POWERING AMERICA: THE ROLE OF ENERGY STORAGE IN THE NATION'S ELECTRICITY SYSTEM

HEARING

BEFORE THE

SUBCOMMITTEE ON ENERGY

OF THE

COMMITTEE ON ENERGY AND COMMERCE

HOUSE OF REPRESENTATIVES

ONE HUNDRED FIFTEENTH CONGRESS

SECOND SESSION

JULY 18, 2018

Serial No. 115–152

Printed for the use of the Committee on Energy and Commerce

energycommerce.house.gov

U.S. GOVERNMENT PUBLISHING OFFICE

35–498 WASHINGTON : 2019

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SUBMITTED MATERIAL

POWERING AMERICA: THE ROLE OF ENERGY STORAGE IN THE NATION'S ELECTRICITY SYSTEM

WEDNESDAY, JULY 18, 2018

HOUSE OF REPRESENTATIVES,
SUBCOMMITTEE ON ENERGY,
COMMITTEE ON ENERGY AND COMMERCE,
Washington, DC.

The subcommittee met, pursuant to call, at 9:03 a.m., in room 2322, Rayburn House Office Building, Hon. Fred Upton (chairman of the subcommittee) presiding.

Present: Representatives Upton, Olson, Barton, Latta, Harper, McKinley, Kinzinger, Griffith, Johnson, Long, Bucshon, Flores, Hudson, Walberg, Walden (ex officio), Rush, McNerney, Peters, Green, Doyle, Castor, Welch, Tonko, Schrader, and Kennedy.

Staff Present: Samantha Bopp, Staff Assistant; Kelly Collins, Legislative Clerk, Energy/Environment; Wyatt Ellertson, Professional Staff Member, Energy/Environment; Margaret Tucker Fogarty, Staff Assistant; Mary Martin, Chief Counsel, Energy/Environment; Sarah Matthews, Press Secretary, Energy/Environment; Drew McDowell, Executive Assistant; Brandon Mooney, Deputy Chief Counsel, Energy; Brannon Rains, Staff Assistant; Annelise Rickert, Counsel, Energy; Peter Spencer, Senior Professional Staff Member, Energy; Austin Stonebraker, Press Assistant; Madeline Wey, Policy Coordinator, Digital Commerce and Consumer Protection; Hamlin Wade, Special Advisor, External Affairs; Rick Kessler, Minority Senior Advisor and Staff Director, Energy/Environment; John Marshall, Minority Policy Coordinator; Alexander Ratner, Minority Policy Analyst; and Tuley Wright, Minority Policy Advisor, Energy/Environment.

OPENING STATEMENT OF HON. FRED UPTON, A REPRESENTATIVE IN CONGRESS FROM THE STATE OF MICHIGAN

Mr. UPTON. Good morning, everybody.

So, on this day a year ago, the Energy Subcommittee launched its "Powering America" hearing series focused on the Nation's electricity system. And, over the past year, the committee has explored important topics such as wholesale power markets; electric generation; infrastructure, both transmission and distribution; reliability; and technological innovation. And this hearing is the 11th in the series and explores the important topic of large-scale energy storage.

Electricity is indeed a fundamental and essential part of our everyday lives and the interruption of which has far reaching impacts on our livelihood, health, welfare, national security, and everything else. That is why it is important to utilize all forums of tools and technologies, including energy storage, to help ensure our nation's electric grid is reliable as well as resilient.

For example, one electric utility who serves Michigan recognized the value of energy storage early on. In 2002, AEP, American Electric Power, demonstrated the use of a sodium sulfur battery for the first time in the U.S., and by 2008 they had deployed three 2-megawatt batteries across the U.S.

Large-scale energy storage has benefits and unique attributes that can improve the reliability and resiliency of the Nation's electric grid. Energy storage can help manage peak electricity load, provide essential reliability services such as voltage and frequency controls, improve reserve capacity, and provide black start capability.

The electricity industry is responsible for planning and preparing for disruptions to the supply of electricity. And in 2017 the Atlantic hurricane season was unprecedented. Multiple storms in close succession slammed into the Gulf Coast, Puerto Rico, U.S. Virgin Islands. These storms left blind catastrophic damage, which resulted in major disruptions of electricity to millions of Americans across the country.

And when power outages occur, electricity providers can use energy storage as a black start resource to restore electricity quickly. Black start is when a power plant is turned back on after an outage with the help of a transmission system. Because energy storage resources have a reserve of electricity available, they can provide the necessary power to bring other power plants back online. This is important because in emergency situations associated with electricity outages access to electricity from the transmission system is often not possible.

Demand for electricity varies depending upon a variety of factors, including the time of day, season, and region. An example of this is during the warmer summer months a greater amount of electricity is consumed through air conditioning compared to cooler spring or fall. During these times of peak electricity consumption, more expensive generation units are generally used to meet the increased demand. Energy storage allows for electricity to be stored during off-peak times when electricity is less expensive and then deployed during these periods of high demand. The ability for energy storage to energy time-shift can reduce costs for electricity providers, which can lead to savings for consumers.

So today's panel of witnesses represents different aspects of the electricity industry when it comes to storage.

Thanks for taking the time to join with us today.

And I was going to yield to Mr. Hudson, but he is not here, so I will yield back my time and recognize the ranking member of the subcommittee, Mr. Rush, for 5 minutes for an opening statement.

[The prepared statement of Mr. Upton follows:]

PREPARED STATEMENT OF HON. FRED UPTON

On this day, 1 year ago, the energy subcommittee launched its "Powering America" hearing series focused on the Nation's electricity system. Over the past year, the Committee has explored important topics such as wholesale power markets, electric generation, infrastructure—both transmission and distribution, reliability, and technological innovation. Today's hearing is the eleventh hearing in this series and explores the important topic of large-scale energy storage.

Electricity is a fundamental and essential part of our everyday lives, and the interruption of which has far-reaching impacts on our livelihoods, health, welfare, and national security. This is why it is important to utilize all forms of tools and technologies, including energy storage, to help ensure our nation's electric grid is reliable and resilient.

For example, one electric utility, who serves my home State of Michigan, recognized the value of energy storage early on. In 2002, AEP demonstrated the use of a sodium sulfur battery for the first time in the U.S. By 2008, AEP had deployed three 2 megawatt batteries across the United States.

Large-scale energy storage has benefits and unique attributes that can improve the reliability and resiliency of the Nation's electric grid. Energy storage can help manage peak electricity load; provide essential reliability services such as—voltage and frequency control; improve reserve capacity; and provide black start capability.

The electricity industry is responsible for planning and preparing for disruptions to the supply of electricity. The 2017 Atlantic hurricane season was unprecedented—multiple storms in close successions slammed into the Gulf Coast, Puerto Rico, and the U.S. Virgin Islands. These storms left behind catastrophic damage which resulted in major disruptions of electricity to millions of Americans across the Nation.

When power outages occur, electricity providers can use energy storage as a "black start" resource to restore electricity quickly. Black start is when a power plant is turned back on after an outage without the help of the transmission system. Because energy storage resources have a reserve of electricity available, they can provide the necessary power to bring other power plants back online. This is important because in emergency situations associated with electricity outages, access to electricity from the transmission system is often not possible.

Demand for electricity varies depending on a variety of factors, including the time of day, season, and region of the United States. An example of this is during warmer summer months, a greater amount of electricity is consumed through air conditioning compared to cooler spring or fall months.

During these times of peak electricity consumption, more expensive generation units are generally used to meet the increased demand. Energy storage allows for electricity to be stored during offpeak times when electricity is less expensive, and then deployed during these periods of high demand. The ability for energy storage to "energy time-shift" can reduce costs for electricity providers, which can lead to savings for consumers.

Today's panel of witnesses represent different aspects of the electricity industry when it comes to energy storage. Thank you for taking the time to join us today and I look forward to your perspectives on how energy storage improves the nNation's electric grid.

OPENING STATEMENT OF HON. BOBBY L. RUSH, A REPRESENTATIVE IN CONGRESS FROM THE STATE OF ILLINOIS

Mr. RUSH. I want to thank you, Mr. Chairman, for holding this critical and timely hearing.

Mr. Chairman, as we have discussed throughout this "Powering America" series of hearings, the domestic energy landscape is changing drastically in fundamental ways. As we move toward a more decentralized energy economy, storage offers tremendous opportunities to integrate clean, renewable energy resources in order to build a more efficient, resilient, and effective electric grid.

With the evolution, Mr. Chairman, of various technology, in addition to the increased production costs, energy storage offers a uniquely flexible technology that can be utilized to meet the changing demands of customers of utilities as well as of the grid as a whole.

Energy storage, Mr. Chairman, is an incentive, in that it provides consumers more control over when and how they use energy while also helping them save money. With storage technology, Mr. Chairman, utilities are able to defer or even completely avoid making huge investments in other more costly physical assets such as wires, poles, transformers, and substations, while still meeting the needs of energy consumers.

Additionally, Mr. Chairman, energy storage can help make the grid more resilient during severe weather events and provide emergency power during times of disaster. Storage technology can play a vital role in rebuilding electric networks necessary for local communities and is a cost-effective alternative to other traditional options.

This is true whether it be for establishing power for rural or isolated communities or helping to quickly turn the lights back on for residents of Puerto Rico and the Virgin Islands after a disastrous hurricane like Maria. In fact, this technology can be used to establish microgrids and minigrids, or it can be utilized in fully distributed generation networks.

Mr. Chairman, even with all these tremendous benefits that energy storage offers, there are still significant obstacles impeding the emergence of this budding industry, including economic, regulatory, and market barriers.

Mr. Chairman, there must be a strategic and calculated effort by the Federal Government in order to fully develop this technology and appreciate its enormous benefits. Specifically, there must be more Federal funding to help offset the lack of investment from the private sector in electricity storage research, development, and demonstration.

Additionally, we must consider, Mr. Chairman, development of a Federal energy storage roadmap, similar to those established by some States, in order to increase coordination among the various private initiatives, the national labs, and other Federal agencies.

Finally, while FERC Order 841 was issued to ensure fair and equal access for storage resources to compete in wholesale power markets, we must go even further on the Federal level. In each of their testimonies, almost all of the witnesses agree that we must do more to remove barriers to grid and market access, allow storage to compete in all planning and procurement processing, and provide appropriate value and compensation for the unique flexibility that storage technologies provide.

Mr. Chairman, energy storage has the potential to fundamentally transform the way we produce and use electricity in a way that benefits the Nation as a whole, but we must be willing to make the necessary commitments and the necessary investment in this technology for it to do so.

With that, Mr. Chairman, I want to thank you, and I yield back.

Mr. UPTON. The gentleman yields back.

The chair would recognize the chairman of the full committee, Mr. Walden.

OPENING STATEMENT OF HON. GREG WALDEN, A REPRESENTATIVE IN CONGRESS FROM THE STATE OF OREGON

Mr. WALDEN. Good morning, Mr. Chairman.

And to our members and our panelists, thank you for being here.

Today we continue our series on "Powering America," taking a closer look at what a lot of people think to be the next big game-changer, and that is the Nation's, in the electricity sector, large-scale battery storage.

For years, companies have been working to develop and pioneer battery storage technology that is both cost-effective and scalable. We are now at the point where that technology is coming to fruition and being deployed on the grid in a meaningful way.

The potential benefits of battery storage are substantial. Batteries allow us to store energy when demand and prices are low and release the energy when demand and prices are high. This not only optimizes the way our electricity system works, it also lowers electricity costs, meaning that American families can keep more money in their pockets after paying their monthly electricity bills.

So we have a lot of work to do here. My home State of Oregon has been ahead of the curve when it comes to recognizing the benefits of energy storage. Many of our electric utilities are integrating energy storage projects.

The Pacific Northwest is home to the Department's Pacific Northwest National Laboratory, where researchers work to advance and develop energy storage technologies for grid-scale deployment. PNNL has tens of thousands of square feet of laboratory space dedicated to accelerating the development of energy storage technologies.

In 2015, PNNL opened their Advanced Battery Facility, which was built to bridge the gap between fundamental battery research and commercial-scale battery development. I recently toured that facility, I guess about a year ago now, with Secretary Perry. It was really impressive.

Clearly, there is great potential in the role that large-scale battery storage can play in the Nation's electricity system, but, before that potential is fully realized, there are a number of barriers and challenges that still need to be tackled. These challenges range from technological limitations and costs to wholesale market participation rules.

In order to address some of the challenges faced by energy storage, FERC recently issued Order No. 841 directing the RTOs and ISOs to amend their market rules in order to better accommodate the participation of electric storage technologies. As you know, right now, grid operators are in the process of implementing the requirements and directives contained in Order No. 841, which is something this committee will continue to pay attention to as things move forward.

Last fall, as part of the Energy Subcommittee's "Powering America" hearing series, we examined technology's role in the electricity system. Energy storage was a main topic of discussion at that hearing, and, during that hearing, we heard from a witness who provided an example of how market rules can create barriers to competition for energy storage in wholesale electricity markets. That witness described an RTO/ISO rule with a definition of a storage product that only accommodated older storage technologies, such as storage that used a flywheel. This outdated definition did not allow for newer, more advanced energy storage technologies, such as lithium-ion batteries, to participate and be fully compensated in the wholesale electricity markets.

So today's hearing gives us an opportunity to better understand the barriers such as this, and I look forward to discussing further potential solutions. So I want to thank all of you for coming today.

I will say in advance, we have another hearing with the Federal Trade Commissioners going on downstairs that I will be going back and forth with. But thank you for your testimony.

With that, I would yield the balance of my time to the gentleman from North Carolina, Mr. Hudson.

[The prepared statement of Mr. Walden follows:]

PREPARED STATEMENT OF HON. GREG WALDEN

Today we continue our "Powering America" hearing series by taking a closer look at what a lot of people think will be the next big game changer for our nation's electricity sector, large-scale battery storage. For years, companies have been working to develop and pioneer battery storage technology that is both cost effective and scalable and we are now at the point where that technology is coming to fruition and being deployed on the grid in a meaningful way.

The potential benefits of battery storage are substantial. Batteries allow us to store energy when demand and prices are low and then release that energy when demand and prices are high. This not only optimizes the way our electricity system works, it also lowers electricity costs, meaning that American families can keep more money in their pockets after paying their monthly electricity bills.

Storage also allows for a more reliable and flexible electricity system. By strategically placing large-scale energy storage at various locations across the system, grid operators have more tools available at their disposal to protect the grid from power disruptions. Additionally, battery storage can help lower congestion on the transmission system and can even serve as an alternative to building out expen

My home State of Oregon has been ahead of the curve when it comes to recognizing the benefits of energy storage and many of our electric utilities are integrating energy storage projects. The Pacific Northwest is home to the Department of Energy's Pacific Northwest National Laboratory (PNNL), where researchers work to advance and develop energy storage technologies for grid-scale deployment. PNNL has tens of thousands of square feet of laboratory space dedicated to accelerating the development of energy storage technologies. In 2015, PNNL opened their, "Advanced Battery Facility" which was built to bridge the gap between fundamental battery research and commercialscale battery development.

Clearly, there is great potential for the role that large-scale battery storage can play in the Nation's electricity system, but before that potential is fully realized there are a number of barriers and challenges that are still being tackled. These challenges range from technological limitations and costs, to wholesale market participation rules.

In order to address some of the challenges faced by energy storage, FERC recently issued Order No. 841 directing the RTOs and ISOs to amend their market rules in order to better accommodate the participation of electric storage technologies. Right now, grid operators are in the process of implementing the requirements and directives contained in Order No. 841, which is something that this Committee will continue to pay attention to as things move forward.

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Joining us this morning is a panel of witnesses with extensive and varied experience developing, operating, and regulating large-scale energy storage. I would like to thank them for being here and I look forward to hearing their perspectives on how energy storage can strengthen the grid and benefit consumers.

Mr. HUDSON. Thank you, Mr. Chairman and Chairman Upton and Ranking Member Rush.

I just want to take a moment to thank Duke Energy and Mr. Zachary Kuznar for joining us at the hearing today to talk about the important role energy storage can and will play in increasing reliability for our constituents.

Duke Energy, based in Charlotte, North Carolina, is one of the largest electric power holding companies in the United States that are leading the way to modernize the energy grid and generate cleaner energy.

As both a grid manager and operator, I look forward to hearing about how utilities like Duke Energy can leverage energy storage and other grid assets to deliver affordable and reliable power for our customers.

And, with that, Mr. Chairman, I will yield back.

Mr. UPTON. The gentleman yields back.

The chair recognizes Mr. McNerney for an opening statement, 5 minutes.

OPENING STATEMENT OF HON. JERRY MCNERNEY, A REPRESENTATIVE IN CONGRESS FROM THE STATE OF CALIFORNIA

Mr. MCNERNEY. I want to thank the chair.

And I appreciate the opportunity to talk about energy storage. I spent my career developing wind energy technology for about 20 years before coming here, and we have only dreamed about being here today, when we were talking about a realistic application of storage for renewable energy. So we see that that is one of the possible beneficiaries of storage.

But the problem was that the capital costs kind of would add to the capital costs of the equipment, so we have to find a way to make sure the capital costs continue to go down. And we know from manufacturing theory that when you double the manufacturing the price goes down by 10 percent. So we need to find incentives to make sure that the manufacturing curve continues to increase and we can become more affordable over time.

I am also the co-chair, with Mr. Latta, who is not here this morning, of the Grid Innovation Caucus. And we see that storage is going to be a big player in where we move forward with our grids.

Now, we have a lot of challenges. There is demand-side management, there are loads being shifted, there are cyber threats and so on. So we know that storage is going to play a very big role in these new developments and the new challenges we find ahead of us.

So, again, I continue to look for ways, and I hope that you can not only inform us on the technology but how can we best incentivize the continuing technical development of solar technology.

And so, again, I look forward to your testimony.

I am going to be yielding to the gentleman from Pennsylvania, Mr. Doyle.

Mr. DOYLE. Mr. Chairman, I want to thank you, first, for calling this 9:00 a.m. hearing. We all appreciate that.

Mr. UPTON. Were you at the game last night?

Mr. DOYLE. No. No. I was somewhere else.

Mr. UPTON. It was the winning dugout, I want you to know. The American League had the winning Democratic dugout that they had a couple weeks ago.

Mr. DOYLE. Yes, that dugout has been pretty lucky these last few weeks.

Mr. UPTON. Yes.

Mr. DOYLE. Anyway, thank you, Mr. Chairman, for this hearing today. Energy storage presents an incredible opportunity to increase efficiency, grow and reliably use renewables, and provide resiliency to the grid.

I have introduced H.R. 4649, the Energy Storage Tax Incentive and Deployment Act. This legislation would establish an investment tax credit for energy storageinfrastructure for utilities, businesses, and homes.

And I understand, while this legislation is under consideration by the Ways and Means Committee, I think it is important to address options for reducing barriers to deployment and supporting the opportunities that energy storage presents.

There is truly something for everyone with energy storage. This technology supports the deployment of renewables like wind and solar. It can be used as a standalone technology. It increases grid resiliency when responding to extreme weather events and times of peak energy demand. And it reduces infrastructure costs.

It is important to fully realize this technology, and I look forward to working with my colleagues to support the expansion and the integration of energy storage throughout the grid.

Mr. Chairman, I appreciate the time, and I will yield back to Mr. McNerney.

Mr. MCNERNEY. Well, I thank the gentleman for his remarks.

Storage also has a real opportunity in terms of small businesses. I have seen small businesses in my community that are basing new business models on energy storage. So we have a lot to talk about here this morning.

I yield back, Mr. Chairman.

Mr. UPTON. All time has expired on the opening statements.

We are joined by five witnesses today.

And thank you in advance for submitting your testimony for the record. We had a chance to look at it, at least some of us who didn't go to the ball game last night.

We are joined by Zachary Kuznar, the Director of CHP, Microgrid, and Energy Storage Development for Duke Energy; Mark Frigo, V.P. and Head of Energy Storage, North America, E.ON; Keith Casey, Vice President of Market and Infrastructure Development, California Independent System Operator; Kushal Patel, Partner at Energy and Environmental Economics; and Kiran Kumaraswamy—pretty good, no?

Mr. KUMARASWAMY. Yes.

Mr. UPTON. —director of market applications, Fluence.

So, welcome. Each of you will be recognized for 5 minutes to summarize your testimony, at which point we will be asking questions.

Dr. Kuznar, we will start with you. Thank you.

STATEMENTS OF ZACHARY KUZNAR, DIRECTOR, CHP, MICROGRID, AND ENERGY STORAGE DEVELOPMENT, DUKE ENERGY; MARK FRIGO, VICE PRESIDENT, HEAD OF ENERGY STORAGE, NORTH AMERICA, E.ON; KEITH E. CASEY, PH.D., VICE PRESIDENT, MARKET AND INFRASTRUCTURE DEVELOPMENT, CALIFORNIA INDEPENDENT SYSTEM OPERATOR; KUSHAL PATEL, PARTNER, ENERGY AND ENVIRONMENTAL ECONOMICS, INC.; AND KIRAN KUMARASWAMY, DIRECTOR, MARKET APPLICATIONS, FLUENCE

STATEMENT OF ZACHARY KUZNAR

Mr. KUZNAR. Great. Thank you. Is this on? There we go.

Thank you, Chairman Upton, Ranking Member Rush, and members of the subcommittee. Thank you for having me here today.

My name is Zachary Kuznar, and I currently serve as Director of combined Heat and Power, Energy Storage, and Microgrid Development at Duke Energy Corporation, which is headquartered in Charlotte, North Carolina. My team leads all energy storage development in our six regulated States in which we operate, which are North Carolina, South Carolina, Florida, Ohio, Indiana, and Kentucky.

Duke Energy believes storage will play a significant role in how we operate, supply, and deliver energy for our 25 million customers now and well into the future. We see tremendous value in energy storage investments and the benefits they can provide across our generation, transmission, and distribution systems.

Storage allows us to dispatch energy during times of peak demand, enhance the reliability of our grid, provide energy security and backup power for customers who provide critical services for our communities, and enables increased flexibility for helping manage the continued growth of renewable generation on our electric system.

This will become increasingly important as more solar connects to our system. North Carolina, for example, is number two in the country for solar generation, only behind California.

We plan to expand our investment and our regulated footprint for our customers' benefit by building off our decade of storage experience, which includes 8 pilot projects and 40 megawatts of commercially owned and operated assets. As the technology continues to mature and the cost of batteries continues to decline, we believe the time is right to increase our investments in this area. Over the next 5 years, we plan to deploy a minimum of 145 megawatts of storage across our regulated business, representing approximately $300 million of new investment, to continue to modernize our electric system.

In 2017, we received approval from the Florida Public Service Commission to deploy 50 megawatts of battery storage projects in our Florida service territory. We are targeting applications to improve reliability, which will result in better overall customer experience, along with utilizing these storage assets to advance the flexibility of our system as solar generation continues to increase in our Florida footprint.

In North Carolina, we have incorporated a minimum of 75 megawatts of storage into our integrated resource planning process. Our first two projects in our western North Carolina service territory, totaling 13 megawatts, will be used to provide valuable backup power to communities and give us the ability to deliver grid services such as frequency regulation that will help us to incorporate and manage the increased growth of solar generation onto our system.

We also continue to evaluate and explore projects in South Carolina as well.

We recently received approval from the Indiana Utility Regulatory Commission to deploy 10 megawatts of battery projects in Indiana. One of the projects is a partnership with the Indiana National Guard at Camp Atterbury, where we will deploy 3 megawatts of solar along with a 5-megawatt energy storage asset at the base.

During normal grid operations, the solar generation will send power to our electric grid to benefit all Indiana customers, while the battery device will provide frequency regulation to help stabilize the electric system. In the event of a grid outage, the battery will provide backup power, ensuring the base still has energy for critical infrastructure and services. This is a perfect example of how technologies like storage can provide both grid- and customer-sided benefits.

We are also working with large customers such as the Department of Defense, cities, hospitals, and other first responders to evaluate similar partnerships.

In Ohio, we have filed for 10 megawatts of storage as part of our electric security plan, and we are incorporating 2 megawatts year over year in our Kentucky service territory. We believe these investments will grow well beyond the original 145 megawatts we have announced.

At Duke Energy, we serve as both the grid manager and operator, with a clear line of sight and understanding of how storage can be leveraged in conjunction with other grid assets to bring to bear the greatest benefits for the grid and our customers.

The utility is in an ideal position to investment in and own and to capture these stacked benefit streams that storage can provide. Storage can be a more cost-effective mechanism to defer or forego a distribution upgrade, eliminate the need for wires, and provide resource flexibility to ensure reliable energy is delivered continuously.

As a seasoned utility, we have firsthand experience managing these complex dynamics expertly in concert with the broader electric system. More importantly, with over a century of experience providing affordable, reliable electricity to our customers, Duke Energy is positioned to deploy this exciting new technology in a way that increases reliability and maintains the security of our critical infrastructure.

I thank you again for the opportunity to discuss Duke Energy's energy storage plans with you today, as we feel this technology will provide essential benefits for our customers and for our communities.

[The prepared statement of Mr. Kuznar follows:]

Testimony of Zachary Kuznar
Director, Combined Heat and Power, Energy Storage and Micro-grid Development
Duke Energy Corporation

Subcommittee on Energy
Committee on Energy and Commerce
U.S. House of Representatives

July 18, 2018

"Powering America: The Role of Energy Storage in the Nation's Electricity System"

Chairman Upton, Ranking Member Rush, and Members of the Subcommittee:

Thank you for having me here today. My name is Zachary Kuznar, and I currently serve as Director of Combined Heat and Power, Energy Storage and Micro-grid Development at Duke Energy Corporation headquartered in Charlotte, NC. My team leads all energy storage development in the six regulated states in which we operate: North Carolina, South Carolina, Florida, Ohio, Indiana and Kentucky.

Duke Energy believes energy storage will play a significant role in how we operate, supply and deliver energy for our 25 million customers now and well into the future. We see tremendous value in energy storage investments and the benefits they can provide across our generation, transmission and distribution systems. Storage allows us to dispatch energy during times of peak demand, enhance the reliability of our grid, provide energy security and back-up power for customers who provide critical services to our communities, and enable increased flexibility for helping to manage the continued growth of renewable generation on our system. This will become increasingly important as more solar connects to our electric system; North Carolina, for example, is currently number two in the country for solar generation, trailing only California.

We plan to expand our investment in our regulated footprint for our customers' benefit by building off our decade of energy storage experience, which includes 8 pilot projects and 40 MW of commercially owned and operated storage assets. As the technology matures and the costs of batteries continue to decline, we believe the time is right to increase our investments in this area. Over the next 5 years, Duke Energy plans to deploy a minimum of 145 MW of energy storage across our regulated businesses, representing approximately $300 million of new investment to help modernize our electric system.

In 2017, we received approval from the Florida Public Service Commission to deploy 50 MW of battery storage projects in our Florida service territory. We are targeting applications to improve system reliability, which will result in a better overall customer experience, along with utilizing these storage assets to advance the flexibility of our electric system as solar generation continues to increase in our Florida footprint.

In North Carolina, we have incorporated 75 MW of energy storage into our Integrated Resource Planning process. Our first two projects in our western North Carolina service territory, totaling 13 MW, will be used to provide valuable back-up power to communities, and give us the ability to deliver grid services, such as frequency regulation, that will help us to incorporate and manage the increased growth of solar generation onto our electric system. We also continue to evaluate and explore project locations in our South Carolina service territory.

We recently received approval from the Indiana Utility Regulatory Commission to deploy 10 MW of battery storage projects in Indiana. One of the projects is a partnership with the Indiana National Guard at Camp Atterbury, where we will be deploy 3 MW's of solar generation along with a 5 MW energy storage asset at the base. During normal grid operations, the solar generation will send energy to our electric grid to benefit all of our Indiana customers, while the battery storage device will provide frequency regulation to help stabilize the electric system. In the event of a grid outage, the battery will provide back-up power ensuring the base still has energy for critical infrastructure and services. This is a perfect example of how technologies like energy storage can provide both grid and customer-sited benefits. We are also working with large customers such as the Department of Defense, cities, hospitals and other first responders to evaluate similar partnerships.

In Ohio, we have filed for 10 MW of energy storage as part of our Electric Security Plan, and are incorporating 2 MW of storage year over year in our Kentucky Integrated Resource Plan. We believe these investments will grow well beyond the original 145 MW we have announced.

At Duke Energy, we serve as both the grid manager and operator with a clear line of sight and understanding on how energy storage can be leveraged in conjunction with other grid assets to bring to bear the greatest benefits for the grid and our customers. The utility is in an ideal position to invest in and own storage, and to capture these stacked benefit streams that storage can provide. Storage can be a more cost-effective means to defer or forego a distribution system upgrade, eliminate the need for wires, and provide resource flexibility to ensure reliable energy is delivered 24/7. As a seasoned utility, we have first-hand experience managing these complex dynamics expertly in concert with the broader electric system. Most importantly, with over a century of experience providing affordable, reliable electricity to our customers, Duke Energy is best positioned to deploy this exciting new technology in a way that increases reliability and maintains the security of our critical infrastructure.

