U.S. Department of Energy

Electricity Advisory Committee Meeting

National Rural Electric Cooperative Association Conference Center

Arlington, VA

February 26, 2020

Meeting Summary

PARTICIPANTS

Electricity Advisory Committee (EAC) Members:

JOHN ADAMS
Electric Reliability Council of Texas

CHRISTOPHER AYERS
North Carolina Utilities Commission Public Staff

TOM BIALEK
San Diego Gas & Electric Company

ROBERT CUMMINGS
North American Electric Reliability Corporation

ANN DELENELA
Entergy

KIMBERLY DENBOW
American Gas Association

DREW FELLON
Trane Energy Supply Services

FLORA FLYGT
American Transmission Company (Ret.)

SHERI GIVENS
National Grid

LISA GROW
Idaho Power Company

MICHAEL HEYECK
The Grid Group LLC

PAUL HUDSON
General Infrastructure LLC

LOLA INFANTE
Edison Electric Institute

MLADEN KEZUNOVIC
Texas A&M University

CLAY KOPLIN
Cordova Electric Cooperative

ARTHUR KRESSNER
Grid Connections LLC

JEFF MORRIS
Washington State House of Representatives

RICHARD S. MROZ
Resolute Strategies LLC

BRYAN OLNICK
Florida Power & Light Company

DARLENE PHILLIPS
PJM Interconnection LLC

WANDA REDER
Grid-X Partners LLC

RAMTEEN SIOSHANSI
The Ohio State University

DAVID WADE
Electric Power Board of Chattanooga

TOM WEAVER
American Electric Power Company Inc.

U.S. Department of Energy:

HONORABLE BRUCE J. WALKER
Department of Energy

MATT ARONOFF
Department of Energy

EMILY BURDICK
Department of Energy

KERRY CHEUNG
Department of Energy

MICHAEL COE
Department of Energy

MARIELA CURET
Department of Energy

CHRIS DRAKE
Department of Energy

MARCOS GONZALES HARSHA
Department of Energy

JACOB HERBERS
Department of Energy

CHRIS IRWIN
Department of Energy

JOYCE KIM
Department of Energy

CHUCK KOSAK
Department of Energy

CHRIS LAWRENCE
Department of Energy

KEVIN LYNN
Department of Energy

JAKE MCCURDY
Department of Energy

DAVID MEYER
Department of Energy

ALLISON MILLS
Department of Energy

JOE PALADINO
Department of Energy

JULIE SMITH
Department of Energy

KERRY WORTHINGTON
Department of Energy

Speakers, Guests, and Members of the Public:

VENKET BANUNARAYANAN
National Rural Electric Cooperative Association

TANYA BURNS
Arara Blue

JEFF DAGLE
Pacific Northwest National Laboratory

HANNAH DIRKS
Federal Energy Regulatory Commission

TRAVIS FISHER
Federal Energy Regulatory Commission

CYNTHIA HSU
National Rural Electric Cooperative Association

DAVID HUNTER
Electric Power Research Institute

CARL IMHOFF
Pacific Northwest National Laboratory

TOM KING
Oak Ridge National Laboratory

HONORABLE COMMISSIONER BERNARD MCNAMEE
Federal Energy Regulatory Commission

CRAIG MILLER
National Rural Electric Cooperative Association

JAY MORRISON
National Rural Electric Cooperative Association

MARY O'DRISCOLL
Federal Energy Regulatory Commission

JEFFREY PRICE
United States Energy Association

MOIN SHAIKH
National Rural Electric Cooperative Association

DENISE SIMPSON
Ameren

EMMA STEWART
Lawrence Livermore National Laboratory

ICF/ Support:

JEFF BLAIR
BCS

KAREEMAH GRAHAM
BCS

DANIEL GRAY
ICF

RAY LONG
ICF

JOSH SMITH
ICF

KELLY YEE
BCS
* * * * *

Meeting Summary

This was the first Electricity Advisory Committee (EAC) meeting in 2020. On Day 1 of the meeting, Assistant Secretary Bruce J. Walker, of the Department of Energy (DOE) Office of Electricity (OE), and Commissioner Bernard McNamee, of the Federal Energy Regulatory Commission (FERC), gave insights into the energy sector while also providing updates about relevant initiatives of their organizations. Carl Imhoff, of Pacific Northwest National Laboratory (PNNL), presented about the Grid Modernization Laboratory Consortium (GMLC). Mr. Imhoff gave a brief historical overview then highlighted a few projects with an emphasis on industry involvement. Tom King, of Oak Ridge National Laboratory, spoke about the Advanced Sensors and Data Analytics portfolio of the GMLC, which set the stage for the first panel session. The panelists were Emma Stewart, of Lawrence Livermore National Laboratory, and Jeff Dagle, of PNNL. The panel sessions focused on DOE asking the EAC members for feedback about ongoing DOE projects. The second panel was led by Chris Irwin and Kerry Cheung, both of DOE, who provided a few prompted questions to which members provided responses.

