U.S. Department of Energy

Electricity Advisory Committee Meeting

NRECA Conference Center

Arlington, VA

June 8, 2017

Summary of Meeting

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<u>Welcome: Overview of Energy Storage Session during the EAC June 2017 Meeting</u>

Chair Tierney opened the meeting by thanking the EAC members assembled and thanking NRECA for hosting the meeting, before turning over the microphone to Merwin Brown.

Mr. Brown, EAC Energy Storage Subcommittee Chair, added his welcome to those assembled. He began by introducing the day's session as a new format for the EAC. He gave an overview of the history of the EAC, beginning with the establishment of the EAC as an official Federal Advisory Committee under the Energy Independence and Security Act (EISA) of 2007, as well as the statutory creation of the Energy Storage Subcommittee. Mr. Brown shared that the EAC often turns to public and private stakeholders to inform the advice provided to DOE by the EAC.

Mr. Brown introduced the current Work Product, "Securing the 21st Century Grid" by first giving an overview of past Energy Storage Subcommittee work products and next indicating that the Energy Storage Subcommittee plans to establish the potential role for electric storage to provide reliability, resilience, and security services. He described the core work-product activity of the current meeting as a facilitated, discussion-oriented public session of the EAC with invited expert speakers and commenters. Mr. Brown continued by giving a brief introduction and biography of Janice Lin, who would be facilitating the discussions for the day.

Session Scope and Objectives: Overview of Energy Storage and Key Trends

Janice Lin, EAC Energy Storage Subcommittee Member and Session Moderator, introduced the cross-panel contributors:

- Patricia Hoffman, Acting Assistant Secretary, U.S Department of Energy – Office of Electricity Delivery and Energy Reliability (OE);
- Puesh Kumar, Director of Preparedness and Exercises, U.S. Department of Energy – Office of Infrastructure Security and Energy Restoration (ISER);
- Ariel Castillo, Senior Program Manager, U.S. Department of Defense – OASD Energy, Installations, Environment;
- Patrick J. McCormick III, Chief Counsel, U.S. Senate – Committee on Energy & Natural Resources;
- Tom Hassenboehler, Chief Counsel for Energy and Environment, US House of Representatives – House Committee on Energy and Commerce;
- Mark Irwin, Director of Energy Contract Management, Southern California Edison;
- Damian Sciano, Director of Distributed Resource Integration, Consolidated Edison;
- Terry Coleman, Director of the Electrical Training ALLIANCE and IBEW representative;
- Tony Ruffine, Vice President, GAF Materials Corporation; and
- Kiran Kumaraswamy, Market Development Director, AES Energy Storage.

Ms. Lin then welcomed the assembled EAC members, contributors, and other guests,

Ms. Lin began her presentation by discussing last summer's Aliso Canyon gas leak and how the unexpected fuel-supply shortage led to California regulators and system operator's having considered how electric storage could be used for reliability, resilience, and security – in California and elsewhere. Ms. Lin shared that the meeting perhaps was the first to be convened specifically to think about electric storage for reliability, resilience, and security.

Ms. Lin began her overview presentation by referencing the trend of the sharing economy, which is at the core about asset utilization. In the context of the energy sector, Ms. Lin stated that there is a substantial opportunity for better asset utilization in the power sector, especially given that a substantial portion of capacity in the power sector is used very infrequently, either for peaking or to balance hourly and seasonal load changes. So, Ms. Lin asked the group, is there a better way to use electric storage assets to optimize the utilization of power generation technology.

Ms. Lin discussed several types of storage that are available today: electric vehicles, gravitational, mechanical, thermal, and electro-chemical. She continued her presentation by comparing fat storage in the human body to the ability of the power sector to smooth demand for energy. She described other methods by which electric storage use can be taken advantage of for grid operational efficiency. She provided an overview of the session objectives and key working session focus areas to close her introduction. Merwin Brown was asked to contribute that electric storage is a temporal power flow control device. Ms. Lin also listed a series of questions for contributors to keep in mind throughout the day.

Ms. Lin introduced the session's participants and their topics:

- Richard Walje: How are we to value stackable energy storage services?

- Anne Pramaggiore: How do we articulate the regulatory hurdles to implementing energy storage, as well as unique and effective approaches to overcoming these hurdles?

- Gordon Feller: What do we learn from international competitors? For example, the Chinese investments in electric storage and microgrids.

- Pam Silberstein: Considering that NRECA members' infrastructure covers large rural areas, what are the specific electric storage applications that would be most helpful for rural customers for reliability, resilience, and security and affordability?

- Ake Almgren: Where on the system do we expect to see most new electric storage show up?

- Rebecca Wagner: how do we make the transition so that regulators become comfortable with an asset class with which they are unfamiliar?

- Granger Morgan: Are there cost-effective ways to have variable generators that move back and forth between de-salinization and energy storage?

- Laney Brown: How can value be articulated for energy storage?

- Chris Shelton: What single insight speeds the awareness of value and flexibility of energy storage?

- Heather Sanders: How can electric storage be equivalent to a substitution for a wires alternative?

- Anjan Bose: What are the different types of storage (e.g., non-battery) that can be used and what are the statuses of their development?

- John Adams: At what cost per kWh do we expect the expansion of electric storage to explode?

- Merwin Brown: Given the tension in the system between electric storage deployment and value recovery in either a regulated or market space, what are barriers that exist and what are workarounds?

- Paul Centolella: Regarding reliability, resilience, and security, what are the technologies that are potentially available for longer-term storage (multi-day) in areas that may not have the geography for compressed air or pumped storage, and what can be done to achieve significant cost reductions?

- Carl Zichella: There is not always a clear way to compensate for electric storage services. So, can we clarify how the value streams of electric storage may be captured and who pays for energy storage?

- Sue Tierney: Given the entry of various types of storage (most of which are not yet at scale), how do we think about the timing and pace of different electric storage functionalities as we add other assets that storage would compete with, like gas pipelines?

- Katie Jereza: What game are we trying to change? What does DOE need to invent to help electric storage change the game?

- Matt Rosenbaum: What is the role of electric storage in the home, and how can that be used to get people back in their homes after emergencies. In addition, how does that complicate the utilities' power restoration processes?

- Paula Carmody: Given the huge scale of electric storage, what top 3 recommendations would the cross-panel participants give to states, state regulators, and stakeholders as focus areas?

- Rolf Nordstrom: How is electric storage captured – or how could it be captured – in the integrated resource planning models that utilities & regulators use?

- Jeff Morris: Looking at Hawaii as a negative example (note their high capital expenditures and a lack of data for lifecycle costs): when we look at DER planning, we do not have data on how electric storage fits into temporal value sets. So, how can electric storage be used as a resource? Is there growth of those data sets? How or when will they be available?

- Phyllis Currie: What are the range of possible electric storage applications, from the local utility level – like rooftop solar management—, to electric storage serving a resource as part of the energy markets?

- Mark Lauby: Nothing gets built without being planned for. So what models and simulation tools can or will be developed to support electric storage analysis and deployment. What is the status of technological development? And what do we expect for greater tool development?

- Marilyn Brown: Georgia has the second most electric vehicles, behind California. How would a business and governance model help provide balancing requirements for a local distribution system using electric vehicles?

- Jay Caspary: What market mechanisms can be used to help manage wind and solar resources that have excessive curtailments today?

- Clark Gellings: Would it be better to focus on conventional solutions (technology we already have) or to invest in research and development for electric storage, given that we are not making rapid improvements in electric storage? Should we invest in power electronics instead?

- Damian Sciano: I am interested in benchmarking against other places like the UK and PJM and seeing what kind of market features they use batteries for, including frequency control. I am especially excited to see the boards with different time frames of storage applications.

- Kiran Kumaraswamy: Regarding modeling and analytics: What is being done to date by DOE and the national Labs to make use of studies and promote better data?

- Terry Coleman: Given all these developing systems, we are looking toward a skilled worker shortage. To this end, what training needs do the EAC Members see being created that need to be met?
- Mark Irwin: What are others doing in the electric storage space?
- Tom Hassenboehler: How can electric storage help bridge a gap in politics in Energy and Commerce issues? Can there be some bipartisan consensus on how to adequately address and value storage— or a less partisan way to address climate?
- Patrick McCormick: Given the significant fiscal government challenges, how can private capital be attracted to make the most impact in increasing electric storage performance and lowering price? Can it be done without government? Or, what is the lowest level of federal expenditure required?
- Puesh Kumar: As someone focused on reliability, resilience, and security – how can electric storage be used as a means for reliability after an outage? In the longer term, what are the cyber vulnerabilities of electric storage? Are we looking into the solutions from a security perspective, and how are we addressing security issues in the immediate timeframe?
- Jessie Denver: How familiar are attendees with local policies that are driving market transformation for DERs like storage?
- Tony Ruffine: What is the impact of storage on overall cost-benefit analysis? Where is the tipping point between accepting electric storage as a project component versus encouraging storage development independently?
- Heather Sanders: Followed up on her initial question by indicated she is also interested in second use of electric storage and the recycling aspect: if electric storage is built for a specific application, is there a way to repurpose for a second use?
- Janice Lin: As a question for DOE, when can we do another workshop?

