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THE 21ST CENTURY ELECTRICITY CHALLENGE: ENSURING A SECURE, RELIABLE AND MODERN ELECTRICITY SYSTEM

U.S. HOUSE OF REPRESENTATIVES COMMITTEE ON ENERGY & COMMERCE, SUBCOMMITTEE ON ENERGY AND POWER

ONE HUNDRED FOURTEENTH CONGRESS, FIRST SESSION

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This hearing compilation was prepared by the Homeland Security Digital Library, Naval Postgraduate School, Center for Homeland Defense and Security.

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Opening Statement of the Honorable Ed Whitfield
Subcommittee on Energy and Power
Hearing on "21st Century Electricity Challenge: Ensuring a Secure, Reliable, and Modern Electricity System"
March 4, 2015

(As Prepared for Delivery)

Ensuring a secure, reliable, and affordable electricity system that meets the needs of the American people may very well be the most important task within this subcommittee's jurisdiction. Indeed, the National Academy of Engineering cited electrification as the greatest achievement affecting the quality of life in the 20th century. This morning's hearing is focused on improving our electricity system in the 21st century.

The U.S. was the first nation to electrify, and our system of generation, transmission, distribution and related communications remains the best in the world. Nonetheless, new challenges are emerging, as are opportunities to modernize and improve the electric grid.

The challenges are significant – much of our grid is outdated, coal-fired generation facilities are shutting down at an alarming rate, reserve margins are inadequate in several regions, intermittent and remote renewable capacity is coming online, and cyber threats pose a growing concern.

But there are opportunities as well. Utilities plan to invest more than $60 billion dollars in transmission infrastructure through 2024 to modernize the nation's electric grid, while abundant fuel resources and advanced generation, storage, and distribution management technologies can help modernize and diversify the nation's power portfolio.

Further, "big data" energy analytics and new information technologies offer a diverse suite of novel products and services that can identify and mitigate inefficiencies in the electricity supply chain while helping utilities meet changing consumer expectations.

The availability of advanced, user-friendly communications technologies has disrupted the traditional business model for nearly every consumer sector from home entertainment to taxis. The electricity sector is witnessing a similar shift. New innovative products and technologies in the electricity space hold the potential to empower consumers to make smarter decisions in energy usage, while providing new, more efficient and responsive ways to generate and distribute power. As consumer expectations and technology evolve, new business and regulatory models within the electricity sector also may be necessary to better reflect changing market conditions.

A more modern and resilient grid will be better positioned to withstand and minimize any impacts resulting from severe weather, cyber-attacks or any other threats to the grid. However, as the grid becomes increasingly reliant on information technology and digital communications devices, thousands of potential new grid access points are being created. While encouraging technology and innovation in the electricity sector should be a priority, policies must ensure that new grid-related products do no leave the grid more exposed or compromise customer information and privacy.

Given the shift taking place in the electricity sector, it is paramount that policymakers and regulators at the federal, state and local level carefully weigh policies that can adapt to these new challenges and opportunities to build a market-driven, modern and flexible system while ensuring the continued safe, reliable and affordable delivery of electricity to consumers.

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Opening Statement of the Honorable Fred Upton
Subcommittee on Energy and Power
Hearing on "The 21st Century Electricity Challenge: Ensuring a Secure, Reliable and Modern Electricity System"
March 4, 2015

(As Prepared for Delivery)

America is currently enjoying an energy renaissance, and we are all better for it. But this resurgence is not limited to just oil and natural gas. In fact, the nation that created the modern electricity system is poised to reinvent it – bringing with it the potential benefits to both electricity producers and consumers all the while helping to keep the American economy competitive in the decades ahead.

Utilities are spending billions of dollars each year modernizing the grid and making it smarter. These job-creating technology and infrastructure projects are an integral part of our architecture of abundance, and will give us an electricity system that can better serve the current and future needs of users - from homeowners to small businesses to major manufacturers.

Our potential is exciting. The same information technology revolution we have seen in our smart phones and in many new business models can be applied to create an electricity system that is more secure, reliable, efficient, integrated, and responsive to user needs.

Old problems like power outages will be addressed as a smarter grid can substantially reduce the number and duration of blackouts. At the same time, new opportunities are emerging, such as electricity storage breakthroughs that can improve efficiency and allow for greater diversity of supply, and better communications between each link in the electricity chain to further drive efficiencies.

And greater transparency and new technologies increasingly allow consumers and businesses to have more control over their electricity use. For homeowners in Michigan and across the country, that means help where it matters most - the bottom line with lower electric bills. And for businesses, that means less spending on energy and more available for hiring. Lower bills and more jobs – the future is certainly bright.

But with new technologies come new challenges. Just as data theft is a crime that previous generations didn't have to worry about, a digitally-connected grid is subject to new forms of manipulation by bad actors. We need to protect both the grid and consumers from cyber threats and other risks. The good news is that the same advances that make these threats possible are also capable of addressing them.

Of course, Congress must decide the proper role of government in these changes to the electricity system. New mandates and subsidies are not the answer. But we do need to identify and address regulatory barriers to entry, market-distorting incentives, and artificial constraints on competition that will be critical to further innovation.

Although the age of electricity is well into its second century, the pace of innovation is as rapid as ever. Federal energy policy needs to adapt in order to ensure that these advances can continue.

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Written Testimony to the United States House of Representatives Energy & Commerce Committee, Subcommittee on Energy and Power

"The 21st Century Electricity Challenge: Ensuring a Secure, Reliable, and Modern Electricity System"

By Thomas M. Siebel, Chairman and Chief Executive Officer, C3 Energy

March 4, 2015

Summary

The National Academy of Engineering has identified the electrical grid as the most important scientific achievement of the 20th century. That infrastructure is now being substantially upgraded and the resultant advanced smart grid will be one of the largest and most complex machines ever conceived. The Smart Grid will likely prove to be one of the most significant scientific achievements of the 21st century.

It is estimated that as much as $2 trillion is being invested this decade in upgrading the power infrastructure globally to make the devices in the power grid remotely machine addressable. The most common example is the smart meter that allows the grid operator to remotely sense the electric or gas meter's state in near real time. As the grid becomes increasingly sensored, it becomes a fully connected sensor network (think of it as the Internet of Energy) and unprecedented amounts of data are produced. These data can be integrated, processed, and analyzed using state-of-the-art information technology in a manner to optimize the power generation and distribution value chain.

C3 Energy is a private sector response to this challenge and opportunity, harnessing the power of big data, social networking, cloud computing, human-computer interaction models, and machine learning to realize advances in safety, reliability, cost efficiency, and security of power generation and delivery – unlocking a benefit of up to $300 per meter, per year, in recurring annual economic benefit for U.S. utilities, retailers, and their energy customers.

Progress has been dramatic in the current decade. That being said, current state rate regulations have not kept pace with, and actually impede, the ability of utilities to benefit from the new IT models. Utility regulatory agencies should be encouraged to allow rate recovery for cloud-based SaaS license arrangements. This change will accelerate the adoption curve and

accessibility of today's innovative computing models and reduce the current, unnecessary barriers to technology advancement in the utility industry. This is an essential step in the transformation to a smarter, more efficient, and more sustainable energy system.

The Power of the Smart Grid

Thomas M. Siebel

A sociologist from Harvard by the name of Daniel Bell published a book entitled *The Coming of Post-Industrial Society* in 1976 in which he predicted what we know of today as the Information Age. Years before the conception of the Internet, the minicomputer, the personal computer, and the cell phone, Bell predicted that information and communications technology would effect a fundamental change in the structure of the global economy, a change on the order of magnitude of the Industrial Revolution.

This information revolution would portend the preeminence of the "knowledge worker" and result in the emergence and growth of the information technology industry, driving fundamental and ubiquitous changes in the ways we work, communicate, and operate business processes.

With the advent of the utility smart grid, Bell's predictions meet the business value chain associated with power generation, transmission, distribution, consumption, and energy efficiency.

In the United States, more than 3,270 utilities[1] are responsible for operating the grid and delivering over 1,100 GW[2] of power capacity to nearly 150 million electricity customers,

[1] "Electric Power Industry Overview 2007." U.S. Energy Information Administration, n.d. Web. 26 Feb. 2015. <http://www.eia.gov/electricity/archive/primer/>.
[2] "U.S. Energy Information Administration - EIA - Independent Statistics and Analysis." *Electricity Generation Capacity*. U.S. Energy Information Administration, 2011. Web. 26 Feb. 2015.

generating revenues of $376 billion per year[3]. Globally, the electric power industry delivers over 5,500 GW of capacity[4].

It is estimated that as much as $2 trillion is being invested this decade in upgrading the power infrastructure globally to make the devices in the power grid remotely machine addressable[5]. Almost $1 trillion of this investment will occur in the United States[6]. These devices include meters, thermostats, home appliances and HVAC equipment, factory equipment and machinery, transformers, substations, distribution feeders, and power generation and control componentry.

The smart grid is advancing at a rapid rate. A nascent market at the beginning of the 21st century, as of 2015 over 310 million smart meters have been installed globally. That number will more than triple by 2022, reaching nearly 1.1 billion[7]. While representing only a fraction of the sensors on the grid infrastructure, the smart meter installation numbers provide a good indication of the penetration and rate of growth of the smart grid. These developments are occurring worldwide.

The truth is that the smart meters and other smart devices themselves provide little utility. They simply provide the capability to remotely sense a device's state. For example, is the device operative or inoperative? If operative, at what velocity, voltage, or amperage? It might allow us

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[3] *Form EIA-861 Detailed Data Files* (n.d.): n. pag. *Annual Electric Power Industry Report*. U.S. Energy Information Administration, 19 Feb. 2015. Web. 26 Feb. 2015. <http://www.eia.gov/electricity/data/eia861/>.
[4] "International Energy Statistics - EIA." *International Energy Statistics - EIA*. U.S. Energy Information Administration, 2012. Web. 26 Feb. 2015.
[5] Electric Power Research Institute (EPRI), "*Estimating the Costs and Benefits of the Smart Grid: A Preliminary Estimate of the Investment Requirements and the Resultant Benefits of a Fully Functioning Smart Grid*" (2011).
[6] "EEI to Wall Street: The Future Is Here." *EEI Newsroom*. Edison Electric Institute, 11 Feb. 2015. Web. 27 Feb. 2015. <http://www.eei.org/resourcesandmedia/newsroom/Pages/Press%20Releases/EEI%20to%20Wall%20Street%20The%20Future%20is%20Here.aspx>.
[7] Navigant Research. *Smart Electric Meters, Advanced Metering Infrastructure, and Meter Communications: Global Market Analysis and Forecasts*. Chicago: 3Q 2014.

to know the amount of energy that the device has consumed or recorded over some period of time or is consuming in real time.

Collectively, these sensors generate massive amounts of information. With recent developments in information technology, including elastic cloud computing and the sciences of big data, machine learning, and emerging social human-computer interaction models, we are able to realize the economic, social, and environmental value of the smart grid by aggregating the sum of these data to correlate and scientifically analyze *all* of the information generated by smart grid infrastructure in real time.

