U.S. Department of Energy
Electricity Advisory Committee Meeting
National Rural Electric Cooperative Association Conference Center
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Meeting Summary

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Welcome, Introductions, & Review of Developments Since October Meeting

Michael Heyeck, Chairman of the Electricity Advisory Committee (EAC), introduced Lawrence Mansueti, EAC Designated Federal Officer. Mr. Mansueti called the meeting to order and noted that EAC's recommendations are important to the Department of Energy (DOE). He said only three EAC members could not make it to the meeting. He added that the Smart Grid Subcommittee meeting, which took place in the morning, was robust and provided a groundwork for a productive EAC meeting.

After thanking Mr. Mansueti for his comments, Mr. Heyeck introduced himself and welcomed the attendees. He expressed gratitude for the participants' willingness to serve on this advisory committee and to the National Rural Electric Cooperative Association (NRECA) for hosting the meeting. Mr. Heyeck noted that this is a public meeting and will be recorded for the purpose of preparing a detailed written summary. Mr. Heyeck explained the rules of engagement, including how members of the public could join during the public comments section on the agenda for the following day. He added that the panel on Valuation Proposition for Big Data Analytics will take place in the afternoon and the panel on Electric Sector Cybersecurity Preparedness will take place the next morning.

All Committee members introduced themselves with their name and affiliation. After a brief overview of the agenda, Mr. Heyeck recognized Assistant Secretary for the Office of Electricity Bruce J. Walker.

Update on the DOE Office of Electricity Programs and Initiatives

Assistant Secretary Walker provided an update of recent work from the Office of Electricity (OE) and across DOE. Assistant Secretary Walker said that during the last EAC meeting, he had spoken about the North American Energy Resilience Model (NAERM) that OE is currently working on. He has received many questions about threat vectors, which are a major challenge. He said everybody should have read the Annual Threat Assessment testimony of Dan Coats, the Director of National Intelligence, specifically pages 5 and 6. The testimony shows how seriously OE is focused on understanding the threat vectors to make improvements and modifications to the electric system, whether through operational capabilities or through redesign of the system architecture to achieve the highest level of security.

Assistant Secretary Walker said that OE continues to work on the NAERM with the National Laboratories and the North American Electric Reliability Corporation (NERC) to have a static model with all its interdependencies ready by October of this year. He said funding is available for the NAERM in the FY20 budget. OE will be transitioning the static model into a real-time model by working closely with the industry to make sure federal agencies and stakeholder utilities agree on the model. He said OE is working through the defense critical energy infrastructure and has engaged the Power Marketing Administrations (PMAs) to help implement the model. After the DOE Office of Cybersecurity, Energy Security, and Emergency Response (CESER) was split from OE, OE refocused to its original mission. One of the first OE initiatives integrated the four PMAs within DOE into OE. He explained that the PMAs are transmission

companies. Three of the four PMAs that own transmission assets are critically important because they are in 34 U.S. states, cover thousands of miles of transmission, and tie back to 133 federal hydropower units. He explained that this integration of the hydropower system and transmission system covers a significant portion of the United States, and OE has a responsibility for the R&D components for the electric sector.

Assistant Secretary Walker said that he saw EAC's recommendation to DOE regarding the storage component in the latest work product. He noted that within the DOE budget, there is $158 million for advanced storage research, of which $48 million is within OE. He said that within the OE budget, there is $5 million to initiate a grid storage launchpad, which will enable OE to partner with one or more of the National Laboratories on very specific chemistry-based storage solutions, redox equations, and flow batteries, in an effort to drive down the cost for the cell component. That cost is currently about $275/kW, going down to about $200/kW in the next couple of years, and in the future to $150/kW. In addition, OE is focusing on zinc manganese oxide, which has a cell component cost that is believed to come down to $50/kW within the next five years. OE also would like to bring in private sector organizations to capitalize on the private funding and innovation that has taken place in this space. In the original FY19 budget, putting aside CESER, OE was left with a $68 million budget. In the FY20 budget, based on the significant amount of work OE is doing, for example related to the advancements in the NAERM and the defense critical infrastructure, the budget has been increased by $121 million.

Assistant Secretary Walker said that during the last EAC meeting, he spoke about reserve margins. He said that he announced a $1 million Electricity and Industry Technology and Practices "innovation challenge" at the InnovationXLab in Seattle about six weeks ago. This challenge invites public innovators and academics (including students) to look broadly at how technology can be utilized on the grid to change current industry practices. DOE is seeking creative ideas on how to implement new or existing technologies to address a variety of issues facing the grid. Registration ends April 6 and the deadline is April 24. Assistant Secretary Walker said that the 15% spinning reserve margins stipulated by NERC are derived from good electrical engineering principles and were meant to prevent under-frequency load-shedding during the loss of equipment in the system. OE continues to work with the regional transmission organizations (RTOs) to solve these types of issues through technology advances.

Assistant Secretary Walker said that he and Federal Energy Regulatory Commission (FERC) Chair Neil Chatterjee have announced the joint technical conference on Security Investments for Energy Infrastructure to be held on March 28. The purpose of this conference is to explore incentive-based rates for certain investments focused on physical, cybersecurity, and overall resiliency. A group of witnesses will testify during this hearing. The first panel will focus on the technical solutions, capabilities, and threat vectors, and will involve the Department of Homeland Security (DHS), FERC, and industry. The second panel will be focused on the regulatory construct and how best to provide the incentives for utilities. Assistant Secretary Walker added that OE has worked with the National Nuclear Security Administration to identify practices the agency uses that OE can incorporate into the energy infrastructure for providing physical and cybersecurity protection.