<u>Panel: Power Sector Vulnerabilities</u>

As facilitator, Janice Lin opened the day's discussion with the power-sector vulnerabilities panel. She introduced the panelists, including: Granger Morgan, Chair of the Grid Resiliency Committee at the National Academy of Sciences; Damian Sciano, Director of Distributed Resource Integration at Consolidated Edison; and Mark Lauby, Senior Vice President and Chief Reliability Officer at NERC.

Granger Morgan began his presentation by outlining that most power system disruptions are local. He continued by introducing the most common metrics used to measure distribution-level disruptions and reliability: CAIDI, SAIDI and SAIFI. He noted, however, that there is wide variability across the country, so figuring out how to have broadly applicable metrics is not straightforward. Dr. Morgan gave an overview of SAIDI by state. He outlined several major past and present sources of disruption, noting that large disruptions are more common than might be expected. Dr. Morgan listed causes of human-induced major disruptions: physical terrorism, cyberattack (disentangling the power system from infected cyber controls poses a problem), and human operations or operational errors (how to regain situational awareness). He gave an overview of natural causes of outages: extreme weather events such as hurricanes, ice storms, flooding, drought, and wildfires. He noted an additional category of risk is space weather, for which normal events are not a problem, but for which the risk of large geomagnetic disturbance (GMD) or other disturbances are present. His final thought was that local storage could help with ride-through for short term outages. If designs and regulations are innovated, local storage can be combined with local photovoltaic (PV) resources for greater resilience, and electric storage use in bulk storage could be used to ride-through longer outages.

The second panelist, Damian Sciano, began his discussion by introducing ConEd's distributed-energy system platform, which helps manage both the planning and operations of infrastructure use by the utility. Mr. Sciano stated "from the utility's perspective, it is very important to own battery storage." Specifically, he shared that ConEd sees electric storage as a Holy Grail or game changer that can help deliver electricity on demand. While the use case will continue to evolve, other questions need to be answered. Specifically, as the demand curve flattens, other issues – like the value stack for energy storage – ought to be addressed. He shared the history of energy storage in New York, beginning with pumped storage, which has been used for the "crank start" to being the cascade of bringing power back online. Now, battery systems and other technologies are being used for energy storage. As more interconnection points are added, however, physical and cyber security vulnerabilities are compounded. The NY REV plan states that utilities generally cannot own assets, but specifically carved out electric storage as an asset class eligible for utility ownership. Mr. Sciano showed a time-lapse of the New York City area, depicting how the load profile changes over the course of the day. As the time-lapse approaches 5pm, the system peak, solar assets are only operating at 30% of their full capacity rating. In addition, as the load moves to the outer communities at night, a lot of communities move to their peak at night. The Brooklyn/Queens load is the fastest growing in the metropolitan area. So, Mr. Sciano highlighted how observers can see why electric storage is a critical tool for transmission and distribution system balancing.

Mr. Sciano discussed ConEd's System Expansion project, suggesting that the utility had learned lessons from the Brooklyn-Queens Demand-side Management (BQDM) pilot program. The BQDM project had allowed the deferment of $1 billion in traditional network upgrades, including that of a substation, by substituting a distributed solution. Instead of adding a 250 MW substation, the BQDM solution was to install small electric storage blocks in the Brooklyn/Queens area to meet the growing load peak. The battery storage system would be arriving in 2017, having successfully completed the permitting process required by the Fire Department of NY (FDNY). The battery of choice uses lithium iron phosphate, which is more resilient to high heat than lithium ion batteries, but even these batteries need special security standards that make them hard to get permitted on the residential level. All in all, these battery systems have the potential to function as a "virtual power plant at the residential level." Returning to the topic of energy storage in New York, Mr. Sciano added that while utilities are allowed to own energy storage, use cases are under development and include collaborative work across stakeholder groups.

The third panelist, Mark Lauby from NERC, began his presentation by asking how industry could define bulk power system reliability. Mr. Lauby suggested that large-scale storage is a game-changer for reliability, asking several key questions that would scope his presentation. In particular, system dynamics are changing, Mr. Lauby shared, especially as more asynchronous assets are added to the system, outside of the 60 hertz electricity delivery system. "What is energy storage," was one of these key questions. Mr. Lauby stated energy storage is both load and also capacity, and capable of supporting transmission. As a dynamic resource, electric storage can be helpful to support non-dispatchable resources; it is flexible. In addition to storage and flexibility functions, electric storage is capable of providing inertial or primary frequency response, filling the needs that emerges at some point for inertia replacement. Electric storage also serves several essential, fundamental reliability functions. By combining resource adequacy contributions and essential reliability services, electric storage can be a key component of reliability planning. It is also capable of providing load and resource balance, voltage support, and frequency support. Some phase lock logic uses the system's frequency to react, but this assumes a constant frequency is present somewhere in the system, a role which Mr. Lauby suggested could be supported by electric storage.

He described that as frequency excursions happen across the system, there is a serious need for flexibility. Many thought that the full duck curve would happen in California by 2020, but innovations are needed regarding matching ramping with net load. For example, ramping capability was expected to need substantial improvement, but already by 2017 there are indications that generating plants cannot support the necessary ramping quickly enough and have already needed to go to interruptible load. Mr. Lauby characterized Southern California as an example of this trend, especially following the leak at the Aliso Canyon gas storage facility. Solar is expected to increase based on current and planned productions – including two to three year commitments – so today the system is experiencing a control shift. Mr. Lauby relayed that as the electricity delivery system leans more toward a distribution system that is generating electricity, away from a bulk power system, new ways to use electric storage need to be leveraged to manage changes stemming from distributed generation permeating the bulk power system. As a final question for further thought, Mr. Lauby asked: how does the electricity industry – operators and regulators alike – manage this transition, so as to continue to provide support to the bulk power sector?

EAC Discussion of Power Sector Vulnerabilities Panel

Janice Lin called for questions for the Power Sector Vulnerabilities panelists.

Phyllis Currie asked Mr. Sciano how, given residential and political pushback to asset siting, does ConEd manage the public perception of developing infrastructure in an urban area. Mr. Sciano said that NYC councilmember meetings have been critical, as have been stakeholder engagements, in general. He suggested that explaining the purpose and benefits, answering community questions, and lobbying were all key to securing public support.

Carl Zichella commented that flywheel technology has played a role in New York for short-term frequency management. Given the space constraints, he asked where Mr. Sciano saw short-timeline operation of flywheel going. Mr. Zichella also asked whether there was interest in NY for greater deployment. Mr. Sciano offered the example of the A Train from Queens to Rockaway as a good application in the last decade of architecture that provided a momentary frequency boost for the traction load to get through, but noted that progress is back at the research and development level at this point. Mr. Zichella asked if these include examples of value, where ideas could not be funded otherwise. Mr. Sciano replied that the NY/ISO was building a DER roadmap to identify value streams that make sense.

Merwin Brown referenced his earlier question regarding deploying electric storage in a hybrid market system where there is competition, but also participation by rate-based assets. Looking at the different applications of electric storage (frequent, instant use versus rare, large-scale use in emergency support), he asked about what the panelists think needs to be done to distinguish between something is a rate-based asset or a market participant. He also asked whether there was a technological solution that works around the issue. Mr. Sciano argued that battery and electric storage was a key goal before renewables, but that they are even more critical now. That said, with customers wanting perhaps to adopt in the future, current deployment is mostly by the utility as a rate-based asset. Granger Morgan tackled the large outage angle, suggesting that electric storage may not be the solution in these cases.

Janice Lin solicited further input from the attendees. She asked the attendees to write down, from their subject matter expertise, their views about the vulnerabilities that DOE should focus on, going forward, and how electric storage could potentially be a solution for such risks.

