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Before the
Committee on Energy and Natural Resources
Subcommittee on Energy
U.S. Senate

On "Fostering Innovation: Contributions of the Department of Energy's National Laboratories"

Sept. 12, 2017

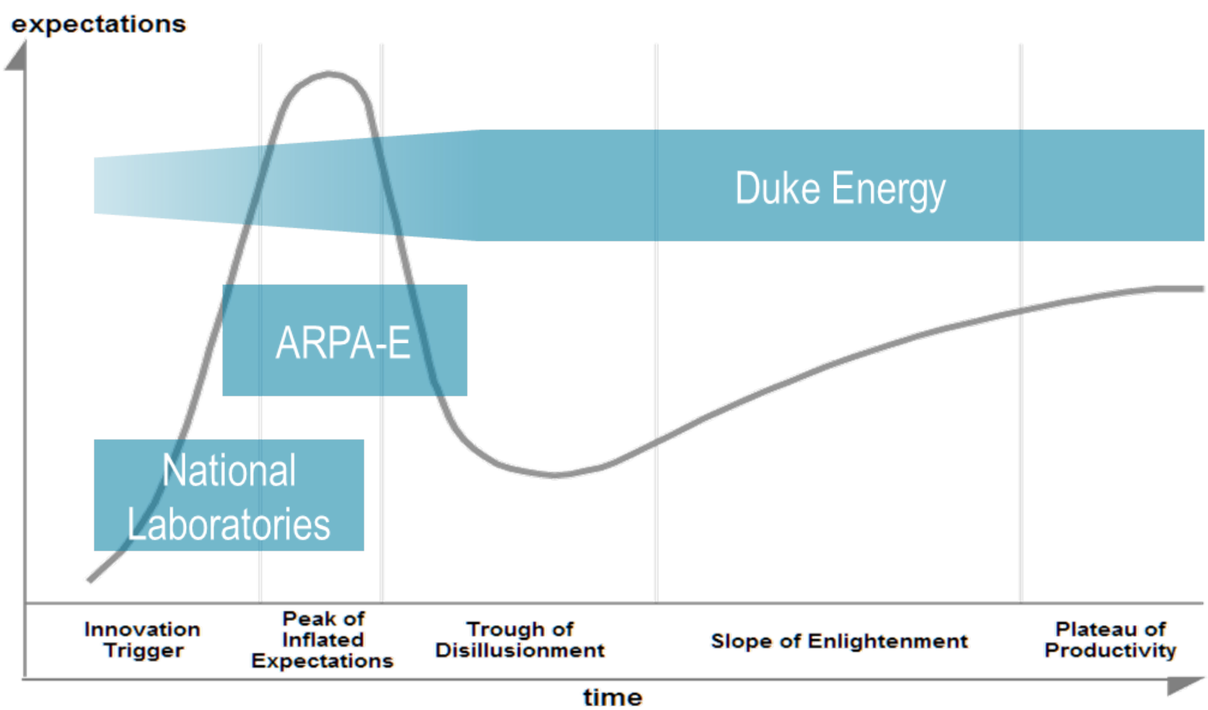
Good morning, Chairman Gardner, Ranking Member Manchin and members of the subcommittee. My name is Anuja Ratnayake, and I serve as Director of Emerging Technology Strategy for Duke Energy. Our team leads emerging technology pilot projects, including energy storage, microgrids and renewable energy integration and work with the National Laboratories.

I appreciate the opportunity to provide the subcommittee with the perspective of a regulated electric utility on the value the Department of Energy's National Laboratories provide to the electric power sector and our customers.

To provide some context for my comments, Duke Energy is one of the largest energy providers in the nation, serving approximately 7.5 million retail electric customers in seven states in the Southeastern and Midwestern regions of the country. We are also one of the largest natural gas distributors in the country, serving approximately 1.6 million customers in the Carolinas, Ohio, Kentucky and Tennessee. Our energy grid, the largest in the United States, is a critical part of our nation's infrastructure. We are investing $25 billion over 10 years to create a smarter, more modern grid that delivers the services our customers expect. Today, the grid stands as a one-way road. In the future, it must become a multilane highway, sending energy and information in both directions. We serve a population of 24 million people, relying on a balanced energy mix that includes natural gas, nuclear, coal, hydropower, solar and wind energy. Our Commercial Renewable Energy business unit operates a large and growing portfolio of solar and wind facilities in 14 states across the United States. We are one of the top five renewable energy companies in the country, having invested more than $5 billion in renewables over the last decade.

