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

## HEARING

BEFORE THE

SUBCOMMITTEE ON ENERGY AND POWER

OF THE

COMMITTEE ON ENERGY AND COMMERCE

HOUSE OF REPRESENTATIVES

ONE HUNDRED FOURTEENTH CONGRESS

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# CONTENTS



[1] The information has been retained in committee files and also is available at *http://docs.house.gov/meetings/IF/IF03/20150304/103072/HHRG-114-IF03-Wstate-SiebelT-20150304-SD001.pdf.*

[2] The information has been retained in committee files and also is available at *http://docs.house.gov/meetings/IF/IF03/20150304/103072/HHRG-114-IF03-Wstate-KamenD-20150304-SD002.pdf.*

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

**WEDNESDAY, MARCH 4, 2015**

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

The subcommittee met, pursuant to call, at 10:17 a.m., in room 2123 of the Rayburn House Office Building, Hon. Ed Whitfield (chairman of the subcommittee) presiding.

Members present: Representatives Whitfield, Olson, Shimkus, Pitts, Latta, Harper, McKinley, Pompeo, Kinzinger, Griffith, Johnson, Ellmers, Mullin, Hudson, McNerney, Tonko, Green, Welch, Loebsack, and Pallone (ex officio).

Staff present: Nick Abraham, Legislative Clerk; Charlotte Baker, Deputy Communications Director; Leighton Brown, Press Assistant; Allison Busbee, Policy Coordinator, Energy and Power; Patrick Currier, Counsel, Energy and Power; Tom Hassenboehler, Chief Counsel, Energy and Power; Tim Pataki, Professional Staff Member; Chris Sarley, Policy Coordinator, Environment and the Economy; Christine Brennan, Democratic Press Secretary; Michael Goo, Democratic Senior Counsel, Energy and Environment; Caitlin Haberman, Democratic Professional Staff Member; and Rick Kessler, Democratic Senior Advisor and Staff Director, Energy and Environment.

## OPENING STATEMENT OF HON. ED WHITFIELD, A REPRESENTATIVE IN CONGRESS FROM THE COMMONWEALTH OF KENTUCKY

Mr. WHITFIELD. I would like to call the hearing to order this morning, and certainly want to thank our panel of distinguished witnesses. I am not going to introduce them at this time, but when you—right before your opening statements, I will introduce each one of you, and each one of you will be given 5 minutes to make your opening statement, and then we will have an opportunity to ask questions.

Today's hearing is entitled "The 21st Century Electricity Challenge: Ensuring a Secure, Reliable, and Modern Electricity System." And I recognize myself for 5 minutes, I see I am already started on the clock.

As we all know, the U.S. was the first nation to electrify, and our system of generation, transmission, distribution, and related communication 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. In fact, I have heard—I think I remember in someone's statement, 70 percent of our grid is over 25 years old. 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. Those are some of the challenges, but the—we have many opportunities also. Utilities are planning to invest more than $60 billion 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.

So we have many opportunities, and that is why we want you distinguished gentlemen here today to give us some insights on opportunities for the future.

[The prepared statement of Mr. Whitfield follows:]

## PREPARED STATEMENT OF HON. ED WHITFIELD

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 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.

Mr. WHITFIELD. So with that, I will yield back the balance of my time. And, Mr. McNerney, I will recognize you for a 5-minute opening statement.

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

Mr. MCNERNEY. Well, thank you, Mr. Chairman.

Hey, this is a really exciting hearing. It is an area I care a lot about. You know, the American grid is one of the great engineering challenges of the—great engineering achievements of the 20th century. It has provided us reliable electric power, it has helped our industry grow, and yet at today's hearing we are going to get a look at what the 21st century grid might look like, but also what the transition between where we are today and what the 21st century grid is going to look like. It is going to be an opportunity and some very big challenges.

Some of the factors that I want to bring to our attention are, coal is still our number one energy producer. Produces about 38 percent of our power. And to the chagrin of some of our colleagues, that number is decreasing over time. New—natural gas is our number two energy—electric energy supplier, and that is growing rapidly. There are some challenges with natural gas. We have the distribution challenge, especially in New England States, and—but the price of natural gas is going down, or is low now because of all the abundance of natural gas. So it is a real opportunity for us. Nuclear is number three, and I think nuclear is kind of stagnant right now. That may change over time. And fourth, renewable energies. It is growing rapidly, but it is only 13 percent of our capacity, and that includes hydro. So we have—with renewable energy, there is cost competitiveness. We can produce renewable energy pretty cheaply now, but we can't dispatch it. It is not going to be there necessarily when we need it, so there needs to be some account taken to that and—when we integrate renewables into the grid. But if you look at what is happening, California is going to require 33 percent nuclear power by 2020, so we have to rise up for this challenge.

We also have the specter of climate change sitting there in front of us. It is going to require us to reduce fossil fuels, but it is also going to require us to increase efficiency. We have a need to make our grid more resilient. We are seeing that with our bigger storms now. We also have physical and cybersecurity. We want to make sure that our grid is strong, is safe. If there are physical attacks, if there are cyber attacks, if there are storms, if there are earthquakes, whatever the—nature throws at us or whatever our fellow human beings throw at us, we have to be able to maintain our grid, so this is a pretty big challenge.

There are big opportunities. I just want to tick off some technology. Some of these I don't even understand myself. We have the automated circuit breakers and feeder switches. That is going to allow us to switch problems, we can—it is just like a transistor in a radio. I mean it is going to allow us to switch back and forth, and that gives us quite a bit of flexibility. There are mapping systems that will allow us to stop grid problems from spreading from one part of the Nation, and one sector to another. We have load management tools like megawatts that are being adopted in San Francisco. We also have smart meter technology, which I helped develop for a period of years in California.

So there is a lot of technology out there, but a big opportunity is if we can provide cheap power for our customers, then manufacturing is going to be able to continue to grow and thrive in this country, and without it, we are going to be hamstrung. So this is a big challenge for Congress. It is going to require continued investment and commitment in Congress and in industry. We need to understand the big picture challenge before we do anything drastic here in Congress. We need to understand the engineering challenges. We need to put money out there so that the engineering challenges can be met. We need to incentivize that. We need to make the investment, and that means investment here in Washington, but it means also investment in our States, and it means investment by private investors. And how are we going to invest—incentivize private investors in grid innovation and grid technology, and development and grid infrastructure development if they are not sure they are going to get their money back? So we have to be able to figure that out. So this is part of the big picture challenge.

But my colleague, Renee Ellmers, and I have started the Grid Innovation Caucus. That is giving us here in Congress several members that are interested in this area an opportunity to talk about some of these issues. So—and think about the big picture.

I do have a story from my past when I developed wind energy technology, I started in the business in about 1980 when the industry was just at the beginning. And, you know, we went out there and we got an investment from some folks out there. We designed a wind turbine from a plain piece of paper. It was a wonderful experience. We put it up in the hills of New Hampshire, turned it on, had all the investors come out, turned it on, and then things started turning, the blades all flew off and everyone had to run for cover. But, you know, the investors stuck with us, and year after year we put a little bit more understanding in the blade roots, in the foundations, and the transmission, and in all engineering parts of that machine, and how, because of that kind of work, wind energy is very cost-effective, it is growing very rapidly. So you have to make the investment, you have to stick with it, and if you do, you get rewarded.

So that will be my opening statement. Mr. Chairman, I yield back.

Mr. WHITFIELD. Mr. McNerney, I am glad to see you so enthusiastic this morning. So, you know, I want to also give a warm welcome to our former Secretary of Energy, Spencer Abraham. Appreciate you joining us today, very much. And Mr. Charlie Bass, a former member of this committee, we appreciate him being here as well.

Our chairman, Fred Upton, is going to be a little late arriving today, so at this time, I would like to recognize Mr. Pallone for his 5-minute opening statement.

## OPENING STATEMENT OF HON. FRANK PALLONE, JR., A REPRESENTATIVE IN CONGRESS FROM THE STATE OF NEW JERSEY

Mr. PALLONE. Thank you, Mr. Chairman, for holding this hearing on the future of the grid. I don't know if I can be as energized as Mr. McNerney, but I did notice how energized you were and I was happy to see it.

The National Academy of Sciences has referred to the U.S. electricity grid as the greatest engineering achievement of the 20th century because it delivers critical energy services to consumers in an instantaneous, affordable and dependable manner. In fact, as a society, we have come to expect that every time we flip the switch in a dark room, light will appear. But our grid is changing as we speak. There are ever-growing demands on the grid to power our new technologies, to accept new forms of generation, while at the same time conventional attacks, cyber attacks, climate change, and other new threats require the grid to become more resilient. And the grid is now the subject of almost constant innovation and entrepreneurship as well as—as many of our witnesses are going to attest. How we unleash that innovative spirit and at the same time ensure overall system reliability is the challenge for the grid of the future.

Fortunately, advanced technologies exist to address these challenges, with substantial benefits for both the electricity sector and, in most cases, consumers. These new technologies are working smarter and promise electricity generation and delivery that is more efficient, economic and environmentally responsive. And while this transition will not be quick or easy, our witnesses today make clear that the move towards smart grid technology is already here.

Today, you can already find this technology deployed around the Nation. You can see it in the deployment of smart meters and other technologies that facilitate greater energy efficiency and cost savings, as well as in the deployment of solar and other distributed generation. These technologies will also help us move forward in the fight against climate change, providing new ways to reduce greenhouse gases emissions, while at the same time enhancing overall system resiliency and reliability.

In my home State of New Jersey, you can also see the deployment of smart grid technologies in the work DOE has done to set up a microgrid to prevent transit service outages in northern New Jersey, like the one we experienced during Super Storm Sandy. And while the movement to these new technologies is important in many cases, its near-turn adoption is not inevitable, nor is it necessarily a panacea for all the problems we face. And we will need to work with our State and local counterparts, including State regulators, to develop workable solutions. For instances, while a microgrid may help preserve power for a portion of a community during an extreme weather event, policymakers will be the ones tasked with deciding who gets the benefits of that power, and who pays for establishing the infrastructure. Similarly, the rate of adoption for many of these new technologies often depends on the incentives put in place by policymakers. For example, real time smart metering can provide consumers with critical information about their energy use during hours of peak demand, yet without the proper structures in place to encourage residential or commercial customers to use energy during off-peak hours, there is little motivation for someone to charge their electric vehicle at night instead of in the morning, or to alter their business plans to ensure others can consume electricity during the day.

And so policy questions still exist, but there is little doubt that adopting these new technologies to move us towards a smarter grid could spur benefits for consumers, our economy and the environment, and the witnesses before us today can help us navigate these obstacles to quickly realize the benefits of these technologies in a cost-effective manner. So I look forward to hearing your views.

I would like to yield the remainder of my time to the gentleman from Texas, Mr. Green.

Mr. GREEN. Thank my colleague for yielding to me—our ranking member colleague. I want to thank all our panelists for being here today, and I look forward to discussing this critical component of our economy.

The electrical system and grid are technological wonders, and the—it is the bedrock of our industrial and commercial and domestic way of life. When folks turn on the switch, they never question whether America's power sector will perform.

In the 20th century, we expanded rapidly, constructing lines and establishing functioning markets. The complexity and vastness of the U.S. utility transmission and distribution system is unmatched across the globe.

In the 21st century, we face challenges and opportunities from a changing marketplace. Traditional utilities face new challenge because the integration of renewable resources, implementing the new environmental regulations built on the rapid expansion of cheap natural gas. Transmission and distribution companies are looking at new dynamics of distributor generation.

Finally, consumers are increasingly savvy and informed about consumption management and household efficiencies. As legislatures, we must provide these constituents the tools required to meet the challenges and capitalize on the opportunities of the new marketplace. Today, it is my hope we can elicit some information that would help us better understand the rapidly changing atmosphere, and assist us in crafting solutions so as to remain innovative, flexible, but 100 percent reliable.

And I yield back my time.

Mr. WHITFIELD. The gentleman yields back. And that concludes the opening statements.

So now I would like to introduce our panel. And once again, we thank all of you for joining us today, and we look forward to your testimony.

Our first witness this morning is Mr. Tom Siebel who is chairman and CEO of C3 Energy, also one of the founders of Oracle.

Each one of you will be given 5 minutes, then the little red light will come on when 5 minutes is up, but we won't go strictly by that red light. But, Mr. Siebel, thanks for being with us, and you are recognized for 5 minutes.

**STATEMENTS OF THOMAS M. SIEBEL, CHAIRMAN AND CHIEF EXECUTIVE OFFICER, C3 ENERGY; DEAN KAMEN, FOUNDER AND PRESIDENT, DEKA RESEARCH AND DEVELOPMENT CORPORATION; MICHAEL ATKINSON, PRESIDENT, ALSTOM GRID, INC., ON BEHALF OF GRIDWISE ALLIANCE; CHRISTOPHER CHRISTIANSEN, CO-FOUNDER AND EXECUTIVE VICE PRESIDENT, ALEVO ENERGY, INC.; JOEL IVY, GENERAL MANAGER, LAKELAND ELECTRIC, ON BEHALF OF AMERICAN PUBLIC POWER ASSOCIATION; PAUL NAHI, CHIEF EXECUTIVE OFFICER, ENPHASE ENERGY; AND NAIMISH PATEL, CHIEF EXECUTIVE OFFICER, GRIDCO SYSTEMS**

## STATEMENT OF THOMAS M. SIEBEL

Mr. SIEBEL. Good morning. Mr. Chairman, thank you for the opportunity.

I am here from Silicon Valley, and I have spent the last 4 decades in the information technology business, and we have been working for the better part of the last decade to think about the problem of applying the state-of-the-art of information technology and communication technology to the value chain associated with power generation, transmission, distribution, metering, and consumption. And if we are to look at this value chain, it would be—today, it would be largely recognizable by Thomas Edison, because we are dealing with late 19th century and early 20th century technologies, where at one end of the value chain we are boiling water and spinning a turbine, OK, we are rotating a magnet within a coil, creating a voltage, stepping up the voltage to, you know, higher voltage, transmitting it over long distances at high voltage, medium distances at medium voltage. It goes to a meter and then to the consumer. This is pretty much what it looks like. And it works great until it breaks. OK, and then when it breaks, whoever, Baltimore Gas and Electric or Constellation Energy or Pacific Gas and Electric, sends trucks out with people with volt meters to climb telephone poles and go down manhole covers, to find boxes that don't conduct electricity, and they keep replacing boxes until the lights go back on. And this is pretty much how it works.

