UNITED STATES DEPARTMENT OF ENERGY

ELECTRICITY ADVISORY COMMITTEE MEETING

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P R O C E E D I N G S

(8:08 a.m.)

CHAIR TIERNEY: Good morning. My name is Sue Tierney and I am from Analysis Group in Denver, Colorado, and have the honor of chairing the Electricity Advisory Committee. Thanks everybody for coming here. Is Pam here yet? I just wanted to thank NRECA once again for their hospitality in letting us use their conference center; but, we'll thank her again later on.

I know we have a packed agenda today, and it looks as though there are some traffic hang-ups for a couple of folks. I'm sure people will be joining -- Pam, just thanked you for hosting us here at NRECA.

MS. SILBERSTEIN: (Inaudible)

CHAIR TIERNEY: I hear the traffic's bad. Thank you.

We have a packed agenda and a lot of wonderful participation from outsiders today; so, thank you in advance for that. What I'd like to do is turn this over to Merwin, and he is going to give us some introductory comments that set the stage for today. So, Merwin Brown from UC Berkeley.

MR. BROWN: I don't know whether I should speak from here. Well, again, I'll add my welcome to everyone here so far, and for those yet to come, for joining us today; we appreciate it. I have just a few comments and maybe I'll make them even briefer than I thought I would, given that we're getting started a little late, but today's session is a regular, but yet special meeting of the Electricity Advisory Committee and what we're doing is focusing on energy storage today. And in a moment, you'll find out more about what we mean by that focus.

First of all, I want to explain though to those in the room who aren't members of this committee sort of what the background is and what's behind it. So, I guess, advance slide, please; go one more. Unfortunately, I used animation. This subcommittee, the Energy Storage Subcommittee, was formed also when the Electricity

Advisory Committee was formed by legislation in 2007, following, really -- the 2003 northeast blackout was the impetus for Congress to take action and to form this advisory group to help the Department of Energy with knowledge about what the status of the grid is; what issues there might be; and what things it could recommend to DOE that they could do to help with those problems; and, specifically, energy storage got picked out at that time, and the charge that was given to this subcommittee was to look for and advise the Secretary of Energy on basic and applied research that could be used to help the United States retain a globally- competitive, domestic energy storage industry.

So, there is that aspect. So, next slide please. To help then formulate those recommendations to DOE, we often turn to the public and private stakeholders related to the electric grid, and to be able to assess the state-of-the-art, in this case, energy storage development and deployment; and then to determine what gaps there are that need to be filled and what research is needed to close those gaps based upon trying to achieve the mission under the legislative directive.

So, that's what today is about. It's one of those events, if you will, or an activity where we are trying to gather information on the status of the grid; the status of energy storage; and try to identify where we want to go from here; and also, if we can, some idea of what we need to do to close (inaudible).

Next slide, please; go on; yeah, thank you. We have also produced -- the subcommittee and the EAC, accordingly -- have produced work products in the past that are similar to what we want to do with this one; and in those work products, identified energy storage as an, if you will, element of interest as a special asset class for modernizing the electric grid. That's somewhat tame language though: what some people often say is that energy storage is the holy grail that the electric grid's been going after for a long time; but, nonetheless, we have good reason based on past work to look into what energy storage can do and mean for the electric grid in the United States.

Next slide, please. So, what we want to do -- and this particular session is geared toward this -- we want to look at the potential role that energy storage provides -- and this is kind of a combination of terms that point to a similar kind of need -- and that has to do with backup resiliency, reliability, security of the electric grid for when the grid is down; and then also, in the same context, that energy storage could also be available for grid operations when the grid is up and running.

So, we've seen -- a number of people have said in passing, so to speak, or mentioned the fact that in the future, energy storage should be able to play a big role in such things as resiliency and reliability for the electric grid; but we're not sure how closely that assumption has been looked at, and what we want to do is kick that off today to get a better handle on where we are with energy storage fulfilling those roles. We do know that energy storage has begun in some places to be put in place to do just that thing, so we want to learn from those experiences what they have accomplished and what problems they've run into in trying to use energy storage in that manner.

