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Summary of Meeting

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Welcome, Introductions, Developments since the September 2016 Meeting

Sue Tierney, EAC Chair, and Matthew Rosenbaum, EAC Designated Federal Officer (DFO), opened the March 2017 Meeting of the Electricity Advisory Committee. Chair Tierney began by welcoming attendees and introducing Rolf Nordstrom of the Great Plains Institute as a new EAC member. Chair Tierney next asked participants to introduce themselves, beginning with Carl Zichella, EAC Vice Chair. Chair Tierney reminded those assembled that the meetings would be recorded and ran through an overview of the schedule for each of the two meeting days before introducing Patricia Hoffman, the Acting Assistant Secretary for the Office of Electricity Delivery and Energy Reliability (OE), who would be presenting remarks on behalf of the DOE-OE.

Update on the DOE Office of Electricity Delivery and Energy Reliability's Programs and Initiatives

Honorable Patricia Hoffman, Acting Assistant Secretary for Electricity Delivery and Energy Reliability, DOE, began her update by thanking NRECA for hosting the EAC meeting at their facilities. Assistant Secretary Hoffman next thanked the EAC members for their valuable support and recommendations before personally thanking Chair Tierney and Vice Chair Zichella for their leadership.

Turning to the state of affairs at DOE, Assistant Secretary Hoffman updated the group on her multiple roles at the Department. She listed her position of record as Principal Deputy Assistant Secretary for the Office of Electricity, Delivery and Energy Reliability, while she is currently Acting as the Assistant Secretary for that organization. Other Acting roles include as the Undersecretary for Science and Energy and as the primary overseer of response to emergency incidents at the Department. Finally, Ms. Hoffman discussed her role overseeing the coordination of activities done on behalf of the Deputy Secretary of Energy (S2), until one gets nominated and able to provide that perspective at DOE. In concluding her discussion of new political appointees, Ms. Hoffman referenced the history of Secretary Perry's leadership of Texas, including his focus on economic development, as a positive note for his role at DOE.

Speaking specifically on behalf of OE, Ms. Hoffman reiterated that the central role of the Office is to address electricity reliability issues in the U.S. She indicated a greater focus on early-stage research, as well as cyber-security and resilience activities. Ms. Hoffman concluded by outlining two recent Executive Orders – one to promote regulatory reform and one to evaluate the organization of the Executive branch – that she indicated could impact DOE. With respect to the first EO, specifically, Ms. Hoffman indicated that the EAC's perspectives would be particularly valuable in outlining programs that contribute to a coordinated effort to achieve greater resilience, reliability and security. To conclude, Assistant Secretary Hoffman described a 'thoughtful review' being undergone at DOE, out of which further discussions would follow.

Panel: Internet of Things

Paul Centolella, EAC Smart Grid Subcommittee Chair, introduced the first panel, developed to address the relationship between the Internet of Things (IoT) and the power delivery system in the U.S. Mr. Centolella began by broadly outlining the impact on the power delivery landscape created by IoT, including the challenges raised when sensors on the grid both gather information and process it over the internet in order to make decisions about grid operation. He mentioned several household devices that are commonly internet-enabled – including anything programmable—and used this comparison as an opening to introduce the panelists. The first panelist was Vinton Cerf, Vice President and Chief Internet Evangelist at Google, whose legendary work in developing the early protocols of the internet led him to build a career around the operation and security of internet communications. The second panelist was Sharon Allan, the CEO and President of the Smart Grid Interoperability Panel (SGIP), who leads development of standards for grid modernization through that organization. The final panelist was Frans Vreeswijk, General Secretary and CEO of the

International Electrotechnical Commission (IEC), who is tasked with leading collaboration on the development and promulgation of standards for both electric and electronic devices. Mr. Centolella closed his introduction by yielding the floor to Vinton. Cerf.

Mr. Cerf began his presentation by asserting that the best outcome would be if IoT devices were not at all integrated with the electric power grid control system. At the current state of development, he indicated that the risks – cybersecurity and related – outweigh the benefits of operational efficiency currently achievable. The presentation was designed to focus on three topics: software, access control and security, and the role of standards. First, Mr. Cerf specifically led off his presentation by appealing to the EAC's understanding of software, suggesting that IoT devices are as vulnerable to bugs as any other technology, with greater consequences if they are connected to the bulk power system. Updating grid tech software is a similarly thorny problem; how frequently, over what communication paths, and with what confirmations are all questions that need to be addressed in order to keep software functional and secure. Specifically, Mr. Cerf highlighted the need for stronger authentication of parties than is currently the norm. Setting limits on who or what can control data, who can configure IoT systems and who can receive data is critical, but using two-factor authentication or other safeguards is equally important in ensuring that those designated to have access to personal usage information are actually the ones receiving it. On the topic of configuration, Mr. Cerf finished by touching on the steep curve of scalability facing IoT for use on the grid – when each house has 200 devices or each manufacturing plant has thousands, the security concerns are compounded with each point of internet interface and security must be addressed accordingly. Following his discussion of software, Mr. Cerf raised several access control and security questions that will be critical to consider as IoT gains market share. Who should have control within households, among parents or children or guests? What happens if the security of the home in breached, as in the case of a break-in? Is there a way to de-authorize access for those who may have been visiting a home temporarily? With regard to emergencies, should emergency personnel have remote access to homes? Should they have the ability to control home systems on-site? Finally, who should have access to the data gathered by devices during the course of their operation?

