UNITED STATES DEPARTMENT OF ENERGY

ELECTRICITY ADVISORY COMMITTEE MEETING

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P R O C E E D I N G S

(1:03 p.m.)

CHAIR TIERNEY: Welcome to the meeting of the Electricity Advisory Committee of the Department of Energy. We have a great agenda. So, I hope everybody's excited about participating in this meeting as much as you can, for those of you who are doing dueling meetings in Washington during this period. Because I know some of you are. I'm Sue Tierney from Analysis Group, and have the pleasure of serving as Chair of the EAC. And what I'd like to do just to begin, is ask everyone to introduce themselves. But before we do that, we do have one new member here for his first meeting. Rolf Nordstrom is here from the Great Plains Institute. And your fame precedes you, of course. And we all know you and love you and we're glad you're here as a member of the group. It's great. Carl, you want to start?

MR. ZICHELLA: Excuse me. I'm Carl Zichella with the Natural Resources Defense Counsel. Vice Chair.

MR. CENTOLELLA: I'm Paul Centolella. I'm President of Paul Centolella and Associates and a Senior Consultant with Tabors, Caramanis and Rudkevich. And Chair the Smart Grid Subcommittee.

MR. BROWN: I'm Merwin Brown with the California Institute for Energy and Environment, which is housed at the University of California, Berkeley. And I'm Chair of the Energy Storage Subcommittee.

MR. ADAMS: John Adams, Principal Engineer with the Electrical Reliability Counsel of Texas. And I somehow ended up Chair of the Power Delivery Subcommittee.

MS. LIN: Janice Lin. I'm the Co-Founder and CEO of Strategen Consulting. The Co-Founder and Executive Director of the California Energy Storage Alliance. And the Co-Founder of the Global Energy Storage Alliance. And I serve on the Energy Storage Subcommittee.

CHAIR TIERNEY: Soon to be the Intergalactic Storage Committee. (Laughter)

MS. LIN: There's always space.

MR. NORDSTROM: So I feel honored to have already been introduced by Sue. And I'm neither the founder of anything nor the chair of anything. But I am the CEO of the Great Plains Institute, which is based in Minneapolis. And really honored to be among you all. Thanks.

MS. SILBERSTEIN: Hi. I'm Pam Silberstein from NRECA. The National Rural Electric Cooperative Association, where you are all meeting. We're pleased to welcome you. And I serve on the Power Delivery Subcommittee with John.

MR. CASPARY: Hi. I'm Jay Caspary. I'm a Director in our Engineering Group at the Southwest Power Pool in Little Rock.

MS. CURRIE: I'm Phyllis Currie. I'm the retired General Manager of Pasadena Water and Power in California.

MR. GELLINGS: Hi. I'm Clark Gellings. I'm an independent.

CHAIR TIERNEY: That's an adjective. What's a noun?

(Laughter)

MR. GELLINGS: Individual.

MS. SANDERS: (inaudible) Heather Sanders. Southern California Edison.

MR. ROBERTI: Hi. I'm Paul Roberti. I'm an Executive Director with Ernst and Young.

MR. FELLER: Good afternoon. Gordon Feller at CISCO Headquarters in Silicon Valley. And I also serve as Founder and Member of the Board of Meeting of the Minds, a non-profit organization.

MR. MORGAN: I'm Granger Morgan from Carnegie Mellon University. I have appointments in the Department of Engineering and Public Policy. And in Electric Wind Computer Engineering.

MR. LAZAR: Jim Lazar from Regulatory Assistance Project. And I've collected two brand new knees. One on the left, one the right, since I saw you last. (Laughter)

MR. BALL: Billy Ball. Chief Transmission Officer at the Southern Company.

MR. BOSE: I'm Anjan Bose from Washington State University. I'm a Professor in Electrical Engineering and Computer Science.

MR. SIOSHANSI: Ramteen Sioshansi from Ohio State University.

MR. MORRIS: Representative Jeff Morris from the Washington State House of Representatives. And that's my night job.

(Laughter)

MS. CARMODY: Paula Carmody. People's Counsel with the Maryland Office of People's Counsel. We represent residential utility customers in the state. And I'm on the Smart Grid Subcommittee.

MS. BROWN: Laney Brown. Vice President of Modern Grid Partners. I'm on the Smart Grid Committee and Storage as well.

MR. ROSENBAUM: Hi. I'm Matt Rosenbaum. I'm the designated Federal Official for the EAC. And obviously part of the Department of Energy.

MR. MEYER: David Meyer. I'm a Senior Advisor in the Office of Electricity at DOE.

MS. HOFFMAN: And I'm Pat Hoffman. I'm the Principal Deputy Assistant Secretary for the Office of Electricity. But I have several acting titles and we can go through that

(Laughter).

CHAIR TIERNEY: And we'll hear more about those titles and other things that Pat's involved in in just a minute. I just wanted to start by reminding everybody that this is a public meeting. And the remarks of the entire meeting will be transcribed. So, please be sure to use your microphone when you'd like to speak. We have two really interesting panels set up for today. One on the Internet of Things. And the other on Issues at the Intersection of the Distribution and Transmission Grid. Lots of interesting things going on in the latter for sure. And then tomorrow, we have a number of presentations, and we will be hearing from acting Chair of the FERC, Cheryl LaFleur. And we have a presentation on the new study that's been issued by the -- by MIT, on the Grid of the Future. But to begin today, we are going to hear some thoughts that Pat has about how things are going on in her office, as well as the Department of Energy. And without further ado, you're up.

MS. HOFFMAN: So, first of all, I'd like to thank NRECA for hosting us today and the facilities. I really appreciate all that you do for the Grid Space. But also, for the Advisory Committee and the advice that you give as the Advisory Committee. I'd like to thank Sue and Carl for acting as Chair and Vice Chair. I always support -- appreciate your support and dedication in the Electric Grid Space. So, just a little bit. So everybody understands, I do have multiple hats right now, trying to do the best I can. I am on the -- my position of record is Principal Deputy Assistant Secretary for the Office of Electricity, Delivery and Energy Reliability. I'm also acting as the Assistant Secretary for that organization. I'm also acting as the Undersecretary for Science and Energy. And so, hoping to keep all the activities and the discussions going within the Office of Science and Energy. I also am responsible for any sort of emergency incidents at the Department. And the coordination of those activities on behalf of what was done under the S2, which is the Deputy Secretary at the time, until one gets nominated and the Department's able to really move forward from that perspective.

MR. ADAMS: And Pat, you sleep when?

(Laughter)

MS. HOFFMAN: I do -- I do manage to catch a little bit of sleep. (Laughter). But, needless to say, a lot of things are going on. Definitely spending most of the time getting the new politicals in the building up to speed. I did want to say that we did have, of course, everybody knows the confirmation of Secretary Perry as the 14th Secretary for the Department of Energy. Most of you are aware before he joined the Administration, he served as the 47th Governor of Texas. And he championed economic development in Texas. Really trying to drive innovation, job creation and economic development. Secretary Perry's leadership in Texas also scans and has proven out that, you can have both economic growth as well as protection of the environment in some of the -- what he's been able to demonstrate in Texas. So, I've had a couple of very good conversations with the Secretary. And very productive. And I think just thoughtful and strategic in moving forward and what he wants to look at in the Department. So, it hasn't changed. Our mission right now is still the same as the responsibility for addressing the electricity reliability issues in the United States. Looking at right now, what we'll be shifting is really going to looking at earlier stage research. And focusing our activities on cyber-security and resilience type activities within the office. But, before we probably get into some of those conversations, as we will, as part of -- part of the discussions at the EAC, I did want to just remind everybody of some of the Executive Orders that have been signed. And some of the Executive

Orders that we are looking at as we continue to reflect on our work and how to do our work better. The first Executive Order that you guys might be aware of is enforcing regulatory reform. I think that's something that is -- that the Electricity Advisory Committee could provide great value into the Department, of looking at whether it's statutory regulatory. Or other opportunities for streamlining. Eliminating overlap. But trying to find a way to better coordinate with respect to some of the objectives that we want to achieve in (inaudible). So each agency has to develop a Regulatory Reform Officer. And we are really going after looking at outdated regulations. Unnecessary and ineffective regulations that could impose additional cost. But, by doing some of that, we can actually have some significant benefit.

There is another Executive Order, looking at reorganizing the Executive Branch. That's a review of all the federal agencies. So, just heads up on that, that we're looking for efficiency across the federal government as well. Then just yesterday, there was the Executive Order to review the Clean Power Plan. And some other -- other rescinding of regulations that were in that Executive Order. So take a look at that. But that also will kind of drive what some of the Department's activities and where the Administration objectives are moving forward from that perspective. So I did want to give you a heads up on a couple of those things. Like I said, we're going through a lot of review currently at the Department on all the programs and activities. A very thoughtful review. And I'm sure, more discussions will occur as a result of that. And I'm going to leave it there. Okay.

CHAIR TIERNEY: Thank you. That's a great update on what's going on. And I imagine that you have to stop, because you need to go get some rest. (Laughter) So that's great. I think it is now the time for beginning the panel. Unless, I'm -- I'm just going to do a check here. Many of you have just come from Subcommittee meetings and have been working on various things in the morning. Is it all right if we proceed without a break? You better start shaking your heads if you're really desperate and you really need a break. We're okay? Okay. Great. So with that, I think it's the Internet of Things. And Paul, you want to tee it up?

MR. CENTOLELLA: Sure. So, I am very pleased to have this panel of speakers here for us to talk with today about the relationship between the Internet of Things and its implications for the power system. As many of you know, you know, the world that we live in has significantly changed over the last decade. You know, many of the things that, you know, were just devices, you know, a decade or two ago, are now platforms with sensors that gather information. Intelligence of some sort. And the ability to then act, based upon, you know, information that they have. And information that may be processed over the internet. So, whether it's our cell phones, or our credit cards. Our cars or the airplanes that we flew here in, or the, you know, the locks on our front door. Or our thermostats. All of these things are potentially, in many instances, connected to a distributed intelligence. That has implications for the power system that operates it all, because all of these devices connect in some way, to that system, either themselves, or through the digital technologies that will underlie and provide the intelligence for them. And fundamentally, run our economy. So, we thought it was important in thinking about this from a Smart Grid perspective, to go beyond the boundaries of the grid per se. And to look at this broader picture. And look at it in the context of what are the challenges. The challenges, in terms of the architecture for this broader system. The challenges in terms of how it's controlled. And of how security is maintained. But also look at the opportunities. The opportunities in terms of more efficiently managing the power system. Enabling us to use the assets of the power system much more efficiently, so that we can move beyond a system that has only, you know, at best, oftentimes 50 percent or lower asset utilization. And, you know, and potentially improve the quality of our lives. So we've put together a fantastic panel that I'm very pleased to have here. We're going to start with someone who almost needs no introduction. But I -- it's such a pleasure to introduce him, so I'm going to do it anyway. Vint Cerf. Vint and I served together on the Board of the Smart Grid Interoperability Panel. And we'll hear more about that, you know, a little later. Vint is -- was one of the people who was responsible for the development of some of the basic protocols of the internet. He was the founding President of the Internet Society. He has won more awards than I can begin to list. But, you know, it's hard not to mention it. National Medal of Science in 1997. An IEEE Fellow in 1998. The -- he was named a Living Legend by the Library of Congress in 2000. You know, the Turing Award in 2004. And a Presidential Medal of Freedom from President Bush in 2005. So, it's a real privilege to have you here Vint, and I'm really glad you're able to join us. Following that, we'll have two other speakers. We have -- we're very privileged to have also the CEO of the Smart Grid Interoperability Panel. The SGIP was formed in 2009, to help accelerate the development of standards for the Grid here in the U.S., and was associated with much of the development of standards for grid modernization here. And so, there are -- there are certainly some success stories that come out of that. But also, some ongoing needs. And it's, you know, it's a real privilege to have Sharon Allan, who's here for that. And finally, our final speaker is going to be Frans Vreeswijk. Frans is the General Secretary and CEO of the International Electrotechnical Commission. The IEC is an international standards body with membership from most of the developed and developing nations around the world. And is very much involved in the development and promulgation of standards for both electrical and electronic devices. He is very much involved in thinking about both the Grid, but also the Internet of Things. And how all this relates to our economy and to the development of Smart cities and Smart systems. So, we're looking forward to having that international perspective as well. So with that, I'm going to turn it over to Vint, and then we'll just go down the line. So, Vint.

MR. CERF: First of all, I really appreciate the opportunity to be here. I guess I would like confirmation of how much time I'm allowed to opine on this. 10 minutes? No. 20 minutes. Okay. We'll negotiate. My problem is that there is more material here than I could cover in that amount of time. I'm going to try to convince you today, that the first order of business is to make sure none of these damn Internet of Things devices comes anywhere close to the Electrical Power Grid Control System. I don't care how much, you know, advantage you might imagine these devices will bring. They're too dangerous at the current state of development to come anywhere close to grid control. The reason this is so critical, is that most of these devices have software in them that is weak, has bugs and vulnerabilities. And they will be exploited and have been exploited. If you can imagine controlling a large number of power consuming devices and deliberately turning them off and on in -- at the scale of millions of devices, you can see the kinds of potential hazards that could arise. So, that's what I want to convince you of from the architectural point of view. The Smart Grid Interoperability Program standards need to take that into account. So let me start out by pointing out that the real risk here is the software. The people who make these devices don't particularly care very much about the software. Many of them are just interested in selling you something and getting out of the way. There are a lot of people who have -- who have a model, that there's a mobile and a device and an app. End of story. And, of course, several things should occur to you right about then. The first one is, what if you have 87 apps that deal with the 87 devices you have in your house, and imagine flipping through the apps to figure out how to turn on the lighting or flush the toilet. That doesn't sound very attractive. The second problem is, that if you can only get to the device through the public internet, what happens if the internet isn't accessible in your home? Does the house stop working? That can't be a good outcome either. So, and to go further, these pieces of software are going to have bugs in them, because for 70 years, we have not succeeded in learning how to write software without bugs. And let's assume that we're even responsible people, and we decide we want to upgrade the software to fix the bugs. Well, how does the device know that it's downloading a piece of software, which is from a legitimate source and hasn't been modified? How do we assure the integrity? Well, digital signatures maybe. So, then what if the company that makes this device has gone out of business? And, so now there are bugs in the software and nobody to fix them. We don't have a framework right now that deals with any of this stuff. And if it were just devices that plugged into the, you know, household mains, and consumed electricity, this wouldn't be such a problem. But the fact that they are potentially remotely controllable, is what creates the scary thing. So, I have believed that, if you're going to design IOT devices, you should start on the presumption that the device will require strong authentication of the party that is attempting to either control the device or to gather data from it. And in the absence of that strong authentication, the device should refuse to cooperate. Now what does that mean? It might mean two factor authentication. It might mean some form of certificate authority. Or some other strong public key crypto mechanism. But I think that's very important. The devices have to be paranoid and refuse to communicate if they can't confirm the party that's trying to control or gather data. There's another problem and it's the 200 devices in the house and the 15 year old next door. When you're trying to configure all those devices, you don't want to sit there typing IPV6 addresses all afternoon. And worse, the 15 year old next door notices that you're in configuration mode and configures himself into control of your entertainment system. Or worse, you accidentally configure your neighbor's devices into your system. You know the joke about the -- the two people in bed with the cross controls for the heated electric blanket? So one's turning it up. The other's turning it down, and they can't figure out why it's not working right. So we have that problem. And in an industrial setting, there could be tens of thousands of these devices. So, scaling up of configuration, making it easy and reliable, is a terribly important thing. So, with regard to access control and security, we've already -- I've already said how important it is to have strong authentication. But now, think about how complicated this is going to get. You have residents and you have guests. So, how long does it take you to introduce the guests to the house? How do they know how to turn the lights off and on and to flush the toilet and so on? Worse, after they leave, you have to revoke their privileges. So how is that supposed to work? What makes it worse, is that what if somebody breaks into the house and somehow manages to configure the control of the house into their favor, and then later on, you know, they'll do other kinds of bad things. What about parents versus kids? Most of the time, you parents want to have more control over the house than the kids do. Although, in these days, the young kids seem to know more about this sort of technology than the parents do. But, it's pretty clear that you don't want your five year old to control the security of the house. How does the system know that? What is the mechanism by which we achieve that? Now there are some places, including my own company, Google, that are offering devices that will do voice control. And while that's kind of cool and it's sort of like Star Trek, the question of identification of speaker and the association of authority with that speaker, is not so easy. And I don't claim that we've solved that problem. I don't think we have. So this leads to other kinds of control platforms or mechanisms, so you might even end up in every room in the house with a little flat panel that lets you say, you know, turn the light on in the corner. As opposed to having an argument with the voice control system. Another thing, which I'd like you to consider, is what happens in an emergency? If the house is on fire, and the Fire Department is on its way, you might want them, at that point, under those conditions, to have access to the webcams in the house, to see if anybody is collapsed on the floor. Or to have access to the temperature sensors, you know, in which parts of the house the fire is burning. After the fire is out, you don't want the Fire Department to have continued access to the internal systems. And so, how do you revoke that privilege? How do you offer the privilege? And how do you deal with strong authentication? Again, the same scenarios can be made up for the Police Department and medical emergency. There's also something, which is not so obvious. And that is, that some data, which seems innocent, isn't. I have a little radio grid in my house. It's a cell forming radio network. Every sensor is storing forward device. It automatically forms a network. Every room in the house captures temperature, humidity and light levels every five minutes, and sends that through this mesh network to a server in the basement. At the end of the year, I have a very good idea of how well the HVAC has worked. But suppose somebody gets access, just to the temperature data. Over a period of a year, you begin to understand how many people live in the house. Which rooms did they use? What are their diurnal patterns? When are they away? And, so that could be fairly damaging information. So, even something as simple as temperature, could turn out to be something that you want to control access to. I don't have to say much about standards to this group. And, especially with the SGIP observations coming up. And IEC as well. But, standards are super important here, because they confer interoperability. And my current impression of the state of the art of IOT, is that there are companies going in 17 different directions. Many different protocols that are being proposed for communication among the devices. Many different stacks layered -- protocol stacks to manage these things. Different forms of authentication. Some strong. Some not so strong. So, in fact, we've got lots and lots of different proprietary contenders. And I think we're going to go through a lot of white water, before we come to any conclusions about what we can commonly agree on. It's terribly important that we get there. Because, in the absence of some commonality, it's going to be very hard to assure safety and security.

Another thing has to do with backward compatibility. Some people are going to buy these devices and leave them in their homes or in their industrial settings. (Coughs) Excuse me. Hang on.

I promise that I will not spread this germ to anyone in the room.

CHAIR TIERNEY: How can you do that?

(Laughter)

MR. CERF: Yeah. I'll try not to breathe too deeply. Backward compatibility is an issue. If the devices are -- last for a long time, like decades. Who's going to maintain that software? And when you release new components, will they be backward compatible with the old ones? Or will you have to rip stuff out of the house or the plant, in order to make things work again, because something has gotten too old? Now, we tend to replace our mobiles fairly quickly. I mean, within a year or two or three. But there's other equipment that you have at home and we certainly have in office settings that is there for much longer periods of time. Especially some of the larger components like HVAC. I think that there will be a lot of pressure from different elements of our socioeconomic organizations to achieve commonality. But it's going to take a lot of time to get there. When I talk to my engineers about my priorities for doing IOT design, at the top of my list is reliability. And that's because -- and ease of use, because if you can't use it, or if it isn't reliable, or you have to keep flipping, you know, I mean an argument with the oral command system to turn the light off and on, that's going to become old really fast. So, reliability is very, very high on my priority list. Safety is the next one. No one wants a device in the house if they think it's not safe. Now, how the heck are you going to show that it's safe? If the maker of the device says it's safe, why would you believe that maker? The maker just wants to sell you a device. So we need an underwriter's laboratory equivalent that will say something about these devices and the software that they have on board. We don't have such a thing right now, although the underwriter's laboratory itself is starting to push in this direction. There's another fellow in Cambridge Massachusetts. He's working in this space as well. And he's got software that will analyze the software of these IOT devices, whether it's source code or perhaps object code, to try to identify whether there are obvious problems with the design. Security is just as important, all partly because of access control. And partly because of the control of access to data emerging from the devices. I can imagine that a lot of people would be very concerned about privacy. If you have webcams in the house, you don't want random people being able to access the webcams. And speaking of webcams, those of you who didn't happen to follow an event last year, half -- 500,000 webcams were taken over as a Botnet, we call them Mirai Botnet. Each of those webcams launched a megabit per second stream at the Dyn Corporation, which also happened to deal with domain name in the look-ups. And so a lot of the World Wide Web became inaccessible when Dyn Corp was collapsed, with a 550 gigabit per second stream. You know, do the math. One megabit times 500,000. 500 gigabits per second, which overwhelm the company's systems.

They actually moved to Google's infrastructure in order to defend themselves against similar attacks. But the reason this worked, is that the Mirai network was built on webcams that had no access control. Either nothing at all or well known usernames and passwords that were not changeable. And so that's irresponsible, from my point of view. And the problem that we face is that there's a -- will be in this competitive environment for IOT devices, a real problem trying to deal with responsible behavior of the makers of these things. Especially given that these are coming from all over the world. They're not just domestic. So, figuring out how to cope with this is a big issue. What about autonomy? This is something that often gets left out. But what if you can't get access to the internet? Does that mean your house stops working? You know, this is not a good idea. So, there has to be some ability to use these devices locally, even if not all of their functionality is available.

And finally, of course, interoperability is valuable, especially if you want to manage an ensemble of these devices scattered around the house. And certainly, it should be obvious and in an industrial setting, in advanced manufacturing, where a lot of these are programmable robots. Or programmable 3D printers. Or programmable other mechanisms, you want them to inter-work, so you can control and manage them. So I think this is coming up to my last slide. No, that was my last slide. So, why don't I stop there. And Paul, do you want to do Q&A now, or should we wait until we've had some --?

CHAIR TIERNEY: Let's go through the panel.

MR. CERF: Okay. You're on.

MS. ALLAN: Sure.

MR. CERF: Here you go.

MS. ALLAN: So, I'm not going to do the SGIP introduction, since it seems like it's been done twice for me, other than to say thank you for the invite today. And I have two and a half more days of being SGIP, because Friday we file a

Certificate of Merger here in Washington, D.C. With another 501C3 called the Smart Electric Power Alliance, which shares a lot of the same beliefs that we do. [SEPA] Has 1100 members of which 560 are utilities. So, thank you for -- for having me here today. So much of what I say is -- will be framed from the work that we do at SGIP. And really, my close to 40 years of being an engineer, a manager and an executive, running various aspects of work within this industry. And we are not -- SGIP is not a standard organization. We work with many, many different standards organizations. And we run a lot of collaboratives with government regulators, utilities, market participants, to work on hard issues outside of a formal proceeding or legislative action. Because, we believe people around the table are much more collaborative if they're doing it, not in a formalized setting. So, our focus areas have been, and I'm going to give the context of my comments. And I'm going to be so bold as to conclude with some considerations for DOE to consider in this particular area. So, one, when I look at, you know, just using our drawing, and thinking about things that perhaps this group has heard about, if I roll back seven years ago, and the inventive automation really started getting in greater swing within -- within the power sector. There was a time, up at the head end, where I'll say, at an enterprise application level, there are such systems as Customer Information System. GIS. Asset Management. AMI Head End. Meter Data Management. And in the early days, what you would see is, integration on point to point connections. You'd -- and so, if you ever remember any of those drawings anybody presenting to you, they would show you a drawing that looked like Spaghetti -- Spaghetti Code. And they'd say, as an interest industry, we need to embrace service oriented architecture. And have something called an ESB. An Enterprise Service Bus, where applications would present information and other applications would subscribe it. And, what we've seen over the last decade, is we've seen members of our sector.

And a lot of implementers implement energy service buses -- enterprise service buses at a server application end. Well, what's happening in our industry right now, is there's a real push to what I call the grid edge. And the grid edge is where you'll see down at the bottom of the chart, things that are in distribution called field devices. Electric storage. Meters. And then you see things on the home. And what is happening that is kind of pulling us towards the grid edge, is that we have customers who, not for energy needs, might be automating their house. There are protocols in standard approaches being pushed inside the home. There were two organizations. One called AllSeen. Had a protocol called AllJoyn, on like, how could you watch your cake bake in the oven? And how do you connect it with other devices? Then there was another one. Open Foundations Committee. And those two consortium have come together. So there's these players, Sony, Panasonic, that really don't come from the power sector, that are saying, how do I automate the building in the home? And it's not a huge leap when you start looking at connecting and modeling devices, to say, how do we model energy as a resource into that network? Now we from the utility sector, have been coming at it for a number of years on the demand side management, saying, how do we define that protocol to the house and the water heater and the thermostat? And guess what, we're not interacting with this other entity going on. We're defining a Smart energy profile now called IEEE 2030.5. And there is this tug of war that will play out in the market. Is energy just another resource in the home automation? Or does energy really drive the home automation? So, when we look at connectivity, I'll take a step up. Internet of Things, to many, in the broader sense, is the connectivity of devices exchanging information and connecting, anytime, anywhere. And when we look at the grid edge and the advent of Distributed Energy Resources, there is this paradigm shift. When we rolled out automated metering infrastructure, we put in Smart meters.