Now, this infrastructure—these—the way that utilities are operated is then tend to run these businesses of generation, transmission, distribution, metering, customer care and billing, as separate business units, and as separate business units they have these separate enterprise information systems that have been supplied over the years by companies like Oracle and General Electric and Siemens and others. There are lots of reasons we can get into some other time why these enterprise information systems don't want to communicate with one another. It makes it very difficult to share information, but let it be said that, you know, this has all been kind of driven by Moore's law. Now, this decade, worldwide, this infrastructure is being upgraded so that all the devices are becoming remotely machine-addressable, so we can remotely sense their state. The most common being the smart meter. So we don't have to send a truck out to read it once a month, we can read it once a minute or once every 15 minutes. But what is significant is not the smart meter, the entire value chain is being sensored, from the vibration sensor on the nuclear reactor to the thermostat, the variable speed fan at Wal-Mart, OK, the single phasers, the step transformers, the stepdown transformers, and the substations. So as this becomes sensored, this begins to look like a fully sensored—basically, a fully connected sensor network. A guy named Bob Metcalfe out of Xerox PARC, he invented something called Ethernet, OK, and he coined something called Metcalfe's law. So the power of that network is the function of the square of the number of nodes that are connected.

So when this is—the amount that is being invested, I don't know if I mentioned this, in upgrading this network worldwide this decade is $2 trillion. So this is the largest and most complex machine every built. The amount being invested in the U.S. this decade upgrading this infrastructure is $1 trillion. So as we do this, if we read a meter every 15 minutes, it is being read 32,000 signals a year. If we read it once a month, it is 12 signals a year. That is four orders of magnitude. Actually, we are increasing the amount of data by six orders of magnitude. So we have massive amounts of data that is being collected, and so what we can do now is we can apply the sciences of big data, cloud-scale computing, analytics, machine learning, and these new social human-computer interaction models to dramatically, you know, to optimize the entire value chain to, you know, if we balance—it reduces the amount of fuel that we need to generate by a percent. OK, if we use these technologies for predictive maintenance, we can replace devices before they fail, dramatically increasing safety, increasing reliability, we can, you know, increase the security infrastructure, and by the way, we can reduce the environmental consequences of the value chain by, say, order of 50 percent.

So this is what we are doing today all over the world. I would say that Europe is probably ahead of the U.S. as it relates to this today. We are doing this now, and now putting this in the perspective of a company based in Rome, they have 67 million meters in 40 countries, and so they are a 100-billion-euro company. It is a utility roughly the size of the U.S. market. And there, we are aggregating I think 7 trillion rows of data into an 800 terabyte cloud image. We process these data at the rate of 800,000 transactions per second, OK. Apply machine learning to optimize the value chain and the economic benefit to do this across the world is 6.3 billion euros a year. We are doing this at Exelon. The economic benefit to them, $2.7 billion. This is the economic benefit to their consumers. Baltimore Gas and Electric, Pacific Gas and Electric, Socal Edison, Commonwealth Edison, we are doing—GDF Suez, so we are doing this all around the world today. This is what will make the smart grids smart, is the information technology, the ability to apply big data, analytics machine learning, and new human-computer interaction models. And the economic, social and environmental benefits are significant. So this is the exercise upon which we have been engaged, and it is fascinatingly difficult and fascinatingly exciting.

Thank you.

[The prepared statement of Mr. Siebel follows:]

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 20$^{th}$ 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 21$^{st}$ 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.

[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 21$^{st}$ 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.

Mr. WHITFIELD. Well, thank you very much.

And our next witness is Mr. Dean Kamen, who is the Founder and President, inventor and—also, but he is the Founder and President of DEKA Research and Development Corporation. And, Mr. Kamen, thank you very much for joining us, and you are recognized for 5 minutes.

### STATEMENT OF DEAN KAMEN

Mr. KAMEN. Thank you, Mr. Chairman, and I think everybody here knows we are not here to talk about whether there will be disruptive change in the grid, but how it is going to happen and hopefully how to make it happen in the best possible way.

Though we are here to talk about energy, I am a technology guy and I thought a very quick review, and it will be a very quick review, of a few other industries that were dramatically transformed at the intersection of new technologies that were properly embraced to take over from old systems that suddenly seemed inefficient and terrible. So as an example, I will give you computing. We all grew up, I think, with big computers that sat some place and, you know, the average kid today doesn't know about what Mr. Watson and his company were about, they have tablets and cell phones, and they changed an industry and they wiped out an old infrastructure. There were interestingly three major infrastructures that were built in the 1880s—were established in the 1880s; photography, communications, and energy.

So quickly, looking at this one, Alexander Bell in the 1880s decided we can let everybody talk to everybody, all you needed was a wire from your ear to anybody else's ear. And it took about 100 years to build up that massive infrastructure. Then the technology came along, and that was really neat. Most kids don't know that a house has a phone. You have a phone. And technology like wireless and cellular and fiber optics have just transformed the communication industry, I think we would all agree, for the better.

Photograph, again, in the 1880s it was a wonderful thing. We all remember our Kodak moments. We remember we could get that stuff to actually develop in only one day. You ask the average kid for a selfie today, they don't know what film is, and the Kodak moment is—Kodak is history, it is a memory. So it is because technologies came along that were just breathtakingly better.

What about energy. That is what we are here to talk about. Well, in the 1880s there was this guy Edison and Tesla, and they gave us big centralized plans, like Ma Bell, photography, what do we know about that great model that we have already heard is from virtually everybody out there and the first speaker, it is 150-year-old architecture. What do we know about it? Is it ready for disruption? Well, it is old, it is inefficient, it is unreliable, it is expensive, and it is dirty.

Quick facts about what the grid is today. We have about 1 terawatt, 1,000 gigawatts, of production capacity at an average of $1 a watt to produce that. That is $1 trillion in generation assets. Well, more than 50 percent of that stuff is 30 years old, and if you only replace the stuff that is that old at $1 a watt, it is $500 billion. Once you make that energy, you have to move it. And you just heard, at high voltage, transmission lines, they cost about $1 million a mile, and oops, sometimes they are not quite what we would like them to be. And 70 percent of those things are 25 years old or more, and there are 280,000 miles of that high voltage stuff, so if you replace the really old stuff, it is another $200 billion. Then you have the low voltage stuff in all your neighborhoods. Wires hanging on wooden poles. What could possibly go wrong? So those things are a real deal, they are only $140,000 a mile, and there are 2.2 million miles of that stuff and 50 percent of that is at least 30 years old. And if you just replace the stuff that old, it is another $150 billion. And then, of course, you have the annual capital cost of that infrastructure. Now, that is $90 billion is what we are spending in this country right now to keep that architecture operating, and we have all heard how critical it is, but by the way, that $90 billion, that is not one drop of oil or one pound of coal, that is just to keep that system up.

So is there a better, more efficient way to do to this industry what has happened to communications, for instance? I think so. Everybody loves solar panels, and I think you will hear from this whole panel, between solar panels, battery technology, wind technology, controls technology, megawatts, all of these things are going to change. The question is how do we catalyze them to work together instead of frustrate each other, both technically and in a regulatory environment.

Well, everybody I know loves solar panels. Very few people I know have put up enough solar panels that they have disconnected themselves from that grid that we all complain about. It is our lifeline. So how do you catalyze more people to do this? Well, the more you put those up without doing something else, you are actually hurting the grid because they add instability, unless you add good technology, and they lower the amount of power coming through the grid, but the models by which the grids are funded is by selling electricity. The more of this stuff you put up, it is a competitive perverse alternative to the grid. You have to do something that can catalyze this stuff to happen in a way that helps everybody, including the people supplying the power. So we said, why don't we make an appliance, like all the other appliances in a house, that might help. This appliance makes 10,000 watts of electricity. We call—it is a sterling thermal technology. It is about as quiet literally as your hot water heater or your furnace, and the ones that we have made now 20 of, and placed them with a great visionary partner, David Crane, the chairman of NRG, have already produced 300 million watt hours of power directly where it is needed in places where we can also use the waste heat because after all, it brings the same fuel as your hot water heater. 100 million of those things could produce as much power as the whole grid. I don't think we need to go that far, but is 100 million a lot? No. Americans have 140 million appliances bigger than this. Much more relevant, they have 117 million hot water heaters and 182 million furnaces, together that is 200 million appliances that use exactly the same infrastructure as us, except we will make your electricity and your heat. Where else could you put these things? This is why I think it can work to make the grid a great new future. Don't put them in the houses, put them out on those transformer pads. By the way, there were 40 million of those transformer pads sitting there now between the grid at that last stop and the user, and it is close enough to the user that we can still recover the heat, so we said put them out there, you lower the installation cost, you will make them easier to service, you will get higher efficiency, higher reliability, because houses can share them. Neighborhoods can start putting these things in under an intelligent control plan, and as you put a bunch of them near a set of houses, you don't need another one of those wooden poles with the wires draped through your trees. You put enough of those neighborhoods together, you don't need that substation. Over the next few years you, in a controlled way, get rid of enough substations, you start eliminating transmission lines, and finally you eliminate the power plants that aren't the efficient ones, and then America has a bright future.

[The prepared statement of Mr. Kamen follows:]

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

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

**HEARING ON "21$^{ST}$ 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 20$^{th}$ 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 20$^{th}$ 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.

**<u>Biography of Dean Kamen</u>**

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.

Mr. WHITFIELD. Marvelous. Thank you, Mr. Kamen. We appreciate that.

Our next witness is Mr. Michael Atkinson, who is the President of Alstom Grid, Incorporated, who is testifying on behalf of GridWise Alliance. So you are recognized for 5 minutes, Mr. Atkinson.

**STATEMENT OF MICHAEL ATKINSON**

Mr. ATKINSON. Good morning, Chairman Whitfield, Ranking Member Rush, full committee Chairman Upton, and Ranking Member Pallone, Congressman McNerney, and distinguished members of this subcommittee. I am Michael Atkinson, President of Alstom Grid, Incorporated, and also I am here on behalf of the GridWise Alliance. I appreciate the opportunity to testify at today's hearing.

The U.S. electric system is undergoing a transformation unlike anything we have experienced in the past 100 years. This transformation will create opportunities to enhance reliability, efficiency, resiliency and security of the grid. The grid will continue to serve as the backbone of the Nation's electric infrastructure. It will enable innovation to flourish, and the supply and demand of electricity across the transmission and distribution networks, all while continuing to provide safe, affordable, reliable power.

The future grid will optimize the management and operations of the entire electric system value chain, which includes power generation, delivery and consumption. For example, new smart grid technologies help to enhance situational awareness, prevent outages, accelerate restoration, and—in the case of extreme events, and also integrate distributed energy resources. In addition, other technologies—other related technologies and capabilities such as energy storage, power electronics, and microgrids will also improve the performance of the grid.

The Electric Power Research Institute has estimated that the total benefit of smart grid is in the trillions of dollars. More importantly, for every dollar invested, $2.80 to $6 in benefits are realized.

GridWise and DOE's Office of Electricity work with hundreds of public and private stakeholders to develop a shared vision for the grid, which includes the following. The grid will be the key component of the future electric system. This system will include both central and distributed generation sources. Powering communications will flow in multiple directions. Residential, commercial and industrial customers will use the grid in different ways, becoming both consumers and producers of electricity. This will help achieve the following three outcomes to accelerate the transformation to the 21st century electricity system. First, building on this shared vision, enable policies to ensure the markets, regulations, and new technologies are all aligned. Congress can exercise its leadership to facilitate ongoing and new public-private collaboration to achieve the grid of the future. Second, the pursuit of this future grid will continue to spur innovation and attract ideas, talent and resources from a range of industries. And I think you only need to look to my right to see that. Third, create additional highly skilled jobs. The transformation of the grid will necessitate advanced skills to implement these technologies.

In conclusion, we have an important opportunity to accelerate the modernization of our Nation's electric grid. This will drive economic growth, strengthen our global competitiveness, and create highly skilled jobs. Action is needed now because this is a complex issue, and the technology and policy changes required could take years to implement. I want to underscore that access to a reliable, efficient, resilient and secure grid is a major source of our Nation's competitive advantage. Congress can play a key leadership role in facilitating the acceleration of grid modernization, and ensuring that we maintain this competitive advantage into the future.

Mr. Chairman, thank you for the opportunity to testify. I look forward to any questions.

[The prepared statement of Mr. Atkinson follows:]

**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.***

[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."

Mr. WHITFIELD. Thank you, Mr. Atkinson.

And our next witness is Mr. Christopher Christiansen, who is Executive Vice President, Alevo Energy. And you are recognized for 5 minutes, Mr. Christiansen.

## STATEMENT OF CHRISTOPHER CHRISTIANSEN

Mr. CHRISTIANSEN. Thank you. And, Chairman Whitfield, Ranking Member Rush, and members of the committee, thank you for inviting me to testify on behalf of Alevo, Inc. You will hear from me today how Alevo believes that energy storage will play a crucial role in ensuring a secure, reliable and modern electricity system.

I will also discuss how Federal policymakers can help to accomplish this goal by reducing regulatory barriers to the development of energy storage to benefit electricity ratepayers and consumers.

My name is Christopher Christiansen, and I am the co-founder of Alevo, and I serve as the executive vice president of the Energy Division, which means I am responsible for all the energy daily activities, which include production design, business development, and sales strategies. I am also overseeing the development of over 200 megawatts of battery energy storage projects, which we are implementing in the next 12 months.

Alevo is a leading provider of energy storage systems designed to deliver grid-scale electricity on demand. Alevo couples grid analytics with our innovative battery technology, the Alevo GridBank. Alevo GridBank features a nonflammable, long life inorganic battery that enables a new source-agnostic architecture for electrical grids that reduce waste, greenhouse gases, 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.

Alevo's manufacturing plant is located in a former cigarette plant in North Carolina in Concord, in the district of Congressman Hudson. We are on track to employ 500 people in 2015, and we expect to employ over 2,500 by the end of next year. We are also set up for significant growth, as Congressman Hudson knows, because we have a 3½ million-square-foot facility that can, at full capacity, produce 16 gigawatt hours a year. Within the next 12 months, we are 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 leading and largest energy companies.

The electric grid is the only system of production that has not had a way to store its product efficiently. Energy storage changes that equation, allowing us to store that electric production and then use it when we need it, where we need it, 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, reduce ramping, 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 emission and water usage, 2 important and environmental benefits realized without adding cost to ratepayers.