I thank you again for the opportunity to discuss Duke Energy's energy storage plans with you today, as we feel this technology will provide essential benefits for our customers and our communities.

Mr. UPTON. Thank you.

Mr. Frigo?

STATEMENT OF MARK FRIGO

Mr. FRIGO. Good morning, Chairman Upton, Ranking Member Rush, and members of the subcommittee. Thank you for the opportunity to appear before you today.

My name is Mark Frigo, and I am the Vice President and Head of Energy storage for E.ON North America. In that role, I am responsible for all aspects of our energy storage business. In my testimony today, I will discuss E.ON's effort to deliver this technology to customers across the United States.

Since 2007, E.ON has invested more than $14 billion in renewable projects worldwide, with roughly half of that investment made in local communities right here in the U.S. As one of the U.S.'s largest owners of renewable power projects, with more than 36 megawatts under operation, we have also taken a lead role in developing energy storage projects.

Traditionally, electricity could not be stored. Our electric grid was developed as a just-in-time delivery system. However, the energy world has changed. It is a world with computers, smartphones, the cloud, rooftop solar on people's homes and businesses, and the explosive growth of electric vehicles. The grid as we know it, with large, centralized power plants delivering power via transmission and distribution, will be challenged to meet our nation's future energy needs.

This is where energy storage comes into play. Low-cost energy storage has the ability to transform and meet the needs of the new energy world. E.ON is helping to lead that change.

E.ON has 3 energy storage projects currently in operation, totaling approximately 30 megawatts, each uniquely designed to solve a specific problem.

Iron Horse, our first energy storage project in the U.S., is a combined energy storage and solar photovoltaic project located in Tucson, Arizona. Working with Tucson Electric Power, our team designed and built a 10-megawatt battery solution paired with a 2-megawatt solar PV array to stabilize Tucson's electric power grid.

We continue to own and operate the project for use within Tucson Electric Power's system. It is our understanding that this energy storage project, along with another one that TEP has implemented, has significantly improved the situation within the greater Tucson area.

Texas Waves, our other operational energy storage facility, is actually comprised of two 9.9-megawatt battery projects in West Texas, one co-located next to our Pyron Wind Farm and the other co-located next to our Inadale Wind Farm. Texas Waves is designed to provide ancillary services to the Electric Reliability Council of Texas market and can respond to shifts in power demand more quickly than traditional generating technologies, thereby improving system reliability and efficiency.

These two projects went online in January of this year and have successfully responded during extreme weather and unplanned generation outages. These projects were able to respond to ERCOT's frequency regulation signal within milliseconds, helping

ERCOT manage minute-to-minute fluctuations between load and generation on their grid and ultimately helping the citizens of Texas keep the lights on.

Despite our successes in the market and its great potential to enhance the grid's reliability and resilience, energy storage remains an emerging technology. While that technology continues to evolve and costs continue to fall, more steps from both a policy and fiscal perspective are needed to unlock this technology's full potential to support the grid and save taxpayer money on their electricity bills.

Energy storage should be part of a grid modernization and optimization effort to contribute to reliability and resilience. FERC Order 841 was a significant step forward to allow for energy storage participation on the grid in organized markets. But FERC must now ensure that the RTOs and ISOs over which it has jurisdiction faithfully and fully implement the order to allow energy storage into their markets to the benefit of customers.

It is also important that utility commissions in states not included in organized markets ensure that the utilities they regulate evaluate energy storage resources as a viable and cost-effective tool in their utility planning process. Market rules should not only ensure participation but should be examined to ensure that interconnection processes do not constitute barriers to entry.

Energy storage would also benefit from fiscal policy that rewards investment in this emerging technology for a limited period. For example, an investment tax credit for energy storage would encourage greater investment and faster deployment of energy storage solutions to help utilities, generators, and, most importantly, customers to unlock the many benefits of storage.

In closing, energy storage is an incredibly useful technology that can meet the needs of the new energy world. It is a uniquely flexible technology that can be designed to meet the specific needs of customers and the grid. It increases grid reliability while enabling all the technological and sustainable advancements our country continues to enjoy. And, best of all, it can do all these things while saving ratepayers, your constituents, money.

I urge you to adopt forward-looking policies to help unlock energy storage potential to keep the United States at the forefront of the new energy world.

Thank you.

[The prepared statement of Mr. Frigo follows:]

Mr. Mark Frigo, Vice President and Head of Energy Storage, E. ON North American

"Powering America: The Role of Energy Storage in the Nation's Electricity System."
House Energy and Commerce Subcommittee on Energy
July 18, 2018

EXECUTIVE SUMMARY

- E.ON is a global company, providing more than 7,000 megawatts (MW) of electricity from utility-scale renewable generation facilities located primarily in the United States and in Europe. Since 2007, E.ON has invested more than $14 billion in renewable projects worldwide, with roughly half of that investment made in local communities in the United States. We build, own, and operate utility-scale wind farms, solar photovoltaic plants, and energy storage systems throughout the United States. As such, E.ON is one of the United States' largest owners of renewable power projects, with more than 3,600 megawatts (MW) under operation.

- As battery technology has evolved and production costs have fallen, energy storage has become an increasingly effective solution to solving grid challenges, making the grid more resilient and saving ratepayers money. More specifically, battery energy storage is a uniquely flexible technology that can be deployed in a myriad of ways to meet the unique needs of the grid, utilities, and ultimately end customers.

- E.ON has three energy storage projects currently in operation, totaling approximately 30 MW, each uniquely designed to solve a problem.

    - Iron Horse, our first energy storage project in the United States, is a combined energy storage and solar photovoltaic project located in Tucson, Arizona. We designed and implemented this energy storage solution to stabilize Tucson Electric Power's grid. Working with TEP, our team designed and built a 10 MW / 2.5 MWh battery solution paired with a 2 MW solar photovoltaic array to solve this problem.

    - Texas Waves, our other operational energy storage facility, is actually comprised of two 9.9 MW battery projects in West Texas -- one co-located next to our Pyron Wind Farm and the other co-located next to our Inadale Wind Farm. Both facilities went online in January 2018. Texas Waves is designed to provide ancillary services to the Electric Reliability Council of Texas (ERCOT) market and can respond to shifts in power demand more quickly than traditional assets, thereby improving system reliability and efficiency.

- While energy storage technology continues to evolve and costs continue to fall, more steps from both a policy and fiscal perspective are needed to unlock this technology's full potential to increase grid reliability and resilience, and to save taxpayers money on their electricity bills.

- Energy storage should be a part of grid modernization and optimization to contribute to reliability and resilience. FERC Order 841 was a significant step forward to allow for energy storage's participation on the grid in organized markets, but FERC must now ensure that the RTO/ISOs, over which it has jurisdiction, faithfully and fully implement the order to allow energy storage into their markets to the benefit of customers.

- It is also important that utility commissions in states not included in organized markets ensure that the utilities they regulate evaluate energy storage resources as a viable and cost-effective tool in the utility planning process. Market rules should not only ensure participation but should be examined to ensure that interconnection processes do not constitute barriers to entry.

- Energy storage would also benefit from fiscal policy that rewards investment in this emerging technology for a limited period. For example, an investment tax credit for energy storage would encourage greater investment and faster deployment of energy storage solutions to help utilities, generators, and, most importantly, customers unlock the many benefits of storage.

- Energy storage is an incredibly useful technology that can help meet the needs of the new energy world. It is a uniquely flexible technology that can be designed to meet the specific needs of customers and the grid. It increases grid reliability and will help ensure America continues to lead on the new energy frontier.

Testimony of
Mr. Mark Frigo
Vice President and Head of Energy Storage
E.ON North America

"Powering America: The Role of Energy Storage in the Nation's Electricity System."

House Energy and Commerce Committee
Subcommittee on Energy
July 18, 2018

Good morning Chairman Upton, Ranking Member Rush, and Members of the Subcommittee. Thank you for the opportunity to appear before you today. My name is Mark Frigo and I am the Vice President and Head of Energy Storage for E.ON North America.

In that role I am responsible for all aspects of our U.S. energy storage business. In my testimony today, I will discuss E.ON's efforts to deliver this technology to customers across the U.S.

Since 2007, E.ON has invested more than $14 billion in renewable projects worldwide, with roughly half of that investment made in local communities right here in the United States. As one of the United States' largest owners of renewable power projects, with more than 3,600 megawatts (MW) under operation, we have also taken a lead role in developing energy storage projects.

Traditionally, electricity could not be stored. Our electric grid was developed as a just-in-time delivery system. However, the energy world has changed. It is a world with computers; smart phones; the Cloud; rooftop solar on people's homes and businesses; and the explosive growth of electric vehicles. The grid as we used to know it --- with large, centralized power plants delivering power via transmission and distribution --- will be challenged to meet our nation's future energy needs. This is where energy storage comes into play. Low-cost energy storage has the ability to transform and meet the needs of the new energy world. E.ON is helping to lead this change.

Our projects

E.ON has three energy storage projects currently in operation, totaling approximately 30 MW, each uniquely designed to solve a problem.

Iron Horse, our first energy storage project in the United States, is a combined energy storage and solar photovoltaic project located in Tucson, Arizona. Working with Tucson Electric Power, our team designed and built a 10 MW battery solution paired with a 2 MW solar photovoltaic array to stabilize Tucson Electric Power's grid.

We continue to own and operate the project for use within Tucson Electric Power's system. It is our understanding that our energy storage project, along with another one that TEP has in its system, has significantly improved the situation within the greater Tucson area.

Texas Waves, our other operational energy storage facility, is actually comprised of two 9.9 MW battery projects in West Texas -- one co-located next to our Pyron Wind Farm and the other co-located next to our Inadale Wind Farm. Texas Waves is designed to provide ancillary services to the Electric Reliability Council of Texas (ERCOT) market and can respond to shifts in power demand more quickly than traditional generating technologies, thereby improving system reliability and efficiency.

These two projects went on-line in January of this year and have successfully responded during extreme weather and unplanned generation outages. These projects were able to respond to ERCOT's frequency regulation signal within milliseconds, helping ERCOT manage minute-to-minute fluctuations between load and generation on their grid, and ultimately helping citizens of Texas keep the lights on.

U.S. Energy Policies Should Allow Storage Integration

Despite our successes in the market and its great potential to enhance the grid's reliability and resilience, energy storage remains an emerging technology. While the technology continues to evolve and costs continue to fall, more steps from both a policy and fiscal perspective are needed to unlock this technology's full potential to support the grid and to save taxpayers money on their electricity bills.

Energy storage should be a part of grid modernization and optimization to contribute to reliability and resilience. FERC Order 841 was a significant step forward to allow for energy storage's participation on the grid in organized markets, but FERC must now ensure that the RTO/ISOs, over which it has jurisdiction, faithfully and fully implement the order to allow energy storage into their markets to the benefit of customers.

It is also important that utility commissions in states not included in organized markets ensure that the utilities they regulate evaluate energy storage resources as a viable and cost-effective tool in the utility planning process. Market rules should not only ensure participation but should be examined to ensure that interconnection processes do not constitute barriers to entry.

Energy storage would also benefit from fiscal policy that rewards investment in this emerging technology for a limited period. For example, an investment tax credit for energy storage would encourage greater investment and faster deployment of energy storage solutions to help utilities, generators, and most importantly customers unlock the many benefits of storage.

Closing

In closing, energy storage is an incredibly useful technology that can help meet the needs of the new energy world. It is a uniquely flexible technology that can be designed to meet the specific needs of customers and the grid. It increases grid reliability, while enabling all of the technological and sustainable advancements our country continues to enjoy. And, best of all, it can do all of these things while saving ratepayers – your constituents – money. I urge you to adopt forward-looking policies to help unlock energy storage's potential to keep the United States at the forefront of the new energy world.

Written Testimony of
Mr. Mark Frigo
Vice President and Head of Energy Storage
E. ON North America

"Powering America: The Role of Energy Storage in the Nation's Electricity System."

House Energy and Commerce Committee
Subcommittee on Energy
July 18, 2018

Good morning Chairman Upton, Ranking Member Rush, and Members of the Subcommittee. Thank you for the opportunity to appear before you today. My name is Mark Frigo and I am the Vice President and Head of Energy Storage for E.ON North America.

In that role I am responsible for all aspects of our U.S. energy storage business, including planning, personnel, and project development and execution. In my testimony today, I will discuss E.ON's efforts to deliver this technology to customers across the U.S. I will also share my personal perspective on the existing landscape, prospects for energy storage, and the need for continued support.

E.ON is a global company, providing more than 7,000 megawatts (MW) of electricity from utility-scale renewable generation facilities located primarily in the United States and in Europe. Since 2007, E.ON has invested more than $14 billion in renewable projects worldwide, with roughly half of that investment made in local communities right here in the United States. We build, own, and operate utility-scale onshore and offshore wind farms, solar photovoltaic plants, and energy storage systems throughout the United States. As such, E.ON is one of the United States' largest owners of renewable power projects, with more than 3,600 megawatts (MW) under operation.

The company develops, constructs, owns, and operates some of the most efficient, highest-performing utility-scale renewable energy projects in the country. In addition, we are a full-service provider of operations, maintenance, and asset management services to a variety of institutional partners across North America. All told, our Control Center manages nearly 7,000 MW of renewable energy across 11 states. Our projects provide enough energy to power approximately 2 million American households.

Delivering energy storage

With nearly 33 million utility customers in Europe, E.ON is acutely aware of the challenges facing utilities and grid operators in the new energy world. As battery technology has evolved and production costs have fallen, energy storage has become an increasingly effective solution to solving grid challenges, making the grid more resilient and saving ratepayers money.

More specifically, battery energy storage is a uniquely flexible technology that can be deployed in a myriad of ways to meet the unique needs of the grid, utilities, and ultimately end customers. E.ON leverages this flexibility to deliver one-stop Energy Storage Systems that provide specifically tailored grid solutions for providers here in the United States. These solutions include providing lower cost and more effective alternatives to transmission and distribution system capital improvements, helping to integrate renewable generation into the grid, accelerating the adoption of distributed energy resources, and delivering electric reliability services to make the grid more flexible, resilient, and reliable.

Traditionally, electricity could not be stored. Our electric grid was developed as a just-in-time delivery system. However, the energy world has changed. It is a world with computers; smart phones; the Cloud; emission-free, yet intermittent, energy; rooftop solar on people's homes and businesses; and the explosive growth of electric vehicles. The grid as we used to know it --- with large, centralized power plants delivering power via transmission and distribution --- will be challenged to meet our nation's future energy needs. This is where energy storage comes into play. Low-cost energy storage has the ability to transform and meet the needs of the new energy world. E.ON is helping to lead this change.

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Iron Horse, our first energy storage project in the United States, is a combined energy storage and solar photovoltaic project located in Tucson, Arizona. We designed and implemented this energy storage solution to stabilize Tucson Electric Power's grid. Working with TEP, our team designed and built a 10 MW / 2.5 MWh battery solution paired with a 2 MW solar photovoltaic array to solve this problem. We continue to own and operate the project for use within Tucson Electric Power's system. TEP purchases the energy and capacity from the project and dispatches the battery based on its system needs. We have been told that our energy storage project, along with another one that Tucson Electric Power has in its system has virtually eliminated their frequency regulation problems, further decreasing the probability of outages within the greater Tucson area.

Texas Waves, our other operational energy storage facility, is actually comprised of two 9.9 MW battery projects; one co-located next to our Pyron Wind Farm and the other co-located next to our Inadale Wind Farm. Both facilities are located in West Texas and are fully owned and operated by E.ON. Texas Waves participates on a merchant basis in the competitive day-ahead ancillary services market and energy market at the Electric Reliability Council of Texas, or

ERCOT. The ancillary services market includes services like frequency response and regulation, which are vital to keeping the grid stable, online, and delivering power to customers.

These two projects went on-line in January of this year and have successfully responded to several grid events where the grid became unstable due to extreme weather and unplanned outages of other generation units. These projects were able to respond to ERCOT's frequency regulation signal within milliseconds, helping ERCOT manage minute-to-minute fluctuations between load and generation on their grid, and ultimately helping citizens of Texas keep the lights on.

U.S. Energy Policies Should Allow Storage Integration

Despite our successes in the market and its great potential to enhance the grid's reliability and resilience, energy storage remains an emerging technology. While energy technology continues to evolve and costs continue to fall, more steps from both a policy and fiscal perspective are needed to unlock this technology's full potential to support the grid and to save taxpayers money on their electricity bills.

Energy storage should be a part of grid modernization and optimization to contribute to reliability and resilience. FERC Order 841 was a significant step forward to allow for energy storage's participation on the grid in organized markets, but FERC must now ensure that the RTO/ISOs, over which it has jurisdiction, faithfully and fully implement the order to allow energy storage into their markets to the benefit of customers. It is also important that utility commissions in states not included in organized markets ensure that the utilities they regulate evaluate energy storage resources as a viable and cost-effective tool in the utility planning process. Market rules should not only ensure participation but should be examined to ensure that interconnection processes do not constitute barriers to entry.

Energy storage would also benefit from fiscal policy that rewards investment in this emerging technology for a limited period. For example, an investment tax credit for energy storage would encourage greater investment and faster deployment of energy storage solutions to help utilities, generators, and most importantly customers unlock the many benefits of storage.

Closing

In closing, energy storage is an incredibly useful technology which can help meet the needs of the new energy world. It is a uniquely flexible technology that can be designed to meet the specific needs of customers and the grid. It increases grid reliability, while enabling all of the technological and sustainable advancements our country continues to enjoy. And, best of all, it can do all of these things while saving ratepayers – your constituents – money. I urge you to adopt forward-looking policies to help unlock energy storage's potential to keep the United States at the forefront of the new energy world.

Mr. UPTON. Thank you.
Dr. Casey?

STATEMENT OF KEITH E. CASEY, PH.D.

Mr. CASEY. Good morning, Chairman Upton, Vice Chairman Olson, Ranking Member Rush, and members of the committee. My name is Keith Casey. I am Vice President of Market and Infrastructure Development at the California Independent System Operator. Thank you for the opportunity to appear before you today to discuss the role of energy storage in organized wholesale electricity markets in California.

California's clean energy policies are dramatically transforming the resource portfolio that serves electric load. California's ambitious renewable portfolio standard, greenhouse gas emission reduction goals, policies concerning the use of water for power plant cooling, as well as distributed energy resource and rooftop solar goals, have all contributed to a dramatic shift away from conventional power plants and to the deployment of new technologies such as battery storage and demand response.

Today, renewables comprise about 33 percent of the total energy produced in our markets and are on track to meet 50 percent of 2030, if not sooner.

These high levels of renewables, which are predominantly solar, do, however, present operational challenges such as oversupply during the middle of the day when solar output is at its greatest and ramping challenges during the late afternoon and early evening when solar output declines but demand on the system is increasing.

Today, these integration challenges are largely managed with natural-gas-fired generation, but achieving California's clean energy goals will require moving off of gas to cleaner resources such as energy storage that can absorb surplus solar output during the middle of the day and put it back on the grid later when it is needed. Storage can also mitigate the reliance on natural gas power plants for serving local electricity demand in transmission-constrained areas of the grid.

Today, California operates with approximately 2,000 megawatts of energy storage on its system. Most of this is legacy pumped hydroelectric generation, but, in recent years, 134 megawatts of battery storage has been added to the ISO system.

Development of battery storage is being driven primarily by State policy. The California Public Utilities Commission requires investor-owned utilities to procure 700 megawatts of transmission-level electricity storage, 425 megawatts of distributed electricity storage, and 200 megawatts of customer electric storage by 2020. And the utilities are making good progress in achieving that goal.

Over the past several years, we have made numerous changes to our wholesale energy markets to enable storage resources to effectively participate. Most notably, we developed a specific storage resource participation model so that our wholesale market can optimally manage the state of charge of a storage resource. We also developed special participation rules for storage to provide other grid reliability functions and have evolved our transmission planning process to consider storage as an alternative to conventional wires and generation.

Earlier this year, through our transmission planning process, we identified and approved two battery storage projects for meeting grid reliability needs. These projects will be treated as transmission assets, with their costs fully recovered through transmission rates.

Currently, we allow storage resources, as well as other types of resources, to participate in the wholesale energy market even if they are connected to the distribution system. While the development is at a very nascent stage, we believe the future grid will be one where distribution and transmission networks are highly integrated, providing for bidirectional flow of energy versus the traditional grid, where power flows one direction from large, centralized power plants to end-use consumers.

The grid of tomorrow will have a much more diverse set of smaller resources, with many located behind a customer's meter, and will have the potential to provide services to the host customer, the distribution network, and the transmission network.

Getting there, however, will require overcoming a number of challenges. Most notably, how do you enable resources behind the meter to provide multiuse services to their host customer, the distribution, and transmission grid in a coordinated and verifiable way that ensures the services being paid for are actually being provided, are not operating at cross-purposes, and are not being double-counted? California is currently grappling with this multiuse concept.

We are also examining how to allow storage resources that are approved as transmission assets and, therefore, able to fully recover their costs through transmission rates to also participate in the wholesale energy market and earn market revenues. FERC policy allows for this type of hybrid treatment, but I do not believe any ISO or RTO has currently implemented this hybrid model, so California may very well be the first.

Finally, the ISO appreciates and supports the proposed reforms in FERC Order 841, which seeks to remove barriers to electric storage resources participating in the organized electricity markets. We are also working with our participating utilities to develop better ways to coordinate transmission and distribution system operation to enable energy transformation in an efficient, reliable, safe manner.

This concludes my comments, and I will be happy to answer any questions you may have.

[The prepared statement of Mr. Casey follows:]

Testimony of Keith Casey,
Vice President, Market and Infrastructure Development
California Independent System Operator Corporation

Committee on Energy and Commerce
Subcommittee on Energy
United States House of Representatives

July 18, 2018

Chairman Upton, Vice Chairman Olson, Ranking Member Rush, and Members of the Committee:

My name is Keith Casey. I am the Vice President of Market and Infrastructure Development at the California Independent System Operator. The California ISO operates wholesale energy and ancillary services markets to reliably manage the high-voltage transmission system that serves approximately 80 percent of California electric load as well as a small portion of Nevada's electric load. Thank you for the opportunity to appear before you today to discuss the role of energy storage in the organized wholesale electricity markets in California.

California clean energy policies are dramatically transforming the resource portfolio that serves electric load. California's ambitious renewable portfolio standard, greenhouse gas emission reduction goals, policies concerning the use of water for power plant cooling, as well as distributed energy resource and rooftop solar goals have all contributed to a dramatic shift away from conventional power plants and to the deployment of new technologies such as battery storage and demand response. Today, renewables comprise about 33 percent of total energy produced in our markets and are on track to meet 50% by 2030 – if not sooner.

These high levels of renewables, which are predominately solar, do, however, present operational challenges such as oversupply during the middle of the day when solar output is greatest and ramping challenges during the late afternoon and early evening when solar output declines but demand on the system is increasing. Today, these integration challenges are largely managed with natural gas-fired generation but achieving California's clean energy goals will require moving off of gas to cleaner resources such as energy storage that can absorb surplus solar output during the middle of the day and put it back on the grid later when it is needed. Storage can also mitigate the reliance on natural gas power plants for serving local electricity demand in transmission constrained areas of the grid.

Today, California ISO operates with approximately 2,000 MW of energy storage on its system. Most of this is legacy pumped hydroelectric generation but in recent years 134 MW of battery storage has been added to the ISO system. Development of battery storage is being driven primarily by state policy. The California Public Utilities Commission requires the investor-owned utilities to procure 700 MW of transmission-level electricity storage, 425 MW of distributed electricity storage, and 200 MW of customer electricity storage by 2020 and the utilities are making good progress in achieving that goal.

Over the past several years, we have made numerous changes to our wholesale energy market to enable storage resources to effectively participate. Most notably, we developed a specific storage resource participation model so that our wholesale market can optimally manage the state of charge of a storage resource. We also developed special participation rules for storage to provide other grid reliability functions and have evolved our transmission planning process to consider storage as an alternative to conventional wires and generation. Earlier this year through our transmission planning process we identified and approved two battery storage projects for meeting grid reliability needs. These projects will be treated as transmission assets with their costs fully recovered through transmission rates.

While battery storage is finding development opportunities in California, the value proposition and need for additional large scale pumped hydro generation is less clear. New large scale pumped hydroelectric projects can significantly help with managing solar oversupply and the need to ramp energy up as solar production declines in the late afternoon but whether such large infrastructure projects are needed given the declining costs of batteries and solar is an open question that is being further investigated at the California Public Utilities Commission.

Currently, we allow storage resources as well as other types of resources to participate in the wholesale energy market even if they are connected to the distribution system. While development is at a very nascent stage, we believe the future grid will be one where the distribution and transmission networks are highly integrated, providing for bi-directional flow of energy versus the traditional grid where power flows one direction from large centralized power plants to end-use consumers. The grid of tomorrow will have a much more diverse set of smaller resources – with many located behind a customer's meter and will have the potential to provide services to the host customer, the distribution network, and the transmission network. Getting there, however, will require overcoming a number of challenges – most notably how do you enable resources behind the meter to provide multi-use services to their host customer, the distribution, and transmission grid in a coordinated and verifiable way that ensures the services being paid for are actually being provided, are not operating at cross purposes, and are not being double counted. California is currently grappling with this multi-use concept.

We are also examining how to allow storage resources that are approved as transmission assets and therefore able to fully recover their costs through transmission rates to also participate in the wholesale energy market and earn market revenues. FERC policy allows for this type of hybrid treatment but I do not believe any ISO or RTO has currently implemented this hybrid model so the California ISO may very well be the first.

Finally, the California ISO appreciates and supports the proposed reforms in the FERC's Order 841, which seeks to remove barriers to electric storage resources participating in the organized electricity markets. The California ISO is seeking clarifications on certain aspects of the order but frankly, we have already implemented all of the major reforms called for under Order 841 so our compliance will mainly involve fine tuning certain design elements we already have in place. Nonetheless, we are very committed and focused on continuing to evolve our market design to better enable storage participation, particularly as we gain actual experience with these resources in our market. We are also working with our participating utilities to develop better ways to coordinate transmission and distribution system operation to enable this energy transformation in an efficient, safe, and reliable manner.

That concludes my comments and I would be happy to answer any questions you may have.

Mr. UPTON. Thank you.
Mr. Patel?

STATEMENT OF KUSHAL PATEL

Mr. PATEL. Thank you, Chairman Upton, Ranking Member Rush, and members of the subcommittee, for inviting me to testify on today's topic of energy storage and its role in the Nation's electricity system.

My name is Kushal Patel, and I am a Partner at Energy and Environmental Economics, or E3, which is a consulting firm based in San Francisco that focuses exclusively on energy issues. E3 advises a wide range of clients across the U.S., including public agencies, wholesale system operators, utilities, project developers, technology companies, and investors.

I lead E3's asset valuation practice, and, in that role, I provide the energy storage developers and investors with various kinds of analytical and strategic support for thousands of megawatts of energy storage projects throughout the U.S., ranging from large pumped hydro projects to small customer-sided lithium-ion batteries.

I also work with a number of other entities, like State public agencies, to analyze and think through the role of energy storage in our electricity system in the near and longer term.

Energy storage has been called the Swiss Army knife of the electricity system because of the many services it can perform. E3 has rigorously analyzed energy storage for over 20 years, beginning with technologies like pumped hydro that have been part of our nation's electrical grid for decades, to current technologies like advanced lithium ion and flow batteries that are now just being deployed at scale, to emerging technologies that are still in the R&D phase.

We have looked at energy storage providing services across multiple applications or use cases. One such a use case is participating directly in the wholesale markets, either as a standalone resource or paired with generation. Another is serving as a non-wires alternative that defers or avoids building costly transmission or distribution assets, which directly benefits utility ratepayers. And a third is as a tool for individual customers to reduce their own electricity bills.

Significant barriers stand in the way of large-scale deployment of mature and emerging storage technologies. These barriers include high but declining technology costs and, more importantly, the limited ability for storage to earn revenues for the numerous services it can perform.

Today, clear routes to market exist for only a handful of storage services, like frequency regulation. Other services cannot be readily monetized, like grid resilience benefits. And still others, such as those related to integrating larger amounts of renewable energy, may not become valuable until the future and then only in certain parts of the country. There may even be market rules and operational rules that hinder and prevent storage from providing multiple services and being multiuse.

This means enabling policies and regulations are needed at both the Federal and State levels to address these barriers to ensure that storage is optimally utilized as well as compensated fairly on a level playing field with other technologies, which is challenging given the unique nature of energy storage.

To this point, I recently collaborated with several New York agencies in the development of the New York Energy Storage Roadmap, which provides an excellent example of how policymakers can proactively address the opportunities and challenges energy storage represents.

The roadmap, just released last month, is a first-of-its-kind, analytically driven set of policy, regulatory, and programatic actions and recommendations meant to help New York dramatically ramp up energy storage deployment beginning in 2019. It was developed specifically to identify the most promising and cost-effective means of realizing New York's target of installing 1,500 megawatts of advanced energy storage by 2025.