We put encryption keys in those smart meters. And the way you unlock and interpret the data, is at the AMI Head End. Then you pull that data out. It goes over to a Meter Data Management System. And we opened it up for third parties with Green Button. Well, now that we look at DER, we need the meters to be able to talk to the distributed devices. To be able to talk to the storage devices. To be able to communicate with grid devices called Load Tap Changers, Capacitor Bank Controllers. And guess what? Those all connect up through unique functional domains. So, while I might be 200 feet apart in devices, I've got to make a round trip. And my meter all the way back to the enterprise. From the AMI Head end to the MDMS, over to the SCADA System. Over to the DERM System, back out into the field. And we believe that the industry is pushing towards monitoring control and interaction of data exchanges at the grid level, which causes a rethinking of, other devices have to be able to come into the network, and be able to exchange information securely, without doing a round trip all the way back up into the enterprise to go back to the field. When you look at various things that are happening, there is good things going on. So, if I look at -- in Europe, it's much more pervasive than in North America. But, in terms of what controls grid devices out of the substation to different distribution automation, there is an IEC standard called 61850. Not as predominant here in North America. We primarily use something called DNP3. But, the IEC has done, what I'll call an internet version. A 61850,and that goes to ballot. So there's a recognition that we need more standard approaches to be able to connect to devices. And there's different standards bodies that are working on it. IEEE has approximately

standards that they've gone through. And have enabled how to connect with standard internet technology. They've got projects on the books, looking at how to do this. In addition to the work that's going on between IEC and IEEE, SGIP championed a proof of concept in an early pilot project with a number of utilities and vendor participants. And we ran it through a NAESB, the North America Energy Standards Board, to become a standard on how devices begin to exchange information, device to device, without going all the way back up to the enterprise. And that's still in its early days. One of the things that we applaud DOE for doing is, there's this thread of cyber-security on a number of the GMLC projects. We at SGIP happened to participate in four of those. But I know that the architecture committee, I know that the interoperability group that is -- project that is formed under GMLC, has the thread. We're constantly on the phone every week talking about, how do you thread cyber-security? And what's the impact of cyber-security? And I think, having the thoughtful leadership, not of just one national lab, but multiple national labs and industry coming together, I think is a good thing, and I applaud DOE for the funding of that. Something that DOE also funded, that is in early days, but there are two projects. One is an Intel project. Another is with another company called RTI, where they're looking at how to create with hardware, essentially, a -- a router device or a device out in the field, on the edge, that has security built in, that can be used as an overlay with certain grid devices, without a utility having to rip and replace everything. It's too early. You know, that project's literally just started. But it's the lessons that are learned that I believe, will help to stimulate the innovation and the thinking and what are the impacts that are needed as we begin to think more clearly towards the grid edge. Earlier this year, the OpenFMB group, which originated -- has originated out of SGIP, has kicked off a cyber-security working function of that. And what we -- what we recognize, is that as you start to look at doing this, so I described in my opening comments, how we've thought a lot up here at the server level and implying enterprise service buses. And once you had applications, talking to applications, there's new software that came into the market. Identity and access management, so you didn't have to log on to every server. How you configure your fire wares. How you -- how you go and make sure that the data and the databases is truly secure. And we've got to think, well, what do we do as we come out of that enterprise, and take some of those lessons learned into the field? So, for consideration, the thoughts I would -- my observations, what I see, is that, we're still very much singularly, functionally focused. So, we have groups who are focused on, how do I securely communicate to storage? How do I securely communicate to an inverter? How do I securely communicate to a meter? But the grid edge is pushing us and our industry, so we are a connected model. It is no longer storage and isolation. It is no longer solar and isolation. It is no longer meters just for billing for customer service. There is a need for this ecosystem, to be able to communicate the grid edge. And what's important about the grid edge, is these devices, while they don't have the full power of a server up there, they are now software enabled. Most of them are now, if they don't, they're being pushed towards communicating. So that means a communication device. So, now we have a device that needs to be configured. It needs to be able to execute and initiate communications with another device. It needs to be able to have a root of trust. So you know it's legitimate coming on the network. And the data that you receive is legitimate. It needs a way to authenticate from device to device. We have demonstrations right now, where you see it individually. You'll see people have put security into the AMI systems. You see people looking at how they overlay security into the substation. But where I think that we've been really lacking, in terms of looking broader, and so I would encourage that this is an area that, I believe, DOE can help with, in terms of leveraging the national labs. Or looking at some of the cooperative agreements, where it is an industry DOE cooperation, is that we don't have so many looking across device. So, when I want to manage things, I don't want to have to do configuration management from my meters here. Go over, do configuration management for storage here. Go over and do configuration management for load tap changes. Cap bank controllers, or whatever here. I need to be able to have a similar process to configure devices. And we need the ability for devices in the field, to be able to exchange information securely, at scale. Why is this important? The reason this is important, as we see more Distributed Energy Resources come on to our distribution grid, whether it is rooftop solar. Whether it is EV charging, that can also be load as well as serve as battery availability of energy. Or, we're looking at some other type of (inaudible) fuel cell. Whatever. The latency of being able to manage everything centrally, starts to become problematic when you're looking at the reliability and the resiliency of the grid. In terms of reliability, the voltage levels down the feeder, are changed and affected. The --

non-useful energy, but something within our industry, we call reactive power. That is affected. And so, there's a need. There's a push that we need devices to be able to communicate with devices. And we need to be able to do that securely, at scale. We need to be able to monitor it. We need to be able to configure it. And we don't have that today in this industry. Everything pretty much does round trip cycles, all the way back up to the enterprise and back into the field. And what that means, is that we have higher costs, because there's a cost of data load to go all the way up to the enterprise to yet come back out to the field. So, if DOE is looking for suggestions as far as things to help motivate the innovation cycle of the adoption of IOT within this sector, I think dealing with this issue of how we do across multiple kinds of devices, in the field, at scale, is one that I would offer up and open for the dialogue that will ensue. Thank you.

MR. VREESWIJK: So good afternoon ladies and gentlemen. First of all, thank you very much for the invitation. It's a great honor to be here. Allow me to start with a little bit of introduction of myself. So my name is Frans Vreeswijk. I'm Dutch. I worked for Phillips Electronics for 30 years. First 12 long years as a researcher. And later on as a manager. And when I became a manager, I knew that I had left a field of the specialist, and became more the generalist. Five years ago I moved to the IEC and I moved to live in Geneva. The IEC is based in Geneva. The IEC is 111 years old. And our first President was Lord Calvin. We have, in our family, 170 countries. And we can do the work, because the industry, all the stake holders, they all provide volunteers. We have some 20,000 volunteers writing standards all over the world. And here in the U.S., the U.S. National Committee, which is the member of the IEC, is hosted by NC. And so, that is say, the phase in the U.S. for us, goes through NC and through the U.S. NC.

Let me say a few things about Internet of Things. I will also, in the coming, say minutes, explain to you our point of view regarding IOT. But also the impact on the power sector, and on the Smart cities, and the relationship between those. Now let me go to the next. Yes. The Internet of Things is not new. It simply wasn't called like that until recently. And to give you an example, the digitization of manufacturing, has been taking place of for many years already. And the same holds for security and surveillance. What has changed, is that IOT has now reached a development stage, where it is becoming naturally universal. The affordability of limitless computing power, the decreasing cost of sensors and our ability to store massive amounts of data, are simply enabling the broad deployment of IOT. This then allows cities and energy networks, to move to greater smartness. And to allow city services to escape their silos. IOT enables the linking of devices and sectors. But have never been connected before. Making them do things that have never been attempted before. That means that interoperability will have to permeate everything. And to have it just at some levels, will simply be no longer an option. And I think some of the examples have already been given here. The concept of Smart Grids, forms now an integral part of Smart cities. And if you realize that by 2050, which seems far away, yet again, if you think about it, our children or grandchildren, it isn't that far away. 70 percent of the global population, lives in urban areas. Energy will be the key enabling factor for sustainable economic development. And it will drive everything in cities. However, before realizing the full potential of IOT for Smart cities, and the energy sectoring, the energy infrastructure, and its operation, needs to be improved and modernized. This will also enhance efficiency and generate cost savings. The modernization of the energy infrastructure, will increase decision making control and planning for milliseconds to years. And the ability to balance the grids from microseconds to nanoseconds. It will directly and positively impact the control of the power quality. Which will become a major and growing concern, with more decentralized power generation. And increasing power demand of network devices. The modernization of the infrastructure, will also enable increased data collection and advanced real time geospatial, situational awareness and the solutions. In turn, this will lead to more cost effective asset planning and maintenance practices. And allow for faster response to emergency situations and/or outages. The impact of weather or fires on daily operations, will be faster and easier to understand. Geospatial and visual analytics, are able to merge and correlate data from Smart meters, switch sensors, weather reports, emergency systems, to support the more informed decisions, which are needed. New energy solutions will lead to new value add services. And this may very well include services that nobody has asked for. But which have been made possible, actually through technology. Any investment will likely result in multiple revenue streams. Here the example of a Smart lamppost, that can address many different citizens needs and city needs. So IOT, in Smart cities, goes well beyond the data collection, or the applications that interact with individual consumers or physical devices. It includes Smart manufacturing, connected health and homecare. Transportation. Smart mobility. Smart buildings. Smart lighting. Distributed energy generation and all related needs for interconnection and data collection. Now, a precondition for the integration of different city sectors, is the broad permeation of sensing technology. The establishment of a joint service delivery platform. A common data warehouse and collective data management and analytics, as well as common communication platforms. In some countries, Smart meters penetration is already very high. And multi-meter collection, allows for information into action, between water, gas and other energy sources. This is the world. Cyber-security. It will be a key element that will have to be designed into every system. Since cyber-security will never be 100 percent, the regulatory needs to define how many 9's, 99.999 percent, have to be reached, or it can't be implemented. This is a common concept, as you know, in aerospace industry. But not generally found everywhere. Cyber-security standards can define concepts and propose minimum levels of performance. But ultimately, the regulator has to decide what remaining risk is acceptable. The IEC has published a white paper that outlines the challenges of smart and secure IOT platforms. In the context of Smart cities, we have also published more than 200 cyber-security standards. Many of which apply to critical infrastructure. As mentioned earlier, network devices are an integral part of IOT. And with their continuous electricity consumption, they represent another set of implications for the energy sector. The last quantity of devices and their continuous sensing, data collection, data sharing, and the need for data storage, will impact power demand exponentially. In some cases, technologies such as, LED OLET, new types of batteries, printed electronics, advances in energy harvesting and others, are able to contribute to limiting the power needs of the individual network devices. However, to satisfy this growing demand, energy demand, and to limit the environmental impacts of IOT, increased integration of sustainable power sources, including renewables and energy storage will be needed. Energy storage is growing in importance, to ensure that the power quality, to ensure power quality, to enable micro grids and to make the most of intermittent renewables, such as solar and wind. Low voltage DC, low voltage that is direct current, opens new opportunities for the direct use of renewable energy. And the integration of data communication into the energy distribution network. The IEC has put in place a systems committee that develops and updates all the relevant standards that are needed to make LVDC, safe and broadly usable. Both in countries that lack universal access to energy. And in situations where a large supply of quality electronics, is needed. For example, for data centers, hospitals or commercial buildings. Another area that will be impacted by IOT, is energy efficiency. For a long time, energy efficiency was addressed in terms of reducing overall power consumption, during the device operation and the stand-by mode. However, network devices are constantly collecting and sharing data. They are staying energized most of the time. This requires a new approach to energy efficiency. The IEC has published relevant standards that cover a network stand-by mode, in an effort to reduce the power consumption of the always on devices. Now let me give you a bit of perspective from the outside. In the U.S., the grids are much more fragmented compared to the rest of the world. And much of the infrastructure is a bit dated, compared to other countries. One could, therefore, presume that the U.S. is, therefore, not in the best situation to address these new demands related to IOT. The U.S. wants to, however, to be a society that is leading from a technical point of view. Or technology point of view. And with IOT, there will be very high expectations on the power infrastructure, which will, therefore, require large investments. But, while the U.S. power industry is fragmented, it is also very agile. And decision processes and funding are much faster and easier than in most other countries. Therefore, it is unlikely, as mentioned before, that IOT can be standardized as a whole. However, industry needs to unite, to ensure that interoperability and security, is built in from the start. That, from semiconductor manufacturers to Network Operators, to system integrators. Regulators and this need for interoperability, will drive the development of cross industry standards, which are needed. There is a lot of value to try to share common platforms internationally, in an effort to be future proof. And to keep the options open, because most of us today, don't know exactly the things that will play out in IOT and elsewhere. Industries are to act quickly and make architecture choices, which, or many of which, might become dead ends. While there are standards that can possibly be homegrown, there are others that need to transcend borders. The challenge is to convince the industry that global thinking will be more valuable to everyone in the long run. It will not allow only -- it will not only allow industry to share the common solutions beyond borders. But it will also stimulate research and development and the growth of markets for these solutions. Thank you for your attention.

(Applause)

MR. CERF: I don't know about anybody else, but I need a change of underwear. This is a really scary prospect ahead of us. (Laughter)

MR. CENTOLELLA: So, I want to kick it off with a -- with a couple of questions. But people should begin to think about their questions and start to raise their cards. So, I think one of the foundational questions is, to what degree are the challenges that we face institutional? And to what degree are they technical? You know, I mean, part of this, you know, we've seen, you know, lots of different organizations trying to put together standards. You know, they are not necessarily all coming together on the same putting. And, you know, as your, you know, example with the webcam pointed out, you know, these situations, even if we had a standard for the U.S., it wouldn't necessarily, you know, protect the system as a whole. So, I wonder if you can talk about this in terms of, what's the institutional need. And how do we being to address that?

MR. CERF: Well, let me take a swag at this. The first observation I would make, is that because standards are, let us say, immature at this point, our first posture should be to do no harm. And to maximize safety and security for the population that's going to be using these IOT devices. And from my point of view, once again, I go back to isolating the devices from access to the control of the power grid. This is going to get harder and harder, because as Sharon points out, distributed generation of power, injecting power back into the grid, creates a real potential hazard, because it's clear that there has to be control going back and forth. One possibility, is to -- is centrally make down a diode and prevent the power that's being generated at home, from actually being injected back in the grid. And that means, if you've invested in solar panels or a back air generator, or windmills or something else, you may reduce your reliability on the power coming from outside. But that you don't push it back into the grid. Now, I'm not enough of a -- a good enough electrical engineer to argue whether that's the smart thing to do. But, anything that reduces instability in the grid, seems to me, worth attention. Second thing to observe, is that security came up in all three of our conversations. And the group least likely to be disciplined about the use of security, is the general public. In an earlier meeting this morning, at USC's Annenberg Center on Pennsylvania Avenue, Lee Raney, from the Pugh Foundation, was describing a questionnaire, which he had given to quite a number of the general public, asking them about cyber-security questions. And it was very clear, that the lowest thing on the recognizable list, and the one that people just didn't even try to answer was, what's two factor authentication? And, you know, I'm at Google, right. We don't allow employees at Google to use our internal services without two factor authentication. Even inside the company, on the internal network, because we've been burned before by poor quality usernames and passwords. Or, somebody managing to fish a password, you know, coming out from a key logger. So, again, I have to say, that the ability to secure the system and to rely on users to take the appropriate action, seems like a really weak plan. And so, I'm back to a kind of posture that says, I'm going to be as defensive, or wish to be as defensive as possible, about the design and implementation of any future grid implementation, in order to avoid reliance on either ordinary mortals or the devices that they populate their homes and businesses with.

MS. ALLAN: So, a lot of the focus that I have, you know, like anything, I think there's a phased approach. So, my comments stem from not so much relying on customers to do something. Within our electric systems today, utilities are putting storage on the distribution grid. Utilities are putting on community solar. Utilities are putting on charging points. And so, when utilities have to now manage and, you know, keep the reliability indices up, and manage that, what we've seen in some of the early pilots, is if you have storage. And that storage is voltage serving back onto the grid. Our current serving that the latency becomes very, very important. And in the context of a micro-grid, it will drop out. And one of the things that we're looking at, in terms of micro-grid, from a resiliency standpoint, is you want micro-grids to always keep power up where possible, so if you lose electricity, you can still serve what's part of the micro-grid. So when, you know, I don't think this is a, you know, we need to be cautioned. I think work needs to be done now, because there are efforts going on from our electric utilities, who are looking, especially after super storm Sandy, to okay, how do I put up a micro-grid? How is it going to help me with meeting my resiliency? How do I keep my reliability up? And, as we started to have micro-grids, this need and issue around latency, becomes very real. So, we need to be able to have devices that are closer to the edge that can be monitoring what's happening on that feeder, so that decisions can be made. And as a result of that, I think we have to -- to really spend some effort looking at how we make those devices. I'm not talking about head end service. These devices more secure and that they can exchange data with each other in a secure manner. So, I think that there's a real meaty project there. And I think that will open up the doors for, you know, figuring out what in the end standard and protocol turns out to be the world dominating protocol. I think there's work that has to happen even before we get to that level.

MR. CENTOLELLA: Frans, did you want to talk about it from an international perspective?

MR. VREESWIJK: Yes thank you. I think from an international perspective, I think -- and I think that it was also the plea I had in my last slide is, the world is larger than the U.S. The world is larger than Europe or Japan or China.

MR. CERF: I'm shocked.

MR. VREESWIJK: (Laughter) Now you know it. I know. But, and so, many of the companies are -- that are instrumental in implementing these new technologies, are say, global players. So, there is a place for international standards. I am very much in favor of ensuring that there are -- there's good cooperation between international civilization organizations, because that is often a question. And, I am supposed to list it and the history is there. There are many competing standards. And that doesn't always make sense. On the other hand, the market place usually finds out things. And regulators have a role to play, I think in those, to streamline where they can. And where it makes sense. Because, I think as Sharon said, the edge of the grid becomes more intimately involved in the grid. And -- and just last week I was in South Korea at Jesu Island at a conference for international electric vehicles. And there, one of the complaints was, of course, the different possibilities of connecting your car to the grid. There are currently several outlets and sockets. And there is not just one. And everyone wants to have just one, so that you can charge your car everywhere where there's a charging station, because it just fits. It just works. Because, that's what the consumer wants. And we have to make sure that we, somehow, through either policies or regulation, ensure that the heads of all those that are active in this field, understand the problem, and work towards it. And in this respect, many of the car manufacturers, and this was my statement there, and they were all there in the room, many of the car manufacturers, they have a, what I call, a combustion refuel point. You know. It means, the car is mine. And the only thing is, there comes some fuel in there. And I know the octane percentage. And I know exactly the size of the gage, and that's it. You know, you don't need anything else. And then it will drive. However, with electric vehicles, it is much different. It is an integral part of the grid in the end. It needs charging. It needs safety. It needs to make sure that, if there is energy stored in that car, you can use or reuse it. Is it fast charging, or slow charging, what are the pricing models? Everything is, therefore, connected. And I think that is, if you talk about institutional challenges, I think that's the big one. It is also to create the awareness with many of the actors, big actors in society. Like, for instance, in this case, the car manufacturer, but it holds for others as well, other areas, to broaden up their mind to say, hey listen, you know, Smart Grids, the utilities, they are your key partner now. You know. You have to talk with them. You have to get into contact with them.

And I think that those are the things we need to do. And if standards -- international standards, in this case, can help to support it, that is my mission. Thank you.

MR. CERF: Are we allowed to argue?

MR. CENTOLELLA: Yes. Please do.

(Laughter)

MR. CERF: I know there's lots of people who want to say something. I guess, I didn't make my point very well Sharon. Because, my big worry is that if we lose control over the power demanding devices, and maybe even the power generating devices, because the users of them don't know anything about security, and don't exercise it. Then, no matter what else you do, we still have this unstable element in the system. And I think that's what causes me so much agony and concern.

MR. CENTOLELLA: So, unless you want to respond Sharon, I'm going to go to --

MS. ALLAN: No. I -- I don't disagree with his comment. I don't disagree with his comment.

MR. CENTOLELLA: Okay. So let's start with Granger here.

MR. MORGAN: That was nice. Thank you. We need to spend more time thinking about what problem we're solving. You know, what need we're meeting. That is, just because we can do this stuff, is not necessarily why we should do it. I think, Dr. Cerf, that in the -- in the context of the power system, there's no avoiding at least some of this technology. But not everything needs to be able to talk to everything. And so we need to figure out some way to begin to separate the services that we have to implement for a variety of control reasons. I've been very concerned about issues of social vulnerability. The examples that you gave were compelling but, you know, I can also imagine people applying ideas, I mean, you know, people do ransom ware with computers, but you know, I could do ransom ware with this building, or with other things. And everybody talked about security, but there is no way, at the moment, to build fully secure systems. And so that suggests that maybe there are some things one shouldn't be doing. We need a critical assessment, I think, of just how widely stuff ought to be interconnected. And as I say, an assessment of some things that at the moment, we shouldn't be doing. We've still got sub-stations across the country that have software that's been lifted out of the Windows Operating System and, you know, that really troubles me.

MR. CENTOLELLA: I don't hear a question, so I'm going to go to Gordon.

MR. MORGAN: Good. No, that was just a comment.

(Laughter)

MR. FELLER: I do have a question. So it comes back to the framing that you provided with the first question, where you said, choose, you know, institutional versus technical. I think there is a third dimension, which is the attitudinal. And it's attitudinal, not only in the device maker, who will say to you, bunk, because we'll make whatever the demand says we should make. And nobody's going to tell us not to make that stuff, even when they say it's illegal to make that stuff. So, the attitudinal problems go up the full spectrum. Insurers don't really care. Many of the big tech companies, CISCO, I think included, don't believe that there's a global protocol any time soon. And have given up some hope that that can happen in our lifetime. Especially after seeing what happened with -- with Mirai. Which some of us thought would be a turning point, and it hasn't been. So, the question is, if you had to blow up one major attitude then, that you see in the tech companies that work with Google on common standards like Thread. Is there a fundamental, attitudinal shift that would get us closer to the goal line that you were describing?

MR. CERF: My reaction to that, at the moment, is no. And the reason is, that too many people, including, I think folks in my own company, are so focused on making product, that they're not really taking into account as much as I would like. The consequences of large quantities of this gear showing up, again, I was saying before, the guys have this model of mobile and the device and an app. And I don't want to, you know, castigate my own colleagues. And I can understand the sort of pressure that the people are under to go produce product. So, all I can do is ask people like you to voice your concerns. And suggest defensive measures that would limit the potential hazards that we face. I don't think that there's a way to declare that this is illegal. People walk into their houses with electricity consuming devices, and they plug them into a wall. And, nothing is going to stop that. And they keep demanding devices that can communicate, because it's cute. And, so the consequence of all that is that there's this whole process running over here. And some place else, in the Smart Grid Interoperability Program, and in your heads, needs to be serious consideration of defending the grid, including the micro grid configurations. Now one other observation to make. Those of us who live here in Washington, theoretically should never experience a major power outage. Well, guess what? A few years ago, didn't we have two five day power outages? The Derecho and the ice storm. I have a wine cellar that has a couple of thousand bottles in it. And after the second week outage, I installed a 50 kilowatt generator in the backyard. It's a gas driven thing. And now I'm feeling so comfortable. Except that when the power does go out, I'm expecting to hear a knock on the door with somebody with a 200 foot long power cord saying, can I borrow a cup of electrons?

(Laughter) [UNIDENTIFIED]: (inaudible)

MR. CERF: Yeah. That is the sort of the beginning of a micro grid.

MR. MORGAN: And the compressor stations on the gas lines now run on electricity.

MR. CENTOLELLA: Hi there.

MS. SANDERS: Okay. Thank you so much

for this panel. This was awesome. And every day I say, I learned I know less. And in the last hour, I have exponentially learned that I know less. So thank you for that. The other thing is, normally when we have these conversations, I am very excited. I'm excited about the possibilities and what the new grid could be. And right now I have so much anxiety, I can hardly breathe. So, I work for a utility. We're responsible for reliability. The expectation is that these Distributed Energy Resources will be part of our integrated future grid. So, here's my question. Do we need to change this expectation? Or and, since it is there and it's so ingrained, it's in everything. I mean, we hook up 5,000 solar rooftops a month and growing. I mean, there's 190,000 plus solar rooftops in our territory. 50,000 square miles. We have procured a significant amount of energy storage to provide local capacity. We have no idea how to do coordinated distributed control. Oh, and thank you for IEC 61850. We just made that part of our new substation standard. And we're implementing it at two of them. And we'll roll it out to all 800 in the next years, provided we get money. So, do we need to change this expectation? Do we need to start changing the conversation? I'm not a doom and gloom person, so for me to come out and say, oh my gosh, time out. Of course, I expect that. I'm in utility, right. I'm on the dark side now. So, don't do anything. Or, do we need to very proactively set out this parallel roadmap of, if you do this, you must do this. And if you don't do this, you can't do this. And what is this -- this of strong authentication? And certification of security and safety? I mean, when we do IEEE 1547, and allow those inverters not to switch off, safety for our workers. And, you know, line outages. And I can go on and on about my anxiety. And I might have to, you know, go have a glass of wine right now, but I don't even -- I don't even know what to do right now. Okay.