According to market research firm, IHS, energy storage growth will explode from 340 megawatts in 2012 to 2013, to 6 gigawatts by 2017, and over 40 gigawatts by 2022. To put that in perspective, 40 gigawatts is equivalent to 40 new coal or gas fire power plants, and it is enough power to power a home—over 32 million homes for 1 hour. This explosion would 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 secure a reliable and modern electric grid. The 21st century grid will be exposed to increased generation from variable sources, and also increased fluctuations in load. States hit by Hurricane 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 storage; instead, they awarded 50—sorry, they awarded 260 megawatts of 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, and with the right policies in place, 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 scales—those costs even further with the manufacturing of hundreds of megawatts of energy storage capacity in the first year alone. One key policy that this committee can change is to reduce regulatory barriers for energy storage facilities, including exemption for Federal and State regulations in the same way those barriers are currently used for qualifying coal generation facilities. Congress could also ask FERC to valuate the value generated by energy storage, and ensure that FERC's current policies recognize and award those values.

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

[The prepared statement of Mr. Christiansen follows:]

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.

Mr. WHITFIELD. Thank you, Mr. Christiansen.

At this time, I would like to recognize Mr. Joel Ivy, who is General Manager of Lakeland Electric, who is testifying on behalf of the American Public Power Association. You are recognized for 5 minutes.

**STATEMENT OF JOEL IVY**

Mr. IVY. Thank you, Mr. Chairman. Good morning, everyone. I bring you warm greetings from sunny Florida.

The American Public Power Association, based in Washington, DC, 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 approximately 122,000 customer accounts in central Florida for the past 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.

Public power utilities have been improving our grid-based technologies for some time now. As fiber optic systems started to become more prolific, the application of smarter tools and equipment became truly viable. Together with newer wireless technologies, we have been able to greatly expand access to information, perhaps like never before.

I will discuss initiatives being, excuse me, under—I will discuss initiatives being undertaken nationwide by public power utilities related to grid innovation, but focus the bulk on my testimony on what Lakeland Electric has done and why. I am defining grid innovation as including deployment of smart meter technologies and communication systems to support those and other technologies, deployment of distributed generation, or DER, distributed energy resources, including storage. Increased real- and near-time 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 want to discuss briefly some of the challenges to deploying these technologies, including cybersecurity.

So the deployment of AMI, or automated metering infrastructure, is significantly more mainstream than a decade ago. It has become almost the default choice for upgrades to meters, leaving on the question of using fiber or wireless, or in Lakeland's case, both. This effort was kick-started with Federal grants and loans, of which my organization was a proud recipient. In fact, we completed our deployment in 2013, and are now offering customer access to their information via our Web portal, and have some creative alternative rate programs for earlier adopters to use to save money and energy in their homes and businesses.

The APPA and Lakeland are generally supportive of distributed energy resource technologies, such as rooftop solar, but the concepts of rate programs that will continue to spur this investment, while allowing utilities recovery of our fixed cost, is among the fastest growing issues in our industry. Excuse me. Net metering in some locations such as Lakeland provides a customer credit based on the full retail rate, which may allow customers to reach a net-zero bill on an annual basis. Changes to our rates must not punish the early adopters who invested in older, more expensive solar technologies. At the same time, we must ensure utilities have proper revenue to recover the cost of our poles, wires and generators. This rate design issue is going on appropriately at local and State levels across the country, including in Lakeland.

Regarding distributed energy resources, utilities are also concerned about customers having access to good information that allows them to make sound decisions without future regrets. 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 payback of the leases, which are in turn being tied to unrealistically high assessments of annual electricity price increases, are at the heart of our concern.

The future construct of the smart grid is full of unknowns as we look out longer into the future, and continued Federal support for funding innovative projects will be very important as our Nation's entrepreneurs provide the newest and best support equipment and processes.

Finally, Lakeland—Federal, State, and local collaboration is essential to maintaining physical and cybersecurity. While Lakeland has adopted cybersecurity as an essential business practice, the collaboration with governments at all levels remains a critical component, particularly related to information sharing.

In summary, public power utilities like Lakeland Electric are deploying a variety of technologies to optimize a grid for more efficient and reliable service. In so doing, we worked very collaboratively with our customers, our policymakers, and our communities to determine what is most appropriate at the local level. The Federal Government can help in terms of targeted grants, and research and development, as well as in the area of cybersecurity, by sharing actionable and timely information with the industry.

Mr. Chairman, thank you for allowing me to be here.

[The prepared statement of Mr. Ivy follows:]

**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. WHITFIELD. Well, thank you, Mr. Ivy.

And at this time, I would like to recognize Mr. Paul Nahi, who is CEO of Enphase Energy. And you are recognized for 5 minutes.

## STATEMENT OF PAUL NAHI

Mr. NAHI. Thank you, Mr. Chairman. Chairman Whitfield and fellow subcommittee members, than 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 market, 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 deployed in over 80 countries. This has enabled us to leverage our solar assets to help strengthen and increase the resilience of the grid, while providing clean, affordable energy for our customers in the U.S. and all over the world. A public utility company located in the San Francisco Bay area, Enphase has grown to over 600 employees since 2006, and plans to employ over 750 employees by the end of 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-collared jobs in our country, and creating competitively priced products that make the United States a global leader in our technology class.

Our advanced technology solutions turns solar systems into assets on the grid, and our energy management system addresses the grid's needs via our intelligent communications technology. 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 their distribution and feeder networks. In essence, we enable solar systems to observe and then respond to the potential grid issues, thus increasing its reliability. By optimizing the grid in this manner, we can either delay or eliminate significant capital costs, thereby reducing cost 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 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 though leader in the 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 also expect to see a dramatic decrease in costs. The same processes and semiconductor technologies used for developing and scaling the consumer electronics market are now 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 health 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 to make a smooth and successful transition. The result will be a strong and vibrant industry, abundant access to clean, affordable energy, a large, well-paid workforce, and a prosperous future for all Americans. The success of our company and 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 this new and growing industry. 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 energy ecosystem.

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 a global technology leader. Thank you.

[The prepared statement of Mr. Nahi follows:]

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.

## 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 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

Mr. WHITFIELD. Thank you.

Our next witness is Mr. Naimish Patel, who is the CEO of Gridco Systems. And you are recognized for 5 minutes.

**STATEMENT OF NAIMISH PATEL**

Mr. PATEL. Thank you, Mr. Chairman, and the other distinguished guests or congressional members of this committee.

This is an important topic we will be speaking about today. My name is Naimish Patel. I am the CEO of Gridco Systems, a leading provider of agile grid infrastructure, that is consisting of advanced control and power flow technologies for the electric grid.

Since the Pearl Street Power Station first went online in Manhattan in 1882, the electric grid in the U.S. has become pervasive in its reach, essential to the sustainable growth of our economy and national security, and a services platform that we have become intimately reliant upon, yet often take for granted; all testament to the work of 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 telephone system experienced a transformation in the 1990s, catalyzed by 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 for the first time, counter to the assumptions underlying its original architecture. Customer adoption of electric vehicles is creating new demand for power, each vehicle equivalent to entire home while charging, requiring new utility demand control measures to avert overloading existing infrastructure. Customer adoption of energy efficiency measures and home automation offer new resources that utilities can potentially harness for systemic benefit, blurring the nature of the relationship between utility and customer. Finally, increasing diversification of customer demand is creating stress on regulatory frameworks that have traditionally been oriented towards one-size-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 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 the aforementioned trends are occurring at the edge of the grid where customers connect, the electric grid's distribution system is on the forefront of change. Historically, investment in the distribution system has targeted upgrades of wires, poles and transformers; what is typically referred to as grid reinforcement. While these investments in grid capacity are indeed necessary, the flexibility to accommodate a more dynamic demand/supply environment relies on investment in infrastructure that can efficiently utilize existing capacity in order to curb costly grid reinforcement and, thus, electricity rates, while assuring reliable delivery of power under rapidly changing conditions. Much as the Internet is based on devices that actively and dynamically manage the flow of information across fiber optic or copper wires, the electric grid will increasingly require devices that actively and dynamically manage the flow of power, all under the control of a reliable, secure and scalable grid operating system. Fortunately, the technology building blocks needed to provide these functions are available, and at the cost, efficiency, and reliability metrics expected of electric utilities. Advancements in power electronics technology borrowed from hybrid and electric vehicles, wind convertors and solar inverters, can now be leveraged to provide dynamic regulation and routing of power flows at utility scale. While ruggedized distributed controllers, coupled with advanced networking techniques borrowed from the telephone sector, enable an emerging grid operating system to manage both utility and customer-owned assets, including power regulators, distributed energy resources, and home automation gateways, amongst many others. These core functions make the grid not just smart, but agile. It is brains and brawn in combination, or smarts in conjunction with action, that underlies agility, and most importantly, provides for a strong, standalone business case.

We at Gridco Systems are singularly focused on providing these essential building blocks of the agile grid. We are working with utilities throughout the Nation in deploying our empower solution to address the challenges of today, while providing the foundation to adapt to the challenges of tomorrow. Strong economics drives our customer engagement process. Gridco's focus is on delivering solutions that are more cost-effective, and delivering more compelling benefits to cost ratio than business-as-usual approaches, avoiding the need for subsidies and rate increases. As such, many utilities are able to leverage existing budgets to implement our solutions to address DER integration, increase asset and capacity utilization, improved energy efficiency, and deliver higher power quality, all justified on the fundamental economic benefits rendered.

Technology availability is currently not the limiting factor in driving modernization of the electric grid. Missing are the financial incentives for utilities to invest in new technologies to address diversification of customer demand. And to be clear, I am not suggesting that use of subsidies. The cost of service-based regulatory compact that has guided the evolution of the distribution system since the Public Utility Holding Company Act of 1935, has proved highly effective during times of simultaneous load growth, relatively uniform customer demand, and increasing economies of scale and supply. Such macroeconomic conditions generally present from the 1930's to the 1980's, maintained low electricity rates and reliable service for end customers, while strong predictable returns for investors. Over the last 2 decades, however, average load growth in the U.S. has slowed, becoming less coupled to GDP growth, owing in part to the adoption of energy efficiency measures, and also to an increase in the service orientation of the U.S.

economy. Nevertheless, the reliable operation of the electric grid is as critical as ever to those customers—to our growth of our economy, and as such, continued investment is essential, but without rate increases for those customers whose use of the grid has not changed. After all, changes in customer use of the electric grid are by no means universal, at least at present. Customer adoption of rooftop solar, energy efficiency measures, and electric vehicles tend to be highly demographically correlated. As such, a minority of end customers, albeit a rapidly growing minority, is demanding something new of the grid, yet, the cost to accommodate them are socialized across the entire customer base under currently regulatory structure. Further compounding this is the fact that such customers may even pay less into the system, owing to their lower consumption of energy. Let us be clear; we want the grid to accommodate such customers. Their behind-the-meter investments are driven by basic economics that are only getting stronger. However, the revenue a utility realizes from these customers must reflect the actual cost of service to accommodate them. Fundamentally, not all customers are alike, and electricity rates structures must not only start to account for diversification of customer demand, but indeed, incentive—incentivize utilities to supply such demand.

Conversations among State regulators, utilities, suppliers and other stakeholders are occurring throughout the Nation on how to evolve rate design to better align utility revenues with their underlying costs.

Mr. WHITFIELD. Mr. Patel, I have let you go over almost 3 minutes, so would you conclude?

Mr. PATEL. Yes, sure.

Let us not forget that modernizing the electric grid is not only good for our national security and economic growth here at home, but also represents an opportunity for the U.S. to lead a global renaissance in energy services and grid infrastructure.

Thank you for the opportunity to speak at this forum.

[The prepared statement of Mr. Patel follows:]

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.

Mr. WHITFIELD. Thank you very much for your testimony. And thank all of you.

And at this time we will open it up for questions, and I will recognize myself for 5 minutes.

Mr. Siebel, you had mentioned that the smart grid analytics technology, the savings are so great over cost that you really don't need incentives or subsidies from the Government for some of this, but anytime we go through transformation of any sector, certainly in the electricity sector, there are always impediments, and you do refer to some State regulations and accounting rules. I was wondering if you would elaborate a little bit on that for us?

Mr. SIEBEL. Thank you. Thank you, Mr. Chairman.

We retained McKinsey and Company to do a study on the economic benefit of a smart grid analytics platform, and you think of this as the operating system for the smart grid, so it is the economic benefit to the U.S. consumer. And the study, which we will be happy to provide the committee if they are interested, concludes that the economic benefit is $300 per meter, per year. So it is pretty significant. So this is like $50 billion a year in economic and social benefit across the United States.

Now, we have the adoption of these new technologies. If we look at all the new technologies that are being developed in Silicon Valley, Boston, Jerusalem, anywhere today, these are all Cloud-based Saas systems, you read about it every day, Google, Facebook, Twitter, whatever, so this is where innovation is happening.

Now, the way that utilities make money is they spend money, and they spend money on capital and they get a guaranteed return on the capital by their regulator. Now, if they spend money on technology that was developed in the last decade, what we call enterprise information systems that you install behind a firewall, they will get a guaranteed return on that investment. It is capital expenditure and they get a return on that investment. If they invest money on this new generation of Cloud-based, what we call software as a service and platform as a service-type technologies, that is not deemed to be a capital investment, it is deemed to be an operating expense. So there is a disincentive to invest in innovation. If they invest in innovation, it results in reduced profitability and reduced cash flow for the utility. If they invest in obsolete technology, you get a 9 percent return on the investment.

So I think the regulatory incentives at the State level need to change, and if they don't change, we are depriving the American consumer of innovation.

Mr. WHITFIELD. Yes. I would ask any of you, in America, we have this pretty well balkanized system. We have some independent systems like California, Texas, we have RTOs, we have regulated States, deregulated States. Does that balkanized system impede the growth of technology in the electricity sector?

Mr. SIEBEL. I would comment briefly. I think it does. I mean if we are dealing with a company like GDF Suez, or a company like Anel, Anel is—both of these companies are roughly the size of the U.S. market.

Mr. WHITFIELD. Yes.

Mr. SIEBEL. They operate in 40 countries, they might be 100-billion-euro businesses, and they have in the order of 70 to 80 million meters. So this is roughly the size of the U.S. This is one decision process addressing——

Mr. WHITFIELD. Yes.

Mr. SIEBEL [continuing]. 25 to 40 countries. In the U.S., you have 3,250 utilities servicing 100 million meters.

Mr. WHITFIELD. All right.

Mr. SIEBEL. So it is highly, highly, as you would say, balkanized.

Mr. WHITFIELD. You know, Mr. Kamen, in your testimony, we go through these transformations, there are always unintended consequences, and you do refer to the distributed energy resource death spiral of Germany. Would you elaborate on that a little bit?