Welcome, Introductions, and Developments Since the October 2019 Meeting

EAC Chairman Michael Heyeck introduced Christopher Lawrence, Designated Federal Officer (DFO). Mr. Lawrence welcomed attendees and thanked EAC members for their continued service. He thanked DOE staff and contractor support for their efforts, as well as the National Rural Electric Cooperative Association (NRECA) for hosting the meeting. He covered several housekeeping items, noting that the meeting is open to the public and will be recorded for the purpose of preparing a detailed written summary. He then officially called the meeting to order and turned it back to Mr. Heyeck.

All EAC members introduced themselves. Mr. Heyeck then announced several upcoming transitions in EAC membership and leadership. The chairs of the Energy Storage and Smart Grid subcommittees will be concluding their terms in June 2020. Wanda Reder will become chair of the Electricity Advisory Committee effective July 1, 2020 and Mr. Heyeck, would become the vice-chair. Mr. Heyeck stated this was planned but became more relevant as his other activities internationally have increased. Wanda will be chairing the Leadership group effective immediately planning for the October 2020 meeting. Mr. Heyeck then invited Assistant Secretary Walker to provide an update on OE programs and initiatives.

Update on Office of Electricity Programs and Initiatives

Assistant Secretary Walker began by discussing the President's fiscal year (FY) 2021 budget request as it relates to the Office of Electricity. He said the budget request includes $195 million for OE. He highlighted several items that impact the EAC. OE has dedicated $21 million in continued funding for the North American Energy Resilience Model (NAERM). The NAERM will transition to a real-time, dynamic model beginning with the Western Interconnect and then with the Eastern Interconnect. At the end of FY 2021, they expect to have a fully operational model. The NAERM will have many layers that can be turned on or off as needed and will focus primarily on natural gas and electricity transmission and generation systems. OE is working closely with the North American Electric Reliability Corporation (NERC), regional transmission organization (RTO) partners, and the industry to validate and test the model. The NAERM highlights the interdependencies of different energy infrastructures. It also allows

for contingency analysis and can help identify where investments can be made to strengthen the overall energy system. DOE will use the NAERM in conjunction with information from national intelligence agencies to identify cyber and physical threats against energy infrastructure from nation-state actors identified in the 2019 Worldwide Threat Assessment. The NAERM is already helping identify strategic opportunities for use of megawatt-scale storage and further integration of renewable resources. The focus in OE is on national security, particularly for Defense Critical Electric Infrastructure (DCEI). NAERM will provide situational awareness of DCEI facilities identified in the 2015 Fixing America's Surface Transportation (FAST) Act and in coordination with the National Nuclear Security Administration and Department of Defense.

Assistant Secretary Walker continued by discussing other relevant areas of funding within OE. In the FY 2021 budget, they have requested $83 million for storage, compared to their normal budget of approximately $43 million. They will continue their research and development (R&D) focus in coordination with National Laboratory partners. They have made progress in dropping costs significantly, while increasing the safety performance of aqueous solution redox equation batteries and bidirectional electric storage. The Assistant Secretary said he believes in the next three to five years they will have cost-effective megawatt-scale storage that is ready to be commercialized. He noted that these efforts tie into the Energy Storage Grand Challenge (ESGC), a recently announced DOE initiative to accelerate the development, commercialization, and utilization of next-generation energy storage technologies and sustain American global leadership in energy storage. The Assistant Secretary continued by describing the Grid Storage Launchpad initiative, funded at $40 million out of the $83 million OE budget, which involves building a new facility at Pacific Northwest National Laboratory to test and evaluate new advanced storage technologies. In FY 2020, $5 million was allocated to begin building the Launchpad facility, which is expected to be completed by FY 2022. The Assistant Secretary noted it is the first facility that has been built within OE.

The Assistant Secretary said OE continues its commitment to developing high-speed, high-fidelity, low-cost sensing technology that enables them to see phenomena on electric systems, such as high harmonics. This increased visibility will allow them to design and control for unwanted degradation or interruption of performance. In addition, the sensing data will be integrated into NAERM.

The Assistant Secretary said that OE's focus on microgrids continues. They have significantly modified how they approach their microgrid efforts in order to incorporate DCEI. This has allowed them to more strategically place prototypes at DCEI facilities.

Finally, the Assistant Secretary said there is a separate line item for DCEI Energy Mission Assurance. The FY 2021 budget request allocates money for preliminary engineering, allowing them to work with industry and National Lab partners to identify investment opportunities to secure the capabilities of those facilities. With that, Assistant Secretary Walker concluded his remarks and invited any questions.

Questions and Answers

Q1. Mr. Heyeck asked how the EAC should focus its efforts to advise DOE related to DCEI.

Assistant Secretary Walker said the Department's DCEI efforts significantly rely on the asset owners that supply DCEI facilities. OE has contacted the CEOs of those companies and is working with them discreetly to make investments that strengthen their posture against cyber, physical, and

electromagnetic pulse threat vectors. The Assistant Secretary said storage has many capabilities that can assist in DCEI efforts through strategic placement in the electric system. EAC Energy Storage Subcommittee work on storage dovetails with OE's DCEI efforts and DOE's ESGC and Grid Storage Launchpad. Grid modernization and smart grid initiatives are helping DOE understand cyber vulnerabilities in electric infrastructure.

