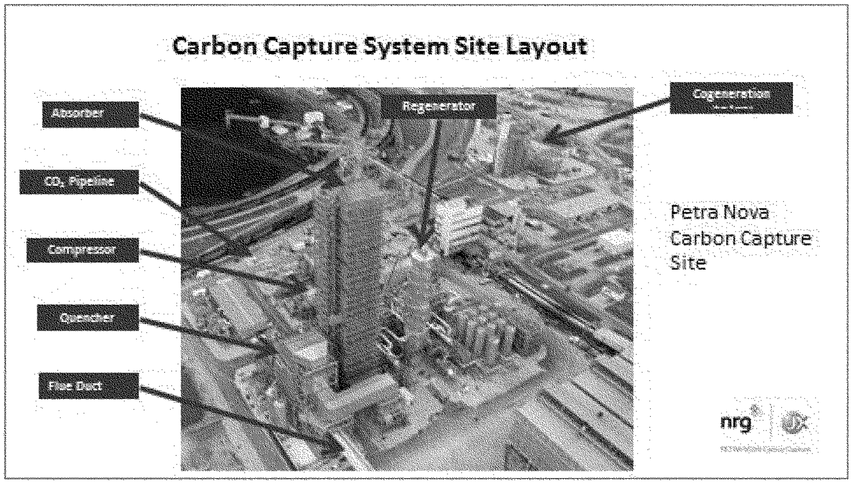

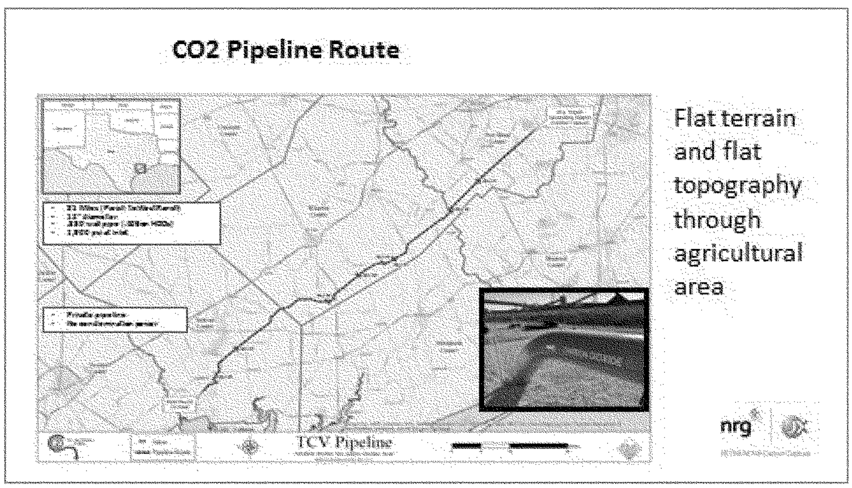

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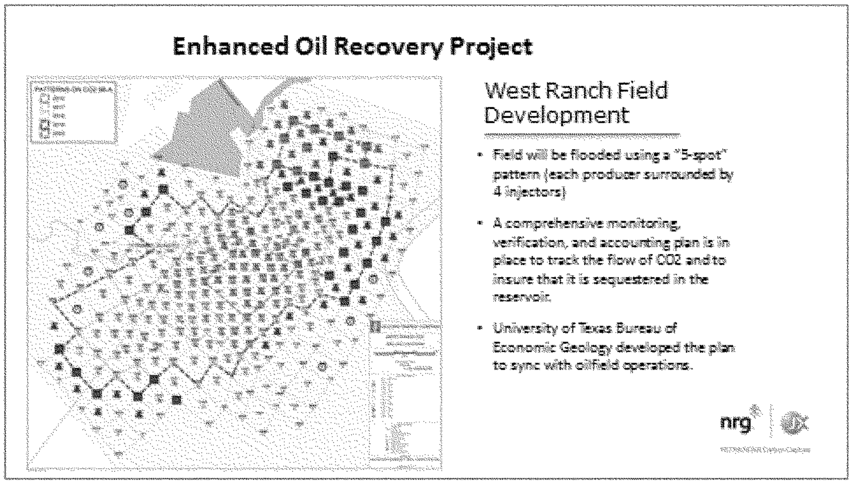

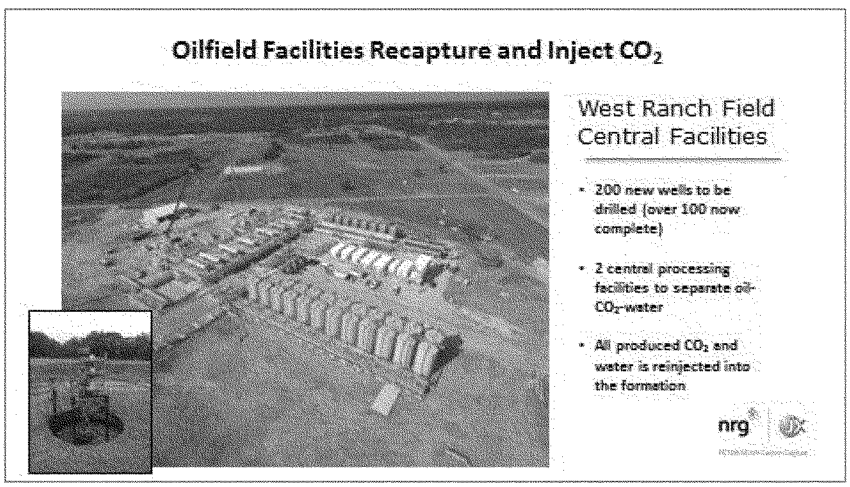

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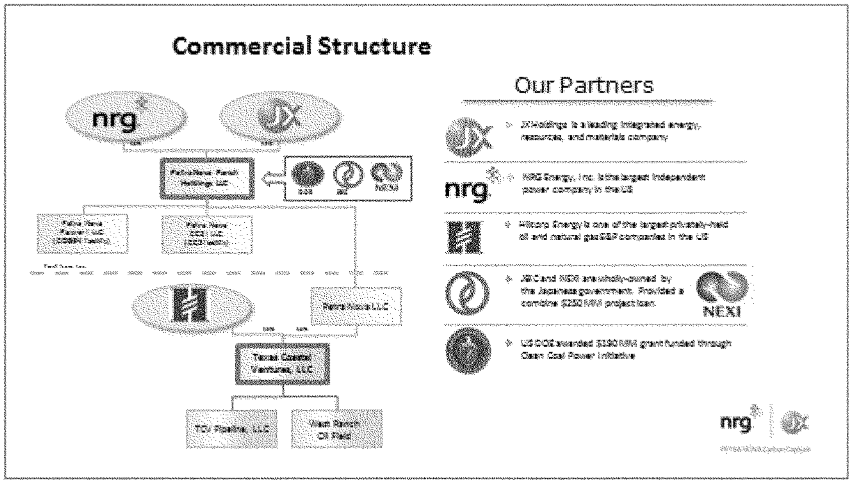

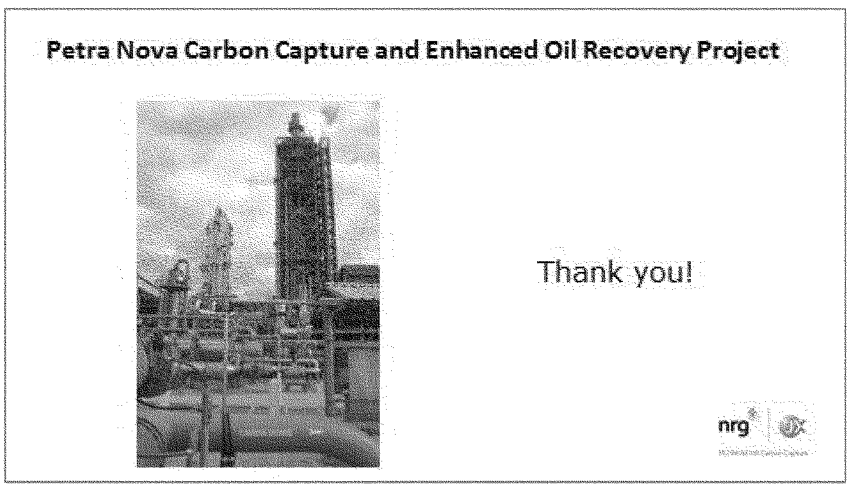

The CHAIRMAN. Thank you, Mr. Greeson.

Mr. Merritt, welcome.

STATEMENT OF GREG MERRITT, VICE PRESIDENT, MARKETING AND PUBLIC AFFAIRS, CREE, INC.

Mr. MERRITT. Good morning. I would like to thank Chairman Murkowski and Ranking Member Cantwell and the rest of the Committee for the invitation to speak with you this morning.

Cree, Inc., is a leading U.S.-based developer and manufacturer of LEDs, LED lighting systems, and also advanced power and wireless semiconductors. We are headquartered in Durham, North Carolina. We also have facilities in Wisconsin, Arkansas and California and have about 6,300 employees worldwide. Since our founding 30 years ago, Cree has been focused on innovation, pushing the boundaries of technology in order to enable people to do more while they consume less energy.

So let's talk a little bit about LED technology. Cree introduced the first LED technology that met the stringent requirements of what we call general illumination, or you might think of it as white lighting in spaces, in about 2006. This enabled the first commercially viable LED lighting products beginning in 2007.

I would like to point out that, importantly, our focus has always been on efficiency, but also on the quality of the light that's provided by these products. If we don't meet people's expectations for the appearance of light and the quality of light, they won't adopt it. I think we very clearly focused on not repeating the failures of the compact fluorescent bulb, which people didn't adopt because they didn't like the way it looked.

These early products were relatively expensive compared to the products they were intended to replace, and even though they paid for themselves through energy and maintenance savings, adoption was more limited. Payback periods were often seen in three to five years, sometimes even as high as seven to nine years in some applications. I would contrast that to the fact that most commercial organizations are looking for returns on their investment in 18 to 24 months.

Therefore, to make the economics work and to drive and increase adoption we went back to the lab, effectively to invent new technology to not only reduce the cost but also to improve the performance. This invention and innovation was required at multiple levels throughout an LED system. However, the LEDs themselves had the greatest initial impact. Through innovation and technical advancement, we have been able to increase the performance of LEDs by over four times since 2006, and we're not finished yet.

So how does this work? A higher performance LED which is more efficient and, in fact, smaller, enables us to generate more light and use less power. That results in reduced cost throughout the system: smaller power supplies, smaller heat sinks, et cetera.

In addition to the product innovations, which are important, adoption was also aided by utility incentive programs that were available throughout the country, and also the associated energy efficiency certifications that go along with those. Think ENERGY STAR. Those rebate programs were available to reduce the initial first cost of what I had already mentioned were expensive products.

I would also like to point out that in the consumer market, ENERGY STAR served a very important role by offering consumers confidence to buy what was a new technology for them. Essentially, people trust the ENERGY STAR brand when they see it on the shelf.

I would also like to point out the role that the Department of Energy played in helping to get LED technology to market in volume. Because of these continued innovations, we can now see certain LED streetlights that are available for under $100 that use 70 percent less energy than the technology they're replacing and pay for themselves in less than two years.

In the consumer market, LED bulbs are available that pay for themselves in around six months and then last another two decades under normal usage, saving an average of over $150 a bulb.

I would also like to point out an area we see of real promise, and that is of going beyond individual product efficiency to look at systems efficiency. In our case, this means intelligent lighting systems. These systems use integrated sensors to sense occupancy and ambient light. Combine that with communications, you may have heard of it referred to as the Internet of Things, and software data analytics in order to reduce the energy used by lighting systems by over 80 percent. What's more important is we can actually go beyond just making the lighting more efficient to make the buildings themselves more efficient, the people in them more productive, and, in fact, the organizations more profitable.

Thank you for your attention.

[The prepared statement of Mr. Merritt follows:]

U.S. Senate Energy and Natural Resources Committee – June 8, 2017

Testimony by Cree, Inc.

Cree, Inc. is a leading U.S.-based developer and producer of LEDs, LED lighting and advanced power and RF semiconductors. Cree was founded in 1987 out of NC State University. The global headquarters is in Durham, NC with facilities throughout the United States (Wisconsin, Arkansas, North Carolina and California). Our global employee population is over 6,300.

Cree is a technology company focused on continuous innovation and pushing the boundaries of technology performance to do more and consume less energy. We invented much of the LED technology now delivering energy efficient LED lighting solutions in homes, offices, schools, public facilities and cities across the U.S.

Early LED technology was used in many applications such as flashlights, signs, indicators and signals, but not for general white lighting applications. As Cree continued to improve the performance of its LED technology, we introduced the first white LEDs that met the stringent requirements of general lighting applications in 2006. These LEDs enabled the first commercially viable LED general lighting products beginning in 2007.

Importantly, Cree's focus has always been on both energy efficiency and the quality of light. LED lighting products must meet people's expectations for the quality and appearance of light. Cree didn't want the industry to repeat the failures of CFL bulbs to gain widespread adoption because of user dissatisfaction with the lighting experience.

The early LED lighting products were more expensive than traditional lighting and although they paid for themselves through energy and maintenance savings, adoption was limited by the capital requirements and the "newness" of the technology. Initial payback periods were often 3-5 years, and in some cases as high as 7-9 years. Public institutions and some other organizations were willing to accept longer payback periods, but most commercial entities were looking for paybacks on their investments of 18-24 months.

To make the economics work for more organizations and accelerate adoption, Cree took multiple approaches. One was to invent new technology that increased performance and energy savings thereby improving the payback periods. The second was to invent new technology that allowed us to reduce the manufactured cost of the products, also leading to improved payback periods.