Mr. KAMEN. Well, as I said, new technologies bring new opportunities. They also sometimes bring problems, especially to stranded infrastructure. And I am not a policy guy, but as I said, there are some perverse incentives out there. From a practical point of view, if the entire system that has ran for 150 years premised on the generating company only making money by selling more power, there is not an encouragement to save. If they have to run it through a whole system that they already own, and somebody puts a solar panel at the other end, instead of supporting the overall system, it hurts the guys that are losing some of that. But from a technology point of view, there is a subtlety that I don't think maybe the regulators understand as well as the technology people which is, those big power plants are very good at producing a constant amount of power. It takes, in many cases, hours and hours and hours to bring those big boilers up. When you start putting transient capability online without enough battery, for instance, or other kinds of new technologies, what happens when that cloud goes by and suddenly a couple of hundred megawatts that was there goes away, or when that wind stops, you are asking that big tired grid that you were trying to avoid paying their bill an hour ago, suddenly you are desperate for more power. They have a tougher time reacting and keeping a stable grid with these other systems online than they had before, and they are making less money.

In the case of Germany, the instability from a pure technology point of view, not an economic or financial point of view, but the instability induced in their large systems by all these new transient systems is making life difficult from a technology——

Mr. WHITFIELD. Right.

Mr. KAMEN [continuing]. Point of view, therefore, making a reliability issue and a security issue. And I think we should avoid that in this country.

Mr. WHITFIELD. Yes. Yes. My time is out, but I did want to just convey one thing. I was talking to a CEO of a big utility company in California, and they were building some additional transmission lines underground, and he said that the cost for them per mile was $100 million, which—that is a lot.

At this time, recognize the gentleman from California, Mr. McNerney, 5 minutes.

Mr. MCNERNEY. Thank you, Mr. Chairman. I want to thank the witnesses for all your testimonies. Very good this morning.

Mr. Kamen, I just want to ask you a question here. What do you think the microgenerators that you discussed, I forget what you called them, what do you think they would do to the grid system, to the transmission system, to the traditional utility company?

Mr. KAMEN. So one of the things I particularly think should be attractive about it, again, as I said before, almost all of the systems out there are presented, some—it is true, some it is by perception, as a somebody wins, somebody loses alternative, as we move forward.

I think if you can make, for instance, these generators, which is what they are, that use the—a lot of the infrastructure, for instance, the largest buried infrastructure in the country that we don't need $100 million a mile for is natural gas, and many, many buildings have buried tanks with oil, propane. If our device could be moved so close to where it is needed, but still on the energy producer's side of that equation, still just outside the meter, then the energy producers could have millions of these small devices that they own and operate, because most buildings and, certainly, grandma doesn't want to become her own utility company because she has a solar panel, but if the utility companies and energy providers could compete with each other to have small units that are so close to the loads, they still get the full advantage of being a supplier of energy with just millions of little plants, but they get to avoid needing those transmission lines, distribution lines, substations, et cetera, that everybody is talking about being expensive, unreliable, and subject to issues.

Mr. MCNERNEY. Right. Thank you. Nice answer.

Mr. Atkinson, you said that the future will spur innovation and investment. How do you see it spurring investment in transmission systems, the future technology?

Mr. ATKINSON. Today, it is spurring investment. As we get a framework, you are aligning our market, our policy, our technology, everything, you know, lines up for companies to come in, you know, drive solutions forward and invest. Again, as I point to the gentlemen on my right, came from different places, have come into the grid, and now are investing based on what exists today, based on the, you know, again, the policy and the technology that is available today and looking forward into the future.

Mr. MCNERNEY. OK. Mr. Christiansen, just sort of an estimate, if someone puts a solar system on their house, how much will the storage devices that you are talking about add to the capital cost? Will it add 20 percent to the capital cost in order to serve the—a good purpose for the homeowner?

Mr. CHRISTIANSEN. To direct cost, I mean on our unit we really do not approach the distributed solar household market, we see greater benefit of the grid connected bigger units.

Mr. MCNERNEY. So you are not talking about a residential——

Mr. CHRISTIANSEN. We are talking megawatts scale, that is what we produce.

Mr. MCNERNEY. OK.

Mr. CHRISTIANSEN. We produce—yes, and then multi-mega—our standard building block is 1 megawatt hour, 2 megawatt units.

Mr. MCNERNEY. OK. So you don't want to answer that question for the residential——

Mr. CHRISTIANSEN. I mean I could estimate based on competing—competitors' price estimates, but——

Mr. McNERNEY. OK, I will give you a chance to answer that off-line later.

Mr. Atkinson, do you think there is a role for the Federal Government, then, with respect to grid modernization?

Mr. ATKINSON. Absolutely. I—again, I think you are helping drive that shared vision forward, aligning, you know, the public and creating new public-private partnerships. You know, today, companies like myself, you know, we are working with the national labs, we are working with our customers, and creating, you know, a more defined framework for that I think is a great job for the Federal Government to do, and that then allows the public and the private sectors to get together, you know, and fill out the space. Again, there is significant investment going on in the grid today, and it needs to continue. It is—it will exist in the future. It is the backbone of, you know, what we do, and it needs to be utilized in different ways.

Mr. McNERNEY. So you see a significant role for the national labs then in creating this future?

Mr. ATKINSON. Absolutely. I think the national labs, you know, we are out—our technology center, Global Center of Excellence for Grid Technologies in Redmond, Washington, we have a very close relationship with VNNL. We work with several of the others as well. They have a different timescale that they look at, and it is great getting together with them and a customer. A customer who is doing things today, national lab is looking out 3, 5, 10 years, us looking out 1 to 3 years, and merging that together and figuring out what is going to work, and then figuring out how to commercialize that.

Mr. McNERNEY. Thank you.

Mr. Chairman, I yield back.

Mr. WHITFIELD. At this time, recognize the gentleman from Illinois, Mr. Shimkus, for 5 minutes.

Mr. SHIMKUS. Thank you. Sorry for bouncing back and forth. I have another hearing upstairs, and met with the funeral home directors, and so we are trying to do multiple things at once.

Mr. Kamen, it is great to see you. Charlie Bass, it is good to see you. Secretary, good to see you back in the crowd.

FIRST Robotics. I will do the plug, right? We talked earlier, so the actual—the championship is in St. Louis, Missouri, which is right across the river from where I live. We follow it very, very closely. Thank you for that because now, it has gone not just into high school, but in the middle schools and in the grade schools with the Lego thing. And our Christian Dade School that I graduated from, my wife teaches at, they are all in it, and it is a great thing that you have started and I want to give that plug here.

Also, I would like to go on just the issue, I know you have a great diverse background as an inventor in the medical field, insulin pumps, dialysis, why are you interested in this energy debate?

Mr. KAMEN. First of all, thanks for the plug for FIRST. You are all invited to our——

Mr. SHIMKUS. It is the—and you have to use it when you get it, right?

Mr. KAMEN. Well, we have events in every congressional district. Schools from every district. I hope all of you will get involved, but thank you for that. And also thank you for asking because, honestly, we did not start building a small power generation systems for the U.S. After all is said and done, we still have a world class energy system. We have heard about that. I am a member of the National Academies. We did determine a few years ago it was one of the great achievements of the last century.

I started building these small boxes because there are 2 billion people around the world that have never used electricity. And I made a box of a similar size that would make clean water without a lot of other stuff. It didn't need filters or membranes or chemicals, but it needs a little electricity to run. And I thought the two most basic human needs around the world, water and power, ought to be available to everybody, and the rest of the world they are going to skip over ever building a power grid, just the way they skipped over landlines for cell phones—for phones, and now most of the developing world has this productivity called a cell phone, but they don't have a grid. Our little boxes can operate remotely to make true microgrids, and in fact, we ran two villages in Bangladesh for 6 months off two of these boxes, and the only fuel that went into them was the methane coming off a pit full of cow dung. If we bring these things into production here, the U.S. could start supplying electricity to a couple of billion friends around the world.

Mr. SHIMKUS. And I think the last time you really testified was on that technology also, as I remember.

Mr. Christiansen, I was interested in your testimony, and of course, I am from a cold part of the country, that is a big debate here, but you—this—as I understand it, the provisions of getting—we want to create efficiencies by our major generators, the base load folks, and sometimes that goes up and down, and then—and peekers come in, so just briefly, how do we segue your technology, and what is it again, and then how do you think it is being reviewed and accepted by our friends down the street at the Environmental Protection Agency?

Mr. CHRISTIANSEN. Well, we actually have sent this idea to the EPA as well. We did that last April. And the concept is essentially coupled with base load. You can optimize heat grades, basically have a unit that operates at constant output, almost like your car going down the highway at highway speeds where your battery system handles the flexible components, and that is what batteries are good at. They excel at responding quickly, fast and accurately, and that is what batteries should do. And then you have a unit that generates—that gets to be a generator and generates constant. And we have done a study that—on the whole west end connector, we sent it to the EPA on that, and you can essentially incorporate storage and have the efficiency pay for the storage units.

Mr. SHIMKUS. Great, thank you.

And I want to end up with Mr. Siebel. What do you see the primary regulatory burdens preventing utilities from grading adoption of new information technologies?

Mr. SIEBEL. Great question. The barrier is very simple. OK. Utilities get a return on things that are deemed to be capital expense. Information technologies developed in the 20th century are deemed to be capital expense. You buy a piece of iron, a computer, disks, you put it behind your firewall, you get a disk from Oracle and you install it, that is a capital expense. The new—and you get a guaranteed return on those investments through your rate case, so you can pass it on to the rate case.

Investments in the new generations of technologies that they never see and touch, these softwares of service technologies like using Google or Facebook or Twitter, where nothing is ever installed, they get—that is not a capital expense for accounting treatment, so they—not deemed to be capital, so they cannot pass the cost on to the ratepayer. So it is deemed an operating expense, lowers profitability, lowers cash flow, major disincentive to invest in innovation. Consumers—U.S. consumers deprived of all the innovation going on today.

Mr. SHIMKUS. And I thank you.

Thank you, Mr. Chairman. Sorry for going past.

Mr. WHITFIELD. At this time, recognize the gentleman from New Jersey, Mr. Pallone, for 5 minutes.

Mr. PALLONE. Thank you, Mr. Chairman.

I wanted to ask two things of Mr. Atkinson. First, you talked a lot about—and I wasn't here so I have to apologize, I had to go to the other hearing, but you talked a lot about increasing reliability. What has industry been doing since the blackout in August 2003 that, you know, went from Ohio to New York, to improve the reliability of the grid, and where are there technology gaps at this point?

Mr. ATKINSON. There has been a lot of activity since 2003. It was a bit of a wakeup call. You know, one of the things it spurred, honestly, was the creation of the GridWise Alliance. That is what—the reason it was formed was to, you know, move forward and address these things.

Another thing this, you know, people started paying a lot of attention to—as you looked at the root cause of why it happened, was situational awareness. We as a company came out with a product around situational awareness, letting people understand what is happening with the bigger picture and not just in the specific numbers and charts and graphs they are used to looking at.

Since that point, us and, you know, frankly, our competition as well, has driven that, you know, situational awareness through all of the technologies that they have, making sure, again, that there is a bigger picture look at what is happening in the grid, not just right in front of me, but the potential ripple effects as it extends out from just my system.

Mr. PALLONE. And then I wanted to ask you with regard to Super Storm Sandy, my constituents and I personally endured Super Storm Sandy, and could you explain—could you please explain whether and how we might avoid such severe and long-lasting power outages in future extreme events? It think it was about 2 weeks or so that we were out of power. What is being done now to prepare for future extreme events like that?

Mr. ATKINSON. An awful lot is being done. You know, the—as the grid is being, you know, rebuilt and revamped, it is being hardened. New technologies are coming into play. There was a microgrid that was—you discussed yourself with the trains, making sure that they can continue to flow. Also I believe around Princeton there is a microgrid that has been put in place as well to maintain power.

The—at the same time, there is a lot we could learn from each other. The GridWise Alliance, you know, joined together a bunch of people to discuss best practices. And just, you know, some people came back differently, better or worse than others. What are the best practices and how can utilities leverage that for the next event. We know these events are going to continue to happen, and it is minimizing their impact that we need to, you know, focus on.

And then additionally, just the grid technologies continue to advance. You know, distribution systems that are being put in place today, the advanced systems, you know, they automatically identify a fault. You no longer have people out in a dicey situation, you know, looking for where the fault may be along miles of lines. You can identify very closely where a fault is. You can also do some automatic reconfiguration of the system to bring some people back automatically, thus minimizing the number of people that are, you know, experiencing the outage. And all this is helping things come back faster from the inevitable events.

Mr. PALLONE. All right, thanks.

I wanted to move to Mr. Nahi, if I am pronouncing it right. There was an earlier question, again, I wasn't here, raised by one of my colleagues about issues relating to integration of solar and wind to the grid, but to the extent there are truly issues there, aren't they easily dealt with? Could you just respond to that?

Mr. NAHI. Sure. So I think we have to acknowledge that the dynamics that are making solar as powerful as it is today are doing nothing but getting better. The cost of solar energy continues to decrease exponentially year on year, while at the same time grid electricity, utility electricity, is continuing to increase in price. So the—it is less a question of how we do it, if we do it, it is a question of how we do it, and the reality is that the integration, the technologies that are available today at the—at—for distributed generation are so sophisticated that not only does it make the integration relatively straightforward, it actually acts to strengthen the grid. The fact is that the old hub and spoke model that we currently have is inherently flawed. What we want is more generation of all kinds, more distributed generation, and associated with that brings about greater visibility, greater control, there is more and more we can do to leverage solar as an asset on the grid and increase stability if we have the will. The technology is here. We don't need any more. And I would say that it has become so sophisticated that it is relatively straightforward to integrate right now. With the appropriate policy and regulatory issues, with the right—the will to support it, we can easily integrate more and more distributed generation.

Mr. PALLONE. All right, thanks a lot.

Thank you, Chairman.

Mr. WHITFIELD. At this time, recognize the gentleman from Pennsylvania, Mr. Pitts, for 5 minutes.

Mr. PITTS. Thank you, Mr. Chairman. Thank you for your testimony. Good to see you. Charlie Bass, the Secretary, welcome.

Mr. Atkinson, please tell us a bit about your R and D process, how does Alstom Grid go about bringing R and D to the market?

Mr. ATKINSON. First and foremost, we listen to our customers. The—and we work on solutions that are solving, you know, business problems. We are constantly, and I believe all technology providers are constantly working towards a more cost-effective delivery of electricity. You know, as we look longer out again, I thought that we have, you know, we discuss a lot with the national labs and we, you know, taking a step back, looking even further out as to what may be happening and, you know, begin planning ahead, but a lot of our efforts are focused in the now-to-3 years, you know, things that can, you know, be commercial pretty quickly.