Today, each component of the power value chain, from generation, transmission, distribution, metering, to customer consumption, is supported by multiple, independent, information technology systems that are not designed to work with each other and therefore prevent data sharing, data analysis, and interoperability. This results in high levels of inefficiency and risk.

As the sensored smart grid is enabled, by holistically correlating and analyzing all of the dynamics and interactions associated with the end-to-end power infrastructure—including current and predicted demand, consumption, electrical vehicle load, distributed generation capacity, technical and non-technical losses, weather, and generation capacity—across the entire value chain, we can realize dramatic advances in safety, reliability, infrastructure security, and energy efficiency.

Smart grid analytics enable us to provide real-time pricing signals to energy consumers, manage sophisticated energy efficiency and demand response programs, conserve energy use, reduce the fuel necessary to power the grid, reconfigure the power network around points of failure, recover instantly from power interruptions, accurately predict load and distributed generation capacity, rapidly recover from damage inflicted by weather events and system failures, prevent cyber attacks, and reduce adverse environmental impact. The advent of smart grid analytics represents a major advance in the development of energy efficiency technology.

Many leading utilities including Enel, GDF Suez, and Exelon are driving innovation by applying the science of big data and smart grid analytics to the benefit of their communities, consumers, and stakeholders.

At C3 Energy, we are committed to advancing the state-of-the-art of smart grid analytics in the hope of making a substantial contribution to the important dialogue on the future of energy.

The rapid growth of sensor investments in the smart grid opens up a new opportunity for utilities to take advantage of next-generation information technology including elastic cloud computing, analytics, machine learning, and social human-computer interaction models to fully unlock the insights and value that a modern grid has to offer. Current state utility rate regulations however, have not kept pace with, and actually impede, the ability of utilities to benefit from the new IT models that will substantially improve system performance, reduce capital and operating costs, and produce substantial economic value to utility customers and shareholders.

Under current guidelines, a utility may generally classify investments in legacy hardware and supporting on-premise software as a capital expense, which can be included as part of the rate case on which it can receive a guaranteed rate of return. Counter-intuitively, if a utility invests in state-of-the-art cloud-based technologies that offer immense economic and social benefit, it typically must treat the investment as an operating expense for which it does not receive a rate of return, resulting in decreased cash flow and lower profitability.

This establishes a perverse incentive for U.S. utilities to pursue more costly, less effective, and riskier on-premise technology investments, depriving ratepayers of the performance and economic benefits of the more advanced technology innovations that many other industry sectors are now experiencing. The effect is to deprive ratepayers of the benefits of innovation.

Utilities are investing billions of dollars to make the devices in the power grid remotely IP-addressable, including the nearly 1.1 billion smart meters that will be installed by 2022[8]. While representing only a fraction of the sensored devices on the grid, the number of smart meters provides a good indication of the growth rate of the smart grid.

McKinsey & Company has estimated that widespread use of big data analytics solutions could cut more than $50 billion per year from electricity bills in the U.S. Globally, the opportunity is $300 billion[9] annually. Smart grid analytics solutions across the entire power value chain can deliver $1.5 billion in recurring annual economic benefit to a typical integrated, 5 million meter U.S. utility and its customers[8]. That is a very real private sector stimulus for the economy.

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[8] Navigant Research. *Smart Electric Meters, Advanced Metering Infrastructure, and Meter Communications: Global Market Analysis and Forecasts*. Chicago: 3Q 2014.
[9] Client Study, McKinsey & Company: February 2013.

I would like to share a few examples of these "big data" smart grid analytic solutions and their benefit to U.S. consumers. The following estimates are based upon research conducted by McKinsey & Company.

Predictive Maintenance applications help utilities predict asset failure and take proactive action, saving customers $18 to 20 per year[10].

Revenue Protection applications help identify energy theft and asset malfunctions, saving each customer $8 to 10 per year[11].

Grid Cybersecurity applications secure grid reliability and help utilities identify and reduce the grid cyber attack vulnerabilities, saving customers $8 to 10 per year[12], in addition to mitigating national security risk.

Voltage Optimization applications reduce unnecessary power generation and deliver higher-quality power, saving each consumer $25 to 36 per year[13].

Some of the world's leading utilities, such as Exelon in the U.S. and Enel in Italy, are among the first to use these new technologies to deliver substantial savings from their grid modernization investments.

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[10] "Estimating the Costs and Benefits of the Smart Grid: A Preliminary Estimate of the Investment Requirements and the Resultant Benefits of a Fully Functioning Smart Grid." EPRI, Palo Alto, CA: 2011. 1022519.
[11] Ibid.
[12] Ibid.
[13] "Volt/VAR Control and Optimization Concepts and Issues", EPRI, 2011.

Baltimore Gas and Electric (Exelon Corporation) in the United States[14,15]

In 2014, Baltimore Gas and Electric Company (BGE), a subsidiary of Exelon Corporation, launched two of C3 Energy's smart grid applications across the two million meters in its service territory. BGE is leveraging C3 AMI Operations™ to optimize the deployment and ongoing health of its advanced metering infrastructure (AMI) network and C3 Revenue Protection™ to identify and reduce unbilled energy usage. BGE expects these applications to deliver an annual economic benefit of $20 million to BGE and its customers. Deploying the smart grid analytics platform across the three Exelon utilities is estimated to result in $383 million in recurring annual economic benefit to Exelon and its consumers.

The deployment of C3 AMI Operations and C3 Revenue Protection involved unprecedented levels of data integration at BGE, requiring 42 integrations to 12 source information systems. C3 Energy loaded two years of historical BGE data into a 10-terabyte federated cloud image and configured more than 140 complex analytic and predictive algorithms to meet BGE's requirements.

C3 Revenue Protection identified over 15,000 non-technical loss cases (energy theft) with field investigation accuracy rates of 90%, spurring BGE to develop a new back-billing process to handle the large volume of identified cases. During the same timeframe, C3 AMI Operations identified 3,600 meter health problems with a 99% accuracy rate, avoiding many billing errors.

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[14] "Baltimore Gas & Electric Wins Project of the Year for Deployment of C3 Energy Smart Grid Applications." *C3 Community*. C3 Energy, 3 Feb. 2015. Web. 26 Feb. 2015.

[15] *Case Study: Exelon | Driving Grid Efficiency and Revenue Protection Efforts*. Rep. Redwood City: C3 Energy, 2015. Print.

The primary economic benefit comes from identifying and resolving unbilled energy usage, which reduces the cost of non-technical energy losses—a cost typically passed on to customers. Additional benefit derives from detecting problems with meters or with the communication network. This reduces the amount of missing usage data and increases billing accuracy and the overall effectiveness of the AMI meter deployment. These benefits represent a significant improvement over the benefits of smart grid infrastructure alone.

Other benefits come from the streamlining of existing BGE business processes across smart grid operations, revenue management, and field operations, saving time and effort and increasing customer satisfaction. The solutions also provide safety benefits. C3 AMI Operations and C3 Revenue Protection reduce risks to customers and utility employees in the field by alerting users to potentially hazardous meter conditions, such as unsafe meter temperature or potential meter tampering.

Enel in Italy[16]

Enel is one of the world's largest utilities, and the first utility to replace traditional meters with smart meters at scale—currently more than 40 million meters are installed, or 80% of all smart meters in Europe. In total, Enel operates 67 million meters in 40 countries. At Enel Italy, we integrate and process over 50 billion rows of data from 11 legacy systems, and have identified 93% of likely cases of theft or other non-technical loss. This is the largest smart grid analytics deployment in the world. The economic benefit of Revenue Protection and Predictive Asset Maintenance analytics for Enel, in Italy alone, is estimated to exceed €350 million annually.

[16] "Enel: Improving Smart Grid Reliability and Operational Efficiency." *Innovations Across the Grid | Partnerships Transforming the Power Sector* II (2014): 153-55. The Edison Foundation - Institute for Electric Innovation, Dec. 2014. Web. 26 Feb. 2015. <http://www.edisonfoundation.net/iei/Documents/IEI_InnovationsGrid_volII_final_LowRes.pdf>.

Because smart grid analytics technology produces far more savings than costs, it does not need any financial assistance or incentives from the federal government to succeed. But success will advance more rapidly if regulatory obstacles are removed. For example, by updating rate regulations to recognize Software as a Service products as the equivalent of a capital expense, and by updating rules and guidance to encourage utilities to add analytics solutions to their planned budgets for grid modernization, progress will accelerate.

All of the hardware sensor advances on the grid are of limited usefulness without the cloud-based software innovations that will actually make the grid "smart". As the grid becomes increasingly sensored, an unprecedented amount of data are produced, that can only be addressed using the state-of-the-art information technology. IT offerings have rapidly evolved into today's innovative cloud computing models, including Software as a Service, Platform as a Service, and Infrastructure as a Service. With these come opportunities to leverage numerous capabilities essential to fulfilling the promise of the smart grid – continuous access to increased processing speeds and power, more flexibility and mobility, elasticity/on-demand surge capacity, and lower costs through scale.

The majority of IT innovation and development in the 21st century is focused upon next generation, cloud-based, Software as a Service (SaaS) computing models. The acceleration of this trend is breathtaking, with examples in the news daily from leading companies including Google, Facebook, Amazon Web Services, and Apple. CISCO recently predicted that by 2018, more than three-quarters of all corporate information will be processed via the Internet cloud

rather than internal company computer servers[17]. Just last week, Ginni Rometty, CEO of IBM, announced a $4 billion new investment in cloud-based technology development, predicting that 40% of IBM's expected total revenues will accrue from cloud computing by 2018[18].

The U.S. regulatory treatment of cloud computing models has not kept pace to allow utilities to take advantage of these technology innovations, and utilities are faced with adverse consequences when they select modern cloud computing solutions. The existing guidelines are based on decades-old regulatory models that classify last-generation on-premise software licenses as capital expenses, and modern cloud computing arrangements as operating expenses. The classification as a capital versus operating expense influences a utility's ability to obtain rate-base coverage consistent with other capital expenditures, effectively incenting investments in antiquated technology.

To enable the goal of a modern electric transmission and distribution system, advanced cloud-based IT offerings are necessary. Regulators should respond by removing barriers and providing incentives to deploy cost-saving, high-performing 21st century software systems similar to those that a utility receives for investing in other capital infrastructure, including 20th century IT systems.

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[17] Barlas, Pete. "Cisco Systems: Cloud Will House Most Data By 2018."*Investors Business Daily*. Investors.Com, 4 Nov. 2014. Web. 1 Mar. 2015. <http://news.investors.com/technology/110414-724654-cisco-forecasts-huge-cloud-growthcisco-systems-cloud-will-house-most-data-by-2018.htm#ixzz3IcFWDjsj>.

[18] Clark, Don. "IBM Pumps $4 Billion Into Cloud and Mobile Initiatives." Wall Street Journal, 26 Feb. 2015. Web. 02 Mar. 2015. <http://www.wsj.com/articles/ibm-pumps-4-billion-into-strategic-imperatives-1424959681>.