Innovation was applied at many levels within LED lighting products to drive overall system performance and lower system costs. Improvements in the performance of LED component technology had the greatest impact initially, and we improved performance by over 4x through LED semiconductor research and advancements.

More efficient and higher performance LEDs reduced the system cost of lighting products by reducing the amount of power needed which led to smaller and lower cost power supplies, reducing the amount of cooling needed which led to smaller and lower cost heat sinks and reducing the overall physical size of the products which reduced the material needed.

In addition to higher performance LEDs, the development of more efficient and effective optical designs reduced the amount of light needed, requiring fewer LEDs, and improving the user experience. Each area of the LED lighting system was a target for innovation to increase performance and reduce costs.

As described earlier, the economics of LED lighting was a key enabler of technology adoption. Another factor affecting adoption was the newness and unfamiliarity of the new technology which was often realized as risk by potential customers. To help offset these perceived risks, Cree offered a strong warranty, based on the quality of our products.

Adoption was aided, as well, by utility incentive programs and associated energy efficiency certifications, such as ENERGY STAR, that enabled rebates to reduce the initial cost and hence improve payback. In the consumer market, the strength of the ENERGY STAR brand fostered adoption by giving customers confidence in the new technology.

The federal government, and DOE specifically played a key role in helping LED technology succeed in the market through strategic R&D support, industry demonstrations and trials as well as ENERGY STAR certifications.

Through innovation, we've improved LED lighting performance and reduced costs to the point where some LED streetlights are available under $100, use up to 70% less energy than previous technologies and have paybacks under 2 years. In residential applications, LED bulbs are now available that pay for themselves in 6 months and then last another two decades under normal usage.

Beyond the performance and economics of individual LED lighting products, an area of real promise is that of systems efficiency, in our case intelligent lighting systems. These systems use integrated sensors to detect occupancy and ambient light, as well as communications (the Internet of Things) and data analytics, to save up to 80% of the energy used for lighting while improving the lighting experience for people in buildings. More importantly, these systems can also go beyond just making the lighting more efficient to make the buildings more efficient, the people in them more productive and the organizations more profitable.

The CHAIRMAN. Thank you, Mr. Merritt.
Mr. Simonton.

STATEMENT OF STEVE SIMONTON, VICE PRESIDENT, DRILLING & COMPLETION OPERATIONS, CIMAREX ENERGY CO.

Mr. SIMONTON. Chairman Murkowski and Ranking Member Cantwell, members of the Committee, it's an honor to be with you this morning. My name is Steve Simonton. I'm the Vice President of Drilling and Completion Operations for Cimarex Energy Co., a publicly-traded oil and gas exploration company with operations primarily in Oklahoma, Texas and New Mexico.

The majority of our current activity is in the Permian Basin of West Texas, New Mexico and the Anadarko Basin in Western Oklahoma. We pride ourselves on having strong technical teams with a common goal of adding shareholder value through drilling and production. Simply stated, our business strategy is to maximize our cash flow from producing oil and gas properties and effectively redeploy the cash flow in drilling projects to grow the company.

In order to be competitive and ultimately be successful in our business strategy, it is imperative that we stay ahead of the technologies that continue to evolve in our industry. Over the last decade, our industry has made tremendous advancements to improve the productivity of the wells we drill.

Years ago, we drilled vertical wells into the earth to extract oil and gas from rock intervals which were, in general, 20 to 300 feet thick. These "vertical completions" only allowed us to extract the oil and gas from the vertical section of the interval we contacted. With the evolution of horizontal drilling technology, we are now able to drill the vertical section of the well down to the rock interval we are targeting, and then drill horizontally out into the interval, thereby contacting up to 10,000 feet of rock section from which to produce.

With more of the rock interval now contacted, producing rates from horizontal wells are multiples of those in vertical producing wells from the same rock interval while producing—reducing impacts to landowners, wildlife and other surface resources. Horizontal drilling now dominates the U.S. oil and gas industry landscape. Today, approximately 85 percent of North America's active drilling rigs are drilling horizontal wells, opening a new window of opportunity for the industry.

With more rock interval now encountered in horizontal wells came the advancements in completion technology, mostly derived from empirical testing. Surprisingly enough, the industry downturn allowed industry participants to try many experiments which otherwise would have been too costly to attempt prior to the downturn. Low commodity prices resulted in lower cost of services. With lower costs for service came lower costs to experiment, especially in the completion or frac design of horizontal wells. The experimentation proved larger and larger frac designs would more efficiently contact horizontal rock interval and further improve well productivity. As a result, although today's total cost to drill and complete a well may be just at or below before the downturn, we are completing better and better wells, allowing us to drill economic wells and compete in today's low oil and gas price environment.

Our industry has made tremendous advancements over the years. My world is drilling and completing these wells, and I have over 40 years of oilfield experience. I want to share just a few of the technological advancements that have allowed us to more efficiently drill and complete our wells. With these examples, I'll just be scratching the surface on advancements our industry has made, but hopefully will leave you with a flavor of the technology gains the industry has accomplished.

Modern drilling rig design has played a large role in our ability to drill wells faster. The rig designs enhance safe drilling operations, allow for a digital data acquisition of all drilling parameters, and are fit-for-purpose to drill horizontal wells. They have the capability to "walk or skid" from well to well on multi-well pads to accelerate project timelines and lower mobilization costs.

Data gathering and communication technology has allowed us to make tremendous strides to drill our wells faster. Downhole rotary steering tool technology now allows us to "point and steer" the downhole drilling tools from the surface using real-time data. Technology gains in drill bit material and cutter design have resulted in faster drilling with longer run times for the bits we use to drill our wells. The bottom line is reduced time to drill equates to reduced cost.

We are utilizing technologies to understand the oil and gas reservoir rock we are penetrating to optimize our completion design. Digital data obtained from fiber-optic recording tools provide us with real-time temperature and acoustic information to evaluate the effectiveness of frac operations and completion designs. With this data, we have the means to recalibrate our completion design with a goal of maximizing well productivity.

Resources once considered out of reach are now the targets of the "Unconventional Revolution." Because of advancement in technology, in our view, this revolution is uniquely American. Through technology, creative trial and error and perseverance, the U.S. oil and gas industry has been able to change forever the landscape of our industry.

And with that, I would welcome any questions.

[The prepared statement of Mr. Simonton follows:]

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Steve J. Simonton
Vice President, Drilling & Completion Operations
DIRECT: 918.295.1710
ssimonton@cimarex.com

Chairman Murkowski, Ranking Member Cantwell, members of the committee, it is an honor to be with you this morning. My name is Steve Simonton, Vice President of Drilling and Completion Operations for Cimarex Energy Co., a publically traded (NYSE:XEC) oil and gas exploration company with operations primarily located in Oklahoma, Texas and New Mexico. The majority of our current activity is in the Permian Basin of West Texas and New Mexico and the Anadarko Basin in Western Oklahoma. We pride ourselves on having strong technical teams with a common goal of adding shareholder value through drilling and production. Simply stated, our business strategy is to maximize our cash flow from producing oil and gas properties and effectively redeploy the cash flow in drilling projects to grow the company. In order to be competitive and ultimately be successful in our business strategy, it is imperative we stay ahead in the technologies that continue to evolve in our industry.

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Resources, once considered out of reach, are now the targets of the "Unconventional Revolution" because of advancement in technology. In our view, this revolution is uniquely American. Through technology, creative trial and error, and perseverance, the U.S. Oil and Gas Industry has been able to change forever the landscape of our industry.

I welcome any specific questions you may have with regard to these or other industry technologies you may be interested in discussing.

The CHAIRMAN. Thank you, Mr. Simonton. I had an opportunity just last week to take a couple members of this Committee, along with Secretary Zinke, to Alaska's North Slope where we viewed much of what you have just discussed with regards to the technology. So seeing it firsthand is pretty impressive.

Mr. Vare, welcome to the Committee.

STATEMENT OF RUSSELL VARE, MANAGER, BUSINESS DEVELOPMENT, MERCEDES-BENZ ENERGY AMERICAS, LLC

Mr. VARE. Thank you. Good morning, Chairman Murkowski, Ranking Member Cantwell, and members of the Committee. Thank you for the opportunity to participate in today's meeting. My name is Russell Vare and I'm Manager of Business Development for Mercedes-Benz Energy Americas, headquartered in Sunnyvale, California. I appreciate the Committee's interest in how innovation is advancing new energy technologies to help drive down costs.

As a major global automaker, our parent company, Daimler, plans to continue our leadership in innovation by adopting a strategic framework called CASE, which stands for Connected, Autonomous, Shared & Service, and Electric. Our new vehicles and services will focus on connectivity, autonomous driving, flexible use, and electric drive systems.

So we're taking a holistic approach to electrification of transportation during this truly fundamental shift in the automotive industry. We will have ten plug-in hybrid models available in 2018, and ten all-electric models available in 2022.

Beyond electrifying our cars, vans, buses, and trucks, we are investing in electric mobility solutions beyond the vehicle, including stationary energy storage, shared mobility services, and electric vehicle charging infrastructure. Globally, we are investing around $10 billion euros in our technological competence and new electric fleet.

Mercedes-Benz Energy was established last year to directly support the electrification strategy behind CASE, providing innovative energy storage and EV charging solutions for homes, businesses and utilities to manage resources more efficiently and sustainably.

What we are doing is unique to others in the automotive space. We recognize the value of electric vehicles that they can have on the grid, and we're using the same automotive grade battery technology used in Mercedes-Benz electric plug-in hybrids and electric vehicles for stationary storage applications. Mercedes-Benz stationary energy storage systems can optimize solar consumption, reduce expensive peak electric loads, provide back-up power, and offer a variety of other grid services, such as frequency regulation, transmission and distribution deferral, renewable integration and other ancillary services.

Just three weeks ago, we launched our home energy storage solution in the U.S. with the Utah-based residential solar company, Vivint Solar, to bring clean energy solutions to American homes.

We are excited by the growing demand for clean energy technology. In 2016, revenue from the U.S. energy storage market surged by 54 percent from the previous year to reach $427 million. By 2022, the U.S. energy storage market is expected to be worth $3.2 billion.

One of the major drivers of this growth is the rapid decline in battery prices. As also mentioned earlier this morning, since 2010 the price of lithium-ion batteries fell roughly 80 percent, from more than $1,000 a kilowatt-hour down to $227 a kilowatt-hour at the end of 2016. We are driving this price reduction by increasing scale production. Two weeks ago we announced the expansion of our battery factory in Kamenz, Germany, to 80,000 square meters to produce more electric vehicle batteries at scale.

In addition to the decreasing prices, advancement in battery efficiency is rapidly improving. From 2012 to 2016, we've seen a 64 percent improvement in cell energy density. Such economic and technological improvements will lead to faster and greater adoption of electric vehicles and energy storage into our transition to a clean energy economy.

According to Bloomberg New Energy Finance, between 2020 and 2030, electric vehicles will become cheaper to own than cars with internal combustion engines, and this matches our internal predictions as well.

We are strongly committed to innovating electric drive technology for further cost reductions on vehicles and batteries. And we're also committed to continue to work with agencies at national, regional, and city levels to support electrification of our transportation systems.

So thank you for the opportunity to participate in today's hearing. I'm happy to answer any questions.

[The prepared statement of Mr. Vare follows:]

Opening Statement of Russell Vare,
Manager, Business Development
Mercedes-Benz Energy Americas, LLC

Senate Energy and Natural Resources Committee

Hearing to "study cost reductions in emerging energy technologies with a specific focus on how recent trends may affect today's energy landscape"

June 8, 2017

Good morning Chairman Murkowski, Ranking Member Cantwell, and members of the Committee. Thank you for the opportunity to participate in today's hearing. My name is Russell Vare and I am the Manager of Business Development at Mercedes-Benz Energy Americas, headquartered in Sunnyvale, California. I appreciate the Committee's interest in how innovation is advancing new energy technologies and helping to drive down energy costs.

As a major global automaker, our parent company Daimler plans to continue our leadership in innovation by adopting a strategic framework called CASE, which stands for Connected, Autonomous, Shared & Service, and Electric. Our new vehicles and services will focus on connectivity (Connected), autonomous driving (Autonomous), flexible use (Shared & Services) and electric drive systems (Electric). We are taking a holistic approach to electrification of transportation during this fundamental shift of the automotive industry. We will have ten plug-in hybrid models available in 2018 and ten all-electric vehicles available by 2022.

Beyond electrifying our cars, vans, buses and trucks, we are investing in electric mobility solutions beyond the vehicle including stationary energy storage, shared mobility services, and electric vehicle charging infrastructure. Globally, we are investing around $10 billion euros in our technological competence and new electric fleet.

Mercedes-Benz Energy was established last year to directly support the electrification strategy behind CASE, by providing innovative energy storage and EV charging solutions for homes, businesses, and utilities to manage resources more efficiently and sustainably.

What we are doing is unique to others in the automotive space. We recognize the value EVs can have on the grid and are using the same automotive-grade battery technology used in Mercedes-Benz electric and plug-in hybrid vehicles for stationary storage applications. Mercedes-Benz Energy storage systems can optimize solar consumption, reduce expensive peak electric loads, provide backup power, and offer a variety of grid benefits, including frequency regulation, transmission and distribution deferral, renewable integration, and other ancillary services.

Just three weeks ago, we launched our home energy storage system in the U.S. with Utah-based residential solar company Vivint Solar to bring clean energy solutions to American homes. We are excited by the growing demand for clean energy technology. In 2016, revenue from the U.S. energy storage market surged by 54% from the previous year to reach $427 million. By 2022, the U.S. energy storage market is expected to be worth $3.2 billion.