Assistant Secretary Walker then provided an update on Puerto Rico. He said OE continues to

work with the U.S. Department of Housing and Urban Development (HUD), as well as the Federal Emergency Management Agency (FEMA), to help Puerto Rico. OE is working with the U.S. Department of the Treasury to establish mechanisms to get the HUD funding that was appropriated to Puerto Rico, not only for the energy sector—where there was at least $2 billion in HUD funding—but for housing and transportation infrastructure. OE has put together a foundational plan based on all the technical work that has been done within DOE to improve resiliency and reliability for the Puerto Rico Electric Power Authority (PREPA). OE continues to work with the 26 largest power organizations in the American Public Power Association (APPA) and PREPA to help provide day-to-day leadership. As part of this process, OE focused on resilience to find out how to best leverage the capabilities of the industry moving forward. Assistant Secretary Walker said the Stafford Act (Stafford Disaster Relief and Emergency Assistance Act) was used in 2017 for the restoration of Puerto Rico, though the Stafford Act was not written for the purpose of restoration of an electric grid because it only contemplated replacement of equipment with like equipment. Through the mutual aid system, the power system was instead restored up to the National Electrical Safety Code. He said that Congress was concerned that these upgrades violated the Stafford Act, so Congress passed significant changes to the Stafford Act in November 2018 allowing the ability to add resiliency to restoration efforts. These changes give OE the opportunity to replace, upgrade, and redesign as best they can throughout the restoration process, and make investments that are part of the emergency restoration component of a FEMA response. Within 18 months of ratification, the FEMA Administrator is to hold a public hearing about defining resiliency.

Assistant Secretary Walker said that independently owned utilities were not eligible for community development block grant funding. He has modified that policy, and OE is in the process of finalizing language with HUD to enable investments in the community development block grants to be applied to independently owned utilities as well as municipal utilities and cooperatives. He noted that this effort is focused on critical infrastructure, as defined by DHS, but the idea is to take every funding opportunity and figure out ways to build resiliency into it.

Referring to a panel on spinning reserves that EAC is planning for its June meeting, John Adams asked Assistant Secretary Walker if at a previous meeting he had meant optimizing spinning reserves or eliminating them.

Assistant Secretary Walker responded that he was not sure of the right answer, which is why he had posed it as a challenge. He noted that the electric system has dramatically changed over the last two decades and there is a need to step back and look at ways to optimize the spinning reserve with some R&D.

Mr. Heyeck asked where the EAC should go for other critical energy infrastructure information that does not have the same rubric as the electric grid, such as gas and telecommunications.

Assistant Secretary Walker said that OE will be promulgating the formal rules for the Critical Energy Infrastructure Information (CEII) before June. OE is not limiting itself to electric. Gas and telecommunications will also fall under CEII because they have an impact on the electric system.

Anda Ray asked Assistant Secretary Walker about his ongoing role at DOE.

Assistant Secretary Walker responded that he works closely with Karen Evans, the Assistant Secretary for CESER, and with DHS to understand the impact of national security. He added that many projects within DOE overlap and they coordinate across the different offices.

Wanda Reder said that OE's five pillars have helped frame the EAC's work, and asked Assistant Secretary Walker to elaborate on how the pillars will come into play in light of the pending budget increase.

Assistant Secretary Walker responded that the pillars have not changed and storage remains a key component. The NAERM is the platform for initiatives that happened in the past and are ongoing for the Grid Modernization Initiative (GMI) and the Grid Modernization Laboratory Consortium (GMLC). He said the model will facilitate the type of storage that will go into the system. The sensing capabilities are about understanding the electrical and physical phenomena that exist throughout the energy sector. The NAERM design is comparable to a geographic information system (GIS) platform in that there will be layers and capabilities that can be turned on and off. OE will be involved less with Puerto Rico because most of the technical engineering work has been completed, but it will remain available for technical expertise and analysis as needed.

Tom Bialek asked, in the context of CEII efforts, how OE deals with legacy information available, such as maps of transmission systems and gas systems that are now dated.

Assistant Secretary Walker acknowledged that this is a constant problem. Information that has been designated as CEII by OE is required by different sources. OE has tried to educate people by personally making phone calls to companies and encouraging utilities to get the information offline.

Shaun Mann asked how the conflict between privacy and public information can be resolved. Mr. Mann said each of the stations on the natural gas system has an air permit, which is a public document, and that he thinks the information within the air permits is sensitive.

Assistant Secretary Walker responded that OE continues to work with organizations such as the Federal Communications Commission (FCC) and the Environmental Protection Agency (EPA) to try to resolve such conflicts as they come.

Mr. Heyeck asked if Assistant Secretary Walker can provide guidance to the EAC about their performance and areas the EAC should focus on.

Assistant Secretary Walker said that when he reads over the EAC recommendations with Mr. Mansueti and Deputy Assistant Secretary Katie Jereza, he is encouraged that many other people are thinking about similar ideas that he is. He noted that there should be a flow of new ideas about possible new tools because the electric grid has changed so much in the past few decades. For example, when the systems were designed, cyber threats did not exist and domestic threats were minimal. He added that DOE is in the process of redesigning the architecture of the electric

system from scratch. He encouraged EAC members to think big and not get stuck thinking about the system the way it used to be.

Mr. Heyeck thanked Assistant Secretary Walker for the updates and said that the EAC really appreciates his feedback.

Presentation: OE Activities Related to Data Analytics

Mr. Heyeck introduced Eric Lightner, OE Program Manager of Advanced Grid Research and Development. Mr. Lightner provided an overview of R&D efforts within OE.

Mr. Lightner gave a brief overview of the Sensor Technologies and Data Analytics Program, which is a new program for 2020. The program's core areas are enhanced power system resilience, incipient failure/fault detection, detecting and forecasting behind-the-meter distributed energy resource (DER) impacts, and monitoring for critical infrastructure interdependencies. Cross-cut technical areas of the program are cyberware sensors and sensor validation. Mr. Lightner noted that this program is an OE priority and a key technical area for the GMI and GMLC roadmap implementation. He explained that GMLC is a strategic partnership between DOE and the National Laboratories, which brings together leading experts, technologies, and resources. GMLC projects laid the groundwork for the Sensor and Data Analytics Program. Mr. Lightner then discussed these OE- and GMLC-funded projects relevant to analytics:

- Discovery Through Situational Awareness (Pacific Northwest National Laboratory [PNNL])

  The goal of this project is to create situational awareness methods and tools that rely on machine-learning, statistical data mining, and data visualizations to provide insight into the power grid behavior. This project has two sub-projects:
  - Eastern Interconnection Situational Awareness Monitoring System (ESAMS), which incorporates multivariate, machine learning algorithms for detecting phase angle anomalies and oscillations.
  - Testing environment using real-time phasor measurement unit (PMU) data, which evaluates anomaly detection algorithms for accuracy and functionality prior to being incorporated into ESAMS.

- Advanced Machine Learning for Synchrophasor Technology (Los Alamos National Laboratory)

  The goal of this project is to use PMU data to develop dynamic machine learning technology for parameter identification and topology change detection, hidden anomaly detection such as asset malfunction, and event/anomaly classification. This project also uses various data science tools, such as graphical model learning, applied statistics, and neural networks, to investigate what can be learned from the PMU data.

