UNITED STATES DEPARTMENT OF ENERGY

ELECTRICITY ADVISORY COMMITTEE MEETING

Arlington, Virginia

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P R O C E E D I N G S

(1:11 p.m.)

CHAIRMAN COWART: Good afternoon, everybody. Let's begin. I'm Richard Cowart, Chair of the Electricity Advisory Committee. I will remind everyone as I always do at the beginning of these meetings that a transcript is being prepared of our proceedings, so please be sure to speak clearly into your microphone whenever you're speaking and be sure to turn off your microphone when you're not speaking for the benefit of those making the transcription.

We have the pleasure of welcoming to the committee a number of new members. I'm looking around and realizing that we've got some new folks here today. And I'll ask you as we go around the room and introduce ourselves for the new members to say a little bit more about themselves than maybe some of the veteran members do. And normally, we just say our names and our affiliation and then move on. But we'd like to hear from the new folks who are Sue Tierney, Janice Lin, John Adams is here, Paula Carmody, and Phyllis Currie, and I think Anne Pramaggiore will be coming in a little bit later. We'll ask her to introduce herself when she arrives. Anyway, welcome to you all.

I also have the pleasure of announcing that we have -- the pleasure of letting you know, as the veteran committee members know, that there is term limits on this committee. And a number of us are going to be leaving within the next six months or eight months due to term limits, and so we've arranged for a succession in the committee leadership. Sonny Popowsky and I are among those who are term limited. And after six really wonderful years on the committee, as of next March or June depending, we turn into pumpkins and we need to be replaced. Sue Tierney and Carl Zichella will become the chair and vice chair of the committee to succeed us. And this is a decision really made by Pat Hoffman. I am pleased to be able to make the announcement myself having talked to both Sue and Carl about it. We have some other leadership transition decisions to announce a little bit later on as well with the subcommittees.

With that as an introduction, let me just begin by going around the room and ask you to begin introducing yourselves. Pat?

MS. HOFFMAN: So I'm Pat Hoffman, the assistant secretary for the Office of Electricity Delivering and Energy Reliability. And your all advice is much appreciated from my point of view, but I did want to

-- I'm going to let these guys introduce themselves, but I wanted to recognize that we do have some new leadership in our organization. And I'm hoping that all of the new dashers, the new supervisors in our organization have some time to come to the committee because we do evaluate -- we do appreciate your opinion and your advice that you give our organization. First is Liz Dalton has come on board. She's now the new principal deputy assistant secretary for our organization. She is going to be my backup in everything and anything that needs to be done in the organization. She did come from nuclear energy, and she'll tell you a little bit more about herself.

We have Michael Pesin] who also joined our organization. He is the new deputy assistant secretary for our R and D division. His background was -- he actually came from Seattle City and Light where he was the technology strategy and manager for Seattle City and Light, and had been engaged in numerous demonstration projects for them. And so I'm hoping he will be able to come by. If he's not going to be here today, he'll be here tomorrow.

And then also joining us is Meghan Conklin, and she is the new deputy assistant secretary for our permitting division which looks at our transmission

projects, our transmission development congestion study, 1222, the technical assistance to the states, all those activities will fall under Meghan.

And then the last person that we have new joining our organization is Devon Streit, and she is in charge of -- she's the deputy assistant secretary for our infrastructure security and energy restoration, so she is looking at all of our emergency response activities that we do on behalf of FEMA and DHS, as well as the coordination with the coordinated counsel and strategic priorities when it comes to emergencies. So she has joined the office as well.

And I would just like to give my thanks to Rich and Sonny for all of their leadership for the past six years. They have done a wonderful job in guiding the committee and making sure that the topics we go through are relevant and constructive, so I really do appreciate all of the support that you've given the committee. And I look forward to Sue and Carl in taking over the leadership. You got great shoes to fill, but I know we will have -- continue to have the engaging dialogue and discussion. So with that, I'll turn it over to you.

MS. DALTON: I'll try to be quick, but, as Pat said, I'm Liz Dalton. I have been with the Office of

Electricity for going on, I think, three and a half weeks now, so very new to the organization and happy to be here today. I have much -- appreciate you all participating in these sessions. I'm coming from the Office of Nuclear Energy within the Department of Energy where I've been the chief of staff for the last three years working for Assistant Secretary Pete Lyons up until his retirement. I had the opportunity to engage closely with NEAC, the Nuclear Energy Advisory Committee. And in fact, in chatting with Matt and others yesterday, I questioned how well we work with you all and have great positive feedback and really look forward to working with you all. So thanks, Pat. I'm happy to be here. I look forward to meeting you.

MS. CONKLIN: Hi, everyone. I'm Meghan Conklin. As I work for Pat as one of her deputy assistant secretaries in a division that we call NEDD that, as Pat mentioned, oversees allowed the transmission permitting issues and also state and technical assistance. And so I'm looking forward to working with all of you. I've served in senior roles on Capitol Hill, most recently as Democratic staff director of the House Natural Resources Committee. And before that, I worked on the Senate Energy and Natural Resources Committee. I

also worked at the Interior Department as their associate deputy secretary and chief of staff to the Fish and Wildlife Service. So I look forward to getting to know all of you better. Thank you.

MR. MEYER: I'm David Meyer. I'm in the National Electricity Delivery Division, that's the division that Meghan heads, and I provide support to Meghan and Pat and anybody else that I can help.

MR. ROSENBAUM: My name is Matt Rosenbaum. I'm one of the two team leaders in the NEDD division. But for the purposes of this committee, most know me as the DFO, the [FACA] DFO, for the EAC. Thank you all for coming.

MS. CARMODY: Hello. My name is Paula Carmody. I'm one of the new members and really appreciate the opportunity. I am people's counsel for the State of Maryland. And what that means is that I represent residential utility customers throughout the state for five industries, gas, electricity, telecommunications, water, and some transportation issues at the federal and state level. So we generally have a pretty active portfolio and certainly very much appreciate the opportunity to represent consumers here.

MR. ADAMS: Good afternoon. My name is John

Adams. I'm principal engineer from the Electric Reliability Council of Texas. My background is operations engineering. I've supported operation staff at [ERCOT], and before that for Eastern Lighting and Power company for the last 30 years, I guess. My highest level in operations was director of operations about five years ago since I was involved in implementing our NODA market and then currently in our market redesign or market design group under Joel Mickey.

MS. WAGNER: Good afternoon, or actually morning for me coming from the west coast. My name is Rebecca Wagner. I'm a commissioner with Nevada Public Utilities Commission for one more day, so I'm happy to be here instead of there.

MR. ALMGREN: My name is Ake Almgren, and my professional background is electricity transmission and distribution from [low voltage Chapter 8 fiduciary] and systems control. I was in generation as well as energy storage. I also served on the PDM board where I chaired the committee and also served on the public of the board active power.

MR. BALL: I'm Billy Ball, Chief Transmission Officer at the Southern Company.

MR. THILLY: Roy Thilly. I'm unaffiliated.

I was the -- ran in the joint action agency that invoked power utility to serve 51 communities in Wisconsin, Iowa, and Michigan. I also serve on the NERC board, but I don't represent NERC here. And I co-chaired the Eastern Interconnect Planning Cooperative on behalf of ATC.

MS. BROWN: Merwin Brown. I am a buyer's professor of Sustainable Systems at the Georgia Institute of Technology, and also on the board of directors of the Tennessee Valley Authority.

MR. COE: Hi. My name is Carlos Coe, the managing director for Millennium Energy. We are an advanced power systems company focused mainly in renewables and the energy storage.

MR. CENTOTELLA: Hi. I'm Paul Centotella. And I, among other affiliations, have my own consulting company, and am a former commissioner on the Public Utilities Commission of Ohio.

MR. ROBERTI: Hi there. I'm Paul Roberti. I'm a commissioner at the Rhode Island Public Utilities Commission.

MR. SIOSHANSI: Good afternoon. I'm Ramteen Sioshansi. I'm in the industrial and systems engineering department at The Ohio State University.

MS. TIERNEY: I'm Sue Tierney from The

Analysis Group. We're lesser known than you guys are. I'm so honored to be a part of this group. I know many of you, if not most of you, and it's really great to have a chance to say hello. I am a senior advisor at Analysis Group and am in Boston and about to move to Denver where I will now be a Rockies gal. That will be fun. That's after 33 years. And if you see a couple of tears on the ground, it's just because it's hard to leave Boston. I have worked at the Department of Energy in the Clinton Administration as head of policy and had a number of state jobs in Massachusetts as head of environment and as a public utility commissioner. And I have to say that one of the things I'm spending most of my time on these days is things associated with great integration, reliability, markets associated with a clean power plant. So that's how I'm working these days. Again, it's so nice to be here.

MR. BOSE: I'm Anjan Bose. I'm a professor at Washington State University where I teach electric power engineering.

MR. SHELTON: I'm Chris Shelton. I'm vice president of New Energy Solutions at the AES Corporation, also not quite as important to make the distinction. I'm responsible for our distributed energy and energy storage

teams at AES.

MS. SANDERS: I'm Heather Sanders, and for the last month I've been with Southern California Edison, so I'm the same person, new role. I am responsible for the integrated grid strategy and engagement, so making our new future happen.

MS. LIN: My name is Janice Lin. It's really great to be here. I'm one of the new people. I'm the managing partner at Stratagen Consulting. We do strategic advisory work exclusively in clean energy. I co-founded the California Energy Storage Alliance. I am the co-founder and chair of the Global Energy Storage Alliance and the chair of Energy Storage North America which is one of the largest grid connected storage conferences in the world. Thanks.

MR. GELLINGS: Hi. I'm Clark Gellings. I'm with the Electric Power Research Institute or EPRI. I'm a fellow there.

MR. LAUBY: Mark Lauby, Senior Vice President and Chief Officer of NERC.

MS. CURRIE: Phyllis Currie, another new person. Up until July, I was general manager of Pasadena Water and Power, Pasadena, California, and also I was president of the California Municipal Utilities

Association that is the legislative group for public power there. And I formerly was chair of the board of American Public Power Association. I've been pleased to spend the last 14 years at Pasadena. Prior to that, I was the chief financial officer at LAPWP.

MR. VAN WELIE: Good afternoon, everyone. Gordon Van Welie, CEO of ISO New England.

MR. MORRIS: Representative Jeff Morris from Washington State. I chair the technology, energy, and communications and our development committee there, and the National Conference of State Legislative Energy Task Force, and I support my political hobby with my energy company that helps commercialize clean tech technologies.

MR. TILL: David Till, Chair of the Power Delivery Subcommittee, and since July the senior manager of Performance Analysis with the North American Electric Reliability Corporation.

MR. BROWN: Hello. I'm Merwin Brown. I'm chair of the Energy Storage Subcommittee of this full committee. I'm also co-director of Electric Grid Research at the California Institute for Energy Environment which is housed at the University of California Berkeley.

MS. REDER: I am Wanda Reder. I chair the

Smart Grid Subcommittee within the EAC. I'm the chief strategy officer at S and C Electric Company, and I also serve as a board of director on [Nitroply].

MR. POPOWSKY: Hi. I'm Sonny Popowsky. I was the consumer advocate of Pennsylvania for many years, now retired, and I'm the vice chair of the EAC.

MR. COWART: All right. Thank you very much, everybody. I have to say that as I hear the short recitation of people's interest and expertise I am constantly impressed by the group that DOE has assembled here. So congratulations to the department actually for attracting you all to this committee. We have one bit of business here, the ethics briefing. Are we prepared for that right now? At point -- I know the new members have received their ethics briefing, and I know that the old members have all received their ethics briefing, so I know we've all been briefed. If there's an additional formality that we need to go through once again, the department will let us know.

We also announced at the beginning of every one of these meetings that the public is invited to address the committee by signing up. There will be a sign-up sheet today and tomorrow actually. And what we do is reserve time at the end of the meeting tomorrow for

any member of the public who wishes to address the committee. So if there are members of the public present who wish to address the committee, please make a point of signing the sign-up sheet which will be posted in the foyer. All right. I think, Pat, it's up to you.

MS. HOFFMAN: So what I thought I'd do is give a little bit of an update of what's going on in the department, some of the things that we're currently looking at, so maybe some of the success stories, things that we accomplished. September 30th, of course, is the end of the fiscal year for the Department of Energy. And then hopefully with the continuum resolution and budget we will have a new year starting up with work that we'll continue to do. But I did want to give you an update, first of all.