One of the major drivers of this growth is the rapid decline in battery prices. Since 2010, the price of lithium-ion batteries fell roughly 80% [from ~$1,000/kWh to ~$227/kWh at the end of 2016]. We are driving this price reduction by increasing scale production. Two weeks ago we announced the expansion of our battery factory in Kamenz, Germany to 80,000 square meters to produce more electric vehicle batteries at scale. In addition to decreasing prices, advancement in battery efficiency is rapidly improving. From 2012 to 2016, we've seen a 64% improvement in cell energy density. Such economic and technological improvements will lead to faster and greater adoption of electric vehicles and energy storage in our transition to a clean energy economy. According to Bloomberg New Energy Finance, between 2020 and 2030, EVs will become cheaper to own than cars with internal combustion engines. This matches our internal predictions. We are strongly committed to innovating electric drive technology for further cost reductions on vehicles and batteries. We also look forward to our continued work with agencies at national, regional, and city levels to support electrification of our transportation systems.

Thank you again for the opportunity to participate in today's hearing. I am happy to answer any questions.

The CHAIRMAN. Thank you. I appreciate that update.

Mr. Yates, welcome.

STATEMENT OF KEVIN YATES, PRESIDENT, ENERGY MANAGEMENT DIVISION, SIEMENS USA

Mr. YATES. Thank you, Chairman Murkowski and Ranking Member Cantwell and members of the Committee. I'm Kevin Yates, President of Siemens Energy Management Division here in the U.S., and it is a privilege to testify today on behalf of Siemens' 50,000 employees in the U.S. represented in all 50 states.

In the past 15 years, Siemens has invested $40 billion in the U.S., and we invest $1 billion annually in U.S.-based research and development. So while we're a global company, we are proud to say that we're U.S. local, setting a high expectation for advancing critical technology in the fields of energy, health care, mobility and manufacturing efficiency.

Specific to the energy space, since our first day in the U.S. more than 160 years ago, Siemens has been inventing, optimizing and reengineering machines capable of generating electrical energy at all levels. One might conclude that our DNA has a foundation of electrifying the world. It's because of this deep-rooted foundation in electrification that we continue to invest in innovation around power generation, transmission and distribution.

I would like to spend my opening remarks this morning to share a few examples of technology that enable the development of not only a reliable and an affordable electrical infrastructure, but also a sustainable future.

First, Siemens offers wind and solar solutions for various operating environments. In fact, in Alaska we are proud to provide technology that enabled the Cold Climate Housing Research Center to be fueled almost exclusively by solar energy. In Iowa and Kansas today, Siemens Gamesa Renewable Energy designs and manufactures equipment that make wind energy production more efficient, innovation that has had a U.S. influence and a contribution which has enabled wind production to be very competitive.

Now while wind and solar generation offer advantages in terms of sustainability, they do present new challenges, two specifically. How do we efficiently transmit renewable generation to consumers? And how do we manage the intermittency of renewable energy?

Siemens is responding to this challenge as well by advancing transmission technology to move electrical energy across vast distances while using software to effectively plan assets and help manage intermittency. In fact, next year we expect to start work on a new transmission line that will carry wind energy from Texas into the Southeast U.S. And this project will not only provide sustainable generation to reach consumers, but it will inject about $4 billion into the economies of the two states that that wind energy crosses, Louisiana and Mississippi.

Third, Siemens is involved in another key trend in the electrification landscape, distributed energy resources. You might think about this as the other end of the spectrum. This is where energy is now being generated on a much smaller scale and in much closer proximity to the consumer. In these cases, Siemens is working with cities, manufacturers, hospitals and universities alike to help them build a more reliable and efficient electrical infrastructure.

And finally, Siemens is focused on modernizing our grid. Our nation's power grid is one of the most complex, massive machines the world has ever seen. In fact, someone once said that our utility grid is the great enabler. I happen to agree with this perspective, but the grid, the great enabler, is aged and needs to be renewed, rebuilt, rewired, but also made more intelligent. Whether we're talking about large-scale renewable generation or localized, distributed small power, Siemens is focused on helping our customers manage these assets in a more reliable and efficient manner through automation and software.

As an example, we recently celebrated a successful microgrid installation of a low carbon community at a Native American reservation in California. The project not only helped the reservation solve an issue of regular brownouts, but our software has enabled the connection of four different types of electricity generation—including solar and storage technology—with a result to save the community $200,000 per year in energy costs, reduce CO_2 emissions by 150 tons per year and increase tribal clean energy jobs by 10 percent.

So I'll just close with this final point. At Siemens, we work closely with our customers in a wide variety of industries to develop new technologies that help move the industry forward without losing focus on the next big advancement. A critical component of what enables us to do this in the U.S. is a culture of innovation at work in this country. We think of it as an energy ecosystem, and we do believe in an energy future that is affordable, reliable, and sustainable, but the ecosystem transcends any one entity.

We look forward to helping foster a more collaborative energy ecosystem of the future. Thank you for your time. And I look forward to your questions.

[The prepared statement of Mr. Yates follows:]

SIEMENS
Ingenuity for Life

Kevin Yates
President
Siemens Energy Management Division

Testimony before the Senate Committee on Energy and Natural Resources

"Studying cost reductions in emerging energy technologies with a specific focus on how recent trends may affect today's energy landscape."

June 8, 2017

Chairman Murkowski, Ranking Member Cantwell, members of the committee, thank you for inviting me to testify to share Siemens' perspective on advancing critical energy technology. My name is Kevin Yates, and I am President of Siemens' Energy Management business. From efficient power generation to digital factories, from wellhead to thermostat, and from medical diagnostics to locomotives and light rail vehicles, Siemens is proud to be a global technology leader that has stood for engineering excellence, innovation, quality, and reliability for over 160 years.

Siemens in the United States

For over a century, Siemens has set the standard for excellence in power generation, transmission, and distribution in the United States. Siemens continues to build on that proud tradition, using engineering expertise and global leadership in technology to provide innovative next generation technologies for our customers. We are committed to supporting the development of low carbon energy – natural gas, wind, and solar – to pursue sustainable and cost-saving energy options.

While Siemens is a global leader, our deep roots in the United States and connection to our communities and our customers across this country make us proud to say we are also "U.S. local." We have over 50,000 employees in all 50 states, and we innovate, manufacture, and help develop the workforce across the U.S. We invest $1 billion annually in research and development. We have over 60 manufacturing sites, for example: Heber Springs, Arkansas; Pomona, California; Fort Madison, IA; Jackson, Mississippi; Wendell and Charlotte, North Carolina; Norwood, Ohio; Spartanburg, South Carolina; and Grand Prairie and Fort Worth, Texas. We spend approximately $50 million annually for training and continuing education of our workforce. And our investment in the U.S. continues to expand. For example, Siemens recently expanded its digital industrial leadership with the acquisition of Oregon-based software company, Mentor Graphics.

The business I oversee, Siemens Energy Management, is responsible for developing and providing technologies for the economic, reliable, and intelligent transmission and distribution of electrical power. Across the low-voltage and distribution power grid level, Siemens designs and manufactures smart grid and energy automation technology, power supply for industrial plants, and high-voltage transmission systems.

I would like to highlight some specific areas and technologies that Siemens is working to research and develop, and then deploy widely, to modernize the U.S. energy sector. First, the grid underpins electric reliability and delivery, and modernizing the grid has to be a key component of electricity. Meanwhile, the growing penetration of new generation technologies, including renewable energy, in today's electricity mix comes with great opportunities for localized, sustainable generation, but also with new challenges that we are working to meet, through software that accommodates increased intermittency in generation; microgrids that effectively serve smaller and more isolated or off-grid demand loads; and transmission that needs to deliver energy along new and different routes. Energy storage is a critical need for all of this electric innovation, and it is a need that Siemens takes seriously. Finally, Siemens strongly believes that a culture of innovation that supports and inspires this ever-improving landscape is critical.

Modernizing the Grid

First, I'd like to talk about modernizing the grid.

Our power grid is the most complex, massive machine the world has ever seen. Now it not only has to be made newer, it has to be made smarter: gutted and re-wired with software and computers. This will take time – decades – to complete. Whether their concern is sustainability, resiliency, or cost, our utility, industrial and residential consumers are eager to reap the benefits of a digital grid today. They've been shaken out of their traditionally passive stance with how they purchase and consume electricity. We are confident that we can reduce the time consumers have to wait to see these advancements.

There isn't a one size fits all approach to these new power systems. Needs and energy availability vary between industries and regions, so building a localized energy system requires an equally flexible strategy.

Renewable Energy

Siemens is an industry leader in the development of renewable energy technology, and all those technologies that support it. At the front end of a renewable energy project, Siemens can specify, design and install the right solar array solution for each operating environment. Wind solutions can be configured for each unique situation. The latest wind turbine models are designed specifically to capture more wind energy at mid-to-low wind sites.

As we work to maximize the benefits offered by renewable technologies, costs inevitably come down. For instance, the levelized cost of wind energy in the U.S. has dropped by more than 50% over the last 5 years[i]. The regions with the most abundant wind resources are seeing long-term wind energy contracts for 2-3 cents per kWh [ii]. Because wind is coming into its own as a competitive domestic energy resource, 18 GW of wind energy contracts have been signed by electric utilities and corporate purchasers since 2013 [iii]. Recent statistics show that wind generation comprises 5.5% of U.S. electricity nationally: over 20% in the states of Kansas, Oklahoma, North and South Dakota; and over 35% in the state of Iowa (1)[iv], where Siemens Gamesa Renewable Energy has more than 1,300 wind turbines (2)[v].

A significant part of this cost decline stems from manufacturers' ability to innovate, increasing turbines electricity production and driving down capital cost. One of the major innovations that has resulted in improved energy productivity is longer blades, along with other aerodynamic improvements, to enhance energy capture. In Siemens Gamesa Renewable Energy's blade R&D center in Boulder, Colorado, we assess tradeoffs in shape and design blades constantly seeking ways to improve production – for example, analysis shows that a 10% reduction in blade mass could result in a 4.5% improvement in turbine output.

Bloomberg New Energy Finance also reported a 16% decline in the global cost of wind energy just in the second half of 2016 (4)[vi]. Similarly, the market is seeing a dramatic shift in the contractual price of offshore wind energy as well.

In addition to wind and solar, hydropower also remains an important renewable power generator in the U.S. Because it plays a critical role in meeting our energy needs and carbon reduction goals, we must ensure that these systems are operating efficiently and reliably, and that this technology, like all electric generation technologies, continues to improve. For example, Siemens is working to improve critical power infrastructure at hydro plants, including environmentally-friendly transformers that are safe to locate near water and can also increase power transmission capacity.

Transmission

As energy development continues to advance, generation is coming from different geographical areas than it has historically. This means businesses like ours must also keep pace, helping to ensure that power reaches consumers across the U.S.

With more than 50 high-voltage direct current (HVDC) projects implemented worldwide, Siemens is a leading provider and is further developing this technology in significant ways: "HVDC PLUS" solutions function as efficient power highways and also help to stabilize power transmission. Because the constant demand for power requires maximum supply security, it is crucial to prevent line faults from causing power failures in conjunction with full-bridge technology.

Today there are greater distances between new generation from wind turbines, photovoltaic systems, and hydroelectric installations and the cities, industrial plants, and infrastructure facilities where the power is needed. HVDC transmission is a proven method for transmitting enormous amounts of power over great distances.

The Southern Cross Transmission project is an innovative high-voltage direct current transmission line that would facilitate the delivery of low-cost renewable and conventional energy from the ERCOT system of Texas into the SERC system of the southeastern U.S. The Southern Cross project will help to increase reliability across the American grid by connecting two robust electrical systems. The dynamic project would help move renewable energy from west to east, as well as move low-cost power from existing nuclear, gas, and coal generation from east to west when the wind is not blowing.

Once in operation, the Southern Cross project will inject $3.9 billion into the economies of Louisiana and Mississippi, the two states the project crosses. The project received FERC approval in May of 2014 and is currently undergoing a late-stage routing study, while working closely with the requisite permitting and routing authorities. Construction is expected to start in 2018, with an expected service date of 2021.

Distributed Energy Solutions

Even as we work to modernize the grid and the high voltage transmission lines that it relies on, we are also working on distributed energy solutions. Siemens enables customers to stay connected to the grid, while also having the capability of generating and managing power themselves, using the latest technologies and software. Using localized, efficient power systems and automated controls, consumers become "prosumers" who buy power from the grid when rates are lowest, and also sell excess power supplies back to a utility. These customers have more control over how they manage their energy supply, how they use it, and how much they pay for it. And critically, they are shielded from damaging storms and severe weather.

Siemens intelligent software and automation controls for distributed energy assets and microgrids ensure self-sustainability and independent operation. They bring together and operate all of the essential elements in each customer's local power solution. Using Siemens Spectrum power management software, customers can optimally manage all generation resources. The software:

- predicts power load needs;
- dynamically manages and controls assets;
- identifies when to generate power independently and optimal situations for saving on energy costs;
- and allows for seamless integration of additional power sources, from renewable energies such as wind and solar, to biomass fuel cells, traditional co-generation and even diesel generators.

Siemens and the New York startup LO3 Energy are collaborating in the field of innovative microgrids. The goal of the collaboration is to jointly develop microgrids that enable local energy trading based on blockchain technology. Siemens is taking a leading role in the evolving decentralized energy system market. Together we are developing a solution for a blockchain-based microgrid in Brooklyn. This will be the first of its kind in the world and a starting point for developing other joint microgrid projects in the U.S. and in other countries.

The combination of a microgrid control solution and blockchain technology will make it possible for a provider of photovoltaic systems on the roofs of buildings in Brooklyn to feed its excess electricity back into the existing local grid and receive payments from the purchasers. Preliminary tests of peer-to-peer transactions between neighbors were successfully completed in April 2016.