MR. CENTOLELLA: Oh, can we ease your

anxiety? Go ahead.

MS. ALLAN: So Heather, let me.

MS. SANDERS: (inaudible)

MS. ALLAN: What I -- what is occurring and what I think will continue to occur for a period of time. So, Vint had suggested, well, can we --? Have them put a (inaudible) You can't go back under the ground. I mean, oh my God, unless we want all North America chaos. I mean, the train is on the track. You know, the cat is out of the bag. I mean, there is --.

MS. SANDERS: I mean, we back feed almost all of our distribution substations right now. At some point in time, low load, you know, spring now, we back feed all the time. So, it's happening.

MS. ALLAN: So, California has a rule making, where every utility had to put a filing in how they were going accommodate the yard. The State of New York. Detroit Edison up in Michigan is looking at how to accommodate. So, I mean, things, it's kind of hard to put stuff back in the bag, once there's movement. Well, what I believe, you know, what I see happening and what is going on is, there's a lot of integration work. And I'll call it, you know, go back to the olden days of the servers. Point to point integrations. I mean, there's a lot of integration throttling on security. Putting little security gateways and appliances in front of devices to -- to layer that on. And, what I would assert and I would offer up, is that we need to think longer term. So, those that go first, I mean, the reality is, the California utilities are going to be a lot of lessons learned, because they're being pushed to move first. But, we've got a lot of other states. And we've got a lot of other utilities. And we've got a lot of other suppliers into the ecosystem, that won't move quite as quickly. And so, there is time for us to be thinking very diligently and intentional, about how do we handle this. In the short term, I think we're going to layer stuff on. I think there's not going to be standard approaches. They may employ different standards.

But, there's not going to be good lift and move. Every utility's going to spend a bomb of money on integration work with lots of consultants to be able to get these things up and running. And in a secure manner. But, for the overall long term view, and if we look at a global view, we need to be thoughtful so that, you know, down the road, this is easier and not as expensive to implement.

MR. CERF: I'm thinking a little bit about the current way in which we build residential systems. Typically, there used to be a fuse box. Now we've replaced that with circuit breakers. But the philosophy behind this was to prevent you from growing too much power. Or creating a short circuit and things like that. So, that's the kind of defensive move to get you off the grid, at least at the edge. At that edge. So, I wonder whether that kind of thinking, of how do I defend the system against potential abuses going on in a residential setting. Or, for that matter, an industrial setting. What other kinds of defenses could we design and build, into this distributed system. Your point about distributed control and stability, is the bugaboo for me for quite some time. I get so nervous about how to do distributed control in a stable way. And I -- one question I have, is how critical is the atomic clock timing in order to maintain phase and frequency for the power generation system? I hope we're not relying on GPS signals for that. Do we have atomic clocks that are built into the system?

MR. CENTOLELLA: So I -- I mean, I think that is true at the ISO level. I think one of the questions I have is, to what degree can we begin to build in some distributed response that is autonomous? And, is offsetting some of this potential instability. So we, you know, we do that a little bit with voltage. There are some folks who have experimented with it in frequency. I don't know, you know, how stable we can make the system in that way. But that strikes me as one thing that is at least worth further exploration.

MR. CERF: There is something going on right now, that you guys know more than I do about. And that's this shift towards an increasing amount of DC generation. Part of it's coming about because of the renewable resources. They generate, well, it's easier to combine the output of those generated resources, if it's DC rather than AC, because of all the complexity of phase and frequency. So, if DC is turning out to be increasingly important and valuable, it would probably have a number of positive effects. One of them is, all the devices you have in your house right now, that have to convert from AC to DC, could just pull stuff off the DC wiring. So maybe, you know, there's this thing going on in the background. I don't know if that helps us at all. But at least DC doesn't have frequency and phase problems. So, does that --?

MR. FELLER: We know that Larry Page is fixated on this. Is he planning a large scale investment by Google in the DC conversion again?

MR. CERF: We invested in the northeast, in the DC bus that was intended. I don't know where we've gotten with this. But it's intended to take power from the windmills that are some 45 miles away, into the power grid. And I presume that what will happen is they'll be DC injected into transformers, which they are then keyed up to the appropriate phase and frequency in the regular grid.

MR. CENTOLELLA: Frans, did you --?

MR. VREESWIJK: Yeah, I just wanted to latch on to the low voltage DC, as we called it. But DC is definitely a very important technology. And I think most of you know that, one way or the other. And, I think for the future, I can definitely imagine whatever, as you say, all the appliances we have in the home, except for the washing machines. And so far, but all the others can definitely do with a low voltage DC feed. And that could, over time, I mean, that's not -- we have time to do that. But, it will change the wiring in the house. And it will also make things more simple. But, the question you asked is absolutely an important one. I think we -- it is not easy to move from where we are to where we think we should be going. And we will make mistakes. And the only thing I can suggest is, look around you. Not just here in the room and here in the U.S. Because, there are many who face the same problem. Share the knowledge. Learn from each other. Look outside U.S. Because, there are some places where they have different conditions, where they can do different things. And you, perhaps, sometimes see the problem from outside even better. And, so communicate with that. And the other thing is, I can only say, because it's -- it's the DOE, is try to harmonize all the regulations across all your states, to make the life of all of you simpler. (Laughter)

CHAIR TIERNEY: Never.

MR. VREESWIJK: Sorry. Sorry, I said something wrong probably. I'm -- sorry. I'm just --.

CHAIR TIERNEY: They can't do that.

(Laughter)

MR. CERF: You know, if you --.

SPEAKER: It's a nice idea. It's a nice

idea.

MR. CERF: Frans, if you could do that, I would reduce 20 pounds of power converters and other little devices that I have to carry around in my computer bag.

MS. ALLAN: So, you know, it's hard, but I know it and believe it to be doable. If we roll back, and some of you look like you're as old as me. But you might have not lived in technology. When we started out communicating to devices in this sector, we used something called an RS45 loop. Which, was a serial connection, you know. Then we went to optical communications. Then we went to, you know, a RS485 loop. Then, eventually, we had serial, you know, over something else. Then we had a plethora of wireless technologies. We went through Datatech, Mobiletech, etc. You know, the early CDMA. I mean, the -- we've been evolving. And this is in -- just in the last 10 years. When AMI Meters first started, that was back in 1999. We have over 65 million connected meters here in North

America. And those meters, and those AMI companies have had to learn how to -- how do you encrypt it? How do you authenticate it? How do you commission it? And how do you deploy 65 million of them? So, what I would assert is, we've done it for 65 million meters. Let's think about how we do it between meter inverter storage devices, low tap changer. There's -- there's lessons that we've learned. We just need to do it broader. And we need to do it in a more standardized approach. It's not that we haven't gotten smart people who've figured out how to do some of this. But we're not looking at things as a system. We're looking at things on storage. We're looking at things on home automation. We're looking at things on, you know, we're not thinking of it, that this is a system and all these devices interact and play a part on the distribution side with regard to grid stability, reliability, and resiliency with the advent of Distributed Energy Resources.

MR. CERF: Can we at least isolate all

that stuff from the public internet? I mean, I don't care if they use the TCP/IP protocols. That's fine. It's just that it shouldn't be part of the public grid.

MS. ALLAN: Yeah. I don't think I hear anybody out there asserting, let's put it over the public internet. I think you've -- your interpretation of IOT, you jump to public internet. Most of the communication paths are subnets within the -- or private networks. They -- I don't know of any of our North America utilities who are pushing out communications to field devices over the public.

MR. CERF: No. That's -- that's not the point I'm trying to make.

MS. SANDERS: It's in -- it's in future use cases for sure. Sorry to interrupt. It's contemplated. Because those devices connect to the -- to the public internet. And by the virtue of the fact that they connect, and we have demand response, and you want all of these things. They're there. Now, we from the utility, do have secured communications. Right? Between our devices. But as you start to rely on other devices, and the other networks of all the inverter companies or the solar companies or whatever. We've got to figure this one out. And I'm just, you know, we have a lot of investment in cyber-security. In physical grid configuration that disconnects and so forth. But, if you have a mass amount of all of this going off at once, I mean, you can only protect yourself so much. So, I -- I just don't know.

MR. CERF: Well, this gets back to my desire to find a defensive posture somehow, while all this stuff is going on.

MR. CENTOLELLA: Okay. Let's continue with the questions. Rolf?

MR. NORDSTROM: Yeah. So, first of all, thank you for a really excellent panel. I love the fact that we have the whole continuum there. From nothing should be connected to the electric system, to lot of things are already connected to the electric system to, we should connect more things. Or can connect more things. Who can blame Heather for being a little freaked out over that? (Laughter) It feels like a -- it's sort of like telling a family, you know, parents of 11, whatever you do, don't have kids.

(Laughter) So, I'm wondering, this is for Mr. Cerf, but anybody please weigh in. I mean, I really actually appreciate the abundance of caution that it seems like you bring to this. Is there some subset of devices that you can imagine being safely connected to the electric grid? Either now or ever? Understanding the conversation we've already had. Which is that, in a way, the ship has sailed. But I'm -- I'm just interested, I guess, I heard you say that so categorically, that I'm just wanting to test how categorical, in fact, you feel about that? Or can you, in your mind's eye, can you imagine a set of conditions in which we could do it?

MR. CERF: So, in keeping with my defensive posture, if a device is going to be intimately connected to the grid, I would feel a lot more comfortable if I thought that it would not permit the passage of control, or other information from the public internet to the grid, on the presumption that some of those devices are advantageously connected to the public internet. Because, people want to see what their state is. Or control them remotely. If the energy companies, the distribution power and generation and distribution companies, have a well-defined access control strategy and implementation. And if it gets implemented in those devices that have to be part of the grid, what I would like is that that mechanism, that access control mechanism, not be penetrable from any other direction. And so, if there are, in fact, devices that want to --

whose state wants to be known, you know, through the mobile or whatever, I'd like it to be the case that there is an absolute barrier in communication from the side that's talking to your mobile and the side that's talking to the grid.

MR. VREESWIJK: Thank you.

MR. LAZAR: But one of the things that makes it cost effective to put grid integrated water heating into an apartment complex, is the fact that the building has building wide WiFi, to allow us to communicate to those water heaters. We don't need to build a second communication system. And --.

MR. CERF: I'm sorry. We don't need to build a second communication system.

MR. LAZAR: Right.

MR. CERF: I thought you already had one. I thought that the power --.

MR. LAZAR: The building wide WiFi for the public internet. And that's how we're communicating to the individual water heaters to turn on and off.

MR. CERF: Oh.

MR. LAZAR: And we have to install a parallel communication system. We've doubled the cost of the control system.

MR. CERF: Several bad words occur to me right now.

(Laughter) So, the question is, if you have this shared communication resource, how do you make sure that the water heater, for example, is not compromised? Look, let me mention one thing about the original internet design that might be relevant here. We didn't start out with fire walls at all. We started out with edge devices on the net. And a fully connected system. Deliberately, because we didn't know what would usefully talk to what else that we said opened it up. But at the same time we said that, we said, by the way,

if you don't want to talk to
somebody, you don't have to. And
if you demand that there's somebody
on the other end authenticate
themselves, to your satisfaction.
And then if they don't, you can
say, I'm not talking to you. Now
that doesn't deal with the other
problem where a package shows up,
and it's got some funny little bits
on. And your software misses the,
you know, doesn't understand what
to do, and you get penetrated.
That's a different problem. But,
it's conceivable to use the shared
communication resource, if there is
strong enough authentication to
prevent the obvious problem.

MS. ALLAN: So, you're changing your position?

MR. CERF: No I'm not. I'm saying, he's forcing me into a different position. But we're back to relying on the strong authentication. And anybody who's ever discovered or penetrated certificate authority, should be nervous at this point.

MR. CENTOLELLA: Okay. Merwin.

MR. BROWN: I'm Merwin Brown, of the University of California, Berkeley. I'm going to ask some questions similar to what's been asked, but in a different vein. And, where I'm heading for, is some advice on what we or DOE should be focusing on for the future. The developments. And to do that, ask this question I'm going to get to in a minute, I would like to offer, but I'm not sure, well it matters whether or not the customer devices are connected or not, to the control systems or grid, because as long as those devices themselves, such as a thermostat, can be breached, I can think of ways to bring the grid down without ever getting into the grid control system. Such as, turning on every air conditioner in the L.A. basin at one time. That kind of thing. So, I'd have to use some with more imagination. But, it's conceivable that, it's sort of as similar to, I guess, flooding the internet with lots of data. This would be a similar kind of thing. You're flooding the system with a lot of demand. Or you turn the demand off all of a sudden. So, that unto itself, the customers wouldn't even have to be connected to the utility. But that aside, if you'll accept that some way or another, we're going to have this kind of interconnection of devices that are subject to cyber-security threats. What I'd like to ask you is, I can think of some potential solutions. And it's, which of these solutions, if you had to pick one, which one would you pursue? The one is, I think, obvious. We would be able to make every device secure from a cyber-attack. That frankly doesn't sound very promising, what you said, but nonetheless, that's a potential solution. Another solution that is sort of been - - as a matter of fact, it's been sort of -- what's being proposed, I'm not sure they know what they're doing, but there's a Senate, a U.S. Senate Subcommittee right now, that's -- has a bill at the moment. That they said, they're going to pass a law that says, the grid has to be operable without the Smarts. In other words, if you get into trouble, you have to be able to operate the grid manually. And, they're patterning this after what happened with the cyber-attack to, oh shoot, I can't think of the place now.

CHAIR TIERNEY: Ukraine.

MR. BROWN: Ukraine. Yeah, thank you. And, so that's kind of another extreme. Is that we designed the grid so fail safes, if the Smart systems are completely compromised. That has a lot of challenges too. And then there's another possibility, which we happened to be involved in at our research area, by the way. So, but I'm not saying I have a bias or just --. Is, you're able to detect a cyber-threat activity fast enough, that you can take defensive actions to isolate them. And limit the damage that can be done. So, the three systems. Okay, I guess you're shaking your head. Of those three, which one would you pursue if --?

MR. CERF: I would discard the last one on the grounds that the cyber-attacks may actually be quite subtle. And deposit software, for example, that eventually goes off because of a timer or something else. So that the actual attack is not the one that installed the malware. It's the malware executing later on. So, I would not go for that. Let's think for a minute about the meter system. This is something Sharon knows a lot about. The meters, first order, trying to keep track of how much energy we're using. The first order. There's also the possibility of demand response. But you can imagine a box, in the house, which isn't the meter, or maybe it's incorporated into the meter. Which is providing information to the appliances that are in the house. And if those appliances are smart enough, they can take the advice and decide what to do with it. Now, the complexity of configuring all this, you know, for ordinary users, might turn out to be difficult. But then, that creates new jobs for people whose job it is to configure your house for management, so maybe that would be a good thing. More jobs. So the idea, in this case, would be to have a device, which we trust, which has, you know, tamper resistant design. And strong authentication. So that the device can't -- will refuse any information that it gets from the grid provider, that isn't authenticatable. And, that's the moral equivalent of the secured meter that I understood Sharon was describing, of which there are 65 million now. So, that device is now the thing which secures the communication between the power generation and distribution and, you know, energy provider. And the devices that are in the house. In parallel with the meter itself. So, and Sharon, how do you react to that?

MS. ALLAN: Using the meter analogy, and one of the things that you said, is that the grid needs, you know, the bill of -- the grid needs to be able to be controlled manually. It reminds me of some of the legislation that's on the books today, when we first moved to Smart metering. So in a Smart meter, you know, the roughly $100 is about $14 for the metrology part. One of the very material costly parts of the meter is the actual display, which is about $2.50. And even though, if the communications broke, the metrology and all the recording data is still in the meter. And you can go read it via optical port. Next day, man in the boots. Next day, 3 days, 30, 45 days later, we're still required as a nation, to have a display on the meter. Which is very material if you think of the cost. To me, that's the same analogy of saying, oh, you've still got to be able to operate the grid manually, should all technology fail. That seems to be --

MR. CERF: So --

MS. ALLAN: -- an extreme.

MR. CERF: -- so this is interesting. I wish you'd been at my meeting this morning, because this same kind of question came up. And, the response was, after -- after we were talking about various and some fragilities, brittleness and potential hazards, it was asserted that, for all of the complexity and fancy things that we designed, what happens if all the power goes out? We still have to have the ability to do other things. And we have to have a back-up. A low tech kind of back-up. So, I can kind of understand where that might be coming from. Although, if the power's out, at this point, looking at the meter isn't going to help you very much, is it? So maybe that's not one of the low tech things that we have to hang on to.

MS. ALLAN: Yeah, I mean, technology is evolving. Our lives are different today than they were even five years ago. I mean, most people -- we didn't have smart phones five, six years ago.

MR. CERF: More like 10.

MS. ALLAN: So, when you start to think about the utility of the future moving forward, is one less technology enabled. It is. And if there's anybody in this room who doesn't believe that then, you know, all I can say is wait and see. It is technology enabled. I think we set the aspiration of trying to protect the devices on the field that, you know, obviously nobody doesn't try. We try to the best of our ability. We have risk mitigation plans. And we have cyber frameworks that go and access our assets that, if certain ones are breached or failed, which are the top priorities. So we do a little bit extra due diligence around there. And you do your best to try and mitigate. But, you know, you have the aspiration of trying to secure every device. The fact that, if something is breached, then your next step is to mitigate it as to minimize the impact as much as possible.

MR. CENTOLELLA: Just briefly Vint. Does your secure energy box work in a system where you have to have laminate controls and some of the data exchanges are happening at a very distributed layer within the grid?

MR. CERF: I'm sorry --.

MR. CENTOLELLA: They -- you had this idea of sort of the secure gateway. The secure energy box. Does that work in a system where you have laminate architecture and you have lots of control happening at a very distributed layer, and not going back up to a central authentication?

MR. CERF: One of the authentication presumably has to operate at a fairly high level in the architecture, in order to strongly authenticate the content that's being generated in the exchange. So, it would be a mistake to imagine that security mechanisms can only be in -- implemented in one layer of the architecture. In fact, you see it requiring -- it's required in several different layers in most of these systems.

MR. CENTOLELLA: Okay. Carl.

MR. ZICHELLA: Okay.

MR. BROWN: Oh. May I add a comment?

MR. CENTOLELLA: Sure.

MR. BROWN: On the measurement system I mentioned, it actually, one of its mechanism is an authentication type thing. In other words, the measurement system doesn't rely on the actual integrated system. What it's doing is monitoring the integrated system for behavior that doesn't make sense with the data that's coming out of the integrated system. So it is an authentication type process. The secret to it is how fast you can detect the change. And can you move fast enough to do something about it. That's where the big research question is I think. So in a sense, it can do what you just said. That is how it works. So, for what --. But, what I didn't really hear, was -- is there a clear direction on where DOE should put their research? I -- somewhere in your comments, can --? You know, would you work on making things more secure? Would you work on being able to have a system that's very flexible? Can adapt to attack, to minimize --? Or, can we come up with a system that we can turn off all of the Smart stuff and go to a manual mode and run this thing? So, maybe that's an unfair question to actually to ask that. But I thought it would be fun anyway to see if you could pick one.

MR. CERF: Well, I can tell you my wife would resonate with this, because I have a bunch of (inaudible) stuff in the house. And she's an artist. And she wants to have the -- as a back-up, the switches that turn off and on and do what she wants them to do. And none of this poking the buttons and programming and everything else. And when it doesn't work, I have to bring a guy in from 100 miles away to reprogram it, because I don't have time to do it myself. So the back-up, simple stuff, is pretty attractive.

MR. CENTOLELLA: Carl.

MR. ZICHELLA: Thank you. Terrific panel. It is somewhat terrifying, when you look at the magnitude of this and how fast it's changing. I have to say Frans, I'm somewhat delighted and terrified both that you think our utilities are more nimble than your European counterpart. That's not saying a lot, as was mentioned earlier. But I think, you know, my question is more about the standard transferability. We're getting devices and equipment from all over the world. Manufacturers located all over the world, developing products for every market in the world. Our standards development, similar throughout other parts of the world right now, is there some coordination on standards in EU or Asia or whatever? It does seem to me that we need to be able to have some consistency among the protocols in these things for security. And then, you know, that leads to another questions. Because, as quickly as things develop, you know, there are people who are spending every hour of every day trying to figure out how to defeat them. So is it even desirable to have all our eggs in one basket standards wise? Or is it more useful to have a more diverse approach? So, standardized and universal? Or, somewhat more compartmentalized?

MR. CERF: So, let me use an analogy and see if it helps. In the layered architecture, sometimes by establishing a very uniform and sustainable interface, you can get away with doing a bunch of stuff below that level. So in the case of the internet protocol, if you don't mind my using that as an example, below that level, all kinds of different communication systems have been able to support the transporter IP packets. The applications above the layer of IP don't know anything about how this stuff is being transported. And they don't care, because that layer has been stable for a long time, not counting the hair raising IPV4 to IPV6 transition that we're in the middle of. And which IOT, by the way, is going to drive, because we need a larger address base. So what could be good for us is to establish some standards below which variation is easily accommodated. And there might be several different places in these architectures where such stabilization would be beneficial because it isolates implementations from each other. So, if I were trying to cope with what Sharon is coping with, and what Frans is coping with, I would be trying to get the architects to identify places in this layered architecture where we should all try really hard to come to a common standard. And suffer whatever variations there are in places that are less painful to suffer them.

MR. CENTOTELLA: Frans, do you have some ideas what that common standard might be?

MR. VREESWIJK: Yeah. Yeah, I think what you just said is very -- very logical. And what you just brought to the table is, yes, I think the fact that, as I mentioned in my presentation, manufacturers are global manufacturers. And we saw after Sandy that, you know, spare parts had to be shipped from all around the world, because there was nothing available here. And that type of issue wanted to think through when designing or redesigning or upgrading the grids I think. And having, therefore, and there is a lot of discussion between utilities. There is a lot of discussion between all the stakeholders in the IEC on all these. So, I think that is definitely a platform, where at least, you know, it is strived for to achieve a position and get standards that are applicable everywhere. So the manufacturers can make products that fit one onto the other, so to speak. And can replicate each other if something breaks down. Or it gets all the outages. And I think the architecture and I think Sharon also mentioned it, it is a system. That means you have to think about it as a system. And, as the Smart Grid is a system, what I showed you, you can think about everything has to be a very big system. Now, I know that's daunting. And that's on purpose. We put it that way. But, it's also important, I think, to open up our minds to say, okay, but what does it mean? And I think, Vint, you mentioned a lot of good things that, you know, there will be issues. And you can take solutions to deal with the issues and this way and going that way. And as Merwin asked, what is the best way? Personally, I don't know. As I said, I'm not the specialist, I'm a generalist. I can imagine the ambition is to make everything secure, would be the best. And even then, it will never be 100 percent as I mentioned. And I think here, also, a policy maker, regulator has to say, but we should strive for 99.99 percent. Or something like that. Whatever way you -- but you have to --

you have to make it measurable. Smart, so that, you know, the industry, the ecosystem, can work with it. Because if you don't do that as a regulator, then, you know, you leave it up. And then, you know, okay, solutions that are 97 percent are then fine enough, right, if you don't define it. So, there are things to do. But you have to do it together. And you have to create the awareness together that this is a big thing. And our world is changing. And one thing we all know, I think, because we're all educated, is you cannot stop innovation. You know, even though technology push, we don't always make it in the market place. The technology will be developed, you know. And so, it will come at you. Sorry, if I'm getting too enthusiastic. Sorry.

MR. ZICHELLA: Well, I like the idea of having some sort of a common layers within the architecture that can act somewhat as firewalls. Because they're the stable layers. You can have innovation below that level. But there is a way to actually insulate the rest of the system. And it built into it, to actually occur. We've seen many ways to get at this technology. And someone else mentioned, maybe it was Vint, you know, simple things can be hacked at, or Merwin made allusion to this too. I mean, it's a good example. Clocks and synchrophasors, for example. Keep the costs low, as Sharon was saying. You know, we need to use lower cost components. Try to make it more universal. But here's a low cost component that could be easily changed externally, and could actually feed false information into the system about what was happening. You know, there are going to be vulnerabilities like that that always turn up. But you have to have a way to insulate the rest of the system from that.