Several topics raised aloud included short responses on reactive and active power, the optimization of short-term response over longer periods, and how to manage the non-functional market gap between a disruption and frequency or voltage response. Richard Walje asked about who could/would coordinate the recovery of DERs within the bulk power system, following an emergency outage. Mr. Sciano added that peak-shaving for deferral of transmission and distribution investment would fall into the “hours” category. Other suggestions in the “months” duration category included Granger Morgan’s view that electrochemical and pumped storage would not work for this length of time, so there might be a need for synthetic fuels. Clark Gellings suggested that, at least in theory, a thermal device could meet this need. Phyllis Currie asked whether, on balance, electric storage was adding to overall grid resilience or adding more vulnerabilities. Pam Silberstein wondered whether – given more, extreme weather, and the range of electric storage technologies – some technologies might be better suited in such situations. Puesh Kumar commented that the Ukraine incident disconnected three substations for three hours. However, there was a long outage. He shared that DOE’s Office of Infrastructure Security and Energy Restoration (ISER) is working with the Massachusetts Institute of Technology (MIT) to look at pockets of critical lifeline functions (location-specific) that could be supported by various resilient technologies. Janice Lin commented that he raised two issues: the criticality of islanding or energy storage’s restorative role, as well as the cybersecurity function of islanding that would allow DERs to separate themselves – or be separated – from the internet, as a defense.

These comments and others are included in the full list of participant contributions included later in the summary, under the “Final Discussion” heading.

Panel: Advances in Energy Storage for System Reliability and Resiliency

Janice Lin introduced the panelists for this session:

- Fred Hoover, Senior Program Director at the National Association of State Energy Officials;
- Mark Irwin, Director of Energy Contract Management at Southern California Edison; and
- Praveen Kathpal, Chair of the Board at the Energy Storage Association.

Mark Irwin began his presentation by discussing California's mandate for storage procurement, before adding that Southern California Edison (SCE) bought most of its electric storage to meet other needs, not in response to the mandate. He detailed SCE's solicitation process, which included several requests for offers (RFOs) before a request for a proposal (RFP) was issued in 2016 following the leak at Aliso Canyon. He discussed in detail the "Goleta Challenge," which entailed purchasing a portfolio of local resources to manage N-2 risk.

Even though this issue was named for Goleta, it involves the Santa Barbara substation, which represents the end of the SCE system on the way up to Monterey. Pacific Gas and Electric (PG&E's) system starts after Point Conception, up into the mountains. As an overview, the location includes two lines on one set of towers. SCE has had to shut these lines before for fire risk, but the long-term risk is landslide risk, due to alluvial soil.

Mr. Irwin suggested that electric storage may be part of the solution. Earlier, he had heard NRECA staff discuss electric storage solutions. Building a backup wired system can be expensive, with electric storage as a potentially cheaper alternative. Mr. Irwin suggested the solution to Aliso Canyon also included electric storage. With power plant construction, the timeline is 7-10 years. Electric storage was a quick-response option to an Aliso-induced gas shortage. SCE had looked both at utility ownership and non-utility owned project.

Mr. Irwin shared that when the utility is procuring for reliability, it needs to look at the cost of the alternative reliability device, rather than pure cost. Electric storage might not be economic in the regular market, but might be an affordable alternative to other reliability. He added that using DERs to meet distribution deferral needs proved challenging. Different need profiles heavily influence the resource mix and cost of the DER system. Local capacity resource RFOs require an overview of the service area and substations, but provide opportunity. Overall, Mr. Irwin indicated that SCE has done a lot with electric storage, for a number of reasons. He recapped the specific focus on reliability in Goleta, but also added that when SCE goes to procurement and looks at economic alternatives in California for reliability, storage has performed well.

The second panelist, Fred Hoover from NASEO, gave an overview of state energy offices (SEOs), and noted that SEOs represent their states for the sound use of resources and promoting energy system development, including pursuing economic opportunities and opportunities for increased reliability, resilience, and security of the electric grid. SEOs are responsible for planning Emergency Service Function (ESF) response at the state level for energy emergencies. This includes work with the State PUC, under DOE Office of Electricity Delivery and Energy Restoration (OE) oversight for dealing with energy emergencies. NASEO relies heavily on DOE staff both for planning and incident response. Mr. Hoover said that he would cover a small sample of examples in which states want to use electric storage as part of their emergency planning.

Connecticut, for example, started a series of actions to increase reliability, resilience, and security on the electric grid after Hurricane Irene and others. Grants and loans were made available to municipal utilities, investor-owned utilities, and others to develop microgrids to secure critical infrastructure, including power, water, and emergency services. He added that it is a short step from microgrids to electric storage inclusion in microgrids. In 2015, Connecticut authorized the state to solicit long-term contracts for energy resources, including electric storage. Maryland had a severe electrical outage following the derecho. The governor instituted a study to increase reliability and resilience on the grid, with recommendations for investments.

The Maryland SEO also recently reported to the legislature the benefits of electric storage for reliability and resilience. Maryland has an incentive program (which Mr. Hoover calls a game changer) where applicants are funded for demonstration projects or other applications of pre-commercial technologies. The first fully-funded microgrid project was supported through this program.

In New Jersey, in comparison, 71% of the grid was impacted by Sandy, which resulted in 2.8 million customers losing power. This caused both electric and fuel accidents, as well as shortages, with 75% of stations out of supply for a week and the governor forced to invoke fuel rationing. The outage affected critical infrastructure – waste treatment, hospitals, and the police – as well as impacted their operations. Overall, the state was overwhelmed with requests for generators. Other events that caused grid problems were recurring. The state decided to examine the acquisition and deployment of generators, in addition to searching for other ways to add reliable and resilient technology to the grid. In addition, New Jersey wanted to evaluate islanding during outages, supported by microgrids. A pilot process was established in localities designated by FEMA as storm-vulnerable. The state issued an RFP in 2014 for behind-meter storage to support renewables, and needed to include a reliability benefit in order to be funded.

New York, in comparison, saw a funding request issued by NYSERDA for commercially distributed storage systems. Other states' actions included Washington, which though the clean energy fund has provided grants to projects that show how to improve reliability and resilience. Massachusetts, too, issued a report in 2016 valuing deploying electric storage in the state, both to state industry and for reliability. The report discussed various manners of electric storage use.

Finally, Mr. Hoover shared that NASEO members are interested in electric storage both for resilience and for economic benefits. The state energy program is part of the DOE budget to enable states to plan similar programs and supports emergency planning and response overall.

The third panelist, Praveen Kathpal, was introduced as leading the global development team at AES, as well as serving as the chair of the board of directors for the Energy Storage Association (ESA). He began his presentation by describing global implementation of grid-scale electric storage, based on his experience at AES. Mr. Kathpal played a time-lapse video of an electric storage project being built at Escondido, which at the time was the world's largest Li-Ion storage array. He described this video as not suggesting deployment was simple or easy, but that it was imminently possible, even on a short time scale. In particular, Mr. Kathpal focused on energy storage as a generation alternative. The battery can provide peak power and capacity, as well as local reliability, ramping and flexibility, and ancillary services. Benefits of using battery storage can include rapid deployment, competitive and cost effective pricing, and meeting flexibility (duck curve) needs. Mr. Kathpal shared that electric storage also could be used to meet expected expansion in supply needs, on the order of tens of gigawatts.

Mr. Kathpal also said that because California had the familiarity and institutional infrastructure in place to support electric storage deployment, it was able to respond to emerging issues (nuclear plant retirement and the Aliso leak) with quick electric storage deployment. Mr. Kathpal also described how electric storage could be used as a distribution alternative, by embedding storage in the distribution network for reliability. Services include peak demand management and renewable integration, while impacts include supporting rooftop solar growth, managing local feeder reliability, and serving as an alternative to substation upgrades. Finally, Mr. Kathpal discussed the use of electric storage for renewable integration. He pointed to solving peak energy demand through solar-plus-storage in Hawaii, which would give the island the ability to maximize the use of locally produced energy and to reduce the reliance on shipped fuel oil. Mr. Kathpal commented that he was seeing this trend increasing, where solar and storage could meet the energy needs of a greater set of the U.S. energy system.

EAC Discussion of Energy Storage for Reliability and Resiliency Panel

Janice Lin asked, in reconsidering a recent Executive Order released by President Trump on cybersecurity, what the panelists would say they are thinking about how to address this issue.

Mr. Hoover suggested that from the states' perspective, considering widespread impacts of a major cyberattack, the states are considering not just grid impacts, but those on other sectors, including pipelines and petroleum supply. He also suggested that fuel shortages are exacerbated by people migrating away from outage areas to boundary areas changing response needs. He shared that states are convening large, multi-agency groupings to evaluate response options. However, he also cautioned that substantial impacts may result from communication issues: social media use, as well as what happens when wrong information is spread. One key goal of state energy officials is to delay social unrest. Mr. Irwin indicated he was not familiar with SCE cyber planning. Mr. Kathpal commented on the ways in which cyber threats manifest into a physical vulnerability. He suggested that electric storage provides inherently more resilient infrastructure because of modularity. In addition, interference may be simpler to detect.