Another example is Blue Lake Rancheria, a century-old Native American reservation in Northern California, which has recently launched its low-carbon community microgrid that is helping power government offices, economic enterprises, and critical Red Cross safety shelter-in-place facilities across 100 acres. In collaboration with Humboldt State University's Schatz Energy Research Center, Siemens, the Idaho National Laboratory and additional partners, the microgrid uses decentralized energy resources and intelligent software to provide its residents and economic enterprises with reliable power without interruption.

The microgrid includes a 500-kilowatt solar photovoltaic system and a 950 kWh battery storage system, all managed and controlled with Siemens Spectrum Power Microgrid Management System (MGMS) software. Funded in part through a $5 million grant from the California Energy Commission's Electric Program Investment Charge (EPIC) program, the system allows the reservation to operate independently of the power grid in coordination with local utility Pacific Gas & Electric. This project incorporates the largest solar array currently in operation in Humboldt County, California. It is estimated to save the Tribe over $200,000 in annual energy costs and will reduce at least 150 tons of carbon per year. It is also expected to grow Tribal clean energy jobs by 10 percent.

Conventional Fuels Used More Efficiently

While we work to integrate new energy sources, our customers also want to continue to get the most fuel for their dollar by maximizing efficiency of conventional fuels such as natural gas. By investing in a cogeneration, or co-gen, plant, a utility or industrial consumer can use natural gas, taking advantage of low prices, and generate power much more efficiently.

Combined Heat and Power (CHP) solutions produce a reliable source of electricity and heating. CHP plants are typically based on a combination of a gas turbine and a steam turbine in a simple combined cycle configuration by making use of the hot exhausts normally emitted as waste, to create heat or to power the steam turbine. This improves overall efficiency by as much as 90%, reduces overall fuel consumption, and decreases carbon emissions.

Energy Storage

Energy storage has emerged as one of the most critical technologies for moving the energy sector to the next level. Anything that enables electricity to be produced and consumed at different times is a type of storage. One of the earliest types of storage is the pumped storage that often is maintained in conjunction with hydro generation facilities; water can be stored indefinitely, and then released when demand increases. The grid itself is another kind of storage, as it accommodates two-way flows of energy, thereby increasing the ability to accommodate intermittent energy sources.

Siemens storage technology enables customers to take energy from their local on-site grid during low load periods and store it, releasing it back for peak load periods. In this way, supply and demand can be balanced cost efficiently.

One type of energy storage that I will highlight here is Compressed Air Energy Storage (CAES). Siemens subsidiary, Dresser-Rand, pioneered the development of CAES technology more than 20 years ago by designing and supplying the entire turbomachinery train and controls for the first 110MW CAES plant in North America, located in McIntosh, Alabama. Dresser-Rand is in the planning and design phases for multiple new domestic and international plants based on upgraded CAES technology. These developing advanced technologies will further help improve operating efficiency while reducing CAES' inherently low carbon emissions.

CAES systems use excess electricity from wind, solar, coal, or nuclear power to compress air to high pressure and store it in an underground cavern. The compressed air is stored energy. When electricity is needed, the compressed air is brought to the surface, heated, and burned with a small amount of natural gas before expansion through turbines to drive a generator and generate power. Exhaust waste heat is captured and used to improve system performance.

There are many benefits of a CAES plant. A CAES plant allows for a rapid start through high ramping and turn down rates. For example, a CAES plant can ramp up as fast as 26 to 32 MW per minute. CAES also provides a buffer between intermittent renewable power and the grid, allowing wind and solar to become base load generators.

CAES offers a unique solution to improve grid reliability and further enables the use of solar and wind based renewable energy. With further development and policies promoting increased bulk storage capacity, CAES and other energy storage options will help advance the state of the technology and provide a compelling solution that responds to the pressing need for grid modernization in the U.S. and around the world.

Conclusion: Disrupting the Energy Future

While we are proud of all that we have achieved, we remain focused on the next big advancement that will help continue to move us forward. We strongly believe that a broad culture of innovation is key to success not only for Siemens, but for the U.S. as an incubator of the ideas and technologies that will power us for the next century and beyond.

Siemens is doing its part to promote a culture of innovation. In October 2016, Siemens set up a separate unit to foster disruptive ideas more vigorously and to accelerate the development of new technologies. The unit's name, "next47," plays on the fact that Siemens was founded in 1847. The new unit has funding of about $1 billion for the first five years and will build on Siemens' existing startup activities. Next47, which is set up to be independent, is able to leverage the advantages offered by Siemens, has offices in Berkeley, Shanghai and Munich and covers all regions of the world. It is available to all of our employees, external startups and established companies that want to pursue business ideas in the company's strategic innovation fields.

Siemens hopes that the U.S. will continue to be a world leader in innovation. Due to the partnerships between universities, laboratories such as those at the world-class Department of Energy, with the U.S. Government, and companies like Siemens, we have experienced ground breaking technological advancements. Continued success in such partnerships is critical to our shared future. Thank you again for the opportunity to testify.

[i] DOE 2015 Wind Technologies Market Report [link]

[ii] Ibid.

[iii] AWEA Annual Market Report 2016 [link]
[iv] Ibid.

[v] AWEA Market Database Pro [link]

[vi] Bloomberg New Energy Finance, H2 2016 LCOE [link]

The CHAIRMAN. Thank you, Mr. Yates, and thank all of you. This has been a very interesting hearing this morning, and I appreciate what each of you is contributing. My husband and I just put solar on our home here in Washington, DC, rooftop solar, and we actually argue over who gets to open the bill each month now to see what it is that we are, quote, "saving." But it has been an eye-opener for us as a family.

I would invite my colleagues to come to my office upstairs on the fifth floor here. Just yesterday, we installed our own little, we call it a "grow tower." It is comprised of several orange buckets from Home Depot, and we have hydroponic lettuce growing in it with a small circulating pump. It is a system that costs about $200 overall. We are utilizing some LED lights to really help demonstrate what it is that we can grow. We encourage everyone in the office to have a little bit of fresh salad every day.

What we are trying to demonstrate is that even in a cold and a dark remote place we can, as Alaskans, grow some healthy things in a space that is very, very limited utilizing the efficiencies that we have with these LED light strips. So I think about the different things that individuals can do to spark that imagination. It is kind of fun on top of it all.

I would like to take my questions to you this morning to a higher level instead of what we, as individuals, are doing. Let me just ask generally to each of you, because you all bring a different perspective here. I mentioned in my opening that we really have not updated our energy policies around here for about a decade now. Can you give me some examples of where we have either impeded the progress in the areas that we are seeking to develop these enhanced efficiencies, or our opportunities, or reduce our costs? Or, if you can't think of those areas where the Federal Government has been in the way, can you provide us some examples where technical assistance or funding from DOE or from the Federal Government has made the difference?

I think, Mr. Greeson, you mentioned in your comments a 20 percent grant from DOE, a very specific example of how that financing helped kick your project over. So I am throwing this out to each of you because I think it is important for us to understand what, from the federal perspective, we can be doing more of or less of to help these opportunities advance. I do not care who starts.

Ms. Donge.

Ms. DONGE. Thank you. Just two very specific points, when it comes to corporate renewables and what the buyers are thinking, are definitely the PTC and ITC extensions. It is not necessarily that the tax credits are helpful, it is the certainty of when they phase out, so that planning and OEMs can ensure their capital costs meet the demands of the developers. That's one example. Then the second example is the DOE's SunShot Initiative, which has reached its goal a few years ahead of time—reached its goal this January—of reducing costs to $1.00 per kilowatt-hour. I think that's a very significant way to, technical way, to prove that the cost reductions can go further for these technologies.

Thank you.

The CHAIRMAN. Others? Mr. Yates?

Mr. YATES. Yes, ma'am. Thank you. A two-part answer to the question. The first would be as we look at the implementation of even further renewable assets, the key is going to be connecting those generation sources with consumers. And sometimes that crosses state utility types of jurisdictions, and so the permitting process, and how we can make that more expedient, more streamlined is, I think, a key opportunity.

And then the second comment that I would make is we absolutely—we have a great relationship with renewable—some of the national labs. And one specific example, we worked with a renewable energy lab on some e-car charging technology to help automate that there in Colorado, working with an auto manufacturer and a utility. And so, I think a collaborative environment and a collaborative ecosystem is key to continuing to move our energy sector forward.

The CHAIRMAN. Good. Anybody else? Mr. Simonton?

Mr. SIMONTON. Thank you. As far as the Federal Government impeding our progress, I would say, and second, the regulatory turnaround is what really is impeding us, and trying to schedule all of our drilling and completion permits in the federal acreage that we operate in. It's not the expectation of the federal requirements, and we're certainly willing and able to do that, but it's absolutely the turnaround is delayed by many, many months. And I think there is an understaffing issue that the regulatory body is having in the different regions that we operate.

The CHAIRMAN. Good. I appreciate that.

Mr. Vare?

Mr. VARE. I would say that I don't see anything that's been in the way, but as energy storage is a new technology, right now the federal Investment Tax Credit for solar does have some applications to energy storage, which is good, but I would just suggest for any future energy policy that was created, that energy storage fits into renewables as in the way that it can help with distributed generation.

The CHAIRMAN. Great.

Mr. Merritt, you get to wrap up the question.

Mr. MERRITT. Yes. So I would like to point out three key areas I think are important for the role the Federal Government plays. One is, and I mentioned this earlier, early R&D funding and support for projects that have long lead-times and potentially high levels of risk. These are projects that often won't be undertaken at the same scale or perhaps as soon if private industry does not have the support of federal research dollars. I think the role of the Federal Government in terms of demonstrations and trial projects and, in fact, early adoption is also a very key role. It does a few things. It validates the technology in the marketplace. It also provides early revenue for those companies that are trying to justify continued investment. And then lastly, I would mention the certifications and standards to encourage adoption, such as what's happened in the ENERGY STAR program are important.

I would highlight going forward, I would mention systems efficiencies and the potentially very large gains that are available there. I think the government, the Federal Government, can have a very key role there in terms of demonstration and trial activities. Thank you.

The CHAIRMAN. Great. Thank you.

Senator Cantwell.

Senator CANTWELL. Thank you, Madam Chair.

Mr. Yates, not to put you on the spot, but I actually think everybody here talked about various aspects that the government is involved in, technology and R&D, but are we the leaders? You are a global company. Is the United States the leader in renewable energy?

Mr. YATES. I would say the United States is absolutely at the forefront, and I would go and point to the advances that we've made in the wind energy market as an example. Some of the numbers that you and the Chairman cited earlier today, as well as some of my colleagues on the panel have cited, the tremendous improvements in production costs, and that is a direct result of the investments that we've made both domestically here in the U.S. in our own wind energy facilities as well as abroad. So I think we absolutely have the environment to continue to do that, and we look forward to working both with the Administration and with Congress as well as the Department of Energy on ways to continue that evolution in the wind and renewable markets.

Senator CANTWELL. So now would not be the time to pull your punch on the leadership.

Mr. YATES. As far as the Administration goes, I mean, from our standpoint, we have a corporate sustainability target to be carbon-neutral by 2030, Siemens Global.

Senator CANTWELL. Yes. I am not even talking about Paris. I am just talking about maybe, more specifically, the Office of Energy Efficiency and Renewable Energy (EERE), the President suggesting a 70 percent cut.

Mr. YATES. Well, again, we would be interested in moving technology forward, and I would say that we see the Department of Energy as a key part of that. It's not the only part of that moving forward, but we would ask that Congress and the Department of Energy reach out to the private sector and engage in public-private partnerships that could help continue to advance technology.

Senator CANTWELL. So if we want to keep being a leader, we need to keep our investments in R&D and deployment going.

Mr. YATES. We need to keep fostering environments where we have collaborative partnerships with the Federal Government and the state governments as a part of that but also reaching into the private sector to do that.

Senator CANTWELL. What do you think on grid development—from the context of how big that opportunity is if we were the pioneers in the next phases of that grid technology—how big is the opportunity around the globe for that kind of technology?

Mr. YATES. I don't know that I would specifically say that I know what the opportunity is from a dollars and cents standpoint. What I would say is that geographically across the globe there are different types of energy challenges. And at Siemens, we focus on not only innovation here in the U.S., but how we can take that abroad. And to get on a global scale, I think technologies are going to be developed in different regions of the world that are applicable. But

I think creating an environment in the U.S. where we continue to innovate energy infrastructure not only is going to help us domestically but give us a platform to take technology global.

Senator CANTWELL. I would agree. The United States has a huge opportunity for other parts of the world that are so energy inefficient and whose grids are so elementary to take and create the smart grid and smart building platform for the future and really capitalize on those jobs and investments.

I wanted to point out, Madam Chair, I think we are getting a letter today from all the former leaders of the Office of Energy Efficiency and Renewable Energy—from the Clinton Administration, Obama Administration, both Bush Administrations—saying not to gut the EERE office. And so certainly I know one of the things that has been highlighted here are all the great ways in which that agency has been working with so many of these partners here. We definitely want to bolster that organization. Thank you, Madam Chair.

The CHAIRMAN. Thank you, Senator Cantwell.

Senator Hirono.

Senator HIRONO. Thank you, Madam Chair, and thank all of you for your testimony.

I am glad that Senator Cantwell has focused on EERE, the Department of Energy's Office of Energy Efficiency and Renewable Energy, and the huge cuts that the President's budget reflects on that program. And as I observed Secretary Perry, during his nomination hearing, the Department of Energy has been a key supporter of Hawaii's efforts to transition from importing oil to renewable energy, including a goal of 100 percent renewable electricity by 2045.