Cloud Computing

Over the last decade, a rapidly growing number of companies have shifted from buying on-premise software components under perpetual or term licenses to leveraging cloud-based, SaaS software built, managed, and continually improved by the technology vendor. These companies are replacing traditional on-premise software applications and platforms – even the underlying IT infrastructures – with these cloud-based computing solutions.

Cloud computing refers to the use of Internet-based computing to deliver a variety of product offerings. Under cloud computing arrangements, the customer has a right to use or benefit from the functionality of software but does not receive a copy of it.

The most common cloud computing models for utilities are Software as a Service (SaaS). With a SaaS model, utilities pay to use an Internet-based software product hosted by the SaaS solution provider. With SaaS models, the solutions are essentially rented by the utility instead of purchased outright. This allows utilities access to the latest advances in technology, mobility, elasticity, and scalability to realize operational efficiencies, without having to invest capital in hardware and software to meet their requirements. However, regulation has not kept apace, and despite the efficiencies available, utilities are not incented to invest in these solutions and are effectively encouraged to continue to procure obsolete technology.

Solutions

Utilities should not be penalized for or discouraged from investing in technology advancements. Instead, utilities should be encouraged to lead the way to a more modernized electric system. In order to do so, they need modification to rate recovery rules on a state by state basis to support a model rule to benefit from rate recovery from modern cloud computing solutions.

To move forward, utility regulatory agencies should be encouraged to allow rate recovery for SaaS license arrangements. This change will accelerate the adoption curve and accessibility of today's innovative computing models and unlock the scalability, elasticity, performance power, integration speeds, and cost/benefit for utilities and their customers. The classification of SaaS in a manner to allow rate recovery will remove the current regulatory barriers towards technology advancement in the utility industry, which is an essential step in the transformation to a smarter, more efficient, and more sustainable energy system. State utility regulatory agencies should consider allowing utilities rate recovery from 21st century information technology, providing ratepayers the many significant benefits of IT innovation.

Speaker Biography

Thomas M. Siebel is the Chairman and Chief Executive Officer of C3 Energy, where he leads an accomplished team of machine learning, computer science, power system, and engineering experts to tackle one of the toughest technology challenges—to apply the science of big data and machine learning to today's energy industry to unlock significant value across the power grid. As the founder, chairman, and CEO of Siebel Systems—one of the world's fastest-growing software companies, Mr. Siebel built the foundation of the CRM market. Founded in 1993, Siebel Systems rapidly became a leader in application software with more than 8,000 employees in 32 countries, over 4,500 corporate customers, and annual revenue in excess of $2 billion before it merged with Oracle Corporation in January 2006.

Mr. Siebel serves on the Board of Advisors for the University of Illinois at Urbana College of Engineering, and the University of California at Berkeley College of Engineering. He is a Director of the Hoover Institution at Stanford University and is the Chairman of the Board of the American Agora Foundation. He was elected to the American Academy of Arts and Science in 2013.

Mr. Siebel is a graduate of the University of Illinois at Urbana-Champaign, where he received a B.A. in History, an M.B.A., and an M.S. in Computer Science.

About C3 Energy

C3 Energy was founded in 2009 by a highly experienced team of executives with deep experience in software, analytics, and cloud computing, and a long track record of serving enterprise customers. C3 Energy is a SaaS and PaaS enterprise application software company that harnesses the power of big data, smart grid analytics, social networking, machine learning, and cloud computing to improve the safety, reliability, and efficiency of power generation and delivery. C3 Energy's family of utility-tested and proven smart grid analytics products deliver end-to-end solutions across the entire smart grid, from energy grid capital asset allocation, transmission, distribution, and advanced metering, to the customer experience and energy efficiency programs. C3 Energy products enable utility operators to realize the full benefit of their smart grid and energy system investments.

TESTIMONY OF DEAN KAMEN
FOUNDER AND PRESIDENT, DEKA RESEARCH & DEVELOPMENT

BEFORE THE HOUSE COMMITTEE ON ENERGY AND COMMERCESUBCOMMITTEE ON ENERGY AND POWER

HEARING ON "21ST CENTURY ELECTRICITY CHALLENGE: ENSURING A SECURE, RELIABLE, AND MODERN ELECTRICITY SYSTEM

MARCH 4, 2015

Chairman Upton, Chairman Whitfield, and Ranking Member Rush, Vice Chairman Scalise, I greatly appreciate the Subcommittee's invitation to testify this morning on how innovative technologies and business models can enable a modern, reliable, and secure electricity system. I am an inventor, entrepreneur, and President of Manchester, NH-based DEKA Research & Development. For more than 30 years, DEKA has been developing breakthrough technologies that have dramatically improved lives for millions of people around the world.

Today, I am here to present my perspective on how innovative technology and approaches could provide some solutions to the issues and challenges confronting this Committee and our country.

There is no doubt that the U.S. electric grid is an amazing achievement. In 2003, the National Academy of Engineering, of which I am a proud member, described the vast network of power plants and aluminum wires commonly known the U.S. electric power grid as the greatest engineering achievement of the 20th century. In 1882 Thomas Edison oversaw the deployment of the world's first electric distribution system in New York City, which provided direct current for 59 customers in the Wall Street Area at a price of about $5 per kilowatt hour. Today, the US electric power grid annually delivers close to 4,000 terawatt hours to more than 300 million Americans.

As great an engineering marvel as our electric grid has been, it is quickly becoming an icon of the 20th century that has not significantly evolved to embrace technological innovation as many other aspects of our economy have. I think we can all agree that America's electric grid is in desperate need of modernization.

Consider the following facts about the U.S. electric system (from the U.S. Department of Energy and the Edison Electricity Institute):

- Electric generation capacity costs are approximately $1 per watt. Current U.S. generation capacity is more than 1 trillion watts.

- Transmission lines cost an average of $1 million per mile.
- Distribution lines cost an average of $140,000 per mile.
- More than 50% of generating capacity in the U.S. is more than 30 years old.
- More than 70% of the 280,000 miles of transmission lines are more than 25 years old.
- More than 50% of the 2.2 million miles of distribution lines are more than 30 years old
- Annual capital costs for generation, transmission, and distribution is more than $90 billion.
- In a traditional coal plant, only about 30-35% of the energy in the coal ends up as electricity.

Fortunately, I do not believe that we need to spend the billions, if not trillions, required to upgrade the electric grid to ensure the electricity quality and reliability we expect. As an observer of history, I believe that a distributed energy future is inevitable. [I will share a few slides that explain that perspective.] In recent years there has been a great deal of innovation with distributed generation and renewable, smart grid technologies, as well as energy storage systems. While these technologies offer a promising future for the U.S. electric system, our collective immediate challenge is to develop the appropriate business models and regulatory structures to effectively manage the integration of modern technologies while ensuring the continued operation and viability of our nation's electric grid. As we evolve toward a more diverse electric future enabled by new technologies, the challenge confronting this Committee and our country is to manage this transition in a way that does not endanger the availability of electricity.

Germany's energy transition offers some valuable lessons for the U.S. Through dramatic action and substantial subsidies, renewables now account for more than a quarter of German energy production. However, Germany is not yet a success story. It has some of the highest electricity prices in the world, but despite those high prices, the German electricity grid is neither technically nor economically healthy. It is facing significant challenges integrating intermittent solar power with the rest of its electricity infrastructure, and power quality and reliability are threatened. To meet the old challenges of an aging infrastructure as well as the new challenges of intermittent distributed renewables, the Economist projects that European utilities will spend more than EUR 1 trillion by 2020 – in an economic environment where revenues have moved from utilities to solar providers and utilities have lost half of their value since 2008. The German example illustrates what many have called the "Distributed Energy Resource (DER) death spiral".

Learning the lessons from Germany, avoiding the DER "death spiral" and managing our modern electric transition in a way that preserves our grid while maintaining viable

business models for our electric utilities is no small task. New utility models and regulatory structures will be required. These models must promote competition while encouraging smart investments to modernize the grid will be required.

DEKA has been working on a technology that we believe could be part of a more robust and efficient solution: a Stirling-cycle energy appliance that can cleanly, quietly, and reliability convert a wide variety of fuels into electricity and useful heat. Our Stirling-cycle appliance is highly complementary to recent advances in photovoltaics and energy storage, with the advantage that it can generate electricity indefinitely, even when the sky is dark and the grid is down. DEKA has been conducting field trials of this device in partnership with NRG, and I am enthusiastic about its potential to help the US have a smooth transition to its distributed energy future.

I appreciate the opportunity to testify this morning. I applaud your efforts to examine how new technologies and business models can be employed to tackle our 21st Century Electricity challenges. I look forward to working with you on this important endeavor.

Biography of Dean Kamen

Dean Kamen is an inventor, an entrepreneur, and a tireless advocate for science and technology. His roles as inventor and advocate are intertwined—his own passion for technology and its practical uses has driven his personal determination to spread the word about technology's virtues and by so doing to change the culture of the United States.

As an inventor, he holds more than 440 U.S. and foreign patents, many of them for innovative medical devices that have expanded the frontiers of health care worldwide. While still a college undergraduate, he invented the first wearable infusion pump, which rapidly gained acceptance from such diverse medical specialties as oncology, neonatology, and endocrinology. In 1976, he founded his first medical device company, AutoSyringe, Inc., to manufacture and market the pumps. At age 30, he sold that company to Baxter Healthcare Corporation. By then, he had added a number of other infusion devices, including the first wearable insulin pump for diabetics.

Following the sale of AutoSyringe, Inc., he founded DEKA Research & Development Corporation to develop internally generated inventions as well as to provide research and development for major corporate clients. Kamen led DEKA's development of the HomeChoice™ peritoneal dialysis system for Baxter International Inc. The HomeChoice™ system allows patients to be dialyzed in the privacy and comfort of their home and quickly became the worldwide market leader. Kamen also led the development of technology to improve slide preparation for the CYTYC (now Hologic

Inc.) ThinPrep® Pap Test. Kamen-led DEKA teams have also developed critical components of the UVAR™ XTS™ System, an extracorporeal photophereisis device marketed by Therakos, a unit of Johnson & Johnson, for treatment of T-Cell lymphoma. An advanced prosthetic arm in development for DARPA should advance the quality of life for returning injured soldiers. Other notable developments include the Hydroflex™ surgical irrigation pump for C.R. Bard, the Crown™ stent, an improvement to the original Palmaz-Schatz stent, for Johnson & Johnson, the iBOT™ mobility device, and the Segway® Human Transporter.

Kamen has received many awards for his efforts. Notably, Kamen was awarded the National Medal of Technology in 2000. Presented by President Clinton, this award was in recognition for inventions that have advanced medical care worldwide, and for innovative and imaginative leadership in awakening America to the excitement of science and technology. Kamen was also awarded the Lemelson-MIT Prize in 2002, and was inducted into the National Inventors Hall of Fame in May 2005. He is a Fellow of the American Institute for Medical & Biological Engineering, and has been a member of the National Academy of Engineering since 1997.