MR. CENTOLELLA: Sue.

CHAIR TIERNEY: So I have a ridiculous thing and then a -- an equally ridiculous question, because it's -- I wonder how you solve this problem. The ridiculous one is, how simple it was when I was younger and my children only hacked their Nerf guns, to overcome the safety things to make them powerful at age six. And they could do that. So this really scares me. Really scares me, what you're talking about. I'm with you Heather. So, who really has to like do something about this problem? (Laughter) Yes. Like, who's in charge? It would worry me if Congress were in charge. (Laughter) Seriously. So, you know, in the electric side, we have a system where we have layers of, Congress gave to a regulator the enforcement power, and then by delegation, there was an industry standards setting process for reliability. But, like who are those players here? Are there institutions? Because, I do not trust this marketplace of little six year olds being able, much less, nefarious characters, being able to get through all of this. So, would you answer the question, who can do something about this?

MS. ALLAN: You know, it reminds me of, let's see, when was it? The year 2000, coming up and testifying before FERC. Suedeen Kelly was on FERC at the time. And we were talking about the early days of deploying Smart meters. And I heard all the same things. Oh my God, because now it's no longer just monitoring and measure. It's a control device. There's a switch in there, and people are nefarious. People are going to hack in and disconnect meters and connect them. And then we're going to have voltage instability all over the nation. And, oh my God, we've got connected meters. There's going to be a cyber-security breach. And we're going to have a complete black-out in a state. And I would say, how many hacks have we had of those 65 million AMI meters that we've deployed?

CHAIR TIERNEY: New Year's issue.

MS. ALLAN: It's not. But we're talking about a Smart device that was a meter. Now we're talking about Smart devices called inverters. Now we're talking about Smart devices called EV charging stations. What are they made of? They're made of memory. Microprocessor communication technology that you have to put keys in. You have to authenticate and you have to commission. Yes, they're different devices. But guess what? The components of an inverter. The components of an RTU. The components of a relay. A lot of them are very similar components to what you have in a meter. We're talking about memory, and operating systems and communications. And, there's lessons to be learned. Yes, meters are not that most glamorous thing. But we've put 65 million of them out here in North America and they're communicating. And we haven't had anything hit the Wall Street Journal or any major press, about someone hacking them and turning off the electricity to houses. Now, I don't want to be tongue and cheek to say that it doesn't mean we don't to be prudent. But some of the, how you go about encrypting, authenticating, commissioning. Those similar processes, we need to expand the thinking of, what I think, Mr. Morgan said, well, what are the key one's that we need to look at? I think there are priority devices. So you don't initially go out. And it's easy to find those priority devices. One you can look at from your cyber-security frameworks, of which many of the utilities have been doing as a result of, you know, the various, uses, of looking at and changing what's the category of critical assets. And then, some of them have been broader than just critical assets, to say, what are key assets on our distribution line? So I think our utilities have some insight into what those priorities of assets are. I'm not standing here to tell you there's not something that we need to not be diligent and prudent and do more work at. But, I also don't believe, you know, we need to say, oh my God, I'm so fearful, we should not have made anything.

MR. CERF: So now, let's fight. How many different manufacturers of those Smart meters are there?

MS. ALLAN: In North America, there are five.

MR. CERF: Okay. So, I would argue that there are a lot more than five makers of IOT devices around the world. And there will be 50 billion of them or something, in the next 20 years. So, let's be careful about scaling. Five manufacturers --.

MS. ALLAN: Hold there. Let's talk about grid equipment. Not all the home things, you know.

MR. CERF: I understand. I understand. But that's --.

MS. ALLAN: How many manufacturers are there of relays in the U.S.?

MR. CERF: Hang on.

MS. ALLAN: Five.

MR. CERF: Yes. But I want to be really careful not to allow this conversation to conclude that you're okay on the grid devices. And, therefore, make the conclusion that everything else is okay too. It isn't. So, on the grid device case, if there are a limited number of manufacturers, and you can make them sustain, you know, the effort required for commissioning and security. That's a lot more believable than dealing with 50 billion devices made all over the world. So, now let's focus on the grid extension that you're arguing for. I don't know whether any of those devices have ever had to be rekeyed. So an interesting question is something that's in the internet world, has been bothering me for a long time. We started signing the domain name, the root zone of the domain name system. You know, the dot com, dot net, dot org and everything else. That digital signature has never been rolled over in the last six years. And a lot of us are nervous that we don't know what will happen if we do it. So, there's this big plan now to try to do that. Because we want to be able to update the digital signature at some point. Because running for too long with one variable, is a big issue. So, I guess the question I have for you, is whether you've ever had the experience of having to rekey it? Any significant fraction of all those meters?

MS. ALLAN: So it's -- I think it's a fair question. And, to my knowledge, and I'm no longer in the weeds as close to it, I do not believe so. But today's session, I believe what we were to come to talk about, are what are suggestions and area focus for DOE around that. So, yes. When I talk about what is more work? How do we do more work around roots of trust authentication commissioning of multiple devices at scale. I think that's where we're -- that's where further effort leveraging national labs in collaboration with industry, need to look at that. Because we have to be able to do that.

MR. CERF: Yeah.

MS. ALLAN: And do that at scale. And I think there's work to be done there.

MR. CENTOLELLA: Pat.

MS. HOFFMAN: So, as I was listening to this conversation, I was thinking about a couple of things. At the end of the day, we're not going to be 100 percent secure. So, really what we're going after, is a risk mitigation strategy. And what really needs to happen to have -- allow for an entity, whether it's consumer or whether they choose to read the material or not, is their choice. But a utility or a telecommunication company or Google itself, what would you want to have to be able to look at your risk mitigation strategy, and think about it from that perspective? I mean, from DOE's perspective, in order to help the utilities. We work with utilities on a cybersecurity capability maturity model. Which was basically to help look at some of the risk. Look at what authentication was in there. Evaluate your level of maturity with respect to authentication. So, some of those tools are out there. But at the end of the day, I keep moving towards the timeframe, or the frame of not only having device testing, but looking at systems testing. And then having some sort of responsible disclosure to the person that either has the product. Owns the products. Buying the products. You think about it from the medicine analysis that, you know, you've been told to go take this medicine, and you get this sheet of paper that says, these are the potential vulnerabilities. Or side effects that may occur from the medicine. But it's almost like, you still need to have that. Because then at least you're evaluating the risk to yourself. And I think we've got to think about how do we move this into the risk conversation? And so that's my first question, is if -- do you have any recommendations or thoughts along those lines? The second is, just the whole market of how do we value security? I was curious, Vinton, from your presentation, you talked about some of the changes Google made, as a result of some of, I think, the events or issues that you've seen. And, does -- is there a way to make security investments valued in the market place? Because of the challenge and the issue is that security investments aren't valued. And we're in a competitive market in some of the regions of the country, that it's the least cost solutions. But yet, you don't want to gold plate the system. And so it goes -- it's tying those risk assessments or that risk evaluation, to how do you deal with markets? And I'd like your thoughts.

MR. CERF: So, let me start out with the first question. I think that what would -- our focus has been largely to protect to the consumers. To protect their privacy and safety. And so, the devices that we make and that are made by the Alphabet companies have, as a very high priority, assuring that they won't get penetrated. They won't get, you know, abused by some third party somewhere. I still think that we have a lot of work to do to make them habitable. You know, if we're really trying to exercise access control, you know, in a way that's comfortable, convenient and effective, I still think we have work to do. But the focus of attention has been largely protecting a homeowner who has put these devices in their homes. I think a separate issue, and one which I hope that the power industry will accept, is to adopt a very defensive position with regard to uncontrollable electrical devices that may, in fact, have been penetrated and turned into a Botnet or under the -- be under the control of the Botnet herder. Just like the Mirai problem. And that preparing for the worst cases, you somehow can decouple a particular house or a collection of houses that have been penetrated from the rest of the grid. And so, and to similarly as Sharon was pointing out, if we're going to extend the devices that are -- we consider part of the grid, whether it's a home storage unit, or, you know, other power generation devices, that we somehow treat those distinctly, because they are becoming part of the grid from the consumer devices that may consumer power. And so, I would try to separate some of these things into different categories. And address them that way. Now I have to go and look at your second question, because --. Oh, the value security. I must confess to you that people have not shown much interest in security. After our -- in 2010 penetration by, what we believe was a Chinese source, we immediately began encrypting everything on the network. At rest and in transit. And we issued two factor authentication keys to every employee. And we made those available to the general public. As far as I know, they're a very modest percentage of the consumer accounts at Google, are using two factor authentication. There's a certain amount of inconvenience associated with security. I don't have -- as an academic, a reformer academic, I keep wondering, is there an irreducible amount of inconvenience associated with good security? And how would you measure that? Well, so the honest answer is, that I think most people are hoping that, if it didn't happen to them, then it won't happen to them. Or it won't happen to me. It happened to my, you know, my friend. And -- or they're hoping that, you know, people like you and me and others, will somehow take care of this problem, so they don't have to worry about it. And I don't know of a good way --. Look at all the headlines. Look at the OMB penetration. Look at Walmart. Or Target, I guess, is the one that --. Sorry. Somehow, it doesn't penetrate. And the thing that is truly annoying about all this, is that what happens is, you get a note from OMB saying, all of your data about your top secret clearances and everything else, has been spilled to the Chinese. We're going to monitor your credit cards for you for the next year and a half.

(Laughter) Wow. Great. I feel so much better. So, I don't know what the magic is. Now, since you reviewed your responsibilities at the beginning of this meeting, I thought you were in charge.

(Laughter)

CHAIR TIERNEY: One more question.

MR. HOFFMAN: I am. But, at the end of the day, the utilities are still in charge.

(Laughter)

MR. CENTOLELLA: So, Susan informed me we can take one more question. We have three cards up. Would you like to raffle this off? Jim, you've had a chance already, so Paula. If that's okay?

MS. CARMODY: Thanks. I think this is like the third time I've been like the last -- the last question.

(Laughter) And a lot -- and I -- this panel has been really wonderful. And for me, you know, I guess, I would be focusing things more on Vint, because since I represent residential consumers and those consumer device issues are, you know, of concern. That is really my focus. I do think that there is a real distinction when we're talking about, what is controllable with utility and those issues? And manageable. And I would tend to be more optimistic about handling those issues. But, for the past few years, this whole issue of the consumer devices, and kind of what is being pushed, at least as an idea, or a possibility for households, really does seem to concern me. Because, consumers don't know. And you cannot expect them to respond to safety issues. Disclosures. Anything like this. They are relying on -- and this goes back to who? Who is overseeing this? Are they relying on the manufacturers of the devices, to make this secure? And I use secure, you know, secure, both in the sense of breaching, you know, the system. The resilience reliability. But also privacy. I think, Vint, you have mentioned this. But it really kind of gets lost. And it seems to me that the privacy issue has to be worked on at the same time as the resiliency and reliability, when you're looking at security. And I think it gets kind of, you know, sort of passed. But I really do think, you know, Sue's question, who is overseeing this? When you're looking at, in particular, the consumer devices. You've got the manufacturers. You've got the standards. But the standards are voluntary. So, is it the utilities that are going to enter the space and somehow exercise control over consumers' devices that are going to be able to manage? Is it the state commissions that are going direct the utilities to do this? Is it a state, you know, some other state agency or federal agency? And, the reason I bring -- I do think that this is important, is because, it goes back to the point the Chairman was making, things are moving very quickly. And I've seen a lot of spaces with things being sold to our consumers. Energy supply and related things. Home management systems. All of that stuff is moving at a pace, in terms of conversations from the company to the consumer. And is that going to move more quickly than the standards? Is it going to move more quickly than deciding who has oversight over this? And folks aren't going to, you know, without their knowledge allow, you know, security lapses? Or allow privacy breaches? My big picture question is how, you know, while you're working on the technical issues. Whether you're working on the security issues. How do we manage those time elements? And I'm not sure that there's an answer. But, I think it is a concern. And, I guess, from my point of view, I'd like to call a time out on the less -- the low priority, you know, consumer devices. But I don't

think that's going to happen. I do
agree with Sharon. It's going to
keep moving

MR. CERF: Oh. From my point of view, privacy is just as important, as many of the other things that we've been talking about. And, unfortunately, we have mixed jurisdictions that have responsibility for various aspects of privacy. And we have HIPAA. We have PII and the like. What's interesting is that, most of those involve personally identifiable stuff. And, the thing which is not so clear, are the kinds of data that I mentioned earlier, about temperatures, for example. The fact that that data, if it could be associated with your home, could be used to invade the house. And, you know, and break in and so on. I consider that to be a breach of privacy too. And so, in this -- in that case, confidentiality of the information is important. And the question is, who should have access to it? I don't know that we have, as a government anyway, quite sorted out where responsibility should lie for the protection of people's privacy, when it isn't specifically, you know, personally identifiable data. So, I don't have a good answer for you. Except to say that I'm as concerned as I think you are about that.

MR. CERF: I mean, I think, yeah, there with Sue, I was involved with the Department of Energy Voluntary Code of Conduct, which was a stakeholder work group a couple of years ago. And again, there was a voluntary standard set up for, you know, kind of third parties. So, if you've got utility data through the Smart meters, and somebody wants to give a third party energy management company access to it, these third party companies could agree to the set of principles. Put their little, you know, seal of approval up on their, you know, website and so forth. And say, I will abide by, I won't release this kind of information and so forth. But what strikes me as concerning, number one, is it voluntary relies on companies wanting to be, you know, seen as protecting privacy. And when you start looking at consumer devices and products and the kinds of things that kind of multiply. I'm not, you know, I'm not quite sure that that's going to do it. It was extremely helpful and a really smart process. But it just strikes me that, somehow the discussion, when you're looking at developing security features, we kind of separate the conversation. The privacy conversation from the -- kind of the reliability and resilient security conversation. And I would just suggest, you know, how do we mesh that? Even within DOE itself, which has these kind of two kind of tracks.

MR. CERF: Just to make you feel worse, does anybody know here that it's possible to monitor the grid in the house, and figure out which devices are being turned off and turned on by their signature? And so, you can imagine, identifying a particular house, if you could observe it enough, you can actually figure out which house is the one that is producing the signal. So, yeah, this is a truly tricky issue to deal with. And I don't think we have a very good

legislative situation right now to cope with it.
MS. CARMODY: I would just like to interject. I mean, the Code of Conduct was a good start in the privacy conversation. But, it does come down to what -- how is it going to be utilized? How is it going to be deployed? You know, because from that, that went through the commissions and the State Commissions, and I think it, you know, there was the voluntary aspect of it that people looked at. But we have to think about what is the next steps on that? I should go back and clarify. I was referring to the FAST Act, with respect to the secretarial authority. With respect to the Internet of Things going back to who's in charge. At the end of the day, everybody has a responsibility on security and cyber-security. Well there's the developer of the product. Whether it's the standards organization. And, I'd be more comfortable at night, if everybody recognized cyber-security as part of their responsibilities and their role. And so that, going back to, how do we get the consumers

to value cyber- security? It has to be integral in every part of the product development cycle, as well as the deployment and market cycle.

MR. CERF: Mr. Chairman, I would like to offer to send you, if others would like to have a copy of a paper that my colleagues and I wrote called, "Securities -- A Shared Responsibility". Trying to convince people that, your security is just as dependent on my actions, as much as the -- it is on your actions. And we still need to work pretty hard to get people to understand that.

MR. CENTOLELLA: Okay. Well, with that, I want to really thank this panel. I really appreciate the panel and all of the comments and questions. I think this has been a great discussion. So thank you all very much.

(Applause)

CHAIR TIERNEY: I'll add my thanks. That was -- this was one of the most thought provoking panels we've had. So thank you very much for your effort to get here. It was very, very helpful to us. We are going to take a 15 minute break. And then come back to the Transmission Distribution Interface issue and another great panel. Thank you.

MR. ZICHELLA: We have another panel. We want to make sure they get enough time to run through their topic. And as you can see from the slide, we've got five people that are going to be presenting for us this afternoon. So, this next panel is on the Transmission Distribution Interface, in the context of increasing distributed energy additions. John Adams is going to be leading this session. And I'm just going to hand it off to John. It's all yours John.

MR. ADAMS: Thank you. Just how we got to this topic, the Power Delivery Subcommittee has been aware, as everyone's been aware, of the changing technologies making power generation available down on the distribution system. There's examples across the world of different levels of deployment of new technologies. Germany certainly fully embraced distribution technologies. I wanted to get the opportunity to say, that California is kind of slow in adopting this new technology relative to Germany. (Laughter) And we're behind them. But there's always -- there's been a question of, okay, now what happens at the Transmission Distribution Interface? DOE hasn't been ignoring this. They've got a lot of initiatives in this area. Sunshot. Storage. The Quadrennial Technology Review and Energy Review and Grid Modernization. So, there's been a lot going on. And DOE's been in the middle of it. But we want to -- we're interested in that narrow area of what happens between the silo of transmission and the silo of distribution. Our first impulse was to try and find out what's happening across the country, because believe it or not, things aren't done exactly the same in Texas as they're done in California. And it might even be different at Southern Company. I wouldn't know. So, we wanted to reach out to get people from across the country to talk about the topic. What's going on in their areas? Whether this is a problem. And what exactly is going on. And we found that DOE has expertise in this area. Joe Paladino, Technical Advisor at the DOE Office of Electric Delivery and Energy Reliability, has a lot of background and has been leading efforts at the Department in energy infrastructure modernization. And trying to convey the impact of the Smart Grid upon the infrastructure to everyone on what is changing. And so we've asked Joe to moderate a panel of people from around the country. Experts from -- well, Lorenzo from California. Has worked as Principal of Market and Infrastructure at California ISO. He was the lead engineer in their LMP effort. Is very knowledgeable of this subject. He's frankly probably the primo example of the -- the expert in this DER integration process. Worked on industry infrastructure in the 1990's. He's worked with the California Energy Commission. So has a lot of expertise in this area. We've got from FERC, Arnie Quinn, who is Director of the Office of Energy Policy and Innovation. I appreciate your coming Arnie. Who has a global overview. Has worked in the Division of Economic and Technical Analysis at FERC in Energy Policy. In Energy Market Oversights. Or has a broad overview of the entire United States. Dr. Quinn has studied economics and has a PhD in economics at University of Minnesota. We have, from my boss's boss, Woody Rickerson from Texas. Who always has a Texas outlook on the Transmission Grid planning. He's director of both Planning and Operations. So, he is familiar with the operations of the ISO. And the planning for the ISO. Has a background in, frankly I'm -- it's not on his bio. But he frankly got our CIM integration. Our model integration to work. Which I don't think anyone else in the world has gotten to work. In the timeframe we've got going, we've got Mike Bryson, who's Director of Operations at PJM. So we have two ISO's to contrast how things work. And what the penetration's like. How that interface vision is taking place. Mr. Bryson's got 10 years of military experience as a pilot before joining PJM.

And is well known in the industry. Thank you for coming Mike. And finally, we've got Joseph Brannan, Executive Vice President and CEO of North Carolina Electric Membership Corporation. Joseph is a little bit -- he's got experience in both Distribution and Risk Management. So, he's seen both sides of this. And I think he has experience both in markets and integrated areas. So, he's going to be able to provide us with more of a, how do I say this? Bottom up view and provide both markets and integrated viewpoints on this. So, we've got a great panel. I really appreciate all of them coming today. And with that, I'm going to turn it over to Joe.

MR. ADAMS: Thank you very much.

MR. PALADINO: It's nice to see you again John.

MR. ADAMS: Good to see you.

MR. PALADINO: Okay. Hello everybody. My name's Joe Paladino. I'm with the Department of Energy. I just wanted to provide some opening -- just some opening remarks. I don't want to take too much time from these folks, because they've got an incredible amount of experience and a lot of things they want to say. But I just want to tee up the discussion just a little bit. There are some principal drivers that are occurring right now, that are pushing this concept of grid transformation. We've got emerging, evolving federal and state policies. We've got emerging technologies. We're not only talking about information and communication and technologies. We're also talking about Distributed Energy Resources. PV. The cost of energy storage coming down. Things like this. And we've also got customers and third parties that want to apply these technologies. And want to get a little bit more control over the generation and management of electricity. And we've got other technology providers coming into that mix. And when you take all of these factors and put them together, you've got a situation where the grid is going to have to transform to be able to enable all of these things to happen. There's sort of a top down bottom up thing going on here. So, in the absence of federal and state policies driving these things, we've got a very rich, robust technology movement going on. We've got technology providers that really want to get this technology into the marketplace. They're just waiting there. And then the technology providers are really, you know, sometimes they're a little bit ahead of everybody else, with respect to how we're going to manage this. So, for instance, in Minnesota, when the Minnesota legislation in 2013 required their -- required the investor owned utilities to obtain 1.5 percent of their energy from the sun, by 2020, Xcel Energy was flooded. It has been flooded with applications to be able to deploy solar gardens. And they've got way out ahead in front of the headlights of the -- of the regulators. And now they're trying to hand -- figure out how to address that. We have a FERC Notice of Proposed Rulemaking on energy storage and the aggregation of DERs in transmission level markets. That may have a similar effect. We don't know. But that

Notice of Proposed Rulemaking is out and there's going to be a lot of discussion about how to enable markets for energy storage devices, as well as Distributed Energy Resources. I want to try to provide a realistic picture of where we're headed, because a lot of folks might take a look at our discussion and our dialogue, and think, we're just headed towards trying to develop a Distribution System Grid Platform that will enable the plug and play of Distributed Energy Resources, etcetera. But, in reality, the modernization of the grid is moving at different ways across the country. So, at one level, states might be pushing a Distributed System Platform. At another level, they're pushing local energy determinism, where we might have more micro grids. And community choice, etcetera. And, at a less sophisticated level, business as usual, where we'll have less automation, but some DER penetration. So there's a set of co-existing futures that we just have to always remember, is probably how we're going to be moving forward in this space. I almost had hesitated to bring this curve up again. But it is highly illustrative. As we bring more Distributed Energy Resources onto this system, they have -- they have great -- they cause great operational impacts. So, for instance, you're familiar with the California "Duck" Curve. As we provide, deploy more PV systems, mostly behind the meter, in California, as the sun comes up during the day, we've got more generation of electricity from PV installations, that lowers the net load during the day. Great amounts of net load reduction may cause over generation, where we might have to actually even come back on -- curtail some of the renewable generation. But also, we might have to actually curtail and reduce the generation from the bulk power systems. But, when the sun goes down at the end of the day, we're going -- we have to bring on very flexible resources to be able to deal with the increase in load. And, in fact, we need very flexible resources that can ramp up or ramp down quickly. We need resources that, like energy storage and other flexible resources that we can also bring onto the grid to be able to deal with this. The bottom line here is that, as we start to bring on a more -- a mixed set of Distributed Energy Resources, it's not just energy storage, or PV. But, we start thinking about electric vehicles in that mix, as well as, you know, Smart buildings, etcetera. And we start taking a look at a lot of variability and load. We're going to have to start thinking about how we increase the flexibility of the system. And that is implications for both planning and operations. Because in the planning space, we're going to have to think about what resources we need to bring on to deal with -- to deal with flexibility. And, obviously, we're going to have to be able to apply those resources in an operational framework.

So, as we bring on DER's, we're going to really have to start thinking about flexibility. And you'll see that we've got DER's, Distributed Energy Resources, at the distribution level. They were affecting things at the transmission level. To the transmission system level, has its own issues to deal with. Right? Because, it's uncertain as to even what bulk power systems are going to remain available. We saw issues with respect to natural gas availability in California and things like that. So, there's variability happening in the bulk power system. There's a lot of variability, because the DER's happening in the -- at the distribution level. And, we're going to have to really look at integrated transmission and distribution planning and operations to be able to deal with that. I'm showing this picture, because on the other hand, DER's cause impacts of the system. But DER's also provide value. And the question is, is how much value the -- do they provide? And how do we actually access that value? And so you can look at this from two different standpoints. Let's look at it from a customer perspective, for instance. Okay? The customer will either lease or buy a Distributed Energy Resource system. PV system. And, they'll derive value, based upon, perhaps lower electricity costs. Maybe some value from increased reliability. Or environmental considerations. A lot of that value is also coming from the fact that there are tax subsidies. And they're involved with that. And the question then becomes, when those tax subsidies and other incentives go away, how does the customer then make up that value? Where is that -- does that value still reside in the system? And can we actually provide value to customers by enabling them to get -- to provide value to the grid? Or they able to get -- compensate for that value by providing services to the grid. So that's one question. The other perspective to look at is, what is the incremental value to the grid from Distributed Energy Resources? From a transmission space -- from a transmission system aspect, we're looking at things like, deferred generation and transmission capacity. Increased flexibility capability. Reducing congestion and - - and other losses on the transmission system. On the distribution system, we're looking at reducing capacity requirements and saving money there.