Update from the Federal Energy Regulatory Commission

Commissioner McNamee began by saying that Assistant Secretary Walker is a huge asset to DOE because of his in-depth understanding of the security and vulnerabilities of the electric grid. Before he began his presentation, the Commissioner provided the disclaimer that the views he expressed were his own and did not represent his fellow commissioners nor FERC as a whole. He then described his history and experience with energy policy and electricity regulation. He emphasized that decisions made by FERC are based on the evidentiary record, which helps ensure greater fairness. He provided an overview of the types of work FERC does and discussed changes to the regulatory landscape in recent decades. He continued by discussing changes in the country's energy portfolio, including increased use of natural gas generation and energy storage. He focused on energy storage by discussing FERC Order 841, which addressed how energy storage resources can participate in markets. The Commissioner said he gave a partial dissent on that decision because he did not think FERC had the authority to mandate that storage be able to participate in the market if it is on the distribution system or behind the meter. He went on to discuss the Public Utilities Regulatory Policies Act of 1978 (PURPA) provisions of which FERC is charged with implementing. He then addressed transmission issues, pointing out that there can be agreement on overarching goals but disagreements about specific issues such as cost allocation. He emphasized the importance of grid security, both cyber and physical, and the collaboration required between government and the private sector. With that, the Commissioner McNamee concluded and invited questions.

Questions and Answers

Q1. Kimberly Denbow referenced unintended consequences in relation to a proposed natural gas ban and the problems associated with letting politics drive policy decisions. She asked how FERC plans to move forward considering the push for a less diversified energy portfolio.

Commissioner McNamee said it is not his role to make resource choices. He considers it his responsibility to ensure a level playing field for competition.

Q2. John Adams referenced the Smart Grid Subcommittee's work related to state-federal coordination and asked if FERC has any advice or feedback on that issue. Commissioner McNamee said DOE focuses on policy options, while FERC focuses on regulating wholesale rates and not pushing markets toward any particular technology. He said the subcommittee should work closely with Assistant Secretary Walker.

Q3. Mr. Heyeck referenced FERC Order 1000, which is related to growing competitive transmission, and said it does not appear to have brought in new players.

Commissioner McNamee said there has been a lot of discussion about Order 1000 and whether it has been a success. As a general observation, he said trying to plan projects and raise capital is more

complicated than people realize. He said it is important to think about what changes can be made to improve the process.

Overview of Grid Modernization Laboratory Consortium Goals, Capacity, and Capabilities

Mr. Heyeck introduced Mr. Imhoff, Electricity Market Sector Manager at Pacific Northwest National Laboratory (PNNL).

Mr. Imhoff gave context that his work involves about 200 people across the National Laboratories and these would be considered the top people in their respective research field. The GMLC initiative has been active for five years. Mr. Imhoff highlighted the massive imprint that GMLC touches because of the 14 National Laboratories involved, about $300 billion allocated toward R&D, and its 200 industry and state partners. He then pivoted to areas they can improve. The first area is getting strategic linkages with industry partners earlier in the process. The second area is to provide capacity to take completed projects and maintain support so the entire industry can gain benefit from these projects. Finally, industry and DOE should work to better distribute GMLC information.

Mr. Imhoff explained that DOE spends about $300 million a year on grid modernization efforts dispersed among labs, industry, and academia. He outlined the evenly dispersed demographic of their 200 partners across a wide array of backgrounds. Mr. Imhoff then shared priorities the GMLC is addressing. These projects included "Devices and Integrated System Testing," "Sensing and Measurement," "System Operations, Control, and Power Flow," "Design and Planning Tools," "Grid Security and Resilience," and "Generation." For each project, Mr. Imhoff provided expected outcomes and the federal role.

Mr. Imhoff gave insight into how his team interacts with industry, especially because they have so many partners. He used the EEI Wildfire Task Force as a microcosm of their overall interactions with industry. An outside entity will ask DOE its perspective on a given topic. Then DOE will provide the resources that entity needs to successfully address the issue in an expedited amount of time. This specific project has the short-term vision of preparing for the 2020 fire season. He clarified that DOE does not have a specific wildfire program. DOE is doing research that addresses many of these issues that can be leveraged with outside industry.

Mr. Imhoff listed a few other techniques the GMLC uses to engage with industry partners. A few of these are IEEE events, GMLC-held peer review, Distributech, and membership entity outreach. They often received the same reaction at many of these events in that people did not realize DOE was working on a given project. Building off this, Mr. Imhoff overviewed his recent Distributech event presentation. Two major questions that are always discussed are if laboratories are aiming at the right problem and how can their successes effectively be delivered to industry on a grand scale.

Questions and Answers

Q1. Bob Cummings said he is impressed with the GMLC's success.

Q2. Paul Hudson asked Mr. Imhoff to speak about intellectual property ownership.

Mr. Imhoff said most of these projects include a 20% industry cost share. The license for a given technology will usually be shared among multiple firms and laboratories. He added that many of the analytic platforms are using the Berkeley model for open platform activities. This means utilities can pull out a specific piece to pair it with their already existing technology.

Q3. Lola Infante echoed praise for the GMLC and said EEI is thrilled with the ongoing partnership.