In 2010, Dean hosted the Planet Green television series Dean of Invention.

In addition to DEKA, one of Dean's proudest accomplishments is founding FIRST® (For Inspiration and Recognition of Science and Technology), an organization dedicated to motivating the next generation to understand, use and enjoy science and technology. Founded in 1989, this year FIRST will serve more than 1 million young people, ages 6 to 18, in more than 80countries around the globe. High-school-aged participants are eligible to apply for more than $30 million in scholarships from leading colleges, universities, and corporations. Studies have shown that FIRST alumni are highly motivated to pursue careers in science and engineering, thus fulfilling Dean's goal of inspiring the next generation of technological leaders.

TESTIMONY OF MR. MICHAEL ATKINSON, P.E.
PRESIDENT, ALSTOM GRID INC., ON BEHALF OF GRIDWISE ALLIANCE
March 4, 2015

Twenty-First Century Electricity Challenge: Transformation of Our Nation's Electric System

- The United States (U.S.) electric system is undergoing a transformation unlike anything we have experienced in the past 100 years, with major implications for the reliability, resiliency, and security of the power grid.
- The future grid must continue to deliver affordable, reliable power, regardless of where it is generated, and will serve as the backbone of the nation's electric infrastructure, while enabling the innovation that is happening on the supply and demand sides of the electric system to flourish.
- Thus, the grid will become the critical enabling platform for the entire electricity value chain.

Grid Modernization Technologies are Transforming the Electricity System

- The future grid must optimize the management and operation(s) of the entire electric system value chain, which includes power generation, delivery, and consumption. The innovation advancing on the supply and demand sides of the power system must be matched with innovation on the transmission and distribution parts of the grid.
- Modernizing the grid will reduce costs in the long run, and increase reliability, resilience, and security in the near and long term.
    - New smart grid technologies prevent outages and enable the grid to better withstand outages when they do occur, due to an extreme weather event, such as Superstorm Sandy.
    - More technologies and capabilities, such as energy storage, will be forthcoming in the future to ensure we not only maintain, but improve the performance of the grid.
- The Electric Power Research Institute (EPRI) has estimated **the total benefit from the smart grid to be between $1.3-2 trillion from 2010-2030** and benefit-to-cost ratios are found to range from 2.8 to 6.0.[1]

Path to Accelerating the Transformation to the Twenty-First Century Electricity System

- Establish a shared vision and develop guidance and best practices through industry stakeholder collaboration.
- Maximize transparency for system operators and customers.
- Make adjustments to the utility business model and regulatory model.
- Educate and empower consumers so they can better manage their electricity consumption.
- Develop a more highly-skilled workforce.

Conclusion

- We have a historic opportunity to continue and accelerate the modernization and transformation of our Nation's electric grid.
- Action is needed now, because this is a complex issue, and the technology and policy changes required could take years to implement, even if they are put in place today.
- Congress can play a key leadership role in facilitating the acceleration of grid modernization and fostering more public-private collaboration.
- This transformation can help optimize the grid, spark economic growth and competitiveness, and create highly-skilled jobs.

TESTIMONY OF MR. MICHAEL ATKINSON, P.E.
PRESIDENT
ALSTOM GRID INC.
BEFORE THE
SUBCOMMITTEE ON ENERGY AND POWER
OF THE
HOUSE ENERGY AND COMMERCE COMMITTEE
"THE TWENTY-FIRST CENTURY ELECTRICITY CHALLENGE: ENSURING A SECURE, RELIABLE, AND MODERN ELECTRICITY SYSTEM" HEARING
March 4, 2015

Introduction

Good morning Chairman Whitfield, Ranking Member Rush, full Committee Chairman Upton and Ranking Member Pallone, and distinguished Members of this Subcommittee. I am Michael Atkinson, President of Alstom Grid Inc. and here also on behalf of the GridWise Alliance (GWA). I appreciate the opportunity to testify at today's hearing.

New technology is changing the way Americans consume electricity. Innovations from electric vehicles to smarter appliances will require a smarter, more sophisticated electrical grid. **Alstom Grid** is meeting that requirement today with new equipment and solutions that are preparing the country's grid to meet the demands of tomorrow and incorporate a range of energy resources (both supply and demand). In other words, Alstom Grid is bringing more intelligence and increased communications to the grid; it is developing the technologies and services to integrate distributed, remote and intermittent power generation systems into the grid. And, in doing so, it is working in close collaboration with electric utilities, national laboratories, research universities, and other technology and research stakeholders to prevent outages, and to rapidly restore power when outages do occur.

Alstom Grid is proud to be one of the founding members of the GridWise Alliance, which was established in 2003 to advance the modernization of the electric grid. I also serve on GridWise's

Board of Directors. GWA's members include electric utilities, information and communications equipment and service providers, Regional Transmission Organizations (RTOs) and Independent System Operators (ISOs), national laboratories, academic institutions, and more.

Twenty-First Century Electricity Challenge: Transforming Our Nation's Electric System

The United States (U.S.) electric system is undergoing a transformation unlike anything we have experienced in the past 100 years, with major implications for the reliability, resiliency, and security of the nation's transmission and distribution grids. At the same time, our nation has an increasingly digital economy and is, therefore, even more dependent on reliable, safe, secure, and affordable electricity. Going forward, the grid will need to be managed not only for daily operations that our digital economy requires, but also for increasing resiliency and reliability during natural- and human-caused events. Neither the threats nor the digital economy were factors on a scope or scale sufficient to warrant significant consideration when most of today's electric infrastructure was originally built.

The future grid must continue to deliver affordable, reliable power, regardless of where it is generated. It will serve as the backbone of the nation's electric infrastructure, while enabling the innovation that is happening on the supply and demand sides of the electric system to flourish. Thus, the grid will become the enabling platform that connects consumers and producers of electricity for a sustainable energy future. The future grid will enable electricity information to flow together in real time and in two or multiple directions, rather than the one-way flow of electrons from the utility to the consumer that historically has been the case.

By incorporating advanced information and communications technologies and capabilities, the grid will have increased flexibility, which will enable the integration of diverse energy resources, including: centralized and decentralized generation, energy storage, new controllable "smart" loads, microgrids, renewable or intermittent resources, and more. This underscores the need to take into account the entire electric system, from generator to consumer, as well as many of the innovations we are discussing today.

The Importance of Innovative Grid Modernization Technologies and Capabilities to Facilitate the Transformation of the Electricity System to the Twenty-First Century

New grid technologies and capabilities also will help ensure the grid operates both efficiently and effectively – dynamically balancing supply and demand in a much more complex system. That is, the future grid must be able to optimize the management and operation of the entire electric system value chain, which includes power generation, delivery, and consumption. Such optimization will occur not only by using "smart" meters, but also by deploying advanced energy management systems, digital sensors, and a range of other technologies that provide end-to-end visibility and control of the electric system.

In addition, some consumers already have started to interact with the grid very differently, a trend which will become the new normal in the future. As consumers, we already have more choices and greater control over the ways in which we meet our electricity needs, and these choices are growing. Consumers are becoming what we call "prosumers," that is, both producers and consumers of energy. Therefore, in the future, grid operators will have to be able to balance supply and demand, not only at the transmission level, but also all the way down to the distribution grid and to the end prosumer.

Consumers also will be able to better understand and manage their energy consumption. Not only will smart thermostats, lights, security systems, and other appliances further enhance energy management capabilities, but applications (apps) on mobile phones will enable consumers to activate these remotely, with additional attendant benefits.

This transformation of the electric grid already is advancing in different ways and at different speeds across the U.S., with some states moving more quickly than others – but all are moving in the same direction.

Grid Modernization Technologies and Capabilities Enhance System Resilience, Reliability, and Security

The innovation advancing the supply and demand sides must be matched with innovation on the grid. Modernizing the grid will reduce costs in the long run, and increase reliability, resilience, and security in the near and long term.

Let me turn to this point and focus on the need to enhance the **resilience, reliability, and security** of the grid for a moment: many "smart grid" technologies already exist and are making a difference in significantly enhancing electric system reliability and resilience. Based on a June 2013 Report published by the GridWise Alliance, in collaboration with the U.S. Department of Energy's Office of Electricity Delivery and Energy Reliability (DOE-OE), entitled, *Improving Electric Grid Reliability and Resilience: Lessons Learned from Superstorm Sandy and Other Extreme Events,* these technologies help prevent outages and enable the grid to better withstand outages when they do occur due to an extreme weather event such as Superstorm Sandy. More technologies and capabilities such as energy storage will be forthcoming in the future to ensure we not only maintain, but improve, resilience, reliability, and security.

I am not suggesting that technology alone will solve all outage-related problems; they will not. Nor will we prevent ***all*** outages. Yet "smart grid" technologies and capabilities help reduce power outages and restore power more quickly when outages do occur, for example, by helping to facilitate increased automation and situational awareness of conditions on the ground. For example, during extreme events such technologies will allow for the isolation and continued service to limited portions of the grid, as needed, to prevent larger outages or provide for localized grid recovery from such events.

Grid Modernization Technologies and Capabilities Help Create Jobs, Enhance Economic Growth and Competitiveness, and are Cost Effective

Consequently, these types of technologies allow control room operators to gain better and faster visibility of faults on the grid, which can facilitate faster outage restorations. These dramatic technological developments also provide utility crews with greater situational awareness in often dangerous situations, which allows them to do their jobs more safely and efficiently. Homes and businesses can continue operating electricity and heat or air conditioning, depending on the locale, thus ensuring continued safety, health, and economic productivity. Thus, investing in and deploying these technologies, and improving our grid infrastructure on the front end, will substantially reduce the economic impacts from outages and power quality disturbances down the road, thereby resulting in dramatic cost savings to society as a whole.

Cybersecurity threats, extreme weather events, and other hazards present challenges and strong incentives for prompt action to proactively facilitate the transition to our twenty-first century electric system. The above technologies and capabilities will improve daily operations as well as

emergency situations. They also will help balance load and optimize the management and operation of the grid.

Moreover, the adoption of new technology and further innovation in these fields also will lead to the creation of highly-skilled jobs and will enhance our nation's economic growth and competitiveness.

The GridWise Alliance found through collaborative efforts with DOE-OE and over 400 public and private sector stakeholders over the past year on "The Future of the Grid" (referenced above), that today's regulatory rules are not designed to facilitate or promote the types of investments that utilities need to make in their systems, largely because many of the benefits are realized outside the utility.[1]

The Electric Power Research Institute (EPRI) has estimated **the total benefit from the smart grid to be between $1.3-2 trillion from 2010-2030** and benefit-to-cost ratios are found to range from 2.8 to 6.0.[2] Some additional examples of the types of cost savings and benefits these technologies can provide may be found in the ***Appendix.***

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[1] GridWise Alliance-DOE-OE, *The Future of the Grid: Evolving to Meet America's Energy Needs,* Final Report, An Industry-Driven Vision of the 2030 Grid and Recommendations for a Path Forward, December 2014.
[2] EPRI, *Estimating the Costs and Benefits of Smart Grid: A Preliminary Estimate of the Investment Requirements and the Resultant Benefits of a Fully Functioning Smart Grid, 2011 Technical Report,* Final Report, March 2011 (March 2011 Final Report), p. 1-4, available at: http://www.epri.com/abstracts/Pages/ProductAbstract.aspx?ProductId=000000000001022519&Mode=download.