Potentially improving voltage management capabilities. Reducing losses. Improving reliability and resilience and things like that. So there are value streams that are transmission level based streams, as well as distribution level value streams. Again, the question is, how do we extract these? And I think a lot of these gentlemen, the gentlemen here in this panel, are actually trying to address that. One other thing I just want to note here, is the fact that there's going to be an evolution with respect to markets. And the -- with respect to the way we extract value from Distributed Energy Resources. For instance, if you take a look at what's happening in the Brooklyn Queens Project, and what's being considered in other states as well, perhaps the biggest value component right now, is the ability to defer other distribution capacity. And so, from a distribution market standpoint, that might be the place where DER's provide value first. Another place where DER's could provide value, would be to improve frequency response and things like that. Or to manage voltage on a distribution system. Okay. And it may be over time that we're able to extract smaller and smaller increments of value that leads again to, what we keep on talking about, is this transactive energy future. But it's really going to be really important to look at the magnitude of these value streams. And how we evolve over time to develop these market practices, to be able to extract that value in a reasonable way. In a way that provides value. Not only to the DER service provider, or the customer. But in a way that provides tangible value to the utility or the distribution system owner. Transition system owner as well. So, we have to move through that conversation in an integrated way very carefully. Just some considerations. We've already talked about that the fact that DERs were at capacity, energy and ancillary services. They provide this value. But, they require flexible systems to do that. And that flexibility is a coordinated effort between the transmission folks and the distribution folks. As we increase the level of DER penetration in the system, some people say eight percent. Some people are throwing out percentages, etcetera. There's some examples to look at there. That will require integration of planning operations and markets, between the transmission folks and the distribution folks, but also the customers and the aggregators of these DER services and DER service providers. All of those participants are in that, are going to have to play in that mix somehow. Because value's going to have to come to all of those different components of the system. One thing that is really important, and we started touching upon it in the last session, was this concept of coordination framework. A coordination -- I didn't understand this basically, until about nine months ago. Okay. But it has come -- I've come to appreciate the fact that we need to understand and establish what the rules are. The respective responsibilities are. The points of interconnection. The data requirements and flow amongst all the participants. That needs to be understood. That's the coordination framework. And we need to understand that for scheduling and dispatch. Because Transmission System Operators require predictability and assurance from the DER commitments to satisfy their markets. They need visibility into that system. They need guarantees. But then again, Distribution System Operators may need dispatch rights. Because, if a lot of these Distributed Energy Resources are playing in the transmission market, a Distribution Operator's going to go, time out. You can't use that DER at this point in time, because I need that to maintain reliability on my system. There needs to be that level of coordination. A coordination framework, also will be able to address, should be able to address scalability issues as well as optimization issues. Scalability, in terms of, if we've got millions of points in the distribution system, that are -- that the distribution system owner has to control, but are also playing in the transmission space, we need to be able to figure out how to scale that system logically. And we actually also be able to enable selfish, local optimization, with system optimization. And the work that's being done by Jeff Taft and the thing -- and the efforts I think that FERC is looking into right now, with respect to laminar coordination frameworks, is one promising way to try to approach that in a practical way, as well as to respect the physical constraints of the system. And we need to actually look at this coordination framework, to determine what the appropriate communication and control structures are. Understanding the coordination framework again, is a prerequisite to determining what the appropriate communication and control structure requirements are.

And then, finally, we're going to need better optimization tools. Because in a macro sense, from a macro sense, if we're looking to cross the T and D spectrum, what is the best mix of bulk technologies versus Distributed Energy Resources technologies, with respect to all of those value streams. From a micro sense, if I'm a -- if I own a note, if I'm a building owner or from a distribution system company, how do I want to optimize my system? And how -- how is that stuff supposed to play together? And so I'll need planning tools to be able to do that. And then, finally, we're going to need better technologies to actually enable flexible operations. Okay. Things will potentially be working at a much faster pace. And need to interact and decide at a much quicker time scale. So, technologies like Smart inverters and energy storage devices and things like that play into that. And then, just lastly, we're just talking about the transmission and distribution interface, including also the customer's and DER service providers. But, we're heading into a future where we're converging, not only ICT with the grid T and D, but we're looking at the convergence of the electricity system with the transportation system, with the financial system, with natural gas systems. We're looking at that kind of convergence too. So, I'm just throwing this out there, because we're looking at a very practical problem here that's approaching us. But, moving down the road, this is a much bigger problem. So thank you very much. And, Lorenzo, I think you're up.

MR. KRISTOV: Okay.

MR. ADAMS: Okay. Thank you.

MR. KRISTOV: I have to click. Okay. Thanks. Oh that's good. I get to see this, so I don't have to look over my shoulder. (Laughter) I was worried about that. Good. Good afternoon everyone. And thank you very much for the invitation to be here and be talking about this subject. I -- Joe really filled in a lot of material there. So, thanks for starting things off right. I'll go quickly through some of the things that might be redundant to focus really on what we're doing in California. How we're thinking about it. And some interesting work that we've got going on. So, do I point it this way and it works? Yes. Growth of DER. So these are some things that you -- many of you are familiar with. The growth of DER and potential distribution level markets call for an updated coordination framework. There's the term. And basically, we're seeing the industry changes characterized by shifts to renewables, away from fossil. Grid edge adoption of diverse resources. Sort of how we started out today's discussion in the earlier panel. The decline of the traditional centralized one way power flow. And commodity based revenue models. I want to just introduce that idea where, since the market restructuring of the 1990's, we bought into pretty much the notion that energy is a commodity. But, maybe with DER and some of the changes happening, there's other ways we should think about energy. Potential for distribution level, peer to peer markets. And then, new roles for DO's or Distribution Utilities. I'll use DO as the Distribution Operator generally. The idea of DSO's was something that we introduced a few years ago. And now it's kind of become a hot topic like, ooh, I don't want to be a DSO. Or, I really do want to be a DSO. Or I don't want somebody else to be a DSO. (Laughter) So, you know, it's become an interesting issue and the fact is, my great insight last year at the Rocky Mountain Institute ELAB meeting, was that a DSO was really a golden unicorn. Everybody knows they must exist, but no one's ever seen one.

(Laughter) And they can't -- they can't quite describe them, you know. Anyway, whatever we do with all these ideas, the system has to work. And that's why where a lot of the work that I've been doing and the ISO's focus is, let's figure out operationally, what needs to happen, you know. In those few seconds when disturbances happen, etcetera, and planning to be able to operate with this higher environment. And therefore, that brings us to the question of coordination between transmission-distribution systems and markets. And on that note, because it's focused on operations, I'll come back to this theme. I don't think these questions are particular to ISO/ RTO areas, or any particular areas of the country. Or particular industry structures, even vertically integrated utilities. In many cases, I know, that the Transmission Department and the Distribution Department are separate departments. And if they're considering serious growth of DER, then a new relationship between the Transmission and Distribution System Operators will be needed. So, DER business models are really looking to provide services at multiple levels of the system. And to be able to stack revenue streams. When I use the term DER, I mean it very broadly to mean, essentially, anything that's connected below the ISO grid level distribution system, behind the meter, that's going to then affect the flow of electricity and could have an impact at the T and D interface. Or at least we'll have an impact on distribution reliability. So, it's all of the devices you can imagine. Many of them controllable. Storage and vehicle charging and so on. Plus, all of the new sophisticated controls in communication technologies, that allow such things as, very fast response to signals, aggregation optimization and so on. So, the different levels are in the next bunch of bullets, where the developer's thinking about stacking resources and revenue streams. First, behind the meter. That's kind of the optimal place to locate, because you can provide services to the customer, and then move up and provide services to the distribution system. And move up there. From there, provide transmission system and wholesale market services. Many of these are stackable. This brings us to the question of, what we call multiple use applications. The California Public Utilities Commission has a proceeding now as part of its storage track too, where they're looking at multiple use applications. And the ISO is collaborating with the CPUC staff, to spell out, what are the situations where you can have a resource or a given amount of capacity, provide multiple services among these different levels, without causing conflicts. And, it's not the kind of thing where you come up with generic answers. It's really, you've got to look at the different use cases and the different configurations, and figure out what's workable and what's not. Besides this, there may be bilateral contracts that some of these resources are engaged in. And then peer-to- peer transactions, we may get there. I view that as, further down the road, this other stuff is happening already. But peer-to- peer is certainly on the horizon. So we started working at the end of 2015, beginning of 2016, starting to convene a working group. Two --

two working groups actually. One, where we're just meeting with the distribution utilities, trying to bring the operational perspective and expertise into the room. And just really focus on that kind of stuff, without getting into business models and rates and a lot of other things. Make it the mechanical physical stuff. And then another group, which is under the More Than Smart organization, which is now a more diverse stakeholder group. So it started last year. It's continuing this year. And, what we've observed so far is, first of all, the idea of a coordination framework has these three fundamental points in it. It's the ISO. It's the Distribution Operator. And the DER provider. And it's really a three way. This is one of the questions that FERC asks in the NOPR in fact, about this communication. Now, there will be some communication or coordination activities that may be just among two of the parties. But the whole framework has to involve all three. We also noted specific needs for near term 2017 enhancements. Because we're expecting to see, FERC approved our DER provider proposal last year. We've got DER providers that is the entity who's participating in our market, has signed agreements. But they haven't brought us the resources yet. But we expect that, probably by the end of the year, we will have some DER aggregate resources in the market. So we want to be prepared, perhaps with just manual procedures to begin with. But at least be able to make sure that we can integrate those resources. The efforts have to continue as DER growth evolves. We're not going to solve everything this year. It's going to be an ongoing process, for several years at least. As we think about the near term arrangements, and then expanding them or making them permanent for the longer term, automation is definitely on the table. We need to think about ways that we can look at larger numbers of things. And you'll see when I get into specifics, why that's fairly obvious. And then the focus on operations makes this relevant to all Distribution Operators, regardless of the structure you're living in. Now, given those three key players of this triumvirate, we wanted to say, well, what does each one of those three care about? ISO. What do we care about primarily? Well, we have to operate the grid reliably. And we have to operate the markets. Provide open access transmission service. That's our fundamental mission. And we've got to be concerned about what's happening at that TD interface, which is also, we call it a P-Node, which in location of marginal pricing terms. That's where we create a marginal price in every settlement interval. We want predictability. If we dispatch DER to do something, we want predictability over what response we're going to get. In addition to that, there would be lots of DER that are not in the market. And what are they going to be doing? What's their behavior going to look like, that's going to have an impact, so that we can see, what's that net load look like at each T-D interface, to plug into our optimization? And then longer term DER growth scenarios. This is a topic the CPUC has taken up in its distribution planning proceeding. How do we come up with growth scenarios over a yearlong planning horizon, where we have to forecast the adoption part of it? That is, customers autonomously deciding to adopt technologies. And then, the behavior of those things, once they're adopted and installed, how are they going to affect the net load? And we want to look at that over a 10 year time period, because that's our planning horizon for transmission planning.

On the Distribution Operator's side, they have very similar ones in a sense, they're focused on reliable operation. They want visibility to the current behavior of the DER. And they want some predictability. What's it going to do in the next 5, 10, 30 minutes. Two hours. They also will need some ability to modify behavior. Because now their operations are going to require that sometimes, they need to tell a DER operator what that resource needs to do. Now that doesn't mean they need controls over everything. Part of the planning for this is going to be look at, well, in a local distribution area, I use that term local distribution area to mean, a single transmission distribution interface, and all of the stuff that's below that interface. So, in that local area, they know that there's a certain amount of different things installed. Whether it's roof top solar, community solar, batteries of different sizes and types and so on. What are the key points on that system, where they need a controllable device? And how do they get those? And that may be the beginnings of a market, which is, they say, I need this performance capability at these 12 different points on my feeders. So, I'm going to put out an RFP, see who responds to that. And then I have these devices that I can have on a control signal. It's beginnings of a kind of market approach. But it's not a spot market that they're responding to necessarily. It may be a control signal that says, you're responding in four seconds, like AGC. But then they also need the same long term DER growth scenarios for distribution planning. So, our perspective is, well, gee, can we create these granular DER growth scenarios that are maybe circuit level for distribution planning? And then simply aggregate them up to the T-D substation. And we're using the same information then for our planning at the transmission level. The DER provider and aggregator, is concerned with a viable business model. So, they want to participate in a non-discriminatory matter. And I'll come back to non-discriminatory in a minute. In all the markets for which their resource has the required performance capabilities. So when the ISO defines needs, what do we need from market performance? We try to be technology neutral. And we say, what are the performance characteristics we need? You, developer, bring us whatever hardware you like. But these are the performance characteristics. And then, the ability of looking at the long term viability of their resource. They want to optimize their choices of market opportunities. And, some of those opportunities will be limited by short term phenomenon. That is, changes on the distribution system. So that then leads us to a sense of, well, what is it that we need in the way of information? This is the -- probably the most frightening diagram that I'll have today. And, this was made up to sort of give us a snapshot of how it is today. And, so this is everybody who's involved in DER. Demand response. The familiar old stuff, where, you know, customers are aggregated and they're going do a demand response type of thing. Who all is involved? Well, the ISO is there at the top. But we deal with transmission connected generation and scheduling coordinators, etcetera. I won't go through all of this, except to note, that when we're thinking about this future coordination framework, the important entities are the boxes that are in pink. It says red, but, you know. The ISO. The Utility Distribution Operator, or potentially a future DSO. And then the DER providers, the two boxes that are on the left side of the diagram, which could be, a resource that's connected at distribution level, goes through WDAT. That stands for the interconnection tariff that a resource goes through to connect as a wholesale resource on distribution. Or it could be simply an aggregator behind the metered devices. So, the Device Operators, the Distribution Operator and the ISO. Note that, in this existing DR framework, there's no direct link between the ISO and the DO. Right now those entities don't talk to each other. When we dispatch a DR, we tell the Transmission Operator. And that word gets passed on. But the DO isn't in the loop. So we have very little need or interaction with them. So, if we think about a future DO or DSO in this new high DER framework, that utility DO box would become the DSO. Or maybe they'd both co-exist in some way, depending on any spill out, their roles and responsibilities. But then there would also be a direct link to the ISO for that. So, we came out with some recommended enhancements for the short term. What should we do? First of all, the DO should provide advisory information to DER providers about system conditions that will affect their operation. So, the Distribution Operator knows where all the sub-resources of an aggregation are located. Because they all went through an interconnection process. And they know how they're bundled into an aggregated resource. So, they can look at circuits and say, oh, I'm switching the circuit today. It's out of service. And initially, this might be a simple red green signal. In other words, this particular circuit is taken out of service. It's a certain amount of your capacity, because some of your sub-resources are on it. You can't use it for the next three hours. Or something like that. Eventually, it should be more subtle than that. But at least the DO needs to get that information. And then they could do something with it. So, the next step would be, the ISO would provide day ahead DER schedules. They -- because as it is today, the DER bids into our market. The DO doesn't see that.

We issue a dispatch instruction. DER tries to respond. All of that is just between the ISO and the resource. The DO doesn't necessarily know anything. So one of the ideas is, let's send the Distribution Operator the day ahead schedules that clear our market. Or the real time -- eventually the real time dispatches, let them then do some sort of feasibility assessment on that, and let us know if there's a problem. The DER provider should communicate any constraints on its resources performance to the ISO. How would you do that? Well, let's say at o'clock in the morning, the DO finds out that percent of its capacity is out because a circuit is out of service. So, it's about to submit bids to the ISO's day ahead market, that closes at 10 o'clock for the next day. So it modifies its bid, recognizing that it's going to have limited capacity the next day. Meanwhile, we also -- it's also in the day of operation, where at T minus 75 minutes, it's going to be putting in its real time bid. So again, it modifies those bids. Now, there may be something more immediate. Like, in the next half hour, it's got to dispatch instruction to do something. And in that case, there's no new bidding opportunities, so it submits an outage notification, or a de-rate notification. So it takes action based on this information, to inform the ISO of what's possible and what's not.

The next thing is, DER aggregators should work closely with the DO early in the resource implementation. The DO, because every sub-resource goes through an interconnection process, the DO knows -- they've studied how those things are going to impact their systems. But they haven't seen this particular aggregation of resources, all functioning together, and perhaps responding in the same direction at the same time in some proportional way, to an ISO dispatch instruction. Part of what the DERP construct, that for -- approved last year, has an opportunity for the Distribution Operator to review a proposed aggregation, and identify problems. We want to push that a little bit more and say, well, don't just identify a problem, let's figure out how to mitigate it. And let's take enough time in advance so that the DER aggregation can work. And if there's a problem that's insurmountable, well let's modify the resource a little bit, or whatever it takes, in order that we have a workable solution. And then finally, the idea of DO's pursuing a Pro-forma Aggregation Agreement. This is a work in progress right now. This is an idea that is still being bounced around. But, when the ISO has a relationship, well our DERP agreement, DER provider, we make an agreement with the provider of that resource, which spells out our mutual roles and responsibilities to each other. And the suggestion here is that something similar is needed between the Distribution

Operator and the resource aggregator. The resource wants to play in the market, going back to those objectives I showed you a moment ago. So, the two entities will have some roles and responsibilities to ensure their compatibility and ability to work together. Here, there's a lot of words on here. I'm expecting, and I think, you know, that you'll be able to get these slides in. Because I don't want to go through all this. But, what I try to do here, is talk about the challenges of high DER in a bit more detail. List them out. And then what are the kinds of mitigations that are needed to address those? These are all things that we're talking about now, and I don't want go through them all. But here's another view of a similar way of looking at this. Down the left side, we've listed different types of information that's available to some parties. Where there's black ink in the right hand columns that information exists and is available today to the parties across the top. But when we think about DER and higher penetration participating in the wholesale market, what do we need to add to improve the coordination? So, for example, I mentioned the fourth line down, Distribution System Topology and Conditions. So there's a red line over on the right that says, the DO informs the DER provider of those conditions, etcetera. There's stuff in there about forecasting. We've added ISO day ahead market schedules and real time dispatches and so on. So this is just a little schematic of the things we're thinking about.

Now, ISO, DSO coordination for high DR, is enmeshed with the design of the future DSO. Back to that word again. Nobody quite knows what it is. But, the value of that, is that we can invent it in ways that make sense that may be different in different utility service areas. Or in different states, depending on what the goals and objectives are. So, we started this in terms of book ends. What would be two extreme versions of a possible DSO design that sort of bound the problem for us? You know, and they're meant to be extreme in a sense. But, bookend A I call the current path, or minimal DSO. And the idea is, that the DSO, in terms of its reason for being is, essentially, the same as it is today. It's providing reliable distribution service, to whoever is connected to it. Now, with DER, that already goes a step beyond what it is today. Because if you look at NERC's definition of what a distribution provider is, it says, the entity who moves energy from the bulk system down to the end use customers. Well that part of it is obsolete. It still is the entity that's providing a reliable distribution system. But more than just moving energy commodity from the bulk system of the customers. It's now creating a viable system, where all of these different resources can operate and fulfill their objectives. So, it's definitely enhanced functionality, compared to what Distribution Operators do today. But, the essential role is reliable distribution service, and not a whole lot more. Whereas, this total DSO on the other end, is really now an entity that's doing quite a lot more, performing a lot of the aggregation for wholesale market participation. Optimizing in local areas. And you start to see that, and balancing supply and demand locally, manage DER variability to minimize impacts. This is another, I think, tremendous opportunity of value for DER that's not realized yet. You look at the Duck Curve that Joe put up. That huge belly in the middle and that really steep ramp in the late afternoon. Well, that's the ISO's system net load curve. And that's made up of load profiles that are coming from all over the system, at distribution level. Some of it's the utility scale generation. But, a lot of it is stuff that can be managed locally. So what if we used DER to flatten load profiles down at the circuit level. Down at the local distribution level. What if we use DER, say storage, dispatchable ones, that can respond quickly and smooth out the minute to minute fluctuation, so that that's not exported to the ISO level. That takes a higher degree of DSO activity, than simply just providing reliable distribution service with high DER. The ultimate of this, I think, is what if the DSO aggregates everything in a local area, such that, at each T-D and interface, the ISO sees a single resource. It just looks like one resource. We don't care what's inside it. Right now we have to care. But, this is an imaginary future. So, we don't have to care what's inside it. It looks like a big micro grid, and somebody's operating it all. And we're just worried about managing to that interface. So that's the ultimate simplicity, which also plays into this idea of laminar decomposition that Joe mentioned. Then multi-use applications, it's one of the big issues with multi-use applications. You have the same resource providing services to the distribution grid and to the ISO. What if it gets conflicting instructions? Who should it listen to? Well, in this total DSO model, there is no conflicting discussion -- instruction. Because the ISO is instructing the DSO. Sorry if I'm in your way. You're flopping back and forth. The ISO is just sending instructions to the DSO. And then the DSO is optimizing the resources in its local area to respond to that. So, this is another table. I won't go through all the details. Hopefully you'll get this presentation. And, I'm just sort of comparing the two DSO's among -- in accordance with a list of different design elements down the left hand side. So, this -- these are some diagrams that came out of a paper poll, and I wrote, just to sort of illustrate this. And the idea of the minimal DSO, what's happening now is that all the things that are in the DER realm, are in a sense, having impact at the transmission level. Many of them are participating in the market. Some of them are just behaving and having impacts. The Distribution Operator is sort of off to the side. And this is, you know, this is a version of our coordination framework. But, you know, the ISO is really directly integrating all of the DER for transmission and distribution. In the really extreme case of this, the ISO could be modeling distribution circuits in our network model. And actually looking at real locations.

Right now, we just see DER as if they're at the T-D substation. But one could imagine a more comprehensive optimization where we're seeing the circuits. This is not advised. Don't try this at home, due to complexity and scaling risks. The total DSO is similar to an ISO at a distribution level. Or else, I like to think of it as similar to a neighboring balancing authority. In a sense, it's taking care of its own system balance. And then so, there's the idea of the DSO coordinating a single aggregation at each T-D interface. And there's more description of that there. New questions that come up. I mentioned an open access structure for Distribution System Operators. I mentioned before, about DER wanting to have non-discriminatory access to participate. So what happens if distribution circuits are now taking out some capacity, and there's five different providers of resources, how is that capacity allocated? In the ISO system, it runs automatically through our five minute economic dispatch. We have economic bids for the resources. We have all the constraints modeled in our network model. The optimization spits out a result. The rules are transparent. Everybody gets their dispatch instruction. And that performs the congestion problem. That actually allocates rights to generate, that respect the constraints on the grid. How do we create something similar? Not necessarily an optimization. But maybe. But, at least in -- in substance, that is non-discriminatory to the participants. So that they have really transparent rules about, when am I going to get curtailed and not this other party? How is that managed? So, that also though, involves around the interconnection cue and planning as well as the ISO has found, because over the years, since the ISO was created, we took more and more control over transmission planning. Over the interconnection cue process. All of those are different aspects of non-discriminatory open access. Is an independent DSO needed? There are advocates who say, that yes, we should have an independent entity like the ISO. I don't know. I personally would start from, well, what are the objectives? Can we achieve non- discrimination open access transparency? It matters less who does it, than being able to achieve those objectives. Possible new boundary definition, for federal/ state jurisdiction. Now, if you look at this, say local distribution area, and there's a market there, well, there may be things in there that look like sales for resale. Is there a way to kind of rethink the federal state boundary, so that a state could regulate local distribution level markets? I don't know. But it's a question I think is worth asking. Could reliability responsibilities be layered? This goes to the laminar decomposition again, idea. Is there a way to say, you know what, you're a micro grid. You can -- you can opt out of resource adequacy. You're responsible for your own load. Take responsibility for it. And if you don't have -- if you can't get enough supply from the grid, well then you'll have to Island. You know, we could make arrangements like that, so that the layered responsibility enables a much simpler level, once you have high -- a simpler arrangement for operation, once you have high levels of these things. So, a micro grid say, taking responsibility for its own reliability. Grid architecture tools. I've been talking with Jeff Taft now for a number of years, so I've sort of absorbed some of his ideas. But, if you take this problem as transforming today's ISO and DSO roles and responsibilities, to transform into some future coordination framework, well, there are certain system qualities we'd like to achieve in doing that. So we define, what are the objectives? And, I think everything needs to start from that perspective. The discussion this morning, where Mr. Cerf raised the question of, just because we can do it, does that mean we should? So, let's think about, what is it we're trying to accomplish? What do we want to accomplish? How do we want the system to work? What benefits do we want it to produce? I put some words in there. You can, you know, you can come up with whatever ones you like. But, stated objectives. Now, those will play out within a policy context, because there's federal and state policies. Maybe even local policies, to incentivize certain things. And those two outer arrows mean these things are interplaying with each other. Hopefully, the desired qualities go into shaping the policies that are enacted. But then once the policies are enacted, they have impact back the other way, and start to shape also the qualities, because, you know, you don't get the policies perfect. And then all of this happens within an external context. What's happening with ecosystem and resource constraints, which may get more stringent as the years go on? Global demographic and economic trends. How are those things shifting? Technological advances and availability. Geopolitics. One of my favorite questions, back last year, I went to one of the workshops on the DOE Grid Modernization Lab Consortium. And one of the early presentations had a banner on the first slide that said, a 21st century economy needs a 21st century grid. So, we started the discussion on, what's a 21st century economy? Is it looking like all the stuff that we do today? Only we're going to do it with clean energy? But we're going to keep doing the same stuff? And if the economy is a driver of the grid that we need, shouldn't we be talking about what that economy looks like? What will economic activity be in this future? What happens if we have automated vehicles? And, you know, 30 million men in America are put out of work, because they don't have things to drive anymore. How does that change the economy? So, it's these bigger questions that go into designing these much smaller ones, which is what he wanted DSO to do. So, the future grid then may be a layered hierarchy. This is one of my favorite diagrams. Smart buildings. Each building can be an optimizing subsystem, with all the devices and equipment. This is a user centric view, or a used centric view of energy. In other words, why does this building need energy? What does it want to do with it? Space conditioning. Lighting. Running equipment. Whatever. And, in this future we're seeing, they'll be more and more equipment and control technologies and so on. So it might be able to meet 30, 40, 50, 60, 70, who knows, how much percentage of its energy needs, just from local equipment. And now, the grid becomes the residual supplier of energy, not the primary supplier of energy. And the Smart building is optimizing itself. Micro grids, you could have a University campus, and it's got 15 Smart buildings inside it. Each of the buildings is optimizing, but then so is the operator of the micro grid. That's now inside the local distribution area, operated by the DSO. The interesting thing is, that the DSO can look at the micro grid as a single interface point. It doesn't need to be concerned with what's inside. Now, each of these DSO's has a local connection at the T-D interface with the ISO. There's the balancing authority area. And the ISO is connected in some regional interconnection to other balancing authority areas. In the west, we have 38 of them. Each tier only needs to see interchange with the next tier above and below. Not the details of what's inside. The ISO then focuses on the regional bulk system optimization, while the DSO coordinates DER behavior. This layered or laminar control structure reduces complexity. Allows scalability. Increases resilience and security and the fractal structure mimics nature's design of complex organisms and eco systems. We kind of work that way. And that's all. Next.