Our R and D center is located, you know, for the globe, is located here in the U.S. We have, you know, we hired, you know, in the last 8 years we have more than doubled the number of advanced engineers, power system engineers, and computer scientists. We work mostly with Masters in PhD, you know, people. It is a high-end workforce, and they are sitting around working with customers, working to solve their problems, and then working to adapt what was a specific customer problem to a larger set of, you know, use cases across the industry, and that is when you come up with a full commercial product.

We are focused on single code base and, you know, we created here and again for use cases in the U.S. and globally but, you know, making sure we have a single product pack that we can leverage globally.

Mr. PITTS. Thank you.

Mr. Christiansen, you stated that your technology is source agnostic architecture that helps balance the grid. What is the importance of being source agnostic?

Mr. CHRISTIANSEN. I think the key point is that we are a flexible resource that is not purely a renewable integration, it is an optimizer for all assets. You look at the grid itself, the grid needs flexibility, it needs a dynamic resource that can adjust to changing load, change in generation, and can do it quickly, and that is unrelated to the source reflected. We have done studies where collocated with coal, we are collocated with natural gas, we have been working with cases where we collocated with nuclear. And the value proposition for storage is unique that it fits into all generation resources.

Mr. PITTS. Mr. Ivy, how do the advanced grid technologies being deployed by Lakeland Electric better empower consumers to save energy and reduce their electricity bills?

Mr. IVY. So we have enabled the customer information to be available on a customer account basis by anybody that is willing to get in there and look at what their consumption patterns are. We have also deployed shift-to-save rates. Our shift-to-save rate is a three-tiered rate. It is intended to incentivize people to go to a lower cost rate that is in an off-peak period of the day. We have a winter peak, oddly enough, in Florida, but we have a lot of northern visitors. So the tendency of wanting to get people to shift their consumption patterns from like 7 o'clock in the morning, everybody takes a shower, everybody turns on their heater, a cold morning, or two or three cold mornings in a row, and all of a sudden we have a winter peak that looks like this. That is what we have to build our system to.

So we are actively engaged with the consumers in outreach groups and civic organizations, and whatnot, trying to get them to get a good feel for how they can use that data to their advantage.

Mr. PITTS. OK. Mr. Kamen, in your testimony you noted the need to promote renewable energy technology while ensuring continued viability of the utility-based model, siting Germany as a cautionary tale. How do you think these 2 seemingly opposing objectives can be achieved?

Mr. KAMEN. Well, I think if you include all the energy producers and the people that handle transmission, distribution and retail, and included them in making these transitions to modern, clean, efficient technologies, first of all, a lot of people in the public don't want to own and operate their own photovoltaic farms, et cetera. They are used to having somebody from whom they get a bill once a month and they have reliable power. So if you could make small distributed generators, but make them compatible, for instance, with solar panels, and as you have heard, the technology to make instant power electronically is pretty good, but the big old plants can't respond as quickly when suddenly there is a cloud or the wind dies, but if those utility companies had access to distributed, very quick response ways to make energy so if the wind went away, if the cloud came by, if those batteries, even those great batteries go down a little, if those utilities and those energy suppliers are part of an integrated—that could say I am going to put clean, efficient, small, new stuff out there, it still helps them as the old guard get rid of some of their problems with these aging systems, right back to those big plants, those old transmission lines, those unreliable distribution, the switch gears, the transmission that the substations that we are hearing about being a problem during Sandy. So I think creating a piece of technology that could be put behind the meter, could be put in front of the meter, but giving all of the stakeholders the capability to find competitive ways to optimize producing energy, doing it cleanly, doing it effectively, everybody wins.

Mr. PITTS. My time has expired. Thank you.

Mr. WHITFIELD. At this time, recognize the gentleman from New York, Mr. Tonko, for 5 minutes.

Mr. TONKO. Thank you, Mr. Chair. And welcome to our panelists.

A number of you have mentioned in your testimony the increased role of customer involvement in the current operation of the grid, and the prospects for much more involvement in the future. Of course, this represents a significant departure from the mostly passive role that the average consumer plays now. They receive a bill and they pay it. If the power goes out, they call their local utility and report it. Now, consumers are also producing energy, and their ability to refine and manage their appliances and sources of energy are expanding. This is certainly part of what the smart grid is all about.

You all mentioned the need for better information to go to consumers about their choices, and to educate them about how all this is going to work. How are utilities approaching this given phenomenon? Anyone? Yes, Mr. Siebel?

Mr. SIEBEL. If we look at the utility engagement model, customer engagement model, it is firmly entrenched in, say, 1950. OK, so where the primary communication is through direct mail and the call center. So if any of you remember Publisher's Clearinghouse when we grew up, that is kind of what it is like.

Now, it is clear that consumer expectations are dramatically changing. You know, with Uber and Amazon and Google, we can do anything in 30 seconds and two clicks. And fundamentally, there are very few transactions that we want to engage in with a—with our utility. Pay a bill, question a bill, establish service, change service, hook up our PV array, whatever it may—that is about it. All of those things are very time-consuming and painful transactions for a consumer to engage with. So we are working today with Northeast Utilities, Exelon, Commonwealth Edison, Pacific Gas and Electric, Socal Edison, Anel in Italy, GDF Suez and Europe, and basically what is going on is applying the learnings that we have learned from Uber and Google and Amazon, and applying that level of interaction to the customer engagement problem, so a consumer can get—basically do anything they want to do, you know, within a minute and say 5 clicks.

Mr. TONKO. Um-hum.

Mr. SIEBEL. And so there is major investment going on in this. Much of it was driven initially by the State-mandated energy efficiency mandates that are coming out, I think 39 States where they have almost $10 billion a year allocated for energy efficiency programs, but with, you know, fuel prices diminishing, those efforts are now being put to, you know, reinvent the customer engagement model, and we are working with utilities all over the world to do that.

Mr. TONKO. Well, I agree we need to provide sufficient engagement of consumers early enough in the process to get good input from them on the frontend of program design.

I would point out an issue we had in New York with rolling out smart meters. There were a significant number of consumers that strongly opposed having them installed because of a variety of concerns, including privacy. I would also point out that opening up the utility and the grid to a broader two-way conversation with customers presents both opportunities and problems in terms of computer security. I think with a much more dynamic and two-way role for the consumer and grid operations, we are going to need a more inclusive process to engage our consumers. Have any of you thoughts about what that might be in terms of engagement? Yes, Mr. Ivy?

Mr. IVY. We are actually going through the throws of that in Florida. The Sunshine State has sunshine laws that allows everything be done in the sunshine. So if you are a public agency like we are, for example, we are kind of beholding to public records requests and we are to be providing what the requestor is asking for. At the heart of kind of what you are saying with us is, there is also information that we are keeping hourly information on metering data, things that can indicate whether or not people are home or not, closer to a real-time basis than just the monthly consumption information perhaps that they could get before. So we are wanting to push the notion in Tallahassee that perhaps we want to close that down just a little bit without getting rid of peoples' ability to still get access to historical-type information.

Those conversations are important. They need to be had because we need to make sure that we are protecting the consumers' information.

Mr. TONKO. Thank you very much.

And, Mr. Christiansen, as an advocate for renewable energy, I am very interested in the work your firm is doing with energy storage. You seem very encouraging. I feel encouraged about the possibilities. But the other day I heard a bit more skepticism about how fast this technology could evolve to make a significant contribution to the grid. What are the biggest challenges, and how quickly down the road will we see a meaningful energy storage outcome?

Mr. CHRISTIANSEN. So we are in the process now of deploying over 200 megawatts, which we will do in 2015, and that is in markets that have been opened by, you know, FERC Order 755, opened the way to some of these markets. We also have tremendous interest now from utilities and also international. I think we can do some work on the policy part and ensuring that storage gets cheated for the value of the—and the flexibility, and the speed and accuracy it provides, and that will help more installations come up.

Mr. TONKO. Thank you very much.

With that, Mr. Chair, I yield back.

Mr. WHITFIELD. Gentleman yields back.

At this time, recognize the gentleman from West Virginia, Mr. McKinley, for 5 minutes.

Mr. MCKINLEY. Thank you, Mr. Chairman.

I thought that when we came here, the hearing was the ensuring a secure, reliable and modern electric system, and I thought by extension, we were going to be talking a lot more about the grid, and I have got more confused as I have heard all this discussion. It is much like, you know, I am an engineer by training and, by virtue of that, I suppose I can take on the lawyers in the room, because you ask 100 lawyers an opinion on something, you are going to get 100 different opinions. So I am curious, I have heard very professorial comments, very in-depth, your white papers that you have all developed about this topic, but I wonder whether or not we have been able to reach America with the story, because we have been talking about source agnostic architecture. We have even heard about balkanizing. We have heard about platforms, we have talked about polar vortexes. Mr. Kamen, you were about as close to talking to the American public as I have seen in this panel. One thing I have learned in Congress in my 4 years here, that we have trouble when we are confronted with more than one option, and I haven't heard the option. I have heard seven or eight different themes of where we should go, and I am really trying to get to a point with the grid of what is—and the folks on the other side, they all keep talking about consensus, so I will take their word. Is there a consensus of where we should go to develop grid reliability, because what we have not talked about is the public's resistance, the public doesn't want—"don't put that high-tension line over my property, not in my back yard". We haven't talked about electromagnetic pulse, the threat to our grid reliability with that, because we know that is a serious challenge. We have talked about the fact that we have had briefings, I don't think I am breaching protocol here, but we can shut off someone else's grid in another country, and they can shut off our grid, because we have that capability. There was just some mention slightly about the EPA regulations and shutting down some of our powerhouses that when we had this polar vortex, that we are now leading to a point that we came within, what I was told, 700 megawatts of having a brown-out last winter. That is really threatening. I don't know whether people across American understand, that is really just one powerhouse, 700 megawatts.

And then the option of the age issue, I would like for you to just explain in terms that we don't use here in the beltway for Mildred Schmidt to understand, what does that have to do with what—tell me a little bit more about the age because we have waterlines and sewer lines, and buildings and roads and bridges that are far older than 25 years. Why should I be worried about electric grid—why should I be worried about the electric power lines being 25 years old? So with that, I would like to hear, is there a consensus of where we should go, where Congress should be putting its first priority in getting greater reliance or dependability, or are we just kind of talking abstract again? Is there a consensus? Mr. Kamen.

Mr. KAMEN. First of all, thanks for being an engineer in Congress.

Mr. MCKINLEY. It is lonely.

Mr. KAMEN. Secondly, I would continue, you know, in our FIRST competitions we call it coopertition. We believe that if you apply technologies properly, everybody can win as they compete because the public gets the best that way. And I think what you have heard from everybody is the grid is getting older, it is getting, for various reasons, the environment, terrorism, cyber attacks, and it is more fragile, and you are hearing a lot of people adding a lot of new technologies, but I would think where there is a consensus should be that you have to get all the people that provide the net result to the public, as you point out, working together so that you don't create an if-I-win-you-lose situation. And the energy providers, the transmission or the generation—for instance, our partner for our little box is a major generator, NRG, yet they are now becoming one of the biggest suppliers of solar panels, and working with us on these small distributed boxes. In one perverse way, you could say they are undermining their core business, but, you know, like they always say, the railroads went away because they thought they were in the train business, not the transportation business.

And to your point, the public doesn't care about CDMA and TDMA and Time Division—they care about a cell phone being more convenience than a landline. So the public—if the public could have a simple appliance put into their home that already used infrastructure that we have great confidence in, because it is buried under the ground, like gas lines, like their oil, like their propane, and it could be made to work in parallel with solar and wind and the grid, because it sits at the intersection of all those things, somebody with an appliance like that would say, my costs went down because the waste heat from this thing is now my water system and my furnace, and I have more security and reliability because it is distributed, it is sort of like getting a back-up generator free, the people that run the grid and all the other systems win with it because it deals with transient problems, it is compatible with solar panels, it is compatible with batteries, it is compatible with the big producers.

Mr. MCKINLEY. My time has expired, but I just—so thank you for your comments. I am going to ask if you could please—I don't have time, we are limited to 5 minutes here, so if you could please each of you could—would you mind, I would like to hear from you what is the number one thing we should do. If you could write that to me, I would like——

Mr. KAMEN. Yes.

Mr. MCKINLEY. So that it is more direct. Instead of this abstract idea, let us get down to concrete where we can——

Mr. WHITFIELD. And did anyone else want to briefly respond to that? You looked like you wanted to say something, Mr. Siebel.

Mr. SIEBEL. Yes, sir. You have an 800-pound gorilla in the room here, is the cybersecurity problem. OK, now, every now and then, I mean and this is an opportunity where the Federal Government can play a role. All right, so every year or so, we get the word out of Washington that this is a priority. The fact of the matter is any hostile government, OK, any 10 smart engineers from UC Berkeley, OK, could bring down the grid from Boston to New York, you know, in 4 days. And this system is entirely exposed. And if you bring in the leadership from Homeland Security, DHS, in here to talk what they—I think what they will say, and what I believe, before we really do something about this, we are going to have the equivalent of 9/11. There is going to be some disaster, and it is not going to be good, and it will come from just some bad actor or some kids. And then we will get serious and spend, you know, $100 billion a year on it for, you know, 10 years and declare a war on whatever it is. OK, but this system is so vulnerable and so fragile, and there is going to be a problem and we are not going to be happy. And it is fixable.

Mr. MCKINLEY. So if you—again, when you——

Mr. SIEBEL. I will personally send you a letter, sir.

Mr. MCKINLEY [continuing]. See it, you have that—tell me what is——

Mr. WHITFIELD. And Mr. Patel wanted to make a comment.

Mr. PATEL. Yes. On a basic level, customers care about the cost of electricity and it being on when they want it. And for the variety of reasons we have discussed, we are at a point in the evolution of the grid where there are fundamentally two paths that utilities can go. One is to do what they have done in the past, which his to invest in wires and transformers, and poles and grid hardening, another option is to actually take a different path where the cost of upgrading the infrastructure can be lower. See, the challenge with the first path is costs are going to go up. That means your rates are going to go up. Investing in wires and poles is expensive.

Now, with the technologies that we have all been discussing today, there is an opportunity for a much lower-cost path. Now, the question is why isn't that happening? Why are utilities not pursuing the lower-cost path? And from my perspective, it comes down to incentives. You know, the regulatory compact that has driven decision making at distribution utilities is not directly incentivizing them to take the lower-cost path. Why? Because it is a little bit more risky, because of, you know, adoption of new technology is always somewhat risky, but also because there isn't the direct financial incentive for them to adopt something lower cost. And so in my view, there needs to be a change on a State-by-State basis to the regulatory compact insomuch as it relates to how utilities invest in a capitally efficient way, rather than just investing in capital——

Mr. WHITFIELD. Yes.