The QTR, we did release the Quadrennial Technology Review earlier this month. For those of you that aren't aware, it is a sister document to the Quadrennial Energy Review. But the technology review is an update of the prior document that was developed by the Department of Energy where the goal was to take a very hard look at what some of the technology options are, what some of the solution sets are for a wide variety of activities that is under the jurisdiction of the

Department of Energy. So we talk about nuclear technologies, fossil technologies, grid technologies, and use technologies such as vehicles, buildings, and it's a very comprehensive document that looks at a rich set of technologies and options for advancing the industry writ large -- so it's a big document. It is up on the website. I encourage you to take a quick scan of it, look at it, think about some of the things that are in there. Specifically for the electricity chapter and section which I believe is Chapter 3, it really goes through the whole kind of plethora of technologies that I think the committee has talked about.

And I'll have to say I thank the committee members that have participated in the newer stakeholder sessions that we held in the development of the Quadrennial Technology Review. I think the document is extremely valuable as a result of your input, so I do appreciate that. We are going to post some additional documents that supported the development of the Quadrennial Technology Review. Some of these are already available on the web, some of them will be posted as soon as they're finalized. The ones that are available are the cyber and physical security background paper. The flexible and distributed energy resources paper is also

posted, and the transmission and distribution component section of the QTR is posted. The sections that we still have yet to post are the design architecture and concepts, electrical energy storage, measurement communication and control. Those are three areas that we're still finalizing in the sections, and we'll have those posted soon.

With respect to -- I had some time to think about some of the accomplishments that our organization has had over the last year. And I thought while I was doing that for our organization, I'd just share a couple with you today, some of the things that I think we're pretty proud of in looking at what we've accomplished for the fiscal year 2015. First and foremost, which I think most of you are aware, September was the final -- in fact, September 30th is the final day we can allocate funds and close out funds for the Recovery Act. We have successfully done every sort of financial transaction that we were required to do. Some of it is just like there was a small amount of money left on contracts which we had to clean up and work out, so we did everything -- now that doesn't mean that all of the contracts have ended. Some of them are still going with industry funds and the cost shared funds as part of the program. And we

will continue to follow that and continue to work on that, but there are numerous reports that are on the website that go through and take a hard look at the success stories and recovery act on the smart grid investments but also some of the lessons learned. So I think that's a significant advancement that has gone on there.

Some other things that are also things to take note of with respect to energy storage, we've been working with Washington State and Uni Energy Technologies. They did license of Vanadium Redox Flow Battery technology that was developed in partnership with Pacific Northwest National Laboratories and funded by our office. They are looking at installing different case studies and looking at the use of flow batteries as a support for the electric system.

In the area of microgrids, the State of Vermont is working on a resiliency project in Rutland, Vermont. And this was a partnership with the Vermont Public Service Department with the state. And we're really proud of some of the partnerships that we can work out with the states. But we're looking at a microgrid with energy storage and some photable ticks, but the goal was to go after emergency situations to be able to

provide power during emergency -- time periods of emergency. And so it was done in association with our emergency facilities in the local region.

The Pacific Northwest National Laboratory had a dedication in August for their new systems, engineering laboratory. If anybody has some time or opportunity to go visit PNNL, it is a fantastic facility that's looking at modeling and computation and control tools for the electric grid. They're also going to have a training facility which is going to engage in the cyber side of things. It's a very worthwhile facility that just opened up in August.

For emergency response, even though, knock on wood, I've got to be quiet, we didn't have any major hurricanes that hit the mainland United States. We did have some activity that affected Guam and Hawaii and Martin Marietta Islands. But surprisingly we actually did activate for 13 different incidents for emergency response and for our organization. Nine of them were tropical weather events, three of them were severe weather events including like cold weather, and then one wild fire we did provide some support and activation for the wild fire side of things.

From a cyber security point of view, we had

some technology that was licensed. It was a technology that was developed by Oak Ridge National Laboratory, and it was really looking at trying to take and analyze the functioning of control systems and taking a hard look at some of the source code without having disclosure of the source code, so it was a technology that has been licensed. So that is -- at least it's good to get the technologies from the laboratories and transfer out into the marketplace.

So with respect to transmission, we did release two environmental impact statements. So that's pretty good from our point of view. And we are working to finalize what we're calling a pre-application process. The Department, and rightfully so, I would say the government at large has been challenged on can we effectively look at environmental permitting and the need to actions and do this in a very efficient manner, still taking into consideration all of the environmental regulations that we have to follow but to work to make this efficient. So we have developed a pre-application process where we work with any sort of developer to make sure that they have the right materials coming into the Department, so that we can effectively process the permit and the request for either a presidential permit or a

NEPA application that's under our responsibility.

Going into 2016, I would say that we're going to continue to push the major thrusts in our organization that we are currently working on with cyber security looking at transmission, looking at technologies, advanced technologies. But some of the other things that are coming out in the dialogue that I just want to raise attention to the committee for the sake of if you have interest in the future taking a look at some of this as well, the Administration did announce a smart cities initiative. And from our organization, what we're going to contribute as part of that is really the grid side of it, investing in the grid architecture in saying, how can we continue to invest? And you'll hear that theme probably more and more with what I have to say. We are really trying to take a look at how do we continue to invest for the future? And so it's best seen in the city infrastructure, but it's also the best thing to optimize the services and the value that the grid providers, consumers, and also from a resiliency point of view. How do we prioritize some of those investments and those investment strategies?

The second area is really just continuing to look at the control system software, data, data

management, building off the smart grid technology, building off of sensors, and really trying to capitalize as much as we can from data analytics from being able to see if we can look at asset management, to look at outage management, but to continue to look at technology and capabilities for the sector from a resiliency point of point. And the third one I hinted to earlier, and that's really trying to help with some of the discussions of how do we invest for the future, making sure that we have an all-hazard approach, look at whether it's looking at climate, whether it's looking at physical security, whether it's looking at cyber security. We really want to take a strong effort to look at if priorities are in these strategies near term or long term for investing in the future.

One of the things that will come out probably over the next year is the National Academy is doing a R and D opportunity to look at risk and resiliency for the sector. And so I'm hoping that as that -- as the National Academy concludes their work we'll be able to engage the committee on that. So with that, those are some of my initial thoughts. And I know we're going to have a great meeting with some great discussions going on today with the agenda. And I look forward to a dialogue

with you in the future. Thank you.

MR. COWART: Pat, thank you. Our next agenda item is an update on the grid modernization initiative. And I believe Bill Parks is here to do that.

MR. PARKS: Kevin and I are here, and Kevin is going to walk you through the presentation.

MR. COWART: All right.

MR. LYNN: So good afternoon, everybody. My name is Kevin Lynn. And I'll just give you a brief update today on the grid modernization initiative. So why are we doing the grid modernization initiative? I think we've given you a few presentations on this before. I think the emergent threats, whether they be cyber, physical, extreme events, the onset of renewables, variable generation, both on the transmission and distribution system, plus a host of new services that are coming in presumers looking at distributed energy resources are all sort of general drivers coming from the system moving us from the 20th century into the 21st century. These are some broad drivers that we work with on the QTR in terms of what are some of the five broad drivers that are driving us from this 20th century grid to the 21st century. So the aging infrastructure being one. Looking at a mix of different kind of generation,

variable generation, both looking at variable generation wind and solar on the transmission side but also looking at reverse power flow, things like reverse power flow on that distribution, growing demands for more resilient and reliable grid, things with Hurricane sandy, Hurricane Katrina and others, again this growing supply -- opportunity for customers to participate in electricity markets through presumers and then also the emergence of the ICT information, communication and control technology, to be able to control systems, to be able to get visibility on the system, actually do controls in a whole new way that we haven't been able to do in the past. So from this, we've been looking at our vision and really been focusing on a more -- one thing I think from the grid modernization perspective, at least from my perspective and I'm originally from -- worked at Sun Shop for several years, but we focused on different attributes of the system, whether it be can we build a more reliable system, can we build a more resilient system or affordable or more clean system?

One thing I think we want to try to do with this particular initiative is how can we focus on multiple attributes at once? Can we build a reliable, resilient, affordable, clean system? Looking at all of

these different attributes and trying to do them all at the same time. So that's kind of, I think, one of the things that we've really tried to focus on. And as we move forward with this initiative, we're trying to -- as we get five, ten years down the road, how can we push that forward looking at again public policy like this, trying to make things more clean with renewable portfolio standards or energy efficiency portfolio standards.

Also, one of the things that's a big piece of this is increasing innovation, so developing a platform for innovation on the system is one of the key -- really key pieces of this. And also again to mitigate risks and to secure the nation in terms of cyber and physical threats. So these are the key attributes of the modernized grid. Forget the color. I'll try to do better with colors next time. But in terms of looking at how can we do all of these -- manage all of these attributes simultaneously? So again, reliable, secure, affordable, flexible, sustainable, and resilient. And one of the things that we're trying to do as part of our grid modernization lab consortium is actually these are -- there's a lot of different definitions in terms of -- and all in terms of the baseline across both nationally and across regions of the country. What do we mean as

part of this group modernization initiative when we say reliable, when we say secure, when we say resilient? We are working with a national out consortium to try to determine very strong, very firm definitions and what those mean both nationally and then across different regions of the country. So as we make progress, we'll actually be able to measure success against those baselines. So that's one of the key things that we're trying to do as part of this.

So we've talked about this before, but these are the six different technical thrust areas that we work within the multi-year program plan. We've got 13 different programs from across the Department of Energy that are moving into these six different areas. There's at least six different chapters of the multi-year program plan. So institutional support, starting from devices and integrated systems, looking at characterizing new devices, how can they support providing ancillary services and other grid services to the grid, looking at inner operability standards, looking at testing standards to see how multiple different devices can support the system all at once, looking at sensing of measurements, looking at new ways of low cost visibility both on buildings, the distribution system, the transmission

system, and looking at the analytics to take all of that data and be able to do something meaningful with it with operators.

System operations and power flow, how can we build new grid architectures, new control paradigms to control all of these different devices that are going on in the system? New design and planning tools, how do we know -- in ten years from today, how are we going to design a system that can actually utilize all of these new assets on the grid in a real way and a low cost way and a beneficial way for everyone? Then institutional support, how can we really reduce the risk for regulators as all of these new devices are coming on the system, being able to help them understand and develop, give them the tools so they can actually implement many of these research and development implications coming out of these six different areas?

So I think as Pat mentioned, the QTR, much of what we've done within the department of this multi-year program plan comes directly out of the Quadrennial Energy Report. It's a specific high level call out for in chapter 3 of the Quadrennial Energy Report. Also, we work closely with the QTR as well. And all of those things were stakeholder and came into both the multi-year

program plan as well as the QER and the QTR. We're in the middle. We're expecting to get back quite a host of different proposals out of an integrated lab call for modernization where we've had 14 different national labs propose areas out of the multi-year program plan and giving us proposals. We're expecting those tomorrow. We're, in the near future, looking at ways where we can actually do funding opportunities together across 13 different programs. We are working on that right now. Obviously we're also looking at CRADAs and other ways we can provide technical assistance, and that also ties back to the lab call itself.

This is our organizational structure. I think one of the things that take it way across is we have each one of these lower -- we have our executive committee, which Pat is the chair of. Looking with S4, what David Daniel sent from energy efficiency and renewable energy, and Melanie Kenderdine from EPSA, the DOE leads, Bill Parks is the chair, I'm the vice chair, as well as our national lab leads, Carl Imhoff] and Brian Hannigan who have been here before as well. We also have our six technical team leads, representatives from each one of the national labs that lead each one of those six technical areas that I just showed before,

devices, institutional, design and planning, et cetera, that lead a whole host of about 65 different national lab members, about ten within each one of those different areas that are focused on actually using this structure to respond to the lab call that's going on right now. So this is a broad stretch of the energy -- Electricity Advisory Committee is up there as well advising us as well.

So this is some of the broad areas of the grid modernization lab call. I mentioned some of the foundational analysis creating -- you know, one of the things was really just trying to create a baseline. What do we mean by reliability, what do we mean by resilience, and what does it look like across the country? That's one of the things that we ask from the national labs. Core activities include -- help us develop a baseline or sort of an overall structure for evaluation for grid architecture, a sensing measurement strategy that we can apply across the board. Device characterization, what kind of services can devices provide? Those are some of the core activities we worked with. The pioneer regional partnerships were one year partnerships. We were going out to places like California, Vermont, Hawaii, across the country trying to help them with their grid

modernization efforts more specifically. And then foundational technical areas, basically within the multi-year plan, we have developed all sorts of different targets within the multi-year plan in each one of those six different areas. Join proposals across multiple labs to apply and then try to address each one of these areas for FY16, that's in the multi-year program.