Carl Zichella asked how physical security concerns factor into (a) siting and (b) construction of facilities. He broadened his question to include the implications of fires and other events occurring at substations, noting that battery technologies can be located in urban systems, but asked what risks are being created. Mr. Irwin followed up, raising for debate the idea that more might need to be done to secure electric storage. He suggested that it would be critical to lean on industry standards, as well as to implement safety standards on the utility-owned deployments that are adjacent to or near existing assets. He added that SCE had to learn the hard way that some substations may be less secure than thought.

Mr. Kumar asked, from a resilience and reliability perspective at the distribution level, for Mr.

Hoover to address how he would consider working with the local communities and states to contribute to decisions made about where and how to place energy storage. Mr. Hoover replied that states look to siting as a way to bolster overall resilience and reliability of the grid. Most are predicated on after-action reports; others on in-depth studies that have tasked the states with examining storage as parts of a microgrid. Mr. Irwin added that the East Coast experiences storm events that require critical planning, but that California's critical event is an earthquake, with location unknown. He gave the example in California of a microgrid at Apple headquarters from a resilience standpoint – Apple was not worried about the earthquake, but worried about how much money a multi-hour or -day disruption would cost in terms of lost revenue. He added that military facilities can similarly value resilience more highly, both in terms of supporting the local and regional response area, such that microgrid investments may be pursued.

Mr. McCormick suggested he had developed the impression that electric storage is commercially ready, with a cost case to be made. He asked whether others agreed that this was the case, and specifically what it is that project finance and commercial operations brings to the table regarding new opportunities for storage. Mr. Kathpal replied that on a technology basis, mature electric storage technology exists that can be deployed in significant scale (Li-Ion). That said, battery storage relies on significant upstream research and development that came out of consumer electronics and automotive demand. Mr. Kathpal expects the increments of technological progress and shifts to occur for other storage technology; here there is a role to play for DOE. That said, he added that continued technical milestones are not a precursor for widespread use on the grid. Mr. Kathpal reviewed other hurdles that center around the adoption curve in the utility industry. He mentioned having seen forward-leaning customers come out and embrace energy storage, but that it is the beginning of the domino effect. The technology and economic incentives are present, but accelerating the adoption rate will involve many stakeholders. Mr. Irwin indicated that California was acting because it needs electric storage to meet renewable demand. In addition, preparing for that future DNA requires some immediate implementation. Mr. Irwin added that developing market rules for multi-use devices and systems will be key. He suggested seeing FERC's role and that of the state PUCs as critical, with DOE's role less clear. He also noted as critical that the cost curve is being driven down. Noting the constancy of technological progress, Mr. Irwin added that today's technology might be lithium ion, but that tomorrow could be something else; trying to push forward that research and development – either for technology or supporting technology—is critical. In addition to cost, size is important. The drive to low-cost technology is underway, but the footprint also matters, with a small footprint being critical for use (adoption) as well as cost (with a high energy density). Responding to an earlier question regarding a price tipping point, Mr. Irwin commented that he does not know what that price is. When multi-use applications are clear and scale is there, then the price will come down. Mr. Hoover followed up that many states are closely examining their energy markets, not just New York and California, to serve economic and environmental needs.

Laney Brown asked a question regarding institutional infrastructure: If the panelists were to provide advice to a state about building institutional infrastructure, what would that be? Mr. Irwin answered that from the technical side, states should examine how the device will be used and what lessons learned can be gathered from early adopters. He noted EPRI is a good space for information sharing. On the commercial side, California has experience in contracting space (energy and capacity services from 3rd parties), so having already had a working contract that was (a) proven in the marketplace from merchants, (b) proven to be acceptable to project finance backers, proved the value of institutional knowledge. He noted the advantage was about commercial experience, throughout: utility, counterparty, financial institutions. Mr. Kathpal added that knowing what already exists is critical, whether that's existing capacity for a PPA or an existing rate recovery structure for transmission. In addition, states need to know which stakeholders need to be involved and commitment to action is key. In California, there is often talk of state-level legislation, but the untold story is that the PUC can make many of these decisions (like a local capacity RFO authorized). Chris Shelton added that in California the norm is all-source procurement. He advised not to go narrowly to market – to go with needs, and accept solutions to those need. He noted that maybe a buyer cannot afford to evaluate every crazy solution, but going with needs and an open mind is critical.

Heather Sanders asked, other than the commercial terms, what else needs to be in place to get quick electric storage deployment. For example, what is needed for future six-month deployment of energy storage? Mr. Irwin answered that there is a regulator expectation that this can be done, but from an interconnection standpoint, small projects move faster. For example, a previous call was for who could respond to Aliso. CAISO had to accelerate a new resource integration project and another third-party project was an existing interconnection. So, ultra-fast is doable, but it narrows the participants to (a) small project on the distribution system, or (b) existing interconnection player that is not raising the amount. He added that the cost of doing it fast is to narrow the market, navigating less competition. In addition, if there was only a minimum and not a price benchmark, it would have been more difficult to deploy storage resources. Mr. Kathpal noted that if deployment needs to be done, it can be, with typically lengthy planning and coordination processes potentially able to be streamlined.

Granger Morgan asked: if the distribution system has been flattened, combined with flooding, what can be done? Mr. Hoover replied that certain states – like Connecticut and New Jersey—have tried to look strategically at critical infrastructure and facilities that would be impacted. This includes examining causes, as well as looking to create microgrids tied to either renewable or local power sources that would help these critical structures come back on before the poles and wires go back up. However, he noted that "even from the point of the microgrid, you need a grid."

Ms. Lin asked all attendees to think about the top three items that they think DOE should be looking at in the future, if electric storage is to help address potential threats. Mr. Irwin suggested DOE can help with technological innovation – footprint reduction and others. Mr. Hoover suggested that, as states figure out overall energy planning, DOE can help by examining new technologies. States can be the labs for new technology pilots. From a resiliency standpoint, he advocated continuing federal-state coordination on energy emergency planning and response, with increased focus on cybersecurity. Mr. Kathpal commented that there is a potential for DOE to play a role in recognizing adoption, other than just research and development or demo projects. He said that the Energy Storage Association has begun unveiling a vision for 35 GW of storage by 2025. DOE can help in identification of needs (i.e. peaking capacity to support reliability and resilience or supply adequacy). He added there is similar work to be done to identify transmission investments that could be avoided with energy storage. He suggested DOE study the economics of avoided costs at the system level for electric storage and other solutions. Mr. Kathpal also suggested convening stakeholders on a state and regional basis to drive the commitment to action.

All in all, DOE can identify need, clarify economics, and facilitate cooperation.

Panel: Storage and Microgrids – New Applications

Janice Lin, Session Moderator, introduced the Storage and Microgrids Panelists, including: Paul Hibbard, Principal at Analysis Group; Jessie Denver, Energy Program Manager at the San Francisco Department of the Environment; Mark Vanderhelm, Vice President for Energy at Walmart; and Ariel Castillo, Senior Program Manager at the U.S. Department of Defense.

The first panelist, Paul Hibbard, shared he would generally be discussing value streams for energy storage. He began by sharing a pilot project in Massachusetts funded by the Massachusetts Clean Energy Commission. One key question was what the microgrid benefits are and what other benefits go beyond the microgrid itself. Mr. Hibbard gave an overview of the project and site. Joint base Cape Cod is a major electricity user and major holder of renewable resources, serving as a classic microgrid; it has two points of connection to utility, but owns all assets on base. Since the base is at the end of the distribution system, it is a relatively weak system with a lot of outage issues. Together with a significant penetration of renewables and some diesel generation, the base is capable of islanding. Mr. Hibbard noted that in a situation like this, economics are important, but reliability is key and there may be a role for electric storage.

He reviewed the analysis conducted for electric storage to support the base. The liquid battery was supplied by MIT, while the Analysis Group conducted an optimization analysis for its use, evaluating what the possible benefits are, as well as what the costs of capturing those benefits over time are. Used for reliability, the battery would help in two ways: it would outright increase reliability and it would also decrease diesel generation used. Analysis evaluated what the best use of the battery, both for cost and for reliability, could be. Mr. Hibbard also outlined how the project facilitates Massachusetts' state energy and climate goals. When optimized, the model he used, given a full set of constraints and assumptions, determined that 16 MWh of battery storage was optimal, delivered by four 4 MWh cells. He found that $5-10 million per year could be achieved in cost savings (a 25% reduction) and that the wholesale value of the assets could be greater than $20 million. However, the base decided not to become a wholesale market participant, in part because it would be difficult for them to become a producer, but also because it raised issues with the local utility.