Q4. Tom Bialek also noted the GMLC's success. Mentioning concerns about cybersecurity of grid devices, he then asked about grid security and if GMLC has an adoption plan.

Mr. Imhoff replied he is working with DOE entities that focus on the customer side. He does not believe the next-level analytic tools will be developed out of this, but rather that best practices will be put together. A challenge they face is that large companies (Boeing, Microsoft) are pulling out of their traditional utility service providers so a major transition is underway with microgrid renewable integration. On a different note, Mr. Imhoff mentioned that work addressing DOE's overall grid modernization effort (not GMLC) stemmed from OE. That work puts together design principles for digital device developers so they can better design to plan against vulnerabilities on the supply chain side. He said that CESER (the Office of Cybersecurity, Energy Security, and Emergency Response) may have a bigger role given its focus on cyber.

Q5. Mr. Adams commented that the technical people are excited about the lab work, but executives are not too thrilled. He suggested utilizing the Electric Power Research Institute (EPRI) model that better involves the executive level so they can understand the benefits from a business case perspective.

Q6. Ms. Reder said the emerging focus should be getting the message out effectively. She reiterated the need to get industry involved earlier in the process, which will lead to major payoffs from the utilization side by the end of the process. She asked if there are metrics for success or ways to track messaging, industry's involvement, and their adoption of GMLC work.

Mr. Imhoff replied that they track progress, but he does not believe these KPIs are the right ones to drive outcomes for the nation. A successful tactic they used is to piggyback off major conferences or gatherings to get input from key stakeholders all at once. He is open to feedback about how to do this process better. Mr. Imhoff said it is critical for DOE to partner with regulators and utilities to keep them updated about case studies and the work DOE is producing. The technology side is moving significantly faster than a pace regulators can keep up and this is causing problems to arise. Once regulators catch up to a given technology changes are required. Cost is a major barrier for co-ops and utilities in attending training, but Mr. Imhoff says the training will pay dividends down the line.

Q7. Mladen Kezunovic asked Mr. Imhoff to share feedback that he received, specifically from vendors and utilities, regarding the transition from legacy systems to new systems. He highlighted the transitions related to the digitalization of substations and invention of synchrophasors.

Mr. Imhoff stated the importance of getting early adopters involved. There is often a disconnect in the vendor-utility relationship because they wait for one another to push for new technology. He also brought up the diversity of entities, whether they are early adopters, proven adopters, or regional practices. Mr. Imhoff said that energy is rapidly changing at the local and regional levels but lags at the higher level. He called for early adopters to better share successes or failures so the industry as a whole can see the technology innovation occurring.

Overview of Grid Modernization Laboratory Consortium Advanced Sensors and Data Analytics Portfolio and Goals

Mr. King, Director of the Sustainable Electricity Program at Oak Ridge National Laboratory, described the growth in partnerships he's seen over the past five years. When the GMLC began, the focus was on distribution. The electric power system is experiencing a major transformation with distributed energy resources integration, and DOE needed to get more visibility of generation to the end use. Mr. King said that with all the new technology coming online, growing security threats need to be addressed. He said a goal of GMLC is to develop low-cost, high-fidelity sensors. He provided context for how the GMLC group came up with its multi-year plan. His team held six regional workshops that included participants from industry and regulators. A common theme from the workshops was the importance of communication, but at the time this did not fit into a research and development plan.

Mr. King walked through the Sensing & Measurement track from its first call to present day. They had a vision to involve industry from the beginning, even having an industry advisory board for each of the projects undertaken. The beginning included getting a baseline on addressing what technologies to focus on, what is going to be measured, and if a tool can be developed. Their roadmap for this track consists of the three main categories of sensing and measurement devices, communication, and data management and analytics.

Mr. King reviewed a few of the industry engagements and discussed how to further these relationships. He reiterated Mr. Imhoff's observation that industry is unaware of the work DOE is doing. He noted that there is a need for better communication and outreach, especially for peer reviews. An idea being discussed is a "Shark Tank" type peer review event that would bring in venture capitalists to show them successes. Mr. King highlighted a few GMLC projects that make it a point to showcase industry involvement. Some key factors the team considers when developing a project are commercialization, technology to market, and cybersecurity.

Select Advanced Sensors and Data Analytics Project Presentations

Dr. Stewart, Associate Program Leader for Defense Infrastructure at Lawrence Livermore National Laboratory, began the presentation by explaining her presentation is about a newly awarded GMLC project, "Incipient Failure Identification for Common Grid Asset Classes." She gave context to the developmental phase of the project. Although there are large sums of sensors online feeding in data, it is still quite difficult to predict what will happen in the near future. They are taking a three-tiered approach that begins with classifying a problem locally. The next part is being able to predict, diagnose, and prescribe a remediation pathway. The final aspect involves determining the location of the problem occurring and solving it. One of the ways this is deployed is working with veterans about traumatic brain events to better predict treatment options. This transitioned well to transformers, because human consciousness was used to classify transformers as working well, not operating normally, or fully failing.

Dr. Stewart then talked about mapping out the grid architecture and how each step affects one another if failure occurs. She said Oakridge National Laboratory is creating a signature library for sensors across the country. This allows for analysis to quickly detect the status of a transformer in near real time. She clarified that the analysis discussed can be done for any part of the grid if it has data. The big picture of how everything ties together was displayed through the combined solution that utilizes several labs within the process.