This is a question that maybe Mr. Merritt could respond to. Can you comment on the importance of public investments and clean energy technology and what the impacts could be of the major funding cuts to DOE, in the case of EERE, a two-thirds cut, on the pace of clean energy technology innovation and working with a state like Hawaii to move us off reliance on fossil fuels?

Mr. MERRITT. Surely. So I think, as I mentioned earlier, there are a couple of key roles that EERE and the Department of Energy play. One is early R&D funding. You know, in our case, I would argue R&D technology have moved beyond the point where it's now past the tipping point and is fully self-sufficient.

However, what I would point to would be the next generation of technologies which are going to be required for us to achieve the goals you highlighted. The early long lead-time investment and perhaps higher-risk investment that's required for these technologies absolutely requires, or if not requires, benefits from public funding and public support. Would it happen anyway? Potentially, but it would take longer, and it would not be as powerful.

Senator HIRONO. I would agree with that. I think that that is a rather tactful response because in the area of moving toward clean energy and energy self-sufficiency, tax credits and other kinds of support that governments at both the state and federal levels have been very much relied upon, which takes me to the question relating to energy storage.

This is for Mr. Vare. You mentioned that your company just launched a home energy storage service in the U.S. with a Utah-based residential solar company. Many people in Hawaii see energy storage as potentially a big help in reaching our goal of 100 percent renewable electricity by 2045. What are your company's forecasts for the long-term cost savings for customers installing residential storage systems? And how is your company reaching out to residential customers to explain the potential benefits to them of energy storage?

Mr. VARE. Yeah, we absolutely see Hawaii as one of the leaders in renewable energy integration and see the residential home storage market as one of our key markets that we're focusing on.

In terms of the cost savings per customer, we would need to look—we look individually at that customer's utility rate structure, so it's hard to give a specific number, but we do see a financial benefit and we are planning with Vivint Solar, as you mentioned, to launch in Hawaii. There are some specific requirements for the Hawaiian market for zero net export that we're looking to be able to have our systems function there, so——

Senator HIRONO. It sounds as though you are already interacting with folks in Hawaii?

Mr. VARE. Absolutely, yes.

Senator HIRONO. That is good to know. And, of course, you mentioned that you would like energy storage to be part of discussion around investment tax credits.

Mr. VARE. Correct.

Senator HIRONO. As you know, there are bills to do that.

Mr. VARE. Correct.

Senator HIRONO. I am certainly supportive because when you are talking about intermittent energy, storage is a huge part of how we can actually bring all of that online.

Again for you, since 2006 Hawaii has cut its annual use of petroleum by 41 percent, or 22 million barrels, while renewable energy grew from 9.5 percent of the electricity market in 2010 to 26.6 percent in 2016. I would like to see a similar transition in the transportation sector because we are focusing, in Hawaii particularly, on the electricity sector. What policies do you recommend to accelerate the transition to electric vehicles that you referred to in your testimony?

Mr. VARE. I believe the electric vehicle charging infrastructure support would be a key policy, and where Mercedes-Benz Energy fits within Daimler is, how can we support this vehicle electrification? So for the residential energy storage, we see that as the customer purchases an electric car, as they have solar in their home, they have residential battery storage, that they can efficiently manage the energy at their home. So in order to help increase that transition to full electrification at the home, they need the electric car, and I think that more EV charging infrastructure would help make that decision easier to transition to electric drive.

Senator HIRONO. Thank you.

Thank you, Madam Chair.

The CHAIRMAN. Thank you. We have some really great projects going on in some of our smaller communities. Our capital city in Alaska—Juneau—is on an island, primarily powered by—the energy is generated by hydropower. We are looking to do some interesting things with distributed heat generation. And when you think about the opportunity for islanded communities, whether it is a state like Hawaii or communities like Juneau, they are just perfectly brilliant prototypes for doing some of what we are talking about, particularly in areas where you are a renewable energy base.

The island of Kodiak is about 98 percent renewable between its wind, its hydro and the storage capacity that they have there. And when you think about that island community, it is our second largest community in terms of the volume of seafood that comes in. You have a processing industry that is a pretty big consumer. You can look at these small towns and say, well, anybody can make success happen, but when you think about the demand during the season, it is pretty high.

We are demonstrating significant progress as we look to the energy assets that are there rather than trying to bring things—although you know, we would like to do more with our natural gas to share with Hawaii. But the reality is the more that you can use what is around you, whether it is these villages like Kongiganak that take a little wind and combine it with some other interesting applications and figure out ways to get off diesel-powered generation, these are some breakthrough innovations that we are seeing. It is not on large scale, but if you can prove it out in high-cost places like Alaska and Hawaii, I think we just have extraordinary potential.

Mr. Merritt, you mentioned intelligent lighting. As I look to some of the real cost drivers in our villages, again, these are communities that are not connected by roads, everything has to be flown in. When you think about anything that needs to be frozen in a grocery store, you have the expense of the freezer, and you are running it by diesel, but you also have the cost of that little grocery store. If you have the technologies that recognize that the light does not need to be on in that display case or the light does not need to be on in the refrigeration unit, these small little operators save money and thus are able to help, in a little way, reduce the cost to the consumer when it comes to the goods that are provided to them.

I think about some of these lighting applications that we have out there, again, where you have streetlights that are using outdated and inefficient lighting, the incremental gains that we can make in just the lighting application I think is really quite considerable in these remote, high-cost areas.

I wanted to ask just a couple more questions, and then I will let everyone kind of throw into the conversation anything that you had hoped to get on the table but were perhaps not asked.

Mr. Simonton, you described a lot of the technological innovations. I mentioned that we had an opportunity up north a couple weeks ago to see for ourselves and really get a better understanding of where the industry is headed, how you can use the digital data that is really helping us be smarter, quicker and more efficient. But as we see those efficiencies, what does that do to the workforce? Does this mean that there is a different requirement for this skilled worker? Instead of the roughneck that we all, or those of us that come from oil-producing states, called the guys that were making it happen, is it now the computer technicians? Are we seeing that we need fewer workers out in the oilfield? What are you seeing?

Mr. SIMONTON. Yes, thank you. The innovation of technology in the oil and gas industry has certainly accelerated the whole process across the board. One of the things, for instance, the drilling rigs that we have today are modern drilling rigs that are all computerized, and what we find is the younger generation of employees are acclimated to this technology. They grow up with the technology, so it really is an easy acclimation and a process for them to develop.

As far as, are we needing fewer and fewer employees in the industry? I would tell you in my career today the complexity of the type of wells that we drill is requiring more personnel, more people on location, more than ever in my career. So I would say that we're an accelerated industry, things are getting faster. The investment for the unit of hydrocarbon that we find, we're finding more and able to produce more efficiently more hydrocarbons per dollar of investment.

So I think quite to the contrary, we're actually a fast-paced and faster-paced industry with a young workforce that is acclimated to the technology, and they're thriving.

The CHAIRMAN. Great.

Mr. Greeson, as you discussed, the innovation that you are advancing with the Petra Nova project and all that we are seeing with that commercialized CCS project, have you been working with other groups who are interested in pursuing this technology either here in the United States or abroad? Are you kind of working on your own or are others viewing this as a future opportunity?

Mr. GREESON. Thank you, Chairman. We are seeing worldwide interest. I hosted the Australian Energy Minister on a tour of the facility about three weeks ago. I just returned this week from spending time in India, who is interested in CCS EOR, enhanced oil recovery. I think the last total was we've hosted eight international delegations on tours of the facility to see how we were able to achieve this project on time, on budget and get the commercial structure set so that oil pays for everything we did and electric customers don't have to pay for reducing carbon emissions.

The CHAIRMAN. Great.

Mr. Yates, as we are considering the opportunities and the challenges that we face in developing some of these really small microgrids and bigger expansions, you mentioned the involvement with the Cold Climate Housing Research Center in Fairbanks and what you had done to help facilitate the solar generation there. What do we need to be doing to structure partnerships between industry, between our communities, our universities, the Department of Energy and our national labs to build out more when it comes to the innovation that we might see within this space of microgrids?

Mr. YATES. Thank you, Chairman. I believe that, as you rightfully pointed out in your question, there is a partnership aspect to it. And I would point to the best case that I would give you is this project that I mentioned earlier in my opening remarks, the Blue

Lake Rancheria project out of Northern California where we had a Native American reservation that was dealing with brownouts on a regular basis. They were at the end of a large utility transmission and distribution grid. And it wasn't just about dealing with the brownouts, it was also—once we started to talk partnerships with the local university, the utility, the tribe itself, and some other technology partners—it was really about, how do we give them energy independence but also do it in an affordable way? And the answer to that and to many of the questions that we've talked about is software.

And so I think that whether we're talking about the integration of 200 megawatts of wind and transmitting it 250 miles to a core consumer base, or we're talking about a very small microgrid with 10,000 metered customers, the enabler of both of those and many of these challenges is technology specifically around software. I think the key is, how do we create an environment where all the parties come to the table with a common goal to not only implement these renewable energy technologies or the various types of energy-generation technologies, but do it in the most reliable, affordable and sustainable way?

The CHAIRMAN. Your comments remind me that in many parts of my state, and you get into areas of whether it is Africa or other parts of the world, where the biggest complicating factor here is that we don't have that broadband capacity. That software that is so necessary to allow us to really capitalize on this, we cannot make work yet. So we are filling in the gaps in Alaska, we are making some headway there. That is not our problem here in this Committee, that is Commerce, but it does remind me how connected this all is and how important it is that we have that level of access when it comes to our ability to communicate.

Mr. Vare, I want to ask you a question because you mentioned how the reduction in costs that we are seeing with the lithium-ion batteries has really helped to advance movement within the electric vehicles and the home energy storage systems. We recognize that is significant. Is it all about cost? Is that what the consumer wants to see? That is what my husband wants to see, I will tell you. But how much of it is just an awareness and understanding and just kind of some of the human behavior that we need to change in order to move to some of these different approaches?

Mr. VARE. I think that some of it still is about cost, so when we hear these numbers of battery price declines, it's easy to think that it's cost competitive. But, for example, an energy storage system has power, electronics, energy management software. So as a system, it's still expensive and it's still a new market. So I think there is still further justification for incentives and cost declines that are needed.

For maybe on the electric vehicle side, I think that there is this maybe a mental shift or paradigm shift that needs to happen. We're still at one percent. We've been growing every month in terms of electric vehicle sales in this country, but it's still one percent market share in terms of new vehicle sales. So there is, I think, an additional maybe mindset shift needed there to help transition people to electric drive.

The CHAIRMAN. Okay. Last chance for anyone to add for the good of the order any comments that you may want the Committee to be aware of.

[No response.]

All right. You are all happy. We are happy. I am pleased that you were with us this morning.

Again, I do not think the Committee attendance this morning is at all reflective of an interest in this subject. It is, let us just say, an interesting day here in the United States Senate, and there is a lot going on. Know that the Committee members will have an opportunity to review everything that has been presented here as well as, again, your full statements. I would imagine that Committee members will be submitting questions to you for the record so that we can have further information as to that.

I thank you for being here this morning, making the trip and for all of your contribution. I think we are making a difference, and that is a good thing for the country.

With that, we stand adjourned.

[Whereupon, at 11:25 a.m., the hearing was adjourned.]

APPENDIX MATERIAL SUBMITTED

ROCKY MOUNTAIN INSTITUTE

BUSINESS RENEWABLES CENTER
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U.S. Senate Committee on Energy and Natural Resources
June 8, 2017 Hearing: The Study of Cost Reductions in Emerging Energy Technologies with a Specific Focus on How Recent Trends May Affect Today's Energy Landscape
Questions for the Record Submitted to Ms. Lily Donge

Questions from Ranking Member Maria Cantwell

Question 1: Can you describe why companies are purchasing renewable?

There are two main reasons why companies pursue off-site renewable power:
To achieve their sustainability targets;
To capture economic benefits.

Achieving sustainability targets
Many U.S. corporations are under increasing pressure from a variety of stakeholders, including their customers and shareholders, to set ambitious sustainability targets and deliver on them. This sentiment is reflected in public opinion polling as "58% of Americans are worried about global warming" according to the Yale University climate survey, and 71 percent of Americans support continued development of clean energy technologies, according to Gallup. In response, 66 percent of Fortune 100 and approximately 50 percent of Fortune 500 companies currently have public sustainability commitments.

To act on the energy portion of these targets, companies typically utilize one or several of the following options:

- Large off-site renewable transactions;
- On-site renewable investments (e.g. PV);
- Energy efficiency.

For many companies, the potential of on-site renewables is limited – typically 5–10% of their energy consumption – due to the physical size constraints on their properties. Energy efficiency programs can noticeably reduce electricity consumption, but unlocking this potential may require a lot of detailed work and often takes years to realize. Large off-site renewable energy transactions offer a relatively quick way for the private sector to achieve significant carbon reduction results.

Capturing economic benefits
Wind and solar energy is now cost-competitive with traditional, fossil fuel-based energy sources in an increasing range of applications and geographies. Companies that buy renewable energy can expect to receive three economic benefits:

- A competitive energy price today;
- A fixed price for electricity that protects them from fluctuating fossil fuel prices for the next 10–20 years;

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- The opportunity to capture tax and/or regulatory benefits.

BRC interviewed six corporations that collectively have signed eight deals for a total of over 1000 MW of renewables during the past few years. We asked each of them the same question: "Why did you enter into one or more large off-site renewable energy transactions?"

The answers below are listed the in order provided by the interviewees; they give a flavor of the diversity of perspectives that corporations have and the relative importance they attribute to sustainability and economic benefits.