Solutions to Ensure and Accelerate the Transformation to the Twenty-First Century Electricity System

I am not talking here about deploying technology for technology's sake. I do not think any of us ever could have imagined the dramatic changes we have experienced on the telecommunications front. By unleashing innovation, we can experience the transformation that we will and must undergo in the electricity sector. And, the convergence of our information and communications technologies with our electric grid translates to our twenty-first century "smart" electric system.

I offer the following initial recommendations to help catalyze grid modernization.

- Achieve a twenty-first century electric system, by further enhancing the grid infrastructure and enabling related policy, economic, technological innovation, and other mechanisms. Adjustments to the utility business model and the regulatory model, as well as shifts in consumer engagement are critical components of this process. Because of the significant complexities involved in the transformation of the electric system, and to avoid unintended consequences, it is critical to ensure the markets, regulations, and new technologies all are aligned. This can be accomplished most successfully through collaboration among all stakeholders.

- Foster ongoing public-private collaboration, which is essential to facilitating this transformation. For example, utilities, technology companies, and other stakeholders already are partnering with national laboratories to help determine and simulate potential threats to the electric system, and demonstrate technologies and capabilities that improve situational awareness, and reduce major outages.

- Maximize transparency and educate and empower consumers so they can better manage their electricity consumption, especially as they become "prosumers."

- Establish a shared vision. We need to work collaboratively to develop guidance for states and leverage best practices in a way that offers tools for states to undergo the transition to a twenty-first century electricity system. During this transition, it will be important to take into consideration regional, state, and local geographic and other key differences. Over the past year, GridWise members have been working collaboratively with utilities and other stakeholders to further define these recommendations.

Conclusion

In conclusion, we have a historic opportunity to continue and accelerate the modernization and transformation of our Nation's electric grid. Action is needed now because this is a complex issue and the technology and policy changes required will take years to implement.

- We must build the momentum to enhance and ensure the resilience, reliability, and security of the electricity system.
- We must increase the visibility and awareness of what is occurring across our transmission and distribution systems.
- We must manage and operate the electric system in a way that balances loads effectively and strategically and integrates diverse resources.

This transformation can help optimize the grid, spark economic growth and competitiveness, and create jobs.

There is a broad consensus that it is a national imperative to modernize our nation's electric system. We are facing an unprecedented period in which we are encountering a range of driving forces that are affecting our grid, including an increasingly digital economy and a convergence of new technologies, as well as cybersecurity and other threats to our grid system. Unless we prepare now, our system could be vulnerable and might not adequately cope with challenges that already are being experienced. Additionally, we could lose significant economic opportunities and benefits.

Congress can play a leadership role in helping to set the stage for ensuring and accelerating this transformation by fostering even greater collaboration between federal, state, and local governments, the private sector, and the entire ecosystem of stakeholders. To this end, I applaud your efforts to develop bipartisan energy legislation. I urge you to consider grid modernization as an essential component of our shared objective of moving the country toward a more resilient, secure, and sustainable electric system. We want to be a part of this effort and offer to be a resource to you and your colleagues as you proceed.

Mr. Chairman, thank you for this opportunity to testify today. I look forward to answering any questions.

Appendix: Key Statistics Pertaining to Some of the Benefits of Various Advanced Grid Technologies

It has been found that:

- *Integrating AMI with restoration processes* ***shaved 2–3 days*** *off the time it otherwise would have taken to completely restore power during a VLSE; a 10–15 percent improvement in the speed of power restoration.*[3]

According to a Report entitled "Innovations Across the Grid" by the Edison Foundation's Institute for Electric Innovation, U.S. utilities are investing in grid modernization technologies. A few brief examples from this report include the following:

- "Duke Energy is actively engaged in an ongoing transformation of the electric distribution system with the goal of enhancing system performance to deliver better customer service, improve efficiency, and reduce operating cost. While Duke Energy has long focused on demand management, it has recently implemented an effort targeted at providing better management on the energy supply side." This project:
  - "Created a Distributed Energy Resource Management System (DERMS) to integrate distributed energy resources into the electrical grid more efficiently.
  - Enhanced abilities to model, forecast, and control the utility's portfolio of distributed energy resources, including solar generation, energy storage, demand response and electric vehicles."

- NV Energy, using remote connect and disconnect, experienced a net operational savings of about $25 million annually.

[3] GridWise Alliance, *Improving Electric Grid Reliability and Resilience: Lessons Learned from Superstorm Sandy and Other Extreme Events*, Workshop Summary and Recommendations, June 2013, p. 13.

- PG&E in its synchrophasor project is installing or upgrading “160 Phasor Measurement Units at 27 key PG&E substations, including communications, and data management infrastructure to improve wide-area situational awareness.”
    - “This provides unprecedented visibility into power system dynamics and wide-area grid stress indicators across PG&E’s footprint. The solution is akin to using MRI technology in addition to traditional X-rays.”

Testimony Before

United State House of Representatives

Committee on Energy and Commerce

Subcommittee on Energy and Power

By

Christopher Christiansen

Alevo, North Carolina

Chairman Whitfield, Ranking Member Rush, and members of the Committee, thank you for inviting me to testify today on behalf of Alevo, Inc., before the Subcommittee on Energy and Power of the Committee on Energy and Commerce. I appreciate the opportunity to participate in a discussion of "The 21st Century Electricity Challenge: Ensuring a Secure, Reliable, and Modern Electricity System". You will hear from me today how Alevo believes that energy storage will play a crucial role in ensuring that this challenge is met.

My name is Christopher Christiansen and I am a co-founder of Alevo and serve as the Executive Vice President of Alevo Energy. I am responsible for all daily energy division activities, including production design, business development and sales strategies. I am also overseeing the development of over 200 megawatts of operating storage projects in the next 12 months. I have experience developing business concepts for the energy industry as well as a wide range of other sectors, including software, food and electronics.

Alevo is a leading provider of energy storage systems designed to deliver grid-scale electricity on demand. Our innovative battery technology, which features an inflammable, long life inorganic battery, the Alevo GridBanks, enables new source-agnostic architecture for

electrical grids that reduce waste, greenhouse gases and other emissions, create efficiencies and lower costs for the world's energy producers and their consumers. Our mission is to maximize the value, availability, usability and cleanliness of electricity to better serve mankind and the environment. We were recently the proud recipients of the CLT Joules 2015 Energy Innovation of the Year Award, which recognizes an outstanding company that has made significant impact with a transformative energy technology or service. Alevo is also a member and serves on the Board of the Energy Storage Association, the trade association that represents a wide range of energy storage technologies that serve a variety of functions throughout the electric grid.

Alevo's manufacturing plant is located in a former cigarette factory in Concord, North Carolina. We expect to employ 500 people in 2015 and 2500 in 2016. Alevo is set up for significant growth and our site in North Carolina can at full capacity produce 16 GWh with employees exceeding 5000. Within the next twelve months we will be manufacturing and commissioning more than 200 megawatts of energy storage batteries. Alevo is building a vertically integrated manufacturing and deployment organization, creating a global energy storage business to work with the world's largest energy companies.

The electric grid is the only system of production that has not had a way to store its product efficiently. As electricity is generated, it must be used or it goes back to ground. Energy storage changes that equation, allowing us to store that electric production and then use it when we need it, where we need, and at the best price.

Energy storage technologies, like the battery Alevo is manufacturing, will change the way our electric grid works--to enable greater efficiency of our existing generation fleet, by optimizing heat-rates , to integrate new innovations in generation, to allow for increased resilience and reliability of the system, and to lower the cost of electricity for every consumer.

Additionally, the increased efficiency provided by storage lowers emissions and water usage, two important environmental benefits realized without adding cost to rate payers.

According to market research firm IHS, energy storage growth will "explode" from .34 gigawatts in 2012-2013 to 6 gigawatts by 2017 and over 40 gigawatts by 2022. To put this in perspective, 40 gigawatts is equivalent to 40 new coal or gas fired power plants and provides enough electricity to power more than 32 million homes for 1 hour. This explosion will create jobs in manufacturing, as with Alevo, right here in the U.S., allowing us to put our innovation to use to the benefit of the electric grid and consumers.

As the theme of this hearing suggests, energy storage technologies like Alevo's GridBank will enable a secure, reliable and modern electric grid. States hit by Superstorm Sandy, like New Jersey and New York, are already building these technologies into their resilience plans to ensure that emergency services are kept functional during catastrophic events. Even during ordinary power blips or outages, energy storage can help a system and its consumers ride through those events seamlessly. Southern California Edison recently issued a series of awards to accommodate local capacity requirements for their electric customers. They were required to consider 50 megawatts of energy storage in the mix; instead, they awarded 260 megawatts of energy storage since it was competitive and provided the flexibility the utility needed for the system. As utilities and system operators consider their needs both now and in the future, more and more energy storage is being deployed, decreasing the perceived risk inherent in new technologies, and reducing the cost of those technologies through increased scale. Alevo is positioned to drive down those costs even further with the manufacturing of hundreds of megawatts of energy storage capacity in the first year alone.

I look forward to addressing any questions the Committee has about Alevo and our innovation or about energy storage technologies more generally. Thank you for the opportunity to present this testimony.

Summary of Testimony by Joel Ivy, Lakeland Electric, on

"The 21st Century Electricity Challenge: Ensuring a Secure, Reliable, and Modern Electricity System"

The American Public Power Association (APPA), based in Washington, D.C., is the national service organization for the more than 2,000 not-for-profit community-owned electric utilities in the United States. Lakeland Electric, in Lakeland, Florida, is an APPA member serving 122,000 customer accounts in central Florida for the last 110 years. Like other public power utilities represented by APPA, Lakeland Electric was created to serve the needs of its local community by providing low-cost, reliable electric service on a not-for-profit basis.

In this testimony, I first give a brief overview of how the electricity production and delivery system works. I then discuss initiatives being undertaken nationwide by public power utilities related to "grid innovation," but focus the bulk of my testimony on what Lakeland Electric has done and why. For purposes of this testimony, I have defined "grid innovation" as including: deployment of smart meter technologies and the communications systems to support those and other technologies; deployment of distributed generation (or distributed energy resources), including storage; increased real- and near real-time monitoring of power systems, which enhances situational awareness; and management of the "big data" being accumulated through the use of smart grid technologies. In addition, I discuss some of the challenges to deploying these technologies, including the need to address cyber security.