- Integrated Multi Scale Data Analytics and Machine Learning for the Grid (Lawrence

Livermore National Laboratory)

The objective of this project is to develop advanced, distributed data analytics solutions, provide visibility, and controllability to distribution grid and building operators, leveraging multiscale datasets from both sides of the meter, and to evaluate and demonstrate machine learning techniques to create actionable information for grid and building operators. This project investigates how machine learning techniques can be applied to streaming distributed datasets and evaluates impacts of data quality on those methods. Topology and parameter estimation, demand response and DER availability and verification, and event detection are some of the applications that have been investigated.

- Sensing Electrical Networks Securely and Economically (Georgia Institute of Technology)

  The goal of this project is to develop and demonstrate a secure, ubiquitous, low-cost sensor network for monitoring distribution assets, which provides a sustainable return on investment (ROI) for utility deployments. This project incorporates modular sensors based on 3D printing for voltage, current, and temperature, configurable for transformers, capacitor banks, reclosers, and fuses. In addition, this project integrates flexible energy management, communications, advanced functionality, data storage, cloud connectivity, cybersecurity, analytics, machine learning, and user interface.

- Advanced Distribution Management System (ADMS) Test Bed-Volt/VAR Optimization (VVO) Use Case (National Renewable Energy Laboratory)

  This project evaluates the performance of an ADMS VVO application for different levels of data remediation and measurement density. The project's first phase involves only software simulation, with four levels of model quality and four levels of measurement density. The second phase focuses on simulation on ADMS test bed and various scenarios (model-quality levels and measurement-density levels).

Mr. Lightner also summarized a couple of new Funding Opportunity Announcements (FOAs):

- FY19 FOA: Big Data Analysis of Synchrophasor Data

  This project will explore the use of big data, artificial intelligence, and machine learning technology and tools on PMU data for better grid operation and management in order to enhance the reliability and resiliency of the nation's power grid.

- FY19 GMI Lab Call: Advanced Sensors & Data Analytics

  This Lab Call will address key OE opportunities and will reflect the foundational R&D topics identified in the Sensor Technologies and Data Analytics Multi-Year Program Plan.

Mr. Lightner talked about the "Voices of Experience" series, which focuses on areas that pose

operational challenges that are critical to industry transformation and encourages sharing knowledge to further enhance grid modernization efforts. This program tries to bring utilities together to share lessons learned through regional meetings and conference calls.

Mr. Lightner said that through the DataGuard Program, DOE facilitated an industry-developed framework for the protection, access, use, and sharing of customers' electricity usage data. This program outlines a voluntary code of conduct for energy usage data, which respects existing laws, regulations, governance policies, and business environments.

Panel: Value Proposition for Big Data Analytics

Mr. Heyeck introduced moderator Mladen Kezunovic, EAC Member and Eugene E. Webb Professor and Regents Professor at Texas A&M University, and panelists:

- Doug Dorr, Program Manager, Electric Power Research Institute;
- Mahesh Sudhakaran, Chief Digital Officer, IBM Energy and Utility Business; and
- Mark Johnson, Managing Director, Utility Analytics Institute.

Dr. Kezunovic thanked everyone who provided input for the panel as well as the panelists for participating. He outlined expectations for the panelists.

He said that because of the ability to analyze events in the power system, foresight is new territory. With more data available, expectations are growing. With new technology, we think we should get all information from data. He said the physical model and its relationship to data is important since, while patterns can be identified from data, that does not mean we understand the root cause. He gave an example of the Navy using data analytics to predict aircraft motor failures, which was a very successful application. However, data alone could not identify the root cause; one must understand the physical systems to know why a motor is failing. He said this example is relevant to power systems and that the industry is not used to the challenge of maintaining the relationship between data and physical models.

Dr. Kezunovic then gave a big data analytics example. Big data processing deals with extraction of features, and the data itself has many properties – such as volume, velocity, variety, veracity, value, validity, variability, venue, vocabulary, and vagueness – that create integration issues. Integrating data properties that are different is extremely hard. Of time spent on a project, 80% may be spent on preparing data and 20% on developing analytics. Dr. Kezunovic added that it is expensive to prepare data. Problems have to be big so that there is a reasonable return on solution implementation investment.

He then spoke about time scale and the different sampling rates of different types of data collection, some of which can only be dealt with if the process is automated. We are reaching a point in data analytics that we must update vocabulary to facilitate knowledge exchange. Decisions, he said, can be made only if you know all aspects of what is going on in data analytics implementation. He then deferred to other panelists to talk about big data analytics infrastructure. He said that while machine learning and artificial intelligence concepts have been around for years, data science is more recent and trying to introduce some new concepts based on these

different techniques. He said that, as an example, in predicting outages in transmission and distribution—it does not matter how you do it, but what you do with it in the utility application framework. When he discussed solutions with utilities in the past, he often encountered this issue.

Dr. Kezunovic then gave an example of why it is important to select a "big problem." In the United States, he said, billions of dollars are lost to outages. For most systems, this is related to equipment deterioration or weather stresses. This process is not the same across an electricity system, so there is a spatial-temporal component to big data analytics.

Dr. Kezunovic asked, how does one decide what data to use? Though some key data comes from the utility, much also comes from outside sources. Sources and properties of data should be automatically integrated into the prediction analytics; intuition of utility staff cannot be solely relied upon. Dr. Kezunovic emphasized the need for more research and said he would come back to his takeaways listed on the slide.

Dr. Kezunovic then gave the floor to Mr. Dorr.

Mr. Dorr has been doing analytics-related research associated with electric distribution, mostly with the Electric Power Research Institute (EPRI) for the past three decades. The techniques discussed today are just expanded versions of techniques that have been in use for decades, he said. He said value cases are where to focus—whether or not the cost of what you are trying to do with data increases your cost-payback ratio. He then said that DOE has many of these high-value cases.

At EPRI, he said they had looked at use cases for utilities where there was a value proposition in which someone had data from sensors and was doing something innovative, allowing other utilities to learn from it and then decide what they may want to do from a pilot or full-scale demo.