Mr. PATEL [continuing]. As has been referred to multiple times. And I think those incentives, once in place, the market and efficiency will naturally drive to an outcome that addresses reliability in a cost-effective way.

Mr. WHITFIELD. Thank you, Mr. Patel.

At this time, I would like to recognize the gentleman from Iowa, Mr. Loebsack, for 5 minutes.

Mr. LOEBSACK. Thank you, Mr. Chair. Thank you for having this very, very critical hearing today, and thanks to all of you for being here. I really appreciate this very much.

I am new on this committee, on the larger committee. I am new on the subcommittee, but I have been dealing with these issues, especially in rural Iowa, since I have been in office since 2007. Trying to get my head around all of this. It isn't all that easy, as you might imagine as well, because all of you are kind of coming at this from different angles and what have you. But, you know, clearly, the idea of the smart grid makes a lot of sense. The whole idea of the—of an individual sort of having more control over how they use energy, the amount of energy they use and all, I mean I get my, you know, monthly utility bill, it tells you sort of in a macro-sense how much I have used, but that is not nearly the same as being able to control, you know, time of day and all kinds of things much better than I am able to do now, so I really appreciate that. And I do believe in individuals taking their own responsibility for their decisions.

And we see in Iowa, for example, we do see a lot of wind turbines, you know, at farms, and solar panels powering, you know, hog farms, for example. I mean there is all kinds of stuff like that going on around this country, and around the 24 counties in my congressional district. It is really quite fascinating to see how this is all going. And the local RECs are kind of coming onboard more on solar, and some of these alternative energies as well. So it is really pretty exciting, and I am glad that Mr. McNerney was excited because—I am not quite as excited, but I am excited about all this, and sort of where we can go from here.

You know, Iowa, traditionally, we were a coal State, not unlike parts of Illinois where Congressman Shimkus is from. John L. Lewis, actually, is from Iowa, long ago. But we have made this transition in many ways. I like to remind people that 27.3 percent of our energy in Iowa is wind-generated. We have a heck of a lot of wind energy in Iowa. Now there is big controversy about building a transmission line across the State carrying, you know, energy that is not necessarily generated in Iowa, but in other places, over to other markets to the east of us. But we are really making tremendous progress when it comes to renewables, there is no doubt about that.

But I do want to ask kind of a general question. Anybody wants to answer this. And keeping in mind that if I get—if that takes my time—I want to come back to you, Mr. Kamen, especially the German issue and some things you were talking about, and if I don't get to that then we will do it for the record, if that is OK. Thank you.

So, you know, I am from a rural area. We have a lot of challenges. We have natural disasters. Aligned Energy said they lost 6,000 poles in February of 2007 when we had this massive ice storm. And I guess if you could be as specific as possible, how do we look at making sure that we get sufficient energy—continue to get sufficient energy to the more rural areas in places like Iowa and other places? I know it is a general question, and it is a big challenge to answer that question, but I want to open that up to anyone. You are nodding, Mr. Kamen. I don't want to be preferential here, but you are nodding like you do want to answer that question.

Mr. KAMEN. Well, as I said before, the actual stimulus to make our little box was for the parts of the world that have no grid at all——

Mr. LOEBSACK. Right.

Mr. KAMEN [continuing]. Because it is very compatible with microgrids and can be networked, especially when you put smart technology around to connect them, and you make them compatible with solar, so you reduce your fuel needs, which could be hog waste or other things, but I think the more you have an unstructured area that doesn't have a big grid already in place, transmission, distribution, substations, the more the 21st century is going to start from the other end of this equation and start integrating local solar, local wind——

Mr. LOEBSACK. Right.

Mr. KAMEN [continuing]. But you need a system to make sure it is there all the time. And so since most places have some sources of fuel, natural gas or propane or——

Mr. LOEBSACK. Um-hum.

Mr. KAMEN [continuing]. Number two, and, you know, we build a technology that is agnostic to that, if you have a hot water heater or a furnace, well you have—you can make electricity. So I think, again, it is also a piece of hardware that the competitive environment will say any forward-thinking utility or energy generator, or transmission company or any other provider would say it is compatible with what they are doing, and it should be made part of the equation for the future.

Mr. LOEBSACK. If I could just skip—I know I kind of opened that up to everybody, but now I am thinking in terms of regulatory framework, making sure that we integrate some of these things into, you know, the generation and provision of power to folks, because it was mentioned, you know, we have to have the right regulatory framework, right policy, right regulatory approach. What is that approach? I think you were saying—talking about that, Mr. Nahi.

Mr. NAHI. Exactly. So I completely agree with Mr. Kamen that the right answer is distributor generation.

Mr. LOEBSACK. Um-hum.

Mr. NAHI. It can't be done at the expense of the grid, this is done in concert with the grid, but really what we need is more and more of all kinds of distributor generation.

Mr. LOEBSACK. OK.

Mr. NAHI. In terms of the regulatory and policy changes that need to be adopted for that, we have to recognize that the potential for an adverse relationship between the renewable energy companies and the utilities exist. It doesn't have to be.

Mr. LOEBSACK. Right.

Mr. NAHI. There are ways these companies can work together, there are ways that we can help the utilities adopt to a business model that would provide for more distributed generation. Right now, most of the distributed generation, not all but most, is done by third-party companies.

Mr. LOEBSACK. Right.

Mr. NAHI. There is no reason why the utilities themselves can't take a greater ownership and greater responsibility for putting on more of that distributed generation.

Mr. WHITFIELD. Thank you.

Mr. LOEBSACK. Thank you. And, Mr. Chair, thank you. And I am going to pursue this with you, Mr. Nahi, more after this, and also Mr. Kamen on the German issue, if I may. Thank you. Thank you.

Mr. LATTA [presiding]. Well, thank you very much. The gentleman yields back. And the Chair recognizes himself for 5 minutes. And I apologize, there is another subcommittee of the full committee running at the same time as this, but I tell you, this is a very, very important issue and I really appreciate the testimony that you all submitted today, and also being here today.

And, Mr. Siebel, if I could start with you, how do the kinds of energy analytics you have described help us with energy security and reliability?

Mr. SIEBEL. Great question. So what we do when we look at this as a big data problem is we aggregate all the data from all of the operating systems in the utility, generation information, meter data management, customer care and billing, outage management, Volt/VAR, all of it into a unified data image in the Cloud. These can be like petabyte-sized data images, which are, in engineering speak, bigger than a breadbox. OK, and then we can correlate so that we get these, say, for predictive maintenance or grid reliability, or energy efficiency or whatever it may be, we can see in real time across the entire value chain from when somebody is moving a thermostat, to making a decision on whether we are going to bring on a peaker plant or change capacitates to balance Volt/VAR. Now, over in another building, OK, in a subbasement, there are 13 people looking at computer screens, and they are looking at utilities that are provided by companies like Symantec and like Hewlett Packard, and whatnot, looking for virus detection and malware detection that are penetrating the network. And basically, this is a pattern recognition problem, where they are looking for strings that look similar to malware that they have seen come out of China or Syria or Korea, or whatever it may be. And then this person, almost like an accountant with green iron shade, is kind of looking at this gibberish coming across the screen that says this is the type of malware that is trying to come in from this point. The question is what do you do with it.

By being on a core like that as just another data source with the entire grid infrastructure, you can say, what does this mean, what portion of the grid is impacted, what critical infrastructure is impacted, what is the single point of failure, so you can then prioritize, and so you can both prevent them at the perimeter and you can do something about it right away. And so this is where cybersecurity comes together with kind of big data analytics. And we have done a lot of work with this at the University of Illinois with—and UC Berkeley, The Trust Group, and it is a well-understood problem. The fact is there are no budgets at the utility level to deal with it, and this is where I think the Federal Government can do something to encourage investment in hardening the system.

Mr. LATTA. Well, thank you very much.

Mr. Atkinson, and how do advanced grid technologies help prevent the outages and enable the grid to better withstand outages when they do occur, and how can the technologies facilitate faster outage restorations and provide utility crews with greater situational awareness?

Mr. ATKINSON. It comes down to situational awareness. Allowing people to understand what is going on with the grid at all levels, pushing that information out from a centralized room into the hands of the people in the field that are there, and giving them more accurate information. And the technologies that exist today, you can identify the location of faults to, you know, a very close geographic proximity, rather than it is somewhere in, you know, in this, you know, series of seven blocks. You can send people directly out to a—the fault. They have a knowledge of what is happening because, you know, one of the things we discussed is things are, you know, more distributed energy resources are in play, you have to be careful, and you have multidirectional flow of electricity that changes the safety environment for the line worker pretty dramatically, and he needs to understand what is going on, and there needs to be, you know, that communication about what is going on. The technology that exists today is allowing that, and it continues to get better and better.

As far as preventing outages, you know, as you see things happening, you know, from the transmission system down into the distribution systems, you see harmonics building, you get a chance to adapt quickly where, you know, the faster, you know, talking system today. The phasor measurement units are providing data 100 times a second, versus once every 6 seconds. You are able to get an accurate dynamic picture of what is happening, and it gives you a chance actually to, in some cases, you know, and there is proof this, eliminate when an outage was about to happen. If an outage does happen, you are now working on coming back faster, and eliminating as many people from that outage as you can. And again, that is where the fault identification, automatic restoration through switching on the rest of the grid, brings back a portion of the people, leaving a subset that is still out, and again, you have identified it very closely where it is, giving you a better chance to come back quickly.

Mr. LATTA. Well, thank you very much.

My time has expired, and the Chair recognizes the gentleman from Ohio, Mr. Johnson, for 5 minutes.

Mr. JOHNSON. Thank you, Mr. Chairman.

Mr. Kamen, you testified that advanced grid technologies offer a promising future for U.S. electric systems, but the immediate challenge is to develop the appropriate business models and regulatory structures to effectively manage the integration of modern technologies. Do you have any recommendations as to what these business models and regulatory structures might look like?

Mr. KAMEN. So with the caveat that I think thermodynamics is way easier than Government, way easier, I——

Mr. JOHNSON. I would agree with that.

Mr. KAMEN [continuing]. I would give you an example from my practical life experience. I spent 30 years building medical equipment. We built some very advanced medical equipment, life support equipment, and as tough as the standard is to get an FDA approval, once you get it, you have it, and every hospital, whether it is Harvard or UCLA or—you know what the standard is, you build stuff, it gets approved and you are done.

We just built 20 of these model systems that our partner, NRG, has put around the country, but pretty much not only every State but almost every city and every town has a different set of rules about how you put these in, what you are required to do, and how do you make them become legally part of the grid. I think if there was some standard that the feds could put out so what the FDA does for medical products, if you guys could do for energy products, you could encourage innovators to start making stuff because they know what they have to do——

Mr. JOHNSON. OK.

Mr. KAMEN [continuing]. They know if they did it, it could be used everywhere.

Mr. JOHNSON. OK. Good.

Mr. Atkinson, your testimony suggests that the grid of the future will enable electrons to flow into or even multiple directions. Why is having flexibility in power flows significant, and how can advanced grid technologies facilitate this?

Mr. ATKINSON. In the traditional hub and spoke that was mentioned before, you have an outage upstream, everybody downstream is out. When you have multiple directional flow, you get a chance to re-switch your system, reconfigure your grid on the fly, thus allowing, you know, all or some of the people to be brought back up immediately and not suffer that outage.

The technologies today, you know, they exist to do this and they continue to get better, and the algorithms that are written, you know, continue to improve and, you know, it continues to move forward. Again, it exists today, getting better into the future.

Mr. JOHNSON. OK. Mr. Christiansen, how can energy storage help utilities and consumers ride through outages and other power interruptions seamlessly? I understand it, but for the American people I would like——

Mr. CHRISTIANSEN. I think, first of all——

Mr. JOHNSON [continuing]. For them to hear from you.

Mr. CHRISTIANSEN. Yes. First of all, to piggyback on everybody's comments here on having a distributed network and really, in my creative environment but almost local balancing authorities, adds a lot of reliability to the system. You have this capacitance in the grid that is able to soak up capacity and quickly deliver it back when it is needed really helps you ride through any peak, you know, that nature. Also as a good blank start——

Mr. JOHNSON. Sure.

Mr. CHRISTIANSEN [continuing]. Get—helps us just to get back up to speed again after an outage, and this is a huge benefit by energy storage.

Mr. JOHNSON. Yes. I—as a chief information officer for a global publicly traded manufacturing company, I had to be concerned about the data center and UPSs and those kinds of things, to make sure that we had that steady power.

A lot of folks don't realize in today's high-tech arena what a power outage, a power surge, and what those constantly changing power parameters do to solid state circuitry and those kinds of things. It wreaks havoc.

Mr. Ivy, you state in your testimony that greater adoption of advance grid technologies may help create self-healing grids. Can you expand on this concept of a self-healing grid a little bit?

Mr. IVY. We have actually touched on this quite a bit, and Mr. Atkinson did a fair job of describing that I think. So if there is an outage somewhere in the field, like he said, in the original hub and spoke method, you are just out if you are downstream of that, or even in some area around it you are still out.

We are installing in our company, and other municipalities and investment utilities around the country are pretty advanced already in the tactics of installing these high-speed switches that are sensing where these short-circuits are in the system, and they are talking to each other to try to figure out how to isolate it——

Mr. JOHNSON. Um-hum.

Mr. IVY [continuing]. And then the goal is to have it just isolated to the smallest area that you can possibly have it in. So then that allows us then also to dispatch somebody straight to what the problem is, because normally it is lightning, it is trees, it is an animal, something that can be cleared up very quickly, we can get the lights back on very, very quickly.

Mr. JOHNSON. OK, very good.

Well, thank you, Mr. Chairman, and I yield back. Thank you, gentlemen.

Mr. WHITFIELD. Gentleman yields back.

At this time, recognize Mr. Mullin, the gentleman from Oklahoma, for 5 minutes.

Mr. MULLIN. Thank you, Mr. Chairman.

I want to start with Mr. Ivy, and I know these two may not actually go together, but in practical and legal terms, which those are the two I am talking about, is it better for the development of advanced grid technology to be managed at the local or State levels?