Dr. Stewart shifted to how her team is working with industry. The team begins by classifying faults of both known and unknown data. They plan to present the ranking table to the industry in mid-March, and to the general public later. They are currently working to develop their algorithms for utility adoption. Commercial vendors have been included from early in the process.

Mr. Dagle, Chief Electrical Engineer for Electricity Infrastructure Resilience at PNNL, discussed the North American Synchrophasor Initiative (NASPI), which he noted is outside the GMLC. For context, he said that time-synchronized measurements are enabled by wide-area time synchronization (which can be up to hundreds of miles). He noted that phasor measurement units (PMUs) act as a data reduction process to help wide-area communications and measurement systems.

Mr. Dagle said NASPI "is going beyond positive sequence estimations of grid parameters and looking at higher speed things to characterize behavior of inverters." Mr. Dagle then gave a historical overview of NASPI over the past 10-plus years, which showed how much NASPI has expanded. One of NASPI's unique features is that it brings together utilities, vendors, and academia. Mr. Dagle then discussed the "Big Data Analysis of Synchrophasor Data" FOA for analysis of large data sets. He showcased several companies that received funding and pointed out how each of them is utilizing it in a different way. Data for the FOA analysis were anonymously provided by utilities. This analysis has already led to several outcomes.

Questions and Answers

Q1. Dr. Kezunovic observed that vendors wait for utilities to make a move and vice versa. This could potentially be a place for DOE to step in. He asked if they have looked at pushing the boundaries of traditional functionalities. He also asked if they are looking at predictively addressing problems and predictive maintenance.

Mr. King replied that incorporating new technologies to legacy systems is something they have been discussing for many years. This is a major challenge—addressing "valley of death" issues—and some of the projects look at this. He said Dr. Stewart's signature library addressed Dr. Kezunovic's question about predictive capabilities. As they grow their data library, there will be more opportunities for analytics and in-turn predictive modeling. Mr. King said the protective piece is where bringing the sensing and measurement area to the systems and operations control areas is critical.

Mr. Dagle added that some projects show what is and is not feasible. A challenge is that although something is doable, it does not mean there will be buy-in from vendors. He said DOE's role is to convene different groups and communities.

Dr. Stewart said that for the predictive analytics piece, they looked at many different utility approaches. For the multi-model piece, they are trying to create flexible architecture so new sensors can be added to the system and evolve over time.

Q2. Artie Kressner asked if they have thought about ways to operationalize their predictive capability. For example, if they are gathering real-time data and predicting incipient failures in the near term, can that information be used to rank susceptibility of assets? Mr. Kressner said his vision is a system that can detect a fault before it occurs, and which will create total buy-in from manufacturers. He suggested the attributes change with time and circumstances. He said the third element would be to link all of this with models that are both deterministic and non-deterministic. Mr. Kressner said this is a completely different paradigm. If the rest of the industry catches onto it, a Pandora's box scenario will unfold.

Dr. Stewart replied that another part of her work looks at attack analysis. This helps with pairing a visualization to some data for people to better understand it.

Assistant Secretary Walker said a layer of the NAERM model is the utilization of what Mr. Kressner was discussing for defense critical pathways.

Mr. Dagle said this aligns with DOE FOA 1861. Part of what they are doing is progressive disclosure of data.

Q3. Dr. Bialek began by noting the importance of access to data. He would like to know how one gets data or creates databases that can be accessed. Dr. Bialek followed up on Dr. Stewart's comment and said they are doing similar work with third parties. He suggested that DOE consider third parties and the potential contributions they may be able to add.

Mr. Dagle responded that the aggregate data set stops short of providing geo-referenced data and is not combined with a model. NAERM can do this because it has sensitive data that can be classified. The academic community has created synthetic data to create grid models for research purposes. He sees this as a big step forward to having synchrophasor data available to researchers.

Dr. Stewart provided insight that before the projects began, they signed non-disclosure agreements and were working with utilities to gather data to create models.

Mr. King said they are looking to bring in systems and component data.

Q4. In a quick back-and-forth, Mr. Adams asked for clarification about their work. After Mr. King replied, he said ERCOT (the Electric Reliability Council of Texas) grants outages even when they know there is a real risk. This prompted the question of: Can sensors be put in place non-invasively on live equipment?

Mr. King said they are looking at both the wiring of a large transformer then predicting its failure, and putting in sensors to monitor a region and then predicting failures. He responded to Mr. Adams' second question, that it depends on what they are trying to measure and monitor. He gave a couple of examples of situations where this can and cannot occur.

Q5. Tom Weaver has been pushing his company (American Electric Power), EPRI, and others to develop sensors and has not seen the results envisioned. He asked Mr. King how distribution-type sensors are powered. Mr. Weaver clarified he was inquiring about the current sensor given its price.

Mr. King replied that there are different technologies touching this, such as plugging in a system to an algorithm. He then referenced Dr. Stewart's PQ technology being developed outside the GMLC. Dr. Stewart said they learned a lot of basic lessons early in the developmental phase along with working with commercial vendors and utilities. Mr. King clarified that refurbished transformers would have sensors in them. Mr. Dagle added that the data they look at for NASPI are from substations.