And then one of the questions that we've had is -- when you have all of these six technical areas, how do you pull it all together? What does that mean? So we have these demonstrations where we're really looking at how can we do demonstrations both on the transmission system and the distribution system that basically take all of those attributes and look at them in an integral way. So how can we -- one of the major achievements when we're trying to pull these areas together is wind solar power systems. So can we basically help utilities -- instead of having a 15 percent reserve margin, look at -- with generation, look at maybe a 10 percent reserve margin using distributed energy resources, using a variety of new tools and technologies that are coming out of the R and D efforts. Within the multi-year plan, making it more affordable, maintaining the same level of reliability. And at the same time, when you're pulling

all of these distributor energy resources, can you make it maintain security as well when you're bringing all of these different devices into the system? And you may be needing more reserves as you bring in more clean technology, like wind and solar into the system, can you really lower reserves, generation-based reserves, while bringing all of those clean devices onto the system and, of course, maintaining resiliency?

So a second demonstration as are on the distribution system where we're looking at developing increasing the amount of clean energy, looking at a more reliable system, focusing on microgrids, targeting fewer outages and shorter recovery times. And again, when you're pulling all of this DER onto the system, can you maintain security when you have all of these new devices on the system? And I think one of the more important things that we've heard from the EAC a number of times is trying to develop the right set of tools for folks to be able to implement these new strategies. If you're trying to modernize the grid and understand the implications of a modernized grid -- most people don't have the tools to figure out what it means to put hundreds of thousands of distributed energy resource devices on the system. How do we build those new tools so we can help and form

regulators, utilities, and others, the impacts of what this means ten years from now? What does that mean? What do those tools look like? So that's one of the things that we're trying to build here as well as one of these demonstrations.

So I think our request really from this committee, and I think you have a lot of great ideas that I've heard just even this morning, we have this multi-year program plan. We're going to try to finalize Version 1 of it in the next few weeks, but we're also going to actually try to look at a Version 2 coming in the spring of next year. And we're going to have multiple different workshops on each one of the chapters led by one of the national -- by the grid modernization lab consortium. Getting your input between now and then and attending these different workshops and providing subject matter experts to attend those workshops would be very helpful, I think, for us.

Also, as I mentioned, all of these solicitor proposals are coming in tomorrow for our grid modernization lab call. They're covering a range of the activities they covered here this afternoon. Getting your input on once we actually do some of the selections, helping us sort of -- giving us ideas on how to shepherd

some of these projects through because some of these are one year projects but many of them are three year projects. And many of them will have implications for all of the people in this room in terms of R and D and what comes out of them, getting your input on that, and again participation at all of the technical workshops. We expect not only to have workshops that will help us with MYPP but also we hope to be teaming with EPSA to be doing -- just getting more regional information across the country so this can be more impactful to all of the different parts of the country. So with that, I'll take questions, if we have time for questions.

MR. COWART: Any questions on this? Because I think we'll then turn to a discussion that Anjan is going to lead about the grid modernization working group. Merwin?

MR. BROWN: Merwin Brown, University of California. Maybe you said this and I didn't catch it, but on the lab call, did you sort of pre-allocate how much dollars was going to go to each area, or did you just leave the whole thing open and sort of let the ground-swell determine the allocation of where dollars get spent?

MR. LYNN: So we did designate a certain

amount of dollars. We had two -- so it was basically about a $200 Million set of solicitations. One we called foundational which looked across multiple offices, funding important areas out of the multi-year program plan. The other was more program specific which focused on -- again still on a multi-year program plan but within each one of the different programs areas of activity. But we did on the foundational side look at, hey, for a baseline, how much money do we think we need to do for a baseline? How much do we need to do for a grid architecture evaluation? So we did targets and values for that. And that's available on the web by the way. We can provide it.

MR. COWART: Billy?

MR. BALL: Billy Ball, Southern County Transmission. Kevin, you mentioned maybe -- I think you said maybe half a dozen technical workshops; is that right?

MR. LYNN: That's correct.

MR. BALL: Are you trying to get all of those in? It sounded like before the spring?

MR. LYNN: Well, we're trying to -- we would like to have a Version 2. We would have liked to have it earlier, but I think January is probably a reasonable

time to start having those workshops, so we were looking probably in the January to March time frame. And we'd like to have -- Bill can talk more about this too -- a grid submit. So sort of, hey, we've got Version 1, we've got all of this input across those six different chapters for Version 2, and then sort of have a broader grid submit so we could sort of talk more about the MYPP itself, some of the early winds on the lab call, and also just sort of pierce MYPP 2.0 as we go forward, and here's some of the work that we've been doing.

MR. BALL: I would just encourage you to, if possible, to get some dates out there as soon as possible. That time of year right after the first of the year, there's just meeting after meeting after meeting. And I know that these would be some good things to attend, and I would just hate them to get lost in the chaos of the first of the year. So if you could send those out as soon as possible, that would be great.

MR. MEYER: Billy, thanks for saying that. We appreciate it. We're also trying to say -- work on some of these -- hook up like to the NAERC meeting or whatever else and then also EPSA is planning meetings as part of the QDR 1.2, so we're trying to coordinate with them, so we don't ask you to go to 18 different meetings.

So we're trying, but we may only be able to get it down to like 15 or 14 or something.

MR. COWART: Along those lines, do you have sort of a lineup for how you're carving up the topics for the technical workshops, or are they more geographically spread and everything is going to be on the table at every one?

MR. LYNN: I mean, we want to do it by chapter. So if you go back to -- or if I went back to the actual breakdown here, so we have the six different technical areas. You can't really read it, but we have the six different technical areas each representing each one of the chapters. We haven't decided where and when exactly they are going to be, but hopefully there will be some geographic disproportion, and we'll be all in the same place.

MR. COWART: All right. Thank you. Anything further? Anjan?

MR. BOSE: Okay. I thought I'll fill you up on what the working group is doing. As you may remember, we formed a working group last -- at the last meeting to help with the grid modernization effort here. And I think Kevin put up on the last slide the things that they would like us to help with. We've had a couple of phone

conversations and a meeting this morning, and we're still trying to lay out what the working group will do. So just to give you an idea of why it's not more definite than that is that what we had -- after the last meeting actually, Bill and Kevin provided us with the drafts of the six chapters, those six different areas in the NYPP. So we had a chance to react to those on our phone calls. As the NYPP, those six chapters are finalized within the next couple of weeks, I believe. I think our job is to sort of give the feedback on those six chapters. Five of them are technical, as you noticed, and one of them institutional.

One issue that we kind of first batted around was the fact that these six chapters are not separate chapters. The plan is an integrated plan of all those together, and so the -- one of the thoughts that we had was to write an executive chapter or help Kevin and Bill write an executive summary off those chapters and how they integrate. So the words that were batted about were words like integration, reliability, planning, system planning, system operation, simulation -- end to end simulations, those kind of things. Those kind of bring together to separate out grid research from component research.

The other thing I think we're kind of working with is the moving landscape as you heard that the QER has a chapter on grid modernization, the QTR has a chapter on grid modernization, and then of course this whole thing is on grid modernization. And so Kevin says that they were already taken care of, that all of these map properly. But the QER, as Kevin pointed out, the same team is going to -- the next thing they're trying to do is to get more details on each of their sections. And the first section they're going to work on is grid modernization. So there's a chapter on the grid. So all of these are moving. In the meantime, the lab call has gone out, and we will have in another month or in the next four to six weeks a set of projects that the labs will embark on as has to do with addressing some of these issues.

And finally, of course, people in DOE are working with the budget tasks. So the future of these issues, of course, depend -- the future of this research is, of course, dependent on whether the money comes in or not. So budget 2016 is sort of slipping away, I think, and we're now working on budget 2017. So all of those are kind of on the table for discussion. So if you have any advise for the working group, we'd be happy to take

them.

MR. COWART: I should also point out for the benefit of new members that this committee is a very participatory committee. And the way we work is that there are some established subcommittees, and then there are working groups. And the established subcommittees tend to stay in place for a long time year after year. A couple of them are actually mandated by congressional act. But the working groups are ad hoc and work on projects that the committee members themselves feel are important and need to be done. So we are constantly in the process of recruiting members of the committee and especially the new members of the committee because we want to tap your brains as quickly and thoroughly as possible. The committee doesn't really have a staff to produce the written work that we produce. By intention, the idea of a FACCA committee like this one is that we ourselves are providing advice to the department individually and through our deliberations as a group. And for that reason, we don't hire staff to prepare papers for us. We write them ourselves. So I'm saying this now as the new members are sitting here to remind you that we will be --

MS. TIERNEY: Why didn't you tell us before?

MR. COWART: We will be recruiting you, and we want you to volunteer to work on the issue areas really concerning you and where you can make a contribution. We have such a huge amount of talent in the room. I didn't want to let the moment pass as we were discussing the launch of this new working group on grid modernization. Thank you. We should, Sami, make sure that we pass around the sign-up sheet. And people should feel free to speak with other members or with me if you want to talk about appropriate assignments and how you can plug in and participate in the work of the group. Anything further on the grid modernization?

Next is a panel that has been put together by the energy storage subcommittee, one of the statutory subcommittees, and Chris Shelton will lead that off.

MR. SHELTON: Okay. Great. Because I was in the leadership meeting, I didn't get a chance to meet all of the participants. Go ahead and come on up, the panel participants. So before I introduce the panelists, I want to give a little bit of a background. No slides except for this one. We have been working on the energy storage subcommittee focusing on trying to find new ground where we could encourage additional analysis by DOE in the area of energy storage adoptions within the

spirit of DOE's mission and our objective here as EAC in advising their activities. Earlier this year, the subcommittee came up with the idea of -- or it may have been the end of last year, early this year, the idea of high penetration of energy storage. So as a backdrop to the panel, I want to encourage everyone here in case you haven't heard about what we're trying to do here to think about sort of the mid 2000s, maybe early 2000s, as renewables were being brought on to the system and many years before that. I believe this analysis actually started in the '70s by what became DOE later. The idea that if we were going to have a lot of renewables on the electric grid, we needed to analyze that and think about what it meant to have 30 percent of our energy on the grid coming from renewables, or 50 percent as now California and other folks are talking about.

The government in the form of DOE and NREL did a lot of good work in exploring what it meant to have a large percentage of renewables on the system, what the implications would be, what we would need to work on as stakeholders to advance the adoption and the absorption of renewable energy on the electric grid. So that's the analogy, I guess, that we're starting this panel with in saying we felt like, as an energy subcommittee, that type

of thought and exploration of a high penetration of storage had not been fully done. There are studies out there that have attempted this. They've come at it from different angles. A lot of them have been limited by technology aspects and hurdles of wondering whether technology would show up or wondering what the cost of the technology would be and how that might limit the amount of storage you would have.

What we're trying to do in this work product and ultimately a paper that would come back to the committee is explore without those constraints, assume that technology evolution happens, and that there is a quality efficient energy storage resource capability that can be deployed. And then let's fast forward and think about what does that mean, and then what do we need to do if that's a possibility in our future. So that's sort of the backdrop.

So before we go into the panel in detail, I want to allow each of our expert panelists to come up and share their perspectives on storage and also their background and what they're working on, so that you understand their perspectives and we get the benefit of having their perspectives as a foundation for what we're talking about today. So I want to start with Ed Cazalet.

He's from TeMIX and Megawatt Storage Farms. He has 45 years of experience in the industry, and he holds a Ph.D. from Stanford, so let's go ahead and listen to what Ed has to bring.

MR. CAZALET: Well, thank you. I know many of you in the audience but certainly not everyone. I'm going to be talking in the next five minutes about my perspective on high penetration storage and particularly the role transactive markets can play in support of that. I'm a markets guy, but I'm also the guy that initiated the concept of the mandate for storage in California, so I'll talk about mandates versus markets, two Ms.

Next, my background, I've developed markets such as automated power exchange, the first online power exchange. I've been on the board of governors at the California ISO, so I see it from that operator point of view. And I've been working on storage for some time.