The roadmap found that value stacking—i.e., being able to perform and be compensated for multiple services, is essential for the long-term commercial viability of energy storage.

This is especially relevant to the issue of dual-market participation, where storage is providing both wholesale market and distribution system services. For example, what should be the operational rules and market structure that maximizes the storage value by allowing it to provide both wholesale capacity services in a constrained urban load pocket like New York City as well as a distribution service like a non-wires alternative to a utility investment like building a large substation.

So, to conclude, I believe the key to maximizing energy storage benefits for our electricity system is twofold. First, policies and rules must be established that allow storage assets to provide multiple services at the wholesale, distribution, and customer levels. Second, storage assets must receive fair and equitable compensation on a level playing field. These actions will both enable the optimal deployment of storage assets onto our electricity grid and create a stable environment for longer-term investing and financing.

Energy storage is a complex set of technologies that goes far beyond batteries, and integrating them cost-effectively into the grid while maintaining safety, reliability, and affordability is no small task. I applaud this subcommittee's leadership in addressing this topic and look forward to providing my expertise wherever it might be helpful.

Thank you.

[The prepared statement of Mr. Patel follows:]

Energy+Environmental Economics
101 Montgomery Street | Suite 1600 | San Francisco, CA 94104 | 415.391.5100 | www.ethree.com

TESTIMONY OF KUSHAL PATEL

PARTNER, ENERGY AND ENVIRONMENTAL ECONOMICS, INC. (E3)

U.S. HOUSE OF REPRESENTATIVES

ENERGY AND COMMERCE COMMITTEE

ENERGY SUBCOMMITTEE

Hearing entitled "Powering America: The Role of Energy Storage in the Nation's Electricity System"

July 18, 2018

Executive Summary

Thank you very much for the invitation to testify at this hearing on the role of energy storage in the nation's electricity system. My name is Kushal Patel and I am a Partner at Energy and Environmental Economics, Inc. ("E3"), a consulting firm based in San Francisco, California, that focuses exclusively on energy issues and has studied energy storage for over 20 years.

Energy storage has been called the "Swiss Army knife" of the electric grid in recognition of the many services it can perform. Energy storage is expected to play an ever-larger role in our electric grid because of the variety of benefits it can provide to customers, utilities, and the wholesale markets. These include helping to manage individual customers' electric bills; helping to lower utilities' infrastructure costs (which benefits utility ratepayers); and helping to lower wholesale system operating costs (which benefits consumers), particularly as larger amounts of renewable and less-emitting energy sources come online in the future. However, the barriers facing energy storage are substantial. These include high (but declining) costs and, more importantly, the limited ability for storage to earn revenues for the numerous services it can perform. Today, clear routes to market exist for only a limited number of storage services; others cannot currently be monetized, while still others, such as those related to integrating larger amounts of renewable energy, may not become valuable until the future and only in certain jurisdictions.

I recently assisted several New York State agencies with the development of the **New York Energy Storage Roadmap**[1], a first-of-its-kind, analytically driven set of recommended policy, regulatory, and programmatic actions to help New York achieve its target of installing 1,500 megawatts (MW) of advanced energy storage by 2025, as per a recent announcement by Governor Andrew M. Cuomo. The roadmap found that many customer-sited and distribution system energy storage use cases and paired solar + storage projects are, or will soon become, viable in New York, mostly in high-value locations in New York City and Long Island. A companion analysis quantified over $3 billion in gross ratepayer benefits from New York's deployment of 2,800 to 3,600 MW of energy storage by 2030.

The key to harnessing energy storage as a beneficial resource for our nation's electric grid **is twofold.** First, policies and rules must be established that **allow storage assets to provide multiple services** at the wholesale, distribution, and customer levels. Second, **storage assets must be fairly compensated**. Doing so will enable the optimal deployment of storage assets and create a stable environment for longer-term investment and financing. Energy storage is a complex set of technologies, and integrating them cost-effectively into the electric grid while maintaining safety, reliability, and affordability is no small task. I applaud the Subcommittee's leadership in addressing this challenge and look forward to providing my expertise in whatever ways might be helpful.

[1] https://www.ethree.com/e3-helps-new-york-state-develop-energy-storage-roadmap/

Introduction

Thank you, Chairman Upton, Ranking Member Rush, and Members of the Subcommittee, for inviting me to testify on the topic of energy storage. My name is Kushal Patel and I am a Partner at Energy and Environmental Economics, Inc. ("E3"). E3 is an economic consulting firm based in San Francisco, California, that focuses exclusively on energy issues. We work across the U.S. on a diverse range of topics supporting numerous clients such as wholesale system operators, electric and natural gas utilities, public agencies, project developers, technology companies, and investors. E3 is able to serve such a broad client base because of our dedication to analytical rigor, our commitment to credibility and integrity, and our ability to think both creatively and realistically about today's and tomorrow's electric grid. This can be especially challenging given the sector's complex and shifting dynamics, which include disparate state-level policy mandates; continuous technology innovation and cost declines; low natural gas prices; and consumers' desire for more choice and control over their electricity supply.

E3 has analyzed today's topic – the role of energy storage[2] in the nation's electricity system – for over 20 years, starting with some of the earliest and most mature technologies like pumped storage-hydroelectric (pumped hydro), to current technologies like advanced lithium ion and flow batteries, to nascent technologies that may emerge over time. We have reviewed storage as both a stand-alone resource and one that is paired with generation (renewable or conventional). We have also looked at leveraging storage in multiple applications: participating directly in wholesale markets; as a "non-wires" solution that defers or avoids building transmission and/or distribution assets; and as a way for customers to reduce their electric bills.

I have almost 20 years of experience in the energy industry, primarily as a consultant. I lead E3's Asset Valuation practice, which involves working closely with energy storage developers and investors

[2] The terms "energy storage" and "storage" are used interchangeably in this testimony.

throughout the U.S. I have provided developers and investors with various kinds of analytical and strategic support for over 2,000 MW of energy storage projects in the U.S. ranging from large (>500 MW) pumped hydro storage projects to small, customer-sited lithium-ion batteries. In 2016, I supported a major equity investor in its successful effort to execute the world's first-ever project financing of a large battery project, which is located in Southern California. My work also includes supporting a number of public agencies. Most recently, I worked with several New York state agencies to develop a comprehensive "roadmap"[3] for that state to reach a storage deployment target of 1,500 MW by 2025 and a larger, as-yet-unspecified target for 2030. It is expected that many of the recommendations presented in that roadmap will lead to a number of enforceable regulatory and programmatic actions by the state of New York beginning next year. It is also expected that New York's experience with deploying large amounts of energy storage over the next few years may inform similar efforts in other states.

The conclusion of my testimony, to which I will return, is as follows: **The key to harnessing energy storage** as a beneficial resource for our nation's electric grid **is twofold.** First, policies and rules must be established that **allow storage assets to provide multiple services** at the wholesale, distribution, and customer levels. Second, **storage assets must be fairly compensated**. Doing so will enable the optimal deployment of storage assets and create a stable environment for longer-term investment and financing.

What Services Can Energy Storage Technologies Provide?

Energy has been called the "Swiss Army knife" of the electricity grid in recognition of the many services it can perform. Some services[4] are mutually exclusive and cannot be performed at the same time, while others can be "stacked" and performed at the same time and/or by the same resource. This flexibility is

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[3] https://www.nyserda.ny.gov/All%20Programs/Programs/Energy%20Storage/Achieving%20NY%20Energy%20Goals/The%20New%20York%20State%20Energy%20Storage%20Roadmap; https://www.governor.ny.gov/news/governor-cuomo-announces-new-york-energy-storage-roadmap-achieve-nation-leading-target-1500;

[4] Note, certain services can be performed singly or combined to construct energy storage "use cases" for examination/analysis.

especially important as our electric system evolves to become more decarbonized, decentralized, and complex.[5] Our current electric system was designed to operate with conventional assets, which are long-lived, relatively inflexible, "lumpy", fixed-in-place, and single-use. By contrast, storage offers flexible, modular, mobile, and potentially multi-use assets that can provide a range of services to the wholesale market as well as the distribution system and individual customers. Ultimately, the type, number, and value of services that storage can provide are likely to change as the needs of the electric system change and storage technology advances. This means that certain services may be valuable in the near-term and for perhaps only short periods of time, while others may not be valuable until further in the future. Generally, storage technologies cannot perform all services of which they are capable simultaneously, which creates a need for clear market rules as well as performance, dispatch, and control requirements and signals in order to enable maximum and reliable value at minimum cost.

It is also important to remember that energy storage is much more than just large-scale lithium ion batteries. Rather, storage is a complex set of technologies[6], including some that have supported the U.S. electric grid for decades (e.g., large pumped hydro); some more recent technologies like flywheels and thermal storage (e.g., ice, hot water, molten salt); and other technologies that are still in the research and development phase. These technologies differ in terms of their performance, scale, and other physical and economic characteristics (see Figure 1), and policy makers must keep these differences in mind as they seek to deploy energy storage solutions.

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[5] This complexity will most likely take the form of a system with two-way power flow characterized by more renewable, intermittent energy; increasing diversity of end-uses and customer preferences; greater levels of data analytics and control technologies, the potential electrification of the heating and transportation sectors of the economy; and the need for increased system resiliency and lower costs to maintain a safe, affordable, and reliable electric system.

[6] Energy storage can be based on **chemical, electric, thermal, and mechanical** technologies. Chemical technologies include lithium-ion and flow batteries under various chemistries as well as fuel cells. Electrical technologies consist of superconductors or capacitors. Thermal technologies include molten salt, ice, and hot water storage. Mechanical technologies include pumped storage-hydroelectric, compressed air, and flywheel storage.

Figure 1: How to group energy storage technologies by the services they perform.

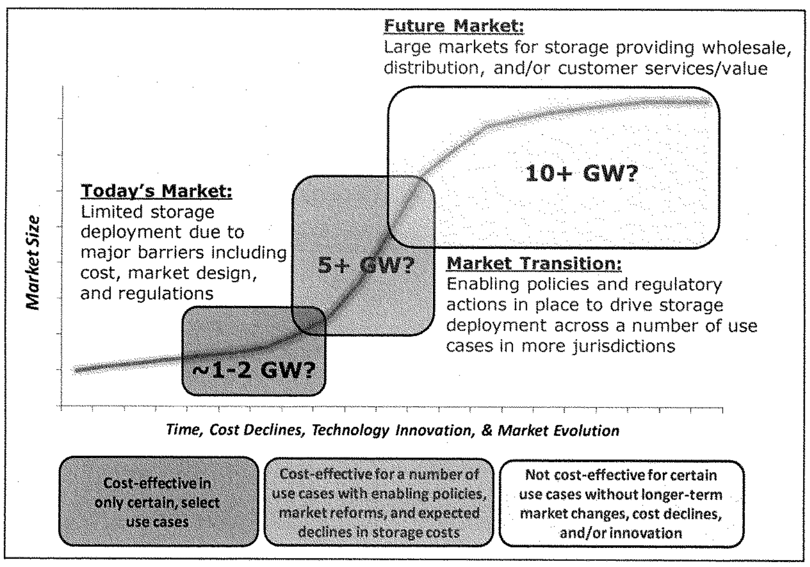
+ Can perform service ± May perform service under certain circumstances - Cannot perform service

1Market	Service (Value/Benefit)	Timescale	Chemical	Electrical	Thermal	Mechanical
Wholesale	Frequency Regulation	Seconds, minutes	+	+	-	+
	Load Following/Ramping	Seconds, minutes, hours	+	+	-	+
	Renewable Integration	Seconds, minutes, hours, days, seasons	+	+	-	+
	Spinning Reserves	Minutes, hours	+	+	-	+
	Non-Spinning Reserves	Minutes, hours	+	+	-	+
	Voltage Support	Minutes, hours	+	+	-	+
	Black Start	Minutes, hours	+	+	-	+
	Energy (arbitrage, peak shaving, shifting)	Minutes, hours, days	+	+	-	+
	Emission Reductions	Minutes, hours, days, months, seasons, years	±	±	±	±
	System Capacity or Resource Adequacy	Months, years	+	-	-	+
	Transmission Deferral/Avoidance	Months, years	+	-	-	+
Distribution	Volt/VaR Control	Seconds, minutes	+	-	-	-
	Outage Mitigation	Minutes, hours, days	+	-	-	-
	DG integration	Minutes, hours, days	+	-	-	-
	Distribution Deferral/Avoidance	Months, years	+	-	-	-
	Distribution Congestion Relief	Months, years	+	-	-	-
Retail (Customer or Ratepayer)	Power Reliability	Seconds, minutes, hours	+	-	-	-
	Backup Power	Minutes, hours	+	-	-	-
	Utility Delivery Charge Savings	Minutes, days, months	+	-	±	-
	Retail Commodity Charge Savings	Hours, days, months	+	-	±	-

Energy storage is expected to play an ever larger role in the electric grid because of the variety of benefits it can provide to customers, utilities, and the wholesale markets. These include helping to manage individual customers' electric bills; helping to lower utilities' infrastructure costs (which benefits utility ratepayers); and helping to lower wholesale system operating costs (which benefits consumers), particularly as larger amounts of renewable and less-emitting energy sources come online in the future.

Figure 2 below summarizes E3's market outlook for energy storage in the U.S. Current barriers limiting cost-effective storage deployment include the high (but declining) cost of storage and, more importantly, its limited ability to earn revenues for the numerous services it can perform. Costs of energy storage are expected to continue declining rapidly over the next few years in parallel with technology innovation and market evolution; this will allow for more cost-effective deployment, especially if more supportive policies and regulatory actions are introduced.

Figure 2: How will the U.S. market for energy storage evolve?



Nevertheless, the current barriers to storage are substantial. Clear routes to market exist for only a limited number of storage services; others cannot currently be monetized, while still others, such as those related to integrating larger amounts of renewable energy, may not become valuable until the future. Consequently, some storage benefits remain unrealized; this is especially true of services that can be stacked, either at the same time or with the same resource over time. The primary challenges facing storage, especially advanced energy storage include:

- **The inability to monetize the full value of storage**. Current operating restrictions and/or high costs from aggregation or telemetry that would enable monetizing multiple stacked services are one of the largest barriers to storage. The inability to fully monetize storage limits its value, and therefore its economics, in today's electricity markets.
- **Limited routes to existing markets.** Regulatory and market rules, which were put in place largely before resources like advanced energy storage were available, often limit the ability of storage to receive appropriate compensation. In some cases, these rules do not fully recognize the value of storage's near-instantaneous response as compared to alternatives in today's markets.
- **Confidence in performance and lifetime**. The diversity and relative "newness" of different types of energy storage technologies, products, applications, and use cases complicate understanding and confidence among potential customers, system operators, and investors.
- **Lack of common financing vehicles**. The relatively low volume of existing advanced energy storage projects contributes to a lack of standardized and transparent processes, procedures, and documentation, which in turn impedes investor confidence and traditional financing and increases transaction costs.
- **High costs** of hardware and "soft costs" related to permitting, siting, interconnection, customer acquisition, and financing.
- **Insufficient data and lack of situational awareness of the electric system**, which impedes efforts to site energy storage for maximum system benefit and identify potential customers.

Some of the key factors driving energy storage adoption include:

- **Declining costs** averaging 10-15 percent per year, which are forecasted to continue through at least the early 2020s.
- **Better performance and longevity** of different energy storage technologies.
- **Increasing investment appetite** among developers and financiers.
- **Improved understanding** of the value provided by energy storage.
- **Policy and regulatory commitments** such as targeted energy storage incentives, utility procurement targets for energy storage and renewables, and wholesale/distribution market participation models for energy storage.

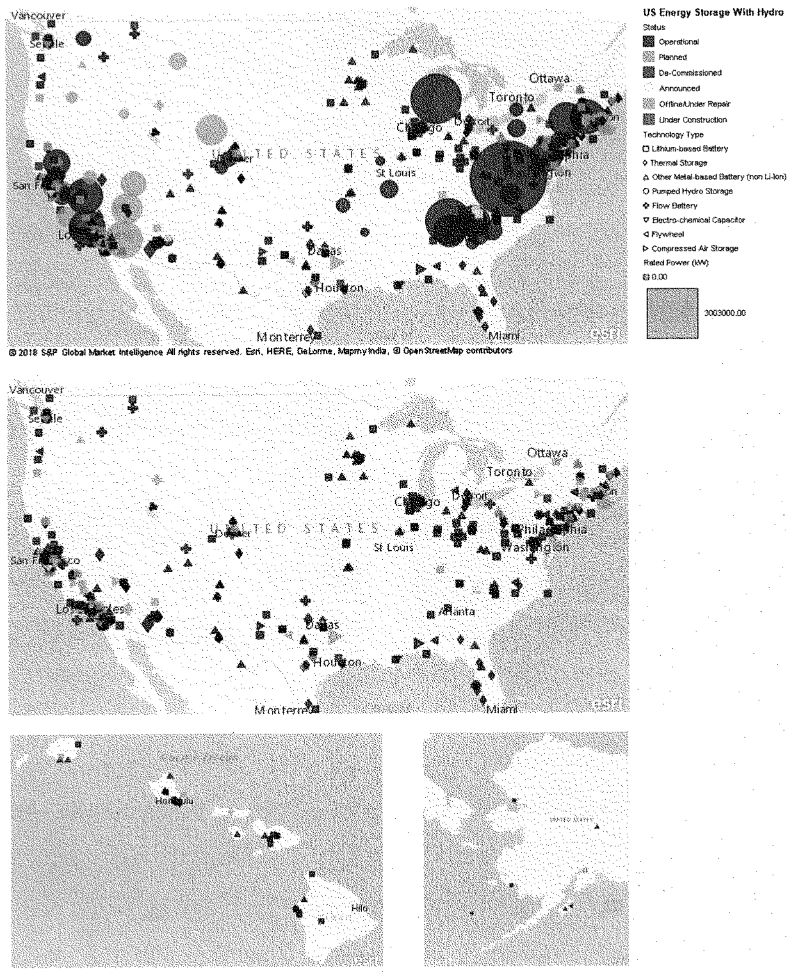
What is the Status of Energy Storage in the U.S.?

Currently the largest U.S. energy storage markets – California and Hawai'i – are driven by utility procurement mandates, state incentives, and high renewable penetration. New York[7], Massachusetts, and New Jersey are poised to become large energy storage markets, while markets such as Arizona, Nevada, Illinois, and Texas are not far behind. A number of diverse storage applications are being piloted and deployed at scale to provide resource adequacy and local distribution value (in California) and to help integrate rooftop solar and large-scale renewables (in Hawai'i). There is a pipeline of projects in the development stage as well as a large number of projects in the planning stage, including potential hybridization[8] of existing conventional power plants.

Figure 3 gives an overview of the U.S. energy storage market, showing approximately 25 GW of existing energy storage with an additional 7.8 GW announced, planned, and/or under construction.[9] The majority of existing energy storage is in the form of large pumped hydro while projects that have been announced, planned, and/or under construction represent a mix of technologies including large lithium ion batteries.

[7] New York State has currently deployed approximately 60 megawatts (MW) of advanced energy storage capacity, with another 500 MW in the pipeline. (This is in addition to its 1,400 MW of traditional pumped hydro.) Under the State's energy storage target, its advanced (non-hydro) storage will grow to 1,500 MW by 2025. Studies performed by Acelerex quantified over $3 billion in gross ratepayer benefits from New York's deployment of 2,800-3,600 MW of energy storage by 2030.
[8] This is where energy storage is added to an existing conventional resource to enhance operations, increase revenues, etc.
[9] S&P Global Market Intelligence data from March 2018.

Figure 3: U.S. energy storage market (with and without large pumped hydro).



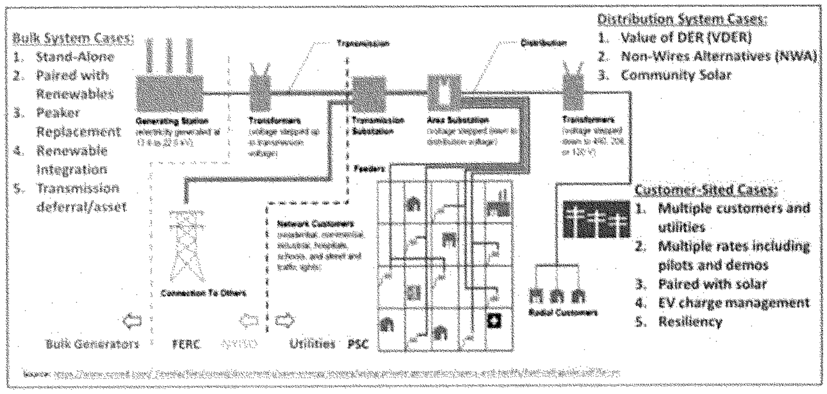
How is New York Accelerating Energy Storage Deployment?

New York is poised to join California and Hawai'i as one of the leading markets for advanced energy storage in the U.S. Earlier this year, Governor Andrew M. Cuomo announced a statewide target to install 1,500 megawatts of energy storage by 2025. In response, state agencies developed the New York Energy Storage Roadmap, an analytically driven set of recommended policy, regulatory, and programmatic actions that represent the best near-term opportunities to support energy storage deployment. These recommendations address barriers that can realistically be remedied on the path to reaching New York's 2025 storage target as it explores an even more ambitious target for 2030.

The roadmap focuses on near-term actions to allow New York to deploy storage in ways that are viable, replicable, and scalable for storage projects that are customer sited as well as sited in the distribution and bulk system (i.e. the wholesale market). It does this by focusing on the storage applications that provide the most value to the system while minimizing overall costs to customers. Accelerating storage deployment in the near term was important to New York for several reasons, including reducing "soft costs" (i.e., non-hardware costs) such as permitting and customer acquisition; increasing awareness and confidence in the ability of energy storage to meet electric system needs; and expanding customer choice by increasing the number of developers selling storage solutions in New York.

The roadmap examined a large and diverse number of energy storage use cases that informed the recommended actions, which can be seen in Figure 4 below.

Figure 4: Categories of use cases analyzed in the New York State Energy Roadmap.



The roadmap found that **many customer-sited and distribution system use cases and paired solar + storage projects are, or will soon become, viable in downstate New York between now and 2025**. This is due to better storage project economics, where higher value streams offset higher costs. Economically attractive opportunities to pair storage with renewables and potentially to hybridize and/or replace fossil peaking units will also begin to arise, as will high-value distribution system use cases in upstate New York. In the longer term, numerous diverse use cases will become economic across New York, especially as the system adds more renewables and the cost of storage solutions continues to decline. Importantly, there will also be cases in which project economics far surpass the illustrative economics shown in the roadmap due to different load shapes and local electric system needs.

The roadmap's key takeaways are as follows:

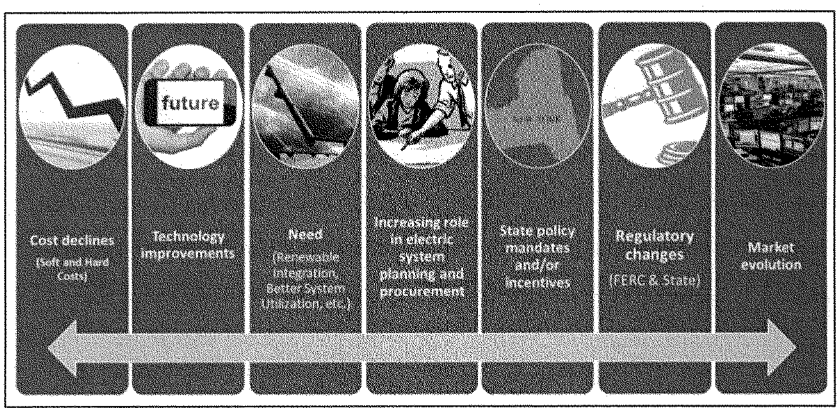
- **Value stacking** – allowing storage to perform and be compensated for multiple services, especially at the wholesale market level – **is essential to maximizing its value**. A Swiss Army knife is just a regular knife if you only use the blade and not its other tools.
- Creating rules and structures to allow for **"dual market" participation** is a key priority so that individual energy storage assets can participate, provide value, and be compensated for both services at the retail/distribution level as well as the wholesale market level.

- There will be an evolution of the market for energy storage as barriers are removed and markets evolve. In the near term, only **certain high-value energy storage use cases or applications will be cost-effective** absent incentives or radical market changes; over time, more and more use cases will become economic, replicable, and scalable.
- **Revenue certainty** is needed to enable investment and financing of energy storage given its 10-20 year asset life and high upfront costs.
- A **market acceleration "bridge" incentive** may be justified to accelerate energy storage deployment. Such an incentive would "buy" 1-2 years' worth of expected storage cost declines in order to bend the overall cost curve downward, producing net savings to customers and reducing future storage costs to meet public policy goals.

The roadmap was developed to drive storage deployment (as per Figure 5 below) by:

1. **Engaging stakeholders** across customers, utilities, the system operator (NYISO), and various other market participants through working groups, conferences, and individual meetings, and leveraging their input.
2. **Identifying and modeling storage deployment use cases** to reflect an extensive but not exhaustive range of potential installations and customer types.
3. **Recognizing key challenges and barriers,** and formulating actions to address them.
4. **Conducting an in-depth analysis** of each use case to evaluate and analyze storage value; develop, inform, and test potential recommended actions; estimate potential market uptake; and develop implementation pathways.
5. **Developing a set of recommended actions** that immediately begin transitioning New York's storage market to the desired end state: a self-sustaining market that responds to system needs and price signals and yields maximum benefit for customers. Importantly, the roadmap is technology-agnostic and recognizes that a range of storage solutions will be deployed to best meet customer and system needs.

Figure 5: The many aspects of unlocking storage value and deployment.



Conclusion: The Future of Energy Storage

Energy storage is poised to assume the primary role in providing many grid services, especially at the wholesale market level as its costs decline. Energy storage can and will perform an increasing number services as technology evolves and costs continue to decline, but **key enabling policies and regulations are needed**.

For years, E3 has been analyzing energy storage and how the electric grid and its various markets across the U.S. might evolve. We feel there is significant value in energy storage, especially when wholesale market services can be stacked on top of retail and distribution services. Specific approaches to value stacking will almost certainly change over time; because the electric grid is evolving at all levels (i.e., retail, distribution, and wholesale), the potential benefits of storage, and the mechanisms for utilizing and compensating those benefits, will evolve as well.

In conclusion, **the key to harnessing energy storage** as a beneficial resource for our nation's electric grid **is twofold.** First, policies and rules must be established that **allow storage assets to provide multiple services** at the wholesale, distribution, and customer levels. Second, **storage assets must be fairly compensated**. Doing so will enable the optimal deployment of storage assets and create a stable environment for longer-term investment and financing.

Energy storage, which most people think of simply as large-scale batteries, is actually a complex set of technologies, and integrating them cost-effectively into the electric grid – while maintaining safety, reliability, and affordability – is no small task. I applaud the Subcommittee's leadership in addressing this challenge, and look forward to providing my expertise and perspective in whatever ways might be helpful.

Thank you.

Mr. UPTON. Thank you.

Mr. Kumaraswamy?

STATEMENT OF KIRAN KUMARASWAMY

Mr. KUMARASWAMY. Thank you, Chairman Upton, Ranking Member Rush, and distinguished members of the subcommittee. My name is Kiran Kumaraswamy, and I am a Market Applications Director at Fluence, a Siemens and AES company. I am honored to testify in front of you today on the topic of energy storage and its role in the Nation's electricity system.

Fluence is an electricity energy storage technology and services company jointly owned by Siemens and the AES Corporation. Fluence combines the engineering, product development, implementation, and service capabilities of AES and Siemens' energy storage teams and is currently engaging in an aggressive expansion of the business, backed by financial support of the two parent organizations.

Energy storage allows us to meet the challenges related to the changing energy landscape, transforming the way we power the world by making better use of all the electricity infrastructure assets we are putting on the grid and utilizing the ones that we already have in place. With the introduction of energy storage, we finally have the technical capability to create unbreakable, resilient power networks that enable the interaction of microgrids, minigrids, and distributed generation.

Renewable energy generation is leading us toward a cleaner, more sustainable future, but the variability of that generation and the influx of low-cost clean energy is shifting the way both generation assets and power markets operate. Energy storage is needed to achieve the full potential of renewable energy and to ensure all market participants are able to benefit from this incredible transformation.

Energy storage is providing flexible peaking capacity today in California and has been deployed as a T&D asset in Arizona. Energy storage also has been proposed and selected in regional transmission planning processes in organized markets across the country.

The economics of advanced energy storage have reached the point where storage is a more cost-effective alternative to traditional single-use infrastructure, such as natural-gas-fired peaking plants, and can provide critical grid services more effectively at a lower cost.

Barriers to energy storage have taken numerous forms, including market rules that inadvertently exclude energy storage from revenue streams because the market rules were written with other technologies in mind.