The second panelist, Mark Vanderhelm, manages energy use for Walmart. He discussed Walmart's energy holdings and sustainability goals (a commitment by 2025 to reduce the company's carbon footprint by 18%). In his overview of "what" and "why" Walmart invested in electric storage, Mr. Vanderhelm noted that electric storage is cost-efficient to meet goals. He also noted that it enables renewables by acting as a distributed asset that is more consistent with what the grid can manage at local levels. He also shared that electric storage creates competition within the electricity space. Lastly, Mr. Vanderhelm appealed to reliability: Walmart has come to the table for conversations at the national level regarding reliability for its stores' roles as lynchpins of communities. Walmart serves communities by providing provisions in major townships, so it is often part of the initial response team to bring communities back after disasters.

In detailing Walmart's energy storage investment, Mr. Vanderhelm shared that its assets are distributed across six locations and primarily comprise 200 kW/ 400 kWh type batteries. These are mainly for peak shaving and moving consumption to off-peak, but also back up solar facilities and take advantage of the ITC. The company has also examined scenarios when switching power allows Walmart to provide lighting, refrigeration, etc. from stored electricity. However, since these batteries can really only hold 2 hours of power, Walmart is looking for ways to stretch that coverage to 4-6 hours to enable placement of backup generation in times of emergency.

The third panelist, Jessie Denver, serves as the Energy Program Manager for the City and County of San Francisco. She led off with goals: San Francisco seeks to reduce its carbon footprint 80% below 1990 levels by 2050. To do so, significant investments in energy efficiency and renewable energy are crucial. Ms. Denver noted that these investments have not come at the loss of economic growth; even with population and GDP sharply up in the city, greenhouse gas emissions are down. In addition to a goal of 50% renewable energy by 2020, San Francisco is aiming for 100% renewable energy by 2030. The city is not only focused on electricity, but also is evaluating transportation and thermal decarbonization. When moving toward a built environment that is fully electrified, energy storage becomes critical.

Ms. Denver detailed a project that was initially supported by a DOE grant in order to evaluate the deployment of storage for resilience. The project enables San Francisco to meet the intersection between climate action goals and goals for grid resilience and functionality. Specifically, the project enables San Francisco to identify facilities throughout the city that have emergency service functions and can pair solar and storage to meet critical loads. Since the main risks in the city are earthquakes and sea level rise, pilot sites need to consider these risks. In comparing restoration timelines, Ms. Denver noted that 95% of the city's electricity system could typically be restored within a week, but that the natural gas system could take six months to be fully restored. During the site selection and modeling process, San Francisco documented and road-mapped how other localities could do the same. The city determined twelve sites, one in each of the district supervisors' jurisdictions. Contrary to the original vision, selected sites did not focus on first responder facilities that were originally envisioned. Instead, it was determined that neighborhoods themselves often serve as first response centers. Having learned this, Ms. Denver shared that the typical site would include a public (shelter) building like a school or rec center, a library for a communication center, and open space for people to gather.

Originally, San Francisco intended for this to be a microgrid project, but due to the additional cost and complexities stemming from the fact that most buildings were served by the municipal utility but that an IOU owns the transmission system, it was determined that a microgrid wouldn't be cost effective, so the project was changed to solar plus storage. Another crucial milestone was the completion of a critical needs assessment. This was based on models of building use, which informed power needs, which yielded an hourly profile for incident response. The city developed a solar plus storage sizing tool, which it made available nationwide to any building owner. The tool can be used for resiliency, but also to address demand charges. Ms. Denver informed the group that the city was currently on a road show sharing information about the tool, and that her team would be willing to set up webinars or other assistance for anyone who requests so. The opportunity for DERs is massive: 6,000 rooftop PV installations were completed in San Francisco, which by many counts is an early adopter community. Ms. Denver added that S.B. 700 was making its way through the legislature, which would establish a behind-meter incentive program for energy storage. Energy storage and electric vehicles represents another promising frontier; California has the largest demand for electric vehicles, and to address demand charges will need energy storage. In addition, Ms. Denver noted that San Francisco is the home to the ride-sharing economy, which requires DC fast chargers and requires storage to develop a business model that works. Finally, Ms. Denver mentioned the city's community choice aggregation program, whereby the city has become the default provider, using city-procured renewables and delivering electricity via the transmission and distribution infrastructure of the local IOU. The city is looking to procure more going forward.

The fourth panelist, Ariel Castillo, works in the office of Energy, Installations & Environment. He presented on the Department of Defense's Installation of Energy Storage for Resilience. Mr. Castillo is the Energy Resiliency program manager, with a broad portfolio. He began by recounting that he defines resilience in a disruption state more than in a steady state, i.e. when the commercial grid is down. His team is focused now on identifying critical loads and critical energy requirements at military installations, including what critical mission needs are. They have published guidance on operations maintenance and testing, with upcoming guidance evaluating energy resilience, mission integration, and metrics. One example of a base-level critical load is the grid on a military base. With mission objectives primary, the military is technology agnostic. Historically the base has been comfortable with fuel, but is looking at all possible solutions. One key variable requires making the trade space comparison: if you have X fuel, how much electric storage do you need to meet energy requirements. In general, when looking at resilience, the military foremost is thinking about decreasing surface area. Decreasing surface area of energy assets can minimized fixed risk, but mobile risks are present too. These play into comparisons of fuel delivery scenarios: what does it take to deliver fuel? Electricity from storage? Mr. Castillo shared that he has found it easiest to discuss risks when comparing fuel to storage.

Mr. Castillo gave a brief overview of the study that he published in 2016, based on visits to four large base sites. His team tried to create a base case and tradeoffs among 48 different energy designs, including comparing levelized costs and availability of resources, then sizing the designs to meet critical load. He noted that MIT may publish the analysis and their source code in MATLAB at the conclusion of the study. He added that thinking about the problem is hard when your day to day is operations and management, but that his team wanted to provide planners with a tool to do cross-checks and more integrated resource planning. Projects coming out of the tool may also receive DOD funding. As a brief summary of the MIT study, the model results from a Monte Carlo analysis yielded a least cost curve that was calculated out over ten years. Measures of unserved energy were based on typical outages, since there is an incentive not to overpay for unnecessary resilience. However, the low cost options include generators, microgrids, and solar, to which Castillo brought perspective from his time at ARPA-E. Batteries sized to provide electricity for outages up to a day were determined to be beneficial, but there were also needs identified for the capability to meet more demanding mission objectives, like ICBM disruptions.

EAC Discussion of New Applications for Storage and Microgrids Panel

Janice Lin commented on the ability for electric storage to provide an opportunity for asset sharing. She noted that it depends on the application, but asked the panelists what the challenges are to reaching the "promised land" where you redeem multiple value streams. Mr. Vanderhelm suggested that there could be up to ten or twenty value streams for energy storage, but not all of which can be realized simultaneously. However, as a purchaser he noted it is difficult when regulators assign a value based on a single stream or two. He suggested that technology is not well positioned to take advantage of multiple value streams.

Mr. McCormick asked what regulations govern the value streams that energy storage can recover. He also asked which ISO/RTO market rules or jurisdictional boundaries come into play. Mr. Vanderhelm suggested that the EAC consider transmission and distribution avoided costs, while energy storage can simultaneously provide reliability and reduce peaks locally, as well as take advantage of components of the wholesale energy and capacity markets. However, since energy storage is a regulated entity with associated benefits, it currently cannot take advantage of the competitive wholesale market. He added that the challenge has been taken up: a recent NOPR from FERC is seeking explicit rules for the asset, at least by the ISOs that operate regulated wholesale electricity markets. Mr. Irwin added that if one party is buying all services from a device, the party can capture all value streams. However, if you only purchase one capability of the device, the device owner may need to try to recoup his costs another way. This raised the question of whether only one party ought to own the resource. Paul Hibbard suggested the group consider if a distribution service operator would invest in electric storage for avoided cost purposes. Even so, they cannot then sell into wholesale electricity markets to peak shave, since they cannot operate as a generation source. So, a challenge is getting the full value factored into the investment cost-benefit analysis.

Ake Almgren asked about Ms. Denver's calculations that include 600 MW of electric storage for electric vehicles. Ms. Denver answered that utilities see electric vehicles as a way to increase load, which helps the utility retain their business model as they see load shed from energy efficiency and renewable energy. In the Bay Area, 25% of new vehicle registrations are EVs. In addition, EV charging providers are also interested in energy storage, since in California you can own electric storage on multiple sites, aggregate, and participate in CAISO's wholesale electricity market. Also, California has community choice aggregation; there are four active programs, including San Francisco's Clean Power SF. By 2020, 60% of the California population will have access to CCA programs, which are developing demand-side management programs that pair EV charging with solar with energy storage. Finally, other San Francisco commercial sector partners have integrated energy storage. But, similar to ConEd, San Francisco needs to work with the fire department for it to be comfortable with different forms of tech. The fire department can close down an industry if they are not comfortable with the technology. In addition, Ms. Denver pointed to streamlined permitting that provides an advantage in California; these processes can help industry reduce soft costs and deploy technology faster. Mr. Castillo added that another challenge is to convince military stakeholders that it is okay to participate in revenue streams and prove that the mission will not be interrupted in the process. For example, mission requirements at sites may mean inability to participate in the demand response market. A key part of his responsibility is to figure out what the mission risk tolerances are, requirements are, and then what is possible.