EPRI identified 132 use cases that had better than a net breakeven for the cost-benefit and prioritized the use cases into groups—outage awareness, asset awareness, system performance situational awareness, and load and distributed energy resource situational awareness. EPRI then prioritized what they wanted to understand about the data and determined what use cases required algorithms to solve.

Many vendors that offered analytics to utilities thought they had an excellent platform and wanted to access EPRI data. They allowed the vendors to access this data in a "loosely cleaned structure." After posting 30 use cases of value to the utility research partners, EPRI let the vendors present their results after working with the data.

Before this endeavor, EPRI came up with a road map for data analytics for the smart grid, listing the qualities that the future grid needed, such as interactivity, flexibility, and predictability. He noted that all use cases have to do with enhanced situational awareness. These use cases are all available publicly on EPRI's website.

Mr. Dorr then noted the challenge of lacking sensors on assets, and how one infers from other sensors what's going on. He said smart meters tend to have the largest number of use cases that we can solve across the system and gave examples of these use cases. He noted the privacy challenges, though, of using these datasets.

He also noted that you cannot analyze utility data reliably with only one dataset. He provided three takeaways. (1) Public data has been curated and stored but is difficult to get in a format that is useable. (2) The right analytic algorithms cannot be developed in a silo, it is best to consult a common algorithm repository. (3) Machine learning and artificial intelligence improved the outcome for every use case applied.

Mr. Sudhakaran introduced himself as the Chief Digital Officer for IBM's energy and utilities business. He thanked DOE and EAC for allowing him to speak about applying analytics and artificial intelligence at scale. He said at IBM, they build:

- IT systems for large utilities;
- Operational and market platforms;
- Digital foundations for the enterprises, infused with artificial intelligence; and
- Solutions for energy and utilities.

He introduced the three teams he leads—operations and innovations, customer engagement, and work and asset optimization—which work on six core solution areas. He said they work globally and have been in the business for decades.

Mr. Sudhakaran then spoke about nine technologies that are moving into the maturation stage and beginning to provide business value. He said he would focus on artificial intelligence, blockchain, and Internet of Things (IoT). He added that the transition from a value chain perspective to a business platform was one where utilities must deliver one or all of five fundamental capabilities. In all these areas, he said having data insights flowing through the network is fundamental. To properly implement artificial intelligence, you have to have advanced data analytics capabilities and you have to have data. To have data, you have to have an information architecture.

He continued that it is important to get the right data to drive artificial intelligence, and that many times, people do not even understand the data required for artificial intelligence. He said people focus on algorithmic sophistication but without data that will not help. He then discussed three technologies that are mature enough to be distributed at utility scale: IoT, vision technologies, and blockchain.

Vegetation management is a great use case where the data is available but is unstandardized—spread across an enterprise in different formats, projections, and units. He said they looked at it as a data curation problem and created an engine that could normalize the different data and convert it to a key value store. He said that vision as a technology has matured, given the progress made in other industries. Cross-industry advancement has given IBM lessons that can apply to utilities.

Mr. Sudhakaran described data science as like a team sport: It needs different players and, the

more complicated the problem, the more expensive the players. In utilities, you do not just need a data scientist, but also a subject matter expert, he said. To help with this problem, IBM created a point-and-click artificial intelligence training model to help subject matter experts identify problems in a way that is useful.

He then spoke about blockchain becoming a reality. For example, TenneT, a European utility, looked at their work from a blockchain perspective. Mr. Sudhakaran said that they helped a supplier of TenneT use blockchain in electric breakers to help TenneT with ancillary services. He said this has also provided an incentive for automakers. To do all this, one must be agile and use a design-thinking methodology.

Mr. Johnson introduced himself and his experience in information and operation technologies. He opened by saying that data is everywhere and that the work of his institute is agnostic. The Utility Analytics Institute (UAI) works with municipalities, investor-owned utilities, and an electric cooperative. Collaboration is important. He also said that data unlocks creativity and curiosity. He believes data will help change culture in utilities and that it is faster, safer, and quicker for stakeholders to address these challenges together. Mr. Johnson added that UAI began in 2011 to give utilities context for where they are today so that they can advance up the maturity curve.

He said that in 2017 UAI conducted an analytics maturity assessment with the utilities through self-assessment across seven areas, made the data anonymous, and shared it with all members. He said this gave a sense of where each was compared to the other utilities.

Mr. Johnson then spoke about some technologies he believed were close to maturation, including generative adversarial networks for design and augmented reality for field workers. He then mentioned a few stumbling blocks the institute faces:

- Tracking and digesting all the new field literature. For example, he had no idea what DOE was doing related to data analytics. UAI wants the Labs to be part of what they are doing, share information with its members, and listen to what members are doing.
- Internet Protocol (IP) is becoming more and more important for utilities. Utilities want to protect themselves legally, so do not share their vendors' technologies with members.
- Advance utilities are spending substantive time cleaning data to do analytics.

In the Q&A that followed, Dr. Kezunovic said that EAC members should not give recommendations on the fly, but the Committee may develop a work product at a later date. Mr. Lightner also joined the table for questions.

Mr. Adams asked the panel if DOE has any data curating or hosting resources. Dr. Kezunovic responded that in the case data comes from government sources, whether federal or state, data outputs provided are controlled by government. Mr. Dorr added that it would be helpful for the utilities to define what properties they need and have someone at DOE curate data with the time window and resolution needed. Mr. Lightner continued that it depends on how clean is good enough and that DOE can help answer this question; looking at model quality with measurement density is an example. For different applications, DOE would need help defining what level of accuracy is needed for ROI. Mr. Sudhakaran added that another class of problems to solve is to

identify the amount of data needed. The amount of insights from public information is spectacular, and can be combined with additional data to solve challenges.

Mr. Johnson added that the industry needs help facilitating the formatting and sharing of information and that sharing data across utilities is sometimes impossible. He added that it can even be challenging with internal data. Dr. Kezunovic added that the properties of the data—accuracies and uncertainties—do not typically come with data, and that the government could offer quality of data parameters that may be used if data comes from government sources.

Dr. Bialek added that some data that is needed would not reside in the Laboratories. He asked how to move toward datasets that are readily available for parties who are interested in looking at them and trying to develop algorithms for various problems. He also asked about what expectations exist for utilities to stand up the platforms they would need to do some of the work. Carl Imhoff was invited to address the question, and responded that in the past several years DOE has invested in three or four data repositories that look at different classes of problems (e.g., distribution data for uses in business cases for energy storage). PNNL also developed synthetic sets for data that are otherwise too sensitive to share if directly provided by utilities. Other Labs are making such synthetic sets for other topic areas. As an example, ARPA-E is also running an optimal power flow algorithm competition because algorithms need to be tuned against a standard set to compare them against each other. This is the emerging class of those data assets, however there is opportunity to strategically coordinate this effort.