Fundamentally, policymakers can continue removing barriers to storage by focusing on three main policy goals: first, removing barriers to grid and market access; second, allowing storage to compete in all planning and procurement that happens across the country; and, third, appropriately valuing and compensating storage for the flexibility that it provides for our power network.

California has led the way in ensuring storage can participate in markets by allowing energy storage to be owned by both utilities and third parties, allowing it to participate and earn multiple revenue streams, and ensuring that capacity market rules don't unduly discriminate against the characteristics of energy storage.

Some States have chosen to set a storage target to increase adoption of technology and realization of potential benefits to ratepayers. This has had the beneficial effect of clarifying the benefits storage can provide to the State and providing confidence to developers that the State is committed to energy storage over the longer term.

These storage targets, whether binding or aspirational, can be a key factor in encouraging utilities, regulators, and stakeholders to modernize their planning and procurement practices to take advantage of energy storage, as well as to focus State regulators on identifying and addressing barriers to storage deployment.

States are also removing barriers to storage by including it in planning processes. A model in this regard is Washington State, where the commission has ruled that energy storage must be considered robustly in utilities' integrated resource plans and that generation procurement needs to happen via technology-neutral solicitations to maximize competition. By directing utilities to consider storage along with other investment options in generation, transmission, and distribution, State regulators are ensuring appropriate competition of solutions for electric grid reliability.

States are leading by making storage part of the generation mix. Storage can save U.S. consumers tens of billions of dollars, but this can happen only if the Federal Energy Regulatory Commission makes energy storage part of traditional transmission planning processes.

Federal policymakers have acted to remove barriers to storage. We are pleased that FERC finalized Order 841 to ensure fair and equal access for storage resources to compete in wholesale power markets. In addition, we are pleased that FERC finalized Order 845 to better enable storage to connect to the electric grid when colocated at existing power plants. We believe these are important policy initiatives at FERC that can create lasting wholesale market changes.

Chairman Upton, thank you again for the opportunity to testify today. I would like to invite you and other members of the subcommittee to visit any of our storage facilities in the United States.

Thank you.

[The prepared statement of Mr. Kumaraswamy follows:]

FLUENCE
A Siemens and AES Company

Kiran Kumaraswamy
Market Applications Director
Fluence

July 18, 2018

Testimony of Kiran Kumaraswamy, Market Applications Director of Fluence Before the U.S. House, Subcommittee on Energy hearing entitled "Powering America: The Role of Energy Storage in the Nation's Electricity System."

Thank you, Chairman Upton, Ranking Member Rush and Distinguished Members of the Subcommittee. My name is Kiran Kumaraswamy and I am Market Applications Director of Global Market Applications team at Fluence, a Siemens and AES company. I am honored to testify in front of you today on the topic of energy storage and its role in the nation's electricity system.

Background on Fluence

Fluence Energy, LLC ("Fluence") is an energy storage technology and services company jointly owned by Siemens AG and The AES Corporation ("AES"). Fluence combines the engineering, product development, implementation and services capabilities of AES' and Siemens' energy storage teams and is currently engaging in an aggressive expansion of the business backed by the financial support of the two parent organizations.

The market for energy storage is accelerating quickly. Utilities, developers and large energy users worldwide recognize energy storage's value as critical infrastructure that provides greater reliability, resilience and efficiency. Customers are calling for industrial-grade solutions, power sector expertise and financial stability not available from technology startups, battery manufacturers, automakers or others. Fluence was designed as a trusted partner to answer those needs, custom-built to deliver the most comprehensive set of energy storage solutions and services globally.

Fluence's sole focus is accelerating the speed and guiding the direction of global energy network transformation. Backed by the insights, reach and scale of Siemens and AES, we're creating a new generation of solutions and services provider that believes in prioritizing lasting partnerships over delivering products, the desire of users to have input into their energy choices, and the importance of the entire power ecosystem in forging a path to making a sustainable future model a certainty.

Energy storage is the next big thing in our nation's energy landscape

Electricity networks are as important as the Internet, powering everything we do and fueling the nearly $80 trillion global economy. However, when, where, and how people consume electricity is changing with the rise of renewables and distributed generation.

Countries around the world are making a transition, from centralized power systems designed over a century ago to decentralized and renewable power that's created closer to where it is needed. Coupled with aging infrastructure, this shift is posing significant challenges to communities around the world as they look to modernize their grids for the needs of the next century.

Energy storage allows us to meet those challenges, transforming the way we power our world by making better use of all of the electricity infrastructure assets we are putting on the grid and those we already have in place.

With the introduction of energy storage, we finally have the technical capability to create unbreakable and self-healing **networks** that enable the interaction of microgrids, mini-grids, and fully distributed generation. Energy storage also enables improved system utilization and right-sized investments to reduce system-level costs.

Renewable energy **generation** is leading us towards a cleaner, more sustainable future, but the variability of that generation and the influx of low-cost clean energy is shifting the way all both generation assets and power markets operate. Energy storage is needed to achieve the full potential of renewable energy and to ensure all market participants are able to benefit from this incredible transformation. Energy storage adds much needed capacity, which ensures there will always be power available to meet peak requirements. It also manages short-term variability in the system, by providing grid-stabilizing services in milliseconds and flexibility that is nearly three times as valuable per megawatt as that provided by the fastest gas turbines.

Energy storage is also the unique tool that gives **large energy users** the ability to control when they use grid power or their own reserves, enabling them to gain control over their energy costs. Storage help can protect businesses and other customers from demand charges and variable energy rates to deliver significant savings. Storage

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also safeguards their operations against outages, which can potentially result in lost revenue and equipment damage. If an outage occurs, energy storage can quickly and efficiently operate in islanded mode and can be paired with generation to ensure continuous operation.

Fluence brings proven technology solutions and services that overcome the commercial and regulatory barriers that stand in the way of modernizing our energy networks. We are the partner that can deliver energy storage solutions and provide guidance at a global scale with the most experienced and knowledgeable team in the world.

Commercial Applications for Utility-Scale Battery Energy Storage

Energy storage, unlike many single-use assets in our electric power system, can serve a variety of functions on the electric grid. Fluence delivers solutions that provide eight different applications and each of our technology platforms have been designed to stand up to the rigorous needs of these industrial applications. Several of these are illustrated below using real-world deployments already in operation or under construction.

The eight focus applications include Frequency Regulation, Microgrids & Islands, Critical Power, Energy Cost Control, Generation Enhancement, Capacity Peak Power, Renewable Integration, and Transmission & Distribution Enhancement.

	8 - Applications		18 – Use Cases
1	Frequency Regulation	1	Frequency Regulation/Control
		2	Generation Capacity Release
2	Microgrids & Islands	3	Microgrids
		4	Island Dispatch Optimization
3	Critical Power	5	Critical Power
4	Energy Cost Control	6	Energy Cost Control
5	Generation Enhancement	7	Generation Black Start
		8	Spinning Reserves
		9	Storage + Generation
6	Capacity Peak Power	10	Flexible Peaking Capacity
7	Renewable Integration	11	Grid Renewable Integration
		12	Storage + Renewables
8	Transmission & Distribution Enhancement	13	Transmission Capacity Release
		14	Network Peak Load Relief
		15	Congestion Management
		16	Network Black Start
		17	Distribution System Reliability
		18	Frequency Response

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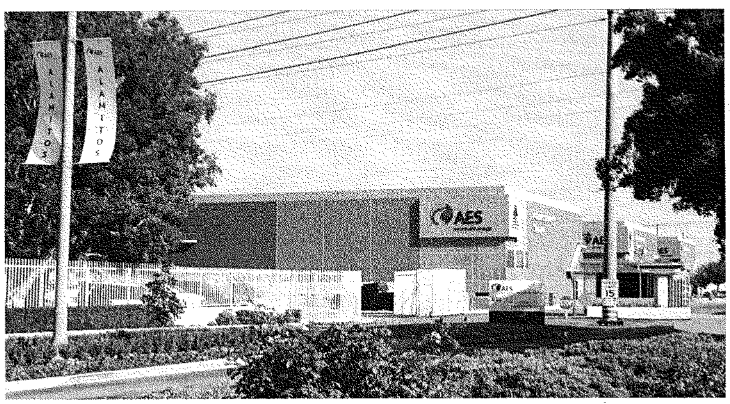
Storage as Flexible Peaking Capacity

Two utilities in the western U.S. are leading the way in harnessing energy storage for flexible peaking capacity. In 2014, Southern California Edison (SCE), the largest utility in our most populous state, was facing the retirement of older natural gas-fired power plants and the unexpected retirement of a large nuclear power plant. They needed to select new sources of capacity to meet their customer's needs. SCE ran a procurement solicitation in which energy storage was compared against gas-fired generation, demand response and other resources. They awarded AES the world's first long-term contract to provide peaking capacity from a battery-based energy storage facility in Long Beach, California. This plant will be able to provide 100 megawatts (MW) of power for four continuous hours, directly substituting for the need to build a new gas-fired peaking plant. It was selected by SCE on an economic basis, meaning that it will provide the capacity at a lower net cost to SCE's customers than obtaining the same amount capacity from a traditional gas-fired peaking plant. SCE's decision in this case was a watershed proof point for the economics, scale, and technology maturity of battery-based energy storage to meet electric system needs.



Site of 100 MW AES Alamitos Energy Center – Long Beach, CA

Then in 2016, when a critical natural gas storage facility providing peak reserve capacity near Los Angeles had to be taken out of service, the California Public Utility Commission (CPUC) directed investor-owned electric utilities in southern California to

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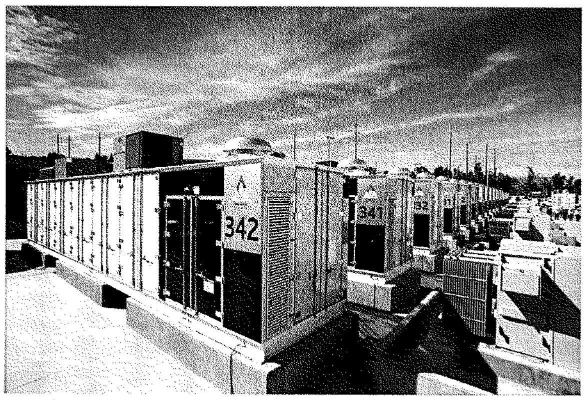
fast-track additional energy storage options to enhance regional energy reliability. In response, San Diego Gas & Electric (SDG&E) expedited ongoing negotiations and contracted with AES Energy Storage to build two projects for a total of 37.5 MW of 4-hour duration lithium-ion battery energy storage. The larger project, a 30 MW facility built in Escondido, Calif., is currently North America's largest lithium-ion battery installation, and both the Escondido project and a smaller 7.5 MW installation built in El Cajon were completed and online in eight months. SDG&E has already contracted with Fluence for a larger follow-up project, a 40 MW 4-hour duration installation in Fallbrook, which will be part of an 83.5 MW portfolio of additional 4-hour energy storage. Battery-based energy storage can be deployed in months compared to years required for traditional assets, which enabled southern California's utilities unparalleled flexibility to meet their local capacity needs.



30 MW SDG&E Advancion Energy Storage Facility – Escondido, CA

Storage as a Reliable Transmission & Distribution Asset

Arizona Public Service (APS) recently partnered with Fluence to become one of the first electric utilities in the country to choose energy storage to avoid the need to rebuild 20 miles of transmission and distribution poles and wires, which serve a small town 90 miles outside of Phoenix where peak electricity demand is increasing. By placing a relatively modest sized battery array at the end of the last 20-mile segment of power line, APS will save its customers the cost of rebuilding those lines, which cross over

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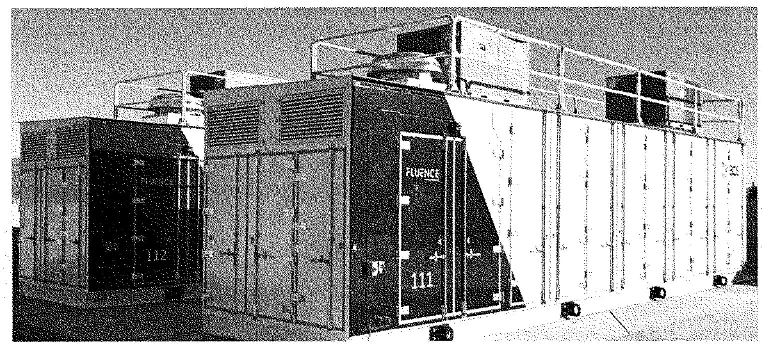
difficult terrain. When not being used to serve customer demand, the battery system will provide additional benefits like voltage regulation and delivery of excess solar power, as well as the capability to add additional storage as needed in lockstep with growth, all at a similar cost. In a number of cases, energy storage enables utilities to defer or avoid entirely investments in a variety of fundamental, single-function grid assets like wires, poles, transformers and substations, and in the process, get the most value from the transmission and distribution lines they already own and use. As communities across the U.S. and elsewhere around the globe work to modernize their electric grids, utilities are beginning to recognize that energy storage offers them new and different options for their infrastructure investment options and strategy.



2 MW APS Advancion Energy Storage Facility – Punkin Center, AZ

Energy storage also has been proposed and selected in regional transmission planning processes in organized markets across the country. In a recent example, the California Independent System Operator (CAISO) in its 2017/18 transmission planning process selected Pacific Gas & Electric (PG&E)'s Oakland Clean Energy Initiative, a portfolio of transmission projects designed to increase reliability in the East Bay area of San Francisco. Energy storage was included in the initiative, along with traditional transmission upgrades, because it was found to be cost-effective compared to other options and will enable the local area to operate without relying on local gas-fired generation in the future. We find this example compelling because it highlights the role that energy storage can play in rebuilding electric networks that serve local communities, providing a cost-effective alternative to traditional options available for upgrading our grid.

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Storage to enhance traditional generation assets

Deploying battery energy storage also provides significant value on small, isolated grid systems like those in northern Chile, where AES has deployed three energy storage systems. They work in concert with conventional generation sources to provide grid stability, responding instantly to disturbances in the grid, such as when a large power plant or transmission line suddenly stops working. These applications are similar to how energy storage would be used in island or microgrid applications, where many energy resources need to work in concert with each other. In these cases, energy storage fills the gaps between supply and demand, ensuring the reliable and efficient delivery of electricity and often avoiding the need to burn diesel fuel in generators, the predominant source of fuel in remote areas.

Battery energy storage paired with traditional generators can provide similar benefits on the large connected grids that are common in the United States. For example, SCE has deployed energy storage with a gas turbine at one of its facilities to increase the utilization of an existing gas turbine, while lower emissions and operating costs. The benefits of this hybrid resource are already being realized. Between July and December 2017, battery-based energy storage increased the utilization of the hybrid gas turbine to nearly 100%, compared to approximately 50% for standalone turbines[1]. The hybrid gas turbine was also able to provide the higher value and faster responding grid service known as spinning reserve, compared to standalone turbines that predominantly provide the lower value and slower responding service known as non-spinning reserve. This hybrid approach has resulted in lower fuel use and emissions, as well as higher revenues that were passed along to customers.

Other power plant operators are considering using energy storage to provide black start, a critical grid service that enables the grid to be repowered after a blackout. Traditionally this service has been provided by diesel generation, but the high pollutant emissions of those resources cause them to violate their air permits, particularly in dense urban areas. Energy storage can provide the same service without any direct emissions, enabling generating units to stay in compliance with existing air permits.

[1] http://www3.sce.com/sscc/law/dis/dbattach5e.nsf/0/723BE6C98E04967C8825826E0072B736/$FILE/A1703020-SCE%20Notice%20of%20Ex%20Parte%20Communication%20(4-10-18).pdf

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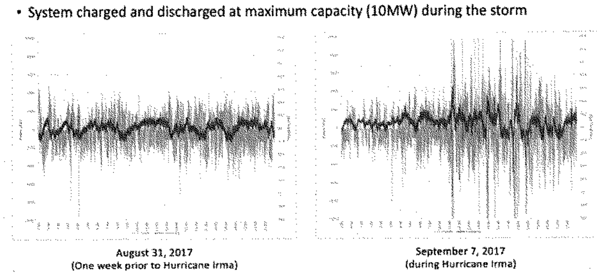
Storage providing frequency regulation and adding system resilience

Energy storage also adds resilience and can protect electric grids during severe weather events. During last year, when Hurricanes Irma and Maria – Category 4 and 3 hurricanes on the Saffir-Simpson scale, respectively – impacted the Dominican Republic on September 7th and 21st, 2017 and stressed the local grid. Fluence's team and AES had just deployed two 10-megawatt energy storage arrays on the Dominican grid, and as each hurricane approached the island, the grid operator requested that both systems be kept online and operational during the storm to help maintain grid stability. Conditions on the Dominican electric grid were volatile during both hurricanes as generation, transmission, and distribution networks were damaged or shut down. Both of the energy storage arrays responded as intended and helped keep the grid operating throughout the storm, even with nearly 40 and 55 percent of the Dominican Republic's generation assets forced to shut down during Hurricane Irma and Hurricane Maria, respectively.

Andres Power and Frequency – Hurricane Irma

- System charged and discharged at maximum capacity (10MW) during the storm



Source: Fluence

State and Federal Policy Can Remove Barriers to Energy Storage

The economics of advanced energy storage have reached the point where storage is a more cost-effective alternative to traditional single-use infrastructure, such as natural gas-fired peaking plants, and can provide critical grid services more effectively and at lower cost. Yet, as the economics of storage have progressed, state and federal regulators have discovered and are removing policy barriers that stand in the way of storage competing on a level playing field.

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These barriers to energy storage have taken numerous forms, including market rules that inadvertently exclude energy storage from revenue streams because they were written with other technologies in mind. Fundamentally, policymakers can continue removing barriers to storage by focusing on three major goals: (1) removing barriers to grid and market access, including for storage providing multiple uses; (2) allowing storage to compete in all planning and procurement; and (3) appropriately valuing and compensating storage for the flexibility it provides.

California has led the way in ensuring storage can participate in markets by allowing energy storage to be owned by both utilities and third parties, allowing it to participate in multiple revenue streams, and ensuring that capacity market rules don't unduly discriminate against the characteristics of storage. Ownership models are being tested in multiple states, including Maryland's Public Conference 44 (PC 44) proceeding, which includes a workstream on a single storage asset being owned and shared by two parties. Massachusetts has allowed utilities to own storage, but not more than 20% of the storage in the state. These are just a few of the many examples where states are experimenting with regulatory structures to ensure their businesses and residential consumers benefit from energy storage.

Some states have chosen to set a storage target to increase adoption of technology and realization of potential benefits to ratepayers. This has had the beneficial effect of clarifying the benefits storage can provide to the state and providing confidence to developers that the state is committed to energy storage over the long term. The setting of a target often follows a cost-benefit study for energy storage, as we've seen in states ranging from California to Massachusetts to New York. These targets, whether binding or aspirational, can be a key factor in encouraging utilities, regulators, and stakeholders to modernize their planning and procurement practices to take advantage of energy storage, as well as to focus state regulators on identifying and addressing barriers to deployment. In California, establishing a storage target led to utilities becoming comfortable with buying and operating energy storage, and ultimately led them to adopt storage well ahead of the pace set by the original target.

States are also removing barriers to storage by including it in planning and prudency standards. A model state in this regard is Washington, where the commission has ruled that energy storage must be considered robustly in utilities' integrated resource plans, and that generation procurement needs to happen via technology-neutral requests for proposals (RFPs) to maximize competition. By directing utilities to consider storage

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alongside other investment options in generation, transmission, and distribution assets, state regulators are ensuring appropriate competition of solutions for electric grid reliability.

Federal policymakers have also acted to remove barriers to energy storage. We are pleased that the Federal Energy Regulatory Commission finalized Order 841 to ensure fair and equal access for storage resources to compete in wholesale power markets. In addition, we are pleased that FERC finalized Order 845 to better enable storage to connect to the electric grid when co-located at existing power plants. We believe these are important policy initiatives at FERC that can create lasting wholesale market changes that fully value the unique capabilities that storage brings and to encourage consideration of storage use for infrastructure needs. We note that FERC is currently considering requests for rehearing of both Order 841 and Order 845. FERC unanimously approved both Orders after extensive deliberation, and we caution that re-opening them as RTOs seek to finalize compliance would create significant uncertainty for storage developers planning projects in anticipation of their implementation.

Federal policymakers can continue removing barriers to incorporating storage into electric infrastructure as well. We are pleased that FERC has clarified that storage resources serving as a part of transmission infrastructure can seek cost recovery through cost-based and market-based rate structures. As conversations on resilience needs of the grid continue, we encourage FERC and grid operators to go further and include storage as a regular part of transmission planning, as well as establish a clearer regulatory framework for storage as a part of our nation's transmission infrastructure.

Finally, we note that there is uncertainty for storage developers awaiting new guidance from the IRS regarding circumstances under which storage is eligible for the Section 48 investment tax credit. The IRS issued received comments from industry over two years ago in response to its notice of new guidance, and we encourage the Department of Treasury and IRS to accelerate finalization of that guidance. Alternatively, Congress can resolve that uncertainty for the industry by issuing clarifying statutory guidance, such as the bipartisan Energy Storage Tax Incentive and Deployment Act (H.R. 4649). Doing so would remove constraints to storage project development while enabling all grid assets – gas plants, wind plants, and others – to benefit from the addition of energy storage to the electric system.

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Chairman Upton thank you again for the opportunity to testify today – I would like to invite you and the other Members of the Subcommittee to visit any of our storage facilities in the United States. I am happy to take any questions.

Thank you.

Mr. UPTON. Well, thank you all for your testimony.

You know, many of us here on this panel, I mean, we have pursued the all-of-the-above energy strategy, and part of that, obviously, is renewables. And we have seen great advancement in wind and solar and other forms over the last number of years. But, of course, the one knock on renewables has always been what happens when the wind doesn't blow and the sun doesn't shine, what is going to happen to that power, whether it is in West Texas or Tucson or anyplace else.

And so it really is exciting to hear the advancements that are made in energy storage, whether it is being an individual that has got that solar rooftop application or whether it may be in a big field outside of a nature center or a community college or a university or a military base. It really is exciting to see that, in fact, we can see those things happen.

And, of course, many of us here, a number of us here, went down to Puerto Rico and the Virgin Islands, as well as those Members from Texas who experienced firsthand the awful hurricanes from a year ago and the real problems of getting that power back up to speed, particularly in Puerto Rico and the Virgin Islands.

And I know that, Mr. Kumaraswamy, you talked a little bit in your testimony about how the hurricane season was certainly unprecedented. And I think that you all actually put in some electric infrastructure in the Gulf in advance. It wasn't in the islands directly impacted by the hurricane, I don't think, was it?

Mr. KUMARASWAMY. One of the islands was Dominican Republic, so——

Mr. UPTON. So it was impacted.

Mr. KUMARASWAMY. It was impacted.

Mr. UPTON. So did it perform as expected? Tell us a little bit about that.

Mr. KUMARASWAMY. Sure.

So we did put two energy storage projects in the Dominican Republic, and both of those energy storage projects provided very critical frequency response to the local electricity system during the Hurricane Irma and Maria conditions.

Conditions on the Dominican electric grid were very volatile during both hurricanes, as generation, transmission, and distribution networks were either damaged or shut down. Both of these energy storage arrays that we deployed responded as intended and helped to keep the grid operating through the storm, even with nearly 40 to 45 percent of the Dominican Republic's generation assets that were forced to shut down during Hurricane Irma and Hurricane Maria.

Mr. UPTON. In the Dominican Republic—so what we saw firsthand when we were down in Puerto Rico were, the downed power lines everywhere. There was a picture again, I think in the USA Today or perhaps Wall Street Journal, earlier this week about a bridge that we actually saw that was taken out.

The cost to the ratepayers, to the consumers, as we have looked at additional storage capabilities, what is the actual either reductions in power rates—how does it financially benefit the consumers?

Mr. KUMARASWAMY. That is a good question. One of the things that I highlighted in my testimony also is that we find energy storage to be a much more cost-effective option as opposed to a single-use infrastructure asset like a natural-gas-fired peaking plant that runs for a fraction of the year, right? So, if you think about a natural-gas-fired peaking generation plant, typically they run 40 to 60 hours of the year, so you are really fractionally utilizing a capital asset, spending several millions of dollars on this asset for the next 20 to 30 years and subjecting ratepayers for the cost recovery for all of these assets.

We think that energy storage is a way more cost-effective option, because it is able to provide the peaking capacity when you actually need it for the electric grid, but it is also able to provide a whole range of other services that the grid needs, because energy storage assets are connected to the grid 24-by-7, in comparison to a natural-gas-fired peaking plant, which needs to be started up and shut down.

Mr. UPTON. So one of the exciting things that has been happening in Michigan—this was legislation that was adopted in a bipartisan way a number of years ago—is that in Michigan we now have a 15-percent renewable standard. And all the utilities are able to meet that, and they have done a really good job. The indications are that by 2040 or 2045, in fact, that 15 percent is going to move up to perhaps as much as 40 to 45 percent of the electricity consumed will be from renewables.

So, to get to that point, obviously we need the storage. And I guess, though my time is expiring, I would like to know if there is one thing that we could do legislatively to help provide some incentives. How do we get all States to what we hope will be attained in Michigan, as it relates to perhaps legislation that might expedite the improvements of battery storage?

Just real quickly, if you have any ideas, knowing that my time is expiring. But I have the gavel, and it hasn't come down yet.

Mr. KUMARASWAMY. Maybe I will just go very quickly.

The easiest thing to do really is to ensure that energy storage is considered in the traditional planning and procurement processes, right? So, if it is related to traditional generation options that are being procured or transmission or distribution infrastructure that needs to be put in place, to the extent that you can consider energy storage as an option in that type of analysis, I think we have seen that putting that as an option really goes a long way in terms of enabling the utilities to better understand the benefits that the technology provides.

Thanks.

Mr. UPTON. Yes.

Any other quick comments?

Mr. FRIGO. No, I would wholeheartedly agree with that. All utilities need to put together an integrated resource plan. And I have seen this with the States, that has been done on a State level, which have pushed energy storage to basically mandate their utilities to really look to use energy storage in their system. So they have started to actively look at different ways across our system. And that is really what has jump-started it.

So I think it is providing direction through a regulatory way to have utilities look at it as a tool within their system and to—also, the other big thing is through the interconnection process that you have throughout the U.S., different in different markets, but to clear that path as well.

Mr. UPTON. Thank you.

Mr. Rush?

Mr. RUSH. I want to thank you, Mr. Chairman.

Mr. Kumaraswamy, you had indicated to the chairman that you were very involved in the Dominican Republic during the Hurricane Maria and you were able to stabilize the electricity network there in the Dominican Republic.

Do you know anything about the Dominican Republic's next-door neighbor? Can you compare what happened to them with what happened in Haiti? Or do you have any insight into——

Mr. KUMARASWAMY. That is a good question also. The impact of the hurricanes was, to my knowledge, less than on the Dominican Republic. And so I can't quite answer the question of comparing how much it was impacted in the Dominican versus Haiti or Puerto Rico.

But I think the real issue here is that energy storage is able to add resiliency to the electric system. And that is because it is able to provide frequency control for the electric grid in a manner that is very superior to some of the traditional resources that we have on the electric system that perform the same job.

So, if you think about the traditional electric generators that we have, they are usually pretty slow in responding to changes in the system frequency. Because of the thermal inertia that they have, it takes a while for them to actually stabilize the grid frequency. In comparison, energy storage is extremely quick to provide the response, which means that it is able to arrest any frequency decline much faster, right?

And so that is the nature in which the energy storage arrays that we deployed in Dominican actually acted. And so it should provide the same type of response wherever it is deployed.

Mr. RUSH. Well, thank you.

Mr. Patel, you mentioned your work in helping to establish the New York Energy Storage Roadmap. In your opinion, could there also be a Federal energy storage roadmap? And, if so, what would a plan look like? And what would it require from Congress, FERC, the RTOs, ISOs, or some combination of each of these stakeholders?

And the last part of the question is, what policies do you think are needed to help monetize storage benefits?

Mr. PATEL. Thank you, Ranking Member Rush. That is a great question.

Like with any roadmap, there is a beginning, a road, and the end. And I think, for New York, it is basically trying to figure out exactly how to reach a fairly ambitious target set by Governor Cuomo, and there are a lot of things that can be done in the near term, in the long term.

And I think, one of the big things about energy storage is that costs are coming down so fast, so the idea, then, is the timing element of identifying what are the highest-value applications now that can actually justify paying for itself and then how to actually take advantage of all the cost declines that are happening from technology providers and other people that are working hard on that and then incorporating that into the grid in a way that benefits all consumers and ratepayers.

Knowing that the electricity grid and things like that have been set for a very long time and in a very particular way, so it takes time to, like Keith said, be able to make sure that you are paying for the services you are getting and also integrating it in a way that enhances resiliency and reliability and not that makes it worse.