Q6. Darlene Phillips said PJM is thinking about next-gen emergency management system technology and trying to deploy a more robust PMU strategy. She asked if they have thought about a rollout strategy for these technologies.

Dr. Stewart said one of their first tasks is to find better ways to deploy algorithms. They are working with commercial vendors to make this happen effectively.

Mr. Dagle said EMS vendors are looking at these technologies. He gave examples of how PMUs can be paired with SCADA data. The measurement infrastructure will come together as one in the future.

Q7. Bryan Olnick said there is potential to put sensors everywhere. He asked what makes the most economic sense for getting to the answers they are looking for. Florida Power & Light is struggling with finding this happy medium point. He also noted that the economic model is highly important for large regulated utilities like his.

Mr. King said they are also toying with this issue. The question is whether to deploy many low-cost sensors or fewer high-fidelity sensors that are more expensive. The Sensor Placement Optimization Tool (SPOT) was created to identify places where sensors are needed and provide the most value. SPOT also identifies areas where sensors are placed unnecessarily. Utilities are excited by this feature.

Mr. Dagle added that detecting oscillations is a great application of sensors.

Assistant Secretary Walker said they have looked at pole issues using satellite imagery and AI analysis.

Q8. Mr. Cummings provided advice to get ahead by predicting *n* minus 1 and *n* minus 2 events. DOE needs to prioritize looking at events that might cause an *n* minus *x* scenario as opposed to putting sensors everywhere. Eventually the sensors will become cheap enough to be placed everywhere.

Mr. King replied that this ties into Assistant Secretary Walker's priority of DCEI.

Q9. Mr. Heyeck said the daunting task is ahead, given the complexities and variability of technology in the grid. Collecting and interpreting data is a major challenge that EMS vendors are not keeping up with.

Mr. Dagle said that some EMS vendors have been involved with developing advanced tools. Unexpected vendors are also getting involved, bringing in different perspectives.

Mr. King said they have looked at technology development that can plug into the EMS system.

Moderated Roundtable Discussion Among DOE, GMLC, and EAC on Advanced Sensors and Data Analytics Portfolio

Mr. Heyeck introduced the context of the panel and explained that DOE will ask the EAC questions for feedback.

Mr. Lawrence introduced this session's panelists, Mr. Irwin and Mr. Cheung. The goal, by the end of the conversation, is to have recommendations for DOE about the direction of the sensor R&D portfolio, including about some GMLC projects.

Questions and Answers

Q1. *Mr. Cheung, Program Manager and Strategist within OE's Advanced Grid R&D section, provided context to today's agenda. These projects were chosen to reflect the diversity of projects being worked on throughout the OE portfolio. For this session, he wanted to focus on the technology commercialization aspect because the goal is for these technologies to make an impact on the industry. Mr. Cheung asked the members what best practices or advice they would give to accelerate technologies to market and industry.*

Flora Flygt said it is an uphill battle trying to convince CEOs and engineering departments to do things differently, even if it will be more cost-effective. Involving industry from the beginning is imperative because you will be able to show where they can save money and how they will get approvals from the regulators. She noted the process will take a lot of time and there will be a lot of back-and-forth.

Ms. Phillips said identifying supporters and naysayers is important because then you can build a business case addressing both sides.

Chris Ayers said regulatory inertia is a major barrier. Utilities' willingness to invest is directly tied to their ability to recover that cost through rates. He said the ability to recover is dependent on how much the regulators and consumer advocates understand about the technology. From the regulators' perspective on data-sensing and analytics, he would ask for the problem to be defined in a way that it can be compared to other problems.

Rick Mroz said the cost issues and value proposition are information the state regulators will want to know. Transmission costs are becoming the focus of state regulators because of the growing cost of transmission. Technology can be a benefit or value using a historical perspective of reliability or it can fit into the newer perspective of how it improves resilience. The resilience factor should be able to sway regulators, policymakers, and consumer advocates. Mr. Mroz suggested they think about the value of incremental costs.

Dr. Kezunovic said two issues he's learned are defining the value to investors and addressing the customer. The two sides of this from the utility perspective are investing and recovering. He also said some utilities brought in regulators to show hands on what is occurring.

Ms. Reder suggested that a good place to start is to identify the value proposition and problem, then get to the technology piece. This should allow you to look at the bigger picture rather than myopically focused on a single aspect. Ms. Reder also advised to look at the full stream of the technology.

Drew Fellon said it comes down to the user's experience. The regulator will look at how a given technology will benefit the ratepayer. Mr. Fellon listed several factors the regulators consider, including national security.

Mr. Olnick said a challenge he's noticed is that consumers need to understand what a utility is trying to do. They have worked on framing the benefits in a way people other than engineers and scientists will understand. He advised DOE to take this into account.

Mr. Weaver said the distribution side needs to know what are the most effective uses of sensors and the minimum number needed to be effective for those uses. He listed applications that sensors address. Mr. Weaver said this will help build the case with customers and regulators about where the value lies.