The ability to use communications devices to connect to parts of both the bulk transmission grid and the distribution grid/individual customers (known as "smart grid") is providing electric utilities of all kinds greater opportunities to "optimize" use of the grid. This includes use of such devices to align electric power supply with actual demand from individual customers, thereby enabling smarter use of energy conservation techniques. Deployment of these technologies can also enable utilities to understand where outages are occurring on a real-time basis, which can minimize outage duration and impacts, thus improving reliability. At the same time, the use of such communications devices poses challenges related to customer privacy, data collection and security.

The deployment of a variety of distributed energy resources has been part of the electric utility landscape for decades. But as the economies of scale associated with large power plants and bulk transmission lines have diminished because of increased regulations, wholesale market failures, and environmental concerns, the cost-benefit calculation between DER and large-scale plants/transmission has changed. In addition, DER technologies such as solar photovoltaic (PV) have decreased in price in recent years, thus making their deployment more affordable in some areas of the country. While some of the price differentials are attributable to federal, state, and utility rate subsidies and other favorable policies, there have been substantial advances in technology that have brought prices down as well. The result has been an increased interest in deployment/use of such technologies.

APPA and Lakeland Electric firmly believe that decisions about deployment of smart grid technologies and DER should be made at the local level (for public power systems) and state level for investor-owned utilities (and rural electric cooperatives, where applicable).

The federal government can continue to provide/enhance crucial funding for research and development of these types of technologies, particularly storage. The federal government can also review business practices that may be leading to the provision of erroneous information to customers, including information provided by certain solar leasing companies related to the pay back on the leases, which are in turn being tied to unrealistically high assessments of annual electricity price increases. Access to good information that allows customers to make sound decisions without future regrets is our goal. Finally, the federal government can help to provide timely and actionable information related to cyber-security.

Joel Ivy

General Manager, Lakeland Electric

On Behalf of the American Public Power Association (APPA)

Testimony before the House Energy and Commerce Committee's Subcommittee on Energy and Power on:

"The 21st Century Electricity Challenge: Ensuring a Secure, Reliable, and Modern Electricity System"

March 4, 2015

The American Public Power Association (APPA), based in Washington, D.C., and established in 1940, is the national service organization for the more than 2,000 not-for-profit community-owned electric utilities in the United States. Collectively, these utilities serve more than 48 million Americans in 49 states (all but Hawaii). Lakeland Electric, in Lakeland, Florida, is an APPA member serving 122,000 customer accounts in central Florida for the last 110 years. Lakeland Electric appreciates the opportunity to provide the following testimony on its own behalf and on behalf of APPA for the Subcommittee on Energy and Power's hearing regarding "The 21st Century Electricity Challenge: Ensuring a Secure, Reliable, and Modern Electricity System."

APPA was created in 1940 as a nonprofit, non-partisan organization to advance the public policy interests of its members and their customers, and to provide member services to ensure adequate, reliable electricity at a reasonable price with the proper protection of the environment. Most public power utilities are owned by municipalities, with others owned by counties, public utility districts, and states. APPA members also include joint action agencies (state and regional entities formed by public power utilities) and state, regional, and local associations that have purposes similar to APPA.

Like other public power utilities represented by APPA, Lakeland Electric was created to serve the needs of its local community by providing low-cost, reliable electric service on a not-for-profit basis. While much has changed in the intervening 110 years, the fundamental tenets of local decision-making and serving customers reliably and affordably have remained constant. The core value of local control has fostered Lakeland Electric's intrinsic relationship with its community and has enabled the utility to evolve over the decades as the community has evolved to take advantage of technological, environmental, and economic advances.

Introduction

In this testimony, I first give a brief overview of how the electricity production and delivery system works. I will then discuss initiatives being undertaken nationwide by public power utilities related to "grid innovation," but will focus the bulk of my testimony on what Lakeland

Electric has done and why. For purposes of this testimony, I have defined "grid innovation" as including: deployment of smart meter technologies and the communications systems to support those and other technologies; deployment of distributed generation (or distributed energy resources), including storage; increased real- and near real-time monitoring of power systems, which enhances situational awareness; and management of the "big data" being accumulated through the use of smart grid technologies. In addition, I will discuss some of the challenges to deploying these technologies, including the need to address cyber security.

Electricity, the movement of electrons, occurs naturally. But to serve industrial, commercial and residential needs for lighting, heating, cooling, refrigeration, computers, and many other daily needs, large amounts of moving electrons must be generated from some other fuel or energy source. Electricity is created from the conversion of a fuel or other source of energy into electrons. When electricity is generated from a large power plant, it typically travels over high-voltage bulk power transmission lines to the lower voltage distribution systems where it will be delivered to homes and businesses and consumed. In the case of distributed generation, the power is generated on a smaller scale, sometimes directly at homes or businesses, and therefore does not have to access the bulk transmission system to be used. While distributed generation has long been available, and used for back-up power for times of peak usage (or "load") or in emergencies, the economies of scale created by large power plants drove down electricity costs for end-use customers and they were, therefore, the preferred generation option for many decades.

In recent years, environmental concerns and technological breakthroughs in certain areas have combined to cause utilities and their customers to revisit the use of distributed generation (DG) or distributed energy resources (DER) because the type of resource used to generate electricity varies, as it does in large power plants. Such DER include: solar photovoltaic, typically in the form of solar cells built into panels that absorb sunlight and convert it to electricity; cogeneration or combined heat and power, which uses natural gas-fired fuel cells, micro-turbines or reciprocating engines to turn generators, but then captures the excess heat generated for other uses such as water heating or air conditioning; small wind turbines; small hydropower or hydrokinetic technologies that do not need a dam to harness the power of moving water; waste-to-energy, which uses the methane gas released by decomposing human and animal waste to fuel microturbines; and the use of storage technologies, such as pumped storage, flywheels, or batteries. While still more expensive in most cases than traditional power plants, the use of these technologies to hedge against wholesale market volatility or to address environmental concerns can provide compelling reasons to spend the extra money. Public power utilities like Lakeland Electric must assess the availability, costs and benefits of DER technologies based on the characteristics and needs of the communities they serve.

In addition, and as discussed below in more detail, the ability to use communications devices to connect to parts of both the bulk transmission grid and the distribution grid/individual customers (known as "smart grid") is providing electric utilities of all kinds greater opportunities to "optimize" use of the grid. This includes use of such devices to align electric power supply with actual demand from individual customers, thereby enabling smarter use of energy conservation techniques. Deployment of these technologies can also enable utilities to understand where outages are occurring on a real-time basis, which can minimize outage duration and impacts, thus

improving reliability. At the same time, the use of such communications devices poses challenges related to customer privacy, data collection and security.

The Subcommittee has been active in exploring the cyber-security challenges faced by electric utilities. Those challenges are increased by the use of these smart grid technologies. Therefore, in addition to the greater efficiencies/benefits that can be gained over time through the use of smart grid technologies, public power utilities must assess the costs of deploying cyber-security measures and, where applicable, of complying with the regulations developed and enforced under the Federal Power Act Section 215 regime established in the Energy Policy Act of 2005 that apply to cyber-security as well as reliability. This "eyes wide open" approach is imperative when evaluating the deployment of innovative technologies so that policy makers and customers are not surprised by the associated security-related costs.

Use of Smart Grid Technologies

As public power utilities have undertaken assessments to deploy smart grid technologies, they have realized that they must assess the "core value" of such technologies, including the fiber-optic and wireless communications systems that will support items like advanced metering infrastructure (AMI, which encompasses both the smart meters and the infrastructure underpinning the meters), distributed automation and mobile data collection.

Many public power utilities throughout the country have deployed such technologies, and have seen benefits in the areas of: reduced truck rolls (how often utility employees have to drive to a remote location to assess damage, address a faulty meter reading, or terminate service); lowered costs of upgrading and adding new equipment because of the ability to monitor voltage and detect outages in near real-time, thereby enabling incremental investments rather than outright replacements of damaged infrastructure; and, empowered customers who can save energy and money on their bills. On the other hand, public power utilities have learned that customer concerns about privacy must be discussed with their communities in advance. In so doing, some public power utilities have chosen to allow customers to "opt out" of smart meter installations. Even in these circumstances, however, the vast majority of customers have chosen to deploy the smart meters.

In Lakeland, full deployment of AMI was achieved in February 2013. Lakeland was awarded a smart grid investment grant from the Department of Energy (DOE) in 2009 specifically for this purpose. Since the initial deployment, Lakeland has been working to add data management tools and processes to best leverage the new information we are receiving through the AMI technology. We have integrated information into our grid monitoring program, often referred to as SCADA (system control and data acquisition). Using new graphic-based tools, our system operators are able to spot problems on our circuits well before our customers notify us of outages, and more effectively determine the number of utility employees needed to remedy the problem. Another enhancement that this has allowed is our "integrated systems" team to automatically notify customers by text messages if their residences or businesses have power outages. This is an "opt in" program for our customers, and has been very well received by those who have chosen to take advantage of the service.

Other benefits of deployment of AMI include Lakeland Electric's ability to locate overloaded transformers, and even those transformers with wiring issues. Previously, we would have to wait

until a transformer had blown a fuse or failed in some way, but now we can assess the situation in advance and do repairs when most convenient and cost-effective. Other areas of improved service include: improved customer access to their own information via our web portal; lower rates of illegal meter tampering; and ability of our customer service representatives to remotely read a customer's meter to verify whether a meter reading is correct on request.

In addition to AMI devices deployed directly at our customers' homes and businesses, Lakeland has also deployed smart devices on our distribution and transmission systems over the last several years. These devices have provided a higher level of oversight to our system operators, who are in charge of grid integrity. One such device is a digital relay. Prior to these relays becoming commercially viable, we were not able to effectively capture events such as short circuits without using other, very expensive, recording equipment. Now, in one or two generations of upgrades to our system, we have the ability to see and record whatever information we deem necessary to enable us to troubleshoot more quickly and have access to data for R&D purposes.

Lakeland is leveraging its over 300 miles of fiber optic lines to start deploying equipment that can detect and isolate short circuit events in seconds. This is another evolution into the area of "self-healing" grids. Other utilities are at different stages of this evolution and are seeing great improvements in reliability for their customers.

Distributed Energy Resources

As discussed above, the deployment of a variety of distributed energy resources has been part of the electric utility landscape for decades. But as the economies of scale associated with large power plants and bulk transmission lines have diminished because of increased regulations, wholesale market failures, and environmental concerns, the cost-benefit calculation between DER and large-scale plants/transmission has changed. In addition, DER technologies such as solar photovoltaic (PV) have decreased in price in recent years, thus making their deployment more affordable in some areas of the country. While some of the price differentials are attributable to federal, state, and utility rate subsidies and other favorable policies, there have been substantial advances in technology that have brought prices down as well. The result has been an increased interest in deployment/use of such technologies, particularly rooftop solar.

Although Lakeland, as a municipal utility, is not obligated to do so, it has adopted the state of Florida's net metering rules and we are facilitating roof top solar projects at a moderate pace. Lakeland currently has over 100 customer-owned systems connected, with a capacity of over 415 kW (kilowatts) and a 2013 production rate of 587,000 kWh (kilowatt hours). Lakeland's current policy allows the consumption and generation to be netted out at the full retail rate. This, in many cases, provides the customer a "net-zero" or significantly reduced bill on an annual basis. Customers with roof top systems are also able to see their billing information via our updated web portal.