The next bullet, please. So, today is a major piece of this work effort that we're going to launch here. So, the core activity of this product is to conduct this facilitated discussion, at a public session of the EAC with invited expert speakers, and along with industry, academic, and public sector participants. What we want out of the experts is what's the state-of-the-art of energy storage for the applications of security, resiliency, and reliability; that kind of thing. What are some of the expectations or anticipations going forward? And what we would like out of other participants in this session -- we've invited those-- as well as the EAC Members around the table for those who have some knowledge is needed in terms of making sure that we have a reliable and resilient electric grid.

So, there are really two different components of information and input that we want here. I might add there are also those invited and sitting around this table that we're asking to participate in this full discussion today. Also, there are public members seated outside the table range here, I want to let them know that there will be an opportunity at the end of this session to make public comments that will go on the record. So, please keep that in mind and perhaps take notes if that's what you want to do.

Next slide. Okay, what I want to do is introduce the EAC member who is going to facilitate our meeting today, Janice Lin; and I thought I'd just give you a little bit background on her. First of all, she's an enthusiastic member of this Energy Storage Subcommittee, and that's been evidenced by what she has had to go through to put this meeting together -- a lot of work went into this. Then she's CEO of Strategen Consulting, which is an advisory firm that specializes in clean energy and grid transformation. Next, please.

She's also the founder and executive director of the California Energy Storage Alliance (CESA). It's the world's first advocacy group to represent energy storage in the private sector; and then, lastly, she's co-founder and chair of Energy Storage North America which is -- as it says up there -- the largest grid-connected energy storage conference in North America. So, I think, without further ado, I'm going to turn it over to Janice.

MS. LIN: Thanks, Merwin. Can everybody hear me okay; is this microphone working? So, welcome everyone. First, I'd like to start with a thank you, as with everything, something like this it takes a village; and I'd like to especially thank the DOE staff; Matt; Assistant Secretary Hoffman; Katie [Jereza]; the EAC leadership -- you guys have been awesome; Merwin and the Energy

Storage Subcommittee; and then all of you and the EAC members for agreeing to stay long today.

Today's going to be a little bit different. We have, first of all, coffee in the back -- that's for anyone who wants some. Help yourself throughout the day.

CHAIR TIERNEY: And to those who are guests here today, that is an awesome thing.

MS. LIN: Normally, there is no coffee. Secondly, we have, courtesy of AES, an informal reception immediately following this meeting, across the street, at AES' headquarters. Address, please? 4300 Wilson Boulevard. So, I changed my flight to be there. If you guys are able to come, we really, really welcome that; and everybody who's in this room is welcome as well; so, just come on by.

So, I'd like to start and I'm going to really try to keep us on schedule; so, my remarks here to kind of welcome all of you will be very brief. I'll tell you a little story. About 18 months ago, in California -- I'm from California

-- our very large, underground methane storage facility, known as Aliso Canyon, experienced an unforeseen leak; and this was truly unforeseen because no one expected it. It took a really long time to stop the leak; and the reason it created an electric-reliability problem is this was the sole source of natural gas to 18 power plants in the LA Basin. So, it created a state of emergency in California. There were a number of mitigation measures that were deployed. One of them was to very quickly deploy energy storage -- grid-connected energy storage -- and together San Diego Gas & Electric

(SDG&E) and Southern California Edison (SCE) deployed about 100 megawatts of new capacity from RFO to installation in under 8 months. I don't think anything like that had ever happened before.

And, as you know, there's a lot of grid storage being procured in California, and, I think, this might have been the first major procurement from a resiliency application. So, it was only natural we thought here at the EAC, wow, if this is a trend that's happening, maybe we should consider how can storage be used as a strategic energy asset for our country. Given that it is being used and procured for grid operations and to make the grid more efficient and it has been procured for this resiliency effort -- and the many thousands of hours that I've sat in workshops and all kinds of public stakeholder meetings -- this may be the very first meeting that specifically focused on how storage can be used to help increase resiliency and reliability; and this is such an amazing brain trust -- all of you are experts in energy and your related fields. It's an extremely diverse crowd, so I encourage everyone to jump in and participate.