As Chris said, we've got -- doing really well in renewables. We've got low-cost solar right now, and it's getting cheaper. We got this quest for resiliency. We're getting inexpensive, low-cost storage. We're getting high volume manufacturing. I suggest that what we're going to need is markets as systems where any party can install storage when, where, and any size, and move

it when he wants to. We need coordinated decentralized operation investment, and we need new business of regulatory mile. Storage is going to change the game in electricity just because it's a two-way system that is neither generation nor load.

What's going to inhibit high penetration storage? Attempts to centrally dispatch. Just think of the problem when I've got millions of batteries out there all made by different manufacturers, all a different age, all a different state and charge and temperature and degree of wear. I don't know exactly what those batteries are because they're moving. Each of the batteries is a different purpose for the -- it also may have a grid purpose. How are you going to centrally dispatch that? You can't. So we need systems that will do it differently. One approach is to say, well, we'll just aggregate that and create a virtual power plant out of that. When you do that, you lose a lot of information, you lose a lot of control, and you really don't get what you want.

Along those same lines, well, we'll just create this independent distribution system operator on the distribution grid. It will act like an ISO for the distribution grid and centrally dispatch all of those

resources. Same problem even more complex. And then you got to coordinate it with the system operator. So an impossible coordination problem. You've heard in this panel the concept of transactive energy, and certainly you've spent some money and time with PNNL necessary and transactive energy. The approach to transactive energy I'm describing here is different. It's got four big ideas in it that are fundamental to the way the industry has worked and ought to work. First off, it's not just about spot pricing. It's about coordinating forward investments by consumers, producers, transmission owners, and that sort of thing using transactions that may involve a negotiating process, involves price and contracts.

Secondly, you spot transactions to coordinate operations end to end on the grid. In this new framework, all parties can act anonymously coordinated through these transactions. And when you look at it very fundamentally, there are only two products, energy and the ability to move energy from one point to the other. Start with a simple product rather than starting with lots of complex problems. It creates new business models. I have a book called Transactive Energy, a Sustainable Business and Regulatory Model for

Electricity. You implement this on platforms like -- everybody is talking about platforms for transactions. Here you have a platform in the middle. The set of intermediaries help create a market, sets that energy service providers, the presumers, the storage owners, the producers and consumers all can receive offers to buy and sell both current and forward so they know how to make decisions.

The transport services parties can also participate in this market in a similar way. What does that look like from an individual facility? Imagine a facility where a home, a business in this cartoon-like facility where the car comes home, plugs in, and it knows -- it can buy or sell power for the next five intervals, five minutes after that, five minutes after that to the rest of the day. The owner knows he needs the car charged in six hours. It can be done in three hours. So it goes and finds the cheapest set of five minute intervals and buys the power in those five minute intervals. Some intervals can reverse flow and it can sell back power and make money.

The wind changes, the solar changes, it can re-optimize that all done in a decentralized way, all interacting. The same concept applies to the battery in

the home, the water heater, the generator, HVAC system, anything out on the grid. This is what transactive energy looks like when you implement it. So I'll be coming back and addressing some of these issues during the following discussion. Thank you.

MR. SHELTON: Okay. Next I would like to invite Susan Kennedy up. She's CEO at Advanced Microgrid Solutions doing work at the edge of the grid. So please welcome Susan.

MS. KENNEDY: Thank you. I've decided to change my name. I'm going to be called Donna Quixote. I'm going to -- my job is to do everything that Ed Cazalet says is impossible. Can I control the slides? Yes, okay. So my background is I was Governor Schwarzenegger's chief of staff and in that role did a lot of the policy work on climate change, low carbon fuel standards renewable portfolio standards. And before that, I was Governor Davis's cabinet secretary during the energy crisis in California where I led under the emergency demand response campaigns called Flex Your Power. We shaved 5,000 megawatts off peak using voluntary building management systems.

In between those two stints in government, I was sentenced to the Public Utilities Commission where I

focused for three years on mostly energy efficiency renewables telecommunications, but I really -- my job was to help straighten out the energy markets in California and put in place what is now called the loading order energy efficiency first, demand response first, renewable second, fossil fuel third. And that is the loading order which our procurement is still organized today in California.

So the seminal experience for me though was during the energy crisis where we had to figure out how to control our fate by tapping into the demand responsibility of the buildings themselves before we had smart meters, before we had many of these technologies that were out there. So I learned a tremendous about the power of that. Co-founder in AMS was Jackie Pfannensteil who was the -- she was a chairman of the energy commission in California, and then she went to the Navy as the assistant secretary for energy in the environment where she did a lot of the Navy's microgrid work. So Jackie and I started the company because we saw that in California where we have moved the needle on renewables to a great degree permitting 5,000 megawatts of renewables in 2009 alone, and then 7,000 in 2010 -- or the next year. We've sort of become the victims of our

success.

And when San Onofre nuclear facility was taken off line, we suddenly had problems balancing the load even though we had brought on -- we had a 44 percent reserve margin in California. We had trouble getting the load or the generation where the load was, so we realized that the secret to moving forward is going to be upgrading the distribution grid and focusing on demand response and behind the meter. So what we did was focus on the -- Southern California Edison was doing the first all-resource procurement in California where demand response and renewables and peaker plants, gas fired would all compete in the same procurement. And so we had to take this concept of using demand response with battery technology and software and advanced software and make it look, feel, act, value just like a capacity resource that the utility could value alongside a generation plant. And what Edison did was truly, truly groundbreaking in that they bought a product, a capacity product that came in the form of demand response and they valued it in the same way they would value a peaker plant. And so we won a 50 megawatt contract with Southern California Edison. And so I now have one revenue stream which is a capacity payment from the

utility. Now, I have to go and develop the additional revenue streams that allow this new model to be economic. So I'm just going to describe a couple of our projects so you get sort of how we're doing this.

The first ten megawatts of our project is a concentrated 26 commercial office buildings owned by one owner, so we have one agreement with the owner. They gave us their fleet of buildings in this particular area concentrated around substations where we know the grid is vulnerable. And by concentrating the largest systems, we can develop as much of the building load as possible, we are using the building load itself as the storage unit, and we are able to shave 25 percent off their peak demand reduction. It saves them almost a million dollars a year. There's ten megawatts of firm dispatch able capacity for the utility, zero emissions and zero distribution upgrades. And so you can see by the -- we are basically -- the batteries turn the building into a hybrid electric building where it shaves its own peak, and then we reserve enough capacity so when we get a dispatch order from the utility we can develop the designated amount of load, and we operate the whole 26 buildings as a portfolio. And so that ten megawatts will always be there when the utility needs it.

Some of our projects are big industrial facilities like waste water treatment plants where we're using the batteries to firm and shape the on-site solar that's already on the facility. And you can see from this that not only does it -- because we are integrating the solar with the batteries for the host customer, they're saving an enormous amount, anywhere between 8 and 15 percent of their bill, and it helps to pay for the system. In addition, we're also reserving the same capacity for dispatch to the utility.

So in my view, the technology exists out there today in order to lead to a world where penetration of storage is very deep. But in order to really get full penetration, we'll need to have building standards that require all facilities to be able to store their own energy, have advanced metering and auto demand response built in. We don't think about energy efficiency in California today because we put in place some of the very forward leaning aggressive energy efficiency technologies 40 years ago. And today, it's an enormous asset, enormously valuable, but we don't think about it because the buildings come equipped with that.

Some day if you want to get to really deep penetration, we can't think about the fact that --

someone has to pay to install the AMI and the ADR and the storage stuff today, which makes it very cost prohibitive. If all facilities came with that built in, it opens up a lot of the -- takes a lot of the cost out of the system. The distribution system -- right now, we have these artificial lines between where the distribution system begins and ends, and we have to be able to eliminate that line. The distribution system does not stop at the customer meter. That's an artifice. And it's a market based artifice. So in order to -- if you're really going to tap into it, there has to be some -- a seamless integration so that we're using building load that's backed by storage for conservation, voltage reduction, and managing the distribution -- and avoiding any of the distribution upgrades that are being planned today. Rate design has to incentivize energy storage. As simple as a differential between peak and off peak so you can charge the batteries cost effectively at night so that any utility can look at the levelized cost of energy and be able to compare that to the distribution upgrade or the capacity that they would be purchasing.

The market rules have to be clear that allow wholesale participation. Right now, the contracts that we're negotiating, it's unclear whether or not our

product can even be sold in the wholesale market, how it's measured and settled. Well, utility can't value a product if they don't know whether or not it can be used at the wholesale level. They don't know how to value it, so they can't issue contracts.

A couple of final points. The utilities spent about $100 Billion a year in 2014 on the distribution system alone. We're chasing the load curve. And if storage and auto demand response software is deployed throughout, we can actually be reshaping the road curve, and we can do it a lot more cost effectively than we are today. We're at the very, very beginning of being able to articulate what the various uses of energy storage are. And I'm talking to host customers today with a couple of our projects about the multiple uses peak shaving they get, load shifting, load shaping they're starting to get. We're seeing clients where they've got enormous potential for negative demand recapture if we can -- if we can set up the batteries that way. The backup power, the power quality is an enormous issue for most of these folks. So finding a way to value that when -- on the customer side of the meter is a key. Instituting the auto demand response, the transparency, so this type of a resource at the disputed

level is controllable and transparent in real time to the utility is absolutely critical. We're only at five percent today where we even have a two-way verifiable signal on load management, five percent. So we have a long way to go before we can access the distributed resources by the utilities.

The key in the long-term is going to be to be able to have these distributed resources deployed, to have this transparent communication system in place, and to be able to literally manage demand below -- at the feeder level for purposes of congestion relief or peaking and spinning reserve and things where you don't need to have a generation resource and move that energy from one place to another to do it when you have the built-in capability at the buildings themselves.

Finally, this is, I think -- the area that we're working in as an aggregator of these resources, we're really the pioneers at the grid edge. And everything we're focused on is eliminating the lines between the grid -- the customer side and the utility side so that we can ascribe multiple values on both sides of the meter to an energy storage system. For one energy storage system that's installed can produce peak shaving energy cost reduction, islanding capability, demand

response, solar integration, be integrated with EV charging. On the utility side, it can be performed dispatchable capacity, volt VAR optimization, generation sync, and all of these products in the wholesale market. And a distributed resource aggregator, I believe, is the key in order to be able to put these in portfolios that are utility facing not customer facing. So instead of us going out and trying to sell our equipment to everybody under the sun and then aggregating that load and trying to sell it to the utility, we're actually designing these installations in an area where the utility needs it in a concentrated area so that it's a resource for the utility. I'll stop there.

MR. SHELTON: Thank you, Susan. Next we have John Shelk from Electric Power Supply Association.

MR. SHELK: Good afternoon. It's a privilege to be here with so many folks I've worked with over the years. And whenever I'm before a DEO audience, I always have to say we are the other EPSA. While I worked with Melanie [Kendradine] well into the last century, we kid that the acronyms are the same, but we're still the vintage private sector EPSA. Basically, this slide, I think, folks are well aware of us. We have over 200,000 megawatts, fuel diverse megawatts. And the important

point I think for purposes of this discussion is that over 95 percent of the membered megawatts are in the RTOs and ISOs where our members are relying on market revenues from energy capacity and ancillary service markets to make investment decisions and to provide service.

I wish everyone had to be a member to get a market based rate approval from FERC, but that is not the case, so we have many nonmember competitive suppliers that make up about 40 percent of the capacity in the country. And I think it's important to say that underestimates the importance of those dependent on market revenues because there's many -- I think all around the room know -- many regions of the country from New England, New York, PJM, and certainly Texas are almost entirely served by competitive suppliers.

We're very interested in energy storage. It's an issue that we had a specific panel about at our annual meeting this past year. We don't have a specific association policy, so I'm making these remarks, and I appreciate the chance to offer, I think, a point of view you might not otherwise hear based on our overall policy about well-functioning markets. This list is -- well, let's see if we can advance the slides here. There we go. I think this is well familiar to everybody, and I

won't go through it too much except to say that a lot is already happening.

As everyone knows from technology changes public policy changes, such as the clean power plant which we certainly welcome. There's a lot of potential for good things to happen. There's a lot of potential for some unintended harmful things to happen. And based on the discussion coming into the panel and Chris's description, I sort of say on the uncle of some submit, and I think that's sort of the premise of some of the discussion that you have to have a high penetration of energy storage to handle the rise of distributed resources and renewables. I'm not here to say yes or no. I'm the lawyer not the technical expert. I would just point out that as we heard at our annual meeting and if you look at some papers just yesterday, [Enese] ClimateWire talked about a new paper from two professors at Harvard who challenged the assumption that at least in the short-term high penetrations of energy storage would be needed. There was even an American Chemical Society paper the last couple of months saying that emissions may actually increase from storage. So the main point I'm trying to make is I think it would be incumbent upon the department and the committee to really take a

comprehensive view of all of the effects of having a higher level of storage not assume or work backwards from an end state that some might desire but instead define attributes and functions and determine the best way to go about it.