Dr. Bialek said a lot of people have yet to deploy AMI and this will lead to other issues about sensors. California spent billions of dollars deploying AMIs for a billing system and now they are looking to increase the AMI functions. To go beyond the current sensor paradigm, customers will ask what value they'll get. This leads back to the value proposition and crafting a roadmap.

Mr. Heyeck provided an anecdote before commenting that obsolescence, life cycles, and false positives in sensors are all important.

Mr. Kressner emphasized the need to make the analytic interface simple and actionable when presenting it to the end user. He provided examples of how different industries utilize technology like this to monitor their operations. Mr. Kressner would like to see an artificial indicator for the grid.

Sheri Givens encouraged DOE to consider its audience and how this will frame the narrative. She suggested to come in with a different story about the benefits of sensors depending on the audience being addressed. Ms. Givens advised DOE to think about how to get its message out publicly.

Dr. Kezunovic commented that when presenting about predictions and root cause analysis, the differences must be made clear. He reiterated Mr. Kressner's point of the need to clear presentation.

Mr. Mroz said the teams should ask themselves if the utilities have the backbone to manage all the unanticipated data collection if things start to unfold. He gave context that New Jersey did not do AMI because the backbone was not built out. There may not be a backbone, especially as data increases exponentially.

Q2. *Mr. Irwin said that based on GMLC projects invested to date, DOE has invested in sensing, data origination, and analytics. Mr. Irwin noted that they have not committed any R&D projects to data transport or communications networks. He asked if this trend should continue (is communications already addressed?) If not, what other considerations are there?*

Ms. Reder replied that the communications aspect is often the Achilles heel. A lot of money is invested in sensors, devices, and modeling, but communications is often forgotten. She said communications is incorporated for a certain function but often it does not perform as intended after a period of time for a variety of reasons. On the regulatory side, education is important but often difficult because of the technical nature of the topic. Communications is often designed for a single application. DOE might want to explore creating communications tools that can be altered for future improvements.

Dr. Kezunovic said processing at the source is extremely important and has a huge impact on the choice of the communications. There are intrasubstation and intersubstation aspects making up communications. He said an underrated part of communication is that many of the sensors are outside of utility companies. This showcases the need for the intra- and intersubstations.

Mr. Kressner noted that there is definitely a need for investments in communications R&D. The communications industry has not stepped up to develop technology, so a gap is left for DOE to fill.

Ms. Phillips said it is important to address who will need this data with the mindset of "when, why, and how." When developing this technology, it has to be looked at with a birds-eye view.

Mr. Weaver said they put out a large number of sensors using cellular communications. He used this example to highlight that they are looking for better communications methods. Mr. Weaver emphasized the massive need for broadband in rural areas. He said AEP is installing fiber for these areas because the benefits will be tenfold compared to the inputs.

Assistant Secretary Walker said DOE set up an MOU with USDA for rural broadband. This MOU incorporates the Power Marketing Administrations (PMAs) to oversee this. He said DOE does not build transmission without OPGW fiber optic cables. Mr. Walker said they are adding this to critical infrastructure because the security benefits provided cannot be quantified.

David Wade spoke about Chattanooga's 2009 fiber system infrastructure project. He noted that the commercial system has paid for itself by bringing in higher net income and giving more people access to electricity. Another benefit is they now have ownership of their communications and can implement cutting-edge technology.

Mr. Koplin emphasized the importance of owning your communications network and reiterated the need for using OPGW fiber cables for security and reliability purposes. For micro-PMUs, they have an agreement with PNNL to receive real-time data and store it. When an event occurs, PNNL can provide instant feedback and work with Cordova to solve the problem. Mr. Koplin discussed the importance of control data versus mass data. He wrapped up by overviewing that the algorithms in their assets are programmed to be ready for lost communications so the system is prepared in the event of an outage.

Jeff Morris spoke about smart buildings. He said there are multiple issues with communications and signaling as transactive energy is playing a bigger role beyond the meter. He advised taking market barriers into account because different areas have different standards. Mr. Morris said to make sure two-way communication is implemented and that there are options from remote sensors to wholesale markets for communications pathways.

Mr. Heyeck gave the opinion of being a locally elected official for over 27 years in a city that has a municipal electric system. Mr. Heyeck said dealing with the public is a major aspect unaccounted for. He likes Mladen's idea of computation at the source.

Dr. Bialek brought up that large utilities have vast resources to develop and gain access to various types of technologies. He gave the example that SDG&E is using the same technology as the city of San Diego but in different ways. Dr. Bialek noted that while DOE is working on sensors, utilities are still buying sensors from companies. So the challenge will be connecting the interface of the various sensors. He suggested that a standard would be important for a smooth transition. He concluded about the

importance of future planning because better technology will inevitably be invented and will have to come onto the grid.

Mr. King said data transport will need to be changed dramatically as machine learning environments play a bigger role. He said this is part of Dr. Stewart's research.

Mr. Lawrence asked Mr. Dagle to speak about the alternatives they are analyzing to improve two-way communication.

