

# Advancing the US Electric Grid

BY DARRELL DELAMAIDE & CARL WINFIELD

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**BIG CHANGES HAVE BEEN COMING TO THE ELECTRIC GRID FOR MORE THAN A DECADE.**

The pace and the scope of the transformation of our vital electric grid is about to ramp up significantly.

Innovative technologies are the key to renewable energies taking up the slack from fossil fuels as demand for energy grows exponentially.

So said a number of well-respected, high positioned energy sector thought leaders at **Icons of Infrastructure's** inaugural conference in Washington, **Advancing the Electrical Grid**. Icons is meant to identify and promulgate American infrastructure wins.

**Protect Our Power** and the **Bipartisan Policy Center** sponsored the half-day conference.

NuScale Power intends to take a big bite out of future energy demand using its innovative small modular reactors or SMRs.

“The younger generation is new to nuclear,” explained Christopher Colbert, chief strategy officer. “They see nuclear as potentially a key contributor.”

SMRs solve many of the traditional problems associated with nuclear power, Colbert explained, from the potential of a toxic meltdown to the long planning and construction times. The 60-megawatt modules are assembled at the factor and delivered to the site. “There is no more construction on site,” Colbert said.

The reactor is 65 feet tall and 9 feet in diameter and sits in a containment vessel that is 76 feet by 15 feet. In line with simplifying the whole process, the cooling water operates

on the convection principle – no pumps are needed to circulate it through the reactor.

The cascading problems of a meltdown like the one at Fukushima in Japan can also be avoided. The loss of power made it impossible for technicians to supply sufficient cooling to the large reactor.

NuScale’s modules shut down automatically when power fails.

“If there’s no power, there’s no need for cooling,” Colbert said. “If you do nothing, the plant will be safe.”

Up to 12 modules can be connected to provide 720 megawatt of power, with modules added as needed. NuScale has already signed up the Utah Associated Municipal Power Systems (UAMPS), even though the first reactor won’t be ready to go online until 2026. The nonprofit serves 45 community-owned power systems in Utah, California, Idaho, Nevada, New Mexico and Wyoming.



Change is coming at the very roots of our electric system.

“Solar and wind will account for about two-thirds of electrification by 2050,” said Peter Green, chief research director at **National Renewable Energy Laboratory**.

The global population will reach 9.8 billion by then and worldwide GDP will double, according to NREL’s forecast. Primary power use in 2050 is projected to be around 50 terawatt, compared to less than 10 now.

Nuclear power, as well as renewables, will be in the mix.

Similarly, new technologies in solar and wind will lead to an expanded role for these energy sources, Green said. “Already the cost for utility scale generation is cheaper than conventional sources,” the NREL official said.

Solar energy is limited by its reliance on silicon for photovoltaic generation. “Silicon is actually not the best material for solar panels,” Green said. It happened to be in abundant supply when PV panels were developed, but it is not the most efficient material. It is also expensive and harder to produce. “Crystalline silicon alone will not meet the projected terawatt power needs for solar energy,” Green said.

Perovskite, a simpler crystalline structure, is cheaper and more efficient, if less stable. However, a hybrid perovskite solar cell can be quickly mass produced and fill the need for the expansion of solar energy. “It would take three years to manufacture 25 terawatts of 15 percent-efficient HPSCs, compared to 170 years at current capacity for silicon PVs,” Green said.

Wind energy, too, requires great improvements in efficiency, Green said. Improving efficiency at the wind farm level is one of the “grand challenges” facing growth in wind as an energy source. Turbines need to be taller, and that will require lighter materials. It will also require more research into the atmosphere to better understand wind activity at those heights and how it will affect “rotating skyscrapers.” A final challenge will be to generate huge amounts of data and modeling techniques to figure out how to best leverage wind energy to service the grid.

Green feels the industry will be up to these challenges. “The drop in the cost of wind and solar tell you about the future,” he said. “We need investment to get game-changing technologies.”

Colbert seconded the notion and attributed the new acceptance of nuclear as alternative to a younger generation without preconceptions. He noted that city councils in 28 of the UAMPS municipalities had already voted in favor of the NuScale modules. “That shows there is not quite the opposition we think there is,” he said.

Even so, Colbert said three-quarters of NuScale business will be outside of the United States – in Europe, Africa and the Middle East – once the module is operational. “They have higher gas prices than the United States,” he noted, which has benefited from shale gas exploitation.

Also, many places in Africa simply don’t have the electricity



Caitlin Durkovich, of Toffler Associates, Paul Feldman, of Protect our Power, and moderator Marty Rosenberg.

resources Americans take for granted. “In some places, they shut off the electricity at night,” he said.