Multinational retailer: Achieved cost savings Improved public image Improved customer satisfaction	*Large internet company:* Delivered stable, predictable energy costs not subject to fossil fuel commodity price risk Improved reputation among customers and peers Improved support from local constituencies
Another large internet company: Increased profitability Hedged fuel prices Reduced reputational risk Demonstrated environmental leadership Simplified GHG reduction program by aggregating efforts into one large project	*Major consumer goods company:* Achieved cost savings Made major progress towards sustainability goals Improved reputation among customers and NGOs Raised employee morale
Global technology company: Raised internal awareness of energy and sustainability efforts Improved external awareness, adding value to brand Achieved cost savings	*Major healthcare provider:* Improved health of the community by reducing fossil fuel generation Aligned operations with mission Increased renewable energy generation without increasing expected costs

Question 2: What factors do companies consider when choosing a location and technology for each project?

Location Factors

- Proximity to Facilities: Large companies and other organizations often prefer to purchase renewable energy from facilities in the same state or electricity market as their facilities. There are several motivations for this, including but not limited to a desire to:
    1. Support the local economy by enabling renewable energy jobs and providing a source of revenue for the local government through taxes paid by the facility;

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2. Improve the health of the local communities by displacing fossil fueled generation and the associated pollution;
3. Hedge against future energy cost increases. If a company's electricity expenditures are correlated with wholesale market prices, the organization is exposed to potential future increases in electricity prices. "Virtual," or "synthetic," power purchase agreements can help companies counterbalance this risk. However, electricity prices in deregulated markets are location-specific. As a result, the risk mitigation benefit provided by PPAs is most effective if the renewable energy facility is located relatively close to the company's facilities. This factor is leading some companies to consider states' attitude toward renewable energy development as a factor when planning for new facilities or operations.

- Economics: While large companies and other organizations that buy renewable energy may have many reasons for doing so, the economics of these transactions remain an important consideration. Location can impact the economics of these transactions for a buyer in three important ways:
  1. Energy Production: Companies signing PPAs often do so in order to meet internal targets for renewable energy procurement or greenhouse gas emissions reductions. As such, they may prefer facilities that generate more electricity to get offsets. A wind, solar, or other facility will be able to produce more or less energy depending on the amount of resources at its location. For example, a solar panel located in the American Southwest will produce significantly more electricity over the course of the year than it would if installed in a less-sunny climate, such as New England.
  2. Cost: When companies sign a power purchase agreement, they agree to pay a predetermined price per unit of energy over several years. Location can impact this unit price of energy (*i.e.* the PPA price) in two ways. First, facilities that generate more energy over their lifetime are able to charge a lower price per megawatt hour. Second, some regions of the country have lower land, labor, and other types of costs related to the facility's installation and maintenance.
  3. Revenue: Companies that sign virtual PPAs typically do not use the power they purchase; rather, they receive the revenue generated by selling that power into the local wholesale market. Wholesale electricity prices can vary significantly across different regions due to local supply and demand. As a result, placing a wind or solar farm in locations with higher electricity prices can lead to higher revenue for the off-taker, thereby improving their economic return.
- Pollution Reduction: Each region of the United States has a different mixture of generation assets. Furthermore, the amount of pollution generated by assets of a

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particular type, such as coal plants, can vary significantly depending on the efficiency of the plant, the quality of the fuel, and other factors. Some companies choose to site their renewable energy facilities in regions with particularly high emissions per megawatt-hour in order to displace these polluting generation or high carbon assets and maximize the impact of their transaction. This approach can be particularly attractive for companies with high greenhouse gas emission reduction targets.

Technology Factors

All else being equal, most companies do not have a strong preference for one form of renewable energy over another. Companies are usually most interested in finding projects that generate local benefits to their communities, meet their economic criteria, and reduce emissions. Due to its lower cost, wind has traditionally been the most commonly purchased form of renewable energy to date. However, the installed cost of solar photovoltaic systems has fallen 64 percent since 2009 according to the Department of Energy, and is becoming increasingly competitive in several markets.

Questions from Senator Catherine Cortez Masto

Question 1: Ms. Donge, you mention that your team is rolling out a fair value tool so that companies can understand the economics of a wind or solar project. Can you discuss the value tool in more detail? Should the federal government incorporate a similar tool?

The Business Renewable Center's Fair Value Tool is designed to help buyers better understand the economics of potential transactions and compare different opportunities in deregulated electricity markets. To create this tool, the BRC team spent over a year collecting data, creating models, and developing the necessary software. Today, the tool can evaluate and visually depict the economic value of hypothetical wind and solar projects at over 4,300 nodal points in 39 states across the continental U.S.

If the federal government wishes to pursue increased transparency to allow markets to function with clear pricing signals and economic information, support of open-source software platforms similar to the Fair Value Tool and the data behind them could be informative to market participants. Such investments by the federal government could help educate policymakers, utilities, and agencies on key economic considerations and inform policy decisions and encourage private sector growth. In particular, federal agencies have a significant potential to

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increase data transparency of electricity markets. Disclosure of data, pricing, and energy information, such as the knowledge from the Energy Information Administration, as well as the information and analysis provided by the National Laboratories is of significant importance to these growing markets.

Additionally, electrical infrastructure projects are uniquely challenging investments to analyze from an economic perspective. This is an area of opportunity for government agencies with an invested interest in improving America's electrical grid system – an increasingly important need. Due to the need to constantly balance the supply and demand of electricity across the grid, the price of electricity can fluctuate significantly over the course of year or even within a single day. Moreover, physical limitations within the grid can cause the price of electricity to vary significantly over the course of only a few miles. And evaluating the expected value of energy from renewable energy projects is particularly complex, as these assets will generate electricity at varying times, and to varying degrees, over the course of a day or year. As a result, analyzing the economic value of a wind or solar farm requires significant amounts of data on wholesale electricity prices, wind speeds, and solar insolation on an hourly basis across an entire year. The grid is starting to successfully evolve to meet these needs. Today, states like Iowa are achieving wind power penetration of more than 30 percent of total capacity with no negative effects on grid reliability. But as renewables are increasingly in demand across the country, better information on grid management and economics will be necessary to make informed policy, regulatory and investment decisions.

Looking forward, the BRC plans to expand the geographic scope and granularity of this tool to provide a more robust and detailed set of results. Moreover, our team is hoping to utilize the collected data and analytic platform to develop insights on other potential infrastructure investments, such as:

- identifying where to install electrical transmission by identifying which areas have particularly low or high electricity prices throughout the year;
- calculating the net benefit of adding batteries or other forms of energy storage to a wind or solar project.

Question 2: Large companies in the energy and tech sector have moved to Nevada for many reasons, including its abundant renewable resources. You mention that open market conditions are a key enabling factor in industry's decision-making process on where to purchase clean energy. Can you elaborate on what you mean by open market conditions?

We increasingly hear BRC member companies voice their desire for "consumer choice" around energy planning and purchasing decisions – i.e. a business's ability to buy renewables directly at

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market pricing. Generally speaking, this approach is most practical in deregulated markets that embrace the growth of and access to new renewable energy projects. States that limit the growth of renewables through policy or regulatory constraints, or regulated markets where the local utility does not offer a "green tariff" or other renewable energy product can be disadvantaged when seeking to attract investment from companies seeking clean power.

The Energy Choice Initiative currently under consideration in Nevada is an example of legislation that could further open the power markets. If passed, companies will be allowed a choice of energy provider, and Nevada will become the first state in decades to deregulate its electricity markets. This would allow non-utility companies to invest in growing solar and wind power at a much more rapid pace than is currently possible under Nevada's regulated power monopolies. But potential deregulation in any state is complicated by the numerous issues currently before the Federal Energy Regulatory Commission (FERC) regarding structured wholesale markets, and FERC's lack of quorum to take action.

Additional opportunities to expand markets to allow the spread of renewables across the country are emerging, but they will require federal support and possibly even federal legislation. These opportunities include larger wholesale markets and balancing areas, such as the proposal to expand the California Independent System Operator (CAISO) balancing area to integrate the grids of six other Western states, as well as new transmission projects that could make it possible for Nevada to export electricity across the West.

Question 3: Nevada is leading the charge in innovation and utilizing renewable technologies. In fact, the city government of Las Vegas, encouraged by federal funding, is getting 100 percent of its energy for its buildings from renewable sources. What other federal government policies do you think will further encourage cities and businesses to adopt renewables?

The production tax credit (PTC) and investment tax credit (ITC) for renewable energy technologies has proven critical in leveling the playing field with incumbent fossil fuels that have benefited from decades of federal support. While these technologies are sun-setting as renewables become cost competitive, any attempts to accelerate their step-down or outright elimination would severely disincentivize cities and businesses from adopting renewables.

Federal authorities can also help to increase renewable energy portfolios nation-wide by protecting the Public Utility Regulatory Policies Act (PURPA) which has been critical to supporting the development of renewable energy across the country for many years. PURPA helped create the market for non-utility power producers who, today, serve a large portion of corporate procurement in deregulated markets.

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Lastly, a critically important role for federal oversight currently is in vetting Executive appointments to the Federal Energy Regulatory Commission (FERC). FERC is currently facing a long list of important and long-lasting decisions that will affect how wholesale power markets will function in the coming decades, with enormous economic growth and employment implications for renewable energy. FERC currently has only one of five commissioners seated, however. Having a diverse group of non-partisan energy experts, especially those who understand current market pricing and deregulated markets, would be a significant step forward in modernizing our nation's power systems.

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[No responses were received as of the date of printing.]

Question from Senator Barrasso

<u>Question</u>: In 2005, coal accounted for 51% of U.S. power generation. In 2016, that number declined to 30%. This steep decline in coal-fired generation is due in part to downward pressure on wholesale energy and capacity prices caused by cheap shale gas and renewable energy subsidies. We must reverse this decline in order to maintain a reliable and resilient electric grid. Carbon capture, utilization and storage technologies like the Petra Nova project have the potential to help reverse coal's decline while also reducing emissions. Successfully achieving the commercialization of these technologies will both protect the environment and ensure that coal plants remain in service and competitive in energy markets. What are the most important actions that the federal government should take to facilitate the development and scaling up of carbon capture, storage and utilization technologies to power plants across the nation?

Questions from Senator Joe Manchin III

<u>Question 1</u>: The Petra Nova carbon capture and sequestration project is a joint venture between NRG and JX Nippon Oil & Gas operating a commercial scale post combustion carbon capture facility at NRG's Parish power plant southwest of Houston, Texas. This plant captures more than 90% of the carbon dioxide from a 240 megawatt plant for the use and sequestration of 1.6 million tons of carbon annually. The project came online in 2016. It has received $190 million from the DOE's Clean Coal Power Initiative (CCPI) – a cost-share collaboration. Petra Nova is the world's largest post-combustion carbon capture facility on an existing coal-fired power plant. It utilizes a Mitsubishi and Kansai Electric Power technology. The captured CO2 will be used for enhanced oil recovery in the West Ranch oil field. The oil production is expected to go from 300 barrels to up to 15,000. The plant first captured CO2 in September of 2016 and has delivered over 100,000 tons of CO2 to the oil field through an 80-mile pipeline. The facility turned over for operations on December 29, 2016. The plant can capture over 5,000 tons of CO2 per day which is the equivalent of taking more than 350,000 cars off the road. Still, it is enough to capture 1.6 million tons of carbon dioxide each year — equivalent to the greenhouse gas produced by driving 3.5 million miles, or the CO2 from generating electricity for 214,338 homes.

As experienced by your company, name for me the three largest barriers you experienced in getting Petra Nova off the ground.

Would you have undertaken this project without federal support?

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As experienced by your company, name for me the three largest barriers you see to realizing the commercial scale deployment of carbon capture utilization and sequestration (CCUS) technology.

Question 2: Given the importance of reliable and affordable electricity, and the critical role that coal plays in providing that power, do you agree the federal government should continue to provide financial support for the development and commercialization of advanced coal power generation technologies even beyond basic R&D?

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Questions for the Record Submitted to Mr. Greg Merritt

Question from Ranking Member Maria Cantwell

Question: Can you describe in more detail what role federal programs played in helping the LED industry and Cree specifically achieve cost reductions, product quality, and customer adoption?

Reply: Early DOE investment through shared cost R&D project funding as well as industry organizing via the Next Generation Lighting Industry Alliance (NGLIA) were important to accelerate the early technology advancements in LEDs. The R&D project funding enabled industry, including Cree to undertake projects earlier than would have been possible without the federal funding, and helped broaden participation among LED companies.

The ENERGY STAR program played a critical role in both encouraging higher levels of product quality and performance and in giving consumers greater confidence to try new technology. Without the ENERGY STAR program, consumers would have been subjected to products of unknown quality and would have adopted more slowly.

Questions from Senator Debbie Stabenow

Questions: Mr. Merritt, I am a strong advocate for core research funding at the Department of Energy and for bringing together government, private industry, and academia to advance new technologies. It is my understanding that the technologies that Cree has pioneered began with work conducted by students at NC State University. Do you believe that federal partnerships with private industry and academia are critical to developing the next-generation technologies and driving them to market? Additionally, do you support strong federal funding for Department of Energy research programs?

Reply: Yes, I believe that federal support of early technology development is critical to advancing the U.S. leadership position in developing new technologies. I also support strong funding for Department of Energy research programs, such as ARPA-E.

Questions from Senator Catherine Cortez Masto

Question 1: How have utility incentive programs and federal program certifications, such as ENERGY STAR, benefitted your company? If there are cuts to these programs, how will that impact the industry?

Reply: The early versions of new technology products can appear to be expensive, even though they pay for themselves through energy and other savings. Utility incentives and the associated certification programs, such as ENERGY STAR, help to encourage early adoption of these beneficial technologies. The early sales encourage companies to continue R&D investments and provide volumes to help create manufacturing efficiencies.