Mr. Cerf transitioned from the discussion of security to the discussion of the necessity of standards, not only for customer safety and privacy, but also for grid-level security and interoperability. He named several proprietary and private sector consortia and conventions, as well as noted that both national and international standards organizations were examining the issues associated with IoT. Touching back on the issue of software and updates, Mr. Cerf highlighted backward compatibility as a key area in which support from standards organizations will be critical. With the number of grid-compatible devices going to market each year, new components will need to be backward-compatible with those already in operation, or else entire systems will suffer from the obsolescence or inoperability of certain components. When compatibility is threatened, in addition, reliability is threatened. To finish his presentation, Mr. Cerf left the EAC with several major considerations. These include: reliability, ease of use, safety, security, privacy, autonomy, and interoperability. Although these qualities mean different things for a range of IoT technologies, they frame the challenges facing developers and grid owners as they attempt to reconcile new plug-and-play technology with the existing grid infrastructure.

Sharon Allan began her presentation by thanking the EAC members for her invitation and by announcing that her tenure as the voice of SGIP would be coming to a close at the end of the week, when a merger would be finalized with the Smart Electric Power Alliance (SEPA). Ms. Allan also clarified that while SGIP is not a standards organization itself, the Panel works with many standards organizations and runs a number of collaboratives with government regulators, utilities, and other market participants. In beginning her discussion about the evolution of IoT on the electric grid, Ms. Allan referenced a time around 2010 when inventive automation began to be applied to the power sector. She listed Customer Information Systems, GIS, asset management software and AMI Head End – as well as other meter data management systems – as all examples of integration on point to point connections. These technologies led to the rise of service-oriented architecture, most prominently the Enterprise Service Bus (ESB), where applications would present information and other applications would receive and process those data. While the ESB phase has dominated the last five years, however, Ms. Allan indicated that the trend is to move toward the grid edge in terms of customer-driven automation of their homes to have greater control and flexibility over how they use power.

With the rise of cross-functional domain devices, technology has outpaced standards development, Ms. Allan indicated. With customer-driven IoT adoption, grid device communications are expected to happen – and happen securely – in ways that they haven't been asked to do so previously. Meters are expected to talk to storage devices, while other grid control devices – like Load Tap Changers and Capacitor Bank Controllers – are connecting up through unique, functional domains. Ms. Allan emphasized how this 'round trip' of information, from the meter to all the way to the enterprise, from the AMI Head End to the MDMS over to the SCADA system, to the DERM system and back into the field, had revealed shortfalls in the existing standards and have caused the industry to think on their feet in developing ways to monitor control and interaction of data exchanges. Ms. Allen called out certain standards – primarily developed by the IEC – that have made progress toward promoting the secure integration of these systems. She also identified two IEEE standards that address IoT standardization – 2030.5, which is based on RESTful web protocols, and P1451-99, which is geared toward harmonization of IoT devices and systems onto the larger grid. On the domestic side, Ms. Allen specifically applauded DOE for including the thread of cybersecurity throughout several GMLC projects, led by the GMLC architecture committee. Ms. Allen also called out the cybersecurity-focused OpenFMB working group, which evaluated how adopters of new software can maintain data and database security.

Pivoting her presentation toward the future work needed in the area of IoT device and integration standards, Ms. Allan returned to the theme of grid-edge innovation. In order to have grid-edge IoT devices that can (1) cross communicate; (2) scale; (3) automate, (4) be managed per ad hoc cluster, and (5) be monitored and analyzed effectively, more standards development will be required. These capabilities, if achieved, will lead to greater control over device access and the commissioning or upgrading processes. In addition, Ms. Allan specifically noted that great security benefits would result from standard implementation. Device integrity protection and data protection are expected to be critical components of designing a modernized grid that is hardened against attack. To conclude, Ms. Allen highlighted that siloing is a threat to effective standards development. While currently certain oversight groups are focused on communication between specific DER technologies and grid devices, communication across all IoT devices and sensors – all the way to the grid edge – must be enabled and secured in order to facilitate the safe deployment

of greater automation of devices that interact with or modify customer loads. Ms. Allan also built on what Mr. Cerf highlighted in his presentation regarding authentication, namely that not only should users be require to authenticate their identities, but also that devices need a way of authenticating the signals that they are receiving from other devices. Dealing with the issue of how to facilitate secure communication among grid devices, all the way from the grid edge to the enterprise, Ms. Allan concluded, is a critical area in which DOE support could help motivate the innovation cycle of the inclusion of IoT within this sector.