MR. PALADINO: Lorenzo that was great. There was a lot of information there. It stimulated a lot of thought. So thank you very much. Appreciate that. Next, we're going to have Arnie Quinn, who's the Director of the Office of Energy Policy and Innovation at FERC. Thanks Arnie.

MR. QUINN: Thank you for the invitation to participate. I have to start with my standard disclaimer that my opinion reflects my own views.

It does not represent the opinions of FERC or any of the two remaining Commissioners.

(Laughter) So I think a lot of what I have to say probably fits principally into -- to maybe different words, but the same ideas that Lorenzo went through. So, I'll try not to be repetitive, and I'll focus a little bit more on maybe areas that -- where we've seen things develop slightly differently than they've developed within California. And then, spend a little bit more time on our recent notice of proposed rule on aggregated Distributed Energy Resources and energy storage. At the very highest level, I think from the FERC perspective, we're at a fairly early stage of mass penetration of Distributed Energy Resources. My sense is that we --

we're seeing various models emerge. So, you've got a model emerging out of California. You see different kinds of work out of the -- New York. And most of the other ISO's are just beginning to think about a lot of these issues. My sense is, and my suspicion is that, what we'll see in terms of evolution, is that as various commercial and system needs materialize and become urgent, those will be the needs, both commercial and system, that will drive the evolution. Whether we're kind of doing that minimal DSO that Lorenzo talked about. Or whether we're doing that kind of full DSO that he talked about. From the federal regulator perspective, I think we see these issues, and again, these were the themes that, I think, overlap a lot with what Lorenzo said. Along three categories. Visibility or situational awareness. Coordination. And then market and value -- valuation opportunities, or barriers to distribute the energy resources participating in wholesale markets. I'll talk through each one of those things a bit. And then connect it into what we did in our notice of proposed rulemaking. This ability or situational awareness, I'll point out that the ISO/ RTO Council put out a paper about a week or two ago, about emerging technologies, where they focused a lot about their needs for situational awareness and what that means for the tools that they need to employ. For many ISO's, DER output looks like negative load or net load.

And so, the way to think about it is, any place where an ISO needs to know what the load is, is a place where they need to understand what's happening with the DER. From an operational perspective. From a transmission planning perspective. Even from a resource adequacy perspective. That visibility can come in a couple of forms. And the form it takes has cost impacts for the Distributed Energy Resources themselves. It can be as simple as information sharing. It can be as expensive as telemetry and mirroring. And to some extent, the degree to which you do either one of those, might depend on the degree to which that DER wants to get credit in compensation for providing something to the system. And so

I'll give you an example from ISO New England, because I don't think there's any from ISO New England here. So, if I get it wrong, I won't be corrected. They had a tariff rule that said, if Distributed Energy Resources, Massachusetts is doing a decent amount with solar PV. If Distributed Energy Resources were willing to be telemetered, so that the ISO could see them in real time, then the local load serving entity would get capacity credit for that DER. And that meant that they wouldn't have to go into the capacity market and buy that capacity. They'd get credit in the first auction three years forward for that DER output. That's an expensive proposition. And most DER's didn't do that. Just last year, ISO New England decided that it wanted to update its capacity -- its load forecast for this capacity market, to include its expectations about DER growth. That meant though, that no individual LSE was going to get credit for that DER. But the market overall, wasn't going to buy too much capacity. So, there was simple information sharing. But the implication was that, there was kind of a spread benefit to the market and no individual market participant got benefit. On the coordination side, again from the federal perspective, the first instance what we're worried about and what I see ISO's worried about, is that what's happening on the distribution system doesn't negatively impact what's happening on the transmission system. And, again, for the very early stages, that's the number one concern. And a lot of that concern, again, goes to just enhanced visibility. So low penetrations, more visibility, probably helps with that first coordination question. When we allow DER to participate in markets, then the coordination problem goes the other direction. You want to be sure that whatever the DER are doing as they participate in the wholesale market, aren't causing problems back down in the distribution system. And then finally, on the market side, I think it's still yet to be seen how much of the valuation -- the value proposition for DER, will go to ability to get revenue from the wholesale market.

You know, of those stacked values that Lorenzo talked about. How many of those stacked values are at the wholesale market? And how much -- how important are those stacked values? But, on the flip side of that, as a federal regulator, you want to worry that you're not creating rules that prevent that value stream from being available. And you want to make sure that that value stream, if it's important, is there. Because if that's the thing that drives the commercial viability of DER, you would be bad to have that wholesale market opportunity not available. And, I think the more the wholesale market is important for DER value proposition, then those coordination issues and that visibility issues, those things are going to materialize and become important. So, that kind of leads us to the Notice of Proposed Rule that the Commission did last November. At the very highest level, all the Commission did was require ISO's and RTO's to create an opportunity for aggregators of Distributed Energy Resources to participate in wholesale markets and provide all the services that they're technically capable of providing. So it's, to some extent, creating tariff provisions that say that an aggregator of DER is a market type. That market type can go do these services. And doesn't create any barriers that says, well, you can only provide these two services, because we've decided on the front end, that we're going to limit -- limit the things we let you do. But, of course, when that, as I kind of -- to go work backwards on the three areas that we've -- we talked about, once you create that participation opportunity, then there are issues about coordination and visibility that come along. So the Notice of Proposed Rule then also proposed certain elements that ISO's would have to create to make that participation possible. One thing I will emphasize, as we were doing that Notice of Proposed Rule and some of the conversations we've had since then, you know, an important element for the aggregator's of Distributed Energy Resources, is this desire to be able to provide value by kind of dispatching the set of the portfolio resources that they have, in a way that they think is optimal. And so, a lot of them have talked about the desire to say, have 15 megawatts of resources or capability, but maybe only provide 10 megawatts of service to the wholesale market, and then use their software and their algorithms to decide which of the resources they've got, are going to provide that 10 megawatts. And that desire drives some of the things you see in the NOPR. And then some of the requirements on coordination and visibility. So the NOPR requires the ISO's to establish locational requirements for the aggregations of Distributed Energy Resources. You know, especially in wholesale electricity markets, compensation and valuation is very location specific. So to some extent, you'd really need to know exactly where those resources are, so that the compensation is right. But other products, like some of the reserve products, are not very locationally specific. They're either ISO wide or they're zonal. So that locational requirement is not as important. So, the NOPR simply required the establishment of locational requirements that are as geographically broad as technically possible. And, then we'll leave it to the ISO's to figure out what that means, if that proposal ends up becoming a final rule. But that also then goes to one of the things Lorenzo mentioned about outages. The idea would be, that if there is an outage on the distribution system that knocks out a set of resources in an aggregator's

portfolio, that rather than have to
go from day ahead into real time
with not enough energy and
experience the (inaudible) that
goes along with that, the DER
aggregator would be -- be able to
re-optimize its portfolio, and
still provide the level of service
that it committed to on a day ahead
basis.

Second thing that the Notice of Proposed Rule did, was discuss and require some of the establishment of metering and telemetering requirements. The NOPR -- and a lot of the details in the aggregation of DER, part of the NOPR didn't get into a lot of detail, but rather established principals. And asked the ISO's to kind of comply with those principals. So, we didn't require anything specific on telemetering or metering. Simply, require that ISO's create a tariff provision, and identify in a transparent way, what those metering requirements were going to be. And do so in a way that wouldn't unnecessarily limit the ability for aggregators to enter into the wholesale market. And then, finally on coordination, this is where again, a lot of the things that Lorenzo said, kind of fall into the NOPR. That there's going to be -- there's going to have to be some amount of coordination. NOPR recognizes that the ISO's going to have to establish a coordination regime. That coordination is going to be between the RTO, the aggregator and the distribution utility. That coordination goes both to registering of resources so that the distribution utility knows what resources are in the aggregation on the front end. But also requires that those requirements don't unnecessarily limit the ability of the aggregator to change that portfolio of time. One concern was that, if that registration process is particularly onerous, that the -- that the aggregator will have a harder time being dynamic in creating its portfolio. And also, to some extent, recognizes that the distribution utility has an incentive.

Or could have a financial incentive to limit the ability of the aggregator to -- to be commercially viable. And then also, that coordination has to go around operations. And so, there's a real question about information flow. The NOPR, I thought, interestingly takes the tact that, in terms of coordinating how the aggregator will react to outages on the distribution system, the NOPR proposal is that the aggregator would be responsible for managing that coordination. So that the aggregator would have to get information about the outage on the distribution system, and then use that information to tell the ISO that part of its fleet won't be available. Either on a next day basis for planning. Or if it's already gotten an award, so as it goes into real time. And then finally, on the coordination section, we welcome comments on whether a Distribution System Operator would facilitate the coordination that we talked about in the NOPR. Or whether it was necessary or not necessary. Or, a fairly broad question about what role a Distribution System

Operator can play in that coordination process. And again, this highlights, I think, a lot of what Lorenzo talked at the end. But I'll try to create kind of the distinction on what we heard as we were doing outreach, how that went into the NOPR. The third party aggregator's really see their value proposition as dynamically changing the portfolio that's providing the service. And, one of the storage providers, or the DER providers that we talked to, actually talked about themselves as more of a software provider than anything else. And they put a lot of time and effort into creating that optimization software. And they want to be the font of that. They want to be the font of the coordination between that set of resources and the ISO. And they drive a lot of commercial value out of being the center of that coordination. So, I think early on, what you could see, is aggregators as their commercial needs start to deride the evolution, potentially crowding out the role of a Distribution System Operator, in providing that -- that coordination.

But, you -- but there's also a recognition that the Distribution System Operator might be the efficient way to move the -- all the information. So I think it -- it highlights that there is this tension between the role the aggregators might play, and the role the Distribution System Operator might play. And where you're getting commercial value versus where you're getting operational efficiency. And it's possible that there will be no tension there. But it's also possible that there will be tension. And I think the Commission's staffers were doing and the NOPR were aware of that, some of the things that we did in the NOPR, kind of recognized that possible tension. So, I'll simply mention that we received comments on the NOPR on February 13th. And we're now just doing the process. We're reviewing the comments. The staff is considering what we heard. Contemplating what next steps would be. And, if we ever get a full commission, we would provide recommendations to that full commission on what to do next. So, just to wrap up, I think it's possible that all of this could develop fairly organically. That some RTO's will go faster than other RTO's. As RTO's that are going, you know, kind of at a more deliberate pace. Those operational and commercial needs will materialize. Those will be addressed. There won't necessarily need to be a grant plan in place ahead of time. That that grand plan might just get put in place, step by step, as those needs get identified. And the needs become addressed. But clearly, throughout the process, there's going to be a need to coordinate amongst not just the Distribution System Operator and the Transmission Systems Operator. But, the people who regulate those entities and the stakeholders are a part of that entire group. Thank you.

MR. PALADINO: Again, that was a lot of information. And it's really -- it's a little bit challenging to figure out how to compartmentalize the conversation. Where do you start? Do you start with valuation? Do you start with coordination frameworks? Where -- where does this conversation begin? But, to our next speaker, Woody Rickerson is the Vice President of Grid Planning and Operations at ERCOT. Thanks Woody.

MR. RICKERSON: Well thank you. Thank you to John and to the Committee for inviting me here today. So, I'm going to give you kind of -- ERCOT's a little bit different. We're going to give you a short overview of ERCOT. And then show you that what we're doing with DER. One of the things you'll notice with this -- with the things I give you today, is that DER is kind of an emerging condition in ERCOT. It's not something that is on fire and at the forefront of what we're -- what we're dealing with. But, as you go through this with me today, you'll see that. So, ERCOT, just some - - just kind of a quick overview. (inaudible) not synchronously connected, obviously. A 71,000 megawatt peak. It serves about 90 percent of the load in Texas. About 75 percent of the load is in competitive choice areas. We have about 17,000 megawatts of installed wind now. Which is one of our major --

probably our major challenge. We've seen 16,000 megawatts of that online at one time with a system penetration of almost 50 percent. If we hadn't curtailed it, it would have been more than 50 percent. So, I know other places have had more than 50 percent penetration. But, I would say that they're not an Island. (Laughter) So, we take a lot of pride in the fact that we've been able to manage to that level of penetration. Solar is another emerging new type of resource. Not to the extent that -- that wind has in, but we see a much more rapid expected growth of solar in the coming years. So, that's kind of a quick overview of the ERCOT system. So, in the outline, what I'm going to talk about today is the existing electricity market and the processes that we have. What we see in DER at ERCOT. The potential effect that DER could have on our operations and planning on our market. And the kind of a vision of what we have laid out is our future. So, moving on. So, ERCOT and the market -- wholesale market. So, transmission connected generators, over 10 megawatts, are required to register as generation resources. And they're paid on locational marginal prices. LMP's. As we calculate it in SCED. We don't have a capacity market. It's an energy only market. Ancillary services are procured in the Day-Ahead, and are paid hourly, clearing prices. So, DER's that are less than 10 megawatts, may choose to register as a generation resource to participate in the SCED. Or ancillary services. Otherwise, they're considered part -- they're just considered a passive participant. We've had a very, very, very few number of DER that have chosen to register as -- as what we call a -- a GR, Generation Resource. Something that we had to define. DER's not registered as Generation Resources are paid zonal prices. Not LMP prices. So they're paid the same price that load pays. And it's a weighted average of LMP prices in the zone that they're located. ERCOT models the transmission grid, down to the 69 KB level. But we don't have anything on the distribution. We don't model any distribution. So, in the ERCOT grid, there is -- ERCOT model, there is a -- what we call a CIM, a Common Information Model load. That CIM load encapsulates what's in the distribution. And so those DER that aren't registered as Generation Resources are captured in that -- in that CIM load. The Common Information Model load. I threw this in just so you could see, these are the load zones in ERCOT. So, a DER that has registered as a Generation Resource, that's maybe up here San Antonio area versus the valley area. You get paid the same price, even though the LMP's may be completely different in those areas. But they would get paid the same price, if they aren't registered as a Generation Resource. So the retail market, about 75 percent of ERCOT's loads are in competitive choice areas. About 25 percent are what we -- are in what we call NOIE's. Or Non Opt-in Entities. They're usually municipal owned utilities, or electric cooperatives. And they've chosen not to offer a competitive choice to their customers. They go out as one big customer, and represent their customers. Retail electric providers are the ones that offer the competitive choice. They may offer service to any load operating in the competitive area. The Public Utility Commission provides the power to choose a website where you can go get the information on for REP comparisons. Go out and get the kind of rates you want. The kind of power that you might want. A distribution service provider may provide distribution services to consumers served by many different REP's. So a -- they may have hundreds of REP's in their service areas. Which causes a lot of confusion actually for the customers, when they go back and forth between the wire company, the delivery company and the REP. Which I think could actually cause some confusion with the DER eventually as well. This is a quick little map to show you the competitive versus the NOIE areas. So the blue actually there is the -- is the NOIE area. So we have a lot more area. But there's not much in those areas. So the Houston, Dallas, a lot of the large metropolitan areas are all in competitive areas where they have retail choice. That's those green areas.

So, growing Distributed Energy Resources. So, like I said, this is an emerging condition at ERCOT. Approximately 900 megawatts of DER's in competitive areas. About 200 megawatts in NOIE areas. So we kind of have the luxury of sitting back and listening to what's been done in other places. And forming our strategy based on some of the things that have been done in other places. You can break those DER's into two basic groups. There's self-dispatched generation. What we see in ERCOT is, and maybe other places as well, is a lot of the self-dispatched generation is providing back-up power for critical infrastructure. Hospitals or things like that. And it's often responding to prices. There are less than 200 units in operation. And approximately 70 inject into the grid. The other group is just intermittent generation. Primarily rooftop solar. Typically offsetting native load. Exporting (inaudible) generation during light load conditions. There are an estimated 23,000 locations representing about a fifth of the -- not generations. It says "sites" there. It should say "generation." So that's kind of where ERCOT is in the DER world. Like I said, we're just beginning to -- to see this emerge as something we have to pay attention to. So, some of the potential effects we see in -- on our grid operations and planning. The current DER penetration represents about 1.4 percent of total generated capacity. So, theoretically you could see one and a half percent of our load being served by DER at some theoretical point in time. It would have to be at peak. But, potentially, you could see something like that. Increased -- and so, DER dispatch already affects congestion. If you think back on that load map that I showed you, I'll give you guys a story. I was in the control room with an operator during kind of a critical time. And the operator on the transmission desk said, hey, come here, I want to show you something. And he's sitting there with his -- the other operator. And they're looking at the -- they're looking at the congestion screen. And they're looking at the price map up on the wall board. And he says, watch this. That's going to go down by -- by -- the congestion's going to go down by 40 megawatts and the price is going to go down by $100. And they almost went to the point where they were counting down. Ready. Sure enough, it happened. And of course, those LMP's are being calculated all the time. And I asked them, well, what was that? What changed? Because nothing else changed on the generation. He said, that was a DER. And so, there are points on the grid already, where we're seeing DER coming on, responding to, not to an LMP, but to a load zone price. But affecting LMP's. And so we're already seeing points. And they're -- it's almost like a rock sticking up above the water. There's a lot more underneath the water. But, there's a couple of points where they're starting to stick up now. And we're starting to see some problems.

And, when an operator calls you over and says, watch this, but he can't tell you from another screen what changed to show you that, then you know you've got some -- some things going on in the load that -- and that's that DER. So that's one of the things I wanted to point out today, is that we're already seeing in a few isolated points in time, the DER can affect congestion and prices. Increased -- the second point there, is increased error in load forecasting and load adaptation and state estimation results. So, you know, load forecasting obviously, if you don't know what comprises of your -- what your load is comprised of, and what the DER penetration is, it makes it very hard to -- to do forecasting. Accurate forecasting. And load adaptation is the same way. Our load forecasting will learn adapt from previous days. And so you can imagine a Texas summer, where you have multiple 100 degree days, and all that rooftop solar is running at high output. And then the fifth day, which has a forecast based on what's been covered up the previous four days, we had the same conditions, and then a thunderstorm comes over. And all of a sudden, the solar is gone. And the load doesn't change very much. And our load forecast is blind to that. And the load -- the load adaptation makes it even worse. So that's another concern with DER.

State estimation results. We currently aren't able to estimate a negative load. So that's a -- a -- if you have a -- if you have DER putting power back onto the transmission grid, we currently -- not that we can't, but we currently don't have that in our energy management system. That's something we'll have to change. Another bullet here, is the incorrectly modeled response to faults and system disturbances. And maybe what's even more concerning in this area, is that we're tuning our existing models for generators, based on the responses that we actually see, which are influenced by DER, that we don't know about. So we're inaccurately tuning the existing models to compensate for something that we're not monitoring. That's a problem. That's something we're going to have to change. Lack of coordination during system restoration is another instance. What happens during a black start, when we -- especially during our simulations for black starts, when you have unaccounted for DER that suddenly crops up on the system. How do you coordinate that? When you're operating with very small Islands during a restoration, the stability of those Islands in three or four or five megawatts make a big difference. And so, the coordination during system restoration is something that we have, at least in theory, think it's going to be a real problem. Hopefully, we'll never have to put that into practice. But when we do our simulations, we would like to start incorporating that. Over operation of voltage control equipment, not coordinated with active resources. We recently started a -- a project to optimize our switching of reactive devices. But one of the things that we are lacking, is information about load, especially as DER is related. So that's a major input to this project, that if we had started that project 10 years ago, it would have been a much more straight forward project. The project is much more complex now with DER involved, than it would have been 10 years ago. And, maybe out of all of these, maybe the most pressing for ERCOT is planning. I mean, we're planning a future system today. We're deciding where transmission is terminated and started and where it's needed, based on load forecast for five and ten years from now. We're not incorporating DER into that forecast with -- it's being incorporated, but it's being incorporated in a -- a net way that we can't quantify. And that's a real concern, because we say that DER is not a reliability problem for us today. But today, we're making decisions about transmission lines from where they terminate, and transformers and all kinds of -- all parts of the grid five and ten years from now, when we will have needed to have known that. So that's a -- that's a -- probably the most pressing area for us right now, is how do you incorporate the DER in transmission planning? Like, what differences would it make, if you knew that a northwest side of a city might have a high penetration of DER? What differences would that make in how you plan for transmission lines that might be terminated in that part of the city? Potential effects on markets. Existing market. We do not include DER's in price formations at all. Someone could argue maybe that we do indirectly. But there is no direct. There is no direct price formation with DER's. There's no LMP's. Failure to apply LMP pricing to distribution injections could lead to conflicting price incentives. An example of that is a -- let's say we have a -- a congested transmission element that's in one zone. The north end of the zone and the south end of the zone have the -- or the north end of the congested element and the south end, have the same price. And yet, we want stuff at the north maybe to run. And stuff at the south to turn off. And we don't have a mechanism to provide that price incentive for those DER's.

Finally, the current market has price spikes from ramping requirements exceeding modeled resources as we increase the number of resources that are non-responsive, that's just going to get -- become worse. So that's another -- that's another issue that's going to aggravate that situation. So, a vision for ERCOT's future. ERCOT's plan for integrating DER's does not involve the modeling of distribution circuits. We've looked at modeling of distribution. We've looked at what it would require. ERCOT and coordination with TSP's, we would just -- we would assume a registered DER or unregistered cluster of DER would be normally located at specific CIM load. That CIM is that Common Information Model load. We currently have a modeling system in place that uses the CIM loads and applies them for any point in time in the future. So, accumulating that information in the CIM load, will aid our operations and our planning. As well as the building of dynamic models and things like that.