So, I think at the Federal level, I echo what we say here in the panel, is that the planning process and procurement has to change. Anyone who is in the energy industry is very excited about storage, including the utilities and everyone else. But the way that they do planning and procurement is very prescribed. So allowing more flexibility, looking at more assets, and things like that I think would be a very useful way for the Federal Government to help States and other entities that are regulated at the wholesale level to be able to think through how to utilize the storage in the most beneficial way, now in the next couple years but also in the long term, especially as we add more renewables and other types of resources.

Mr. RUSH. Mr. Chairman, since you are a fair chairman and since you took some extra time——

Mr. UPTON. You go right ahead. The gavel hasn't come down yet.

Mr. RUSH. All right.

Mr. UPTON. Are you yielding back?

Mr. RUSH. No, I'm not. I want to ask Dr. Casey a question.

Dr. Casey, can you just assess the level of the working relationship or the quality of the working relationship that you have with the Department of Energy? Are they fully engaged in partnership with this whole effort around storage?

Mr. CASEY. The Department of Energy you are asking?

Mr. RUSH. Yes.

Mr. CASEY. Yes, I would say the Department of Energy is actually a leader in developing microgrids, advanced energy storage systems. They have a number of projects in California that we have been collaborating with, as have the California State agencies.

So I think from a defense standpoint they view it as very imperative, from a resiliency standpoint, to maintain their operations. So I think they have been doing a terrific job in that regard.

Mr. RUSH. Thank you, Mr. Chairman.

Mr. UPTON. Mr. Barton.

Mr. BARTON. Thank you, Mr. Chairman.

I have been on this committee quite a while. I have been on the subcommittee I think the whole time. Rarely do we have a hearing or something like this where I know nothing about it, but you have got me today. I know almost nothing about battery storage capacity for the grid, so I am really glad to have this hearing.

I have got one parochial question, and then I have got a series of questions just on how you evaluate cost. The Brinkman book says that California ISO and the PJM ISO up in the Midwest have more capacity than Ercon, which hurts me as a Texan. I assume that is because Texas has such unlimited production energy capacity and coal-fired, natural gas fired, lignite—wind power, even solar power and nuclear power. Is that right, Mr. Frigo? Is that correct? Is that why Texas is lagging behind California?

Mr. FRIGO. Well, I think it is just a numbers game with demand. PJM encompasses several States, from Illinois ranging all the way to the east to New Jersey, and that is a very large area with a very large industrial, commercial, and residential base.

So as I mentioned before in my testimony, the power system here in the U.S. is built on a just-in-time system. So you have to have generation available to meet demand. So if you have an area with a large demand, such as PJM, you are going to have a lot of generation. California is—you know, if you just look at its GDP by itself, it is a very large area. So that obviously has a significant amount of load to—that is needed and, therefore, you have a lot of generation as well.

Texas has quite a bit of generation, but most of the load or demand, as you well know, is in the eastern part of the State with the major cities out in the western part of the State. It is more rural, and so you don't have as great a demand, but you do have a lot of wind power in the western part of the State.

Mr. BARTON. My Texas pride doesn't need to be hurt by that, is what you are telling me.

Now I want to ask some questions about cost. What is the incremental added cost of storage versus standby generation? Because it would seem to me—and I listened to what you said. It seemed to me that it would be better to have a power plant, maybe it is an old one, but it has already been discounted and depreciated, that is there than the added cost of building a big battery powered storage facility. Am I wrong on that?

Because, one of you said how much the costs are coming down. Is it more cost-effective now to have storage capacity that can't generate as opposed to an actual power plant that is on standby?

IWhoever is smartest can answer that.

Mr. CASEY. Well, I for sure won't go first then, at least not on that criteria.

I think the question you are asking is, if you have an existing power plant that is fully depreciated, would it make sense to add storage in place of it. And I think that really depends on the circumstance. But when you look at cost, I think part of the cost needs to, at least in the case of California, look at the environmental implications. California has a very aggressive goal to decarbonize its grid, which means they are looking for alternatives to relying on dirty, old convention power plants that are providing peak shaving capacity.

Mr. BARTON. Is it fair to say—and I am not against battery storage. Don't misunderstand. Or water storage or whatever storage is most cost-effective. But I am a little bit skeptical if we are doing this simply because we don't like natural gas power, we don't like coal power, we don't like nuclear power, because that would be an added cost that somebody's got to bear. Is that correct? It may be socially politically viable, but it is not economically the best decision.

Mr. CASEY. Yes. And, again, I would say—and, again, I think this is very much a matter of State policy. But if you have a State policy where you are focused on decarbonizing the grid and incorporating the cost when it comes to planning of the environmental cost of emissions, then when you look at it from that scope, adding battery storage to replacing an existing power plant can make sense from an economic standpoint.

Mr. BARTON. My time has expired. I will have a number of questions, I hope for the record, that they can answer on on how they value cost and the various algorithms, things like that.

Thank you, Mr. Chairman.

Mr. UPTON. Mr. McNerney.

Mr. MCNERNEY. I thank the chairman. And I neglected to welcome our two Californians here this morning. Mr. Casey and Mr. Patel, welcome. Thank you for testifying. Thank you all. Very interesting testimony this morning.

Mr. Casey, you mentioned that California is mostly compliant with FERC Order 841. What are some of the lessons learned from that implementation that could be brought to other States?

Mr. CASEY. Well, I think we are still learning. Battery storage in California is relatively new. Operationally, we have had just about 2 years of experience. I think the big thing is to really, as ISO/RTOs, to really engage with the storage resources that are participating, to understand what they are seeing. We have made refinements to our market model for battery storage based on feedback we have received from developers. So I think that is important.

I also think, when it comes to the value proposition of storage in organized markets, I think California can check the box on every value category for storage. The challenge is how do you stack those values and not look at them in silos. So if you are looking at battery storage as a transmission alternative, what are the other values it could provide to the ISO? And I think that is kind of the next stage of market sophistication with battery storage is stacking those multiuse values.

Mr. MCKINLEY. And that goes into my next question of behind the meter storage. How do you value that? And is blockchains one of the potential solutions? And if it is, what about the energy implications of using blockchains?

Mr. CASEY. Yes. Well, behind the meter storage can actually, in the California ISO, participate in the wholesale market. It can do it as a demand response, which is what we typically see. So we never see the actual output of battery storage, but what we do see is a reduction in demand at the end-use consumer. So we have a number of applications where behind the meter storage is providing demand response capability.

In terms of facilitating procurement of those types of resources, the California Public Utilities Commission does run an auction process where people can bid to offer those services and utilities buy them. I know they have talked about the potential for blockchain technology to help facilitate that. But I think it has all been very preliminary, so—I am not an expert on blockchain technology. I don't think it has been seriously considered in the context of behind the meter storage. But that is something we could certainly follow up with you on.

Mr. MCKINLEY. Can anyone on the panel address the blockchain energy question that we are using blockchains for residential mere valuation drive a large energy cost?

No one on the panel?

OK. Thank you.

Mr. Kuznar, thank you for your testimony this morning. What incentives will encourage you to reach the 145-megawatt goal more quickly?

Mr. KUZNAR. I think a couple of things. One, we have got a lot of those projects kind of planned out. We actually want to grow beyond that. One thing that was touched upon, which we are really focused on and I would like to expound upon a bit which is going to help us, is the planning process. And one thing we have traditionally always done is looked at kind of a generation planning to meet our load and looked at what is the lowest cost generation. We have looked at transmission distribution.

One of the projects that we are really rolling out and was just going to help us, I think, exceed that is coupling those. So when I look at battery storage, for example, I can put it out at distribution circuit and defer an upgrade. That could improve reliability. I could also use a fleet of those assets to peak shave. I could use it for frequency regulation. So how do we bundle those values together? And that has been one of our big focuses. But our plan is to execute on those and then exceed that number going forward.

Mr. MCKINLEY. Thank you.

My next question is for Mr. Patel and Mr. Kumaraswamy. How would you properly value storage? How would you do it? I mean, you are telling us we need to figure out how to properly value storage. What are your recommendations?

Mr. PATEL. I can go first.

We have done a lot of economic analysis at E3 on this, and it is challenging because storage is so flexible. So sometimes, as others have said it, it uses kind of a Pico replacement. So, instead of building a new combined cycle or combustion turbine, we are using it to avoid that. So it is providing that service. And other times I might be doing something for the distribution utility. And behind the meter, I might be doing something for the customer itself reducing their bills.

So the idea, then, is to figure out exactly how that all works together and in a market participation model. So you are making sure that it is doing the things it is supposed to be doing, getting paid for it, but also making sure they can actually perform and do that.

So I think that is—what values can actually be stacked realistically with the technology we have today. And then also going forward, you have those values change too. So it is, what we can do today and what is value today. Then also the grid is changing, so the values will change as well.

So, maybe for some years some values will be very high and other years it will be very low. And then, how can you take advantage of that? Very big challenge.

Mr. MCKINLEY. In the interest of time, I am going to just ask—I will propose this as a question for the record for both of you, and anyone else that would like to answer that.

Thank you. I yield back.

Mr. UPTON. Mr. McKinley.

Mr. MCKINLEY. Thank you, Mr. Chairman.

I am maybe a little bit like Barton, just curious more about how this all operates. I can understand when I see a power plant, whether it is coal, nuclear, gas. But when we have battery storage, are they onsite with these facilities, tangential? Where are these lithium batteries? Because about 80 percent of our storage is in lithium. Where are these and how secure are they?

Mr. FRIGO. I could probably answer that first.

These lithium ion batteries actually can be used for—we talk about multiple applications. They can be used for multiple different things. They can be used for generation and they could actually be used as a transmission or distribution type of device. So depending on who you talk to, there is upwards of, call it 15 to 20 different applications. And we talked a little bit about them today.

But they can be located depending on—it is very dependent upon the application. If it is a T&D, transmission and distribution deferral type of application that was mentioned earlier, you would locate it near the substation or the power line where you have the problem on. If you are using it more——

Mr. MCKINLEY. OK. Maybe we need to have a followup with that.

I think, Dr. Casey, you comment a little bit about it, is that you can't—I thought I heard you say you can't measure the outflow. Someone may have implied that. But I am just—PJM and California, between the two of them, 70 to 80 percent of all battery storage in America. How often is it used? How often are we drawing down on it? And when we do draw down on it, over an annualized basis, what is the equivalent? Is it an equivalent of a 1400-megawatt power station that could have been available? I am trying to get to quantify the demand and how we use our battery discharge.

Mr. CASEY. Well, in the case of California——

Mr. MCKINLEY. Go to the PJM.

Mr. CASEY. Well, I can't really speak for PJM, I am afraid.

Mr. MCKINLEY. OK. Well, try your California model.

Mr. CASEY. OK. In the case of California, we use the batteries we have in our market quite frequently. We are almost daily dispatching them. We have a systemic issue where we tend to have oversupply during the middle of the day with the solar output.

Mr. MCKINLEY. What I am driving toward, are we talking about over a year's time in California? They are a little different out there. But I am trying to figure out what is the equivalent for a power station? How many power stations have we avoided by using battery storage?

Mr. CASEY. Well, we have roughly——

Mr. MCKINLEY. What is the discharge? How much do we discharge in a year's time in California?

Mr. CASEY. We have roughly about 134 megawatts of batteries on our system. We operate those daily. So I would suggest to you that they operate at the equivalence of a power plant of that same size.

Mr. MCKINLEY. OK. So does the consumer save money by having battery operations in their grid system?

Mr. CASEY. Yes. They can in multiple ways. And I know some of the panelists are eager to speak to that. But it gets to this multiuse value, particularly if the battery is located behind the customer's meter. So I will defer to some of my colleagues.

Mr. KUMARASWAMY. Yes. It absolutely saves money for repairs. I will give you one example. And I will also answer one of the previous questions.

In 2014, the Southern California Edison, which is one of the utilities in California, they had a shortage of capacity in the Southern California region. And they had a solicitation that was technology-neutral, and they went to the market to actually get all types of resources. And in that process, they actually selected 100 megawatts of grid scale energy storage resource on an economic basis, which means that, to your previous question, the 100 megawatts of four-hour energy storage project is going to be operated like 100 megawatt peaking plant.

Mr. MCKINLEY. OK. Well, I know that we are using primarily lithium-ion batteries, but we know they are much more expensive than the nickel cadmium. Is there a reason that they just stay charged longer? They don't have a loss? What is the rationale? Because by far, people use lithium ion, but they are a more expensive battery to use.

Mr. KUMARASWAMY. I can probably take it also.

The platforms that we have at Fluence are technology agnostic, but by far, most of the projects that we have deployed have been lithium-ion. And that is for a range of reasons, which include the lifetime cost of the overall project and the fact that you have an established supply chain behind this technology right now.

And so if you think about where we can add value for utilities and for ratepayers, we think that lithium ion is the leading technology right now. But, again, that is the situation in present day today.

Mr. MCKINLEY. My time has gone over. My point is, that if lithium ion is 40 percent more expensive, if we went nickel cadmium, wouldn't we be able to lower the rates for the utility consumer?

Mr. FRIGO. Lithium ion is—there is actually different types of chemistries, and lithium ion is a general classification of batteries. And there is different actual chemistries, compositions, of which nickel manganese cobalt is actually one type of lithium ion battery. So it is actually a lithium ion battery.

Mr. UPTON. Mr. Peters.

Mr. PETERS. Thank you, Mr. Chairman. In response to Mr. McKinley, my colleague, I just had this article that SDG&E unveiled the largest lithium ion battery storage facility in 2017. Thirty megawatts of the 130, I think, is probably this facility, equivalent of 20,000 customers for 4 hours.

And I am really excited to hear all this innovation that is going on. I am excited to hear that batteries came back as part of a competition that was technology-neutral. I think we are heading for a lot of great opportunity here.

My questions have to do with what is the role of the Federal Government as opposed to the State government.

Mr. Frigo. Is that right?

Mr. FRIGO. Yes.

Mr. PETERS. Just in your testimony, it says market rules should, not only ensure participation, but should be examined to ensure that interconnection processes do not constitute barriers to entry.

Can you explain that to me?

Mr. FRIGO. Sure.

Mr. PETERS. Is there a Federal role in that or is that a State role?

Mr. FRIGO. That is actually a market role. So PJM, California, ISO, they all have their different interconnection processes. Yes. So for us as an independent power producer, when we go to develop a new project, whether it be wind, solar, natural gas, energy storage, we have to go through the interconnection process which defines—they study the amount of megawatts we propose to put on the system, see how it impacts the system, and if there is any upgrades that are needed associated with that.

And I will use an example. If you have 100-megawatt solar project in California and you are proposing to put, say, a 20-megawatt energy storage system or battery with that, it would be studied as a 120-megawatt facility, but in reality, it would not be operated as a 120-megawatt facility, because what you would be doing is you are actually taking some of that peak generation that is made during the high irradiation during the middle of the day and shifting it toward some shoulder peer. So you really need to study it more where for how it is going to be operated.

So these are the rules from the interconnection process that we need to make sure that it gets studied as it is actually going to be operated.

Mr. PETERS. Is there some government thing that is standing in the way of that happening? That is what I want to understand. What is the impediment to doing that, Dr. Casey?

Mr. CASEY. Well, just to clarify, I am not familiar with interconnection. Not that it is in other ISO/RTOs. But in the case of California, Mr. Frigo's example, we would actually study that project as 100 megawatts, provided the plant facility operator agrees they will never go above that.

So the point is, if they add a 20-megawatt battery, they have the potential to generate at 120. So long as they agree they will manage their facility and never go above 100, we will study it at 100. So that is an accommodation we made in our interconnection process. Maybe that type of accommodation needs to be done elsewhere.

But to get at your more general question about the role of Federal versus——

Mr. PETERS. So just in that instance, this is something that the ISO takes care of?

Mr. CASEY. Yes.

Mr. PETERS. OK. Go ahead.

Mr. CASEY. Yes. I think part of the challenge here is, depending on the scale of the storage facility, if it is a smaller project that is developed on the distribution system, it can have state jurisdiction issues, particularly if it is being connected behind a customer meter.

So when you talk about a Federal roadmap for storage, that might make sense in the context of large scale transmission connected. But I think more generally, these roadmaps, as New York has one, California has an energy storage roadmap, it is really recognizing that a lot of this is state policy. The Federal policy has to align with it, but there is a lot of state policy that has to align as well.

Mr. PETERS. OK. And then, Mr. Patel, you have got in your testimony storage assets must be fairly compensated. Again, that seems like it is something that the States and the ISOs handle. Is that right?

Mr. PATEL. Yes, that is right. I think, to Dr. Casey's point as well, and that seems the issue between the State and the Federal Government. And that's really something that has to be worked on. I think as a part of a Federal energy storage roadmap, that would be something that I think would be top of mind of exactly, how it participates in the wholesale market. And if it was just participating in wholesale markets only, it is fairly straightforward. If it is only doing distribution of retail, it is also straightforward. But if it is doing all of those things, then it starts getting very complicated. And I think that is the role of the Federal Government, FERC, and others to figure out exactly how to manage that.

Tthe easiest thing to do is say you can never do wholesale if you are doing distribution retail, and vice versa. But that, as we know, really diminishes the value of energy storage.

Mr. PETERS. Are you comfortable with the Federal Government prescribing through FERC some sort of national rule on that?

Mr. PATEL. I think it would be part of a pretty ongoing—I mean, it is already happening.

Mr. PETERS. OK. It seems like people are figuring it out without our help. But if you need our help, I want to know.

It has been my impression, before my time runs out too, by the way, that basic research funding for energy is something that the Federal Government can contribute to but that the States are doing a pretty good job of figuring out ways to make efficient markets. And we love the competition between California and Texas. It got my California pride up right now.

Mr. Chairman, I yield back.

Mr. UPTON. Thank you.

Mr. Long.

Mr. LONG. Thank you, Chairman.

Dr. Kuznar and Mr. Frigo, I have a question for both of you. What concerns me the most is when it comes to our electrical infrastructure is grid reliability, which I think that concerns most people, particularly ensuring customers in rural areas get dependable electricity delivered to them.

How do energy storage technologies help your companies ensure rural areas get the reliable electricity that they need? Dr. Kuznar?

Mr. KUZNAR. Great. And I thank you for that question. Perfect example is, one of our projects that we just got approval for in Indiana is actually a very rural community. It is a radially fed line which was to really bring in an additional distribution feeder there to improve the reliability; was extremely difficult just due to the trees, terrain.

So what we are actually doing is we are going to put a battery storage device out there, which, during a grid outage, will provide backup power to that community, give the crews enough time to fix the major outage and get them back up. So hopefully, they don't see there is any outage there.

And I think that is just a perfect example of one of the tools that it provides. When we look at our makeup as a whole, we don't look at storage as a replacement for base-load generation. That is still extremely important for our business. But it provides us these abilities to improve reliability for rural communities, help us integrate solar and provide some peaking needs as well. But I think it is a perfect tool, an example, of how we can improve the reliability.

Mr. LONG. OK. And, Mr. Frigo, how do energy storage technologies help your companies ensure rural areas get the reliable electricity they need?

Mr. FRIGO. I think Dr. Kuznar answered that really well. When you hear the term "microgrid," effectively, rural communities tend to be a microgrid because it is, as you mentioned, at the end of a long radial line, which is a radial line that is just a single line that goes off and ends. And from an electrical perspective, that tends to be a very weak part of the electric system as opposed to an area that weren't very well connected.

So if you put energy storage toward the end of that radial line, it helps stabilize the grid so when you have extreme weather events, it improves the reliability so that it lowers the probability of the grid actually collapsing in those areas.

Mr. LONG. So energy storage technology can be used in microgrids to provide affordable and secure energy for communities?

Mr. FRIGO. Absolutely.

Mr. LONG. OK. I will stick with the two of you. I will let you go first, Mr. Frigo, this time.

Can this technology ultimately lower rates for these customers?

Mr. FRIGO. Yes, they can lower rates. And I will give an example of something we are doing up in New York that helps lower the rates.

So we are working with a large utility up in that State to—they have to build out their distribution system. The reason why they have to build out their distribution system is it is a bit of a weak system and it is in an area that is growing from a residential and a commercial perspective, so they see an increase in demand over the next 10 to 20 years.

So in the past, they would just say, OK, let's go build some new transmission lines, new distribution lines, and upgrade a substation. But that can be a very costly affair. And so what they did is they looked at a non-wires alternative, i.e., energy storage which actually solved the same problem at a fraction of the cost of the alternative distribution.

So that is one example where the cost of an energy storage system solved the same problem—or the cost of the energy storage system was lower than the alternative, which was to upgrade the distribution lines and the substation.

Mr. LONG. OK. Dr. Kuznar, do you agree that the technology ultimately can lower rates for customers?

Mr. KUZNAR. It can. And, I think one of the pieces that we really have to focus on that we are is just how we model that and build those cases.

So a perfect example is the distribution upgrade, an example I gave.You might have an instance where, let's say, the distribution upgrade was $8 million. The battery might be—let's say it is a little more. Let's say it is $10 million. But if I am just building out that distribution upgrade, that is all it is doing. If I have got a storage asset, I can then utilize that for providing some regulation services. If I have a fleet, they can provide peak capacity.

And then when you start adding those values together, you have got an asset that could do a lot more than just the traditional wire.

Mr. LONG. OK. I have several more questions here, but I think I will just submit them for the record, because—and hopefully, you can get with my staff on your answers, because in 8 seconds, I can't give you proper time to respond.

So, Mr. Chairman, I yield back.

Mr. OLSON [presiding]. Thank you.

Mr. Doyle, 5 minutes, sir.

Mr. DOYLE. Thank you, Mr. Chairman.

This is a question for all of the panelists. I want you to talk a little bit about the effect you think an investment tax credit would have on investment and deployment of storage technology for your company or the industry in general. Maybe just start with you, Doctor, and go down the line.

Mr. KUZNAR. Right. And thank you for that question. I think a general investment tax credit will obviously lower the cost to the asset which could increase deployment. I think the only thing we would be interested in there is the utility is to be exempt from any tax normalization so we can kind of play on a level playing field. But, I mean, I think lowering the cost, you will see increased deployment.

Mr. FRIGO. Thanks, Mr. Doyle, for your efforts with the investment tax credit.

It would accelerate the implementation of energy storage, no question about it. And how does that lower the cost to the end consumer? I can give an example. Our Iron Horse project, which actually is paired with a solar project, we were able to take the ITC because it was an integral part of that solar facility. The ITC that we were able to claim on that energy storage project we passed back to Tucson Electric Power in the form of a lower price, which they were able to provide in terms of lower prices for their customers. So there is a real example of it basically benefiting the end user.

Mr. CASEY. Yes. No question, it would accelerate development.

I would note, again, in the case of California, that we do have State procurement mandates. So we have a mandate for the utilities to procure 1300 megawatts of battery storage by 2020. So that is the vehicle that is driving the storage development you are seeing in California.

Mr. PATEL. I also agree with the other panelists. In the New York storage roadmap, we saw that the solar plus storage applications were more cost-effective in the near term because of the ITC when you pair it. So it is just lower costs and, therefore, it becomes more cost-effective earlier, therefore you get more deployment.

Mr. KUMARASWAMY. Thank you, Congressman, for your work on H.R. 4649.

For the record, I would just like to say that storage actually adds value wherever you add it to the electric grid, right? So whether it is paired with renewable resources or whether you pair it with some other traditional energy generation facilities or wireless options, storage is able to add value to the electric system, right?

And so part of the problem that we have with section 48 of the ITC right now is that it wrongly sends a market signal that assumes that the value of storage has to be dependent on being colocated with a renewable facility, which disparts the market signal in terms of communicating the value that storage brings. And so broadening the definition to include energy storage as a standalone asset or as an asset that can be added to any type of option, whether it is traditional generation, operational wires would really provide the right market signal for developers, for regulators, for utilities to make sure that you are able to fully utilize the technology and deliver those benefits to ratepayers.

Mr. DOYLE. Great. Maybe just piggybacking on that, let me ask you all to—you know, the cost is the main barrier, right, to implementing the technology? So what other suggestions or recommendations do you have on how we can bring down cost?

Mr. KUZNAR. I mean, I think as you see increased deployment, the costs will come down as manufacturing continues to improve there. Again, I do think, though, when you look at the cost, again, it is how—at least from a utility's standpoint, how we traditionally modeled it. And I think if you kind of start looking at the values it provides from generation transmission or distribution, which is just a different process for us to use, that you are going to see cost-effective storage solutions in the very near term. We are already.

Mr. FRIGO. I was going to say, I think it is very important for the committee to look into electric vehicles, because electric vehicles are what is really driving the cost down for batteries that are being used in the grid. And, in fact, the batteries that we are currently using for grid solutions are actually being manufactured in the same facilities as electric vehicles. So we are really riding the coattails of that. So as electric vehicles go forward and expanded manufacturing capacity is made for them, we will see lower costs on the electric side as well.

Mr. DOYLE. Interesting.

Anyone else?

Mr. KUMARASWAMY. I would just add, I fully agree with Dr. Kuznar's statement on increased deployment. And I think that is a role that this committee can play. I mentioned it in my testimony previously, through the Federal Energy Regulatory Commission, if there is a way in which energy storage can be considered as a mainstream transmission and distribution asset. We have seen examples of utilities deploying energy storage as a reliable T&D asset. How do we make this systematic change where all the utilities across the country are doing the same thing? Kind of evaluating these energy storage resources on the same hand today, evaluate the wires options.

Because what we have seen is that when that process happens, and when the process happened in the generation side, there was a lot of learning that went through in terms of understanding the technology and understanding the benefits that the technology can provide to ratepayers, and that that discovery process needs to happen on the transmission and distribution side.

Mr. DOYLE. Thank you, Mr. Chairman.

Mr. OLSON. Thank you.

Mr. Walberg, 5 minutes for questions, sir.

Mr. WALBERG. I thank the chairman.

I thank the panel for being here. Interesting. Interesting discussion today.

In my home State of Michigan, there is the Ludington pump storage facility. It has been described as one of the world's largest electric batteries. And I believe when it was built, it was also the largest pumped hydroelectric storage facility in the world. There is roughly 1870 megawatts of electricity that can seemly be dispatched at a moment's notice to help at peak demand.

Pumped hydro facilities like Ludington seem to provide valuable assets to the grid. And to ratepayers, they are very unique, very specific.

Mr. Patel and Dr. Kuznar, I would like you to address these questions, but anyone else that wants to jump in and add a little bit more, I would appreciate it. Could you please describe the unique assets that pumped hydro facilities bring to the table?

Mr. Patel?

Mr. PATEL. Sure. I worked with several developers looking at pumped hydro, mostly on the West Coast. So, the biggest challenges they have are that we haven't built a new pumped hydro facility in this country in quite a long time. So the idea, then, is to basically get the regulators and other folks, you know, onboard with the values that it could provide. And, again, as we have talked about, a lot times, some of these values can be on the transmission side, some could be just from the wholesale markets. And in some jurisdictions, there may be no markets, so the utility has to basically buy in and monetize those values itself.

So, the unique aspects are that it is a proven mature technology that has been in use for decades and can have really reliable performance and things of that nature. The downside of those technologies is that they are large and they require fairly big investment, so——

Mr. WALBERG. Dr. Kuznar.

Mr. KUZNAR. Great. Thank you. We also in North Carolina have a couple thousand megawatts of pumped hydro. And if you talk to our grid operators, they will tell you they can't live without it, just the way it gives them the flexibility.

And I think what we are seeing with lithium technology is kind of the ability to give the operators more storage to give them more flexibility, but to do it in kind of smaller increments at specific locations that are needed, but also do it in a much quicker fashion.

So instead of our pumped hydro facilities, total, I believe are a little over 2,000 megawatts. In this instance, we are able to kind of deploy these a little quicker 5, 10, 15, 20 megawatt chunks on the best locations on the grid, which we feel it is needed. But the pumped hydro is a critical part of our infrastructure as well.

Mr. CASEY. And if I might, as the sole grid operator on the panel, we love pumped hydro. We have a little over 1,800 megawatts of it on our system.

I think in terms of what makes it somewhat unique relative to batteries is the duration of—in the case of California, we have a need to ramp up energy to manage the solar for spans of 10 hours a day. And having the ability to have a big resource like a pumped hydro facility follow that profile, batteries typically have shorter discharge periods.

But as was noted, new pumped hydro is very costly. It is a long lead time investment. And the open issue really is, as battery costs are declining, does it make sense to invest in these huge infrastructure projects. It is something California is grappling with right now.

Mr. WALBERG. Are there any more being developed?

Mr. PATEL. Yes, there are several. I personally worked on at least two in Oregon and Washington that total about 1,600 megawatts. There is a couple proposed in California as well that are a couple thousand and then throughout Arizona and other places. So there are definitely ones that have gotten actually FERC licenses already, at least two that I am aware of, offhand. Nothing has been developed and no kind of contracts have been signed for those sites yet.

Mr. KUMARASWAMY. If I may, just want to add one comment that was not reflected, which is the speed at which you can actually deploy battery energy storage. One of the projects that we delivered at the beginning of last year to San Diego Gas and Electric, the speed at which the project was actually delivered to San Diego Gas and Electric was about 6 to 8 months.