As a vertically integrated utility responsible for the full energy spectrum from generation to delivery to the customer, Duke Energy operates under a regulatory model that prioritizes lowest cost for customers and traditionally proven technologies. The current utility regulatory structure does not incentivize research and development (R&D) due to the inherent risks associated with new technologies, which generally result in higher costs compared to mature, proven technologies. This limits our ability to test new technologies and operational methods – and is exactly the reason the National Laboratories and programs such as ARPA-E serve such a vital role for the power sector. Although Duke Energy invests tens of millions annually on R&D (we spent over $30 million last year), it is important to remember that utilities are not R&D tech companies in the Silicon Valley sense. We are integrators and optimizers of proven, commercialized technology – and we're highly regulated in our scope of business.[i]

Most utilities rely on universities, product manufacturers, consortia, and the federal government to sponsor and pursue innovation that benefits our customers. The Department of Energy (DOE) and the National Labs provide focused research on behalf of the utility industry sector. When new technologies emerge, they can take years of R&D before they become viable both scientifically and economically to utilities, as demonstrated by the "Hype Curve" below.[ii] The transformative potential of these new technologies cannot be realized without the National Laboratories.



Source: Hype Cycle from Gartner for IT Leaders Toolkit, Amended by Duke Energy

The Gartner Hype Cycle can be leveraged to help stakeholders understand where technologies are in their life cycle, and to temper expectations on highly hyped opportunities.

The recent scope of other consortia has become narrow, focusing on the short term. Indeed, the National Labs are critical in developing high-impact technologies with long life cycles, such as advanced combustion technologies that are utilized in our power plants, as they have the unique ability to initiate technology transfer from other industries and sectors (such as aerospace and defense) in a way that few other research organizations can. [iii] The National Labs support public and private partnerships that when combined can more effectively transfer emerging technologies to the industry. Often, the R&D that leads to these transformational innovations is simply too complex for any single private enterprise to undertake, which is why we look to the federal government to recognize the importance to help advance technologies to the point where businesses and entrepreneurs can adopt the technologies. For example, DOE estimates that the $4.1 billion investment in solar photovoltaic (PV) technology R&D from 1975 through 2008 accelerated the cost reduction progress by an estimated 12 years, while providing a net economic benefit of $16.5 billion.[1] Some technologies would otherwise be unable to reach commercialization without the participation of the National Labs, particularly if they are left to be developed in the private sector where returns are expected within short time windows.[iv] This is particularly important given the increasing rate of change in the energy industry that is being driven by technology advancements and evolving customer expectations.

Finally, laboratories are uniquely positioned to handle complex, sensitive and/or classified issues of critical importance to the utility industry, such as cybersecurity and resiliency. The research outcomes that the National Labs produce is open sourced to allow utilities to modify and adapt the results.

Today I will highlight three examples of innovation born out of collaboration with the National Labs that has helped Duke Energy ensure our customers have reliable, affordable and increasingly clean energy. These projects have spanned (1) seamlessly integrating renewables, (2) increasing grid resiliency in a distributed energy resource rich future, and (3) increasing the efficiency of fossil generation. While I will talk specifically about these three examples, there are many more contributions from the National Labs that benefit our customers and will help us build a smarter energy future.

Leveraging National Lab Capabilities to Seamlessly Integrate Renewables

With the increasing role that renewables have on the energy grid, Duke Energy recognized a need to improve system planning and operations to seamlessly integrate these intermittent resources and maintain the electric reliability our customers count on. We found our solution by initiating a collaborative partnership with Pacific Northwest National Laboratory (PNNL) beginning in 2012. We conducted four studies with PNNL to understand and manage potential operational and cost impacts of increasing percentages of solar PV production.

The first study simulated the impacts of high rates of solar PV on the grid so that we could operate system infrastructure and particularly our generation portfolio reliably and at the lowest cost to customers. [2] While the project informed system planning and impact on customer rates from increased levels of intermittent renewables, it also helped us to understand how the system would operate in the future so we could revise operational guidelines and identify opportunities

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[1] U.S. Department of Energy. *Revolution … Now: The Future Arrives for Five Clean Energy Technologies – 2015 Update*. November 2015. Available at: https://www.energy.gov/sites/prod/files/2015/11/f27/Revolution-Now-11132015.pdf

[2] The result of this collaboration was published in 2014 as the Duke Energy Photovoltaic Integration Study: Carolinas Service Areas. Pacific Northwest National Laboratory, Report No. PNNL-23226. Available at: http://www.pnucc.org/sites/default/files/Duke%20Energy%20PV%20Integration%20Study%20201404.pdf

to improve. We dug deeper in a second study with PNNL to evaluate leveraging emerging technologies such as energy storage, smart inverters, and demand side management to most effectively integrate new assets and increase solar generation. This work opened the door for us to rethink how to plan a smarter energy future for our customers.