Because it all comes from the same database. So, some of the problems with this on dense distribution systems, this assumption may be violated. You know, what kind of risk does that involve? This is the DER's that are on one side or the other of a normally open switch. And you switch it to do maintenance. And now that that DER is now subject to a different LMP, we are currently in this initial plan, not going to try to capsulate the switching of the distribution system. We're going to assume that they're right most of the time. Should there be a mechanism for the transmission ISO to exercise some level of control over groups of distributed resources? How do you accomplish that in a market environment? Our main way of controlling generation now, is through pricing. LMP's. How do you get those price LMP's down to the distribution level? How should reactive and transient contributions of distribution resources be included in grid reliability and market studies? The main problem we have there, is that when you go by your solar unit to put on your house, you're not anticipating providing ERCOT with a bunch of operational data. That's the problem. Is those things have dynamic characteristics that affect the grid. And generation resources that put plants on the grid understand that, and provide us with the information we need to operate the grid. DER is going to have to be done in a different way. And, like I mentioned before, how should transmission planning include DER's in the transmission planning? How do we do that? So those are some of the problems. Here's kind of what we've put in place at this point. And where -- this is kind of a preliminary plan we're working with our TSP's. That's why I say, in concurrence with market participants, that there are a lot of discussions going on right now. But step number one is to model in our modeling system all the registered DER's. Which is about half of what we've got from a capacity standpoint. So these are the larger DER's. So we would model those as an attribute of the CIM load. And we would provide them with an

LMP. So the ERCOT CIM currently has over 5500 CIM loads. And we also have the luxury of incorporating lessons learned from higher penetration RTO and ISO's. So that's step #1. I think we have agreement on that. We're moving forward with that. Step #2 is to develop a standardized method for collecting appropriate data for future unregistered DER unit accumulations. So, giving the TSP's and the co-ops and the municipals and all the different people who have that to provide reporting that's consistent. That's our next step. How do you do that? It seems like that should be something that we should be able to get fairly easily. But, reporting costs money. And, small co-ops and municipals may not have the personnel to provide detailed reporting that other places -- and even larger TSP's will often check us and say, wait a minute. What you're asking us to do takes money. Takes time. Takes effort. Where's that going to come from? And so those are some of the discussions we're having now. Step #3 would be once we get the reporting in place, to establish thresholds, where accumulations reach a point where they need to be modeled. I think there's a -- there's kind of an agreement that CIM loads with low penetration levels, probably don't need to be modeled yet. We only need the ones where they're getting to the point where they could inject, or they could affect load forecasting or planning. So, what is threshold? How high is that? And who reports it? And so those are the steps that we have in place now. Like I said, we are just beginning this process. This is a great place to come and gather information. Hear what other people are doing. But that's where ERCOT is now. Thank you.

MR. PALADINO: Our next speaker is Mike Bryson. Vice President of Operations at PJM.

MR. BRYSON: Thank you. And thanks for inviting us. So one of the things, again, we are very, I would describe PJM as very immature in the DER space. And we probably got our feet wet about two years ago next week. I think it was April 7,

2015. I got a call from my shift manager. Actually, it was a text from my shift manager saying, DC just went black. And I said, I'm going to need to know more information than that. So. (Laughter) And so, you know, we started making phone calls. Talking to Pepco. And it turns out that we had an interface issue between a distribution co-op and a transmission owner down there. Lost some transmission lines. Lost nuclear plants. But, when we talked to people in DC, they're like no, lights are on here. What are you talking about? I said, well, we're showing you lost 500 megawatts. Pepco was saying the same thing. Well, it turns out, under the under voltage disturbance that happened, 500 megawatts tripped off and a couple of hundred megawatts came right back on, on back-up generation. There was like a couple of hundred megawatts of back-up generation in this area. And so, it -- from our perspective, you know, we were looking at --. Okay, we have things that are going out on the system there that we don't understand. We don't know how to predict them. We don't know what's going on. So we did -- there was a, you know, certainly a lot of follow-up in terms of, you know, how some of that behaved. So we started looking at this saying, we need to -- we need to really start understanding, if nothing else, how distributed resources out on the grid behave. So, again, two years ago, we're still starting to get into it. Lorenzo's already writing papers about it. (Laughter)

MR. KRISTOV: I'm writing another one right now.

MR. BRYSON: Let's say, he's writing one right now. So. (Laughter) So, a couple of things I'm going to talk about that -- that some of those interface, when we talked to Joe, he said, we'll talk about some of the interface issues. So I'm going to try to add a little bit more color to some of the things you already heard. Because, fundamentally, a lot of the work I've been doing for the last 18 months, looks a lot like what Lorenzo wrote two years ago. So, they're way more mature than we are. So, we're using a lot of their principals. I'll talk a little bit about the NOPR that Arnie mentioned too. And how that kind of interrelates. But just a couple of bullets on some of those issues from our perspective. I think Joe was surprised when he asked me this question. What do you think's your biggest interface friction? It's regulatory for us. It's clearly regulatory. The rules are all over the place. We are a multi-state jurisdiction, so, when you count the

states, DC has their own commission. Add DC to that and, of course, add the two Commissioners that are there at FERC. So we have a lot of jurisdictions. And so the rules and the regulations, in fact, I often tell our technical teams, forget there's no -- think about there's no rules. Forget about the rules for the second. How would you do this? And then we'll try to figure out how we kind of work with the rules. And a big way we try to do that, is we talk to small micro-grids, a DER resource, and say, we're willing to do pilots with you, so we can figure it out kind of under the radar. And then, we'll be able to inform some of the utility commissions and stuff, about how we can do this in terms of data. And one of the areas we've gone out to, is a lot of our municipals and co-ops, because they're really in a pretty good place to be able to do that. The DSO concept, again, all the things that you heard from Lorenzo, we're looking at that. And -- and kind of our philosophy is really, if we can add value in that space, great. But we don't want to compete with our utilities and our members. If that's an area they want to get in, and they're covering it, then we're there to help them. We're there to support them. But we don't want to compete. But, we also recognize, just as Lorenzo pointed out, that independence is important. There's a couple of places on the system that we know there's distribution level upgrades that are being planned. And some of the proposals are Distributed Energy Resources or storage. And when the utility who's proposing the substation is also going to build the substation, who's the independent body that's going to select that? So, we think that's kind of an important part about it. The whole tariff rate model again. This gets back to the jurisdiction. But that's obviously important. And some of the things that Woody talked about is, how do you build that into the existing incentive structures? But the biggest one for us, next to that regulatory, is the visibility. And I'll talk about that a little bit -- a little bit more. I always think about the, you know, my three talking points about PJM's philosophy on Distributed Energy Resources, are really visibility, measure and forecast and incentives. And I'll talk about those a little bit more. Again, visibility for reliability. What we learned from that April 7, 2015 was, we don't necessarily know how all the load is going to behave. Because of a lot of -- and a lot of the DC agencies, essentially over the years, have put in back-up generation for resilience. And that's a great thing. But understanding that, in the planning stage, is important for us.

This is something, again, kind of compiled from Lorenzo, so I'm not going to talk about that. You heard it. Let me jump into the visibility. Again, we have very limited visibility in what's going on from a DER point of view. But we're starting to develop that. One of the things that, when we responded to the NOPR, I told our team is, we have a lot of Demand Response on our system. Very mature Demand Response model. I think three years ago, I had 14,000 megawatts at demand response, going into summer operations. Some will say that's too much Demand Response. But we had a lot of it. But, we learned a lot of lessons over the years from Demand Response. And I said, those are really good lessons that we can learn as we're thinking about, what are the kind of rules we want to put in place for DER. Can they participate in the different markets? And again, very similar questions to what Woody talked about. We also have a capacity market, which is, you know, it's an incentive for the resource to say that they're going to be there, three years down the road. So that we do our system planning. They sign up. They say they're willing to be there. We can plan for them to be there. General awareness of where the location is. One of the things I'll talk about, is this concept of telemetry versus data. And we recognize, we commented on the NOPR, is requiring telemetry is a high hurdle. It's very expensive. You know, a couple, again, we've been in the DER business for a while. And back in summer of 2015, unrelated to the blackout by the way. Summer of 2015, we had a stakeholder process, where we said, hey, we need to -- we need to make our Demand Response more operational, from a control room perspective. We need to know where it is. We need to be able to call it in shorter notice. Call it in smaller areas. Things like that. The pitchforks and the torches came out from Demand Response. You can't change the rules. It's discriminatory. So the only thing I got out of -- and I had a long list. I had like 28 things on the list that I wanted. I got 30 minute notice. I can call them with 30 minute notice. So I got them close to a, you know, a CT out there. But then what I did is, I went back to talk to our internal development. I pulled in my Demand Response team. I pulled a dispatcher from the floor. Our IT people. And I said, I need you to try to do for me with technology, what I couldn't get in terms of telemetry. And they put together this application called a Dispatch Interactive Map Application. And the thing about it, it is -- not only is it a good tool for our -- my operators. It actually allowed us to learn a lot more about what we actually needed from some of these Distributed Energy Resources. So just at a high level, they have their energy management system. But this is a system -- it's basically a map based system, with a lot of overlays. We can put gas pipelines on it. Transmission outages in real time. Weather. All those -- all the generator stations you can see on the right. It gives you information. But I said, can you put behind the meter generation and -- and DR and all that stuff in there? I said, well the problem is, with Demand Response, the only thing I have is zip codes. I said, what can you do with zip codes? I'm like, oh, you know. So they went back, away, came back a couple of weeks later and said, we think we can do something with zip codes. We can actually map zip codes. So they actually literally took the 14,000 megawatts, and none of it is in big chunks, trust me. It's in kilowatts or, you know, smaller. Put it in database. And they set up a tool that -- and this interactive tool, the dispatchers can actually pull up a transmission constraint. So, a line went out. Or two lines went out. We have an impending storm, you know, something's going on. They can take a mouse, draw a loop around the substation. And up pops a list of the Demand Response that's in that area, and able to be called. And so we work with the transmission owner. Called distribution. I had my 30 minute rule. The one thing I got out of my 28 points. I can call them within 30 minutes' notice. I can call kind of as small as I need it. And now, we have distributed resources that we can actually use to help manage transmission issues. We continued to develop this. But one of the things we realized with this is, I don't need ICCP data from the distributor. I just need data. I need some kind of data. And that's really what we're telling some of our pilot programs is, they're like, well what data do you need from us? I'm like, what do you have? Let's start with just tell us what you have. And then we'll see how we can make that work with this kind of a system. I don't know that I'm going to be able to put it in my distribution factor state estimator EMS. But I might be able to put it in here, and I can still use it to help make decisions and help with situational awareness. I told you it would be more colorful, didn't I? I had low color.

The second one. Measure and Forecast. So now, I have for visibility, again, in my mind, kind of the ground level is, I need to have more visibility and I'll take what I can get. But the more I get, now I can develop some algorithms to measure what's going on. And potentially forecast what's going on. So just to look at things like, okay, now I have some data that tells me when there's an under voltage situation south of DC, that the certain amount of the load is going to switch to back-up systems. And start working with our transmission owners to figure out what that looks like. Some of it will be based on data. Some of it will be based on load modeling. But just understanding more of that, we'll now be able to forecast under certain conditions. Forecast, you know, a combination of what's going on with Demand Response. With Micro-grids. With Distributed Energy Resources. We just introduced a production level solar forecasting tool. We've had a wind forecasting tool for a while. And all that just gives us input into, again, not all of it's going to be in our energy management system. But, at least it's going to be in our situational awareness tools. And then, the next step is really in sending operational performance. So, given all this stuff, now that we know how load or distributed resources may behave. And now that we've been able to measure and forecast it, is there ability for us to be able to incent behavior? So, if the price at that bus was higher, would you come off more often? Or things like that. So that's the idea here. Big -- a big thing, and going back to one of the first bullets I said was, we want to do this where appropriate. We've still got to figure out the regulatory issues. We don't want to compete with our members. But having said that, where it's appropriate, are there opportunities for us to incent Distributed Energy Resources? Just as an example, storage is one of the things that we certainly commented on. We have had a lot of experience in storage. And when we look at storage in PJM, so this is in our regulation market now. So it's a grid level ancillary service. It's helping us with reliability. We have about 270 megawatts providing fast regulation in PJM. And you can see it's kind of spread out across different parts of the system. So, a chunk of it is in Distribution Voltage. Then there's a chunk of it in that layer between sub and transmission. A pretty good chunk on -- directly connected to the transmission system at about five megawatts of Demand Response. So, this is stuff that's participating in regulation. It provides, there are, we call it Regulation B. It's fast regulation. It responds essentially sub-second. But can't last. And then our Regulation A kicks in. Which is our typical hydro units. And some of our bigger steam units that kind of take over, providing some pretty base reliability services to PJM. And what we learned again, from this, is very similar to what Woody said is, is depending on what they want to participate in, you can tighten the requirements. So, if you want to participate in regulation, you want to be responding and get the same price as traditional units, I'm going to need telemetry from you. You're going to need to test once a year those kind of things too. But if you're going to be out there, and only sometimes participate or take advantage. Maybe all's I need is just a little bit of data. So anyway, I just wanted to give kind of a picture of where we are with -- with PJM, and we'll turn it back over to Joe. Thanks.

MR. PALADINO: Well, that was very interesting. Just a quick question Mike. In this slide right here, this is for regulation markets specifically? So it's one market that you've got --

MR. BRYSON: Yes.

MR. PALADINO: -- where you're trying to employ these capabilities?

MR. BRYSON: Yeah. It's one market. Any resource in PJM that has been tested can participate in this. So this -- the bigger market of regulation, we carry about 700 megawatts on peak. So 270 of it is the batteries. The rest is traditional generation.

MR. PALADINO: Okay. And are you interfacing directly? Or are you going through aggregators, or --?

MR. BRYSON: For this, we're interfacing directly. That's a requirement. That's kind of a higher level requirement, because it's regulation.

MR. PALADINO: Okay. Thanks. Thank you for that. Appreciate that. Joseph Brannan, is Executive Vice President and CEO of the North Carolina Electric Membership Corporation. So this will be an interesting slant. Thanks. Thank you very much.

MR. BRANNAN: Well thank you everyone for allowing me to participate. And I know you've been sitting for a while, so I'm going to kind of walk through my comments. But what I'd like to do is kind of set up the discussion I'm going to have with you. And it's going to be a little different than what you've heard so far. Each of the individuals that have come before you, have either represented someone that's overseeing a market or someone that's regulating a market. And I would like to say that we're participants. And when you think about it, I want to give you just a quick glimpse into my past, so you'll really understand why I'm focused on some of these issues. So in 1993, most people remember, hopefully, what this country was embarking on. Two major things in the country, as it relates to the electric utility industry. One, we were about to enter a world where we would create ISO's. Two in particular. PJM and CAISO. Second thing is, two states in the country were going to embark on retail choice. Pennsylvania. California. So guess which state I lived in? Pennsylvania. Worked with the utility in Pennsylvania. Spent many years working with PJM when it was considered tight power pool. Learned a lot about how the system should work in an optimal dispatch. Security constraint. All the terminology you hear today. Retail choice overlaid in the market structure like that, asks for one thing. Allocation. We didn't create more generation. We didn't put generation on the system in the first year of retail choice. So you had to allocate what was there. My mind was blown in one area. We are creating more risk for the retail consumer. At that very moment, I realized that as we embark on this evolution of opening up our markets, the electric utility industry, whichever way it goes, we create risk. Everything you heard today, is really how to manage that risk. Call it reliability. Call it resilience. But you have to manage that risk. Managing risk from a consumer level, takes a lot of effort. So now let me move into some of the perspectives of, where and how do you manage that risk? So when I think of the risk, and as I'm going to walk through this discussion, now put yourself in the situation that, you're the Board of an electric distribution co-op. Right? You're Not for Profit. You're democratically elected, so you had to go out and you had to solicit votes to be elected to the Board. You provide oversight to that co-op. Whether it's a GNT, or whether it's a distribution co-op. You provide oversight in how to manage in the world in which we call electric utility. If you're sitting in a boardroom and you just heard all these presentations, what would you be thinking right now? Two things. This is costly. And this is risky. So keep that in perspective as I walk through this. Because I want to give you, I think Joe set it up nicely saying, I'm trying to give you a ground up. But I'm really trying to give you a perspective of, the markets will evolve. You're not going to stop them. And everything's going to move forward. But you have to manage and you have to provide affordable, reliable energy to these consumers. And you have to do it in a manner in which you are an environmental steward. So who we -- who are we? North Carolina. So the shape of the state is going to be important. You can read the statistics. I won't read the statistics to you. But you see all the green areas. That's the electric distribution service territory. So it's about [inaudible] percent of the land mass. 24 percent of the population. North Carolina is a state that you would like to say is a growing state. The population continues to grow. It's moved up in the rankings. I believe it might be ninth right now on the last census. But if you look in the upper right hand corner, and you'll see an area that I'll describe as a market. It's the southernmost area of PJM. So we're one of those 13 states. And ironically, see that sliver, which most people if you know your geography, you see the sliver on the right hand side? That's the outer banks of North Carolina. Go down to the very tip. I think I have a --. Right here. Thank you. That was great, whoever did that.

(Laughter) A little scary. But that was good. But keep that in mind. That's Ocracoke Island. It's in PJM. I think it's probably the southernmost point in PJM. Okay. Because I'm going to talk about a demonstration we're doing, to address everything that Mike talked about. So you have all this information. And when you think about a comment Woody made about, the electric co-ops are not offering retail choice. Think about it from the perspective, if you the Board, are responsible for setting the rates. The -- essentially the regulation of that co-op to provide this affordable, reliable electricity. You would want to do it in a way that you could manage the risk for them. To throw them to somebody that's just looking after, how many people are going to get the low hanging fruit, try to make, obviously this is America, make money? That's not protecting their interest. So, a lot of this is underlying the mission of co-ops while you would not just immediately jump into that arena. So this map is really to demonstrate to you, that to manage risk, you have to understand the problem. So in order to understand the problem, you have partake in a lot of demonstrations in pilots in order to do two things. Understand if there's value. And understand what type of hedgeable instrument can I create, to manage against all the risks that's going to come down the line, from everything that's going to evolve in this market. So, this was created, and a couple of things I'll point out is, solar obviously, I know we're not the sunshine state. But we feel like it some days. There's a lot of solar that's penetrated the system in North Carolina. We've embarked on community solar. Why? Because community solar allows people that may not be interested in putting something on their roof to partake in some type of solar project. But it also gives us an opportunity to understand what that DER does to a distribution system. The second thing we look at is micro grid projects. Why micro grid projects? Micro grid projects are (inaudible), I'd say, aggregation of different components that will exist on the distribution system. And if you were able to interface and hopefully, interface in a way that you can manage and control the activity, I will better understand the impact I'll have on the distribution system, and potentially, I think as Mike pointed out with the one graphic, where they can circle and area and pull it up and see what DER is available, there's only a few reasons they want to know that. One, if there's an event, they can energize or they can ask those devices to come online and help.

And two, if people want to participate in the market, you understand where they are and what impact they would have. What value they would create. And in our case, we're looking at, how can we hedge against the risk that may be created by these systems?

And the last thing I'd point out is the different types of solar. So, the community solar typically 100KV, small, single feeder. And you put it on that feeder because there's other load. And potentially resources on that feeder. The other is utility scale solar. It can be interconnected at levels from 100KV down to a high voltage distribution system, which is not optimal obviously. Because the first thing you're going to recognize, if you're behind a substation, and you're on a feeder or there's multiple feeders in that substation, you have a utility scale solar connecting at that voltage level. That's -- the utility scale of solar can actually generate at a level greater than the load on that -- at that substation. Not an ideal situation. So this really gives you a perspective of, if you are a participant, a load, you better be doing this. You better be doing this, because it emphasizes several points that everybody's made. You need to understand what's happening. More importantly, how do I hedge the risks I will be facing? This is a perspective of North Carolina. Not just cooperative territories. But the entire state. And you can see the existing capacity and the proposed capacity. Anybody that's following activity currently in North Carolina at the North Carolina Utilities Commission, there's a filing before the Commission on avoided cost filing. And in that filing, it is more than just avoided cost. It is talking about the proliferation of solar and the system impacts to the distribution and transmission grid. Believe it or not, we do have a "Duck" Curve in North Carolina. And the "Duck" Curve is something that, from a high level, may not look as ominous. But as you go down and figure out that it -- the concentration of solar in certain areas, create more operational issues, than you can manage at a higher level. One of the nice things we can do with numbers is, we can make numbers talk. And if I just say right now in North Carolina, the amount of solar, about 5800 megawatts on a system, if you take all the generation across the state of North Carolina, about 38,000 megawatts. It's small. Why do you have system impacts? Look at the concentration of solar. So, we're in this experimental stage, I believe, and this proliferation of solar. And understanding the impacts and how do we respond to it. And right now, a lot of the state outside of that area that I designated as PJM, is a vertically integrated environment. And it's -- the Transmission Operator is Duke Energy. And so, when you think about two very distinct areas trying to manage the same situation, it gives us as cooperatives, since we actually have load in both areas. And generation in both areas. It gives us an opportunity to really see how to compare in contrast between a market environment and a vertically integrated environment. Coordination has been talked about a lot. And one of the things I'd like to share with you, is a concept that I think is extremely important. As you start to build up from the ground and through all these experiments and demonstrations, and recognizing the market, the utility industry is going to continue to evolve. These are key, as I call it, I like to call them focal points in consideration for coordination. PJM is the Regional Transmission Operator for us in North Carolina. Obviously, behind PJM is a Transmission Operator. And in PJM in the area that we are, it's Dominion Resources. One interesting fact about Dominion Resources. Obviously, most people realize that they're headquartered in Virginia. They have a small amount of load in North Carolina. Probably an average peak of about 580 megawatts. Currently, on the transmission and distribution system of Dominion North Carolina, they have close to 1200 megawatts of solar. So think about the distribution co-op that's interconnected to that transmission system that has more generation resources that are hard to curtail. And how that's being managed. And really, the reason all that generation is there is one reason. To visit Mike. They're trying to access PJM markets. The other is, the distribution operator, distribution system operator, however you want to look at it. I look at it as a distribution system. As we evolve, there'll be a greater dependence on that entity, providing some type of visibility and coordination with activities on the entire grid, in order to provide more capability in responding to situations, whether they be emergency or normal system operations. As well as, meeting the customers' expectations. The customer as all -- we are all customers, look at things differently. And we've managed a utility industry for over 100 years in this somewhat homogenous state. And we're finding out that that's not the way that people want it managed. So, the coordination and activities at the distribution entity level, are going to grow. Woody made a comment about the costs that would be imposed on entities of different sizes, and their capability to manage that. That's real. Every participant is not equal. But they're all trying to access a market that's non-discriminatory. So costs are going to be something that you have to figure out how to manage them. But how to do it in a way that you can provide, hopefully, value to the end use customer. Challenges and opportunities, I think everybody's touched on a lot of these opportunities. I kind of look at it from the standpoint, whether it's at the distribution level, the transmission level or an overall market level, visibility is going to become extremely important. And the granularity of that visibility is going to be the biggest challenge. And you heard from some of the previous presenters, at what level do we want to see the information? And that's going to be a challenge. Some of the other things we talked about, obviously the voltage power quality. Affected system coordination for a lot of people, you realize that if a generator connects on one system, you have to do a system impact study to determine what impact it'll have on others. We'll think about a DER system one. 10 megawatt system being put on a distribution system. System impact on a larger area, probably nothing. What if you get 20 of those? How do you increment your system impact study? And who pays for the impact? Is it the last generator on? Is it something that's spread across the entire load? Those are all decisions that, more or less, become policy and then regulatory driven. Opportunities, obviously I believe that this system is going to continue to evolve. And for us to be able to serve reliably and in an affordable manner, you have to look at ways to manage on a distribution system that you're not currently involved in. And I look at micro grids. They're not new. Obviously, anybody that's been involved in this industry, micro grids have been around for many, many years. But it's really, what can be -- how you can use micro grids to manage the impacts on your system? But also to provide capability upstream. One thing I want to mention about upstream, we talked about revenue stacking. Today, and I could be wrong, the way I try to look at our system is, that, when you look at the electric utility system, it's basically a closed system. When you add generation, you're going to display something. So when you talk about revenue, anything that's put on a distribution system, is trying to get the revenue stream upstream. And so the revenue stream from upstream, has to give it up in order to drive the value downstream. And I think that's where the contentious issues reside is, how do you transfer that wealth from the upstream downstream? And that's where a lot of people are focused. One of the biggest challenges we face in North Carolina and with solar, is the fact that the solar that's being put on the system, is being put on as qualifying facilities. And everybody understands the federal regulation PURPA, implemented in 1978.

And the perspective, at that point, of why PURPA was necessary. So North Carolina, I'll just share one perspective with you. You asked why North Carolina? Why is PURPA so important in North Carolina? Well, the federal regulation really just provided, what I call and outline, of what you needed to do. Every state and implemented some type of regulatory, in my words, overlay. And North Carolina has something that they implemented in the 1990's. From the 1990's on, here's what happened. Federal incentives for solar. That's 35 percent state tax credit for solar in a renewable energy portfolio standard. So you can build a project at a 65 percent tax deductible. Yes. Where am I going? North Carolina. State tax credit. Sunset. Federal tax credit. Everybody's aware of what's taking place there. Qualifying facility requirements are still in place in North Carolina. So, when you think about what you provided to DER in North Carolina, displacing any type of capability on a system, and you have to pay them. Who pays them? You. Okay?

So those are actually opportunities, right? So those are going to be opportunities, in order to look at policy and regulatory changes, in order to put a balance, a fair playing field, in place. I don't really need to show this. This pales in comparison to some of the other graphics you've seen. But, a bad solar day, what it does from a net load standpoint. I think everybody understands the impact of intermittent resources and what they can do to a distribution system. One of the other, we talked about interconnection and impacts they would have. And, obviously, an area, if you get down into the weeds, you know, protective relaying is extremely important in managing the reliability of any system, whether it be distribution or transmission. And as you go, move away from a one way power delivery system, to a potentially two way system. You really have taken into consideration what you do to your protective relaying. We talked a little bit about under voltage and what happens when solar goes onto the system, and then immediately drops off.