Mr. IVY. Our preference is certainly at the local level because all of our systems have these unique nuances to them. I think somebody had brought up in Iowa, for example, their system is pretty sparse. They don't serve a lot of customers. Their needs are going to be decidedly different from mine. I am like a 258 square mile service area, very dense, pretty good population base. So the kinds of things that we need to do in my area are going to be decidedly different from what other people would want to do. And then you have the State rules that go along with the implementation, or not, incentives or not, that exist, so it can get pretty much—well, I am just going to say, there is no one-size-fits-all for us, and so our preference is to keep it as local as possible.

Mr. MULLIN. Thank you.

Mr. Kamen, you made a point in your written testimony that more than 50 percent of the generating capacity in the U.S. is 30 years old, and at 70 percent of the 280,000 miles of transmission line is more than 25 years old. What do you feel your company, as well as other companies like yours bring to the table in addressing this issue?

Mr. KAMEN. I think that, you know, like with a used car, you reach a point where it is cheaper to buy a new one than to keep fixing the old one. I think if you could——

Mr. MULLIN. Unless it is antique. You have to hold onto those.

Mr. KAMEN. OK. Agreed. I have a 1913 Model T and it is not for sale.

Mr. MULLIN. Wow.

Mr. KAMEN. I would tell you if the proper incentives were put before the people that produce the energy, transmit the energy, distribute the energy, supply it to the end user, if they had a clean piece of paper and could invest their money in alternatives to just fixing these things that are, as you have heard, more—when it is a big central power plant, cybersecurity is a real issue. There are only a few of them to take down, you heard that there are only a few plants that are hub and spoke, it is very hard to make them self-healing. If you could have thousands and thousands of small, locally operated and controlled units that, by the way, when there are thousands or for—hundreds of thousands of them, you can put them so close to where you need the electricity that you can also take their waste heat, because all of these systems make mostly waste heat of whatever energy they burn, but you can't transmit heat very far, but if you made lots of small distributed plants, you would sort of get as a bonus, you could use the waste heat in most places so it is no longer waste, it is what people need for their furnace, not water, you would be much safer against anybody taking one system down. It might require more sophisticated controls and interaction, but as we have heard, that is becoming easier and easier. So if you could create a system instead of taking these very, very old systems, which they sort of have no other choice but to keep them up and operating, and allow them to transition to a new alternative technology, they would do better.

Mr. MULLIN. What is keeping it down? What is keeping the companies from being able to do this? Are we the hindrance?

Mr. KAMEN. From my understanding, when I have talked to people that do generation, that do transmission, it is a—it boggles my mind, as I—I wasn't kidding when I said thermodynamics and engineering is easier than regulation, I have heard CEOs of major energy-related companies say I am not allowed to do transmission, I generate, or I am not allowed to generate, I do transmission. I can't put your box somewhere there. And I get a headache thinking, I think I just spoke to my power company who said I can do this but not do that. Well, my lights only come on when all of that stuff is done.

Mr. MULLIN. Does anybody else on the panel want to address that? What is holding the industry back?

VOICE. I sense they do, but——

Mr. MULLIN. Yes. I am the good guy, I am not going to hurt you, but I need. Look, I come from a business, and the only reason why I am here is because the biggest problem I had with running our company was rules that were being made up here.

Mr. IVY. Um-hum.

Mr. MULLIN. And so I understand it, but I need to know what it is that is holding you back so we can help.

Mr. IVY. Let us look a little bit at the macroeconomic piece of it. And, you know, the answer or the solution for the future is, and I will tell you is a combination of all the stuff that we have been talking about. So you have a great panel here.

We—when we build a $300 million natural gas combined cycle generating unit, we spread the cost of that out over 25 to 40 years maybe, and whoever is on the system at the time gets to help—not only do they get the benefit of it, but they get to help pay their share of the cost for that facility.

I have been challenged with being a little stodgy, little narrow-minded in my thinking, but we are that way be design and I accept that almost as a pat on the back because we are that way by design. We don't change quickly. I am leveraged right now about 60 percent debt to my assets, and that is fairly typical for the utility business. So we still have to look at the long-term payout before we start looking at a rapid and widespread integration of these different types of technologies that we are hearing. That is one of my main concerns. And I will tell you, that is a local issue, and we are talking about it. We are talking about it with our city commission, about the need to start changing our minds about how long we should be amortizing that debt out like that. So it is going on but unfortunately, it is not going to happen really quick.

Mr. MULLIN. Thank you.

My time is out.

Mr. WHITFIELD. At this time recognize the gentleman from Virginia, Mr. Griffith, for 5 minutes.

Mr. GRIFFITH. Thank you very much. Wow, what a great panel you have put together, Mr. Chairman. It has really been a very educational morning. I have been here since the beginning, so I can say that you all have been very helpful in educating me. I happen to be one of the few members of this committee that is one of those evil lawyers everybody talks about, so I need lots of help in understanding these things. But I am concerned about privacy issues, and, Mr. Ivy, your company has some smart meters, as I understand it, and you all have an opt-out provision. Can you tell me what that is important to your customers?

Mr. IVY. The opt-out provision is as much not wanting to have a smart meter on the side of their house as it is anything else, frankly. So they have a standard digital meter that we read manually once a month. That is not very many that are left, and less than ½ a percent of our consumers went that direction. I am more concerned about the hourly information that we can collect and maintain in our large database that we have. That is the part that I am looking to try to conceal, and if people can still get access to more historical-type information that they can get already before smart meters were available, fine. I don't have an issue with that.

Mr. GRIFFITH. OK. I do appreciate that. I am concerned about all the collection of this data and being able to predict with the new smart grids and so forth what the usage is going to be is very important, but when it comes to an individual house, sometimes, you know, just because we can doesn't mean we should. So I appreciate that perspective. I am excited—although I am having some kind of a technical glitch here, I don't know whether my phone is too close or whether I am just electric today or something—but, Mr. Kamen, I am excited about the technology you are talking about with these small generators. So how small a facility can they be used at, and how big can you go?

Mr. KAMEN. Sadly, I think again, the thermodynamics limits this kind of technology from getting very, very big, but it can get pretty small. We built a few small ones for DARPA a number of years ago that a man could carry around base, and run it on any liquid fuel. The ones that we build now at NRG produce 10 kilowatts, that is enough for a small neighborhood of houses or a small business——

Mr. GRIFFITH. All right, let us——

Mr. KAMEN [continuing]. The size of a typical home appliance. I——

Mr. GRIFFITH. Let us define that small neighborhood. I live on a cul-de-sac with 13 houses, do I need to be bigger?

Mr. KAMEN. OK. The average American home consumes less than 2 kilowatts. So a 10 kilowatt unit, and I would probably put a cluster of three or four of them on a pad, and then they, at that last pad at the bottom of what used to come from all those things we have been talking about, distribution, switch—half—let us say four of these on a pad would handle your neighborhood and would have the advantage that if one of them went down, with the redundancy, you have the other three would keep everybody happy, and at their convenience, somebody would fix the one that went down.

Mr. GRIFFITH. And as a part of that, because I was thinking about it when the testimony was going on earlier about the storms and the neighborhoods being wiped out——

Mr. KAMEN. The big advantage we have is, of course, we run on any fuel, and typically your neighborhood has buried lines in it that are bringing natural gas. You probably have buried tanks with heating oil or propane. Those things are way less susceptible to problems than wires running through all the trees that get taken down by ice or wind or hurricanes, and these boxes then are so close to where you need them that the rest of the system going down hundreds of miles away isn't going to affect you, and again, they are so close to your loads that you can also take their "waste heat" and turn it into your heat and hot water. It is no longer waste.

Mr. GRIFFITH. Well, I am hoping I have time to get back to waste heat, but you said it could use any fuel at—on a couple of occasions, but then once you said liquid fuel——

Mr. KAMEN. Or gaseous. We right now run on natural gas, propane, diesel fuel, gasoline. The device is actually running on something that looks like a burner in your hot water heater, which is why it doesn't make lots of noise. An engine, diesel cycle, Rankine cycle, auto cycle, typical—an engine has a very specific kind of fuel because it touches every part of the inside of your engine. It gets atomized, a spark comes in, compression come—an engine typically has a very, very selective appetite for fuel, but your hot water heater will keep water hot if there is a flame under it, and it doesn't really care what the fuel is. We are running a system that looks much more similar to your hot water heater, but we turn some of that energy into electricity instead of heat.

Mr. GRIFFITH. So if I had a big storm, and for some reason I lost—let us say I have natural gas, which my neighborhood doesn't, but let us say that we had natural gas, and some—for some reason we lost our natural gas, would I be able to drive down to the local gas station and——

Mr. KAMEN. Absolutely.

Mr. GRIFFITH [continuing]. Get my tank filled up?

Mr. KAMEN. Absolutely. When we were asked to fire these little ones up for the Department of Defense, the original deal they said was you have to be able to switch from one fuel to another with only a 2-hour cool down, shutdown and refit it. We said to them we don't need 2 hours, we will add a little gasoline to the diesel fuel, throw in a little beer and let it keep running, and we never even shut the engines off as we changed fuel.

Mr. GRIFFITH. I think this is exciting, and I would love to get to waste heat but my time is up, but I find it exciting from another perspective because one of the fears that some folks have, and I am—probably share some of that, is that if you get a smart grid that covers everything, and you have just a few big providers, that gives a lot of power to a few folks in the switch room. This gives power back to smaller communities and so forth, and I think it is very exciting technology.

Thank you all so much for being here, all of you. I had other questions for others but I don't have time, but what a great panel. Thank you.

Mr. WHITFIELD. Gentleman yields back.

At this time, recognize the gentleman from Texas, Mr. Green, 5 minutes.

Mr. GREEN. Thank you, Mr. Chairman. And I want to thank our panel.

You know, we draft legislation and if it becomes law, it may be 30 years before we go back and visit it. And back yesterday, we had a hearing on oil exports, it is from the 1970s. I know you all have a lot of good suggestions in your remarks about what is going to happen in the electricity market over the next few years in alternative fuels. I just am glad to hear that, you know, my generator I bought when Hurricane Ike was hitting Houston, Texas, in September 2008, that I may have another fuel source from going down and, you know, buying gasoline. And the problem is we haven't needed that generator for 7 years, but—so I have to start it up every 30 days to make sure it doesn't foul up when we need it.

I know that sometimes you are all over the board though on envisioning what may happen with industrial and consumer demand. I know the testimony, and we have seen it, efficiencies, that is part of—should be part of what we do, but at least in my area, and I have east Harris County, we have refineries and chemical plants, they are always looking for ways that they can efficiently run those plants and, you know, as cheap as they can. And some of them probably have cut their fuel requirements over the years because the cogeneration and lots of things, in fact, I don't think we have a chemical plant that doesn't have a cogen facility, but do you expect industrial and consumer demand to increase over the new few years? We can't save our way out of the power.

Mr. IVY. If I can jump in. I assume you are talking about retail customer consumption, industrial consumer demand. What we are seeing all across our industry is kind of a suppression of demand increase on us. So on a per unit basis, let us say, households, for example, they are not consuming even though they have as many appliances as they have ever had. They have much more energy-efficient appliances. And we are seeing a little bit of that on the industrial sector as well. We are going to see a—I will caveat this, based on the cost of energy, we could see an increase in industrial demand based on industrial growth, able to add new processes to their facilities and whatnot, and I think that is very important while we continue to keep our eye on what the price that we are giving them is, because that signals what they are going to be doing. That is going to be probably where the main amount of growth in electricity consumption comes from, in my opinion.

Mr. GREEN. Anyone else?

Mr. PATEL. Well, I think there are certain parts of the country that are seeing load growth because of electric vehicles. That is obviously very small as a percentage of load growth right now, but that is occurring, and I think that depending on the price evolution of electric vehicles, we could see a rapid adoption of that. But I would also say there is something that is actually keeping or containing the growth on the electrical demand side, and that is the fact that, it goes back again to our regulatory compact since 1935 which, in effect, utilities are constrained to operate at one point in the customer's demand curve. And it is actually multiple points depending on whether you are a, you know, industrial or commercial customer, but there are relatively few points on the customer's demand curve that utilities are constrained to operate on. If we were imagined to say allow the utility to address different customer demands, but also at different price points, now the total opportunity to the electrical—to the electric delivery ecosystem as a whole actually can increase. And there are some prime examples of where there is a need to do this. In storm—particularly storm-prone areas, there are cases where there is a demographic living in those areas that are actually willing to pay more for electrical service should it be recovered more quickly. Now, the utilities are currently constrained to offer a price of electricity in that area and other areas in their service territory that is the same, yet there is demand that goes unfulfilled because of this fact. And so if you were to enable utilities to operate at multiple points and address—

diversify demand from the customer, you can actually now increase the total size——

Mr. GREEN. I only have 5 minutes, so appreciate it.

One of the issues though, and I understand where you are coming from on that, but—is infrastructure. For example, we have—Texas has grown—wind power—predominantly in west Texas, but also on the Gulf Coast. Gulf Coast it is much easier to do transmission to the urban areas, San Antonio, Austin, Dallas, Fort Worth, whereas west Texas, the ratepayers in Texas to get that spending $5 billion for the transmission. And we are—of course, we have a competitive market in ERCOT that—and we are very proud of that. In fact, whether you are democrat or republican for Texas, we barred our ability—although ERCOT has gone through some tough times, but I think they are back on their feet now, they are much better.

Mr. Ivy, in the sector—the new transmission lines, we—should we be concerned with building more of these intrastate in eastern Texas or interstate?

Mr. IVY. As renewable energy gets to be much more prolific in our industry, our ability to offload the variability is a way to help manage the system reliability. If any one of us believes that we are going to get up to 30, 40, 50 percent penetration and manage it all on our own, we are not drinking the right Kool-Aid. So I think it is very important that we start looking at—in Texas' case, that is almost blasphemy to say that you are going to build transmission outside the State like that, but you may well get to the point where that needs to be the thing that you do just to be able to help manage the variability, but still facilitate——

Mr. GREEN. Mr. Chairman, I appreciate it, and I know I am out of time, but in Texas we don't mind selling it to you, we just don't want you to take it from us.

Mr. WHITFIELD. Thank you.

And at this time, I recognize the gentlelady from North Carolina, Mrs. Ellmers, for 5 minutes.

Mrs. ELLMERS. Thank you so much to my colleague, and thank you for this panel. This is awesome. And, Ranking Member McNerney, I don't know if he had mentioned, because I had to step out, that we co-chair the Grid Innovation Caucus together, and we are very, very excited and energized, no pun intended, on this issue and all of the significance of it.

And, Mr. Kamen, I can't agree with you more, when it comes to thermodynamics and then when you are talking about what we do here, it makes absolutely no sense. You are talking about logic and facts, and unfortunately, many times those things do not fit into what we do here, unfortunately. So, you know, it is so funny, I have my list of questions and I have changed up, you know, as I am listening to the conversation because I want to ask everything and, obviously, I can't.