The National Renewable Energy Laboratory (NREL) further supplemented our understanding of system planning and operational impacts through its Eastern Renewable Generation Integration Study (ERGIS) of the Eastern Interconnection – one of the largest power systems in the world, which spans from central Canada (excluding Québec) eastward to the Atlantic coast, south to Florida and west to the foot of the Rockies (excluding most of Texas). Because of the complexity of the Eastern Interconnection, the unique capabilities of NREL's High Performance Computer (HPC) were critical to this study. The cost of maintaining a HPC for system planning and operations purposes is well outside of even the largest utility's ability. Individual utilities, even partnerships among utilities, would be hard pressed to complete an evaluation this complex both from skill as well as resource availability perspectives. Using high-performance computing and innovative visualization tools, NREL shows the power grid of the eastern United States has the potential to accommodate upward of 30 percent wind and solar/ PV power. These studies are essential to plan for incorporating new technologies and planning the energy grid of tomorrow. Further, it is important for such work to be conducted by unbiased third parties, such as the National Labs, that do not have a commercial interest in the resulting investment portfolio.

Increasing Grid Resiliency with Flexible Distributed Energy Resources

In addition to accommodating greater percentages of intermittent resources like solar, changing weather patterns introduce a new resiliency paradigm for the energy industry. Superstorm Sandy and Hurricane Harvey are providing our industry with real-life indications of how our infrastructure planning will need to evolve in the future. Distributed energy resources (DER) and microgrids will increasingly provide resiliency services during catastrophic events.

Indeed, the electric power industry will continue to evolve as DER and intelligent customer devices are more widely deployed. We must overcome the challenges with today's centralized energy grid, including limitations associated with human monitoring and control of grid resources and aging analog devices, which hamper our ability to integrate high penetrations of renewable energy. Our industry is committed to enhancing grid resiliency and leveraging DER technologies. At Duke Energy, we currently have a proposal under consideration with the Grid Modernization Laboratory Consortium's most recent lab call.[3] The objective of this project is to accelerate the deployment of resilient and secure distribution systems that leverage our traditional distribution assets as well as new DERs and microgrids. While more advanced distribution management solutions are emerging with increasing capabilities, we continue to identify gaps as we work to optimally manage our grid. In the future, it will be critical for the centralized system to be able to coordinate with those decentralized DERs and microgrids that

[3] "Increasing Distribution System Resiliency using Flexible DER and Microgrid Assets Enabled by OpenFMB" partners include PNNL, NREL, Oak Ridge National Laboratory, GE Grid Solutions, UNC Charlotte, University of Tennessee, Smart Electric Power Alliance and Duke Energy with advisors from Entergy, Avista and North American Energy Standards Board.

are located at the edge of the grid – what we call "grid edge" technologies. Duke Energy is committing $1.2 million over three years to this project, and our hope is to work with the National Labs to deploy "distributed intelligence" that will provide for grid security and interoperability. [4] The results of this project would be applicable to a wide range of technology combinations and all regions of the country. For Duke Energy, this project will inform our grid modernization planning as we work to provide an increasingly reliable and resilient grid to power the lives of our customers.

Improving the efficiency – and affordability – of natural gas generation

Natural gas generation serves a vital role in the power system as dispatchable, flexible capacity to meet electric demand and help manage the intermittency of renewables. Natural gas combined-cycle power plants rely on advanced combustion turbine technology. Today's state-of-the-art "J-class" combustion turbines have an average efficiency of 62.6 percent, but a current project with NETL aims to further improve turbine efficiencies – and thus reduce the amount of fuel needed to produce power. Because fuel savings are passed on dollar for dollar back to electric customers, these projects can lead to a direct benefit of lowering customers' energy bills. The Aerojet Rocketdyne Rotating Detonation Engine (RDE) program, led by NETL, is a perfect example of the need for National Labs to be engaged in long lead-time technologies that support our country's energy future. The program advances combustion turbine technology for combined-cycle applications by integrating a rotating detonation engine (RDE), pressure gain combustion system with an air-breathing power-generating turbine system to reduce energy losses and achieve combined-cycle efficiency up to 68.3 percent. Duke Energy is contributing $150K over three years to demonstrate the technology. A promising early indication is that the advanced turbine design of ongoing operating and maintenance costs are similar to current designs, which would indicate the levelized cost of energy for the RDE plant will be lower than current state-of-the-art combined cycle plants. It is important to note that even high-tech, diverse companies such as Aerojet Rocketdyne are unable to develop these technologies without the commitment of the National Labs.

The Role of the National Labs in Our Energy Future

Our mandate as electric utilities is to provide safe, reliable and affordable energy for customers. Investments in the National Labs enable us to leverage new technologies to modernize the power grid and stimulate economic growth while continuing to meet this mandate. As a result of the National Labs' work, all electric customers benefit from the R&D that advances electric power infrastructure, cleaner energy solutions and more efficient technologies. However, if we were to privatize energy R&D, then technology development will be driven by a singular goal or financial return, and the end result is unlikely to benefit all citizens.