And you're looking at smarter inverters to help ride through situations like that. But, a lot of work is still to be done on protective relaying and what that will mean on a distribution system. So I mentioned micro grid and Ocracoke. So there's an active micro grid on the Island of Ocracoke. And this is a, just a schematic, to represent what that micro grid looks like. What we tried to do is build this with what would be in a home, or at a business. So we put solar. 15 -- 15 kilowatts of solar. And now remember where we are. We're on Ocracoke Island. We're in -- it's not called Hurricane Alley. But there's enough hurricanes that come through there, and you have to worry about when. So you're putting solar on a rooftop. And you have to think about the wind shear you will have from, you know, just not normal winds, but also hurricane winds. We also have a diesel generator that's on the island. And that's been in place for a number of years. We implemented Ecobee thermostats. You can do any thermostat, but a controllable thermostat. Why?

Because that's what you will have in your house. And then you will control it from your Smart phone. And you won't control it in a manner in which that we can forecast and then predict it within three percent accuracy on our load forecast. I guarantee you won't. So we put that on there. We put water heaters that are also remotely controlled. And then, the last thing we did, is put battery storage. And we said, if this resembles what could happen, how would we manage it? You know what the most important component of that entire --? I'm sorry?

MR. LAZAR: Who controls the water there?

MR. BRANNAN: Pardon?

MR. LAZAR: Who controls the water there?

MR. BRANNAN: Right now we -- we actually, the utility is controlling the water. As part of this pilot, we asked the consumers, the members, if we can control it to demonstrate. And, so they were willing. It's a tremendous environment on Ocracoke Island. Especially the people that have lived there their whole lives. They're willing to work with you. It's a nice environment. But you ask yourself, what's the most important component of this micro grid experiment? Anybody want to take a guess? It's the micro grid controller. That is the major interface to everything that's happening. And that micro grid controller has to have the capability, not only to receive information, but eventually, and this is the idea of a demonstration, is to work through all the different types of control algorithms that you can implement, to determine how it can respond to different situations, but not create an upstream impact. And eventually, if Mike's willing, we'd like to then interface with them to see what they can see, down at Ocracoke Island. But, we're very early Mike, so I won't call you yet. But these are the types of demonstrations that everybody has mentioned. It's important to embark on these type of demonstrations, really to understand the impact. But also, what are the key components that we have to focus on? And I share that with you, and we're still in the early stages. And I hope, at some point, to be able to provide this information. We're working with different research and development organizations. Within the cooperative industry, we have our research organization that we're working with. We're working with EPRI on this, as well as working with your common manufacturers of different components. This was just a performance in February. Obviously it does get cold in North Carolina. And it's usually January and February. This year we've had a little bit warmer period in January and February. But, what this did, is its typical load curve. You demonstrated you can operate. There's nothing exciting here, right? The point I want to really focus on is, the ability to do this with thermostats and battery, was very important. Because, we simulate in our minds, an event. That's the peak load, right? That's your simulation. And you say, I can turn that. I can discharge the battery. But what will the consumer do? And we sent out a signal to all their thermostats, and they went into a control period. And you can see we're in a couple hour control period. They cannot doubt. So now you're into behavioral science. Will they opt-out or not? And we have all the statistics on how many people opted-out. How many people stayed in? And you send them nice messages when you're in for half an hour to say, hey, we're only a half an hour before we end. Please stay in. This was truly very informative, because the consumer was involved. And so these are things that we continue to do to understand what type of information is necessary, in order to provide a very, very accurate, but very constructive distribution to Transmission Operator interface. So with that, I do appreciate participating and look forward to your questions. Thank you.

CHAIR TIERNEY: Joe, we've got 10 minutes.

MR. PALADINO: Okay.

CHAIR TIERNEY: Which is both terrible, because you guys have had such a great, great panel. But, it is what it is. So, I'm sorry about that.

MR. PALADINO: So, let's just open it up to questions, because there's probably a ton of questions. So, let's start here then.

MR. MORRIS: Thank you. I'm going to aim my question at Lorenzo and Arnie together, being from the west and the WEC. I honestly think that's what frustrating about this conversation, is that, you know, in order to try to get more granularity on the distribution issues, we seem to be always looking through the wrong end of the microscope to answer those questions. And, I'm just wondering, you know, to me there's an inversion point, where if you want to check off a lot of good state policy boxes, less carbon footprint. More efficiency. More resiliency. You know, you would design these systems from the ground up, and not continually look at them from the top down. And my question is, is that, and either, you know, I see a lot of -- in California, Lorenzo, I see a lot of DER planning going on in a construct, that kind of works with, essentially, operated grid. But for the utilities outside of California that don't have that DER process going on, you know, in a sense, they're shipping resources to California in order to treat the -- to treat the symptoms of the "Duck" graph, without understanding the granularity of their own networks. I guess my question for both of you, is that, I think part of the policy concern, is that, you know, we're taking rate payer value from the distribution system underneath that construct. If you're going to propagate it up to the HV side of the system, you're taking rate payer value, and shipping it to the high voltage side, without seeing that value being realized in lower rates for customers on the distribution side. So, it seems to me there's a paradigm that we can't quite break out of here. We can't let deferred cap backs actually be realized within distribution rates, to actually allow unbundling of socialization and rates to let, you know, symbiotic relationships behind the meter, be offered as services, and not have to propagate it up to support the commodity high voltage system we have today.

MR. QUINN: I'll take the first shot. And the -- when you say propagation of the distribution system, one of the things that we heard from some of the aggregators, was that, their service is largely right now to the end use customer. So, the value proposition for them, is helping an end use customer manage retail bills. A lot of its demand charge management. But, for them, the opportunity to participate in the wholesale market, was the place where they could make that investment for the end use customer, a more attractive opportunity. So, you know, what we heard was, ability to participate in the wholesale markets, was going to enable that product down at the end use customer. And, without the opportunity, that might become cost prohibitive. Or just -- there was a set of end use customers that weren't going to take advantage, because this -- the cost structure didn't work. So, to some extent, I felt like the opportunity at the wholesale level. Whether they can take advantage of it. Whether it actually materializes is another thing. But, making that opportunity available, did enable some value creation on the distribution system. Maybe not the deferment of distribution equipment, or things like that. But at the customer side, we definitely heard that -- that what we were doing was a value creation downstream, enabled through revenue on the upstream.

MR. KRISTOV: What I would add to that is, that there's a whole bottom up movement happening in California that I really didn't talk about, which has to do with what's called Community Choice Aggregation. And, the idea there being that cities and counties, local governments, can become the retail electric provider for everybody in their territory. Many areas in California are doing that, not simply to compete on price, or even on renewable energy content. All of that's part of it. But really, to develop local resources. And, part of the equation -- a cost benefit equation, is that there are benefits to DER that aren't valued yet. So, I think, and -- and storage as well. Resilience is talked about a lot. But, it doesn't have a well-defined value when you try to plug in a cost benefit calculation. My expectation is, in the next five or ten years, that's going to get a lot bigger. Same thing with the idea of smoothing load profiles at the local level. At the circuit level. Or the local area level. And smoothing fluctuations. There isn't really a service that you get paid for yet for doing that. The idea that, more DER gradually reduced the need to build transmission, because you're serving more of the load locally. Well, we haven't got a good way to account for that yet either. So, I kind of bundle a lot of those things together, in terms of thinking of energy or electricity as a commodity. That to me is so 20th century. You know, the really new way to think about it is, well, why do we need energy? What's the best way to get it? Let's provide it locally. And to the extent that we're now withdrawing from reliance on that huge central mega system. Then we get some credit for that, and we're satisfying local objectives with regard to resilience, that we might not be able to meet in other ways. So, it's really the whole cost benefit calculation as part of the turmoil that needs to get re-thunk.

MR. PALADINO: Yeah. We should just continue with the questions. Laney, would you like to ask a question?

MS. BROWN: Yeah. That may be building off of that as the -- in that value set, the distribution, you know, the value of D matures. How do you think that's going to change? You know, some of the approaches that you're looking at around the interfaces. And the overall view from, you know, a lot of it's been provided from the, you know, from the market side. But, how do you think that's going to change that interaction?

MR. KRISTOV: As what matures? I'm sorry, I missed that.

MS. BROWN: You know, you look at the value stack - -

MR. KRISTOV: Oh yeah.

MS. BROWN: -- and services at the distribution level. So, the LMP plus D.

MR. KRISTOV: Mm-hmm.

MS. BROWN: How might that change? You know, some of the approaches that you -- you're looking at now.

MR. KRISTOV: Well, personally I don't subscribe to the LMP plus D idea. I tend to think that, when you get into a local area and you're starting to meet your energy needs locally, then LMP is just the price of imports and exports. And that may be a small percentage of the total economics of energy supply in the local area. So, yes, location on the distribution system matters. But to sort of take, you know, the LMP as your reference point, and price everything off of that, to me is -- is too much of a central station centric view of the system. I think we need to rethink the view based on, why do we need energy? Why is it needed here? What are the uses it's being put to? And what are the different ways we can meet those needs?

MR. PALADINO: Mm-hmm. Carl. Or Paul. Go ahead.

MR. CENTOLELLA: Sure. It strikes me that some of what we heard talked about today, and some of the additional problems that might be created by what we do in the future, are in fact, an artifact of a market that we created at the ISO level when DER wasn't a significant player. And, you know, and so, you know, Mike talked about, you know, incenting DER performance where it matters. And he's in a system where, I know there are zones in PJM that on a peak day, you can see within a zone load differentials of $800 a megawatt hour, in some instances. And those are hourly averages at the interval, we would assume that's even larger. We heard Woody talk about, you know, the impact of constraints within a zone. And how prices move things in ways that aren't necessarily rational to solve that. And we're seeing in the NOPR, you know, this view of aggregation, that isn't actually geared to the locational value, even at ISO level, the different resources can provide. So I guess my question is, what would it take to really move away from zonal pricing at the load side of the market, to where we could actually begin to more naturally reflect the value of DER, when and where it operates?

MR. PALADINO: My goodness. (Laughter)

CHAIR TIERNEY: And across you, you have two and a half minutes.

MR. BRYSON: And I was going to start with, could you repeat the question? (Laughter) No, actually, I think that's a -- I think it's a good point. And a lot of that has to do with, in my mind, the level of data that you're getting. It's really based on that. And when you look at, you know, some of the products that we have. And this is why pilots are important to us, is because years ago, someone came to me in our Advanced

Solutions group and said, hey, we want to -- we want to do a pilot with the battery as regulation. I chased them out. I'm like, get out of here. What are you talking about? We're not doing it. We're never going to do storage as regulation. But we have almost 300 megawatts on the system now. Because, we decided, you know what, let's see what we can do with that. I think it's the same thing with that is, let's figure out, you know, let's go down to the Island, only because of the pilot, not because of the nice weather.

(Laughter) And see if we can -- if we can figure out, is there something there that would say, there's enough data that we're going to get from there. We may be able to do nodal pricing at -- for some of these distributed resources, so.

MR. KRISTOV: I would add one thing to that. In a certain sense, getting away from commodity thinking, means rethinking how do we charge for transmission and distribution service? And the whole idea of recovering fixed assets based on a volumetric charger. Even a demand charge is not really quite right. I think once we start adding a lot of DER and variable resources, we ought to be charging at each point of interconnection, based on their impact on the system. Because it's that impact that creates the cost of operating a reliable system. So if we start pricing things for distribution service or transmission service, based on the impact that they have either creating volatility, or removing volatility, or creating an extreme load profile, or mitigating it. Then that changes the whole pricing dynamics. And the location will matter, because where you're located, is going to create an impact on the system that has to be managed.

MR. BRANNAN: Yeah. If I can add, and I think I'll just pick up on what Lorenzo said. So think about it from the standpoint of that person out of that group, in that local area. You know, on Ocracoke Island, they don't have access to low cost nuclear energy. So, one of the things, you're taking advantage of a larger market, to create value at a level that they could not receive that value. And, so as we've created this market, we've tried to figure out, how do we represent that in nodal markets? But, I think as DER grows, and Lorenzo really struck the chord. As DER grows, what we're going to go through, is a process where we can't disconnect from the central generation concept. So, we're creating market products to hedge against the risk as we go through. So, the volatility that's created can be hedged. And eventually, if the future holds that we disconnect from central generation, then you will live with the local resources you have. And it may be priced at a much different level than your neighbor. And I think the experiment, maybe not experiment, but what's happening in California with the community aggregation, I think is a great example. People want something different. And, we can't disconnect from the central generation. So you need this transition period where you need products. I'd do them. Products to hedge against the volatility either you create, or someone else creates for you. And I think it's an -- it's more of a transition than it is a disconnect to that -- or a step change.

MR. PALADINO: So, how are we doing? There are couple more. There are three more questions here. What would you like to do? Can we --?

CHAIR TIERNEY: Well, if -- if anybody needs to go because of commitments, please feel free to do that. But, let's just go for a couple of more minutes if you can. If your planes will allow it and things. Will they?

MR. PALADINO: Thank you Susan.

CHAIR TIERNEY: You okay? Okay.

MR. PALADINO: Thank you very much. Merwin, would you like to ask a question?

MR. BROWN: Thank you. Merwin Brown, UC Berkeley. A number -- my question is going to be around a sense of urgency about when these problems, and so to speak, need to be solved.

MR. PALADINO: Yeah.

MR. BROWN: Because you've raised a number of issues.

MR. PALADINO: Basic change.

MR. BROWN: And when you ask the -- and when you answer the question, if you can, there's another thing that you raised on the panel, at least to different degrees, is that, why you may look at this as a homogenous problem in a given area, it actually is -- the problems are beginning to show up sooner rather than later in heterogeneous type situations. And so, keep that in mind when they think of urgency. In other words, how much time does DOE have, for example, to help us, all of us in the community, solve this problem? Are we talking 10-15 years? 2 years? Any -- any help you can give on that, to know how much to push this.

MR. BRYSON: I'll start out. So, my thought about sense of urgency, and again, given the 15 jurisdictions, is from a reliability perspective, if every one of the state utilities said, stay out of it, I would say, we'll just stick with the visibility. That's the most urgent thing. And we've been working on that problem for a couple of years. That's an urgent problem. All the rest of it is something that again, where it's appropriate, we'll work with it. And we'll run as fast as our utilities and states want to run. And there's different -- there's just different demographics across our system. But, the visibility one, is the one in my mind, that's urgent.

MR. RICKERSON: And I would agree with Mike that we need to solve the visibility part in the next three years that are not --. And that's kind of the goal we have internally is, we need visibility. We need to know what's out there. We'll have time to talk about thresholds and market triggers and things like that. But, we need to know what's there. And that visibility will also aid us in planning studies. Which is a -- is something people don't think about.

MR. PALADINO: Right.

MR. KRISTOV: I would add that the -- the urgency will begin when we have the next Hurricane Sandy. Or the next major cyber-attack. Or the next major disaster that wipes out a whole lot of the energy system. And people start realizing that, you know, building local systems that can -- that can Island, that can function as micro grids, is a good investment. Even though I can't quite calculate the five year return on equity. It's going to become very valuable, because it will enable communities to sustain things like pumping water and pumping sewage. And the various things that are essential for basic quality of life kinds of conditions. So, I think it may take certain natural disasters to make it more urgent. But I would say, start now.

MR. QUINN: It's the only thing I'll add is, on the market opportunity side, I feel like there is a sense of urgency there, simply because, if you don't create the opportunity to extract a value stream, you potentially limit the ability of things to come to market, you know, on a timely basis. And, the other thing I'll note is, I think our experience, like on wind integration was, early on, there was a sense of, this is all going too fast. We need to slow this down. As yet, the markets are incredibly resilient to accepting incremental changes over time. And identifying opportunities to make advancements. And so, that shouldn't be the reason -- we shouldn't wait to figure all of that out, before we create that market opportunity.

MR. BRANNAN: The last thing I'd add and I just -- I think -- I absolutely agree with what's been said. But if I look and think about the sense of urgency, one of the areas that I think it's extremely important to focus, is on policy. I mentioned to you what's happening in North Carolina. Five years ago, nobody was concerned. And because of the -- the confluence of events that were created through policy and regulation, you create -- they created this issue. So, from an operational standpoint, there's the need for visibility, but if we don't get the policy right, and we're going to have this extreme sense of urgency, just from system reliability and resilience. And I'm very concerned that if we get in that mode, the amount of money that's going to be spent on these systems, we won't get a return on.

MR. PALADINO: Janice.

MS. LIN: Thanks. Fascinating panel. I had a super quick question for, I think Mike. And then I have another question for Joe. So my super quick question is, the five megawatts of behind the meter battery storage in PJM, are those direct dispatch? Or are they operated as DR?

MR. BRYSON: So, that was the last slide that I showed?

MS. LIN: Mm-hmm.

MR. BRYSON: It had the five megawatts of the Demand Response. So, because it's in the regulation market, it's direct dispatch.

MS. LIN: Oh okay.

MR. BRYSON: Any storage that's in the regulation market, has to be direct. And it has to be tested and so. Yeah.

MS. LIN: Okay. Thank you. And then so, my other question was, I'm fascinated by this micro grid on the Island. I don't know how to pronounce it.

MR. BRYSON: Uh-huh. Right.

MR. BRANNAN: Ocracoke.

MR. BRYSON: Ocracoke.

MS. LIN: Yeah. I mean, and I --.

CHAIR TIERNEY: We can have our meeting there next time.

MR. BRYSON: Exactly.

MS. LIN: Yeah.

MR. BRYSON: In the summer.

MS. LIN: Take me away. Ocracoke. Well, it's -- and it's, like I heard from all of you that a great solution is micro grids, where you can integrate at one gateway. I was curious if that micro grid controller was off the shelf? Was it expensive? And, could the micro grid controller be a pathway to resolving some of these issues? And potentially addressing some of the cyber-security issues that were raised in our last panel, with The Internet of Things? And, oh my gosh, you know, the sky is falling. And part of my reason for asking is, I'm in the process of getting a house in the mountains with a lot of trees. And it's like, that's what I need. But I haven't been able to find -- that solution doesn't exist. At least, I haven't been able to -- now not at the residential level. Maybe if I was Apple Computer and had a campus, I could buy one. It's really expensive. (Laughter) But like, small consumers and, you know, I've got solar. I've got an EV. I've got an onsite generator. And none of them are integrated. It's kind of a disaster. So, I welcome your thoughts.

MR. BRANNAN: So, there's no quick answer, unfortunately. The micro grid controller was -- it's not truly off the shelf. But when you think about what it is, it's really an interface point, which you can actually run control algorithms. You can use a PC with an interface system to create something like that. One of the things that drove us to consider this, as not the solution to all the things we're talking about, but as a stepping stone towards this ultimate evolution of where we're going, that it's just one piece. But, most folks are familiar with the company Solar City. On the Island of Hawaii, Solar City introduced the micro grid controller in the home. When I recognized that, if you can do that, and I'm not advocating it's good or bad, but when you can do that at a consumer level, you've created an operational point at such a granular level on our system, what do you want to do with it? And so, what we tried to do was back away from it, and look at it from a system. And we're actually in the process of working with an agricultural -- it's a poultry farm. And working at it, looking at it from a consumer standpoint. And doing a micro grid on their system, where they already have solar, swine, waste, the fuel, believe it or not, to electricity. And we're putting battery and looking at the ability to isolate feeders. And supply from a local area.

And I think as Lorenzo said, how do you propose that to a consumer? I can't come to you with a value proposition. The reason we're able to do this, is this is one of the greatest advocates of cooperatives. This individual. And he said, I want to try it because I believe in -- I believe in the idea of renewables. He didn't ask for money. So, I think the idea here is not that this micro grid controller's the solution. But it's going to provide us greater insights into the things that these gentlemen will need. And create a greater and more robust T and D interface, because I truly believe, most of this country's not going to disconnect from the central generation model in the next 15, 20 or even 50 years. Some people may want to. But, I think what we have to be prepared for is these hybrid models that exist. And how do we manage them. And that's where this experimentation in R and D is so critical. So, unfortunately, I didn't give you a quick answer. And I didn't give you a vendor you can go and call for your micro grid controller. But I do think that one of the other things to keep in mind, a micro grid controller is not a device necessarily. You -- if you go out today and look at Apple, in Apple's home kit, you can take all the devices in your home that are enabled, Wii Fi enabled, through Apple TV, and you can run a micro grid system in your home. Google offers the same thing. So does Amazon. So, now I've just taken my micro grid controller and devalued it. Because these commercial product oriented companies, have created it. And the cyber-security question you raised, my one very big concern is, that these gentlemen here, they will do a tremendous job on cyber-security when it comes to grid managed system. The most vulnerable aspect of cyber- security is, if you went to one of those products I mentioned. What level of cyber-security posturing do they have on those devices? And what happens when they go into your home and mess up what's going on? That's the level of cyber-security I'm more concerned about, because these gentlemen, they'll take care of it.

They have a focus on what can be done. And will put enough protection and posturing in recovering, to create the resilience. I'm concerned about the consumer.

MR. PALADINO: Right.

MR. BRANNAN: So. Hopefully I did --.

MR. PALADINO: One --. Oh. One more question here.

CHAIR TIERNEY: One more.

MR. PALADINO: Gordon.

MR. FELLER: Gordon Feller with CISCO. I've looked at a lot of micro grid projects, and I'm familiar with all the manufacturers and I'm convinced that we are going to need to spend more time as a group, looking at micro grids. At the integration issues. At the regulatory opportunities for transformation at the local level. I'll ask the question without expecting a response, because I know people are busy. If you had to suggest to us a focus around micro grids, you've suggested some just a moment ago Joe. But, there are things that each of you alluded to in your presentation, which raised questions in my mind about how micro grids can be valuable as an engine for change, around some of the areas that you were concerned about in the interface. Since it is so close to the interface, the micro grid potentially represents a place where all of us can learn a lot about issues that were now just starting to sense need to be addressed. And if any of you have, you know, anything that you'd want to throw into that mix, I think we're all probably thinking about what can we as a Committee, and with our Subcommittees, and maybe in a field trip to look at a micro grid, what would you want us to really focus on, to get to the Island?

MR. BRYSON: Exactly.

CHAIR TIERNEY: And we really would welcome an --

MR. GELLER: Yeah.

CHAIR TIERNEY: -- email or anything with suggestions like that. Yeah.

MR. BRYSON: Yeah. And just, but real

quick, I'd say -- I'm going to say pilots. Even if they're table top pilots, don't go spend a lot of money, you know, do a pilot first. You know, all of the ISO's, I think, would engage in pilots and a lot of the -- a lot of the utilities as well. So.

MR. KRISTOV: I guess one thing I would add, just real quickly, is that in almost all of the industry conversations I engaged in, the cast of characters is at the top level. The policy makers. The utilities. The big companies and so on. And then it goes down to the individual customer. What's not recognized, is the community as a decision maker. And the Community Choice Aggregation in California, a lot of the drive for community level solar resources, the Ocracoke example I think, and the notion of resilience, is a local community phenomenon. So, it's not just all about the individual consumer. How can we then create the ability of a community with very -- with very diverse income levels, or wealth capabilities or whatever, to be able to implement a reliable, resilient local power system through resources that are available, and put that into operations so that it all works? Something that's replicable in that manner.

MR. BRYSON: Right.

MR. PALADINO: And so to -- thank you. And so, to close, I want to thank the panelists. They did a lot of work to come here. They travelled far. It was very, very insightful. I believe that the Committee is going to continue to explore this topic. And I think we would really like to reach back to you, and gather more insights and see if we can learn. See if we've learned everything that you've conveyed. And the, again, thank you very much. And appreciate the time. (Applause)

CHAIR TIERNEY: And thank you Joe. That was great. A wonderful panel gentlemen. That was great. Thank you. We will see you all at 8:00 a.m., bright and early tomorrow. Except those going to dinner, we'll see each other then.

(Whereupon, the PROCEEDINGS were

adjourned.)

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CERTIFICATE OF NOTARY PUBLIC

COMMONWEALTH OF VIRGINIA

I, Carleton J. Anderson, III, notary public in and for the Commonwealth of Virginia, do hereby certify that the forgoing PROCEEDING was duly recorded and thereafter reduced to print under my direction; that the witnesses were sworn to tell the truth under penalty of perjury; that said transcript is a true record of the testimony given by witnesses; that I am neither counsel for, related to, nor employed by any of the parties to the action in which this proceeding was called; and, furthermore, that I am not a relative or employee of any attorney or counsel employed by the parties hereto, nor financially or otherwise interested in the outcome of this action.

(Signature and Seal on File)

Notary Public, in and for the Commonwealth of Virginia

My Commission Expires: November 30, 2020

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