Laney Brown asked whether any of the panelists were aware of integrated resource planning around electric storage needs. It was discussed whether these plans could be optimized either from the grid side or from the community critical infrastructure perspective. Ms. Denver shared that

California has an IDR proceeding at the local level and that between now and 2020 the community action plan will include an update. Mr. Castillo added that electric storage raises security concerns on Cape Cod and other places, so adding electric storage requires planning in order to address security concerns (e.g. reducing surface area).

Paul Roberti asked the panelists about how to monetize the value of electric storage in wholesale electricity markets: Could they share perceptions on the current market design and what would need to change in the wholesale electricity market construct to more appropriately value storage? In ISO-NE, electric storage seems to offer reliability value to market operator. For the time being, FERC is trying to figure out whether this can be accomplished on the regional level.

Representative Morris posed basic questions to Jessie Denver and Mark Vanderhelm. To Ms. Denver he asked: how do you differentiate between what electric storage development is organic versus what is to meet emissions goals? Ms. Denver answered that each city has its own way of measuring goals and progress. All are asking how to standardize the process. Currently, there is no standard method, but there are ten U.S. cities that are just getting started through the Carbon Neutral Cities Alliance process or the Urban Sustainability Directors Network effort to develop 2050 zero net carbon access plans. Mr. Vanderhelm was asked what the motives are of the developing customer class that wants to participate. Mr. Vanderhelm answered that in addition to corporate ethics programs, deploying energy storage makes economic sense. He suggested that sustainability is the future path and that economic sense is a question of speed, i.e. capturing split incentives and how long it takes to deploy electric storage to capture various value streams.

Paul Centolella asked what the metrics and tools are that the panelists would use to value resilience. Different customers and end-users have different values for reliability, but especially in terms of longer outages. Also, resilience is somewhat dynamic in that different kinds of events will make different kinds of loads critical. Mr. Centolella requested of the panelists what insights might be of most value to DOE. Chair Tierney added that the panelists should also comment on how their entity defines resilience, what metrics they use to evaluate that, and what interests they may have in DOE developing relevant metrics. Mr. Castillo answered with the military's definition of resilience, adding that since recovery time is a big component, measuring downtime accurately could be one key metric. He also suggested that scenarios and groupings ought to be set up along the system boundaries in order to assess tradeoffs in the scenarios. In addition, he explained a need to develop systems solutions exists, as well as long-term solutions for outages two weeks in length or greater. Ms. Denver added that for San Francisco, the definition of resilience is functionality. She suggested DOE's role ought to be to support other initiatives to develop ongoing innovations, including resilient electricity delivery infrastructure (REDI) and others. Ms. Denver also proposed collaborative work with insurance agencies to see how resilience factors into savings, i.e. premiums discounts for those doing resilience work; a value to the insurance industry means they should be engaged. She also reiterated support for DOE funding of local government projects, including local laboratories that rely on DOE grants. Mr. Vanderhelm suggested that measuring resilience from the Walmart perspective is avoiding store shutdowns, loss of sales, and loss of products. On metrics, he suggested that the economic cost of outages could be studied more. He suggested that DOE focus effort on things that are close to making economic sense today, adding that the private industry will drive storage. Mr. Hibbard added that definitions vary among NERC, ISOs, and other stakeholders, and that DOE can help sort through definitions, as well as help with designing system rules. He suggested these measures would help bulk power operators design electric storage into their systems to further support resilience.

Ms. Lin prompted the EAC Members and cross-panel participants to write down additional ideas related to electric storage use for resilience.

Presentation: Regional Resiliency and Security with Bulk Storage

Janice Lin introduced Richard Walje, CEO of Magnum Compressed Air Energy Storage. He began his presentation by announcing that compressed air energy storage (CAES) is currently done in two ways, and that Magnum's technique is different from most others'. Magnum's location and transmission interconnections allow broad distribution of electricity. Regarding location, Magnum's salt dome abuts the intermountain power project (IPP) a 1900 MW transmission line. The Los Angeles Department of Water and Power plans to close IPP, so cost recovery is a major factor. Salt cavern storage has already been stood up to provide underground LNG storage and plans for natural gas and crude storage in other salt domes are in place. Mr. Walje's project was described as using a cavern to operate compressed air energy storage. Another factor making the location attractive was the 2 GW of proposed solar PV projects also abutting the cavern location. Given this unique convergence of assets, Magnum was announced to have planned to use renewable energy to run its motors and compressor in order to store energy in the cavern in the form of compressed air. Given the current cavern capacity, 48 hours of compressed air energy storage was anticipated.

Mr. Walje highlighted a number of factors that distinguish compressed air energy storage from other forms of energy storage. First, the potential for storage capacity is largely dependent on geology and geography. In addition, CAES requires scale to spread fixed costs over many units and is not widely deployable, so it is not a direct competitor with lithium-ion batteries. In addition, the output of compressed air is defined, though the duration is variable. What differentiates Magnum's facility was also that the design supports simultaneous storage and return, since its compressor and its generator operate independently. Unlike chemical batteries, the equipment capability of CAES does not deteriorate over time, Mr. Walje claimed. He also added that the capacity of the storage facility is not affected by operating range and frequency. The combination of air compression and expansion, he shared, results in 1.2 MW of output for each MW of renewable input demanded for powering the components. In terms of system resilience, reliability, and security, Mr. Walje claimed that CAES contributes to grid resilience and is, in fact, ideal for resilience because of ancillary services provided.

He also listed several challenges of project development, some of which are more difficult for CAES projects. Environmental reviews and modeling of thermodynamics and design capabilities are requisites of any energy storage project, as are expensive engineering requirements. However, several other requirements – including quantifying the project for the investment tax credit and maintaining the renewable energy credit (REC) value of the project – are more complex for CAES. Evolving market structures and resource portfolios further complicate development, he said, as does the challenge of recognition of capacity value. Since electric storage can participate as a generation asset, uncertainty exists over how – or whether – this same asset can be treated as both a generation fixture and a participant in retail electricity markets. Mr. Walje suggested that activities underway are related to ironing out these seams.

EAC Discussion of Compressed Air Energy Storage Presentation

Mr. Irwin prefaced his question by referring to Mr. Walje's statement that a value of CAES is multi-day storage. Mr. Irwin asked how Mr. Walje expected to see recognition of that value. Mr. Walje suggested one reason is to capture renewable energy over many days. Given transmission access issues, a reason to store renewable energy generation is to recover costs from renewable energy developers.

Chair Tierney asked a question referring to CAES and other technologies, namely: what is the extent to which the principal barriers are financial, institutional, regulatory, or economic (e.g., reflective of the price of natural gas). Mr. Walje answered that it used to be that planning focused on sites near coal or gas supply. But now, for projects like CAES, it is probably worth experimenting to see which solutions might work and bring value as well as service to customers, given a variety of attributes of project designs and proposals.

Mr. Irwin suggested that one of the challenges faced by Southern California Edison (SCE) is that the utility is no longer doing an integrated resource plan with transmission and procurement together (now CAISO does transmission). He added that SCE does not favor any market-based resource; the utility does procurement at the regional level, without centralized planning. Without migrating to locational planning, he was not sure the utility could address those challenges. Ms. Lin asked whether DOE could help with transmission planning. Mr. Irwin answered that the jurisdictional authority probably falls between FERC and State reliability jurisdiction, since it is more of an operational issue.

Facilitated Discussion: Takeaways and Key Themes from Energy Storage Panels and Presentations

Ms. Lin announced that the next time block would be to enable EAC Members and participants to share comments and suggestions for DOE on priorities to support planning and other project development components.