Arthur Kressner asked that, considering that big data analytics show correlations but not the reasons for them (i.e., root cause analysis), is there any attempt at trying to combine nondeterministic approaches with the models they are used to dealing with? Dr. Kezunovic responded that one can determine from patterns what is wrong, but a root cause analysis is difficult if not impossible unless one uses physical models.

Flora Flygt asked Mr. Johnson, who had mentioned that he did not know what the DOE was doing until last month, to expand on that and how DOE's work could be helpful to organizations. Mr. Johnson responded that he did not know how many Labs were doing work around grid analytics. He saw that bigger utilities are involved, but would love to see municipals and coops involved as well. It would be great if the National Laboratories could listen and present at UAI webcasts.

Richard Mroz asked Mr. Sudhakaran, who mentioned the expense associated with the work and that the investments must be significant, how utilities could capture those costs through a rate base or other options. Mr. Sudhakaran responded that data science is a big sport. It needs the right players, but scientists go to places with money. Utilities need engineers in conjunction with the scientists to reach results. Projects he has seen that have been successful are led by engineers who picked up on data science skills.

Dr. Kezunovic added that utilities typically look at the new equipment and then see if it serves the customer. If so, they make decisions to file rate base case requests for such equipment. The industry loses sight of the infrastructure associated with collecting and processing data. When considering infrastructure, data is no longer associated with original installation of equipment.

There is more data needed outside of the utility-installed sensors to do predictions. Everyone has to be educated, from requesters to approvers. He followed with the question of how to define something that is soft and does not correlate directly with the equipment installed. Mr. Sudhakaran responded that foundational capabilities are needed to collect, organize, and analyze data.

Mr. Mroz asked about whether an investment for a particular purpose needs to be segregated out to its functionality to quantify the investment, and how to capture the cost. Mr. Sudhakaran responded that the industry is moving from a classic to platform-based value chain. Capabilities are driven by a certain set of processes that need to be looked at differently. Mr. Johnson added that EAC members try to get some funding that is not too big and that will show results. When they do achieve results, people internally understand. Then there is a pull, and business starts coming to that utility. Mr. Sudhakaran agreed. When delivering value every few weeks, it is clear what the business value looks like. Mr. Lightner added that in DOE's AMI initiative, many of these solutions are in-house and customized because they cannot buy functionality. As these solutions become monetized and not so customized, the price to implement them should go down over time as more common solutions emerge. Mr. Sudhakaran said this is true when you look at recent solutions. Also, when working with utilities, there is always a discussion about who owns the IP. Utilities are more collaborative than other industries.

Ms. Ray added that while utilities are collaborative, people who want to sell services to them are beginning to offer to pay for data. They are paying for how long and the use, but not getting all the layers of information. They need to know exactly what they are going to use it for. There is also a gap between utilities who know their business and data analysts who know the algorithms. Most utilities do not have their own analytics department and there is a need to collaborate to determine if these algorithms are reaching the right conclusions. The industry needs to work together so we are not duplicating algorithm and sets of data. Mr. Sudhakaran added that there are about 80 to 90 assets to build asset models for. If the industry can form a common base, costs will go down.

Dr. Kezunovic then summarized sources of data. He said the first set of data comes from protected utility-owned data collection infrastructure, which introduces a question of what can be released and what cannot. The second set comes from government; the third comes from other parties; and the fourth comes from the customer.

Chris Ayers added that regulators and consumer advocates grapple with who owns data. He is curious as to when, if at all, that data ownership transfers to the customer, and at what point should the customer have a say. Mr. Johnson responded that for his company, General Data Protection Regulation (GDPR) is a huge issue and that Ontario has a privacy-by-design framework. Mr. Ayers asked Mr. Johnson whether, while he would never give data away, would he ever sell it. Mr. Johnson responded that he would not. Mr. Sudhakaran added that insight created from data is far more valuable. Dr. Kezunovic followed that it is interesting from the perspective of rate cases. For example, outage prediction is used by utilities to manage the system. But imagine if that prediction is passed to consumers, who can do certain things with respect to reliability. The concept of reliability, when sharing results, transfers partially to the customer the responsibility to prepare for outages, and hence reduce reliability burden on

utilities. Mr. Ayers added that the data could also go to third parties. He asked who can monetize and profit from that. Mr. Lightner responded that DOE developed some principles to guide the process through the DataGuard program in an open, collaborative process. The program elected to stay away from addressing ownership of data, but it did address use and consent of data sharing. Mr. Lightner suggested that Mr. Ayers see if it is useful in some way. Mr. Sudhakaran added that IBM grapples with customer bias and that if the data is used to build an application or make an insight, it is imperative to question whether it is biased and look at the lineage of the data. The trust-bias lineage is very important and goes along with the data.

Mr. Ayers said that, optimally, you have an entire set of data. But if some customers do not provide full consent, at what point does that affect data you are working with? Mr. Lightner responded that DOE tried to address anonymization of data and define when that data could be used. The effort failed to come up with methodology that would not allow for re-identification of data, but California has implemented concepts in their regulations and DataGuard has used this as a framework.

Robert Cummings said that NERC runs old databases. When thinking about statistical value in a time-based database, it is necessary to go to 30 years. Over that period, the extensibility of the database over platforms becomes a problem. There is a period where it is no longer viable, but as data gets larger faster, you are talking petabytes of data. Mr. Cummings then asked: How do you transfer data from one place to another other than physically moving the machine given that the volume and methodologies are advancing like crazy? Mr. Dorr responded that is one of a hundred dimensions of the data challenges. The industry needs differing levels of data for different use cases. It is necessary to go back to value each case, find out where the highest value applications are, and find datasets needed to solve use case by use case.

Mr. Cummings followed up that if an entity is able to process data into meaningful observations, it can be easily kept. There must be an additional decision with raw data to decide when old is too old. Dr. Kezunovic added that the physical system state at the time data was captured is needed for root cause analysis. As an example, not having a snapshot of the energy management system (EMS) explaining what was happening at the time may make the data useless. He added that storing the models is an important component of the data analytics process.