[4] Distributed Intelligence (DI) is an architecture that supports building layered intelligence on the grid to enable a multifunction and integrated distributed grid management systems. With the ability to enhance utilities' capability to monitor and control the flow of electricity, to seamlessly integrate with DERs, and to easily scale to handle millions (and potentially billions) of discrete data points in a secure, timely and cost-effective manner, DI offers great promise to aid the electric utility industry to meet the safety, efficiency, reliability and environmental requirements of the 21st century.

Reliable and affordable energy access has become a customer expectation in the United States – and it is the engine for economic development. The energy grid is the highway that delivers that energy to our communities, and we must continue to invest in that highway infrastructure to keep our economy moving. The National Labs and publicly funded research ensures that electric customers will benefit from the modernization of our energy infrastructure.

The energy sector is going through an exciting and important transformation. We're seeing a powerful convergence of trends in energy technologies, telecom & IT, coupled with changing customer expectations, public policies and business models. To secure a stronger energy future for our customers and communities, we must anticipate and adapt to these changes. As we look to the future, we believe the National Labs and the public-private collaborations through DOE, ARPA-E and other partnerships are critical. The suite of capabilities offered by the National Labs are unattainable anywhere else in the industry and are critical to the industry's ability to understand how to better operate and plan our system for the future. This ultimately ensures electric customers and our communities have the lowest cost, most reliable, resilient, and advanced clean energy system in the world.

Thank you for the opportunity to be here today and I look forward to your questions.

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[i] At Duke Energy, our emerging technology team spends time monitoring trends and industry activity to track technology developments and consider the best time to adopt and deploy new technologies. We focus on:

- Maturation: We work hard to ensure technology moves into a lab test or pilot and ultimately into our operations at the right time in their technology maturation process.
- Utility-scale: Sometimes a technology may be commercially ready, and there's more than one unit out there, but we're still monitoring market acceptance. We really want a technology to be utility grade; that's when we're ready to take it to scale and deploy across our system.
- Customer need: Finally, the most important criterion we evaluate when deploying a new technology is simple – it must deliver value to the customer. Otherwise, it's just technology for technology's sake.

[ii] New technologies pass through several stages on the path to commercialization:

1. Innovation Trigger: A breakthrough, public demonstration, technology/product launch, or some other event generates press and industry interest in a technology innovation. These innovations and discoveries are simply too complex and have too large an inherent risk for any single private enterprise to undertake. The National Labs are often engaged in these breakthroughs, with utilities serving as advisors.
2. Peak of Inflated Expectations: A wave of "buzz" builds and the expectations for this new technology rise above the current reality of its capabilities. In some cases, an investment bubble forms. The National Labs continue to work on these efforts. Startups will begin to emerge that look to capitalize on the excitement. Emerging Technology teams, like ours at Duke Energy, begin early testing to confirm or refute the technological claims.
3. Trough of Disillusionment: Inevitably, impatience for results begins to replace the original excitement about potential value. Problems with performance, slower-than-expected adoption or a failure to deliver financial returns in the time anticipated all lead to missed expectations, and disillusionment sets in. The private sector, VCs, and those early startups will divest and move on to other promising technologies. We must rely on DOE, National Labs and ARPA-E to continue to advance promising technologies through this challenging period. Utilities will look to partner with these organizations to better understand the capabilities and possibilities for the future.
4. Slope of Enlightenment: Some early adopters overcome the initial hurdles, begin to experience benefits and recommit efforts to move forward. Drawing on the experience of the early adopters, understanding grows about where and how the technology can be used and, just as importantly, where it delivers little or no value. Utilities may begin developing pilots and conducting pre-scale deployments as we evaluate the best-use cases and applications for new technologies that bring the most value to our customers.

5. Plateau of Productivity: With the real-world benefits of the technology demonstrated and accepted, growing numbers of organizations feel comfortable with the now greatly reduced levels of risk. A sharp uptick in adoption begins, and penetration accelerates rapidly as a result of productive and useful value. This is when you really see the utility industry start adopting – once the product and financial risk has been mitigated, there are clear use cases for adoption and demonstrated value for the customer.

[iii] Drastic reductions in the cost of wind energy are, in part, a result of the $2.4 billion invested by the DOE in wind R&D between 1976 and 2014, which has enabled many key innovations such as the taller turbines, longer blades, and improved electronics. Public-private partnerships R&D investments have also been critical in bringing down costs for LED lighting by 90 percent since 2008.

[iv] Historically, cleantech companies have been more likely to fail and offer lower returns relative to software companies. Since 2007, only 13 American series A cleantech firms exited at over $500M valuations.