Mr. Zichella asked the group to examine how to meet the next few percentage points of additional load. He suggested renewable energy and electric storage could be used to offset thermal resources in rural areas. For Mr. Walje, Mr. Zichella noted the bidirectional component, asking if that was possible in California. Mr. Walje answered that technologically it could be feasible, but jurisdictionally maybe not. Only one transmission line currently operates between Los Angeles and the San Joaquin Valley, so this represents a transmission constraint. Mr. Walje commented that regulators will need to prioritize transmission and transfer capacity between the Los Angeles capacity and direct current lines in order to move renewable energy around the state. That said, he commented that unless the cost is rate-based, thinking about a Western grid as more integrated will be necessary. Mr. Zichella picked up on this thread, suggesting several areas in which DOE could help. These include conducting pre-planning for NEPA and other significant obstacles at the state level, such as the state planning authorities (like in Wyoming) and county-level jurisdictional authorities (as in Colorado) that are tasked with siting interstate transmission. Mr. Walje commented that it took nine years to get a record of decision (ROD) from the Bureau of Land Management (BLM) for the Gateway project.

Mr. Irwin asked whether, with Los Angeles now joining the energy imbalance market, that action helps with the solution. Mr. Walje suggested that questions still remain around who decides who gets what in the economic relationship. Ms. Lin commented that the same problem currently exists for new pumped hydro resources in California; one project is too big for the utility. Mr. Irwin asked whether, if one is too big, it is even required. Mr. McCormick agreed with Mr. Zichella's point about the previous work that had been done to facilitate transmission planning and not to go back on that work. Mr. McCormick followed up with two other questions. First, how many CAES facilities are actually in operation. Mr. Walje answered currently none, though two similar projects have been completed (one German and one in Alabama in 1991). That said, neither project bore the new design (twin charging and discharging). Second, Mr. McCormick asked whether there was any direct current, merchant-type transmission build that could be done with the project. Mr. Walje answered that the Arizona Public Service Commission and Berkshire Hathaway have proposed a merchant transmission line. However, this line faces the same problem as bulk storage: it is too big, expensive, and provides no sure return for investors. Mr. Irwin also adds that different planning regimes around the country make decisions in the best interest of the regime. So, FERC has work to do in coordinating and expediting coordination and planning among regions and entities. Ms. Lin asked what the value is of simplifying planning across the U.S. Mr. Irwin answered that the benefit needs to be studied. Mr. Zichella stated that WECC has done its part in studying simplifying planning. He added that there is an opportunity for regional planning entities to do interregional planning, in connection with FERC 1000 compliance. He gave examples of avenues to pursue to have these studies done. Technical studies—on power flow, cost, and other factors – are in the wheelhouse of DOE. Mr. Walje added that he had approached PNNL to do the study for Magnum. He noted that a technical study was fit for a chemical engineer more than an electrical one, because this is a thermodynamic flow problem.

Ms. Lin called for thoughts and reflections for DOE, given that all EAC committee work products talk about the role DOE can play. Mr. Shelton suggested the discussion should take a step back, as all marketplaces across the states are suffering from a lack of analytics.

Mr. Irwin stated that at the umbrella level, organized markets and non-organized markets demand one set of studies, while coordination between geographically adjacent markets demands another set of studies. Mr. Zichella shared that plenty of activity currently takes place at universities, including the development of new designs for storage chemistry. He suggested it might be useful for DOE to create a clearinghouse for what the universities are discovering. Mr. McCormick shared that GOP senators are skeptical of expense for commercialization, but are very supportive of basic physics and chemistry research, as well as research at the labs. Bill Parks commented that research both is happening and should be supported more, especially given that venture capital funding has been pulled back from uncertainty in the last decade, with the impact that progress has been concentrated in the lithium-ion arena.

Chair Tierney mentioned the recent EAC approval (as a formal recommendation) of a paper reviewing GMI research and of its critical importance as an expression of support for basic *applied* research, which is different than basic research. Ms. Lin highlighted what Mr. Parks suggested about how to connect systems research to private venture capital. Mr. Parks added that it is crucial that DOE research is followed by others, whether in the form of university partnerships, private funding, or public-private partnerships.

Mr. Zichella shared that some EAC Members were part of a National Academy of Sciences panel that issued the “power to change” report, which looks at how to create an effective energy innovation system. The report discusses software, as well as an industry (energy) that is slow to move nascent technology from research to development to implementation. The report suggested ways in which PPPs might begin to address those needs. Mr. McCormick commented that he has heard from chemistry and physics researchers that they have been critical of DOE in recent years for allocating research dollars to uncertain long technologies. Mr. Centolella added that there is a notion of how you strike a balance and that commenters often go back to post-WWII, when the government needed to focus on basic research. Mr. Centolella commented that if basic research is the only focus, then ideas die before commercialization. He added that of critical importance is evaluating ideas at different stages and figuring out the right partnership to move those ideas to the next step.

Ms. Lin raised implementation research. Mr. Shelton pointed out that often implementation is understood to mean deployment, etc. but that what is perhaps more critical is the systems analysis approach and modeling. Mr. Feller commented regarding policy that perhaps the EAC at some point might examine what the value of a statement from the DOE would be regarding enabling experiments and full-scale commercial deployments to succeed; he added that federal customers ought to be early adopters, or national labs could contribute resources. Assuming grants would not happen for discrete projects, Mr. Feller asked whether a DOE declaration would send a signal or result in value. Ms. Lin asked what a public-private partnership would look like, in a successful model. Mr. Feller answered that the private sector wants 20-30 years of certainty for risk assessment, value, and to calculate return on investment. Mr. Vanderhelm added that Walmart engages with the national labs on a daily basis as a partner on specifications and to leverage NREL facilities. Thinking forward, he suggested that companies are lacking a practical framework currently for comparing and thinking about different types of technologies, e.g. comparing between small batteries and large pumped or bulk storage.

Ms. Lin asked whether participants had questions on regulatory guidance. Mr. Gellings commented that the discussion still had not explored other areas outside of technology, including power electronics and digitization, or areas in chemistry. Ms. Lin also raised the point that the group has discussed how electric storage can help with resilience and reliability, but not if it is creating new risk areas. Specifically, she asked what should be on the EAC to-do list in this area. Phyllis Currie commented that it is difficult to separate the value of electric storage from the rest of the electric system, if it is being used for resilience and reliability. Mr. McCormick added that DOE should think about research activity that will not get done if not by the government. In today’s political climate, it may be difficult generally to secure funding, but he suggested that would be a way to focus attention. Mr. Walje commented that for the sake of equity, regulatory guidance ought to consider many storage technologies, as done in the ITC. Ms. Brown added that the EAC could have more discussion on DERs and behind-meter electric storage. Mr. Castillo mentioned that he had issued a request for proposals recently with his requirements to seek alternative funding (not appropriations) from those willing to develop projects from the private sector, proving that some private sector solicitations were possible.

The facilitated discussion session was concluded with an exercise, in which EAC Members and cross-panel participants produced suggestions for energy storage applications at the second, hour, day, and season time scales. Suggestions were submitted in bullet format; these are included verbatim immediately below:

What Can DOE do to Address Power Sector Vulnerabilities?

1. Seconds to Minutes Timescale
    a. "Soften" the impact of intermittency
    b. [Research] solar storms, EMPs, and large natural disasters
    c. DOE should work to address how storage can be used for voltage and frequency response –especially in light of coal retirements
    d. [DOE should evaluate storage use for] ride-through for momentary events
    e. [DOE should evaluate storage use for] system variability and reduced inertial response. How to manage the 7.5 minutes between dispatch signals?
    f. [Research] Real-time situational awareness, both on the "seconds" and "hours" time scales
2. Hours Timescale
    a. [Research] Cyber vulnerabilities of both resources and loads
    b. Regarding vulnerabilities, DOE should focus on tools to optimize operational value of storage in terms of placements and performance characteristics for typical circuits (beyond ESRs)
    c. In rural areas in particular, extreme weather is a particular vulnerability, both in terms of vulnerability and restoration challenges. What types of storage are *best* and/ or *least* suited to address system vulnerabilities stemming from severe weather?
    d. Cyber attacks on distributed energy resources – how do you recover?
    e. [Research] Inverter frequency calculation and use for frequency response as spinning mass is replaced (loss of inertia)
    f. [Research] Cyber attack causing unexpected operation of inverters
    g. Focus on distributed not central [storage?]
    h. [Evaluate]: Are there adequate standards and replacement equipment for DERs
    i. During catastrophic outage events, who is in charge of recovery?
3. Days Timescale
    a. [Considering] A rare but high impact cascading event in the Eastern Interconnect:
        i. [Research] Means to reduce the likelihood and impact of such an event.
        ii. [Research] Means to a fast restoration in case of such an event
    b. [Research] How can energy storage be used for extended energy supply?
4. Months to Seasons Timescale
    a. Batteries, pumped hydro, etc. will not help much on disruptions or other issues that span many days or seasons; for that, one needs chemical storage, i.e. hydrogen, synthetic methane, etc.
    b. [Research] cyber and physical attacks

c. [Research] what bundle of resources (including storage) could replace baseload plants in line for retirement
d. [Consider] a high organic uptake of storage at an unexpected price point that creates more reactive problems in planning
e. Does storage add to the collective vulnerability of the electric systems, or help alleviate it?