So when the utility actually desired to procure storage to when the storage facility actually became operational was about 6 to 8 months. And so that is one of the key advantages of the battery-based energy storage, is that you can really cut down the lead time to where it is actually bringing these assets onto the grid. So——

Mr. WALBERG. So would you conclude that the strength of a role for pumped storage facilities, hydro facilities, in the future is pretty limited or is it moving forward?

Mr. CASEY. I would say, in the case of California, it is an open question that is being studied and evaluated. So it is certainly on the table.

Mr. WALBERG. OK. Thank you. And I yield back.

Mr. OLSON. Thank you.

Mr. Schrader, 5 minutes for questions, sir.

Mr. SCHRADER. Thank you, Mr. Chairman.

I guess first question, Mr. Frigo, following up on some of the discussion about what is the Federal Government's appropriate role. Everyone wants to get a tax credit. That is always wonderful. It lowers the cost, makes things wonderful.

How long and when should the Federal Government intervene in some of these new technologies?

We are spending money like drunken sailors here nowadays. Defense, nondefense mandatory, you name it. But at some point in time, there may be a reckoning. We may want to get fiscally responsible again.

And, I think there is a place for the Federal Government to incentivize new technologies trying to get, you know, the cost down, make it worthwhile for private enterprise, nonprofits to engage.

What is the timeframe for a technology to prove itself, perhaps? And when should the Federal Government start to back out to avoid market distortion?

Mr. FRIGO. That is a very good question. You need one for 2.3 years or something like that. I think, the key is you only need it for the time for it to be competitive. And then at that point where it is competitive, then you shouldn't need to be able to have a tax credit anymore.

Energy storage, I think, as we talked about, the costs are coming down significantly. My guess is that it would happen much sooner than, for instance, the ITC or the PTC for wind and solar.

Mr. SCHRADER. OK.

Mr. FRIGO. So I think it is not that long, but I can't really tell you an exact amount of time.

Mr. SCHRADER. Anyone else have a comment on that?

Mr. Patel—or——

Mr. KUMARASWAMY. Yes. I actually have a comment. This was the same thing that I said earlier. We already have the section 48 of the ITC that is being applied to energy storage. And the IRS actually had a process of getting feedback from stakeholders, and the process has stalled and is slowly beginning back up again.

And so what we are talking about is an issue that is already existing, right? And so storage that is paired with renewable energy generation is able to get the investment tax credit today, subject to certain rules that are slightly fuzzy that are pending clarification by the IRS, right?

And so what we are essentially seeing is that the value of storage to the grid is happening regardless of whether it is paired with renewable energy generation or not, right? Because when you have to fire up a natural gas fired peaking plant and provide the peaking capacity, and storage is able to provide that more cost-effectively, it is able to provide the same level of service in that application, right? And it may do so without being paired with a renewable energy generation facility, right?

And so what we are really asking for is a much more broader, all-encompassing definition of the eligible sort of technologies that can qualify under the section 48. So——

Mr. SCHRADER. Good, good.

Mr. PATEL. And I will add one last thing, if I may.

Mr. SCHRADER. Sure.

Mr. PATEL. In New York, what we saw was that, there are a couple of kind of high-value applications that are cost-effective today. But, they are kind of unique because the costs are so high for energy storage. So one of the things we looked at there was, it doesn't make sense to accelerate the market by utilizing a bridge incentive or some other incentive to basically bring forward some of that development and then reduce some of these costs, that are less hardware but more what we call soft, which is permitting interconnection, getting developers in the State, things like that.

So I think there is that push and pull of, you can just sit there and wait for the market to evolve and then take advantage of it in 5 to 10 years perhaps, or you can push it forward and take advantage of it sooner and then transforming the market, which we have seen in other technologies like solar and wind.

Mr. SCHRADER. All right. Second question. I have got some utilities in my area of the world that are looking at hot water heaters as a battery, potentially. They store a lot of water. They toss a lot of money to keep them going 24/7. They are new smart devices that could be implemented by different utilities. You shut them off at different times.

Are you guys exploring this technology? Do you know any entities that engage? Mr. Frigo, I guess.

Mr. FRIGO. Yes. Those are called demand response type of technologies. And that is what we call low-hanging fruit. That is the elimination of waste and being able to use your energy more effectively and efficiently. Absolutely, that is a tool that should be pursued across the U.S. in the electric system and by all utilities. And most of them are.

Mr. SCHRADER. Very cool.

Last quick question. One quick answer, and then I maybe get more complete answers later.

With storage coming online here, it seems to me the traditional utility model is being disrupted in a big way. And what we pay folks for usually generation-type stuff, now we have storage, we have distribution. Is the utility world going through a renaissance about how they should be applying and charging people? And are the Federal Government and State governments keeping up with that change that is going on?

I think that is really important, because we are no longer in the 20th century. We are in the 21st.

Mr. Kuznar, real quick.

I am sorry, Mr. Chairman.

Mr. KUZNAR. Yes. No. Definitely. Just with distributed generation in general. For years, it was just a one-way flow of electrons from large central power plants to homes and businesses. And now there is rooftop solar, there is storage, there is all these different services. So I would definitely say it is going through an interesting transformation.

Mr. SCHRADER. I will leave it at that. And I thank the committee's indulgence. And I hope we address this issue. It would be something that we should be looking at as a committee, I think, going forward.

Thank you very much, Mr. Chairman.

Mr. OLSON. I thank my friend. And misinformation about sailors like me is noted.

Dr. Bucshon, 5 minutes.

Mr. BUCSHON. Thank you, Mr. Chairman.

Earlier this year, I had the pleasure of touring Indianapolis Power and Lighting Company's battery energy storage system, which uses lithium ion batteries for frequency control and has the capacity of 20 megawatts. It was impressive to see in person, I have to admit. And I am happy to hear that Duke Energy will be adding more energy storage to the Hoosier State.

As you are all aware, FERC has recently begun the process of addressing energy storage's role in the markets. But I would like to hear from you all on what barriers still remain for energy storage's access to the interconnection. And so I can start at—whomever wants to start.

So the question is, are there still barriers that—to integrating the energy storage's role into the grid, essentially, and what are those barriers?

Mr. FRIGO. Yes. Thanks for the question. I think we touched on this a little bit earlier where we talked about that looking at energy storage and the specific application for which it is being used and then making sure that the relevant interconnection process that we have to go through, depending on where it is in the country, actually models that project for how it is going to be used, that Dr. Casey mentioned about how it is being used in California.

So I think more direction to not so much the markets, because I think the markets are pretty on top of this. But also in those States that are not governed by a market, like many of the western states are off on their own, and any interconnection process that you have to go through there to make it easier for companies like us to be able to properly study the energy storage project that is being proposed.

Mr. KUMARASWAMY. Yes. I would probably just add two points that are still barriers. One is that we would definitely like to see FERC finalizing order 841, so they are still rehearing requests that are happening on both order 841 and 845. And so we have gone through a very extensive deliberation process to get to this point where we have an order. And so it is important for us to close that and get to the implementation stage of implementing the spirit of what FERC Order 841 really requires market operators to do.

And then the second thing that I have said earlier is to have FERC require energy storage being considered in traditional transmission planning processes, right? And so FERC has direct jurisdiction over transmission. And how planning is conducted nationally. And so I think that would be an area of keen interest to make sure that storage is equally considered with traditional wires options in planning processes.

Mr. BUCSHON. Whomever.

Mr. CASEY. OK. If I might, the issue of considering storage in transmission planning has come up a lot. I can tell you, in the case of California ISO, we do. As I mentioned in my testimony, we approved two storage projects just this spring as alternatives to traditional wires. So there is an ability for ISO/RTOs to consider storage in its transmission planning process. Whether they all do or not, I don't know.

We have also modified our interconnection process to accommodate energy storage. Storage is unique. It both generates and consumes. So trying to treat it like a conventional generator creates some issues, and we have made changes to our interconnection process to accommodate it. So I think in large part, we have done quite bit to accommodate storage, at least in our footprint.

Mr. KUZNAR. And I would just add to that, Congressman. In Indiana, for example, we got approval for those first 10 megawatts. I think a big part of it is just education and getting—because we are regulated, so we have to get approval from the regulatory commission for us to invest in those assets to show that we are doing something that is cost-effective.

And it is the education piece with the consumer counselors in the commission of we are using this. It is a little different. It got generation value, transmission value, distribution value, and it should be a tool that we could use if it is cost-effective. And we went to the BIC with a number of folks in Indiana and educated people there just on what is storage, what is the value. It is a little different. It is not just the generator. It has this T&D value as well. And I think that was just incredibly important to get their backing that this is good for people in Indiana.

Mr. BUCSHON. Yes. IWell, thank you. And I had another subcommittee hearing at the same time, so I apologize if you had to repeat some of that. But I think it is worth repeating this type of information, if there was some repetition.

But because I think especially if—when people across the country are looking more and more at renewables, reliability of the energy supply and stuff becomes an issue, right? And I firmly believe that without some sort of energy storage, it is going to become a problem if we continue on the current pathway of where we are going with that, how we generate base load for energy. So thank you for your responses.

I yield back.

Mr. OLSON. Thank you.

Mr. Welch, 5 minutes for questions.

Mr. WELCH. Thank you. I thank the panel and thank the chairman and thank my colleagues.

This is such a great issue—we can do something useful for once. And the energy storage industry is a big deal in Vermont. I just want to talk a little bit about that, then ask a few questions.

In Vermont, we are starting to see what it could look like when—our largest utility, Green Mountain Power, is all in on this, they have an energy storage resource, including Stafford Hill Solar Storage Facility in Rutland. It is one of the first microgrids powered solely by solar and battery backup. And it was the first in the region to use battery storage to reduce peak power usage, saving $200,000 in 1 hour. In Vermont, that is like real money. The battery storage can also be used to power an emergency shelter at the Rutland High School.

In 2015, GMP launched its first of a kind program to offer 500 Tesla Powerwall batteries for $37.50 per month, a deal that included customers getting backup power for letting the utilities tap the batteries to manage systemwide or local peak conditions. That is so terrific, because we don't have to have these big backup generators. And we had a firsthand look at what happened. We had a big heat wave in July. And by leveraging these batteries and demand response resources, GMP was able to take the equivalent of

5,000 homes off the grid, saving customers about $500,000. We have got a couple of others. Dynapower in Waterbury.

I am interested to learn more about what we can do to build off this type of work. And I want to talk about FERC Order 841 that came out earlier this year. And as you know, that moves towards opening the U.S. wholesale energy markets to putting storage on an equal footing with generators and other grid resources.

So I want to ask Mr. Frigo, does FERC Order 841 solve all your industries' problems, or what other barriers are there? And do current market designs adequately value and compensate storage for the flexibility it provides to the grid? And what, in your view, needs to be done?

Mr. FRIGO. Right. FERC Order 841 is a great, great start. But as my colleagues have mentioned, I think the big push now is to finalize that. I know there has been a number of stakeholders that have asked FERC for a rehearing on that. I think it is important to deny that rehearing and basically implement the order full on. If you are just delaying the order, you are delaying the implementation.

Mr. WELCH. Thank you.

Mr. FRIGO. So then you also have FERC Order 845, which is dealing with the interconnection. Push that forward as well.

And I think, actually, another thing is there has been a number of States—this gets backs to the Federal-State relationship. There has been a number of States that have really pushed storage forward that I think the Federal Government can learn from. California is one. New York is one. And we have seen it recently with Massachusetts, and just recently New Jersey as well. There are things that these States are doing that could be adopted to the rest of the country.

Mr. WELCH. Thank you.

And, Mr. Kuznar, what do you view as the main limitations of battery technology at this point? And can you update the committee on any new promising storage technologies that may address some of these limitations?

Mr. KUZNAR. Right. I think where storage technology is today is in a very good place. We started doing R&D projects almost 10 years ago. Where it has come from there to now from a control system standpoint to a reliability standpoint, it has improved dramatically.

I think going forward, you look at most technologies that are commercially available. Lithium ion, they are finite in their duration. So I think, one thing as a utility we are always looking for is kind of longer duration batteries, one that can meet more of our peak. And that is something we are really keeping an eye on going forward.

Mr. WELCH. OK. One last question. I introduced a bill that would extend the electric vehicle credit. We are bumped up against the 200,000.

And, Mr. Frigo, can you elaborate on how EV expansion can benefit storage?

Mr. FRIGO. Sure. So these batteries that we use for grid purposes, whether generation or transmission and distribution, are being manufactured in the same facilities as batteries for electric vehicles. And electric vehicles is the bulk of that manufacturing capacity right now. And so as you provide incentives for more electric vehicles to be bought, put on the road, to be implemented obviously increases the demand for the manufacturing capacity, which makes those battery providers expand that capacity, driving cost down, because you get economies of scale. And then the grid applications for the use of batteries just follows as a natural result.

Mr. WELCH. Thank you very much. I thank the panel.

Mr. Chairman, I yield back.

Mr. OLSON. Thank you.

Mr. Griffith, 5 minutes for questions, sir.

Thank you very much. I appreciate it, Mr. Chairman.

And I appreciate the panel being here today.

Mr. Patel, I was glad to hear in your comments that you mentioned pump storage, and other people have asked about it. And while we have pump storage near my district—not yet in the district, although it is being looked at—one of the interesting concepts that has been talked about is taking abandoned coal mines and using those for pump storage facilities. Because, as you mentioned, one of the problems is it takes a lot of money. You got to land there where you are going down. You have electricity already running in there, oftentimes rail; if not rail, good roads. And it has already been secured, because nobody wants folks getting in there and getting lost in the mines or coming into some kind of a problem.

So I would just point out that there is some potential there. Would you agree with that, Mr. Patel?

Mr. PATEL. Yes, absolutely. I think one of the projects I looked at is an old aluminum smelter. That is, obviously, existing. It has water rights. So, it is potentially a lower cost than something that is somewhere else.

Absolutely, site value and those things really drives costs, and if they are lower and they can provide that same value at that lower cost, then it makes sense.

Mr. GRIFFITH. And we have a lot of opportunities in rural America to do that. And we have talked about microgrids. I am going to ask some questions about that too.

Mr. Kumaraswamy, in your testimony, you referenced the interaction of microgrids as one of the benefits of energy storage being introduced to the grid.

And you also talked about that, Dr. Kuznar.

During previous hearings, we have discussed how microgrids could be a solution to quickly restore electricity after natural disasters like hurricanes. I am also interested in how microgrid technology could be used to provide power to rural, mountainous areas across the country. And can you expand on the benefits that you think microgrids provide to the grid? Also, what current limitations do you see associated with that microgrid technology?

And then I will come to you, Dr. Kuznar.

Mr. KUMARASWAMY. So one of the solutions that we deployed for a utility in the southwest U.S., Arizona Public Service, we actually delivered a 2-megawatt energy storage project to them earlier this year. And it is in a city called the city of Punkin, which is on the outskirts of Phoenix metropolitan. And this was a city that was growing very moderately in terms of load growth, and they had figured out that it was actually way more cost-effective for them to add a battery storage project at the end of the radial feeder to serve the city and part of that town that was moderately growing than upgrading a long section of the transmission line, right?

And so I think, as it relates to how we rebuild the network and how we think about modernizing the grid, energy storage has a very critical role to play in that.

On the microgrid topic, we think that storage that is combined with solar or any other renewable sources has incredible potential in terms of increasing the resiliency in the way we actually power our network itself. So there is incredible potential. What we would like to, again, see is the open mindedness from utilities and transmission planning entities to actually include this as a resource to make this a mainstream asset while you are conducting this process.

Mr. GRIFFITH. And one of the things I would like to hear you all comment on, because I represent a mountainous district with lots of trees and mountainous areas, and I noticed when we were visiting Puerto Rico—and you have heard several others mention that in one of the places we visited, they used to have a hydropower facility, but they abandoned it, and now, of course, everything is wheeled into that particular rural, mountainous area of Puerto Rico. And I couldn't help but wonder what if they had kept that just for keeping the lights on in the hospitals and the school, using the school as a shelter in time of a disaster.

Dr. Kuznar, do you have anything that you can add to that? And then talk about Duke.

Mr. KUZNAR. Yes. I mean, one of the main applications that we are looking at with storage is reliability for radially fed areas. You know, we are doing just—as you know, we are doing a project in Indiana, a radially fed town, poor reliability, 5 megawatts, backup power. We are doing a number of projects in western North Carolina in the Asheville area, same exact instance. A lot of trees, mountains, bring down distribution lines. Provide——

Mr. GRIFFITH. It is the same mountains. Mine are just a little further north.

Mr. KUZNAR. A little further north, right. Backup power there. But, also, the unique part about storage, we are also going to use them, in conjunction with backup, to provide regulation services to help incorporate solar into our grid.

So it is the stacked values we are looking at. But distribution reliability is a major use case we are evaluating.

Mr. GRIFFITH. So you think for areas like mine and your western part of North Carolina, this is a real opportunity to make sure that we have, particularly in times of ice, snow, et cetera, usually for us, or heavy rains resulting from a hurricane coming up the spine of the mountains, that microgrids is a really good way for us to go.

Mr. KUZNAR. Without question.

Mr. GRIFFITH. And, Mr. Frigo, 6 seconds. Did you want to add something?

Mr. FRIGO. Yes. Pump storage—and this is important to note, that we have been talking about batteries a lot here. Energy storage, I think most of us would agree, we are really technology-agnostic. There are multiple forms of energy storage that are all very useful.

Mr. GRIFFITH. And I see pump storage as just a big wet battery. Would you agree with that?

Mr. FRIGO. I would agree with that.

Mr. GRIFFITH. Thanks. I appreciate it.

I yield back, Mr. Chairman.

Mr. OLSON. Thank you.

Ms. Castor, 5 minutes for questions, ma'am.

Ms. CASTOR. Thank you, Mr. Chairman.

And thank you to the witnesses. It has been a very interesting hearing. You have given me hope that America can stay in the lead on battery storage and energy storage.

And I think energy storage has so much potential to change, to modernize the way we produce energy, the way it is transmitted to our homes and businesses, I think at great benefit to our neighbors and businesses back home, first incorporating these clean, renewable energy sources, helping us to reduce carbon pollution, help to modernize the grid that is so outdated in so many places across the country. I think I see great potential for jobs, increasing competition, and the opportunity to build the more resilient grid. And you have heard a number of members talk about that in their trip to Puerto Rico.

I think there has been an awakening after the last hurricane season on the importance of a more resilient grid and what microgrids and energy storage can provide, but we run into—as you have provided a long to-do list for policymakers, I think another one we have to face is that FEMA is totally hamstrung by the Stafford Act so that, when a community is demolished, a grid is annihilated by an extreme weather event, they can only build back what was in place before. Now, the Congress did give Puerto Rico a little more flexibility.

But what are you seeing? Are you hearing this discussion among the industry about changes in that area, as well, Mr. Kumaraswamy?

Mr. KUMARASWAMY. Yes, no, that is a good question, and it is an important thing to acknowledge, about how the Stafford Act restricts what we can actually rebuild in Puerto Rico.

One of our parent companies, the AES Corporation, actually provided a vision for rebuilding the Puerto Rico grid itself. We filed those comments with the Puerto Rico Energy Commission. And part of the plan actually envisions creating smaller minigrids and several minigrids and connecting them through a series of transmission lines, which we think would substantially reduce the cost for ratepayers there and also significantly increase the resiliency in terms of being able to serve power for people after disaster conditions like hurricanes.

And I think that we need to really think about using the technological advancements like energy storage, which happen to be more modular, right, so that, like Dr. Kuznar was saying before, you can actually deploy them closer to load centers, unlike traditional assets which need to be sited much farther away because of water issues, because of emissions issues and stuff like that. And so energy storage does not have any of those attributes, right? So there is no fuel, no emissions, no water, no noise. It doesn't have any of these attributes that typically limit the infrastructure that we put on the electric grid.

And they are also available in modular sizes, so that if you have—say you are closer to San Juan, you can actually put energy storage closer to the load centers and power those communities locally there, as opposed to producing electricity farther away and transmitting them.

So I think we do need to carefully consider some of these advances.

Ms. CASTOR. So the technology exists.

Mr. KUMARASWAMY. Absolutely.

Ms. CASTOR. It is a matter of deployment and the high cost of doing that right now. But, otherwise, if we don't do it, taxpayers are going to be on the hook. If we build back what was there before and another storm comes through, taxpayers have to step up again to do this. So it would be smart policy to go ahead and do it right the first time.

Mr. KUMARASWAMY. Absolutely.

Ms. CASTOR. Dr. Kuznar, Floridians are hungry for cleaner energy. And it was great to hear that North Carolina is leading the pack in solar energy, but, really, the State of Florida, the Sunshine State, has great potential, and we are not meeting that potential right now.

I was very pleased to hear you are doing—that the public service commission has now authorized Duke and, I guess, FP&L for 50—not kilowatt-hours——

Mr. KUZNAR. Megawatts.

Ms. CASTOR [continuing]. Megawatts, excuse me. But they are still calling it a pilot project. It doesn't seem like we have a commitment there.

Tell me, are you committed, is Duke Energy committed, and the other utilities? What is standing in the way to do more, and how can you be encouraged to do more?

Mr. KUZNAR. Thank you for that question. We have been through this process—what we got approval for in December was 700 megawatts of solar and 50 megawatts of storage, but our plan is to go well beyond that. That was just the first ask there.

As part of this process, we have identified what we think are much more than 50 megawatts of storage on the grid. We worked with our transmission distribution planners to identify sites of poor reliability, where do we couple with solar, how do we help the integration of solar.

So I would just say this is a first step in what we plan on doing in Florida. Because, as you said, the partnerships that we can have with critical infrastructure to provide grid services and backup power during an outage, we think, is going to be very important going forward.

Ms. CASTOR. It absolutely will be. Thank you so much.

I yield back.

Mr. OLSON. Thank you.

Mr. Johnson, 5 minutes, sir.

Mr. JOHNSON. Thank you, Mr. Chairman.

Thank you, panelists, for being here with us today, by the way.

Several members have talked about the challenges of rural America a little bit. I want to expound on that just a little bit more and maybe dig a little deeper.

I represent rural eastern and southeastern Ohio. The terrain is hilly. Communities are often far apart from one another. And my district is home to very intensive energy development industries—coal, oil and gas. And as that production continues, particularly in the Utica and Marcellus Shale, the need for reliable power only increases as petrochemical operations come to this region of the country. But, thankfully, my district is also home to reliable sources of power, like coal-fired power plants.

Some of you have pointed out that energy storage can be used for other applications as well, such as when a transmission line suddenly stops working.

So, Mr. Kumaraswamy, your testimony touches on energy storage being used in this way. Can you further elaborate, how it can be helpful in rural settings?

Mr. KUMARASWAMY. Absolutely.

So, when we size some of our transmission and distribution systems, we go through the same process that we go through for generation sizing, right? So we build them for peak conditions of the electric system, so we have to meet the summer peak demand for the utility, which typically happens in July and August in the Northeast. And so what we are actually doing is building a solution that you actually need only for 30 or 40 hours of the year, right?

And so we think that it is not the most efficient way of allocating capital, in terms of investing large capital into an asset that you would fractionally utilize. It just seems like, in every other commodity market, we are moving toward increased utilization and more efficient capital spending.

And we think that energy storage, through its capability to be a modular solution, where you can actually add the right size capacity to the network when you need it, and then if the load continues to grow, you can augment the system with an additional set of battery modules, which is incredibly more helpful than a more lumpy capital asset like the traditional wire solutions.

And so we are beginning to see this happen. And like Dr. Casey mentioned, CAL ISO has been leading the charge on this. We have seen energy storage being selected as a transmission asset through the regional market transmission planning process. And so what we would like to see is more of that happening, where the traditional T&D planning folks can actually use this technology that is available in the toolkit and regularly look at this as an option in which you can solve the reliability needs.

Mr. JOHNSON. OK. All right.

Dr. Kuznar, you mentioned that Duke recently filed for 10 megawatts of energy storage as a part of its electric security plan in Ohio. Can you elaborate on the project and explain why Duke decided that energy storage was the best option for this particular situation?

Mr. KUZNAR. Right. So that is where we are currently going through that rate case and hearing right now. But what we have done is, in Ohio, it is interesting because, unlike our other States, we have no generation. So we are just a wireless utility in Ohio with transmission and distribution, where in Kentucky, Indiana, the Carolinas, and Florida, we have generation transmission and distribution.

So what we are looking at for these projects in Ohio is similar, basically looking at areas—and we want to expand beyond this; it was kind of our first ask, but—with poor reliability. So we have some very rural, radially fed lines in Ohio, which to maybe potentially run a second feeder out there to improve the reliability is just not cost-effective, where now storage can give us this tool we can use to put down at these radially fed areas and increase the reliability for our customers.

So that is really what the gist of the project is in Ohio.

Mr. JOHNSON. OK.

Well, thank you very much, gentlemen.

I don't have time to ask my next question. It is too long. I yield back.

Mr. OLSON. Thank you.

Mr. Tonko, 5 minutes for questions, sir.

Mr. TONKO. Thank you, Mr. Chair.

And thank you to our witnesses for offering great advice.

A modernized grid will need to be smarter, more distributed, and certainly more flexible. Storage technologies will be essential to achieve that vision.

In my home State of New York, NYISO, NYSERDA, and the Public Service Commission are all working together to integrate storage resources and remove barriers to the wholesale electricity market. As was noted by Mr. Patel in his testimony, earlier this year New York established a 1,500-megawatt storage goal by 2025 and made a commitment to financial support for project developers from the State's Green Bank.

So, Mr. Patel, I know you helped develop the New York Energy Storage Roadmap. In your view, what are the most significant policy recommendations included in that report?

Mr. PATEL. Yes. Thank you for the question.

There were a whole host of recommendations; it is a long report. But I think the biggest ones were, what I touched on earlier, and I think the other panelists as well, is the value stacking, had how to actually do that in practice.

And, also, there are other initiatives going on at FERC, things like that, and how to accelerate that. So are there ways to, basically—it may be imperfect, until you can actually get full participation in the market and the New York ISO and others. Are there ways to allow the utilities or others to basically get those values sooner, maybe through—in New York, in particular, can you modify load on the utility side versus directly participating in the wholesale market. So that might be a bridge you can do in the next year versus waiting 3 or 4 years until the wholesale markets are in the right place to allow for bigger participation.

And I think the last big recommendation, of course, is the financial support that will be coming from the Green Bank and the Clean Energy Fund of New York. And those have proposed several hundred million dollars, which will obviously accelerate deployment.

Mr. TONKO. Thank you.

And, also, Mr. Patel, why is it important for States or grid operators to signal their commitment to storage through targets or incentives or policy? Why is that critical?

Mr. PATEL. Yes, no, another good question. I think the market is evolving, and, obviously, developers and other folks need a whole infrastructure supply chain, people on the ground to actually go out and figure out how to actually do this.

So the States that are moving forward have committed to being the first of those there. California, New York, they have put some real money and effort into becoming the leaders in this space. So, obviously, that yields folks opening up offices and having more interest and actually getting out there and doing it first.

Mr. TONKO. Thank you.

Dr. Casey, I believe that California and New York have pretty much shared a similar approach. What lessons or advice would you have to other regions on how they might remove barriers within their markets?

Mr. CASEY. Well, I think the big lesson is recognizing the uniqueness of storage compared to conventional generation. I think, even in our case, there is a tendency to try to take the standard approaches we take with generation, like, through interconnecting the resource, as well as participating in the market. Well, they don't work for storage. Storage has unique operating capabilities, as FERC is recognizing.

So being flexible in recognizing that they do have special needs and finding ways to accommodate that, I think that is the biggest lesson learned.

Mr. TONKO. And, as Mr. Patel indicated, there are some opportunities that FERC can offer. Which would you prioritize, in terms of what FERC can do to move the process along?

Mr. CASEY. Well, I guess I have a slightly different view, in that I think FERC has done a lot. I know FERC allows storage to be treated as a transmission asset, to be considered in planning processes. Order 841 is, I think, a huge step forward in enabling wholesale market participation.

So I am not sure how much more there is for FERC to do. I think it is incumbent on the industry and the ISOs and RTOs out there, the organized markets, to really look at, how do we act on the opportunities we have and getting them in place.

Mr. TONKO. Great.

And many State policies and mandates will drive growth moving forward. Is storage being sufficiently considered in State and utility resource planning efforts, such as resource adequacy and transmission and distribution planning?

Mr. CASEY. Yes, in the case of California, it definitely is. There is a whole focused effort, led by the State Public Utilities Commission, on, more generally, distributed energy resource planning, but storage is a big component of that.

Mr. TONKO. Thank you.

Mr. Kumaraswamy, I had a question for you, but you have already tackled it.

But thank you all for being here.

I yield back, Mr. Chairman.

Mr. OLSON. Thank you.

And you all have made it. I will be the last member asking questions. But, like Chairman Emeritus Barton before the current vice chairman of the full committee, my Texas pride makes me respond to some comments that were made in this hearing earlier.