This is a rather busy slide. You can look at it later. I would simply say that the most important point for me in this one -- and I'm glad to discuss any of the seven, but the key is really the impact on energy market price formation. It is the largest single source of revenue for generators such as those I represent and others in these competitive markets. And as I mentioned at the outset together with capacity market revenues really determine the investment decisions including new investment, maintaining existing resources, as well as decisions about retirement. We already know that the resource mix is changing. It will continue to change. That change will accelerate. But the one thing we know it's not overnight. So whether you pick a future percentage of any level, the balance of the resources are still going to have to be met from things that are not related to storage, and you certainly can't bolt on or add a high level of storage without looking at how it impacts the rest of the market. And this isn't something

that I'm just saying that we're just saying because that's who we are and this is our source of revenue.

To his credit, Secretary Moniz has been very actively speaking about energy price formation issues in recent weeks in [Borums]. Most importantly, the Federal Energy Regulatory Commission began a project on this topic over three years ago now at the staff level and publicly really very vocally since the fall of 2013. Just earlier this month, the commission launched a notice of proposed rulemaking that's really the low hanging fruit of how do you deal with some mechanical aspects of how energy prices are formed in these markets that these plants rely on. And it's really around pretty technical things that are important but nonetheless technical like syncing up the dispatch intervals and the financial settlement intervals and looking at other aspects particularly scarcity pricing.

But the commission most importantly into the credit of all five commissioners on a bipartisan basis, they spoke of the importance of tackling a broader set of energy price formation issues. And I mention this first because I think it underscores the importance of the issue. It can't be ignored. It shouldn't be ignored. So other policies and options that might be pursued

should take this into account. And it's not just a theoretical problem, it's a problem that's already happening today. So if renewables increase their penetration because they're cheaper or because of policy mandates, either way the conundrum that we're now facing, and I think we all have to grapple with in this context and others is these are essentially low to zero marginal cost resources at a time when the market design essentially dispatches plants on a marginal cost basis. So we already have the challenge.

Subsidies make the challenge arguably more intense. I think as the commission whose forward in price formation and they've said they're going to look at four topics uplift drivers, uplift transparency, mitigation, and energy market offer caps. You are going to see folks -- and again, this is one since I've got members with water renewables and nuclear and gas, you can imagine some of the differences internally. But I think as the price formation issue moves forward, you're going to see people come to the floor with proposals to deal with the existing challenges not so much in what would happen with storage. And storage could -- frankly could go in two different directions, and so I think some of the work that needs to occur is to try to quantify

that or at least be aware of it. So obviously at off peak hours, shoulder time, a storage charging could actually increase demand during those times and address some of the loathe and negative prices that exist today.

On the other hand, when storage is discharged depending on all of the rules and the issues that Susan and Ed mentioned, you could actually have a crashing of the market. So at a time when energy price is already at historic lows, decisions are being made about investment. The take-away here isn't to say that a storage is good or bad. It's something I think that's coming. We are going to see more of it. My only point, I appreciate the chance to make it, is that we sort of have to take and should take a very comprehensive view to make sure we're looking at this from all of the different angles not presupposed and end state but talk about functions and needs. And it's referred to in Order 755 that's helped storage so much on the frequency side define the function. And they'll let people compete on a market basis to provide that function in a cost effective manner. So again, I appreciate the chance to participate and look forward to the discussion. Thanks.

MR. SHELTON: Thank you, John. I'm sure everyone is chomping at the bit to have a little bit of

conversation about this. We will have plenty. So next I want to invite Mark Irwin up from Southern California Edison. He's director of technology development and responsible for energy storage, the energy storage area. Thanks.

MR. IRWIN: So thank you for having me here today. And I'm going to obviously share a little bit different perspective and some different thoughts than the rest of the panel. My role and my history, I've spent a lot of time in power project development and renewable contracting, in the last four and a half years in energy storage. We've had the great opportunity at Edison to have two ARRA projects that the DOE has supported that's actually a lot of our experience that I'm going to talk about today. So that's helped form what we're doing, and we're really appreciative of that. And I saw the list of opportunities coming up, and I know I've signed a couple of letters to support on different things that are being proposed here in the next few days, so we look forward to continued participation in many of the DOE programs.

So first of all, what is Edison doing? And I'm going to try to put a box around what we're doing and what I'm talking about, so what I'm focused on is utility

owned storage. You heard Susan and Ed talk about market opportunities. At Edison, we're buying market only products in the market. We're buying demand resource products in the market. We're looking at developing utility owned storage for the distribution system that will support the distribution system and also participate in the market when distribution doesn't need it. So it's a little different, little different angle, and it's an angle I think we're one of a few that are playing in that space.

First of all, what's our work informed by? So we've had for a little over 20 years our electric vehicle technical center where we have done work in testing batteries initially for transportation, but we've tested battery chemistries for both transportation and grid in the last few years as we've seen storage, grid storage emerge, and as we've had the two ARRA projects. We've looked at system and subsystem lab testing. We've looked at field demonstrations and pilots. We have our large [e Hatch By] project which is one of our DOE demonstration projects. The other is our urban smart grid demonstration project actually has four different storage systems in that broader smart grid demonstration project. So we've learned from those. We've recently

deployed our first pilot project that we deploy just before this summer out on the distribution system to solve a particular problem so different from demonstration where we try to show what a device can do. We've actually got a device out there that's reliant, the system is reliant on it. And we're moving towards a greater system deployment.

So again, I talked about what we call dual use storage, applying energy storage as a distribution asset and when there's no distribution function need which people have described before, Susan did a great job of talking about the peaking of the system, the distribution system has some needle peaks that we do a lot of our planning and asset build about. As we go on and flatten those peaks out obviously it will change the build but today we see storage as helping us meet those distribution peaks which occur fairly infrequently, and so there's a lot of time for the device to participate in the market when we're not in that situation.

So on the distribution system, one of our biggest challenges is, and we think a right area for utilities generally is what's the value look like? So the value we know is the distribution asset we're going to defer. And we can decide, okay, we've got a wires

upgrade at a particular location, and we can look at what that cost defer is. Things that we're starting to learn that we know there's value to but we don't have all of the value to yet is what can we do about equipment life extension, whether it's extended the life of a transformer by not putting as heavy duty on it, whether it's providing voltage support instead of an alternative device that's doing that. Some of the unknown values that people in storage space are wanting to take credit for and quantify, but I don't think we've yet proven what they are and exactly how to value them. And I think that's some of the things we're talking still about in market space. But distribution space, what's the value of power quality and improvement? What's the value of DER integration? Can we enhance that with storage? What's that incremental delta? Is there value in the reactive power capabilities? There's value, what is it? How can we improve that? What's the uplift and reliability, if any, from a distribution storage device? And other identified values. So this is an area that we think is really ripe for work. And I think it's challenging for utilities to say, I want to build something when somebody hasn't proven the value streams. And I think the market value streams we can assess and

think about, but I think we're still challenged by the distribution market streams. And this is some of the work we're doing as a company today, but it's also some of the work we think that is good to be done in the research area.

So just to conclude my remarks really, you know, some of the gaps we see as we -- in deploying systems is around reliability of system. So when we started deploying these systems from our ARRA grant, we were contracting for these systems in 2011, 2012, started deploying them a little bit after that. We found a real lack of grid readiness of systems. Now, I'd say we've had five years that we've progressed through this. We've seen tremendous improvement. We've bought a number of systems over the past few years. But we still don't see universally good quality product particularly in the integration side.

I think we have battery systems that work, but the software integration and integration into the grid which is another challenge on top of that is an area we see still for further improvement. The value streams that I talked about being able to see what they are and be able to show that we can capture them and capture them simultaneously. The challenge is also if you see five

value streams that are each worth 100 and some of them take something that looks like simultaneous operation, or maybe it is simultaneous operation, can you get 100 percent of all five, or can you get 95 percent of one and 93 percent of the other and 50 of the other? How does that really work? How do we validate that?

And then I think the last is something that I heard described in a lot of things that you're working on in smart grid space is around communication and control. And I know Susan mentioned that also. Communication and control of all of these devices out on the system is going to be crucial to be able to integrate them together in a very rapid manner that's what storage can help do, but they all have to work together effectively to make that happen. So thank you for this opportunity, and I look forward to the discussion of the rest of the panel.

MR. SHELTON: Okay. Thank you, Mark. And thank you for the rest of the really great insights for what we need to address and think about. I want to make sure that I set clearly again the objective. And John mentioned that we don't want foregone conclusions of a high penetration of renewables or of storage. And I think we -- I want to be clear again the purpose for exploring this is precisely some of the things that John

has raised. If we find out that a high penetration of storage for whatever -- however that occurred is going to cause price formation issues, it's important that we've explored the concept of having a lot of storage before that happens. This is exactly the type of thing that we want to explore in this -- in the high penetration of energy storage paper. And it's meant to focus on the latent benefits of such a world and also the latent challenges of such a world. And that's the intention. So in that spirit, we are going to do a little bit of a round table session now for about 15, 20 minutes. And then we'll open it up to the rest of the group as well. So to continue the discussion, I had sent around a few thoughts to the panelists beforehand just to encourage some thinking on this. So I want to start with Ed.

I'll direct the first question to Ed. As an instrument to support thinking about a high penetration of energy storage, let's assume it's 2030 and there is a high penetration of storage according to the industry at the time. So at that time we think, wow, we have a lot of storage on the grid in 2030. You as someone in the past who has put out a number for California, for instance, of the amount of storage California should be taking seriously, what is a high penetration of storage?

Kind of on a percentage basis of peak power and energy, what would that look like in your view? And I would say anybody else can jump in after Ed.

MR. CAZALET: Now, I think -- since you brought up California, let's talk about California. For 2030, the target for renewables is 50 percent. And there have been studies done by E3 that show tremendous amounts of over generation during significant portions of the year that would be wasted energy that we'd somehow have to buy more renewables to provide. So that would take, just eye-balling it, say about -- using storage to recover about half of that and about half of it from rate reform and various other things, that would take about ten gigawatts or about 20 percent of the peak for storage, but it has to be storage of a duration of at least six hours or eight hours according to E3. If you just think about how much time the sun is up, you'd want to store at least six or eight hours of that solar to be cost effective.

MR. SHELTON: Does anybody else want to jump in on that?

MS. KENNEDY: I would just say I would measure it in terms of how much of the distribution system can be -- or the upgrades can be replaced by

storage. In some of the studies I've seen on the potential for cost effective deployment of volt VAR optimization and conservation voltage reduction in any given area, there's 30 to 40 percent of the feeders that could cost effectively be mitigated with some kind of demand response as opposed to expending money on distribution upgrades. So I think if you look at -- I think if 30 or 40 percent of those feeder lines can be handled with storage, I think it would be enormous.

MR. SHELK: I wouldn't want to, as you mentioned -- on the correct percentage. I think honestly we'd prefer it to be market driven based on relative cost and technology and the different uses. But I think again to the price formation thing, I'm encouraged and appreciate your comments about that because what's going to happen is -- and this may happen anyway, by the way, for other reasons that we can talk about, but certainly in these high percentage of storage scenarios, capacity markets are going to be becoming increasingly important. And even as when I'm looking around the room the folks that we've had many capacity market discussion on over the years, they are not for the faint of heart. They are fighting words in the great republic, I mean the State of Texas where folks know, I think, about the battle there.

So if you're going to have a lot of storage, you're still going to have -- pick the percentage. You're still going to have the balance of the resources.

And in these competitive markets, unless we're going to go back to the completely unregulated model which is a whole other scenario, the capacity market has become incredibly important, so I appreciate your earlier comments because again it's easy to say, okay, we'll do that. But as folks know in the present day, they're very controversial, they're essential particularly. And people forget, by the way, that a lot of the attributes of some of these resources including storage is that it shaves the peak, and people say that forgoes the need for peakers. But people forget that it's not only the peakers that are being compensated at peak. Everybody is being compensated at peak. So if you reduce the compensation at peak, and you're running less often as may well happen with all of these things that are happening and many of our members are pursuing them, again at the end of the day you're going to have resources that the compensation scheme is going to need to change. So as you're changing all of these dials on the system, higher storage, you're going to have to have other compensation mechanisms primarily capacity markets.