Mr. Vreeswijk, the final panelist, began his portion of the panel by thanking the EAC members for the invitation and by providing a brief background of both his personal work and the role of his association – the International Electrotechnical Commission (IEC). Mr. Vreeswijk announced that his presentation would focus on discussing the unique challenges posed by smart energy devices and – in a growing number of areas – smart cities, specifically with an eye toward integrating IoT devices. He outlined this progression by pointing to the degree at which IoT devices are now integrated into Smart Grids, which form an integral part of Smart Cities. Turning to his slides, Mr. Vreeswijk indicated that applications to control internet-enabled devices currently are siloed, both in terms of the platform upon which they operate and in terms of the data collected. To realize the full potential of IoT, he countered, modernized infrastructure and improved operations must be established as the 'base' of a pyramid upon which enhanced energy efficiency and cost savings could lead to overall business transformation based on the value-added to customers of high penetrations of IoT devices. New energy services may include not only city operator applications like incident detection and pollution tracking, but also citizen services like traffic alerts and public wi-fi. Broad integration of IoT devices will need to be supported by common software; the service delivery platform, data management functions and communication capabilities will need to be common in order to facilitate the functionality of Smart Cities.

While Mr. Vreeswijk highlighted the extent to which greater IoT penetration would be beneficial in enhancing energy efficiency at the household and city level, as well as generating cost savings both for customers and to service providers, he also outlined several potential drawbacks of widespread IoT deployment in the short run. Cybersecurity was outlined as a particularly critical focus, especially as greater AMI deployment enables remote control of large shares of the grid. Mr. Vreeswijk also clarified that risk is never completely removed, when it comes to security. The question, he posited, was how much risk the utility or grid operator would deem 'acceptable' and how much cost they were willing to bear in order to mitigate the rest of the risk. Specifically turning to the IEC's role in promoting cybersecurity, Mr. Vreeswijk shared that the IEC has published more than 200 standards related to Smart Cities alone. In addition to cybersecurity concerns, Mr. Vreeswijk suggested that to satisfy the growing demand for electricity, increased integration of sustainable power sources will be necessary, as will including renewables and energy storage. These are also areas of focus for the IEC, Mr. Vreeswijk indicated, which have resulted in the establishment of systems committees to review and update standards as the grid landscape changes. He also briefly touched upon ways in which IoT will impact other energy trends – like growth in the use of energy efficiency measures – due to the greater visibility of energy use provided when network devices are able to collect and share data in real time. To conclude, Mr. Vreeswijk indicated that efforts to coordinate interoperability across various countries and continents has been limited to date, but that there is value for device manufacturers in creating a wider market, so he expects there may be greater motivation going forward for

industry standards to facilitate the sharing of common platforms internationally. The challenge, he contended, will be in convincing industry as a whole of the idea that global thinking will be more valuable for everyone in the long run.

EAC Discussion of IoT Panel

Paul Centolella kicked off discussion among the EAC members by posing a couple questions to the panelists: 'To what degree are the challenges we face institutional?' 'And to what degree are they technical?' Mr. Cerf was the first to answer, suggesting that as standards are currently still relatively immature as they relate to IoT integration, the first goal should be to do no harm. After that, he shared his perspective that the best way to maximize safety and security for the population using IoT devices is to isolate them from access to control of the power grid as much as possible. Ms. Allan indicated that achieving interoperability and security of IoT would be accomplished in a phased approach, where utilities – who are currently siting storage, solar, EV charging stations and other infrastructure on the grid – bear the bulk of the responsibility. Merging interests in security and resiliency, Ms. Allan discussed how greater use of microgrids with the capability to island will help both localities and utilities operate reliable grid systems. Mr. Vreeswijk shared that from an international perspective, there is a place for international standards, especially because Smart Grid and IoT adaptation are issues that many countries – more than just the U.S. or Europe as a whole—are dealing with. Mr. Vreeswijk communicated that the market usually leads to the development of a common interconnect, but that regulators have a role to play in streamlining the standard-setting process wherever possible.

Granger Morgan thanked the panelists and indicated that more thought needs to be given to the challenges around IoT integration. He commented specifically that a critical assessment of the optimal penetration of IoT interconnection could be necessary.

Gordon Feller suggested that in addition to the two sides of the framework for standards raised by Mr. Centolella – institutional vs. technical – he would posit a third component: attitudinal, which limits the efficient integration of IoT. He asked the panelists whether they could identify a fundamental, attitudinal shift that would get the industry closer to the point at which they have collaboratively identified shared standards. Mr. Cerf replied first, stating that at least from his vantage point at Google, a focus on making product to a large extent has not translated to product developers taking into account the challenges associated with deployment of their devices at high penetrations. Mr. Cerf called on experts like the EAC members to voice their concerns wherever possible and suggest defensive measures that would limit potential hazards.

Heather Sanders, from the perspective of a utility responsible for reliability, asked whether the utility needs to change its expectation that DERs will be part of the integrated future grid. In addition, she shared progress of SCE on coordinating distributed control, including on implementing standards, but asked whether the utility ought to be doing more to set out a roadmap of expectations for interconnection. Ms. Allan answered that there's a lot of integration work with DERs already underway and that in the short term the CA utilities may need to serve as the lessons learned, since progress will be in layers, while later adopters may be able to benefit from standards that have developed. Mr. Cerf used the example of moving from fuse boxes to circuit breakers to illustrate how protections for the grid will develop.