The witty banter between Chairman Upton and Mr. Doyle about the All-Star Game last night in D.C., they failed to mention the MVP. His name is Alex Bregman. He plays third base for the World Series champion Houston Astros. He and another 'stro, as we call them, George Springer, hit back-to-back home runs in the 10th inning to win the game for the American League. Let the record show: Astros, Astros, Astros, MVP.

Now let's get to business.

My first question is for you, Mr. Frigo. As you know, sir, every air conditioner in Texas is cranking right now, hard. We are having 100-degree days all over the State. Had those for a couple weeks. There is no end in sight. Our ERCOT power grid is under severe stress. Our reserve margins are lower, and we have had some big retirements. Three days ago, we set a record for July power: 70 gigs of power. This week, we may break that record. ERCOT says we might hit 74 or 75 gigs. That is huge.

Reliability can be a hypothetical at times, but right now at home it is as real as it gets. If the power goes out, that affects people on the extremes: the extremely young, the extremely old, and the extremely sick. It is life-threatening to them if the power goes out.

I would like you to talk about what your storage projects in places like the Permian Basin can do for reliability. How can they protect the grid? What scale do you need to see more of an impact? Any thoughts about that, sir?

Mr. FRIGO. Yes. You are correct; today is a very hot day in Texas, and the grid is under tremendous stress. In fact, I was looking at our power curves just before this meeting started, and we have our two projects on standby right now. And they are probably being called upon as we speak to meet the frequency regulation, which is basically making sure the grid stays at 60 hertz. Because if it goes above or below, you potentially could have a grid outage.

And so that is where our storage is actually coming into play as we speak, by getting the frequency regulation back on track.

Mr. OLSON. How about the scale? What to increase the scale? How can we do that?

Mr. FRIGO. Well, unfortunately, we have ERCOT that is not under the jurisdiction of FERC. So they are on their own in terms of implementing their own planning process and looking for the future. Obviously, they do, I think, look—they are smart. They look at what the rest of the country is doing and take what works and implement it back.

I think a lot of the things are on Texas's shoulders and on ERCOT's shoulders to basically implement many of the things that are being done throughout the country at ERCOT itself. The frequency regulation market is actually constrained now in terms of the amount of megawatts that could be put on. And so there have been efforts proposed to put in a fast frequency regulation market that is bigger that would allow for greater energy storage, but it hasn't passed thus far.

Mr. UPTON. Well, thank you.

Mr. Kumaraswamy—is that close?

Mr. KUMARASWAMY. That is spot-on.

Mr. OLSON. Oh, boy. Spot-on for a thick Texas tongue, I will take that as a great compliment.

One of the trends we are seeing in Texas, as you know, is an incredible boom in wind power. My home State is number one in America for wind power production. Wind power is great, but, as mentioned earlier, it has two problems. It blows hard at night where power is not needed, and the biggest wind is in extreme west Texas. As was mentioned earlier, we have to have that power in Houston, Dallas-Fort Worth, Austin, San Antonio, the big cities.

Could you talk about how storage on batteries will mesh with natural gas power? And does that make other forms of energy work better, or does it replace them? And, finally, can battery storage with wind power or solar power actually become sort of baseload power, a quasi-baseload power? Is that possible?

Mr. KUMARASWAMY. That is a good question, and the answer is yes. There are actually enough examples that are happening across the country and internationally that showcase the value that storage can bring. At, like, 3 or 4 hours of duration, if you pad them with wind or solar, you can operate these renewable facilities as partially baseloaded facilities. And so there is incredible potential for you to do that.

I actually want to second the view that Mr. Frigo said previously. In the Texas market, there are two things that I see, particularly. One is that there have been past attempts to reform the ancillary service market there, what is called the FAST, the Future Ancillary Service Team, the FAST acronym, and it didn't see light at the end of the day, and so it was stalled completely. We think those initiatives are extremely important, because you have to go to your place where you start integrating the speed at which storage can actually provide the service and not create artificial barriers in that market.

And so, because it is nonjurisdictional, I think it is really ERCOT and the PUCT that have to resolve that issue. That is number one.

Number two is that there have also been cases where energy storage was actually a more cost-effective option than proposed transmission projects and so utilities there have gone ahead with that, but because of several reasons they have not been approved to date.

We think that, for the same reason that you indicated, which is the wind is in west Texas and the load is down south, it also creates transmission constraints while you are trying to move all of that power. And so storage can actually provide great value as a transmission asset. And I think it is upon the State to make sure that you are creating, then, the policy environment for that to actually happen.

Mr. OLSON. Well, thank you.

Seeing no more members——

Mr. RUSH. Mr. Chairman?

Mr. OLSON [continuing]. Looking to ask questions—Mr. Rush.

Mr. RUSH. I have a question. And maybe any of the panelists could answer this, if I might.

I am interested in how energy storage batteries, microgrids and minigrids, their application to undeveloped countries, in undeveloped countries. It seems to me that we are always looking for a marketplace, for a different, wider market.

And so my question is, in the future of batteries, energy, do you see a wide application in the future for batteries and for, say, underdeveloped countries that are trying to develop a middle class, middle-class lifestyle? Is there any significant potential for the application of mini-grids in some of those countries? And, also, if you can touch on, is there any future for exporting energy based on stored energy?

Mr. FRIGO. That is a good question, Mr. Rush. E.ON is a big, global country. We have operations throughout the world. And, in fact, we have part of our company that is actually looking at this and working in some underdeveloped countries.

What you see is a lot of the grids in those countries are very small, are not well-interconnected. Maybe there are one or two power plants in the entire country and limited transmissions distribution, so you have a number of smaller communities on the peripheries that are just not electrified.

So one of the things that you see being used in underdeveloped countries and these rural communities is the formation of microgrids, what we talked about earlier. And in these microgrids, they will typically have maybe a wind turbine or two or maybe some solar. And this is where energy storage can also play part.

We are working in Tanzania right now where we are looking at solar, pairing it with energy storage to meet the needs of some small communities that are not connected to the centralized grid. So that is definitely one example.

In terms of your other question in terms of export power, it really depends on where you would site that storage. Storage is really used to solve a particular problem in a particular location. So you really wouldn't put it with the intention of exporting power farther away.

Mr. RUSH. Thank you, Mr. Chairman. I yield back.

Mr. OLSON. Thank you, my friend.

One comment on your question is to remember the country called India. I was there this past March and talked with the leaders there. Their motto for energy is: Natural gas is the present, renewables are the future. That means batteries are the future.

Great ally, great market—1.3 billion people who have been held back by energy since probably the last half-century, but now, with America opening up our exports of natural gas and oil, they are looking for a source of energy from us. They have air problems too.

So thank you for bringing that up.

OK. Seeing there are no further members wishing to ask questions——

Mr. RUSH. Mr. Chairman, I ask for unanimous consent to enter into the record the opening statement from Ranking Member Pallone.

Mr. OLSON. Without objection.

[The prepared statement of Mr. Pallone follows:]

PREPARED STATEMENT OF HON. FRANK PALLONE, JR.

Electricity storage is one of the most exciting topics in energy today and I'm glad the Subcommittee is exploring it. Under the leadership of Governor Phil Murphy, my home state of New Jersey recently set an aggressive target to add 2,000 megawatts by 2030, including 600 MW in the next three years.

Energy storage provides flexibility and key reliability services to the electricity grid. It can also be an essential compliment to renewable generation resources like solar and wind by storing excess power generated on a sunny or windy day. That stored power can then be quickly dispatched to the grid as needed when the sun isn't shining or the wind stops blowing.

Grid-level energy storage comes in many different forms, from various types of batteries to molten salt storage. Our committee and the House of Representatives took an important step to promote another type of energy storage late last year when we overwhelmingly passed legislation to expedite closedloop pumped storage hydroelectric project licensing.

Recently, the Federal Energy Regulatory Commission (FERC) issued an order that attempts to remove barriers to storage in U.S. wholesale energy markets. I applaud FERC for moving to place storage on an equal footing with generators and other grid resources. While FERC's Order 841 is not perfect, it is an important first step, and it could help promote deployment of an additional seven gigawatts of storage across the country.

I already mentioned New Jersey's energy storage efforts, but the fact is that states and utilities around the country are moving to incorporate storage into the grid. There are many reasons that new storage projects are being planned or coming on line. In addition to providing reserve capacity, a number of these projects will also provide frequency regulation and voltage support that will make the grid more dependable.

One of the main reasons we're seeing more of these storage projects pop up is the rapidly falling price for incorporating storage into the grid. Storage has become increasingly competitive with generation technologies for managing peak load. In fact, Pacific Gas and Electric just requested approval to replace three natural gas peaking plants with battery storage. Meanwhile, a Tucson, Arizona utility reportedly contracted for 100 megawatts of solar electricity coupled with 30 megawatts of storage for less than $45 per megawatt hour—a price that's fully competitive with a new natural gas plant.

So, what we are beginning to see is the potential for a truly transformative technology to take hold, one that can work with all types of generation. Combined with renewable energy, storage could help us meet our climate goals while also creating new American jobs. Storage is already employing thousands of people in the United States and has the potential to employ many more, while adding billions to our economy and saving money for millions of electric consumers across the country. That should be something both sides of the aisle can easily agree on.

Mr. OLSON. And it looks like my colleague from Texas, Mr. Green, has slipped in here.

We have talked all about the Astros, Gene. Do you want to add some comments about battery power?

Mr. GREEN. And don't forget Altuve getting a hit last night, and Springer helped scoring the run. Although I was worried when our pitcher, Morton, let a home run get away from him. But thank you, Mr. Chairman.

And I thank our colleagues who are here. I know you all didn't want to have—although between Pete and I, we are both Astros fans because, if you couldn't tell it, we are both from Texas.

I want to thank the chair for this, because when it comes to renewables, while were a still great success in the last decade, the sun doesn't always shine and the wind doesn't always blow. But advances in energy storage have the potential to lead to a grid with a expanded renewable portfolio. And I am glad our witnesses are coming here today.

For those of you on the panel who operate or construct storage facilities, what was the regulatory process to build these facilities, and what improvements would you like to see?

Mr. KUZNAR. I can start. So——

Mr. GREEN. Was it a problem with FERC or——

Mr. KUZNAR. Right. So, we operate in a number of different markets. It is a new technology. And so the way we have modeled it in our traditional planning processes that at least our commissions are used to seeing. If you look, we operate in Ohio, Indiana, Kentucky, North Carolina, South Carolina, and Florida. And so, at Duke, we have a lot of different commissions overseeing those States. And we are regulated, so they must approve those projects.

So I think, one of our just initial goals that we needed to tackle was just how do we model storage, how do we show that it is an economic investment for us, and how do we educate and get approval from our commissions.

Mr. GREEN. OK.

Do you feel, Mr. Kumaraswamy—pardon. Having a name like "Green," it is easy. But, in your testimony, you talk about investment tax credit. And I know what we—do you feel the single-year tax credit extension framework that is currently used on a year-to-year basis works for the development of storage projects that require lots of permitting and environmental reviews?

Mr. KUMARASWAMY. Yes, no, that is a good question. I think we talked about this previously, but one of the things that I wanted to highlight is that section 48 of the investment tax credit currently applies for energy storage when it is paired with renewable energy generation.

There has been some ambiguity about that process, and the IRS has actually invited comments on that procedure. And they have not provided formal guidance on the topic. But one thing that we see is that energy storage provides value wherever it is put on a grid, right? Whether it is co-located with renewables or whether it is paired with traditional generation facilities or when it is used as a wires option, right, so while it is replacing traditional T&D infrastructure asset.

So it is able to add value wherever it is added to the grid. And so thinking about energy storage as a class by itself and extending the current section 48 rules to apply for that would be what we would like to see.

Mr. GREEN. OK.

I represent an area that is in ERCOT. And the expansion of wind power has been overwhelming. Not as much solar, but I think the State is going to get into that. And I don't think we would have built most of that without the investment tax credit.

And the same with storage. When I look at information that ERCOT has much less storage capacity than some of the other areas, does anybody know why that would be? Because compared to California or compared to even PJM, the storage capacity is much smaller.

Mr. FRIGO. I can answer that, Mr. Green.

Mr. GREEN. OK.

Mr. FRIGO. ERCOT, which is not under the jurisdiction of FERC, has, effectively, a pilot frequency regulation market that energy storage is well-positioned to participate in. Currently, it is maxed out at 65 megawatts for regulation up and then 35 megawatts for regulation down. And, basically, that is markets already saturated with the existing storage there.

Mr. GREEN. OK.

Mr. FRIGO. So what ERCOT needs to do—and this is one of the things that has been proposed to ERCOT—is to expand that market so that more energy storage could come onto the grid. And that is something that initially got rejected and will probably be revisited, I guess, in the future.

Mr. GREEN. OK. Because last year—I know Congressman Olson, it is not his district now—we didn't have a lot of wind damage, but when you get 55 inches of rain, it has an impact on pipelines, on everything else. And we didn't lose power like Puerto Rico or other States that were hit with high winds, but it would be great to have that storage capacity that maybe some of the plants—and the nuclear power plant continued. Our coal plants could not because all the coal was underwater, literally, in the storage area.

Mr. Chairman, I know I am out of time, but I appreciate the time.

Mr. OLSON. Well, thank you.

And one more time, seeing there are no further members wishing to ask questions and no one wanting to brag about the Houston Astros, I would like to thank all the witnesses for joining us today.

Before we conclude, I would like to ask unanimous consent that we submit the following documents for the record: Number one is a letter from the National Rural Electric Cooperative Association, and the second, a letter from the Edison Electrical Institute.

Without objection, so ordered.

[The information appears at the conclusion of the hearing.]

Mr. OLSON. And pursuant to committee rules, I remind members that they have 10 business days to submit additional questions for the record.

And I ask the witnesses submit their responses within 10 business days upon receipt of the questions.

Without objection, this subcommittee is adjourned.

[Whereupon, at 11:30 a.m., the subcommittee was adjourned.]

[Material submitted for inclusion in the record follows:]

NRECA
America's Electric Cooperatives

July 17, 2018

The Honorable Fred Upton
Chairman
Subcommittee on Energy
Committee on Energy and Commerce
United States House of Representatives
Washington, DC 20515

The Honorable Bobby Rush
Ranking Member
Subcommittee on Energy
Committee on Energy and Commerce
United States House of Representatives
Washington, DC 20515

Dear Chairman Upton and Ranking Member Rush:

The National Rural Electric Cooperative Association (NRECA) would like to commend you on holding today's hearing on "Powering America: The Role of Energy Storage in the Nation's Electricity System." Overall, energy storage should be used to further the ability of electric utilities to continue to provide safe, affordable, and reliable power to consumers. Energy storage holds a great deal of potential, and it should be considered a part of an all-of-the above strategy where rural electric cooperatives (co-ops) and other electric utilities are able to utilize a diverse set of resources to integrate and optimize the electric system on behalf of consumers.

Battery energy storage can be used for a variety of applications, including frequency regulation, demand response, transmission and distribution infrastructure deferral, integration of renewable energy, and microgrids. Different battery technologies can enable different applications that can provide various benefits to the utility services, Independent System Operator (ISO) services, Regional Transmission Organization (RTO) services, and consumer services.

Both lithium-ion and flow battery technologies are projected to see significant cost declines in the coming years. These cost declines coupled with policy incentives will drive increased demand for battery storage from utilities and commercial and industrial consumers, leading to continued growth in the battery market in coming years. Higher penetration of variable renewable generation will drive the need to store the electricity generated during times it cannot be used. Wind energy generation, for instance, tends to be highest in the middle of the night during which time demand is typically low. The capability to store that energy for use during the daytime when demand is higher can allow for more wind energy to be generated. Similarly, excess solar generation during the middle of the day can be stored to be used later in the evening when demand is higher.

Co-ops are currently deploying battery energy storage systems. Interest among co-ops in deploying battery energy storage is growing, and it will likely accelerate as more experience is gained, costs continue to fall, and technological advances improve the performance of battery technology. Important challenges remain, including developing sustainable business models, overcoming technology performance uncertainty, determining comprehensive and credible cost estimates, and integrating battery energy storage with existing utility systems. Some of these challenges will be addressed with the natural maturation of the technology, while others require a broader effort to develop focused programs, projects, tools, and resources.

To optimize the application of energy storage technologies, co-ops must be permitted to own and operate the systems. Co-ops are in the best position to integrate energy storage technologies to best meet the needs of the system, such as the need for peak shaving which reduces capacity and transmission costs.

In February 2018, the Commission issued Order No. 841, which requires ISOs and RTOs to amend their wholesale market rules to better enable electric storage resources to participate. Order No. 841 applies to wholesale market participation by any electric storage resources, including those resources located "behind-the-meter" and on local utility distribution systems, that might be aggregated for such participation. Order No. 841 does not adopt language that the Commission used when it previously provided for the participation of demand response aggregators in ISO and RTO markets (in Commission Order No. 719). That language expressly allows the relevant electric retail regulatory authority to decide whether such aggregators would be allowed to participate in wholesale markets. NRECA is urging the Commission to follow that wise precedent in fashioning its rules for electric storage resources.

Energy storage has the potential to provide benefits to co-ops and their member-owners. NRECA will continue to focus on preserving the ability of each co-op to make informed decisions about energy storage thereby ensuring the optimal use of these technologies.

Sincerely,

Jim Matheson
CEO, NRECA

Edison Electric
INSTITUTE

Thomas R. Kuhn
President

July 18, 2018

The Honorable Fred Upton
Chairman, Energy Subcommittee
House Energy and Commerce Committee
2183 Rayburn House Office Building
Washington, DC 20515

The Honorable Bobby Rush
Ranking Member, Energy Subcommittee
House Energy and Commerce Committee
2188 Rayburn House Office Building
Washington, DC 20515

Dear Chairman Upton and Ranking Member Rush:

The Edison Electric Institute (EEI) is the association that represents all U.S. investor-owned electric companies. Our members provide electricity for about 220 million Americans, and operate in all 50 states and the District of Columbia. As a whole, the electric power industry supports more than 7 million jobs in communities across the United States. In addition to our U.S. members, EEI has more than 60 international electric companies, with operations in more than 90 countries, as International Members, and hundreds of industry suppliers and related organizations as Associate Members.

Energy storage offers multiple benefits for the energy grid and electricity customers. It facilitates the integration of renewable energy resources such as wind and solar into the energy grid by keeping supply and demand balanced at all times. Energy storage also helps to improve electric reliability by providing grid stability services, reducing transmission constraints, and meeting peak demand for all customers.

The electric power industry uses more than 90 percent of all energy storage. While pumped hydropower represents approximately 93 percent of installed storage capacity in the United States, battery storage is a key driver of the energy storage market today. Investment in advanced energy storage is growing rapidly, with an estimated 280 megawatts installed in 2017 alone, up 400 percent from 2014.

Energy storage is a versatile resource that can provide multiple benefits to customers and the energy grid. It is now well on its way to becoming an integral part of our electricity system with the potential to be a true game changer. To allow energy storage technology to develop into its full potential, it is important that electric companies, customers, and third-parties are allowed to participate in the market to achieve the full spectrum of benefits for both customers and the energy grid.

EEI member companies will continue deploying technologies, such as energy storage, that help to enable a smarter, stronger, cleaner, and more reliable energy grid for all customers. We remain committed to working with you and the members of the Energy and Commerce Committee to advance these goals.

Sincerely,

Tom Kuhn

Thomas R. Kuhn

701 Pennsylvania Avenue, NW | Washington, DC 20004-2696 | 202-508-5000 | www.eei.org

GREG WALDEN, OREGON
CHAIRMAN

FRANK PALLONE, JR., NEW JERSEY
RANKING MEMBER

ONE HUNDRED FIFTEENTH CONGRESS

Congress of the United States

House of Representatives

COMMITTEE ON ENERGY AND COMMERCE
2125 RAYBURN HOUSE OFFICE BUILDING
WASHINGTON, DC 20515–6115
Majority (202) 225–2927
Minority (202) 225–3641

August 29, 2018

Dr. Zachary Kuznar
Director, CHP Microgrid and Energy Storage Development
Duke Energy Corporation
550 South Tryon Street
Charlotte, NC 28202

Dear Dr. Kuznar:

Thank you for appearing before the Subcommittee on Energy on July 18, 2018, to testify at the hearing entitled "Powering America: The Role of Energy Storage in the Nation's Electricity System."

Pursuant to the Rules of the Committee on Energy and Commerce, the hearing record remains open for ten business days to permit Members to submit additional questions for the record, which are attached. To facilitate the printing of the hearing record, please respond to these questions with a transmittal letter by the close of business on Wednesday, September 12, 2018. Your responses should be mailed to Kelly Collins, Legislative Clerk, Committee on Energy and Commerce, 2125 Rayburn House Office Building, Washington, DC 20515 and e-mailed in Word format to Kelly.Collins@mail.house.gov.

Thank you again for your time and effort preparing and delivering testimony before the Subcommittee.

Sincerely,

Fred Upton
Chairman
Subcommittee on Energy

cc: The Honorable Bobby L. Rush, Ranking Member, Subcommittee on Energy

Attachment

Additional Questions for the Record

Dr. Zachary Kuznar
Director, CHP Microgrid and Energy Storage Development
Duke Energy Corporation

The Honorable Greg Walden

1a) FERC Order 841 will certainly ensure the barriers are removed for storage participating in capacity, energy and ancillary service markets. However, we need to give these markets time to implement the new rules to see the true impact regulation has on storage adoption

1b) Although we operate in six different states, some of which are in wholesale markets (Indiana, Ohio and Kentucky) and some that are not (North Carolina, South Carolina and Florida), our overall goal around storage deployment is consistent: to capture and deliver the greatest value from these assets for our grid operations, and ultimately, our customers. We believe the vertically integrated utility is in an ideal position to invest and own these assets. We can identify the locations on our electric system where we can capture the most value by stacking the benefits these individual deployments will have over our distribution, transmission and generation systems. The only technical difference between our regulated states that operate in a wholesale market and those that do not is that in a wholesale market, there are specific price signals on bulk system benefits such as frequency regulation. Outside of these wholesale markets, it is a service that is inherently built into our system and valued based on the benefits of delivering the system and the communities we serve.

The Honorable Fred Upton

1a) The reason for the large number of energy storage assets in PJM was driven by a price signal that PJM developed called "Regulation D" pricing. It paid a higher value for regulation service to assets that could perform faster and more accurately than traditional resources such as fossil generation units. This market signal was the driving factor behind these deployments.

1b) Yes. A change in a price signal in other RTOs that rewards assets such as storage for their speed and accuracy could certainly be replicated in other markets to drive additional deployments.

2a) Around 10 years ago, Duke Energy recognized that storage could provide significant benefits to our electric system, but the technology was still quite nascent and therefore was too premature to implement projects at any large scale. Therefore, we invested in smaller systems (less than 1 MW in size) to learn how to operate the systems in the optimal manner for our grid. We continued to monitor the evolution of this technology and believe we are ready to begin deploying it at scale to benefit our customers. Applications may include hardening our transmission and distribution system and providing bulk system benefits such as frequency regulation and capacity value.

2b) The technology has definitely evolved since our earlier pilot projects. We have seen improvements in energy density, reliability and the controls systems necessary to integrate these assets into our electric system along with significant cost declines. The services we envisioned during the pilots are what we are now leveraging in our implementation: using storage to defer or eliminate traditional transmission and distribution upgrades, helping to integrate intermittent renewable generation assets such as solar into our system, and providing bulk system benefits such as regulation and capacity.

3a) As Duke Energy starts to deploy more assets on our distribution system, we believe that partnering with cities, the Department of Defense and other critical infrastructure sites will provide benefits to our broader system as well as customers who provide important services for our communities.

In my testimony, I highlighted our Camp Atterbury project in Indiana as a specific example. This base provides training, equipping and mobilizing resources for all U.S. Armed Forces branches. For this deployment, we are building a 3 MW solar farm and a 5 MW battery asset on base. During normal operation, the solar farm will produce energy for our Indiana customers and the battery asset will provide bulk grid services such as frequency regulation. During a grid outage, the battery/solar microgrid will be able to provide back-up power for the critical base infrastructure and services they provide.

We are also building storage assets that can benefit residential customers in a similar way. We have several projects under development that will be located at substations of communities located at the end of radially-fed distribution lines that have poor reliability. These storage assets will be utilized to provide back-up power to entire communities during a grid outage.

4a) Energy storage can be used in place of a traditional infrastructure upgrade. An example of this would be similar to what I discussed in the response to answer 3a above. In many cases where we realize that a city or community has poor system reliability, we will evaluate running a second feed into that area. Many times, that is cost prohibitive or not technically feasible. Instead, we can now evaluate placing a battery asset at this location to provide back-up power during a grid outage while also providing bulk system benefits such as frequency regulation.

5a) Energy storage provides our customers with the most value when it is located in areas of the grid where you we can leverage it for multiple benefits. The vertically integrated utility is in the best position to identify these locations and deploy these assets to capture primary value on its transmission and distribution systems by also providing bulk system benefits.

5b) In service territories that are part of competitive electricity markets, utility-owned and third-party owned storage assets can co-exist. Third-party owned systems will only provide one value stream (such as frequency regulation) while the utility-owned assets will be able to stack multiple value streams. Deploying storage to only provide one value stream is underutilizing the asset and adds cost for customers.

The Honorable Jerry McNerney

1. Storage is properly valued when you are able to capture the distribution, transmission and generation values that it provides. It takes an integrated planning methodology across all three systems.

GREG WALDEN, OREGON
CHAIRMAN

FRANK PALLONE, JR., NEW JERSEY
RANKING MEMBER

ONE HUNDRED FIFTEENTH CONGRESS

Congress of the United States

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COMMITTEE ON ENERGY AND COMMERCE

2125 RAYBURN HOUSE OFFICE BUILDING
WASHINGTON, DC 20515–6115

Majority (202) 225-2927
Minority (202) 225-3641

August 29, 2018

Mr. Mark Frigo
Vice President and Head of Energy Storage
E.ON North America
353 North Clark Street
Chicago, IL 60654

Dear Mr. Frigo:

Thank you for appearing before the Subcommittee on Energy on July 18, 2018, to testify at the hearing entitled "Powering America: The Role of Energy Storage in the Nation's Electricity System."

Pursuant to the Rules of the Committee on Energy and Commerce, the hearing record remains open for ten business days to permit Members to submit additional questions for the record, which are attached. To facilitate the printing of the hearing record, please respond to these questions with a transmittal letter by the close of business on Wednesday, September 12, 2018. Your responses should be mailed to Kelly Collins, Legislative Clerk, Committee on Energy and Commerce, 2125 Rayburn House Office Building, Washington, DC 20515 and e-mailed in Word format to Kelly.Collins@mail.house.gov.

Thank you again for your time and effort preparing and delivering testimony before the Subcommittee.

Sincerely,

Fred Upton
Chairman
Subcommittee on Energy

cc: The Honorable Bobby L. Rush, Ranking Member, Subcommittee on Energy

Attachment

e·on

September 12, 2018

The Honorable Fred Upton
Chairman Subcommittee on Energy
U.S. House of Representatives Committee on Energy and Commerce
2125 Rayburn House Office Building
Washington, DC 20515-6115

Dear Chairman Upton,

Thank you for the opportunity to testify before your committee on July 18, 2018, at the hearing entitled, "Powering America, The Role of Energy Storage in the Nation's Electricity System." Enclosed are my responses to the questions for the record that were provided to me on August 29, 2018. Please do not hesitate to contact me if I may be of further assistance.

Sincerely,

[redacted]

Mark A. Frigo
Vice President, Head of Energy Storage, North America
E.ON

The Honorable Greg Walden

1. *FERC issued Order No. 841 earlier this year, and asked the RTOs/ISOs to ensure their market rules are not creating barriers to the participation of energy storage resources in their capacity, energy, and ancillary services markets. As these market operators are contemplating their responses.*

    a. *For your perspective, are the markets working? Are energy storage resources able to compete? If not, what are the barriers?*

    The markets are not currently working in a way that completely unleashes the full benefits that energy storage can provide. FERC Order 841 was a great start, with its goal to remove barriers to storage. RTOs/ISOs are still in the beginning stages of implementing the Order, so it is too early to tell the success of that Order. However, a number of stakeholders have lodged rehearing requests at FERC for the Order. These rehearings would only delay the necessary implementation of the Order, and as such, remain a barrier within the organized markets. It would be best for FERC to deny these requests for rehearings to allow the RTOs/ISOs to implement the Order without delay. Also, FERC Order 841 only targets the organized markets, which according to EIA, covers approximately 60% of the U.S. electric power supply. For those areas not in organized markets, the Order does not clarify how the ratepayers and electricity systems will realize the full benefits of energy storage.