In addition to facilitating rooftop solar for residential customers, Lakeland has sought to deploy larger scale solar projects for commercial customers, and has partnered with SunEdison under a master agreement to build up to 24 MW (megawatts) of solar photovoltaic systems. The original thought was to offer this option to larger commercial facilities as a roof mounted option. While

the plan was favorably received, we actually had only one project mature to completion. For various reasons, building owners were reluctant to allow the roof space for this purpose. In true partnership fashion, Lakeland negotiated with SunEdison to alter the program to build larger ground mounted installations around our service area. To date we have installed about 5.5 MW and are looking forward to another 6 MW coming online in July 2015. By the end of 2016, we anticipate having a total solar generation output of over 20 MW. Using larger solar ground mounted systems will lower the originally negotiated energy rate charged by SunEdison by 10%-15%.

Over and above what Lakeland has undertaken, public power utilities have long been leaders in the area of distributed energy resources. In fact, the relatively small service territories of most public power utilities and their affiliation with local governments have made deployment of such technologies more feasible. For example, many public power utilities have long used the methane released from municipal landfills to power "landfill-gas-to-energy" projects. While not large enough in scale to provide significant amounts of generation, these projects have reduced methane emissions in a productive way for these communities.

Public power utilities must assess deployment of DER technologies based on their costs and benefits, as mentioned previously. This calculation can vary widely, not only from state to state, but from locality to locality. Fundamentally, these technologies are being deployed at the distribution level, which in both practical terms and from a legal standpoint, should be managed at the local and state levels. From a practical standpoint, the characteristics of an individual utility's distribution system are unique to that system. Just like all humans share common features, but have individual traits, so do individual distribution systems. Utility distribution systems vary by size, types of equipment, age of equipment, whether or not all or parts of the system are above ground or underground, what types of weather are common, what types of power generation are being used, what levels of voltage are being deployed, and whether or not smart grid technologies have been deployed, among other variables. This variability was acknowledged many years ago when the Federal Power Act was first enacted in the 1930s, and regulation of distribution systems was left to the states (in the case of the investor-owned utilities and some rural electric cooperatives) and localities (in the case of public power and some cooperative utilities).

Therefore, APPA and Lakeland Electric firmly believe that decisions about deployment of smart grid technologies and DER should be made at the local level (for public power systems) and state level for investor-owned utilities (and rural electric cooperatives, where applicable). For example, the net-metering option for rooftop solar for residential customers that Lakeland Electric has deployed, and that reimburses these customers at the retail rate for their solar generation, might not be the optimal approach in other communities.

The federal government can continue to provide/enhance crucial funding for research and development of these types of technologies, particularly storage. While the electric sector has its own R&D program through the Electric Power Research Institute (EPRI) and public power utilities have their own R&D grant program called Demonstration of Energy & Efficiency Development (DEED), more can be done to facilitate affordable commercial scale deployment of storage technologies, among others. The federal government can also review business practices

that may be leading to the provision of erroneous information to customers, including information provided by certain solar leasing companies related to the pay back on the leases, which are in turn being tied to unrealistically high assessments of annual electricity price increases. Access to good information that allows customers to make sound decisions without future regrets is our goal. Finally, the federal government can help to provide timely and actionable information related to cyber-security (as discussed below).

Big Data

Rapid advancements in smart grid deployment have resulted in enormous amounts of data that public power utilities are still assessing how to manage and apply to create more grid efficiencies. Contracting with third-party businesses to help us manage the data is an added cost in the short-term that also needs to be assessed as utilities deploy smart grid technologies. In addition, the cyber-security practices of those third party entities is a factor that must be considered.

Lakeland has considered various ways to manage this big data. We have contracts in place with third parties, and we have our own meter data management database, so we have undertaken the options that work best for us. Given the relatively new arrival of big data, finding and keeping employees with existing and adequate skill sets is an ongoing challenge for us. This issue may be addressed over time as educational institutions provide the appropriate training, but public power utilities, as units of local and state government, are limited in terms of salaries and other incentives that help us attract skilled workers such as those required for managing big data. This is another ongoing challenge for us.

In terms of allowing our customers access to the data we are collecting, Lakeland has enabled visualization tools through its web portal (mentioned earlier) for customers to access their own information. The tools have been formatted and are available for all types of smart devices, such as computers, tablets and smartphones with internet access capabilities. We will continue to enhance this customer experience as we get more feedback and as technologies allow. Our customers are quickly adopting modern methods for accessing their data and making other transactions. Electronic access methods account for over 40% of all of our customer interactions. As our applications mature, we anticipate this number increasing dramatically, although we do still have “real” people ready to answer phones at high performing answer rates.

In the past, Lakeland and other utilities would conduct analyses using strategically placed recording meters. Load research is a process used to analyze customer consumption patterns of various customer groups (residential, commercial and industrial), which contributes to assessing the utility’s cost to serve each specific group. Using our AMI and data capturing capabilities, every metering point and smart grid enabled device potentially contributes to this research. Lakeland recently completed an examination of our cost of providing electric service using these new technologies. Besides addressing the need for additional revenue, we were able to design alternative rates from which customers can choose. Early adopters may be able to leverage our new residential demand rate to both help reduce our peak demand and save money in the process.

During the deployment of AMI, Lakeland posted a pilot "Shift to Save" rate. Shift to Save is a three tiered rate structure whereby the price increases during the time of day that the electric consumption is at its peak. Off-peak time period rates are very attractive and are intended to incentivize customers to shift their consumption from the peak periods. After reviewing this rate offering in the cost of service study, Lakeland decided to make it a permanent, non-mandatory offering. As we continue to mature in managing big data, we anticipate having on-line video guides to assist customers in selecting their most favorable pricing program based both on their consumption patterns and their ability to change their habits. These new rates are also offered in the commercial arena.

Public power utilities are increasingly faced with difficult decisions regarding revenue protection. Modern appliances are increasingly more energy efficient than previous models. Lakeland and other utilities are strongly encouraged to offer programs that actually facilitate lower sales, but we still have to maintain the same level of infrastructure and capital investments needed to keep our systems safe and reliable. While currently manageable, we are at, or approaching, the point of saturation. This is primarily a local and state level concern, but the ability to recover fixed costs must be considered when developing future energy efficiency, DER and other programs.

Cyber-Security

One of APPA's top priorities is the safety, security, and reliability of the U.S. electric grid. By protecting the facilities they own and operate and by following increasingly robust cyber- and physical-security protocols, public power utilities play an important role in the safety and reliability of the grid. APPA's commitment to safety and reliability is not unique in the electric sector—cooperatively and investor-owned electric utilities all share this commitment. That is why our industry collaborated on the mandatory reliability regime spelled out in the Energy Policy Act of 2005, and now incorporated in Section 215 of the Federal Power Act, as mentioned above.

As smart grid technologies are deployed on bulk transmission lines and on the operating systems (SCADA systems) of utilities that are part of the bulk power system, those utilities are subject to mandatory and enforceable reliability standards promulgated by the North American Electric Reliability Corporation (NERC) and approved by the Federal Energy Regulatory Commission (FERC). If utilities subject to the relevant "critical infrastructure protection" (CIP) standards that NERC sets and FERC approves are found to be in violation of such standards, they can be fined up to $1 million/day.

Many distribution utilities can have no material impact on the bulk power grid, and therefore are not subject to this federal regime. However, public power utilities that have deployed smart grid technologies at the distribution level are very cognizant of the cyber-security challenges associated with such deployment. Lakeland Electric has taken this as a business challenge and created an internal compliance program. Our program comes at an annual cost of over $1 million. Lakeland's strategy is to incorporate this culture into our utility as another way of doing business. Cyber based attacks, attempts and threats are all too common in the information age.

Lakeland is obviously taking this risk seriously and is working and collaborating at the state and federal levels to continuously improve our system's security.

One of the challenges public power utilities face in ensuring the cyber-security of smart meter technologies is that they must rely on the vendors of such technologies to guarantee the security of their products. Some of the concern stems from where these vendors are manufacturing or purchasing components of their products. Some vendors may purchase components from other countries, such as China, that are known adversaries when it comes to cyber-warfare. But if utilities are not aware of the potential vulnerabilities with such supply chain purchases, then we could also be vulnerable to attack or even penetration of our facilities. We believe that this issue bears additional scrutiny from this Subcommittee and full Committee, and APPA and Lakeland would welcome the opportunity to work with you on such potential initiatives as part of the energy infrastructure bill you are developing.

APPA believes one of the best ways to support these ongoing efforts and enhance security in the electric sector and across other critical infrastructure sectors is by improving information sharing between the federal government and such sectors, and vice versa. This will help at both levels of the electric system – bulk power and distribution. APPA supported the Cyber Intelligence Sharing and Protection Act (CISPA) bills that have passed the House in previous Congresses, and is reviewing the newly released draft of the Senate Cyber Information Sharing Act (CISA) bill, but expects to support it as well. APPA and Lakeland are heartened that Congress may be poised to pass such needed legislation in the near future.

As the grid evolves, unfortunately, so do threats to its integrity. Thus, APPA recognizes that new -- but narrowly crafted and limited -- authority may be necessary to fully address emergency threats. The threat of cyber attack is relatively new compared to long-known physical threats, but an attack with operational consequences could occur and cause disruptions in the flow of power if malicious actors are able to hack into data overlays used in some electric generation and transmission infrastructure. While APPA believes that the industry itself, with NERC, has made great strides in addressing cyber-security threats, vulnerabilities, and potential emergencies, we recognize that any true national emergency will warrant involvement from many federal entities.

Conclusion

Thank you for the opportunity to testify on behalf of APPA and Lakeland Electric. The opportunities afforded to electric utilities, including public power utilities, to use evolving technology to enhance operational efficiencies and improve reliability are myriad, and we are and will continue to work with our customers directly to evaluate the costs of benefits of doing so. We believe that one-size-fits all approaches would stymie the innovation and flexibility we are undertaking across the country and at Lakeland Electric, in particular, and hope that this Subcommittee would not entertain such initiatives as it develops its energy infrastructure bill.

Mr. Paul Nahi
Chief Executive Officer
Enphase Energy

The 21st Century Electricity Challenge: Ensuring a Secure, Reliable, and Modern Electricity System

March 4, 2015

Subcommittee on Energy and Power

Summary Points

- Enphase Energy provides intelligent, cost effective energy solutions for the residential and commercial solar markets, as well as energy services for utilities.

- Our technology enables solar systems to observe and then respond to the grid, thus increasing its reliability. By optimizing the grid in this manner, we can either delay or eliminate significant capital costs, thereby reducing costs for consumers.

- Our products are installed by tens of thousands of workers across the United States each day. We are creating both blue and white collar jobs in our country and creating competitively priced products that make the United States a global leader in our technology class.