I do want to get to the question of the hurdles that are in place, that are standing in the way of us moving forward with more of the grid innovation, and how do we pay for this, what do we do, how can we do a better job as legislators just being able to tell your story and the advancements that can happen. You know, I just believe that when we are talking about energy, and long-term energy policy for our future of this country, we have the grid technology as a part of that conversation. It is just so vital to our future.

You know, Mr. Atkinson, I just want to go back to the conversation we have been having about the, you know, how we incorporate analytics into everything that we are doing, and obviously, that is a big part. As far as your ability to improve the way you forecast how energy will be used into the future, and the supply that is needed, are your companies incorporating these things, do you have that capability, and are there metrics in place now where we can start measuring the efficiencies and the improvements?

Mr. ATKINSON. Yes, we do those things. The—we do, you know, multiple levels of load forecasting——

Mrs. ELLMERS. Um-hum.

Mr. ATKINSON [continuing]. Or help utilities do multiple levels of load forecasting. We have the technology that allows them, you know, short-term, medium-term, long-term, based on lots of factors, lots of variability, historical patterns, weather patterns, existing weather, you know, in the near-term, you know, projected weather in the far-term. That is, of course, only a small piece of data analytics.

Mrs. ELLMERS. Um-hum.

Mr. ATKINSON [continuing]. But it, you know, it is a pretty major piece for the utilities because, you know, as we have talked about here today, you know, there is a lot of assets on the grid and they are incredible assets. A lot of them are very big and move slowly.

Mrs. ELLMERS. Um-hum.

Mr. ATKINSON. You know, what Mr. Kamen is talking about——

Mrs. ELLMERS. Um-hum.

Mr. ATKINSON [continuing]. Are some smaller and more nimble assets.

Mrs. ELLMERS. Um-hum.

Mr. ATKINSON. And, you know, again, you need kind of an all-the-above though. Everything needs to be considered, everything needs to be integrated, and the more accurate you are in what you do, you can balance those different assets and, you know, the intermittency with the other renewable assets as well, you know, be it wind, solar, storage.

Mrs. ELLMERS. Um-hum.

Mr. ATKINSON. Storage——

Mrs. ELLMERS. Um-hum.

Mr. ATKINSON [continuing]. Is a big piece of what we are also talking about as well. So again, it is a little bit of an all-the-above. We have the analytics today to do this kind of forecasting. We have the technology that also integrates, you know, the control systems, as it were, of all the different types of technologies, understands what they are doing, and is able to present a simple view of that to the operators in the control room, to the utilities who are on the frontlines——

Mrs. ELLMERS. Um-hum.

Mr. ATKINSON [continuing]. Of, you know, making sure that we all have electricity at the flip of a switch. That is what we want.

Mrs. ELLMERS. Yes. And, Mr. Christiansen, you—I can see that you want to comment on that as well.

Mr. CHRISTIANSEN. Yes, and I guess the—my comment goes out to the type of data that we use——

Mrs. ELLMERS. Um-hum.

Mr. CHRISTIANSEN [continuing]. When we typically use these analyses, something that Alevo does as well. We try to—we do base systems to evaluate the proposition of what storage brings. And it goes back to Mr. Siebel's comment that, you know, the amount of data that we need to really optimize the grid is tremendous, and when we look at average data of just typically what is available today as an average heat grid for the year——

Mrs. ELLMERS. Um-hum.

Mr. CHRISTIANSEN [continuing]. It really—when we look at the variability and the granulidity we need for the grid today, it is just not enough data to make the——

Mrs. ELLMERS. Um-hum.

Mr. CHRISTIANSEN [continuing]. Choices or to look at the value proposition.

Mrs. ELLMERS. Um-hum.

Mr. CHRISTIANSEN. So really, it goes down to collecting, you know, down to sub-hourly data——

Mrs. ELLMERS. Um-hum.

Mr. CHRISTIANSEN [continuing]. Regarding automation—

Mrs. ELLMERS. Um-hum.

Mr. CHRISTIANSEN [continuing]. That type of data.

Mrs. ELLMERS. One of the things that I have learned over time is for my rural electric co-ops, the importance of the smart meters for consumers and how they have been able to really have that dynamic relationship with their providers, so that they can actually control cost. So I would just like to add to that in my 5 seconds left. Thank you on behalf of the customers of our rural electric co-ops because you are providing for them the—this vital piece so that they can actually be doing a better job in their costs every day. So thank you. And thank you to the panel. You guys are awesome.

Mr. WHITFIELD. Well, thank you.

That concludes today's hearing, and I want to thank each and every one of you for joining us today, for your testimony, for responding to our questions. And we look forward to working with you as we move forward, and it is going to take the efforts of all of us, of course, to be successful.

And I will keep the record open for 10 days for any additional materials.

And with that, the hearing is concluded.

[Whereupon, at 12:38 p.m., the subcommittee was adjourned.]

[Material submitted for inclusion in the record follows:]

## PREPARED STATEMENT OF HON. FRED UPTON

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 jobcreating 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.

FRED UPTON, MICHIGAN
CHAIRMAN

FRANK PALLONE, JR., NEW JERSEY
RANKING MEMBER

ONE HUNDRED FOURTEENTH CONGRESS

**Congress of the United States**

**House of Representatives**

COMMITTEE ON ENERGY AND COMMERCE

2125 RAYBURN HOUSE OFFICE BUILDING
WASHINGTON, DC 20515-6115

March 27, 2015

Mr. Dean Kamen
Founder and President
DEKA Research & Development Corporation
340 Commercial Street
Manchester, NH 03101

Dear Mr. Kamen:

Thank you for appearing before the Subcommittee on Energy and Power on Wednesday, March 4, 2015, to testify at the hearing entitled "The 21st Century Electricity Challenge: Ensuring a Secure, Reliable, and Modern Electricity System."

Pursuant to the Rules of the Committee on Energy and Commerce, the hearing record remains open for ten business days to permit Members to submit additional questions for the record, which are attached. The format of your responses to these questions should be as follows: (1) the name of the Member whose question you are addressing, (2) the complete text of the question you are addressing in bold, and (3) your answer to that question in plain text.

To facilitate the printing of the hearing record, please respond to these questions with a transmittal letter by the close of business on Friday, April 10, 2015. Your responses should be mailed to Nick Abraham, Legislative Clerk, Committee on Energy and Commerce, 2125 Rayburn House Office Building, Washington, D.C. 20515 and e-mailed to Nick.Abraham@mail.house.gov.

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

Sincerely,

Ed Whitfield
Ed Whitfield
Chairman
Subcommittee on Energy and Power

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

**The Honorable Dave Loebsack**

1. **If Europe, mainly Germany, is not implementing new energy grid capabilities correctly, what can we learn from their mistakes?**

Through dramatic action and substantial subsidies, renewables now account for more than a quarter of German energy production. Photovoltaics have provided the most dramatic growth in renewable capacity, and with good reason. Photovoltaics offer clean, distributed electricity, and their unsubsidized cost will soon be competitive with traditional centralized fossil-fuel generation. However, Germany is facing significant challenges integrating intermittent photovoltaic generation with the rest of its electricity infrastructure, and power quality and reliability are threatened.

Ideally, Germany would have balanced their intermittent solar generation with other forms of clean, reliable, distributed on-demand generation. If they had done so, their electricity generation would be cleaner and more robust.

I believe that the electricity grid of the future will include Stirling engines, fuel cells, or other on-demand distributed infrastructure. For that reason, I have directed the engineers at DEKA to develop a Stirling engine that can help our country meet those needs.

FRED UPTON, MICHIGAN
CHAIRMAN

FRANK PALLONE, JR., NEW JERSEY
RANKING MEMBER

ONE HUNDRED FOURTEENTH CONGRESS

# Congress of the United States
## House of Representatives

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

March 27, 2015

Mr. Paul Nahi
Chief Executive Officer
Enphase Energy
1420 N. McDowell Boulevard
Petaluma, CA 94954

Dear Mr. Nahi:

Thank you for appearing before the Subcommittee on Energy and Power on Wednesday, March 4, 2015, to testify at the hearing entitled "The 21st Century Electricity Challenge: Ensuring a Secure, Reliable, and Modern Electricity System."

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Sincerely,

Ed Whitfield

Ed Whitfield
Chairman
Subcommittee on Energy and Power

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

[e] enphase ENERGY

Mr. Paul Nahi
Chief Executive Officer
Enphase Energy

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

April 10, 2015

Subcommittee on Energy and Power

**Question: How does America integrate renewable energy sources in to the energy grid?**

To The Honorable Dave Loebsack,

Currently, fifty different regulatory agencies are responsible for establishing the rules that mandate the procurement of renewable energy resources in each State of the Union. Of these States, thirty have existing requirements for a targeted percentage of renewable resources. For example, in California the regulatory requirement is for 33% of all generation to come from renewable resources by 2020. Regulations such as the Renewables Portfolio Standard (RPS) 33% requirement in California have been strong drivers of procurement for renewable resources over the past five years, to the extent that the cost of wind and solar resources has come down over 50% in the same time period due to cost rationalization and economies of scale. That said, we believe within the next five years solar and wind resources will be more economic than traditional fossil resources propagating a substantial transformation of the electrical grid in all fifty States. One byproduct of the rapid transition to intermittent (i.e. solar and wind) resources and away from baseload (i.e. fossil) resources is need to smooth out the variability of intermittent resources to ensure that generation is coincident with load requirements. Therefore, there is a need for utilities to capitalize on the many solutions that currently exist to integrate renewable resources into the electricity grid.

One common-sense strategy that utilities can undertake at no cost is a balanced approach to procurement. Similar to an investment portfolio, utilities like those in California meet the State's high renewable requirement by diversifying their generation mix (i.e. gas, wind, solar, geothermal, biomass, hydro) of different assets to ensure that supply and demand remain balanced and mitigate the risk of grid instability. To accommodate an unbalanced generation mix, as could exist under significantly higher penetration levels of solar, for example, storage technologies can be deployed to shift solar generation to times in a day when the generation is needed the most and offset any risk of over-generation that may exist. As with solar and wind technologies, we are confident that storage solutions will decrease rapidly in cost over the next several years making these resources readily attainable and economic to utilities across the United States.

Lastly, the technologies utilized in solar systems over the last several years have evolved meaningfully and are now capable of providing grid stability services, thus turning solar into an "asset" to the grid. Solar systems coupled with storage, advanced inverters (i.e. power conversion device) and a distributed communications topology can match generation to demand "seamlessly" and provide "grid support services at a fraction of the cost" than what it would typically cost a utility. That said, these new "smart" solar resources have the potential to save ratepayers hundreds of millions dollars in avoided capital upgrade costs thus increasing the value of solar to the grid.

To conclude, California and other markets such as Germany have illustrated that higher penetration levels of renewable resources can be achieved without the risk of creating grid reliability issues. While every State is different and with its own infrastructure requirements, the integration strategies and technology solutions Enphase recommends can be utilized to satisfy the reliability needs in any market and for any system. As costs come down even further, it is imperative that utilities across the United States adopt the strategies and technologies that exist today. It is also equally important that State regulators mandate the utilization of these technologies to ensure a smooth transition to a new energy economy. Furthermore, the Federal government has the responsibility to ensure the safety and security of the electricity grid and should seek to pursue policy outcomes that harness these same technologies to protect the public and ensure the safe and reliable delivery of energy.

Sincerely,

Paul Nahi
Chief Executive Officer
Enphase Energy

FRED UPTON, MICHIGAN
CHAIRMAN

FRANK PALLONE, JR., NEW JERSEY
RANKING MEMBER

ONE HUNDRED FOURTEENTH CONGRESS

# Congress of the United States

## House of Representatives

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

March 27, 2015

Mr. Naimish Patel
Chief Executive Officer
Gridco Systems
10 L Commerce Way
Woburn, Massachusetts 01801

Dear Mr. Patel:

Thank you for appearing before the Subcommittee on Energy and Power on Wednesday, March 4, 2015, to testify at the hearing entitled "The 21st Century Electricity Challenge: Ensuring a Secure, Reliable, and Modern Electricity System."

Pursuant to the Rules of the Committee on Energy and Commerce, the hearing record remains open for ten business days to permit Members to submit additional questions for the record, which are attached. The format of your responses to these questions should be as follows: (1) the name of the Member whose question you are addressing, (2) the complete text of the question you are addressing in bold, and (3) your answer to that question in plain text.

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

Sincerely,

Ed Whitfield
Chairman
Subcommittee on Energy and Power

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

GRIDCOSYSTEMS™

POWERING THE AGILE GRID™

April 7, 2015

Ed Whitfield
Chairman
Subcommittee on Energy and Power
Committee on Energy and Commerce
Congress of the United States
House of Representatives
2125 Rayburn House Office Building
Washington, DC 20515-6115

Dear Mr. Whitfield,

Pursuant to your letter dated March 27, 2015 regarding additional questions following the Wednesday, March 4th, 2015 testimony at the hearing entitled, "The 21st Century Electricity Challenge: Ensuring a Secure, Reliable, and Modern Electricity System;"

1. Name of the Member whose question I am addressing: The Honorable H. Morgan Griffith
2. Question: **Mr. Patel – in your opening statement, you said, "Customer adoption of electric vehicles is creating new demand for power, each vehicle equivalent to an entire home while charging, requiring new utility demand control measures to avert overloading of existing infrastructure." Please provide the study or data which you are using as a basis for your statement that electric vehicles are creating new demand for power equivalent to an entire home.**
3. Answer: Various sources of data are available to support my statement that electric vehicles are creating new demand for power, equivalent to an entire home. One such source is a December 2014 ARRA report produced by the U.S. Department of Energy titled: "Evaluating Electric Vehicle Charging Impacts and Customer Charging Behaviors: Experiences from Six Smart Grid Investment Grant Projects" (http://energy.gov/sites/prod/files/2014/12/f19/SGIG-EvaluatingEVcharging-Dec2014.pdf). On page iv of the report, in the Grid Impacts section of Table 1. Summary of Key Project Experiences, it is noted that "The average power demand to charge most vehicles was 3 -6 kilowatts, which is roughly equivalent to powering a small, residential air conditioning unit." It is also noted in the same section that "...depending on the model, the load from one electric vehicle model can be as much as 19 kilowatts, which is more than the load for most large, single-family homes."

Please let me know if I can provide any additional information.

Kind regards, [redacted]

Naimish Patel
CEO, Gridco Systems

Cc: Nick Abraham, Legislative Clerk, Committee on Energy and Commerce