Mr. Centolella asked how the panelists suggest industry leaders pursue building in autonomous distributed response. Mr. Cerf indicated that the current trend toward aggregation of DG and DERs will continue, and that aggregators will drive a second trend toward Direct Current technologies that would eliminate frequency and phase issues. Mr. Vreeswijk acknowledged the capability of most household appliances to operate on low-voltage DC, but concluded the conversation by highlighting that the exact types of conversations being hosted by the EAC, SGIP, IEC and others will really be the key to knowledge-sharing and promoting collaborative standards development. After a few final back-and-forth discussions of IoT, internet protocols, and promoting information sharing over private networks as opposed to the public internet, Mr. Centolella moved to final questions.

Rolf Nordstrom asked Mr. Cerf to answer – and others to chime in – whether there is any set of devices that he could imagine being safely connected to the grid. Mr. Cerf suggested that if it were possible to have a 'barrier' access control mechanism, that allowed utilities to have remote control, given proper authentication, and that allowed user visibility of appliance performance, but did not allow any cross communication, that those types of devices may be permitted. In answering a follow-up question from Jim Lazar, who commented that the cost of building a second communication system (as opposed to using existing wi-fi) would be cost prohibitive in certain grid device applications, Mr. Cerf deferred to his earlier position that open communication is possible but that it relies strictly on authentication.

Merwin Brown asked for the panelists' perspective on what the EAC or DOE, specifically, should be focusing on for the future. In getting around to answering Mr. Brown's question, Mr. Cerf and Ms. Allan discuss cybersecurity efforts associated with meters and the need to be able to control the grid manually. Ms. Allan supported a point made by Mr. Cerf that cyber-attacks are notoriously subtle, but that prevention is key and rapid response is key. Mr. Centolella asked a final question about whether distributed controls still need central authentication and Mr. Cerf replied that at a high level, they do. Mr. Brown added that at its core grid security and resilience is also about authentication, given adaptation after attack will require a coordinated response. He prompted the panelists again to provide specific direction to DOE.

Carl Zichella asked whether in the process of developing standards it would be better for consortia of utilities and other stakeholders to take an 'all eggs in one basket' approach to standards, or whether standards development ought to be compartmentalized. Mr. Cerf replied that in a layered architecture system, as long as there is a common base for communication, compartmentalized innovation can still be supported and useful. He suggested establishing umbrella standards below which variation is easily accommodated could be key. Mr. Centolella asked for input from Mr. Vreeswijk on what those common standards might be. Mr. Vreeswijk described the Smart Grid as a system and regulators as the overseers, indicating that the responsibility may ultimately fall to them to establish common operating principles. Mr. Zichella agreed with the idea of having common layers of architecture that could act as firewalls.

Chair Tierney posed a question about who should be in charge of overseeing standards-setting for reliability. Ms. Allan responded by referencing a scare in 2000 regarding the potential security concerns around smart meters and likened them to worries today about smart inverters, EV

charging stations and other devices. She indicated a need to determine which devices are priorities, to develop security standards for these, to deploy them, and then to work down the priority of assets developing standards. Mr. Cerf and Ms. Allan disagreed with regard to the threat posed by an increasing number of manufacturers of grid devices, but agreed that greater collaboration would be required among manufacturers, perhaps supported by DOE or the national labs.

Assistant Secretary Pat Hoffman shared her view that at the end of the day the grid wouldn't be 100% secure, but that the debate was now over the acceptable level of risk and who should bear it. She highlighted DOE's work to help utilities with a cybersecurity maturity model and requiring disclosure of product risk to customers. She asked the panelists how they would suggest framing this conversation about risk going forward, as well as how – in the wider market context – the industry ought to value security, including valuing investments in security in the marketplace. Mr. Cerf answered that the focus to date has been on consumer protection. Going forward, he advocates that the power industry needs also to adopt a defensive position on the compromise of grid devices. To the second question, Mr. Cerf bemoaned the low value that has been place on security in the past, including as evidenced through muted responses to major security breaches.

Chair Tierney and Mr. Centolella called for one final question, to be asked by Paula Carmody. Ms. Carmody asked who, in the grid space, is overseeing security, whether it's a state agency, federal agency or other jurisdictional authority. Mr. Cerf suggested that while privacy is important, given the mixed jurisdiction for ensuring privacy and security, the government at any level has not yet sorted out where responsibility should lie regarding protecting customer privacy. Ms. Carmody echoed Mr. Cerf's mention of the Code of Conduct, which DOE established as a voluntary measure for third party grid technology companies, but indicated that she still has questions about how these types of agreements will be deployed, used, and what the next steps are for ensuring compliance.

Both Mr. Centolella and Chair Tierney thanked the panelists for their valuable contributions before adjourning the panel.