Mr. Sudhakaran said context is important for certain use cases. That issue comes up with IoT every day, particularly with the idea of how much data do you keep and how much do you throw away. In his experience, the question is always about cost.

Mr. Heyeck added that five years ago, EAC recommended next-generation EMS, and a panel identified a gap. Thirty-five years ago, he was a manager at a power systems dynamic group at American Electric Power (AEP) and had found generators that were oscillating. PMUs in the Pacific NW found a mode and helped staff to adjust the power stabilizers. EMS today cannot capture 1 hertz or 2 hertz oscillations; they deal with supervisory control and data acquisition (SCADA) systems that have limited recording capabilities. Mr. Heyeck provided another example that when NERC was monitoring geomagnetic disturbance, he did not think NERC needed to put currents on transformers; they could just use PMU data to find out transformers are going into saturation. This information is anecdotal, which does not work for EMS systems

today. There are very few EMS customers or vendors out there. Right now, we have five-second intervals and need 30 times-a-second intervals. Mr. Heyeck added that with one more leap, data analytics can find signature analysis that can identify whether the grid is under a cyberattack. He then asked the panel if they thought this would be possible with an EMS if they are driven by 30 intervals a second.

Dr. Kezunovic responded that this is a question for DOE, and depends on whether they are going to revisit the conceptual design of energy management systems for transmission applications. He added that from the 1960s and 1970s, DOE funded the study to define the fundamental concept of EMS as we know it today. He said DOE studied distribution management systems (DMS) and advance DMS (ADMS) in the 1990s, but there were very few vendors at the time. He described outside examples from China where they have developed EMS Generation 5, based entirely on data analytics. It is an entirely new platform and a new design that matures over time as more data becomes available. He added that all the activities in the United States include patching software through maintenance by EMS and DMS vendors or customer request for updates; it is not solving the fundamental problems of the platform being used. Mr. Dorr replied that the industry is stuck with what exists today for the short term, but it does not mean that industry cannot have insight layers that enrich the standard layers. In California, with fires, they will have situational awareness of what rights of way are most likely for having a fire start. This will be disposable data.

Assistant Secretary Walker disagreed that the industry is stuck with what currently exists. One of OE's five pillars is the sensing technology. Additional NAERM is not only a planning tool. The transition to a real-time model will evolve the system away from this five-minute snapshot. He added that PMUs are woefully underequipped and not good for today's use. Fiber optic cable technology is being used in Labs and will be integrated into the model, which will allow a 500,000-per-second sampling rate to be used and optimized to tell where too much data does not add value. Assistant Secretary Walker said this capability will be able to see electric phenomena, incipient faults, or oscillations, as they happen in real-time. The model will then be utilized by DOE from a national security standpoint. Many layers will be informed by federal agencies, intelligence and counterintelligence and 16 other agencies that collaborate on that front. From the energy side, it will be a model that incorporates all the data the federal government is engineering and using in the weapons labs and Department of Defense capability to leverage a model in real-time. Debating on analytics and related components are a part of it, but the focus of NAERM is changing how we monitor the system. NERC monitors the system using quite a lot of data now. This first step will focus on national security, but many capabilities from the work DOE is doing will translate to the sector more broadly.

Jeff Morris asked the panel whether many states were doing "GDPR lite," considering the conflict between large technology firms and states over who owns data at the pixel level. Is there anything that can be done with that and what public data can you monetize? Mr. Lightner responded that the principles and practices included in DataGuard's voluntary code of conduct are in line with the GDPR. The strategy to use that in outreach to states and use it as a framework in their own regulations is an attempt to level the playing field and bring down the number of standards across the country. He continued that while DOE is not a regulatory body, the best DOE can do is encourage people to look at these within their own jurisdictions. He concluded

that he did agree that a national standard modeled after GDPR and eventually DataGuard would go a long way to solve these problems.

Mr. Morris responded that some criticism to technology companies is the "bad data" argument. With utility rates, there is a question of consumer value. It is important to get policy/social issues into the mix. He continued with the example that Amazon's face-recognition has been criticized for being less accurate for minorities. Correct data needs to get into residential rate types, where this issue could happen. He asked the panel if the industry artificial intelligence teams are bringing these types of questions to the algorithms being developed. Mr. Sudhakaran replied that one place IBM sees bias often is with vision. So the company released an unbiased dataset into public domain. He expects this to also happen at some point for customer datasets. Utilities, though, are one of the last bastions that do not link data to customers.

Dr. Kezunovic added that cybersecurity is an issue with any data coming from outside of the utility. Utilities invest a lot of money to control the data security issue. On the customer side, if one is using it for different purposes it is difficult to tell what an adversary has done with the data. He added that sharing data with a third party can also introduce risks with data security. It is not just the privacy issue, but how you trust the data, including disclosure to third-parties.

Clay Koplin mentioned that at a recent NRECA technology advantage conference, cybersecurity and artificial intelligence/big data were front and center. Microgrid and energy storage were right behind. Many of the data presentations focused on situations in which you know what you are looking for and use data analytics to find that. He said there are two other cases: where there are things on which data sheds light and changes the investment/operations approach, and where there are things that jump out that you did not realize are hidden in data. A company can find something they were not looking for that is more valuable. At his utility, 80% of operating expenses are wrapped up in generation. In terms of value in this situation, 90% of the value is in 1% of data.

Mr. Lightner added that he had a roundtable with six CEOs and asked about the top issues they are dealing with. Data was the first thing everyone said. They see value, and the utilities all had advanced metering infrastructure (AMI). They were using data for transformer loading, outage restoration times, and communications. These actions were changing the culture in the utilities, making people explore what else can be done with the data.

Dr. Kezunovic asked what was next when considering the smart meter data as an example. If smart meters are integrated with SCADA, the data coming into SCADA would be at a 100 times faster speed than before if using smart meters as remote terminal units (RTUs). Smart meters can also be easily converted to PMUs and take data at higher sample rates if needed, but he wondered what could be done with this data. The topics he had talked about are roughly five years out, not 10 or 20 years. He added that there is more uncertainty with what to do when we increased data rates by factors of 100 or 1,000. He asked about the role of government to support computational or storage research. Mr. Heyeck responded that he had seen a presentation roughly 10 years ago where PJM Interconnection LLC had 169,000 control points. He could not imagine what to with adding nine more zeros to that total. Mr. Dorr asked, from an energy management perspective and ignoring the challenge of customers needing to opt in, what would

the next generation smart meter look like in terms of the data that it tracks and the kind of time frame? He said he was unsure whether that meant taking a high-resolution sample once a day or once an hour. The metrology chip is as good as an oscilloscope, but the industry does not just collect that data from it. The vendors receive guidance on how much and what to collect at what cost. Mr. Dorr said he wonders what the next generation looks like, when are we going to be ready for the next generation, and will transition need to be a mass or gradual deployment.