New technologies and greater use of renewable energy will pose its own set of challenges, Green said. Low-cost energy storage to minimize curtailment of wind and solar power will become more urgent. Artificial intelligence in the form of machine-learning algorithms will make energy use far more efficient, as will advanced power electronics.

While the grid is transformed – much thought and effort is dedicated to making it more secure.

The nation’s grid remains vulnerable.

This was the message from experts at the conference who discussed the need to secure America’s energy infrastructure for the 21st century.

“The current level of activity is insufficient to prevent risks going forward,” said Paul Feldman, technical director of Protect Our Power and former director of MISO, the Midcontinent Independent System Operator.

“No CIO believes they are sufficient,” he said at the conference late last week.

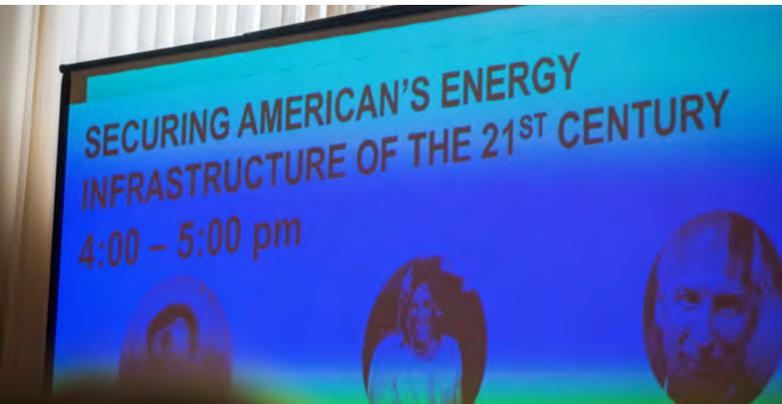
Feldman’s nonprofit focuses on best practices that go beyond just strict compliance. They pin their hopes on vendors to conduct the basic research and development for new security products. “Utilities only do things that have a guaranteed return,” he said. But the 700 or so vendors who sell to utilities have an incentive to develop new products.

If an outage appears inevitable, then the critical issue is how quickly power can be restored, and this is another focus of the nonprofit. “We are looking for ways to make the grid more resilient,” Feldman said. “We examine anything that could take the grid down and then how to reboot or reassemble to restore power quickly.”

This is why it is important to secure the supply chain for the infrastructure, both hardware and software, said Caitlin Durkovich, a consultant with Toffler Associates and former assistant secretary for infrastructure security in the Department of Homeland Security.

Outsourcing for many products and services has increased vulnerability on this score, as has the increase in hostile actors. There needs to be a proactive approach to securing the supply chain, she said. “It goes back to design,” Durkovich said. “You have ensure the provenance of your supply.”

Better design for security is a top priority, she said. This becomes more urgent with the massive electrification of society – from smart buildings to electric cars – along with decentralization and digitalization. “As things grow more interconnected, they become more interdependent,” she noted. The Internet of Things and 5G connectivity are ways this interconnection is increasing, and it will increase vulnerability of the grid.



The grid as it exists has developed haphazardly, but now it is time to step back and rethink things from the point of view of security, panelists said. Security needs to be “engineered from the get-go,” Durkovich said, from transmission to storage. The convergence of information technology and operations technology simplifies the goal – systems need both cybersecurity and physical security.

Redundancy, as is common in IT, must become a feature of all infrastructure. Communications networks, for instance, should have space infrastructure as well as terrestrial. “There should be no single point of failure,” Durkovich said.

Resiliency is the focus of FERC commissioner Neil Chatterjee, his technical adviser Eric Vandenberg said. Chatterjee was due to speak but was detained at the last minute. For the commissioner, the question of storage is

## “We simply don’t have the option to expose the grid to product failure.” Said Rodney Blevins, Dominion Energy senior vice president and chief information officer

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vital to increasing this resilience, reinforcing the role of micro-grids and solving some of the transmission issues, Vandenberg said.

FERC currently is legally barred from making any rules for the distribution system, which lies in the province of the states. It would take a change of the Federal Power Act to give the agency more supervision over the grid itself, Vandenberg said.

But rules may be part of the problem, suggested Durkovich. There is so much focus on compliance with legalistic details that utilities resist any other efforts to require security measures. “We need to rethink entire grid with a risk-based approach,” she said. A change of approach might lead to more openness on the part of the industry.

Although natural catastrophe or human error remain major risks, the fastest-growing threat is a cyberattack. The 2015 cyberattack on the Ukraine power grid showed how effective and dangerous this type of attack can be. Attackers were able to “brick” several systems, Feldman explained. That is, they could overwrite the firmware to disrupt the operation of hardware in substations.