The Honorable Fred Upton

1. *According to EIA, about 90% of large-scale battery storage capacity in the United States is installed in the regions covered by five of the seven organized markets (RTOs/ISOs). Nearly 40% of existing large-scale battery storage power capacity lies in the PJM footprint, the next being CAISO with 18% existing power capacity.*

    a. *What circumstances led to the PJM market having this large share of large-scale battery storage capacity.*

    The PJM RTO recognized the technological benefits of energy storage and its capability to respond to grid problems quicker than traditional resources. As such, PJM in 2012 split their frequency regulation service into two markets: "Reg A" which includes traditional generators with slower ramp rates, and a new fast response frequency regulation market called "Reg D" which have very fast ramp rates. The formation of this Reg D market was the first to recognize the fast ramp rates of energy storage and allowed for a quick proliferation of energy storage. We are seeing the beginning of fast responding frequency regulation markets in other parts of the country, but other RTOs have not been as aggressive in implementing these types of markets.

b. *Could market rules in PJM be utilized in other competitive electricity markets?*

Yes, however, PJM has recently introduced rule changes governing the Reg D market that are at odds with its original design. These rule changes included a cap on the amount of Reg D resources that could be procured, a negative change in the "benefits factor" calculation that determines revenue for Reg D resources, and a change in the signal from 15 to 30-minute dispatches (most PJM energy storage assets were designed for 15 minutes). These changes have subsequently hurt energy storage and thus should not be carried forward to other markets.

2. *In your testimony, you mention that market rules for competitive electricity markets should not only ensure the participation of energy storage resources but should be examined to ensure that interconnection process do not constitute barriers to entry.*

a. *Can you explain in further detail how interconnection processes could be a barrier to entry or impede energy storage resources ability to compete?*

Unlike other projects, energy storage can be designed, built, and brought online relatively quickly, usually in a matter of months. Interconnection processes, which stretch on for years, significantly slows deployment of storage resources on the grid, and adds burdensome costs and delays ratepayer savings. In some organized markets, interconnection processes which should only take up to two years to complete are actually taking up to six years. This has a significant negative impact to all projects, but especially for energy storage projects. In addition to the time burdens, differences in the process and analysis between interconnected markets creates unsynchronized analysis between the two markets. While provisions exist to interconnect under provisional terms, it is not prudent as a business to take the step of investing millions of dollars of capital expenditures in the face of uncertain risks which hinge on completion of a study.

One specific opportunity that has provided benefit in CAISO and has capability under certain provisions elsewhere is allowing for peak-shaving projects (one of the many application of energy storage). This was mentioned in my and others' testimony. This concept is the co-location of large-scale storage with other generation without increasing net output to the grid. This allows grid operators to shift generation to when it is needed most, while at the same time avoiding e·on

unnecessary and costly upgrades. Further expansion of this concept with defined rules across all markets would help lower barriers.

Reliability of the grid, which is nominally the purpose of interconnection studies, is of the utmost importance, but eliminating unnecessary barriers and inefficient processes – particularly between connected markets – to better allow projects to participate on the grid would help spur the deployment of energy storage.

The Honorable Jerry McNerney

1. *How would each of you properly value storage?*

   Energy storage can provide multiple services to the grid, depending upon when and how it is used. The business case for energy storage projects is dependent upon revenue from these multiple sources. This is referred to in the energy industry as the "revenue stack." As such, the value for energy storage is a function of the revenue that is received from these multiple services netted from the costs associated with the operational parameters of the energy storage system. To properly value storage from a compensation perspective, grid operators need to allow for the full revenue stack to be considered for storage projects. Many markets still do not recognize the full value stack of this uniquely flexible technology, resulting in barriers to market participation.

2. *Can you provide examples of how market rules remain a barrier to energy storage? What can be done about each of these barriers?*

   The markets are not currently working in a way that completely unleashes the full benefits that energy storage can provide. FERC Order 841 is a great start, with its goal to remove barriers to the participation of energy storage. RTOs/ISOs are still in the beginning stages of implementing the Order, so it is too early to tell the success of that Order. However, a number of stakeholders have lodged rehearing requests at FERC for the Order. These rehearings would only delay the necessary implementation of the Order, and as such, remain a barrier within the organized markets. It would be best for FERC to deny these requests for rehearings to allow the RTOs/ISOs to implement the Order without delay.

   A couple of examples of barriers include 1) no proper, or wrong, classification of energy storage within the current regulatory framework, and 2) lack of tariff clarity on charging. These examples are prevalent in several markets across the U.S. The current regulatory framework across the country classifies energy assets into one of three general buckets, generation, transmission/distribution, and load (i.e. demand). Because of its unique flexibility, energy storage does not neatly fit into one bucket. It is both generation (discharging) and load (charging). Depending upon its application, or use, it can be a generation or transmission/distribution asset. Until market rules are clear regarding energy storage, and how utilities can properly recoup their cost from ratepayers, utilities will hesitate to use it widely, or delay its implementation. In addition, there is confusion on what tariff structure energy storage should use for charging, as there are no clear tariff structures for energy storage charging. For example, in some places, energy storage projects are billed at higher retail rates for charging, but compensated at lower wholesale rates when they discharge that same energy back to the grid. In other places, energy storage projects pay a demand charge – essentially a markup based on retail energy consumption – but are actually used for generation. These inconsistencies increase uncertainty and remain a barrier to further penetration of energy storage.

GREG WALDEN, OREGON
CHAIRMAN

FRANK PALLONE, JR., NEW JERSEY
RANKING MEMBER

ONE HUNDRED FIFTEENTH CONGRESS

Congress of the United States

House of Representatives

COMMITTEE ON ENERGY AND COMMERCE

2125 RAYBURN HOUSE OFFICE BUILDING
WASHINGTON, DC 20515-6115
Majority (202) 225-2927
Minority (202) 225-3641

August 29, 2018

Dr. Keith E. Casey
Vice President, Market and Infrastructure Development
California ISO
P.O. Box 639014
Folsom, CA 95603

Dear Dr. Casey:

Thank you for appearing before the Subcommittee on Energy on July 18, 2018, to testify at the hearing entitled "Powering America: The Role of Energy Storage in the Nation's Electricity System."

Pursuant to the Rules of the Committee on Energy and Commerce, the hearing record remains open for ten business days to permit Members to submit additional questions for the record, which are attached. To facilitate the printing of the hearing record, please respond to these questions with a transmittal letter by the close of business on Wednesday, September 12, 2018. Your responses should be mailed to Kelly Collins, Legislative Clerk, Committee on Energy and Commerce, 2125 Rayburn House Office Building, Washington, DC 20515 and e-mailed in Word format to Kelly.Collins@mail.house.gov.

Thank you again for your time and effort preparing and delivering testimony before the Subcommittee.

Sincerely,

Fred Upton
Chairman
Subcommittee on Energy

cc: The Honorable Bobby L. Rush, Ranking Member, Subcommittee on Energy

Attachment

California ISO   California Independent System Operator Corporation

Keith E. Casey, Ph.D.
Vice President, Market & Infrastructure Development

September 12, 2018

Chairman Fred Upton
U.S. House of Representatives
Energy and Commerce Committee
Subcommittee on Energy
2125 Rayburn House Office Building
Washington, DC 20515

Re: Powering America: The Role of Energy Storage in the Nation's Electricity System

Answers to Additional Questions from July 18, 2018 Testimony of Keith E. Casey, Ph.D.

Dear Chairman Upton:

I would like to take the opportunity to thank you, Vice Chairman Olson, Ranking Member Rush, and the members of the Subcommittee on Energy for inviting me to discuss the role of energy storage in the California wholesale electricity markets on July 18, 2018. I have prepared the following answers to the additional questions in your August 29, 2018 letter.

From the Honorable Greg Walden
FERC issued Order No. 841 earlier this year, and asked the RTOs/ISOs to ensure their market rules are not creating barriers to the participation of energy storage resources in their capacity, energy, and ancillary services markets. As these market operators are contemplating their responses, From your perspective, are the markets working? Are energy storage resources able to compete? If not, what are the barriers?

Electric storage currently participates in the California ISO's markets. We expect this participation to increase because of the ongoing development of electric storage in California and the grid capabilities that electric storage can offer. Prior to the adoption of Order No. 841, the California ISO deployed a market participation model for electric storage and has continued to refine that model. The ISO's compliance with Order No. 841 will mainly involve fine tuning design elements already in place.

The California Public Utilities Commission requires large investor-owned utilities under its jurisdiction to procure 700 MW of transmission-level electricity storage, 425 MW of distributed electricity storage, and 200 MW of customer electricity storage by 2020. This procurement effort will soon result in a rapid and dramatic rise in the amount and diversity of energy storage resources competing in the California ISO's markets. In 2016, for example, the California ISO had 36 requests for new energy storage resources to interconnect to its grid. These requests comprised 3,093 MW. By last month, the California ISO had 116 interconnection requests for energy storage resources, comprising 23,139 MW. Although only some of these resources are likely to secure power purchase agreements and come to fruition, the increase in greenfield development reflects that developers believe energy storage resources can compete in California. Moreover, a significant number of existing generators—including natural gas, solar, and wind generators—are adding energy storage capacity to their generators, or are retiring older plants and replacing them with energy storage. The California ISO also has seen energy storage resources successfully compete with transmission facilities. In its most recent transmission planning process, the California ISO identified two energy storage projects as the preferred, cost-effective solutions to constraints that previously would have resulted in constructing new transmission facilities such as high-voltage transmission lines or new substations. The California ISO also has a stakeholder initiative underway considering how storage operates as a transmission asset while still having opportunities to participate in the wholesale energy markets.

Although storage resources have demonstrated their ability to compete in California, there are still barriers for storage, particularly large scale pumped hydroelectric storage. New large scale pumped hydroelectric storage projects can significantly help manage solar oversupply and the need to ramp up energy as solar production declines in the late afternoon; however, whether such large infrastructure projects are needed given the declining costs of batteries and solar is an open question being further investigated at the California Public Utilities Commission. Unlike batteries, hydroelectric projects also face very long permitting and construction timelines, which can present real challenges to development.

From the Honorable Fred Upton

According to EIA, about 90% of large-scale battery storage capacity in the United States is installed in the regions covered by five of the seven organized markets (RTOs/ISOs), Nearly 40% of existing large-scale battery storage power capacity lies in the PJM footprint, the next being CAISO with 18% existing power capacity.

a. *What circumstances led to the PJM market having this large share of large-scale battery storage capacity?*

I defer to PJM on what has led to its progress. The California ISO has made numerous enhancements to its market rules over the past several years to enable storage resources to participate effectively. Most notably, the California ISO developed a specific storage resource participation model so our wholesale market can optimally manage the state of charge of a storage resource. The California ISO also has developed special participation rules for storage to provide other grid reliability functions and has evolved its transmission planning process to consider storage as an alternative to conventional wires and generation.

b. *Could market rules in PJM be utilized in other competitive electricity markets?*

ISOs and RTOs continue to work together through the ISO/RTO Council, industry groups, and FERC proceedings to ensure that market rules outpace technological advancement. To the extent any ISO or RTO develops a potential best practice, ISOs and RTOs always strive to understand it and adopt it to meet their region's individual needs.

From the Honorable Jerry McNerney
How would each of you properly value storage?

Energy storage resources represent significant and unique value to the transformation of the electric grid. This value principally derives from storage resources' ability to store and shift energy from low value to high value periods, and to manage the variable and temperamental nature of renewable resources such as wind and solar. It is difficult to imagine a dynamic electric grid dependent on renewable resources without the smoothing effects of energy storage. Energy storage and other energy efficiency tools allow grid operators to bridge the gap between variable generation and consumer needs. Although development is at a nascent stage, the California ISO believes the future grid will be one where the distribution and transmission networks are highly integrated, providing for bi-directional flow of energy versus the traditional grid where power flows one direction from large centralized power plants to consumers. The future grid will have a much more diverse set of smaller resources, with many behind a customer's meter, and will have the potential to provide services to the customer, the distribution grid, and the transmission grid. Energy storage can play a significant role in this future grid by mitigating both the variability of renewable generation and the volatility that customer loads place on the grid. Energy storage with time-variant retail rates can help produce customer load shapes that are more favorable to the grid and consumers.

Energy storage also presents significant value to the transmission grid itself. As explained above, in its most recent transmission planning process, the California ISO identified two energy storage projects as the cost-effective solutions to constraints that previously would have required new transmission facilities.

Although wholesale markets should capture and compensate energy storage resources for all of the bulk system services they provide, it is critical these services be valued consistently across all technology types. To the extent energy storage resources provide energy, demand, and ancillary services, they should be compensated by technology-neutral market prices. Likewise, to the extent that storage provides value to the distribution grid and retail customer, those markets should compensate storage resource owners for their full and fair value.

Respectfully submitted,

[redacted]

Keith E. Casey, Ph.D.
Vice President
Market and Infrastructure Development
California Independent System Operator Corporation

GREG WALDEN, OREGON
CHAIRMAN

FRANK PALLONE, JR., NEW JERSEY
RANKING MEMBER

ONE HUNDRED FIFTEENTH CONGRESS

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COMMITTEE ON ENERGY AND COMMERCE

2125 RAYBURN HOUSE OFFICE BUILDING
WASHINGTON, DC 20515–6115
Majority (202) 225–2927
Minority (202) 225–3641

August 29, 2018

Mr. Kushal Patel
Partner
Energy and Environmental Economics, Incorporated
101 Montgomery Street; Suite 1600
San Francisco, CA 94104

Dear Mr. Patel:

Thank you for appearing before the Subcommittee on Energy on July 18, 2018, to testify at the hearing entitled "Powering America: The Role of Energy Storage in the Nation's Electricity System."

Pursuant to the Rules of the Committee on Energy and Commerce, the hearing record remains open for ten business days to permit Members to submit additional questions for the record, which are attached. To facilitate the printing of the hearing record, please respond to these questions with a transmittal letter by the close of business on Wednesday, September 12, 2018. Your responses should be mailed to Kelly Collins, Legislative Clerk, Committee on Energy and Commerce, 2125 Rayburn House Office Building, Washington, DC 20515 and e-mailed in Word format to Kelly.Collins@mail.house.gov.

Thank you again for your time and effort preparing and delivering testimony before the Subcommittee.

Sincerely,

Fred Upton
Chairman
Subcommittee on Energy

cc: The Honorable Bobby L. Rush, Ranking Member, Subcommittee on Energy

Attachment

Energy+Environmental Economics
101 Montgomery Street | Suite 1600 | San Francisco, CA 94104 | 415.391.5100 | www.ethree.com

RESPONSE TO QUESTIONS FOR THE RECORD FROM KUSHAL PATEL

PARTNER, ENERGY AND ENVIRONMENTAL ECONOMICS, INC. (E3)

U.S. HOUSE OF REPRESENTATIVES

ENERGY AND COMMERCE COMMITTEE

ENERGY SUBCOMMITTEE

Hearing entitled "Powering America: The Role of Energy Storage in the Nation's Electricity System"

November 19, 2018

Thank you again for the invitation to testify at the July 18th hearing entitled "Powering America: The Role of Energy Storage in the Nation's Electricity System". I would also like to thank Congressman Walden, Chairman Upon, and Congressman McNerney for their additional questions for the record. I have included each question and my responses below.

The Honorable Greg Walden

1. *FERC issued Order No. 841, earlier this year, and asked the RTOs/ISOs to ensure their market rules are not creating barriers to the participation of energy storage resources in their capacity, energy, and ancillary services markets. As these market operators are contemplating their responses.*
    a. *From your perspectives, are the markets working? Are energy storage resources able to compete? If not, what are the barriers?*

In short, the markets are not currently working well. Many of the services that storage could provide lack viable market participation structures, and so storage assets are not adequately utilized or compensated.

Until the high (but declining) cost of storage can be offset by well-defined market structures that allow for monetization of the full value of storage, only the highest value storage use cases will be cost-effective and competitive.

The most substantial barrier to storage becoming competitive in markets is the limited ability for storage to earn revenues for the numerous services it can perform. Because of the versatility of energy storage, finding ways to monetize all these services requires addressing many challenges. Some of these challenges are hardware-related; for example, full valuation of distribution- and customer-sited storage requires telemetry and metering infrastructure that may be cost-prohibitive. More challenges stem from outdated market rules that do not value near-instantaneous response times or allow a resource to switch between consuming energy and supplying it. The newness of the technology creates other challenges as well: hardware and "soft costs" continue to decline but are still high, sufficient data on storage performance is not yet available, and financing remains nonstandard and thus increases transaction costs.

With FERC Order 841 and the ongoing development of rules for Distributed Energy Resource participation, markets are evolving. But the coming changes will not be implemented uniformly in each market, because product definitions and participations rules remain nonstandard. Consequently, some regions of the country will become more favorable to storage projects than others. Having more uniform market rules and definitions across the country would result in more standardized and steady value streams, which in turn would lead to well-formed financing structures and increase storage market participation.

The Honorable Fred Upton

1. *According to EIA, about 90% of large-scale battery storage capacity in the United States is installed in the regions covered by five of the seven organized markets (RTOs/ISOs). Nearly 40% of existing large-scale battery storage power capacity lies in the PJM footprint, the next being CAISO with 18% existing power capacity.*
    a. *What circumstances led to the PJM market having this large share of large-scale battery storage capacity?*
    b. *Could market rules in PJM be utilized in other competitive electricity markets?*

In response to FERC Order 755 in 2011, the PJM market created two different regulation products: Regulation A ("RegA") and Regulation D ("RegD"). The RegA signal covers needs on a timescale of minutes, while the RegD signal covers near-instantaneous needs. Short duration energy storage was a perfect fit for the RegD product, and PJM saw over 250 MW of storage installed.

However, changes to the RegD market in 2015 and 2017 capped the procurement amount of RegD resources and decreased the advantage that batteries had over other technologies in the regulation market. These rule changes, along with saturation of the market for RegD, eliminated the revenue streams for short-duration storage in the PJM system. Accordingly, energy storage capacity in PJM has stagnated, with almost no new installed MW in 2017.[1]

While the existence of a fast frequency response market does capture a product that energy storage can uniquely provide, applying the initial PJM rules universally would be imprudent. The initial RegD product promoted rapid growth of storage capacity in the PJM system, but PJM changed these initial rules because they adversely affected system operations. Also, the RegD product only encouraged installations of very short-duration energy storage.

A set of well-defined market rules would promote installations of a wider range of storage technologies and would unilaterally help the system to run more efficiently. We should take the rapid growth in PJM

[1] EIA report on U.S. Battery Storage Market Trends, Figure ES1.
https://www.eia.gov/analysis/studies/electricity/batterystorage/pdf/battery_storage.pdf

as evidence of two things: 1) storage developers are ready to build projects when market rules are favorable; and 2) long-term market design issues should be addressed proactively in the beginning to ensure a viable longer-term market vs. one that is more "boom and bust."

<u>*The Honorable Jerry McNerney*</u>

1. *How would each of you properly value storage?*

E3 has conducted several analyses to assess the potential value of different types of storage – i.e., Li-ion batteries, compressed-air energy storage, and pumped hydro – for clients including utilities, commercial customers, and project developers. In these analyses, the actual value of storage depends on the underlying market and revenue streams available as well the dispatch behavior of the storage asset.

Potential revenue streams come from a wide variety of utility, customer, and grid services. Utility services may include Resource Adequacy, Transmission & Distribution Deferral, and Transmission Congestion Relief. Customer services may include Energy Bill Management, Demand Charge Reduction, Demand Response programs, Backup Power, and Increased PV Self-Consumption. Grid services may include Frequency Regulation, Spin/Non-spin Reserve, Energy Arbitrage, Load Following, Voltage Support, and Black Start.

The revenues available to a given storage asset depend on where the storage is sited (at the transmission, distribution, or customer level) and on the rules of the ISO/RTO or the specific state and utility to which the storage is connected. Given the presently evolving market rules, available revenue streams are still being developed, and the valuation process is filled with uncertainty. Indeed, many of these potential revenue streams are not currently realizable in most regions.

Thank you for your questions. If the Subcommittee has any additional questions after reading my response, I would be happy to provide more information. Once more, I applaud the Subcommittee's leadership in addressing this challenging topic.

Thank you.

Kush Patel

Partner, E3

GREG WALDEN, OREGON
CHAIRMAN

FRANK PALLONE, JR., NEW JERSEY
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ONE HUNDRED FIFTEENTH CONGRESS

Congress of the United States

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COMMITTEE ON ENERGY AND COMMERCE
2125 RAYBURN HOUSE OFFICE BUILDING
WASHINGTON, DC 20515–6115
Majority (202) 225-2927
Minority (202) 225-3641

August 29, 2018

Mr. Kiran Kumaraswamy
Market Applications Director
Fluence
4300 Wilson Boulevard; Suite 900
Arlington, VA 22203

Dear Mr. Kumaraswamy:

Thank you for appearing before the Subcommittee on Energy on July 18, 2018, to testify at the hearing entitled "Powering America: The Role of Energy Storage in the Nation's Electricity System."

Pursuant to the Rules of the Committee on Energy and Commerce, the hearing record remains open for ten business days to permit Members to submit additional questions for the record, which are attached. To facilitate the printing of the hearing record, please respond to these questions with a transmittal letter by the close of business on Wednesday, September 12, 2018. Your responses should be mailed to Kelly Collins, Legislative Clerk, Committee on Energy and Commerce, 2125 Rayburn House Office Building, Washington, DC 20515 and e-mailed in Word format to Kelly.Collins@mail.house.gov.

Thank you again for your time and effort preparing and delivering testimony before the Subcommittee.

Sincerely,

Fred Upton
Chairman
Subcommittee on Energy

cc: The Honorable Bobby L. Rush, Ranking Member, Subcommittee on Energy

Attachment

U.S. House Committee on Energy and Commerce, Subcommittee on Energy
July 18, 2018 Hearing
Powering America: Role of Energy Storage in the Nation's Electricity System
Questions for the Record Submitted to Mr. Kiran Kumaraswamy

Questions from Honorable Greg Walden

Question 1: FERC issued Order 841, earlier this year, and asked the ISO/RTO's to ensure their market rules are not creating barriers to the participation of energy storage resources in their capacity, energy and ancillary service markets. As these market operators are contemplating their responses.

(a) From your perspectives, are the markets working? Are energy storage resources able to compete? If not, what are the barriers?

Answer 1: As mentioned in my written testimony, we are pleased to see the action from FERC in creating market changes to fully allow energy storage resources to participate and deliver services in wholesale power markets. Many of the rules that exist in today's markets were based on and put in place for technologies that existed 10-15 years ago; as a result, because energy storage offers significant improvements in speed, precision and accuracy over older technology, some of these rules may not apply. This has been the biggest barrier for storage participation in markets till now. FERC Order 841 will remedy this by modifying market rules to focus on requirements to provide specific market services. If a resource can qualify under the revised criteria, it should be allowed to participate, deliver the service and get compensated.

Question 2: Large-scale energy storage has many applications and provides unique attributes such as frequency control to improve the reliability and resilience to the nation's electricity system. According to a recent report by EIA, 88 %of large-scale battery storage power provides frequency regulation.

(a) Can you explain in further detail how energy storage resources provide "frequency regulation"?
(b) Is there a reason why the majority of large-scale battery storage power is used for frequency regulation?
(c) Are other energy storage attributes being underutilized?

Answer 2: Energy storage resources have the benefit of providing nearly instantaneous response to changes in grid frequency. They can do so because they do not have rotating machines like we typically see in power plants, but rather are operated by power electronics which have no inertia and can consequently offer significantly faster response time. Energy storage resources provide a very fast, accurate and precise response to second-to-second variations in frequency. This makes them a great resource for providing frequency regulation services. For example, in the PJM regulation market, energy storage resources get a signal every 2 seconds and they provide the output within that timeframe. In fact, all resources providing these services get scored on how

U.S. House Committee on Energy and Commerce, Subcommittee on Energy
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well they responded to that signal, and storage resources consistently score the highest in terms of accuracy of following the signal. In addition, storage can provide other applications for the electric grid, such as providing peaking capacity and addressing transmission/distribution needs of utilities, both of which are being demonstrated by a growing number of projects across the country, especially in the southwestern U.S. The ability of storage to provide high-quality frequency regulation was the starting point, and now we are moving on to some of these other high-value applications that storage can provide to utilities and grid operators.

Questions from Honorable Fred Upton

Question 1: According to EIA, about 90% of large-scale battery storage capacity in the United States is installed in regions covered by five of the seven organized markets (ISO/RTO's). Nearly 40% of existing large-scale battery storage power capacity lies in PJM footprint, the next being CAISO with 18% existing power capacity.

(a) What circumstances led to the PJM market having this large share of large-scale battery storage capacity?
(b) Could market rules in PJM be utilized in other competitive electricity markets?

Answer 1: In 2012, PJM market implemented rule changes to comply with FERC Order 755 and established a "pay-for-performance" mechanism to compensate resources based on the accuracy of providing frequency regulation. This mechanism enabled energy storage to earn a premium on market revenues based on their higher performance capabilities relative to traditional generation resources, while at the same time helping improve the efficiency of the regulation market. The availability of this premium and the market construct that values the higher quality of resources providing this service were the main reasons for increase in storage capacity in PJM. These rules could definitely be utilized in other markets; however, in markets like MISO/SPP, existing market rules still do not fully compensate energy storage for the higher quality regulation service.

Question 2: In your testimony you mention using energy storage in conjunction with a gas turbine to increase the utilization of the existing gas turbine, while lowering emission and operating costs.

(a) How can integrating energy storage with an existing gas turbine increase its utilization?
(b) Could this be applied to other generation resources?

Answer 2: Typically, peaking gas turbines are utilized only for a small fraction of the year (typically 5-6% of the year) to satisfy peak demand conditions of the grid. By hybridizing gas turbines with storage – similar to how a Toyota Prius' gas engine is hybridized with a battery –

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energy storage can help the traditional resource to be better utilized, allowing the gas turbine to turn on only when needed and add flexibility to the gas plant. We are seeing similar ideas being implemented on run-of-river hydro projects where the addition of storage to hydropower turbines can add flexibility and increase utilization.

Question 3: Energy storage resources allow for electricity to be storage during off-peak time periods and then deployed in times of high demand, such as hot summer months.

(a) How does the ability to "energy time-shift" help electricity providers?
(b) How would electricity providers meet demand without energy storage resources?

Answer 3: As additional renewable generation is added to the grid -- particularly solar generation -- there is a risk of generating too much energy during the daylight hours while not having enough firm capacity to capture and redeploy that energy as the sun sets for people's evening energy needs, as they return home, cook dinner, and use or charge electronic devices and vehicles.

As solar becomes a bigger portion of energy generation, grid operators will need solar resources to provide more than just zero-marginal cost energy. Solar resources will need to provide firm, flexible energy commitments even when the sun goes down, as well as critical grid services like frequency regulation and spinning reserves to stabilize the grid.

One solution to ensuring the long-term growth of solar is to deploy solar with storage either collocated or as standalone systems. The deployment of storage with solar provides flexible capacity by both absorbing over-generation midday and discharging it during the evening hours when low-cost, carbon-free energy is needed. This allows grid operators to use a clean, carbon-free resource to provide enough capacity to serve their customers during peak demand periods rather than relying on traditional polluting fossil fuel plants.

The other way of managing this ramping need in the evening time is through the addition of peaking gas turbines, which are a less efficient and more expensive way to meet peak needs. Peaking gas turbines, while having the capability to address evening ramp, offer no capability to address solar overgeneration in the middle of the day by storing energy. Energy storage can perform both these functions, which makes storage a more prudent choice for our electricity networks.

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Question 4: In 2012, PJM, which covers all or parts of 13 eastern states and DC, created a new frequency regulation market product for fast-repsonding resources, such as battery storage:

(a) What do you believe were the reasons behind PJM creating this new market product?
(b) Are there similar frequency regulation products in other wholesale electricity markets?

Answer 4: AES deployed its first project in PJM before 2012 to demonstrate the capability of energy storage in addressing frequency regulation challenges. At the time, there was no fast regulation signal or market premium for storage resources providing this service. AES' successful demonstration of storage capabilities, in addition to other stakeholders that worked with PJM, was the main reason for the creation of FERC Order 755, which provided the systematic framework to compensate resources based on the level of service ("pay for performance"). PJM market's rule changes in reflection of Order 755 really set the stage for storage growth in this market.

Similar products are available in other markets like MISO/SPP, but none of those, truly reflect the spirit of FERC Order 755 in terms of paying for actual performance. This lack of premium for actual performance, coupled with other structural issues, still create an issue for storage participation in some of the other markets.

Questions from Honorable Jerry McNerney

Question 1: How would each of you properly value storage.

Answer 1: Integration of energy storage resources provide various benefits to the grid. However, while some of the benefits can be monetized through wholesale products and services, there are several categories of benefits that our wholesale power markets do not compensate fully. As an example, existing thermal generation plants run more efficiently when paired with energy storage, which leads to reduced emissions. Energy storage also enables traditional generation facilities to start up and stop less frequently, reducing maintenance and fuel costs, and reduces curtailment of intermittent renewable generation. None of these benefits are currently compensated by our power markets. The best way to address this would be to reform wholesale market products to reflect these benefits; however, we recognize this would be a long and arduous process, one that takes several years. In the interim, policies such as an investment tax credit for standalone energy storage could serve as a proxy for these currently uncompensated categories of benefits that storage delivers for our electric grid.