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Cuts to the ENERGY STAR program will cause significant problems for utility incentive programs, as well as for consumers seeking a known endorsement for energy efficiency products. ENERGY STAR serves as a nationwide certification used by utilities to qualify products for their programs.

Question 2: How can the government help educate the public about emerging energy technologies so they can more effectively incorporate them in their lives?

Reply: Federal government support for demonstration projects and trials help to validate new technologies and provide opportunities to promote the technologies. These efforts can be through government deployment of new technologies in federal facilities, or can be through partnerships with private entities or universities.

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Questions from Senator Joe Manchin III

<u>Questions</u>: West Virginia is hurting. The decline of the coal industry has been devastating. We are losing businesses and population. So, in addition to doing everything we can to stop the bleeding and help our people in the near-term, we are also looking for ways to revitalize our home state economy. One of the ideas that I am intrigued by and increasingly optimistic about is an opportunity that we have because of the wet gas in the Marcellus and Utica shale plays. We are working with the Mid-Atlantic Technology Research and Innovation Center (MATRIC) to help realize the potential of an Appalachian Storage Hub which could bring jobs to West Virginia. It would ensure we are maximizing the opportunities associated with our vast reserves of natural gas liquids (NGLs) such as ethane.

According to MATRIC, about 20% of the value in the Marcellus Shale alone is ethane, propane and butane natural gas liquids. So, ideally, the cultivation of such a hub would attract manufacturing companies that need reliable affordable access to these feedstocks. With safety and the environment top of mind, I'd like to see the Storage Hub move forward and it seems to me that this type of effort is what the creators of the Title XVII loan program at the Department of Energy envisioned when the Energy Policy Act of 2005 was passed. The loan program would help provide access to low cost financial capital that would alleviate investor concerns regarding technology and market risks.

In your point of view, how important has the loan guarantee been to the renewable energy and energy efficiency space in helping to commercialize new energy technologies?

What are the barriers to increased utilization of this program in the fossil energy space?

Senator Manchin, thank you for your questions. While I empathize with communities that have been hurt by the changes in the coal industry, I do not believe I can help here. My employer, Cimarex Energy Co., does not have any operations in the Marcellus or Utica, and I am not familiar with the Mid-Atlantic Technology Research, the Appalachian Storage Hub, or the Title XVII loan program.

Cimarex is an upstream oil and gas operator. That is, it looks for and produces oil and gas, and it does so almost exclusively in Oklahoma, Texas and New Mexico, none of which has a coal industry presence. Given this background, I, unfortunately, cannot provide you with meaningful answers to your questions. I suggest you address your questions to representatives of oil and gas companies that have operations in the Northeast, such as EQT, Cabot Oil and Gas or Range

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Resources. All of these companies have significant operations in the Marcellus and may be able to offer some insight.

I appreciate the Committee's willingness to let me come and testify before it, and I look forward to the outcomes of Chairman Murkowski and Ranking Member Cantwell's series of hearings on emerging energy technologies.

Steven J. Simonton
Vice President – Drilling & Completion Operations
Cimarex Energy Co.

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Questions from Ranking Member Maria Cantwell (D-WA)

Question 1: How can electric vehicles serve as an asset to our electricity grid?

Electric vehicles (EVs) can act as distributed energy resources by using the vehicle's battery to enable a cleaner, more efficient, and reliable electricity grid. Managed vehicle charging can help balance the grid by charging at night when electricity demand is low. In addition, EVs can be scheduled to charge at times that complement renewable energy generation, such as mid-morning peaks of solar production. As a mobile energy storage resource, EVs open new possibilities to be an asset to the gird.

Question 2: What are some of the obstacles in deployment of electric vehicle charging infrastructure?

Financing is a major obstacle in deployment of EV charging infrastructure. High capital costs for new infrastructure, associated financing costs, high operating costs, and expired federal tax credits are challenges preventing a profitable business case for EV charging infrastructure. Both public and private sector investments in EV charging infrastructure are needed for greater EV adoption. For private investors, access to financing and incentives can promote growth of EV charging infrastructure.

In addition, retail utility rate design is critical to improving the financial performance of EV charging networks. Utilities and their regulators need to evaluate beyond traditional building loads and into more dynamic electricity demands from EV charging. Their rate structure for EV charging should consider time and locational value and limit fixed and demand charges.

Question 3: What role do utilities play in electric vehicle charging infrastructure development?

Utilities and their regulators can set rate structures that support electrification of transportation. The current rate structure for EV charging poses significant challenges for the financial viability of EV charger ownership. A study of EVgo's 230 DC fast charging stations in California by the Rocky Mountain Institute found that demand charges can be responsible for over 90% of electricity costs. Many existing investments in EV charging have poor financial and operational performance, which prevents market transformation. Utilities, regulators, and charging infrastructure owners need to collaborate on a business model that provides a competitively priced and extensive public network to all EV drivers.

As EV adoption grows at an unpredictable pace, EVs present challenges to effective grid management, such as potential stress, congestion, and distribution upgrades. Utilities will need to adjust quickly and plan for necessary local distribution upgrades to ensure reliability and resiliency of the electric grid. In the latest sales report for the US, the EV market experienced a surge in sales in May 2017 with 16,240 units, a 44% increase compared to a year earlier. As

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automakers continue to introduce more EV products, utilities need to be informed on how they can accommodate new demand on their systems.

Questions from Senator Debbie Stabenow (D-MI)

Question 1: Being from Michigan I am particularly interested in how automobile companies are planning to deliver fuel-efficient, cleaner, and safer vehicles to consumers more quickly. Recognizing that MB Energy is a division of Daimler, what policies are needed to accelerate electric vehicle sales in the United States, particularly in light of the President's deep budget cuts to the Department of Energy, to help speed the deployment of electric and other alternative fuel technologies?

The federal government has an important role to play in advancing EV and alternative fuel technologies. Continued collaboration between industry and the Department of Energy on research that focuses on alternative fuel, advanced technologies both for vehicles and energy storage systems will aid in greater, faster deployment. Federal tax credits for vehicles and charging infrastructure act as motivating incentives for purchasers to make the decision to buy and install. The Department of Energy can act as a powerful convener for manufacturers, businesses, utilities, retailers, and other affected stakeholders to gather and address ways to effectively deploy charging infrastructure across the United States.

Question 2: We know that electric vehicles can deliver societal and economic advantages both in terms of achieving cleaner air and lowering petroleum usage. But, electric vehicles still represent less than 1 percent of vehicle sales in the United States. A significant hurdle is cost. In your testimony you talk about battery costs declining. What factors are contributing to the decline in vehicle battery costs? Do you think federal tax credits for electric vehicles are still needed?

Yes, federal tax credits are still needed. A key concern for customer adoption of electric vehicles is range. Even though battery prices are declining, we are also adding larger batteries to our products to increase range, which increases cost. Currently less than one percent of light-duty vehicles sold in the United States are electric and plug-in electric models. Tax credits help bridge the cost gap that currently exists between electric and traditional, gasoline powered vehicles. Tax credits act as an incentive for purchasers who might be wary of new technology to make the decision to buy. Given the current slow consumer acceptance for electric and plug-in relative to conventional fuel vehicles, tax credits are an important tool in the toolbox to speed sales. Our company is working diligently to improve technology, increase scale production and decrease cost. Once higher sales volumes of electric and plug-in models are achieved, the need for tax credits will naturally recede.

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Questions from Senator Catherine Cortez Masto (D-NV)

Question 1: From lithium mining in the south of our state to full production in Reno, Nevada is at the forefront of a growing battery sector. In your 10+ years of experience in the automotive industry dealing with electric vehicles, the grid, and battery technology, what advancements in battery technology do you envision will occur in the following decade?

We see lithium-ion batteries as the dominant technology for electric vehicles for the next decade. However, our approach is to continue investments in research and development of advanced transportation technologies. Cell chemistry may evolve and we are prepared to incorporate any technology advancements of batteries into our vehicles and energy storage systems. In addition to lithium-ion batteries, we continue to invest in alternative drive trains, such as fuel cell technology, to have a diverse approach to changing consumer needs.

Question 2: As I've witnessed in Nevada and as you stated in your testimony, one of the major drivers of the clean energy sector is the rapid decline in battery prices with a roughly 80% decrease in prices since 2010. In what ways can the government expedite these falling battery costs? And do you anticipate a slowdown in the battery technology sector if government investment is limited?

As mentioned in my testimony, battery prices are in rapid decline as production volume increases to meet the anticipated demand. The government can support continued price declines of battery prices by supporting the market enablers for electric vehicles and energy storage The market success of these technologies will help drive this price reduction by increasing investment in production and technology research. Regarding a slowdown in the sector, costs will continue to go down even in the absence of greater government investment but government investments can accelerate technology deployment.

Question 3: How has Mercedes Benz invested in energy storage, shared mobility services, and electric vehicle charging infrastructure?

As a company, we are transforming from an automobile manufacturer to provider of mobility services. Regarding electrification, we invested over $1 billion in research, development, and manufacturing of lithium-ion battery technology. With the formation of Mercedes-Benz Energy, we are committed to advancing energy storage technology and providing innovative energy solutions. In shared mobility, we have the largest car-sharing company in the world, car2go, which uses our smart cars. Going forward, all of our smart cars in the US will be electric. In EV charging, we led an investment round of $82 million in ChargePoint, the largest EV network in North America.

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Question 4: According to Bloomberg New Energy Finance, between 2020 and 2030, EVs will become cheaper to own than cars with internal combustion engines. What are the factors that will lead to such a decrease in costs for EVs?

The primary factors that can lead EVs to be cheaper than cars with internal combustion engines (ICE) are cost reductions in batteries and fuel economy regulations. The most expensive component of an electric vehicle is currently the battery. As volume manufacturing of batteries continues, battery costs will become comparable and eventually cheaper than ICE vehicles. Furthermore, continuous advancements in battery chemistries, higher material efficiencies and better engineering can lead to significant improvements in battery density. Policy is a major driver to the speed of this EV-ICE parity. More stringent fuel economy rules will increase costs for ICE vehicles.

Question 4: You mention in your testimony that Mercedes is taking a holistic approach to the electrification of transportation. Obviously our transportation system is a significant sector that impacts domestic energy use, emissions, and efficiency opportunities.

One of the efforts that cities like Las Vegas have been working on is the concept of a SMART community where the integration of technology and innovation can help reduce congestion and improve various inefficiencies. That's why I have been working on a SMART communities bill to help expand things like smarter land use, intelligent congestion mitigation efforts, and technology like electric vehicle and charging station utilization. Do you have recommendations for cities like Las Vegas that also want to approach their transportation sector from a holistic perspective?

We commend your efforts to find solutions for cities that can make transportation smarter, cleaner and safer. The holistic approach Daimler is taking to prepare for the future of mobility is a strategic framework called CASE, which stands for connectivity (Connected), autonomous driving (Autonomous), flexible use (Shared & Services) and electric drive systems (Electric). As new technologies and forms of communication open up a host of possibilities between the vehicle and its passengers and between vehicles on the road, we continue to evaluate and expand our services. We recommend that Las Vegas and similar cities stay open to change as new technologies transform the automotive industry and our transportation systems.

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Questions from Ranking Member Maria Cantwell

Question 1: Can you describe why your company supported and continues to support the Paris climate agreement?

Answer: Siemens supports the Paris Climate Accord signed by 194 countries. We have committed to cut our global carbon footprint in half by 2020 and to make our global operations carbon neutral by 2030. This commitment is not contingent on international treaties or regulations.

We understand that taking action to address the causes of climate change is not only prudent, but also makes economic sense. Siemens' $110 million investment targeting our facilities will pay for itself in just five years and generate at least $20 million in annual savings thereafter. The company recognizes that an increased push for energy efficiency, renewable energy technology and electric mobility, along with the growing digitalization movement, will speed up a carbon-free future, supporting the growth of a global middle class as well as prosperity for developing countries and increased resilience of economies.

Question 2: How can electric vehicles serve as an asset to our electricity grid?

Answer: Electric vehicles provide several key benefits to the grid. First, at a time of slowing demand growth and even declining sales in some regions, electric vehicles represent an important growth opportunity for electric utilities. Because most grid costs are fixed, having greater demand for electricity – greater throughput – could help slow the rate of price increases. The cost of the infrastructure is distributed over more kWh delivered. Second, electric vehicles can help balance the grid. With the right price signals, such as automated time-of-use or hourly price, electric vehicle charging occurs at off-peak times, avoiding further burdening the grid during peak hours. At the same time, electric vehicles are a great way to utilize generation at times of abundance – with high amounts of hydro, wind, or solar. We believe that optional time-varying rates are a potential solution. Third, electric vehicles can serve as an additional resource to meet grid needs during peak hours. Electric vehicle batteries can help feed stored electricity back onto the grid. Fourth, with the right communications and automation infrastructure, electric vehicles can provide ancillary services to wholesale markets, potentially including imbalance power, voltage and frequency support, and spinning reserve.

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Question 3: How will renewables help the country become more resilient in light of weather threats?

Answer: As public opinion and consumer demand drives policy toward a balanced energy ecosystem where affordability, reliability and sustainability are placed in equal balance of importance, distributed energy resources will become more prevalent. As such, renewable energy sources will play a major role in providing consumers with access to sustainable distributed energy sources. And, while renewable energy sources do not directly purport reliability, the combination of all distributed energy sources and software can provide a higher level of grid resiliency. In addition to the combination of renewable generation and software, applying energy storage in conjunction with the former technologies allows an even higher level of sustainable generation and reliability. Thus, we can achieve an affordable, reliable and sustainable energy infrastructure through the use of technology designed to efficiently connect distributed energy resources and access energy when it is most needed.

Question 4: How are you addressing the energy workforce skills gap?