Ms. Reder asked: What can DOE do? A lot of what the panel talked about is leveraging data coming out of smart devices, and Assistant Secretary Walker's vision is where DOE can provide that value. She asked about the organizational/institutional challenges outside of technology, considering that the value propositions break down because organizational barriers do not let them get there easily. She challenged the panel to bring thoughts on the organizational element. Mr. Lightner responded that the issue is enabling innovation with data. An example from one of the use cases demonstrated how a company expanded access to data to the rest of company. He thought that the organizations would get solutions from people they would never have thought to reach out to. DOE has this role; if they can liberalize data access and make it available for innovation, it may be good role.

Mr. Johnson added that it is always good to go with the customers. The difficulty comes with a utility that had been a member for five years, always pushing analytics. The culture of an organization is also important and that data scientists need a path. The question he thinks is important is: How do you grow a data scientist and develop a career path in company? The utility industry is solving societal problems, so the challenge is to market that opportunity to younger candidates.

Mr. Sudhakaran added that, during his time with IBM, he has worked on mobile, cloud, blockchain, artificial intelligence, and now quantum—the amount of technologies is going to upscale. He has seen that it takes 10 years of analytics projects to train a utility engineer, and it has to be a career path. Related to the discussion of data, he added that the industry has to get insights and figure out how to store them. An insight catalogue could help.

Mr. Dorr said that in programming, there is a difference between programming for today's needs and doing something massively parallel or with an in-memory system. The industry does not have skillsets in the United States to keep up with that. He said DOE can support a new mindset related to programming with three key features:

1. Synthetic data, including synthetic AMI, where any utility can anonymize data and a dataset that is representative of all the use cases.
2. An Analytics Center of Excellence, which builds on what others have done including an algorithm repository so new efforts do not keep reinventing the wheel. Researchers at his organization have taken AMI data out of repository and found ways to look at heat maps to understand long-term trends. Others saw that this process can apply to many other things, so archiving in a way that others can see and understand would support innovation.
3. Conceptualize an idea of a Twitter-like system with texts from devices in near real-time. The industry is not good at fast, disposable, accessible data; it needs to define what data

is secure and what is informational.

Mr. Johnson added that the safety data available is not enough to train artificial intelligence with. This could be something that DOE can help with. Dr. Kezunovic continued that there needs to be a top-down approach to support how a system would look in the future. He gave as an example that DOE could direct a study to assess the future of EMS/DMS design. He added that the part that is missing in many discussions is related to the data describing behavioral aspects of the users of data analytics outcomes. This refers not only to consumers but to staff behaviors within companies. He wondered, for example, how companies' staff would behave when they have access to outage prediction models and that this behavior change is not trivial.

Dr. Bialek said that there is a challenge of value proposition for a platform approach for analytics. He wondered how you get support to proceed. Is there a way DOE, or others on the panel, can convince regulators/consumer advocates that you need to stand up an expensive platform to do these types of things? Dr. Kezunovic responded that use case demonstrations can help people understand these issues.

Kimberly Denbow added that with data collection comes a responsibility not mentioned: how to protect the results of analytics. She said until Assistant Secretary Walker could provide assurance to this question, she was not comfortable with the plans, but he has done a good job explaining them. She added a comment about her excitement around cyberattack prediction with analytics but is wary of false positives, as the data can confirm what you think should happen.

Tom Weaver said that there are many conversations about big data, equipment, and sensor data, but there is a lot of gain from simple analytics. Focus on simple things, like getting subject matter experts together with data scientists to identify what decisions they have trouble making and how data analytics help us make them. The data make companies curious about what else it can do so there may be an opportunity to get subject matter experts and data scientists together in a structured way.

Dr. Kezunovic then thanked the panel and audience for their participation.

EAC Energy Storage Subcommittee Update

Ramteen Sioshansi, EAC Energy Storage Subcommittee Chair, provided a brief update on the Subcommittee's two white papers. He began with a discussion of the 2018 Biennial Storage Review. The Energy Storage Subcommittee was formed in March 2008, in response to Title VI, Section 641(e) of the Energy Independence and Security Act (EISA) of 2007. Title VI, Section 641(e)(5) states: "The Council shall (a) assess, every two years, the performance of the Department in meeting the goals of the plans developed under paragraph (4), and (b) make specific recommendations to the Secretary on programs or activities that should be established or terminated to meet those goals."

The "2016 Storage Plan Assessment: Recommendations for the U.S. Department of Energy," that was approved September 29, 2016, fulfilled both requirements. Dr. Sioshansi said that the

Subcommittee is currently working on the 2018 Biennial Energy Storage Assessment, which is proposed to fulfill the second requirement.

Dr. Sioshansi said that the scope of the assessment has broadened in the past years. The 2012 review focused exclusively on OE storage-related activities. The 2014 review expanded the 2012 scope to include OE, the Office of Energy Efficiency and Renewable Energy (EERE), the Advanced Research Project Agency-Energy (ARPA-E), and the Office of Science. The report also examined coordination between DOE and other federal agencies, such as the National Science Foundation and the Department of Defense. This was in line with offices and agencies that were included in DOE's overall strategy. The 2016 review maintained the same broad programmatic scope, but the technological scope was expanded beyond electricity in/electricity out storage and included power-to-gas, thermal, and virtual storage. The 2018 review is proposed to maintain the breadth of the 2016 review.

Dr. Sioshansi then summarized the planned process. The Subcommittee is building off of what they did in the 2016 assessment. In 2016, the Subcommittee used the outside interview process, which had "users" and "implementers" of DOE's storage program, to inform the assessment and recommendations. The interviewee group included different sets of stakeholders, such as, energy-storage developers, energy-storage deployers, state policymakers, ISOs/RTOs, NERC, FERC, nongovernmental organizations, renewable developers, and energy and environmental think tanks. The Subcommittee conducted some interviews during OE's Energy Storage Peer Review in Santa Fe, New Mexico, in September 2018. The working group is in the process of conducting expert phone interviews. They plan to have all the supplemental interviews done by mid-April and aim to have the white paper ready for EAC approval in June 2019.