MR. IRWIN: Chris, just one quick comment. I think the -- I agree with my panelists. I don't have a particular percentage. Although, I think Ed had one. I think what's really important is what's it there for. I think we -- Susan described California, Ed described California, very high RPS. We're really after eliminating all of that curtailment. We're after that opportunity. I think nationwide it's going to differ about what state policy is for renewables. I think that's one. And it's also going to differ around what do we have for zero or low incremental cost resources. The more of those we have, the more the opportunity is to recover and to have value and storage. The more we have a common group of easily dispatchable resources that have a larger incremental cost to them, I think the smaller storage penetration. And so we'll see that. As we see the capacity markets vary around the country, we see the ancillary services market vary, we'll see the storage penetration vary based on those issues too.

MR. SHELTON: So, Mark, I think that gets to the next question. I mean, we've already thought of one implication of having a significant amount of storage is the price formation aspect and what that might mean in terms of the structure of the market side. And you

mentioned in your presentation about the distribution value streams. If you had a lot of storage in the system, have you thought about the system wide? Are there any system wide implications? If there were a significant amount of storage dispatchable throughout the system, are there sort of unexpected benefits and have you all explored that, and how should that be explored, I guess, if you have thoughts on that?

MR. IRWIN: So I guess when you think about system wide benefits, I would say, first of all, this is a question I'm thinking about on the fly about system wide benefits, but I think that as you have these communication control capabilities, which is really what we're talking about, storage being a high speed resource and being able to aggregate and understand and respond to need whether that's a market price signal need or whether that's a reliability need, we have to have the speed of resource to supply. I think broader storage deployment will create more value opportunities. I think as I mentioned in my talk, one of our biggest challenges today is to really understand what that value proposition looks like. And I think in the market space people have done a good job. And I think the other thing that will happen is we'll have to see -- as we see these opportunities and

these value-op propositions, we'll have to see where does that leave for market? You know, how much of that device is going to be in market? But in this broad deployment of storage, is there some unique opportunity? I think that's not something we've kind of explored, or I would say discovered yet. We're certainly in kind of a step process, and I think we're trying to step through it as fast as we can, but I don't think we're there yet.

MR. SHELTON: Are there any other derivative benefits or impacts that anyone else has explored? I know, Ed, you've talked about the transactive energy side. Or Susan, have you started to look at the system wide aspects in terms of reliability planning?

MR. CAZALET: So I think when we get to 2030 in states like California or particularly Hawaii which is the target of 100 percent renewables, things look very different. Price formation is on the customer side in variance load and usage. There's no generation to dispatch. So what's the marginal cost? There is no way to calculate marginal cost. So you have a very different market. Capacity markets won't exist. They'll be replaced by forward markets for energy. In other words, customers buy and own storage and renewables or they contract for it on a long-term basis. And the spot

markets are between customers saying, I've got excess, does my neighbor want it? So you get a very different price formation. And with these long-term contracts you have the investment secured. So that creates quite a different approach. And in this new form, I think you'll find the regulatory compact is much less necessary. It's highly decentralized, and you have a much more stable investment system. Just think of what Solar City is doing in terms of its solar and storage products. And that's a model for how you contract with end users and finance all kinds of resources. Very different from today's utility centric model.

MR. SHELTON: So as a final question before I ask you each to sort of wrap up your organized thoughts here before we go on to additional questions, and maybe this is best for Susan. How would we get to a state where there is a lot of storage, a penetration of 20 percent let's say, as Ed threw out there? Who is in the driver's seat, and is it evolutionary or more do we need some type of action to be taken to make -- in such a world, did an action need to be taken to make the high penetration of renewables possible or high penetration of storage?

MS. KENNEDY: That's sort of a

chicken-and-egg question. I mean, I think it's evolutionary in that -- I'm just using my experience as an example. I had to go to the utility a year before they even did their procurement in order to talk about what a hybrid product would look like. That was both demand response and generation because they had to think well in advance how they would even set the RFP parameters to be able to buy it. So there was a lot of forethought into what they were going to do with the asset far removed from the policy debate agent what you'd like to see. So in that respect, they actually moved the market by actively buying something that wasn't fully baked. So they're moving the market that way. So that way, I think it's evolutionary. Did they do it because there was a pressure from the regulators on a mandate? I think there's a thumb on the scale. They bought five times what they had to buy in terms of storage because they saw products that actually could -- they could use in their system. They were given the flexibility to do that. So I think it's a chicken-and-egg, but it will be evolutionary based upon need. If they don't need it, they won't buy it, or it's a dead end.

MR. SHELTON: Right. So to translate, to get to any scenario that had such a high penetration of

storage, it would have had to have met -- clearly have met needs?

MS. KENNEDY: Some need.

MR. SHELTON: And that could happen in the existing system, or we need some type of transformative change to really get the full benefit?

MS. KENNEDY: I think the market will -- the market rules have to change.

MR. SHELTON: Right.

MS. KENNEDY: Right now all the market rules dictate. They're buying things they don't need.

MR. SHELTON: Okay. So I want each of you to chime in to the degree that you like. What we're trying to do with the high penetration of energy storage paper is collect thoughts about what should be explored today in the analysis. And John brought up price formation. Obviously we've mentioned a couple of others here. But if you were trying to direct that analysis, what do you think we need to focus on the most sort of to wrap it up? And you all have mentioned some of these in your previous remarks, but I wanted to give you one last input here.

MR. CAZALET: I think retail terrors, you can call that price formation of the retail level which is where prices as I mentioned are going to be formed

because that's where most of the transactions occur in the future much less so the whole sale level. And then what's the interface to existing wholesale markets as that changes? What's the interface to the distribution grid that fits in with this framework? As I mentioned, you can have one that's an ISO for the distribution grid, but you can also have one that's much more transactive in the sense that the distribution operator acts as it does today and customers buy and sell from the distribution operator for transport, but they interact directly with the interface to the wholesale grid for energy. Very different and much simpler and much more effective way to design the platforms for California and New York or Hawaii in my opinion. Research on that would be helpful.

MR. SHELTON: Susan?

MS. KENNEDY: I would say the lowest hanging fruit is rate design. But it also needs to assume a fixed -- somewhat of a fixed charge for utilities for the -- to pay for the distribution system.

MR. SHELK: Can I just echo the thought that this should be evolutionary? It won't be revolutionary otherwise. Frankly, it would likely backfire as we've seen other examples. I have a great deal of respect for what California is doing. I lived there for a brief

time. And New York and Hawaii. But we have 47 other states that have different opinions, and I think it's important to keep those choices in mind. This will continue to be a state-by-state industry in terms of those kind of choices. So I just -- I started talking about the vintage EPSA. And I do remember being actually here in 1978 when we thought we knew gas was something -- as a senator once said, it was like using good bourbon to brush your teeth, so congress banned it.

I started this job ten years ago, 150 coal plants were on the drawing boards. We went through the nuclear Renaissance, so I don't want to come across as the lightweight here, but the point is that we think we know enough to know what's going to happen and what's needed. And we often find out we're wrong and people that try to push it too fast too far end up losing the tortoise and the hare race. So it may sound counterintuitive to those who want storage, but I think the past history is be reasonable, be evolutionary, be comprehensive in the effects. And in 2030 or 2025, you'll have more storage wisely whether it's 10 percent or 50 percent or whatever as opposed to really trying to push it and assuming that every state and every region needs the same amount.

MR. SHELTON: So can I ask a follow-up on that? So what does -- in terms of directing a recommendation to DOE, what form would that -- your comments there take? Is it maybe that it needs to be recognized that it's regional or that it -- you know, on the comprehensive side?

MR. SHELK: All kidding aside, I'm the lawyer not the physicist and the market designer, and seriously I think folks are aware -- if you haven't seen it, there are papers now out there. As I said, the Harvard paper just came out. There's another paper from the American Chemical Society or published by them through some other authors. Severin Borenstein and James Bushnell have a working paper at the [highcol] in California at Berkeley on 20 years of restructuring. They're touching on these issues. So there are people around this table and around the country far wiser and brighter than I am. I'm just simply making the plea to include them in the discussion to make sure you're looking at it comprehensively. And I like your approach of saying it's going to be different in different states or you will inevitably get a push back that will detour you if not deter you or deter the country. So I think DEO is well-equipped to do this. They've done it before. They've got the right people to

do it. I'm just hoping that -- and I'm reassured by the conversation today that it will be a comprehensive view.

MR. SHELTON: Yes. Mark?

MR. IRWIN: Thanks, Chris. I think a couple of things. First of all, I agree with my colleagues that it will be evolutionary rather than revolutionary, but the evolution is being led by a number of states, California, Hawaii and New York pointed out as I think really important ones. And I think the other thing is it will be in all of the above strategy. And when I say all of the above, there will be behind the meter customer activities in storage. There will be market only activities in storage. And there will be grid or grid and market activities. And I think each of those creates a research opportunity for DOE. I think the customer side and the rate side and rate design in getting the right rate design so we get the right price signals to be able to respond to demand response as an example. The right price signals for energy efficiency. Storage can help with those. I think on the market side to be able to make sure we get market value of all of the different pieces and transparency and trade it in the wholesale markets. And I think on the distribution side, and I'd say not even distribution but on the grid side is to

really spend some time and effort on figuring out how to monatize all of those benefits for the distribution side. And I think the success of storage will be all of the above is to find out what are the most successful, let them compete against each other, let's figure out which is the best economically. And it will be different in different markets. It will be different with different customers. So I think providing that opportunity really will be the key to this high penetration success in the future.

MR. SHELTON: Okay. Great. With that, we are about one hour in. We had -- an hour and a half. So I would like to turn it over to Richard to help us find out where the questions are coming from, and we'll open it up to the broader group.

MR. COWART: All right. Questions and comments. I try to keep track of when people's cards go up, but I apologize in advance if I take you out of order. It looks like -- I'm sorry.

MR. SHELTON: Three over here.

MR. COWART: Yeah, I've got three over here, right. It looks like Ramteen was probably first.

MR. SIOSHANSI: Okay. So I think Merwin is actually before me, but I'll go out of turn. Ed, I'm

curious about two aspects of your vision. One is that to that broadly over generalize, the U.S. has gone -- the organized markets in the U.S. have gone away from simple markets and decentralized coordination to -- centralized coordination. And some people would argue that there are physical realities, nonconvexities, nonlinearities that can't be ignored, can't be repealed, so you need centralized coordination. So how does that sort of jive with your vision of market and price design, and is it a nonstarter in the U.S. and where we've gone over the past 20 years?

MR. CAZALET: I'll address your question, and we can have a deeper discussion. Perhaps the research could address that issue. But the physical limits -- and what I'm proposing would observe the physical limits of the market, you know the transmission, the congress laws, all of that sort of thing. Just because you -- you're still going to have the same power flow models in what I'm proposing. Instead of centrally dispatching generation and storage and transmission simultaneously, you do it more incrementally. In other words, you use the dispatch to suggest the prices you pay for transmission from point to point as opposed to using -- centrally dispatching both generation and storage because

we have to be able to bring the rest of the market into this dispatch which is all of the distributed energy resources and all of the end customers. Unless you have a reportable process, you're going to not achieve the full value. So I think you can make an incremental interface to the existing markets that will enable you to do what I'm proposing.

MR. COWART: Merwin?

MR. BROWN: Merwin Brown, University of California. I'd like to see if I have the correct impression from the panel. My impression is that the high penetration of energy storage is going to be primarily a distribution phenomena not much in the transmission level area with big storage like compressed air, pump tide row, or even large battery systems. Is that a true perception? If it's not a true perception then how might you characterize it's going to look? We've been using 2030 as an example down the road of will it be mostly distribution, mostly transmission, or some kind of even mix? What would it look like in other words?