5. Vulnerabilities Cross-cutting Many Timescales
    a. [Research] Operational/ optimization capability & requirements of storage as alternative: availability, dependability, durability, feasibility
    b. [Research] Peak-shaving (T&D deferral)

What Can DOE Do to Support Storage Development in General? *(n.b. each "+" indicates a colored dot providing emphasis from another EAC member)*

1. How far with small storage? Can there be over-balance for households in larger weather events?
2. Explore related areas: digitization, power electronics.
    a. Ensure balanced portfolio, including basic & applied scheme (++++)
3. [Research] Tools/ processes to create/ identify market rules for multi-use devices
4. Accelerate innovation by connecting R&D efforts and commercialization efforts to scale up storage by promoting public-state and private partnerships
5. Declare goals; send market signal
6. Help create 20 year certainty, financial & regulatory
7. Continue R&D to drive down costs (++++)
8. DOE can develop a model for economic treatment of value streams for storage (+++)
9. Establish a framework for evaluating storage technologies versus applications and investors' needs
10. [Priorities should be]: Energy planning, new technology, energy emergency
11. Involve insurance industry in valuing resiliency
12. Adapt/ develop a resiliency model for other non- DOD applications
13. University programs: Can DOE create a clearinghouse for learning?
14. DOE can accelerate adoption
    a. Identify needs
        i. Generation – capacity needs
        ii. Transmission & Distribution – investment needed
    b. Economic Analysis—targeted to need
        i. Like system-level plexus modeling done at NREL
    c. Convene state/ regional stakeholders
        i. Also targeted to need
        ii. Utilities, PUCs, consumers, NGOs
            1. Drive commitment to action/ build institutional architecture
15. [Research] Analytics & planning across: organized markets, non-organized markets, markets that are geographically adjacent
16. Identify & propose revisions to electricity market designs to include the values of transmission or distribution deferral, carbon reduction, pollution reduction, etc. into electricity price formation (LMP)
    a. i.e. fix markets [to] correctly price transactive energy (++)

17. Re: resilience – how does one value the resiliency of storage separate from the rest of the power system?
    a. Events, natural disasters, etc. don't just affect one component of the system; they affect many components. Isolating the added resilience of storage is an interesting question.
18. DOE needs to help industry develop a standard definition for bulk power system resiliency & create datasets to facilitate appropriate metrics
19. Encourage national labs to sponsor technical studies
20. Connect lab and university research to the private sector
21. [With respect to] WECC, [evaluate] FERC Order 1000 [and] regional planning (+)
22. [Support] analytics in general
23. [Research the] systems aspect of research for grid modernization
24. Study—what is the value of simplifying planning across the U.S. regionally (+)
25. Help establish financial products for resiliency projects (+)
    a. Talk to the finally industry!! Get to bankability
26. Develop storage synergies between the electricity and transportation sectors, e.g.
    a. Smart charging of EV/ PEV
    b. EV/ PEVs as a potential storage resource for the grid (+)
27. Help with differences in TX planning across states
28. [Research] contracts for bulk storage
29. DOE should have more panel "engagements" like this for stakeholders, i.e. regulators, policy makers, customers
30. It's all about jurisdictions
31. [Research] cost reduction & technological innovations
32. [Develop] criteria for strategically locating storage in bulk systems
33. Research and develop new chemistries
34. [Research] role of storage to help with T&D interface issues
35. [Research] sustaining critical functions through a cyber incident (or other threat/ hazard) for hours
36. Focus on R&D hurts deployment of emerging advances
    a. DOE needs a way to accelerate deployments through better analysis & communication (this is part of [the] DOE mission statement)
    b. Not demos – let [the] market act!
37. DOE: conduct a survey & analysis of existing programs & activities underway to use energy storage for resiliency (+)
38. Develop "actuary tables" for resiliency risk/ insurance analysis & evaluation
39. Continue to develop energy storage technology for higher power density at lower costs
40. [Research] potential for creased cyber attack vectors
41. [Research] interface of the large grid and microgrids
42. Support R&D of new energy storage technologies
43. Continue support [for] pilots
44. [Develop] technology neutral resilience planning methods & tools
45. DOE [should] support traditional apprenticeship [programs] working with [the] Department of Labor [to train new skilled workers]
46. [Develop a] repository for commercial deployments & pilots to shorten the learning curve for each state (+)

47. Ensure storage is an alternative
48. The governance issues and market rules seem challenging. Should DER owners be responsible for paying for storage to ensure system reliability?
49. Include storage in cyber-security report
50. [Conduct] system dynamics analysis to inform decision-makers
51. [Address] jurisdictions
52. Broaden the ITC to [include] all storage
53. DOE [should] work with stakeholders (ex. NIBS) to assess the returns on storage. [DOE should] encourage adoptions of appraisal, loan and bond underwriting standards that recognize the value of resilience (e.g. by offering improved bond rating or lower interest rates where resilience standards for storage have been deployed – see RELI ex.))
    a. Key: work with the insurance industry, a critical stakeholder
54. Demonstrate success of fire suppression systems on large Li-ion storage systems in response to a deliberate attack (i.e. gunshot holes) on the facility
    a. Quantify risk in equal terms, i.e. storage is equivalent to small gasoline storage tanks or ammonium nitrate?
55. [Assess] how to make sure storage [joins the] mainstream menu of options in system (G, T&D) planning
56. R&D alternatives to lithium ion needed?
    a. Is there a raw material issue long-term?
57. [Research] rapid deployment of mobile energy storage
58. [Develop] algorithms for prioritizing use of an energy storage asset for multiple applications.
59. Develop scenarios for different resiliency solutions using energy storage
60. Not only should DOE think about storage, it should also ask when are alternatives, such as distributed generation, likely to be more cost effective or be able to better serve specific needs.
61. Top 3 Issues for DOE involvement:
    a. Regulation/ definition of who benefits
    b. Technology standardizations—how to these work together; what are the minimum technical requirements?
    c. Simplified permitting [processes]
62. As we gain more experience with storage and how it responds to resiliency & reliability issues, DOE should catalog/ document “best practices” or lessons learned that can be standardized & shared broadly
63. [Research] how do you value the grid hardening/ resiliency/ security [costs/ benefits provided by] energy storage?
64. Top 3 things for DOE regarding storage:
    a. DOE should look at (1) cyber issues; (2) systems integration (technological); (3) valuation methods
65. Top 3 things DOE should think about:
    a. Storage application targeted to particular sections of the economy, i.e. agriculture, transportation, etc.
    b. Public-private partnerships for R&D (assuming federal $ will be declining)
    c. Widespread deployment of pilot projects under a variety of scenarios: regional; large & small utilities, etc.

66. We need demos in each major geographic region, by application type, so that leaders in each state have "culturally-relevant" examples to draw from.
67. [Focus on] Demos & partnerships with states (+)

Ms. Lin closed the session by thanking contributors for their participation. She also asked what participants may have learned today that they didn't know before, offering that she had learned more about geomagnetic disturbances. Mr. McCormick offered his own thanks to the EAC and the panelists, sharing that he learned a lot. Chair Tierney thanked the invited participants for contributing to the meeting.

John Adams wondered what the level of fire risk with electric storage is. He asked, for example, whether the risk of electric storage in a neighborhood would be less than gas in the same neighborhood – and that this revelation could be important to communicate, if so. Mr. Walje offered his thanks to the EAC and to Ms. Lin directly. Ms. Lin thanked both Chair Tierney and the EAC before Chair Tierney offered final thanks to Ms. Lin on behalf of the EAC for planning and facilitating the session.

Public Comments

Chair Tierney indicated that no public comments were requested.

Wrap-up and Adjourn Day Two of June 2017 Meeting of the EAC

Chair Sue Tierney asked Deputy Assistant Secretary Katie Jereza whether she had any final comments. DAS Jereza commented that a key takeaway for her was the tremendous complexity around electric storage and the issue of microgrids, especially from a systems perspective. She also noted the complex concerns arising from an equity or fairness perspective among possible solutions. She added that she appreciated the thoughtfulness and work of the EAC and Subcommittees.

Chair Tierney thanked DAS Jereza and the DOE staff. She acknowledged that everyone around the room had developed a more thorough understanding of the criticality of electric storage and microgrid applications.

To conclude, Chair Tierney adjourned the June 2017 meeting of the EAC.

Respectfully Submitted and Certified as Accurate,

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Analysis Group
Chair
DOE Electricity Advisory Committee

11/22/2017
Date

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Natural Resources Defense Council
Vice-Chair
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