Dr. Sioshansi summarized the peer review, which took place September 25–27, 2018, in Santa Fe, New Mexico. Ms. Flygt, Lola Infante, and Dr. Sioshansi attended this peer review. EAC members conducted a few interviews with energy-storage developers, researchers, and deployers. Dr. Sioshansi explained that the peer review provided an opportunity to see the totality of OE's research portfolio. So far the working group has had telephone interviews with representatives from Southern California Edison, NRECA, Duke Energy, CMS Energy Corporation, Natural Resources Defense Council, Environmental Defense Fund, NERC, National Association of Regulatory Utility Commissioners (NARUC), NextEra Energy, and Helman Analytics.

Dr. Sioshansi then provided an overview and some updates on the Energy Storage Risk Assessment. Utilities and regulators historically manage operational and financial risks; utilities undertake actions to manage risk, while regulators recognize long-term cost-savings from these actions and allow recovery of their costs. Innovation and deployment of new technologies are difficult because the regulatory community is risk averse. If a new technology is unsuccessful, customers will have to pay for the failed experiment as well as for the replacement. Pilot and demonstration projects supported by DOE are examples of how government can introduce new technologies while hedging customer risk. However, DOE is limited in its ability to underwrite utility-scale pilot projects. In addition, public utility commissions are reluctant to assess cost risks to customers. Thus, the main question then becomes, "How do we reduce risk of technological failure to levels that are acceptable to the principal players—utilities, regulators,

and customers?" Dr. Sioshansi said that the Energy Storage Subcommittee is putting together a webinar for late April to cover sources of technological risks. In June 2019, the Subcommittee will hold a panel to discuss potential approaches to mitigate risks. He noted that a white paper could stem from this panel.

Dr. Sioshansi then discussed the work product to be voted on during this meeting: "DOE's Role in Assisting State-Level Implementation, Valuation, and Policy Treatment of Energy Storage." He said that the Subcommittee has been working on this work product for over a year, and the title has changed multiple times. He noted that energy storage is a unique power system asset that can behave like a different type of asset—such as a generation, load, transmission, or distribution asset. Storage can provide services, some of which are market-priced or market-contingent and others that are not. A traditional regulatory and market design approach that has been developed over the last 20 to 30 years has treated assets as either being market- or rate-based, which may not be suitable from a regulatory or market design perspective for integration of energy storage into electric power system. The aims of this work product are:

- To raise the problems created by historical market, rate, tariff, and regulatory designs as they pertain to energy storage.
- To make recommendations for further work or study.
- To help DOE assist state regulators and legislators in addressing energy storage within regulatory proceedings, market designs, and legislation.

Dr. Sioshansi said that the process of this work product included three milestones: the February 2018 EAC panel session, the June 2018 DOE /National Laboratory briefing, and interviews with state policymakers. Representatives from Quanta, PJM, California Public Utilities Commission, and FERC participated in the February 2018 EAC panel session. The DOE webinar in June 2018 included representatives from DOE, PNNL, Sandia National Laboratory, and Lawrence Berkeley National Laboratory. Seven external interviews were conducted with representatives from the Montana Public Service Commission, Kansas Corporation Commission, Maryland Public Service Commission, Indiana State Senate, Utah State House of Representatives, Illinois State Senate, and California Public Utilities Commission. Some of the key findings of this work product are:

- DOE's focus on storage valuation and multi-use applications is very positive.
- Nevertheless, state policymakers may not understand how to design market and regulatory structures that allow these value streams to be monetized.
- Storage deployers can have difficulty demonstrating project value.
- Projects are developed with expectation of value, which may or may not be realized.
- Projects can reveal values that are not anticipated a priori.
- Sharing lessons learned and experiences from actual projects would be beneficial.

The Energy Storage Subcommittee's recommendations for DOE were to support research and pilot projects addressing market and regulatory designs and to facilitate sharing lessons learned and storage-deployment experiences. Dr. Sioshansi thanked Dr. Infante, Laney Brown, and Mr. Weaver for their efforts on this white paper. He also thanked former EAC member Tom Sloan, who initially provided the idea to pursue this topic, and all the EAC members who provided feedback.

Ms. Ray said that the valuation piece in the Assisting State-Level Implementation, Valuation, and Policy Treatment of Energy Storage work product bothers her. She pointed out that the Energy Storage Association and NARUC are using a storage valuation estimation tool, which is the industry standard. She said that information on how to use the estimation tools would be very helpful rather than developing the tools.

Mr. Morris noted that about 30 to 40 states do some form of Integrated Resource Plan (IRP) and that there is much value in focusing on IRP planning to make the discussions more realistic. Dr. Sioshansi responded that PNNL and some other National Laboratories have been working on comparing the IRP processes undertaken by different utilities and states and examining how IRP models treat energy storage. Mr. Heyeck commented that energy storage is the Number 1 disrupter and an aid to the grid. He noted that recent reports have shown that energy storage may top 500 gigawatts worldwide by 2050.

Ms. Reder motioned to approve the work product. Charlotte Lane seconded the motion. There were no objections. The EAC unanimously approved the work product on DOE's Role in Assisting State-Level Implementation, Valuation, and Policy Treatment of Energy Storage.

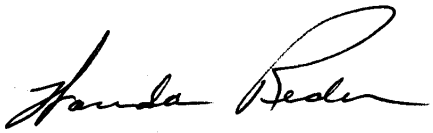
Wrap-Up and Adjourn Day 1 of March 2019 Meeting of the EAC

Mr. Heyeck thanked everyone for attending the EAC meeting and reminded that there will be a Dutch dinner at The Westin's restaurant, Pinzimini, for EAC members. The meeting would resume the next day at 8 a.m., at the same location, and end at noon. The next day would include a panel on Electric Sector Cybersecurity Preparedness followed by the Energy Storage Subcommittee meeting at 1 p.m. There were no closing comments. The meeting was adjourned.

Respectfully Submitted and Certified as Accurate,

Michael Heyeck
The Grid Group, LLC
Chair
DOE Electricity Advisory Committee

06/10/2019
Date



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