Answer: Siemens has developed a formula for success when it comes to helping to address the skills gap. As a company whose technology supports dozens of industries and thousands of companies worldwide, Siemens understands the skills required to not only run its technology but to drive the industry forward. In order to bridge the skills gap and help equip workers with the skills needed to operate this technology, Siemens is creating public-private partnerships bringing together industry, academia and government.

One of those areas of contribution is workforce development, preparing workers with the skills they need to fill the jobs of the 21st century. Siemens understands that developing a highly-skilled workforce in the U.S. goes beyond the bottom line. It adds value to the industries the company works with, strengthens families and communities, supports the economy, and most importantly, builds the middle-class. That is why Siemens is investing in promising training models like apprenticeships and critical workforce development partners like community colleges. Collectively, Siemens is helping build the ecosystem of public and private partnerships necessary to strengthen the middle-class through skills training.

In fact, recently Siemens announced additional commitments to building the U.S. workforce in three critical areas:

- Doubling Siemens' industry-leading apprenticeship program (currently in four states, increasing to eight);
- Hiring at least 300 new veterans per year for the next three years, with a goal to add at least 1,000 veterans;
- Providing an additional $2 billion worth of in-kind grants of our industrial software package to academic and training institutions (above the $3 billion already granted).

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We are eager to continue to work with public and private partners across government, economic development organizations, schools and others to continue building a 21st century workforce and enhancing opportunities in America.

Question 5: Do you support the Export-Import bank and what does the Export-Import bank mean for energy technology?

Answer: The Export-Import Bank is very important to Siemens and our U.S. employees. Siemens has invested over $40 billion in the U.S. over the last 15 years with more than 50,000 U.S. employees and more than 60 manufacturing sites in the U.S. In 2016, Siemens U.S. revenues were $23.7 billion including approximately$5.5 billion in exports. The Export-Import Bank has been a critical part of this success helping Siemens invest further in the U.S. and create additional U.S. jobs. For example, our Charlotte, NC plant is now our worldwide hub for 60 Hz power generating equipment, with additional capabilities for the 50 Hz market. We moved that plant to the U.S. several years ago to take advantage of the Export-Import Bank as an important financing tool for Siemens and our customers. In fact, in 2012 alone, the Bank approved export financing for Power Generation Equipment supporting 825 jobs there at Siemens' Charlotte plant with a $638 million direct loan to finance the sale by Siemens Energy, Inc. of gas and steam turbines to be installed in Saudi Arabia. This is just one example of the importance of the Bank's work. However, the absence of a functioning Export-Import Bank impacts our ability to compete for global deals that would be filled by our U.S. manufacturing facilities. Our projects are typically well over the $10 million threshold requirement needed for a vote. We hope that the Senate will act quickly once nominees are brought forward and we hope those nominees will be individuals who are dedicated to the Bank's mission and understand the benefits of supporting large projects. We hope to see a fully functioning Export-Import Bank as soon as possible.

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Question from Senator Steve Daines

Question: In your testimony, you mention the need and importance of energy storage projects. In order to provide reliable renewable energy from sources such as wind and solar, we have to have an ability to store that energy when the wind is not blowing and the sun is not shining. One of the ways to store energy from intermittent energy sources is through closed-loop pumped hydro storage systems. One of the leading projects in the nation is in Montana at the Gordon Butte pumped hydro facility, recently approved by FERC. It is important that we can streamline these projects so that they can come to market in a reasonable and timely manner. What do you believe Congress can do to help streamline the permitting of these projects?

Answer: Siemens is not currently involved in the Gordon Butte facility; however, we do support smart streamlining of the permitting process that removes unnecessary barriers and helps the United States move forward with necessary infrastructure projects to increase our energy solutions and increase U.S. jobs. We are available to discuss broader ways to streamline the permitting process for infrastructure projects.

Questions from Senator Joe Manchin III

Question 1: Approximately 2.2 million Americans are employed in the design, installation or manufacturing of energy efficiency jobs according to a January 2017 Department of Energy Report on U.S. Energy and Employment. Energy efficiency jobs can broadly be defined as services that reduce end-use energy consumption. This includes the design, manufacture, and installation of ENERGY STAR appliances and ENERGY STAR labeled products. Demand for energy efficiency employment is expected to increase again in 2017 with energy efficiency employers projecting a nine percent growth rate for 2017 and construction employers projecting 11 percent energy efficiency job growth. In West Virginia, we have approximately 6,400 energy efficiency jobs and over 20,000 jobs related to energy efficiency. The U.S. Energy and Employment Report analyzed four sectors of the U.S. Economy: Electric Power Generation and Fuel; Transmission, Distribution and Storage; Energy Efficiency; and Motor Vehicles. Of these four, energy efficiency is the fastest growing sector.

Can we expect this trend of energy efficiency job growth to continue to outpace other sectors? Where are the greatest numbers of job opportunities in the Energy Efficiency space right now?

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Answer: Siemens Building Technologies' current energy efficiency expertise is in the delivery of built infrastructure projects, which include the design, construction, and commissioning of energy efficient solutions, and the manufacturing of components that contribute to achieving those efficiencies. We see growth in both manufacturing of components and the delivery of these projects. Market data from trade associations indicate this sentiment is industry wide and the forecast is for energy efficiency to outpace other industry sectors in terms of growth.

Question 2: The Trump administration has proposed to eliminate the ENERGY STAR program and turn it over to the private sector.

Have you considered the ramifications of eliminating that program, and could that have the unintended consequence of hindering job growth in the energy efficiency job sector?

Answer: From a Siemens Building Technologies perspective we have seen continued interest from customers for efficient projects and products that deliver cost savings. While there are always improvements that can be made to federal programs, ENERGY STAR has a proven record of delivering savings for consumers within the federal government.

Questions from Senator Catherine Cortez Masto

Question 1: Mr. Yates, you stated in your testimony that as energy development continues to advance, the lack of transmission has become a barrier to transporting solar and wind energy to population centers. In your view, what are the main barriers to identifying transmission needs and getting these projects built?

Answer: While conventional electricity generation project locations were based upon population centers, wind and solar project sites are chosen based on the topography and other naturally occurring parameters. These sites are mostly in remote areas away from population centers. Therefore, in most cases, a new and more lengthy transmission infrastructure is required that crosses state lines and multiple jurisdictions. This is compounded by the need of access rights, permitting and higher construction costs. To address these unique challenges and support the build-up of our nation's renewable infrastructure, Congress should support policies that encourage investment and provide regulatory balance to acquire faster permitting. Timely processing and approvals of projects can shorten construction cycles.

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Question 2: What are the some of the ways that Siemens envisions modernizing the grid? Do you think working on a regional basis is the best approach? Or should there be a more localized approach? What do you believe are the best ways for the federal government to facilitate more rapid modernization?

Answer: The grid should be modernized at both regional and local levels. Modernization via software, transmission upgrades, and automated controls technology has made this possible. At the local level – the state or individual utilities – grid modernization improves power quality, reliability, and safety while also enabling the grid to accommodate the full range of distributed energy resources: distributed generation, storage, demand response, energy efficiency, electric vehicles, and microgrids. The federal government can facilitate more rapid modernization by documenting and publicizing success stories to policy-makers and utilities across the country, by identifying and cataloging best practices and standards for use by policy-makers and utilities, and by providing expert assistance to state and local policy-makers, at their request.

Question 3: Can you elaborate on how crucial software, including Siemens software and automation controls, is for the modernizing the grid, distributed energy assets, and micro-grids?

Answer: Software and automation controls are inherently necessary in any grid modernization effort. They provide the brains and tools to enable the systems to manage distributed energy resources, from microgrids to electric vehicles. Our software links central utility systems such as market software, load forecasting, and distribution planning to the day-to-day operation of the grid and the millions of end points connected to it. This includes distributed sensors, controllers, remote intelligent switches, line equipment, smart meters, load control equipment, electric vehicle charging equipment, and more. A crucial element in maximizing the reliability, safety, and economic benefits for electricity consumers is the end-to-end solution we provide, from grid control to grid applications to customer enablement and engagement.

To support the integration of distributed energy resources (DER), the grid (in particular, the distribution grid) needs to be "modernized". The distribution grid has historically operated statically with very little, if any, monitoring, automation or control. Operation, trouble management and maintenance of the distribution grid is, even today, done largely using manual processes which are managed using call handling, outage management, and mobile workforce management systems and software. These systems process customer trouble calls (telephone calls), attempt to predict the most probable equipment that may have operated/failed on the grid, and guide field crews to manually isolate grid sections, locate the problem, repair and restore service.

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Moving forward, grid modernization must include significant amounts of sensors for visibility, be more automated to improve the reliability levels necessary to integrate DER and maximize access and connectivity to the distribution grid, support remote control to ensure safety and expedite restoration, and allow microgrids to continue operations if connection to the grid is lost under extreme conditions. The advent of these changes will increase the amount of information available to grid operators to safely and economically manage the grid by orders of magnitude.

This makes the automation, software, and underlying data models essential to enabling the grid operator's ability to handle increasing variability of energy demand, manage more rapidly changing conditions, and optimize distributed resources for reliability and economic objectives. These systems do for the grid operator what automation and auto-pilot technology does for pilots: improve safety, assess/avoid or rapidly react to problems, process available information to optimize fuel consumption and give clear situational awareness of current and forecast conditions.

Question 4: You mentioned that a significant part of renewable energy cost declines stem from the manufacturers' ability to innovate. Do you believe the federal government has been a valuable partner in R&D investments as well as creating more opportunities for innovation? What do you believe the role for federal government should be with respect to innovation?

Answer: Yes, the role of the federal government through partnerships and R&D has been invaluable in helping to advance the U.S. energy sector. Through partnerships between universities, laboratories such as those at the Department of Energy, and other parts of the U.S. government, and companies like Siemens, we have experienced groundbreaking technological advancements in the U.S. At Siemens we work closely with our customers in a wide variety of industries to develop new technologies that help move the industry forward, without losing focus on the next big advancement. A critical component of what enables us to do this is the broad culture of innovation at work in the United States. Continued success in such partnerships is critical to future advances in the U.S. energy sector.

Question 5: Nevada is considering a renewable portfolio standard that would include a storage target, a policy that contributed to significant growth of that technology in California. Do you think the cost of storage technologies will come down even further? Do you believe that advancing storage technology is benefitted by government research?

Answer: The cost of storage technologies will continue to decrease not only on a product basis ($/kWh), but also on a levelized cost of energy basis which takes into account the long term cost of ownership of a system. Advancing storage technology is benefitted by government research as there are many new solutions that are coming to the forefront. Siemens is also actively engaged in research efforts related to energy storage technology.

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Question 6: Nevada is considering a bill to raise the current percentage requirement of renewables from 25 percent to 40 percent by 2030. Do you believe state renewable portfolio standards are important in incentivizing renewables? Have they been helpful to your company?

Answer: Policy support and customer demand for renewables is important as the renewable industry grows in the U.S. This includes programs such as renewable portfolio standards. According to Lawrence Berkeley National Laboratory (LBNL), "Roughly half of all growth in U.S. renewable electricity generation and capacity since 2000 is associated with state RPS requirements."[i] Additionally LBNL found in a previous study, "that renewable energy developed to meet state RPS requirements in 2013 reduced consumer electricity bills by up to $1.2 billion."[ii]

Question 7: You mentioned the Southern Cross Transmission project in your testimony as an innovative high-voltage transmission line that would facilitate the delivery of low-cost renewable and conventional energy. Nevada and other states in the West are looking at ways to become more interconnected in order to provide an expanded and reliable clean energy supply. Do you believe this project is a model for western states that want to move toward a more interconnected grid with a higher concentration of renewables?

Answer: The Southern Cross Transmission project is a great example of an innovative high-voltage direct current (HVDC) transmission line that would facilitate the delivery of low-cost renewable and conventional energy and help spur economic development. The use of HVDC is a tested and reliable technology that provides controllable transmission of energy including that from renewable energy sources. The technology is portable and can be used in all regions across the U.S. that are in need of transporting new sources of energy effectively and efficiently across a long distance to load centers. This technology also allows for more power to be transferred down a single Overhead Line (OHL) than a traditional AC system with lower losses, which reduces potential environmental impact.

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Questions for the Record Submitted to Mr. Kevin Yates

Question 8: You discussed Compressed Air Energy Storage in your testimony. You mention that this type of technology could allow wind and solar to become base load generators. There are a lot of conversations right now about which energy sources should be considered for base load generation. Can you elaborate? What policies could help advance this technology?

Answer: As discussed in my testimony, energy storage has emerged as one of the most critical technologies for moving the energy sector to the next level. For Siemens, energy storage is not just one technology but a dynamic pursuit of innovative solutions for customers that allow for electricity to be produced and consumed at different points. Energy storage solutions like Compressed Air Energy Storage (CAES) allow electricity generators the ability to store the energy generated when demand is low and then pull from that source when demand increases. Simply put, given the flexibility of the cycle and the gigawatt hours CAES can store, this allows a renewable generator(s) to provide a firm Power Purchase Agreement (PPA). When they generate more than contracted, they store the energy with CAES and when they are not able to generate as much as they contracted, they supplement with CAES.

It is imperative that policies are written with a focus on supporting advanced technologies and removing roadblocks to commercialization. We believe there is a strong need for public-private partnerships including with areas of the government such as the Department of Energy (DOE) and the Federal Energy Regulatory Commission. Early stage R&D, along with advanced modeling and broader work to support energy storage development, will help advance important technologies in this area, not only for CAES but for other energy storage technologies.

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[i] Lawrence Berkeley National Laboratory, https://emp.lbl.gov/publications/us-renewables-portfolio-standards-0
[ii] American Wind Energy Association, http://www.awea.org/Advocacy/Content.aspx?ItemNumber=5217