- Clean energy resources can play a significant role in "enhancing" our energy security. Solar and wind are local, abundant and limitless. Enphase and others will play a fundamental role in ensuring the energy security of our country.

- We take our role as a thought leader in grid cyber security seriously. Each system we ship is embedded with the most advanced security protocols and can be remotely updated as necessary to prevent new cyber threats.

- Our products have realized significant cost reductions through economies of scale and continued innovation. Our ability to further innovate and scale will result in highly cost competitive, reliable and secure energy generation.

- We have no doubt that the creation of a new energy economy will result in hundreds of thousands of new jobs for Americans, and we are looking forward to enabling those interested in participating in this industry make a smooth and successful transition.

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Testimony

Chairman Whitfield, Ranking Member Rush, and Fellow Subcommittee Members,

Thank you for the opportunity to testify at the Subcommittee on Energy and Power's "21st Century Electricity Challenge" hearing.

Enphase Energy provides solar energy solutions for the residential and commercial markets, as well as energy services for utilities. Through the most sophisticated power electronics and communications technology in the world, we are able to bring a level of visibility, intelligence and control to our solar systems, which are in over eighty countries. This has enabled us to leverage solar assets to help strengthen and increase the resiliency of the grid while providing clean, affordable energy for our customers in the U.S. and all over the world.

A publicly traded company located in the San Francisco Bay Area, Enphase has grown to 600 employees since 2006, and plans to employ over 750 employees by the end 2015. Our products are now installed by tens of thousands of workers across the United States each day. We have a profitable business and continue to invest in new technologies and new markets to enable more consumers to enjoy the benefits of clean, affordable energy, while helping our utility partners strengthen and stabilize the grid. In doing so, we are creating both blue and white collar jobs in our country and creating competitively priced products that make the United States a global leader in our technology class.

The Enphase Energy Management System (EMS) consists of intelligent hardware installed at a home or business as part of the customer's solar system, and state of the art communication and data analytics software. Our advanced technology solution turns solar systems into assets on the grid, and our Energy Management System addresses the grid's needs via our intelligent communications technology. This communications technology provides the necessary support to help increase the stability and robustness of our electrical grid. In fact, we just completed an upgrade with a utility partner, to remotely modify the operating characteristics of thousands of solar systems to substantially strengthen the local grid. In essence, we enable solar systems to observe and then respond to the grid, thus increasing its reliability. With Enphase's technology, solar systems will also have the ability to provide regional grid support, as necessary, freeing up capacity from large coal, natural gas and nuclear facilities. By optimizing the grid in this manner, we can either delay or eliminate significant capital costs, thereby reducing costs for consumers.

As is implied by our product offering, it is clear that our number one job at Enphase is to help provide clean affordable energy while increasing grid stability. At the same time, we recognize the urgent need to increase the security of our energy supply. Energy security is fundamental to the health of our country. It is also a specific focus of this Congress. It must be recognized that new, clean energy resources can play a significant role in "enhancing" our energy security. Solar and wind are abundant and limitless and it is our responsibility to harness these resources responsibly. That said, Enphase and others in this new energy economy will play a fundamental role in ensuring the energy security of our country. The technologies we develop leverage years of innovation in the

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semiconductor and information technology markets, and include many of our own advances. Because of this, each system we ship is embedded with the most advanced security protocols and can be remotely updated as necessary to prevent new cyber threats. We take our role as a thought leader in energy security seriously, and believe this arena will become increasingly critical over time.

In order to ensure that our efforts to provide clean energy to consumers, while strengthening the resiliency and security of the grid, continue unabated, we must also maintain our relentless pursuit of more cost effective solutions. Providing clean, secure energy is not enough; we must make it affordable for everyone. We have been able to dramatically lower the cost of our solar solutions, and are now applying the same technology to storage, where we expect to also see a dramatic decrease in costs. The same processes and semiconductor technologies used for developing and scaling the consumer electronics market are being applied by Enphase to the renewable energy market.

Technologies like the Enphase Energy Management System have the ability to realize significant cost reductions through economies of scale and continued innovation. It is my opinion that solar and other energy technologies will play a fundamental role in the new energy economy as a result of our ability to innovate and scale, resulting in highly cost competitive, reliable and secure energy generation.

Enphase Energy is built on a foundation of collaboration. We believe that a healthy industry lifts all market participants. We have no doubt that the creation of a new energy economy will result in hundreds of thousands of new jobs for Americans, and we are looking forward to enabling those interested in participating in this industry make a

smooth and successful transition. The result will be a strong and vibrant energy industry, abundant access to clean, affordable energy, a large well paid work force and a prosperous future for all Americans. The success of our company, and of other new energy participants, is a testament to the increasing demand for affordable clean energy, and we do not expect this to subside. That said, I believe our role as job creators now and in the future cannot be underestimated. With this role comes the responsibility to help others transition to our new energy economy. We must recognize the amazing accomplishments of those in the industry who carved the path before us, and provide the support necessary to enable them to participate in this new energy paradigm.

Lastly, we aim to remain competitive internationally, to ensure the United States retains a position of leadership in the world's new energy economy.

I appreciate the opportunity to testify before this committee and look forward to working with Congress as we continue to add jobs, increase grid stability, protect our citizens against cyber threats, and ensure the United States maintains its position as the global technology leader.

Sincerely,

Paul Nahi
Chief Executive Officer
Enphase Energy

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Good morning. My name is Naimish Patel; I am the CEO of Gridco Systems, a provider of advanced power flow control and grid operating system technologies for the electric grid, what is termed Agile Grid Infrastructure.

Since the first electrification of street lighting in Manhattan in 1882, the electric grid in the US has become pervasive in its reach, essential to the sustainable growth of our economy and our national security, and providing a service that we are so reliant upon but often take for granted; all testament to the numerous utilities that maintain and operate our grid. Today, however, utilities are operating in a changing environment that poses a wide variety of challenges, but also opportunities for innovation. Much as our telephony system experienced a transformation in the 1990s resulting from customer adoption of computing and demand for information services, so too are we seeing the beginning of a customer-driven evolution of the electric grid. Consumers of power are increasingly also becoming producers, through adoption of rooftop solar or small-scale wind power, requiring the distribution grid to accommodate two-way power flow, in contrast to its original architecture. Customer adoption of electric vehicles is creating new demand for power, equivalent to entire homes, requiring demand control measures to avert overloading of existing infrastructure. Customer adoption of energy efficiency measures and home automation offer potential new resources that utilities can harness for systemic benefit. Finally, increasing diversification of customer demand is creating stress on regulatory frameworks that have traditionally been oriented towards 'one-service fits all' power delivery. All of these changes are compounded by the fact that centralized base-load generation and transmission capacity are growing tighter, and increasing volatility in global weather patterns is driving the need for higher levels of grid resiliency. In the face of these challenges, utilities must continue to deliver on their fundamental mission of supplying safe, reliable, and affordable electric power, while also introducing system flexibility in order to be adaptive to a more dynamic and diverse demand/supply environment. Emerging at this intersection of requirements is a historic opportunity for regulators, utilities and technology suppliers to jointly innovate.

Not surprisingly, given that the aforementioned trends are occurring at the edge of the grid where customers connect, the electric grid's distribution system is at the forefront of change. Historically, investment in the distribution system has often gone to upgrading wires, poles and transformers – what is termed grid reinforcement. While these investments in grid capacity are indeed necessary, the flexibility to accommodate a more dynamic demand/supply environment must come from investment in infrastructure that can more efficiently utilize this capacity (to contain costly capacity upgrades and therefore electricity rates) while assuring reliable delivery of high quality power in an increasingly dynamic environment. Much as the internet is based on devices that actively and dynamically manage the flow of information across fiber optic and copper wires, the electric grid will increasingly need devices to actively and dynamically manage the flow of power, under the control of a grid operating system. Fortunately, the technology building blocks to provide these functions is available, and at the cost, efficiency, and reliability the electric grid requires; power electronics to provide dynamic regulation and routing of power flows, and distributed controls that form the grid operating system to manage grid and customer-owned assets like distributed energy resources, home automation gateways, and energy storage, amongst others. It is these functions that make the grid not just smart, but Agile; it is the brains and brawn in combination that enable a cost-effective and flexible system.

We at Gridco Systems are intently focused on providing these essential building blocks of the Agile Grid. We are working with utilities throughout the nation to address the challenges of today, while providing

the foundation to adapt to the challenges of tomorrow. As with all utility investments, cost-effectiveness in the face of alternatives is an essential consideration. As such, our approach has been to deliver solutions that are more cost-effective and deliver a more compelling benefits-to-cost ratio than business-as-usual approaches, and avoiding the need for subsidies or rate increases. As such, many utilities are able to leverage existing budgets to implement our solutions to address DER integration, better asset and capacity utilization, improved energy efficiency, and higher power quality. This has resulted in jobs and economic growth not only for our company, but our ecosystem of suppliers and partners.

For the most part, the technologies required to modernize the grid are available today. Missing are the economic incentives to drive adoption of these technologies. And I am not referring to subsidies, federal or otherwise. As alluded to earlier, the regulatory compact that has guided the evolution of the distribution grid since the mid 1930s, has proved highly effective, particularly during times of simultaneous load growth and increasing economies of scale in supply, which allow for low electricity rates for end customers and reliable power delivery through continued infrastructural investment. Over the last two decades, average load growth has slowed and become less coupled with GDP growth, owing in part to energy efficiency measures and in part to an increase in the service-orientation of the US economy. Nevertheless, the reliable operation of the electric grid is as critical as ever to the growth of our economy, and as such, continued investment is essential, but *cost-effectively so*. The changes in customer use of the electric grid are by no means universal, at least for now; for example, adoption of rooftop-solar, energy efficiency measures, and electric vehicles is highly demographically correlated. As such, a relative minority, albeit a rapidly growing minority, of customers are impacting the operation of the grid, yet the costs to accommodate them are socialized across the entire customer base. Further compounding this is the fact that such customers often pay less into the system, owing to their lower consumption of energy. Let's be clear: we want the grid to accommodate such customers; they are not going away, and their investments are driven by market forces. However, the revenue a utility realizes from these customers must reflect the actual cost of service to accommodate them. As such, electric rates must be designed to account for the increasing differences in the way customers utilize the grid – the diversification of customer demand.

Conversations at the state level are occurring throughout the nation on how to evolve rate design to better align utility revenues with their underlying costs, and also how to incentivize distribution operators to evolve their networks into energy exchange platforms that are increasingly market and customer-driven. We are seeing the beginning of a new era in electric distribution; one in which the customer is center stage in driving change.

Let us not forget that modernizing our grid is critical not only for national security and economic growth here at home, but also represents an opportunity for the US to lead a global renaissance in energy services and grid infrastructure, one that will not only drive US GDP growth, but growth in exports, creating a new class of US-based industry-leading global enterprises. Let us all work together, from legislators to regulators, from utilities to their suppliers, to address customer demand and seize this opportunity for economic growth. Thank you for the opportunity to speak with you.