MR. IRWIN: So I think at least from my perspective when I talked before I think there's three types of systems. I think when you're behind a customer

meter it's a small system, it's fitting that customer's need. When you're on the distribution system, it's still a fairly relatively small system. It's a few hours. It could be three or four, five hours of storage, but it's still again a few megawatts, three four, two megawatts. I think when you're on the market facing system that's really there for market facing, you will absolutely see people building to economies of scale. You'll see -- when you're chasing that market only opportunity, you've got to get economy to scale, and you got to get fast response. Whether that in the end will drive compressed air storage and other things I think is still up in the air. I think those technologies are trying to come forward at different price points to be able to do that. I think we also need to see a market demand for that larger -- longer duration system. I think Ed described some studies he had seen that drives for six to eight hours of storage. Six to eight hours of storage generally is driving away from shaving a distribution peak. It's really driving to a market only type of application or a market driven application. So that's when those bigger systems, at least from what I've seen and from what we've experienced, that's when you're more likely to encounter them.

MR. CAZALET: In fact, generally I agree. I think no matter where you put storage on the grid it can provide a lot of different services. But if you put it closer to the load, you can provide more services. So six hours of storage on the distribution grid can provide local services as well as integration of renewables. I think one of the things that's going to drive the location size of storage is the quest for resiliency via microgrids. And I don't think we need too many more events on the east coast or different events across the country where the customers are going to be demanding resiliency in their grid and storage is an essential element of that. And we want to put the storage where it can also produce that value for customers.

MS. KENNEDY: I would agree. While there are values associated with very large transmission levels, storage is a 20 megawatt pumped hydro is -- the locational constraints on where that is located makes it very little different from a 20 megawatt peaker plant. And so I think the locational value increases dramatically the closer you get to the load itself.

MR. SHELK: A quick point I'd make is that even if it's -- as I think you've heard from those who know this better at the distribution, obviously you're

going to have wholesale of market effects for the reason that your prior presenter talked about what happens when loads are shaved at the peak and that sort of thing. So even though it's physically at the distribution level, you're still going to have to look at the wholesale effects.

MR. SHELTON: We got quite a backlog of questions.

MS. PRAMAGGIORE: Do you want me to follow-up on this?

MR. COWART: Yes.

MS. PRAMAGGIORE: Mine is a follow-up just on this question. Could I jump the line? Is it really empirically settled whether the value proposition is highest at the distribution system versus at the wholesale? I mean, I can really see situations where you would want an arbitrage between both of those, and I bet we don't know that. And maybe that would be something DOE could look at.

MR. IRWIN: So I think from our perspective, the distribution system has opportunities for value. What it has in, in fact, our urban smart grid project, we looked at distribution located all the way down to the last transformer before the customer, so eight customers

off of a storage device way down there with the hypothesis that that was the biggest value to chase. The other side of it is, the diseconomies of scale of smaller deployment. And so I don't think we think it's a fact at this point. I think we're trying to look at on the distribution system what are those value streams, what -- do we chase them, what did it look like? In a high DER environment that's driven by the distribution system then you're going to have more distribution upgrades to build and more opportunities to shave that peak whether it's with the distributed energy resources or DER plus storage to kind of shape that into the right shape with the load there. I think that's still yet to come. And I think that is an area that's ripe for consideration.

MR. CAZALET: I think in the ideal world it's pretty clear to me that the value is highest in the distribution grid, say, at least the substations. But the problem is our markets are so screwed up. You got distribution operators. You've got transmission operators. You've got different ways of recovering costs. You got different modes of dispatch. It's all so screwed up that I don't think we're going to -- it's going to make a difference if you had to put in a storage plant today, you'd have to work through all of those just

as Susan is and say, okay, if I put it on the distribution grid, can I get any benefits from the California ISO or vice versa? It's a mess.

MS. KENNEDY: I will say that the value at the wholesale level is probably a little bit more known today. Whereas the value at the distribution level, there's so many unknowns. It's the greatest untapped potential because we haven't figured out -- we haven't yet crystallized how to extract those values. So I would say it's not -- it's the greatest untapped potential at the distribution level.

MR. SHELK: But I think to the question, I think you're exactly right. That scenario should be examined because at least as I've heard people talk about the subject and you hear analysts -- this is something that Wall Street analysts are starting to do conference calls about. So when that happens, you know people are looking for fun and the opportunity -- and my impression thus far is, as I think folks widely know, the limited charging and discharging of the batteries limits the potential. But if there's some breakthrough from some smart person in a garage somewhere working on it today that we suddenly have the ability to overcome that obstacle then that scenario should be examined because

that could very well be the 2025, 2030 world that might emerge, so it should be examined for sure.

MR. COWART: Paul.

MR. CENTOTELLA: I want to follow-up on a couple of the price formation questions that -- this is Paul Centotella. Follow-up on a couple of the price formation questions. One is taking pricing down within the distribution system, and whether or not you see differences in value depending upon where you are in distribution. And clearly there could be some in terms of VAR support. There could be some in terms of marginal losses. There may be other values. And what kinds of things and how should DOE go about looking at that, Number 1? And Number 2, I want to push back on John just a little bit with his supposition about the importance of capacity markets because it occurs to me that storage is disproportionately benefited in capacity markets since it provides capacity without necessarily providing energy and wondering whether or not we shouldn't be looking at what happens in a high storage situation where you have flatter and less volatile peaks and what that means in terms of the ability to support resources.

MR. SHELK: On the second one, I think that should be examined as well. I mean, I think maybe I was

looking at it too statically, but I think right now what I've heard and read in memos from the discussion we had at the annual meeting from outside folks was that as you all know and I know you know this well, others do, that you've got resources like a base load plant that their primary source of revenue is the energy market. So the assumption -- and of course as soon as you use that word we should all be careful whenever we ever use it. But if the assumption is that you're going to reduce those prices that these resources are depending on then the logical place to make it up is in the capacity market. It may be that as we -- and the department and you all get into the various multiple level of effects what you're talking about could happen, and it may very well flatten it out. And I'm not saying exclude those scenarios. I think every scenario should be looked at that's reasonable, otherwise, we're going to miss something that might come down the road.

I'm just trying to make the appeal, and maybe it was unnecessary to make it as strongly as I did but to make the appeal that as you all are looking at this be mindful of what's going on at 888 First Street and elsewhere in the department on this broader topic because while we all want to get to 2030, I hope not to be

starting to be a fossil fuel by 2030, we have to get to 2030. And what I worry about notwithstanding all the good intentions of a report having spent half my career up on the hill is that a report like this gets waved around, it's the headline of, we can have 90 percent fill in the blank by tomorrow and all the caveats and all the discussion in the report gets lost. And maybe I'm ultra-sensitive on the day when the committee is meeting in 45 minutes to start work on the energy bill. And if a report like that existed today saying we could do 50 percent storage notwithstanding any of these nuances and considerations I would stake my career on an amendment being offered to mandate it or support it with subsidies or some such so. I wish congress were as wise as the folks in this room, but I'll just leave that statement as it stands, and you can draw your own conclusions.

MR. IRWIN: And to respond to the first part of Paul's question about the distribution values being very locational specific is absolutely correct. And I think the challenge will be, first of all, once we can see what that value look likes in different places, and we can actually try it out then we'll see that valuation, and then we'll want people to compete to supply that product and whether that's in a market based competition

with market only resource, market driven resource, whether it's customer sited device, whether it's utility device, we'll want to see how we compete to keep the cost as cost effective for our rate pairs. It's possible, but we first have to be able to unlock that value and then see -- we're working on planning tools and other things to be able to plan this much more complex distribution system in the future and be able to figure out those values and unlock them and then go out and acquire the asset to do that.

MR. COWART: Carlos.

MR. COE: One thing that kind of surprised me in this discussion, I wanted to say this question and get your reaction to it. Do you think energy storage is at or beyond the tipping point where you think the deployment of this is a foregone conclusion?

MR. CAZALET: In certain locations, yes.

MR. SHELK: I hate to be the skunk at the garden party. If you look at least what the energy storage association itself is saying on a recent UBS analyst call and other projections, there's going to be storage to be sure, but the headline again was 46 percent annual growth rate for the next ten years, but it's still gotten into the hundreds maybe over a thousand megawatts

deployed in a system of, what, 900,000 megawatts. So I think it's going to continue. At what rate? I can't predict and wouldn't hazard to guess. But at least from what I'm hearing and reading from folks on Wall Street that are looking at this, it's not going to be -- I think one of the headlines said it best. It said the storage conversation begins, emphasis on begins, and I wouldn't say it's preordained one way or the other. Now, it's out of the money most of the time depending on the location and the uses that you're hearing about today.

MS. KENNEDY: And I would just from the perspective of a company that's focused on the end users, the appetite is enormous and the costs are just coming down to commercially reasonable pay-back periods where the benefits are palpable. I mean, the resiliency alone is a huge benefit to installing storage. And we're analyzing more than a thousand megawatts of load data today. And I mean, they're knocking on our door trying to find ways they can install it. The appetite is there.

MR. IRWIN: I think from our -- at least from my perspective, it's fair to say that certain applications are at a tipping point. I think that number of applications is still much more limited than we'd like to see. The work DOE has done on price forecast of

energy storage has been very helpful for people around setting targets and thinking about that. I think as we think about setting targets for that tipping point, I think from my perspective, wide deployment, we're not at that tipping point. We believe we'll be there. Will we be there in two years? We think it's not likely. Will we be there in five? It's maybe. Will we be there in seven? It's more likely. But I think it has to do with where does research go on cost and where does research go on value. So a lot of the things we've talked about today have been value. We haven't talked about the cost side, but there's still great work to be done, and we're seeing that supported by the DOE and by also capital investment and adventure capital. And we think there's great promise there, but that's what we think will really take for a true tipping point where a lot more applications tip positive.

MR. COWART: Now I have Gordon and Jeff.

MR. VAN WELIE: Chris, first of all, congratulations, great panel. I'm really enjoying the debate. I have a question here for Ed and the panel at large. It was Ed's discussion on transactive energy model that sort of stimulated this. And it occurs to me that we already have a very well-functioning transactive

energy market model operating in the United States that has many of the attributes that you described. So most of the infrastructure is built on a forward contracting model, the operations are coordinated via actions in the spot markets, and it has a very high penetration of storage. So you naturally may be asking what is this energy system? It's called the natural gas industry. And I've learned a lot about the natural gas industry unfortunately in the last ten years. And the reason that this system works quite well is that the system operator can cut you off if you haven't contracted on a forward basis, on an end-to-end basis in terms of the molecules and the transportation to get to your burner. And so I'm curious about your view of whether policy makers and regulators would allow the electric industry to have the system operators cut all people who haven't contracted. Because I think there's a very different construct in the electric industry where eventually policy makers and starting with the most recent Energy Policy Act of 2005 declaring folks to be the overseer, over liability, and so forth after the big blackout in 2003 eventually said the grid has to serve the load. And the grid has to be built out to meet the peak demand on the load. So there's a very different construct there, and I'm curious

as to your thoughts on whether policy makers will ever let go on electric system reliability in order for you to reach the transactive energy model.

MR. CAZALET: Well, it's getting very complicated. I think you described a lot of what goes on in gas markets as being transactive, but that was at the wholesale level. I don't know that anybody is cutting out gas supply to residences right now. But the idea here is that when you've got people who can put in their own storage, put in their own PV, they're taking on much of their own reliability and resiliency responsibility, so should we be -- we should feel free to cut them off, I would think, because they've chosen essentially to leave the grid, and they shouldn't feel obligated to pay for as much of the grid until they're going to take care of it, use it. So if you've got a lot -- customers are making forward contracts either buying their own systems or forwarding contracting with third parties then their basic needs ought to be provided. If you've got people who don't have the means to do that, we can have special programs for that. But once you've got those forward contracts in place then you can allow the spot market to do the allocation of scarcity. So when the prices get very high, nobody's hurting, everybody's got the

opportunity to conserve and sell to their neighbors at a very high price above what their basic needs which already have been contracted for them.

MR. VAN WELIE: Ed, I guess just a quick follow-up. I think the problem is for those consumers that are chosen to disconnect from the grid, I think it's fine. They've made their choice. I think the problem, and this sort of connects back to the price formation problem, is that most consumers, I think, are looking at partially self-supplying, so they don't have the ability to completely disconnect. They are looking to essentially arbitrage between their own generation locally and the wholesale market, and they are given the right by the regulator to connect to the grid whenever they want and draw their energy that they need. And so that then leads to the requirement to pay for not only the wire but everything attached to the wire. And I think that's the problem.

MR. CAZALET: So I understand the questions you're raising. This would be a good thing for the committee to delve into.