Mr. Dagle said they are mainly focused on the timing, with cybersecurity taking a backseat. GPS has long been considered superior to other technologies given its accuracy, cost, and availability. It is too good of a technology and causing concern because of the increased dependence on it and other technologies are being thrown to the wayside. Mr. Dagle highlighted a few other satellite or GPS systems that are coming online. He advised to be cautious when having GPS feedback into a closed loop control (did not mention any reasons). He said alternative technologies do time synchronization to the nanosecond. The Executive Order calls for agencies to come up with a plan and the Department of Homeland Security awarded an FOA for vendors to present their projects.

Assistant Secretary Walker added that DOE has taken atomic clocks out of its weapons labs; two of the clocks are at PMAs. He said the development of synchrophasors will help determine where to place the clocks while developing fiber networks.

Dr. Bialek said time-synchronized data is integral to understanding issues because it is the glue that brings all the sensors together.

Q3. *Mr. Cheung said he is working on projects that address the deployment of high-fidelity optical sensors and he is hitting a major barrier of "geographical tribalism." He asked what strategies the EAC can provide to address these challenges.*

Dr. Bialek said this is a value proposition. He spoke about instances of machines failing and that these failures are an opportunity for DOE to show how its technology will prevent this from happening.

Mr. Dagle gave a shout-out to SDG&E for using PMUs on distribution feeders to detect broken conductors. This directly helps mitigate wildfires.

Mr. Cheung clarified that his challenge is transferring the technology between utilities.

Dr. Bialek said it is important to quantify the cost of machine failures. Once cost savings are presented, utilities should open up.

Mr. Heyeck referenced the EPRI model advisory group as a role model.

Mr. Koplin said he tends to invest in cutting-edge technology even though it will appear cost-negative. In the long term, a given technology may have unintended uses that will pay major dividends. As an example, even small efficiency gains can lead to large payoffs. The sensors he uses are great diagnostic tools.

Ms. Flygt said they need to accept that there will be a few early adopters for a given technology before the masses hop aboard. Her company's CEO had always asked her, "Who else is doing this," showing

that when major players adopt a technology, it will more likely catch on. Ms. Flygt suggested asking other industries about the timeline for a technology to be adopted.

Mr. Kressner noted that some of the tribalism may be a generational thing. He said other factors could be workforce mobility and cultural dimensions.

Mr. Weaver said utilities can do a better job learning from each other and from DOE. For example, Florida Power & Light implemented sensors but other utilities found out about this through vendors. Mr. Weaver said AEP is starting a sensor strategy team and invited DOE to join them. He said DOE can fill a gap by letting utilities know how many sensors to use.

Mr. Hudson said the problem Mr. Cheung faces is happening for many companies that are relatively new and trying to scale up. He suggested reaching out to these companies to gather their experiences getting over the hump.

Ms. Denbow emphasized the importance of partnering with an aligning industry association. She said there is a lot of interest in natural gas pipeline cybersecurity. Ms. Denbow said it comes down to demonstrating to a partner that the technology works, so DOE and the partner can go in on it together.

Mr. Lawrence said there are still outstanding questions that can be sent out to the EAC via email.

Wrap-Up and Adjourn Day 1

Mr. Heyeck asked for feedback about the new format of the in-person meeting.

Chuck Kosak, Deputy Assistant Secretary of Transmission Permitting and Technical Assistance (TPTA) within OE, said OE priorities of NAERM and DCEI are for risk management. Mr. Kosak discussed the importance of partnering and having repeatable processes. He outlined how different stakeholders play certain roles within the NAERM and DCEI conversation. TPTA's new vision will shift to a more proactive approach to build on the strategic, operational, and tactical levels. Mr. Kosak then reinforced OE's commitment to NAERM, both with R&D and utilization. He hopes there will be more collaboration with individual EAC members with the new direction of TPTA. Mr. Kosak walked through the thought process of NAERM, highlighting the multi-tiered factors that drive the model toward its intended use. He will push out the new TPTA vision once it is completed.

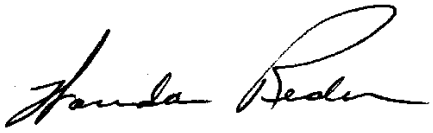
Assistant Secretary Walker thanked all the panelists and guests throughout the day for making time to participate in presentations. He expressed concern about utilities using a cost-benefit analysis system for implementing new technology because certain devices will be able to do applications that are not yet realized. Assistant Secretary Walker reiterated his desire to move away from least-cost models. The Assistant Secretary said the electric industry has to make room for sensing and energy storage regardless of some of the early costs, because it is the right thing to do. He believes the "monopoly model" should be used to implement new technology. The Assistant Secretary encouraged EAC members to provide comments that he will take to the National Association of State Energy Officials (NASEO) or the National Association of Regulatory Utility Commissioners (NARUC). The Customer Average Interruption Duration Index (CAIDI) and System Average Interruption Frequency Index (SAIFI) are outdated and must be updated to reflect the modern grid.

Mr. Heyeck concluded Day 1.

Respectfully Submitted and Certified as Accurate,

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

04/30/2020
Date



Wanda Reder
Grid-X Partners, LLC
Vice-Chair
DOE Electricity Advisory Committee

04/30/2020
Date

Christopher Lawrence
Office of Electricity
Designated Federal Official
DOE Electricity Advisory Committee

04/30/2020
Date