Panel: Transmission-Distribution Interface in the Context of Increasing Distributed Energy Resource Additions

Mr. John Adams, EAC Power Delivery Subcommittee Chair, introduced the moderator, Joe Paladino, and the Transmission-Distribution Interface panelists including: Lorenzo Kristov, Principal, Market and Infrastructure Policy at CAISO; Arnie Quinn, Director of the Office of Energy Policy and Innovation at FERC; Woody Rickerson, Vice President of Grid Planning and Operations at ERCOT; Mike Bryson, Vice President of Operations at PJM; and Joseph Brannan, Executive, VP & CEO at the North Carolina Electric Membership Corporation.

Mr. Adams mentioned several recent DOE initiatives that had recently focused on transmission and distribution system planning, including DOE's SunShot initiative, Quadrennial Technology Review, Quadrennial Energy Review, and many storage analyses. These reports highlight many challenges of managing the technological and policy changes necessary for supporting bidirectional electricity flows on the grid. He noted that one key question that has emerged is

"What happens between the 'transmission' and 'distribution' silos?"

The moderator, Joe Paladino, introduced himself and explained his role at the DOE. He gave opening remarks to begin the conversation. He mentioned several key drivers of market transformation, including emerging technologies (PV, DERs, storage, and declining costs), evolving state and federal regulations, and customers (and third parties) who want to participate in these new markets. All of these factors together demand that the grid transform to enable changes at the transmission and distribution level. Mr. Paladino also discussed the technology movement led by producers of grid devices who want to get their products to market.

Mr. Paladino explained that several recent regulatory developments have highlighted the need for clearer understanding both of the current state of the market and where it is headed. These include both changes at the federal level – like FERC's recent NOPR on energy storage and the aggregation of DERs in transmission-level markets – as well as those driven forward by states, such as in Minnesota, when a 2013 regulation required investor-owned utilities to obtain 1.5% of their energy from solar by 2020. In the latter example, one utility – Xcel – found itself ahead of the regulators after getting flooded by applications from prospective market participants. As an overview, Mr. Paladino indicated that grid modernization is moving in different ways across the country (i.e. high end automation vs. increasing local energy determinism vs. less automation and yet higher penetration in select states). Referencing the well-known 'Duck Curve, Mr. Paladino emphasized the need to think critically about how to increase the flexibility of the electricity delivery system both in resource planning and in its operational capacity, specifically in cases defined by both generation and load curves that are highly variable. A key component of flexible transmission system operation is understanding both the use and the value of DERs at the distribution level. A key question being debated in the field is "What is the incremental value to the grid of DERs?" This value may be determined not only by deferred generation and transmission capacity additions, but also by associated reductions in congestion and transmission line losses, increased voltage management capabilities, and loss reductions at the distribution level.

In sum, Mr. Paladino presented slides that highlighted the value of DERs in providing capacity, energy and ancillary services. However, his presentation provided the caveat that increased variability at both the transmission and distribution levels will require more flexible systems. Critical to system flexibility and reliable operation is the integration not only of transmission and distribution planning, but also the inclusion of DER service providers, aggregators and customers in a more holistic planning process.

To close, Mr. Paladino raised the topic of developing a coordination framework, specifically with respect to the need to understand coordination in order to dispatch resources effectively and to satisfy markets. He indicated that this framework would need to address both scalability issues and optimization issues. With respect to optimization, there is a particular need to balance local optimization with system optimization. One way in which to do so is represented by the concept of Laminar coordination frameworks, which optimize coordination across various levels of operation while respecting the physical constraints of independent system layers. In addition to developing a workable framework, Mr. Paladino asserted the need to discern the optimal system-wide distribution of DERs versus centralized assets.

The first panelist, Lorenzo Kristov introduced himself and outlined the work that California has undertaken in developing an updated coordination framework that is capable of meeting industry changes that include the growth of DER integration and the shift of generation and DER technologies into distribution-level markets. Mr. Kristov further explained how California has approached modernizing transmission-distribution interface coordination in expectation of a high-DER future. He described this future as characterized by several trends: a shift to renewables, greater 'grid edge' adoption of DERs, the decline of centralized power generation and commodity based revenue models, the potential for the creation of distribution-level "peer-to-peer" markets, and the development of a potential need for Distribution System Operators (DSOs). In addition to responding to these trends, Mr. Kristov reinforced that any next generation grid system must also serve state and federal sustainability, resilience and efficiency goals.

Several factors are critical to the success of an updated grid, chief among which is the coordination not only of the physical transmission and distribution systems, but also of the electricity markets at both levels. Mr. Kristov indicated that DER business models "look to provide services and earn revenues at multiple levels of the system," and that both utilities and ISOs need to adapt their planning and operations accordingly. He offered several examples of the actions of California ISO (CAISO) in 2016 to adapt to greater DER penetration. These included CAISO working with distribution utilities and stakeholders to identify operational coordination needs at the transmission – distribution interface and also the need to include DER service providers in multilateral planning processes. By including consideration of each entity's objectives and responsibilities, CAISO enables the development of tools, information flows and procedures that will support future coordination between the ISO, DO (DSO) and market participant levels.