Cyberattacks and electromagnetic pulses are two of the top threats preoccupying FERC, Vandenberg said. In addition, physical attacks on substations remain a threat. “We take a holistic view of the risk,” said Vandenberg, including everything from storage and transmission through micro-grids.

Durkovich cautioned that the rise of micro-grids and distributed energy means the government must expand its field of supervision to include these new entrants into the market. They increase the “attack surfaces” for bad actors.

Nor should the human factor be overlooked, she said. For one thing, there is a shortage of qualified staff and the gap is growing. Utilities are now competing with Silicon Valley

for engineers. By 2020, she said, there will be shortfall of some 1.5 million security experts. The contract economy, which results in employees transferring often to another company, only exacerbates this problem.

But there is also a threat in failure to properly vet people with bad intentions. Durkovich said. The insider threat is increasing as companies scramble for staff and the gig economy leads to frequent transfers.

“We need to raise the awareness of how important the infrastructure is,” she said. Working at a utility should have as much appeal as working at Apple. It is important, she stressed, to keep the interface between human and machine.

“Don’t engineer the human out,” she warned.

That is just part of a multi-pronged approach to grid security now embraced by the utility and energy sector.

The public and private sectors are increasingly focused on using analytics to make the nation’s electrical grid more secure than developing new technology.

“We’re looking at how do you get information out of the data you already have,” said Eric Lightner, director of the Department of Energy’s Smart Grid Task Force.

“You have data coming from your advanced metering infrastructure (AMI) network; you have weather data; and all kinds of voltage data, he said.

“I’m thinking about how you share measurements and applications to determine value you didn’t see before,” Lightner said.

Lightner noted that DOE sees great promise in using algorithms and analytics to extract data. He added that, for the most part, the department’s emphasis has moved away from research and development and more toward the application of existing technology.

“We’re looking at sensors, controls, storage and transmission lines,” Lightner said. “I’d say predominantly, maybe 85 percent of what we’re looking at is how to use the same technology to accomplish different things.”

Rodney Blevins, Dominion Energy senior vice president and chief information officer, said that the utility is currently using analytics in its customer information system to identify those who steal power.

He added that the cyber security component of Dominion Energy’s industrial control system side is able to use data analysis to detect anomalous behavior on the grid. The

potential applications for analytics are far more robust, he said.

“The opportunities for analytics to turn into insight for better operation of the grid in terms of service or resiliency is almost endless at this point,” Blevins said, noting that firms such as Waynesburg, Pennsylvania-based Seven Point Energy in the aftermath of Hurricane Harvey showed the extent to which data could be used.

There are a lot of things you think about in terms of storm restoration but they got into things like coastal flooding and knowing what figures are in the water,” he said. “They got into a level of sophistication that really gets you excited [for what analytics are capable of].”



Dave McCarthy, of Potential Energy DC, and Raj Lakhiani of Athena Power.

Lightner said that the DOE is also investing in high-fidelity, low-cost sensor technology as a means to bolster the speed and amount of data available to utilities. He noted that the sensors will relay high-frequency information about events occurring on the grid to utilities, allowing them to replace assets such as transformers more proactively.

The Trump administration has shifted the agency’s focus to national security and grid reliance and away from research and development, according to Lightner. However, the DOE is also exploring the use of microgrid technology to mitigate the effects of devastating natural disasters such as Hurricane Sandy.

The agency has participated in demonstrations and deployments of microgrid technology in other countries,

Lightner said. Despite having begun researching the technology in 2012, it has not yet been universally adopted on the U.S. grid.

“Hopefully we’ll be able to apply these on a national basis where it will be cost effective to avoid the extent of some of these events in the future,” Lightner said.

Blevins said that the development of grid technology requires a significant amount of R&D, which due to time constraints is not the best fit for venture investors. He added that exiting development models must be explored for continued maintenance and advancement of the grid.

“A development model that allows for longer time horizons to fully develop products before they are deployed by the thousands is absolutely necessary for continued R&D,” Blevins said. “We simply don’t have the option to expose the grid to product failure.”

Blevins also noted during the event that while there are states that fund R&D directly, the regulatory environment largely determines the degree of investment and deployment of new technologies. He added that while infrastructure builders have to be more transparent throughout the construction process, regulators have to deliver certainty in terms of what is required in the timeline.

Lightner said that while other public agencies stand to see reductions in funding due to sweeping federal tax cuts, the DOE and the Smart Grid Task Force remains in a privileged position.

“I think funding for research in the electrical industry is seen as a valuable investment by both parties,” Lightner said. “Moving forward I don’t think there will be huge increases for our budget, but in times of a lot of cost cutting, to be levelly funded is a big win.”

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