MR. MORRIS: Great. Thank you. Jeff Morris from Washington State. And I have a question for Mark and maybe Susan then, a 1A question for Susan. During

the last presentation on grid modernization, I thought it had kind of transcending itself to your presentation, Mark, which is you're talking a lot at the analytics around DER planning. And I'm a huge DER supporter and push it wherever I can go. But the question I have is I'm kind of taking some of my life science hats I wear in different venues. When they had the advent of the basing algorithms with software and advanced processors, they immediately went to a bunch of P words. And we tend to operate in our words. And I'm going to use the surfing analogy since you're both from California. The R words, resiliency, reactive, are all in the back of the wave so to speak. And DER kind of puts you on top of the wave. But it seems to me what we're missing are the P words which are the ones that these new tools, if we push them out, these basing algorithms to give you more predictive viewability of what your customers are doing allowing you to be more preventive as opposed to reactive, it might be a longer range tool we should be focusing on as opposed to the R words. So can you comment on that a little bit?

MR. IRWIN: So I think that in the planning tool space generally I think the predictive analytics is absolutely a place we're spending a lot of time, and I think that's another place that's really valuable for

research. The question is at the end of the day is what's the balance between the customer demand and the capability of that part of the system to supply, and do we balance it with demand response as an example? It's a great easier balancing tool. Do we balance it with DER? Do we balance it with storage? And I think the question is on every circuit being able to understand what that imbalance looks like, being able to have a resource portfolio that fits it, and then being able to create a response process to do that. But it all starts with what's the match look like and what does the distribution system capability look like? So it starts there, it goes through then what are the resources, and then do we run into a system constraint. Because obviously even if there's a mismatch on that circuit and that circuit has the ability to import or export to match it, we're still okay. Right? So I think those planning tools are going to be what really drives, and that brings one piece together. The other side is the communication and control and fast response of demand and generation resources and storage resources. So those are all critical places for research and work.

MR. MORRIS: Great. Thanks. Susan, just before you go into that, my second question for you is

you talked about the lack of aggregators and the DER space. And to me, it's always an area that's lacking its project developers to bring some of these projects because people want shared risk. Can you elaborate about your vision about what those aggregators would look like and who they might be and who would have ownership in developing them?

MS. KENNEDY: I'm going to give you my card as soon as we're done here. First of all, I just want to comment on what you raise. I think it's incredibly important that we focus on the analytics on how one would use storage whether you're at the utility or at the distribution level or end use customer. Without the ability to design it around your specific needs, it's just a very expensive energy efficiency tool. But our rate design is almost singularly focused on influencing customer behavior. So storage behind the meter simply gives them the ability to shape their load, the utility tariff to respond to whatever the utility rate design is telling them to do. So I think having the analytics around the building load management and the predictive capability and how they'll use it is incredibly important to make the market function. I think -- we think like pioneers in this space. There aren't a lot of developers

for behind the meter projects like ours, and we're having to spend a lot of time cutting the path on designing how do you measure and settle for these types of resources behind the meter. I have contracts today where it's absolutely unclear how you -- I don't even know what the telemetry requirements are for the projects we're developing today. Because they're still waiting for answers in terms of from the CAISO on how they're going to view it as how it's going to be bid into the wholesale market or how the PUC is going to see it. So we are -- I think when you get projects that come online, and developers like us, and I think -- again, I'm giving Edison a lot of credit for going as far out on a limb as they have. When these projects start to come online, you will see them replicate at a geometric rate. But some of these issues have to be solved today. And then you'll see, I think, aggregators. There's a lot of -- I think aggregators are a key, key group that will be able to figure out how to extract multiple benefits on one side of the meter and multiple benefits on the other side of the meter. That's a developer role in my view.

MR. COWART: Thank you. Janice?

MS. LIN: Just to build on that, your comment, Susan, I think that that's a role that DOE can

certainly assist with exploring some of the nuts and bolts of how do we get these systems deployed? What does metering the telemetry look like? And once we figure that out and make it doable in a particular jurisdiction then to extract out what's the framework, the approach and the best practices that maybe other locations can borrow from, so you don't have to reinvent the wheel in every corner of the country. But actually my question is for Chris. It's a process question. This is in the spirit of being a new person and maybe wanting to volunteer and help out more. But my question is what is the goal of this working group? And I completely agree with many of the points made that it should not be to presuppose that high penetration is a good thing. Though at the same time at least in the work that I've done in California and elsewhere, one of the frustrating things is we have this system as it's been designed and built and operated for like 100 years, and so often the question of where do you put storage and how do you use it, it's based on this status quo system that never really contemplated the fact that you could technologically have a lot of storage in the system and use it for system wide benefit. So I wonder -- and so it's the question about the goals and the approach of

maybe next steps.

And I also have a suggestion. So one goal that this working group could take is to look at scenarios. And some of the scenarios that I've heard discussed are, is it going to be large and centralized, is it going to be distributed, what is the mix, what does this incremental evolutionary approach look like? Maybe it could be a totally clean sheet of paper which says -- it's like if we just had a grid and designed it from scratch and had a lot of storage comprehensively, what would be the benefits and what would be the cost? Are those chemical engineers really accurate in saying it would make GHGs go wacky and be crazy? Or could it be -- could one of the outputs of this working group be a methodology and a framework and an approach that can be recycled and used to come up with the optimal amount of storage? So these are all questions that I think no one has really ever done before, and if that's something that this working group undertook and then resulted in DOE initiatives, that would be super, duper interesting. I know it would certainly be helpful for California.

And then the final -- I had a scope question and then related to the linkage. Would the scope include the electrification of transportation? And secondly, how

would this link up to the earlier presentation, the modern 21st century grid effort? And I'll stop there. I'm so excited. Thanks.

MR. BROWN: -- (off mic) that in my presentation.

MR. SHELTON: Okay. So Merwin will cover that in his presentation. I think we have another question. Janice, yes, is the answer. I don't know if it was a question that could have a yes-no answer.

MR. COWART: Janice, the answer to your other question is yes, we welcome you as a volunteer. Congratulations.

MR. SHELTON: I forgot to lock that one down. Sorry about that. We are approaching it through a scenario basis. I would say the temptation always on the AC papers is to sort of do the work so we're not actually doing the work, we're exploring the work that can be done so that needs to be the bias but that -- exactly. Because what we're trying to do is form a list of things properly scoped that DOE should consider doing. Right?

MR. COWART: Anjan, you're next.

MR. BOSE: In all of these storage discussions, it always comes up that we -- if only the market can be fixed we can get better penetration and

usage of the batteries. But I was wondering, if the market is not fixed -- I come from an area of the country where there's no organized markets, but even more than that I think -- I can think of many, many states where it's going to be a long time before there's an arbitrage in the distribution system. You are going to have retail type markets. So if the value of storage is in the distribution systems then I was wondering if under the present circumstances if there are already scenarios where there's a value to the utility for putting in storage systems. And I sort of heard Mark Irwin kind of hint that there is already. I mean, what I'm coming from is that most distribution companies are going to be in their stage where they're mandated to serve the customers whether they have DERs or not. And are there systems where you can defer upgrades and so on by putting in storage devices?

MR. IRWIN: So my earlier comment to the question about the tipping point I think is really the issue. I think there is value. The biggest value we find particularly in a very urban utility is we have a lot of underground systems. And when we're having to do a lot of civil work particularly locations where we see a freeway crossing or something like that that's new, or

we're impacting a lot of underground structures, we have a very expensive upgrade. Storage is still relatively expensive. We've got opportunities to defer. Do we have opportunities to cost effective defer? I'd say that would be very unusual. I think we see with where we see prices going and where we think it's likely for prices to go. We think that that will expand. I think -- we did a white paper in 2010 that said we thought it was going to be economic for storage in 2020 to deploy on distribution, and it would be reasonably prevalent. I don't think we've necessarily changed that view. But we do have a mandate in the state to do something, and that mandate is to go do something that makes sense.

I think right now we see value streams we can capture. Those value streams aren't sufficient by themselves to justify the investment. If it's just on an economic basis, we think there's other value opportunities that we need to explore. And I think I listed those earlier. And we believe that the cost of storage is going to continue to come down dramatically. And I think that whole coalescence is what we're still driving for, and we can't wait to start to figure out the value until storage comes down. We have to do it simultaneously. And quite frankly, our state has

encouraged us to do that.

MR. CAZALET: So I think the issue, if you don't have markets then it's up to the legislature to create mandates, whether it's an RPS mandate or resiliency mandate or a storage mandate or clean energy mandate, to help guide the utilities. Because most of their planning won't be able to take into account all of the larger issues the legislaturing people would like to consider.

MS. KENNEDY: I would say without a market structure that allows the various attributes of an energy storage system to be valued and paid for through market forces, there is value but it's because the alternative is so expensive. On the customer side of the meter, the only place where it's cost effective is whether the prices of energy are so steep or so painful for the consumer that it's more cost effective to put in a storage system. The same thing is for the utility. In an area where they have incredibly expensive alternatives, storage is going to be cost effective. So the question is not is there value because there is value. The question is, is it cost effective without a market structure that incentivizes?

MR. COWART: Merwin, the last word is yours.

I pass.

MR. BROWN: Merwin Brown, University of California. Some people say that energy storage is just an alternative to solving problems on the grid. In other words, it can replace a generator or replace demand response or it's in competition with those. And so that's one vision of it going forward. It's just an option. Others have said that it's a paradigm shifter technology because for the first time in the history of the electric industry you can talk about now warehousing the product in the delivery system, and so that has consequences then ratifications that could be very dramatic, change a lot of things. I guess the question that I want to ask, do any of you have any thoughts on looking into the future which role is energy storage going to play? Will it reach high penetration with just competing with the others that have been around, the other solutions, or do you see a potential for it to be a paradigm-shifting situation? And if it is, perhaps you can tell me what that would look like.

MS. KENNEDY: My answer is storage is going to do to the electric industry what storage did to the telecommunications industry. It's going to completely change it.

MR. SHELK: Of course, we don't deliver electricity with individual phones that we get at the Apple store, and that's -- this is an interconnected system financially, physically, operationally, and so while you can do with a small amount of batteries what we all have in our pockets, this system is not quite -- at least I would argue -- necessarily analogous to that. Although, it may get to that point, but it's going to be in a different way precisely because of the difference in what we're delivering.

MR. CAZALET: In the industries including the closely associated natural gas industry have been fundamentally changed by storage where you have storage both at the -- at both ends of the pipeline. And without that, it would be a very different industry. And we're now able to envision that for storage for electricity.

MR. IRWIN: So my response, Merwin, first of all, I think in the near term often it's going to be a choice. Right? I think that as we get better at understanding the value proposition and the costs continue to come down, we'll see wide deployment. And that will be transformational in that the grid will have a different set of capabilities. I think in states where we have -- a lot of the policy issues we have in

California where we have a drive-to-drive carbon out of the system, I think you'll see that transformation happen sooner because there's a big policy support for that transformation. We see the renewables out there. We have to find a way to integrate them cleanly, so that transformation will come. We're not yet, in my mind, to the deployment today of transformational resources. We've contracted for a number of resources. Susan has talked about hers. We've contracted with others, with actually Chris's company, AES. A lot of those resources are out from 2016 through 2021. So they're out a few years. So the contracting is transforming in the early deployments that Susan's company has talked about are transforming our ability to do that. But the big arrival of resources is still a number of years away. So in the meantime, we're going to see some incremental decisions, but eventually transformation, I think, clearly will occur.

MR. BROWN: If I may follow-up. Give us some advice on how we should treat it in this committee for the study we're doing. Should we look at it as a transformational thing or just say it's for the time frame we're talking about it's sort of just more energy storage growing evolutionary but as a competing element

of other solutions?

MR. IRWIN: So the time frame Chris framed was 2030. I didn't know what the time frame for 2030 in our state of California. I think we will be transformational in that window. I think that Hawaii -- I think Ed pointed out another place that clearly will be transformational. I'm not as close to New York, but I've certainly heard things about New York that would say that. I think the question is what's state policy in other places, and is it broadly transformational or is it incremental in between? I think that's not clear to me.

MR. SHELTON: So I think in the interest of time, we had a very thorough discussion, I appreciate all of the questions from everyone on the committee. Please join me in thanking the panelists and for taking all of our questions and their great content that we started with. So thank you.

(Applause.)

MR. COWART: Thanks, Chris. And thanks, panelists. That was really terrific. We are going to take a short break. I think the schedule that we handed out has a ten-minute break. I think realistically we're going to start back at 4 o'clock.

(Whereupon, the PROCEEDINGS were

adjourned.)

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