Speaking specifically of the characteristics that a transmission-distribution coordination framework would need to include in order to be effective in markets with high DER penetration, Mr. Kristov highlighted the need for several additions to existing planning processes. These include: forecasts at both the ISO and DO/ DSO level of load and non-ISO participating DER, ISO day-ahead market schedules and real-time market-dispatch figures, and greater information sharing from the DSO/ DO regarding DER penetration in order to inform reliable ISO scheduling and dispatch at the distribution level. Mr. Kristov introduced two "Bookends" between which he expects the market will evolve. The first can be considered a 'least change' option, characterized by minimal DSO participation and largely reflecting the current path of utility planning and operations. The second bookend, which he calls the "total DSO" option, includes DER aggregation for wholesale market participation and the optimization of local DER to provide transmission grid services, balance local supply and demand, and to manage load variability.

In conclusion, Mr. Kristov offered several questions to stimulate discussion, especially regarding aggregation of DERs to the transmission – distribution interface level. This could be done with a single bid, but would require the ISO to maintain ultimate system control. The DSO, in turn, would meet its load obligation by optimizing local resources, a structure that potentially addresses the concern of conflicting demands on generation resources. Mr. Kristov asserted that a likely future scenario requires grid architecture tools enabling a whole-system approach to electric system transformation. Specifically, he indicated that "the future grid may be a layered hierarchy of optimizing sub-systems," for which a layered control structure reduces complexity while increasing security and resilience.

The second panelist, Arnie Quinn, reiterated that his views are his own and do not represent those either of FERC or of the two remaining commissioners. Mr. Quinn announced that his focus would be on areas where FERC has seen different developments than those discussed by Mr. Kristov. From his location at FERC, Mr. Quinn indicated that the grid is at an early stage of what will be mass DER penetration. He expects that as various commercial and system needs materialize and become urgent, those needs will drive the evolution of the system. With regard to transmission-distribution coordination, Mr. Quinn asserted that "any place where an ISO needs to know what the load is, is where they need to understand the impact of DERs." He added that this coordination could be as simple as information sharing or as complicated as telemetry and metering. Specifically, FERC is concerned that when DER is allowed to participate in the wholesale market, it will adversely impact the distribution system.

The recent Notice of Proposed Rulemaking (NOPR) on this topic announced that FERC would require ISO/ RTOs to create an opportunity for DER aggregators to provide their services in order to participate in wholesale markets. Mr. Quinn commented that once the opportunity is created, greater information is needed regarding the other conditions or opportunities that need to be created in order to make that participation possible. In addition, the NOPR required the establishment of location requirements that are as geographically broad as technically possible. Since compensation and valuation is location specific in wholesale markets, coordination is needed between the ISO, the DER aggregator and the DSO/ DO in order to determine more specific locational values of DER integration. With respect to third party aggregators, Mr. Quinn highlighted that they see their value proposition as dynamically changing the portfolio that's providing the service. Much like a software provider issues optimization software, DER aggregators want to be the source of coordination between DERs and the ISOs and they derive value from being the center of that coordination. This type of relationship raises new questions as well, especially regarding whether these aggregators could potentially drive out the need for a DSO. In sum, when considering where commercial value is added and where operational efficiency is achieved, Mr. Quinn suggested that a DSO may still be the most efficient way to consolidate market information, at least in the near future.

The third panelist, Woody Rickerson, spoke with respect to his role at ERCOT, a system in which DERs represent an emerging condition. High wind penetration in Texas, as well as rapid expansion anticipated in solar penetration in the near future, means that planning and operation processes are experiencing a greater need for transmission-distribution coordination than ever before. Mr. Rickerson outlined ERCOT's existing electricity market and planning processes in several steps. The current options available for DERs are: (1) to register as a Generation Resource to participate in SCED or Ancillary services, (2) not to register, and instead to be paid zonal prices as opposed to the locational marginal price (LMP). At present, ERCOT models down to the 69 kV level and does not model the distribution system. Seventy-five percent of the retail electricity providers (REPs) operating in ERCOT's retail markets offer competitive choice, while the Texas PUC provides REP comparisons. Distribution service providers currently provide distribution services to consumers served by many different REPs.

Mr. Rickerson next highlighted the growing potential of DER within ERCOT's jurisdiction. In competitive areas, 900 MW of DERs are installed, while 200 MW are installed in NOIE areas.

These DERs are divided into two categories: self-dispatched generation and intermittent generation. Mr. Rickerson shared several complications that these DERs introduce to ERCOT. First, ERCOT is not currently equipped to estimate negative load. In addition, inaccurately tuning the existing models to compensate for DER leads to the resources not being measured or modeled accurately. Knowledge of future DER capacities could make a difference in planning studies. Mr. Rickerson indicated that the planning for a future system must be done today and that incorporating DER into that planning forecast on its own – not just in a net way – will be key. While the existing market does not include DERs in price formation, the future market should.

In sharing his vision for ERCOT's future, Mr. Rickerson indicated that the RTO does not plan to model distribution circuits in considering DER planning. Instead, ERCOT will coordinate in order to determine where a registered DER or unregistered cluster of DER would be located on a specific CIM load. This mode of planning will require answering several key questions, however. First, which risks may present when dense distribution systems do not conform to this structure? Second, should there be a mechanism for the ISO to exert any control over the groups, and is this beneficial, given that the mechanism right now is the LMP price? Third, how should reactive and transient contributions resources be included in grid reliability and market studies? Fourth, how do we consider privacy issues? (As an example, consider residential solar customers – are they expecting to provide detailed generation data to utilities?), Fifth – and finally – how should transmission planning consider DERs? In order for ERCOT to successfully integrate DERs into a coordinated planning framework, pursuing answers to these questions will be critical. The planning process itself will need to include a few final steps, as well: (1) Model all registered DERs, (2) Develop a standardized method for collecting appropriate data for future unregistered DER unit accumulations, and (3) Establish thresholds for adding accumulations of DER that exceed agreed upon thresholds into the CIM loads.

The fourth panelist, Mike Bryson, Vice President of Operations at PJM, began his presentation by giving an example from 2015 when an undervoltage disturbance caused by lost accounted for transmission and nuclear plant production caused 500 MW in DC to trip offline. What shocked PJM operators, he indicated, was the 200 MW of backup generation that nearly instantaneously came online to compensate. The recognition that PJM needed a better understanding of the DERs exerting influence on the grid systems under their control led to more focus at the RTO level on including distribution planning in their overall transmission planning processes. From the regulatory perspective, PJM is looking to more mature DER markets (like CAISO) for inspiration. Mr. Bryson strongly emphasized that PJM considers regulatory sphere the biggest friction to transmission and distribution planning; with15 jurisdictions, regulations are "all over the place."

The current plan of action is for PJM to conduct pilot projects to figure out best practices under the radar, so that those lessons learned can be brought to the attention of the state PUCs. Cooperatives and municipal utilities are often in the best position to lead these pilots. In addition to pilot projects, key to solving uncertainties around DER integration and dispatch will be both the multi-state regulatory process and the establishment of a DSO capable of adding value without competing with the RTO's existing member utilities. Overall, Mr. Bryson emphasized "visibility for reliability," sharing that emergency operations and event analysis need to be transparent. In addition, the ability to measure and forecast all DER would enable the grid operator to know the amount, timing and location of generation injected into the grid and/ or load reduced from the grid.

Specific lessons in building operational capacity through increasing the visibility of technologies interconnected to the grid that were learned from Demand Response (DR) can now be applied to DERs. Mr. Bryson asserted that the same lessons and takeaways gleaned from DR programs should be considered when drafting rules and guidelines to govern DERs. Several questions related to grid integration have arisen as especially critical: Can they (DERs) participate in the same markets? Which markets? Capacity markets? In addition, general awareness of the location of additional DERs that do not operate in the wholesale market ought to be sought through tools like the generator attribute tracking system and dispatch interactive map application (DIMA). In some areas, monitoring and control is possible down to the 12 kV level. Mr. Bryson offered final takeaways from PJM's efforts to increase visibility and grid resilience by making their system accessible to DERs. First among these is that planners don't always need ICCP data, but some sort of data is critical. Second, with whatever is available, improvements can be made to decision-making and situational awareness.

The fifth and final panelist, Joseph Brannan, is the executive Vice President and CEO of the North Carolina Electric Membership Corporation (NCEMC). Mr. Brannan opened his presentation with the clarification that his perspective is that of the market participant view, since his organization represents the electric cooperatives of North Carolina, as opposed to a system operator or regulator. One major issue facing market participants is retail choice. Mr. Brannan commented that retail choice overlaid on a market structure relies on allocating existing resources. Opening up markets, on the other hand, has the potential to create risk for the retail consumer. So from a risk management standpoint, closed markets enables less risk, which in turn supports resilience and reliability.

In elaborating on how managing risk for the retail consumer shapes the perspective of NCEMC, Mr. Brannan offered the example of a recent demonstration project sited on Okracoke Island, which allowed NCEMC to experiment with command and control of various DERs across a variety of load conditions. Mr. Brannan also explained other examples of innovation and customer engagement projects being undertaken in the state, including community solar programs, utility scale solar installations, microgrid and energy storage projects, and energy efficiency initiatives.

Conceptually, Mr. Brannan supported the idea of integrated coordination with defined roles for market actors. The RTO would coordinate the market activity of assets including generation, DERs and demand response functions. The transmission owner would provide forecasts, coordinate interconnections at the transmission- distribution interface, and would reconcile the influence of DER use in terms of market impact. Currently, Mr. Brannan notes, distributed generation that is difficult to curtail can have a disruptive impact on markets in which a cooperative may be operating. Finally, the DSO would be tasked with the final oversight roles: managing consumer needs, integrating DER utilization upstream, and managing assets at the distribution level for system stability and resiliency. In this type of integrated coordination framework, "every participant is not equal, but they're all trying to access a market that's nondiscriminatory."

Several challenges and opportunities present themselves with this structure. Load forecasting and system modeling can be difficult, not only in the execution of models but also in determining the level at which information can be most useful. In addition, disagreement exists over whether

payment for impact studies ought to be distributed or borne by the last generator onto the system. Lastly, increased risk in terms of intermittent generation and the resulting voltage and power quality can be concerning to customer advocates. Any time that new generation paradigms affect system coordination, such as the integration of DERs, clear schedules and processes are needed. In terms of opportunities, Mr. Brannan sees several key areas in which customer service may be improved by harnessing the flexibility of DERs. First, microgrid integration can improve system reliability, when interconnected and managed accurately. Looking at new ways to manage the distribution system to manage upstream impacts on the system is one area in which continued research and development will be useful. In addition, Mr. Brannan noted the usefulness of demand response programs not only in saving consumers money on costly capacity expansions, but also in allowing customers to be more active market participants.

EAC Discussion of T-D Panel

Jeff Morris directed his question to Mr. Kristov and Mr. Quinn regarding how the socialization of rates – specifically, taking ratepayer value from the distribution system and shifting it to the high voltage side without seeing rates decrease, can be unbundled. Mr. Quinn responded that aggregators look to participate in the wholesale market to make customers' investments in DERs more cost effective. So, aggregators are most interested in the *opportunity being available* at the wholesale level. Mr. Kristov followed up by expanding on the bottom-up movement building in California around community choice aggregation, where cities & counties can become the retail electricity provider for customers in their area. This trend represents a greater move toward the development of local resources, both to meet electricity demands and to increase local system resilience to disruptions.

Laney Brown asked Mr. Kristov how he expects the utility approach to transmission and distribution interface planning to change as the distribution-level services and their value stack matures. Mr. Kristov indicated he does not subscribe to the LMP + D cost model, indicating instead the opinion that when meeting local energy needs with local resources, the LMP simply represents the cost of imported energy vs. exports.

Carl Zichella asked Mr. Bryson what is necessary in order to move to a system that accurately reflects the value of DERs both where and when they operate. Mr. Bryson indicated that the level of data access is critical, as are pilot projects, since both allow future scenarios to be more accurately modeled and refined. Mr. Kristov added that once we add a greater volume of DERs, each ought to be charged at the interconnection according to their impact on the system (either creating or removing volatility, i.e.) that changes the price dynamics. He reaffirmed that location will matter. Mr. Brannan implored the group to think about customers at the locality level, who might be better off taking advantage of a larger market where cheap, local sources of electricity do not exist. He added that if the system model moves away from central generation, localities are stuck with the price of the electricity that can be provided from local resources.

Merwin Brown asked what the timeline – and therefore the sense of urgency—should be for DOE in providing guidance to help the market participants solve the problems surrounding DER integration and valuation. Mr. Bryson answered that from a reliability perspective, the visibility and data needs are greatest in order to more rigorously model and operate markets. Mr. Rickerson

indicated that the visibility component, at least, needs to be solved in the next 3 years. This would allow greater understanding of system components to inform a more comprehensive discussion about thresholds and market triggers. Mr. Kristov added that the urgency would begin when the next major disaster encourages localities to think more seriously about building resilient local systems that are capable of islanding. Mr. Quinn addressed the market opportunity side, explaining that a sense of urgency already is driving incremental change in markets. Lastly, Mr. Brannan suggested that policy would be the critical area of focus, since policy and regulation created the issue of uncertain system reliability from DER integration.

Janice Lin asked Mr. Bryson to clarify whether the 5 MW of behind-meter battery storage he mentioned was direct dispatch. Mr. Bryson confirmed that since the storage operates in the regulated market it is direct dispatch. Ms. Lin directed a second question to Mr. Brannan regarding the Okracoke microgrid controller. He answered that the controller is not exactly off the shelf, but is a simple interface point on which any PC can run algorithms and add customizations. Since the controller is a platform more than a device, a major concern is that cybersecurity needs to be maintained, but that at the device level and the interconnection point the grid is more vulnerable.

Gordon Feller asked the panelists to suggest functions in which microgrids could be most valuable. Mr. Bryson replied that microgrids are effective as a pilot because they can prove ground usefulness before greater capital investments are made. Mr. Kristov added that microgrids will allow a diverse local community to develop and operate a local and resilient power system as an alternative to the existing industry, which tends to be dominated by major utilities.

Joe Paladino in closing thanked the panelists both for their willingness to travel to the meeting in person and for their valuable insights. He asked for permission to reach back to panelists before officially concluding the panel.

Wrap-up and Adjourn Day One of March 2017 Meeting of the EAC

Sue Tierney, EAC Chair, thanked everyone for their participation and reminded them about the no-host dinner that subcommittee members were welcomed to join. She reviewed the agenda for the second day of the meeting before adjourning Day 1 of the meeting.

Respectfully Submitted and Certified as Accurate,

Susan Tierney
Analysis Group
Chair
DOE Electricity Advisory Committee

06/26/2017
Date

Carl Zichella
Natural Resources Defense Council
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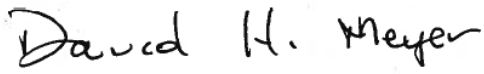

David Meyer
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DOE Electricity Advisory Committee

06/26/2017
Date