So, just a quick overview of the agenda; you should have an agenda of the morning session - it is about context setting. So, we're going to be covering a quick overview of energy shortage and key trends; and when I say quick, I mean like six to eight minutes worth. Then we're going to immediately dive into our first esteemed panel. I hear we've got Damian to talk about what are those vulnerabilities that face our grid; and one thing you will notice is we have these post-its here and everybody has a post-it in front of them; so, we're going to be getting ideas from you, and our goal in that first session is to really think about what are those vulnerabilities that may be addressed by storage; and what does storage need to do, because at the end of the day, we need to think of those ideas; what are the gaps; the challenges so that our committee can summarize the brain trust that's in this room and formulate them into a coherent set of recommendations for DOE and our federal government.

So, is everybody clear on why we're here today? Any questions? Great.

CHAIR TIERNEY: Just one, not a question; but would you just spend maybe three minutes to have everybody in the room just go around -- not everybody in the room.

MS. LIN: We will. We're going to do introductions, but I wanted to -- just in the timing, Sue, we're going to go through a quick presentation and then do introductions because what I want to do is have an overview of what we're going to do today, and I am going to ask each one of you when you quickly introduce yourself, if you would be so kind to volunteer a question that you're hoping to have answered. Just super quick -- like just 10, 15 seconds per person. I'm going to give you that advance heads-up. But I want to have some level setting first. Thanks.

Okay, so I want to start this conversation with an off-topic topic which is this is actually The Economist from 2013, the sharing economy, and it was when Uber -- how many people here have used Airbnb, or Uber, or Lyft? I mean, probably, everyone in the room? So, what's this about? You know, this is this huge trend that's happening to everything, and it's really about asset utilization. Howe do we take fixed assets that we spend a ton of money in and how do we utilize them either to make money or to save money; and I would proffer that this is a trend that's happening worldwide. It's happening to everything, and it's happening to our grid. And it's kind of a good thing because when you look at our grid -- and this, by the way, is a slide from Pacific Gas & Electric's overview presentation of their DER programs. We have a huge opportunity to better utilize our power sector.

You know, we -- and this is for PG&E -- 5 percent of our capacity is used less than 50 hours a year; 25 percent of our available capacity is needed less than 10 percent of the time; and so, the caption here is this capacity is expensive; it's inefficient; and they say environmentally unfriendly. I didn't say that, but that's right from their slide presentation. So, I would say this is some real low hanging fruit when you think about how many billions and billions of dollars are wrapped up in our power sector in these underutilized assets.

And, of course, the other great benefit of energy storage -- and we as a civilization have been using energy storage, primarily lead acid for decades and decades for emergency backup. This is a picture of the aftermath of Hurricane Sandy of residents were huddled around generators for days just to charge their cellphones. So, the question is, is there a better way? Can we use these assets that are being deployed for improving the utilization of the grid and also use these advanced new assets to help with this problem?

When I say storage -- okay, so just a little context setting and so you guys know the scope of what we're talking about -- I'm not just talking about batteries, we're talking about the full gamut of different types of storage: chemical; electrochemical; mechanical; bulk mechanical, which we're going to have a speaker later today to address underground compressed air; thermal storage; fair game; bulk gravitational, which is pump storage; and, of course, our storage on wheels in the form of electric vehicles.

After we have our context setting this morning, we're then going to go into three specific applications of real world projects of storage and, again, be thinking about well, what are the gaps, what are the challenges; and, specifically, what can we do going forward to use this asset as a strategic energy asset.

Okay. Another way this meeting is a little different, not a lot of words; I have to say that I am not a PhD, or a chemist, or an engineer, so this is how I talk about things and, you know, people always say well, how do you use storage in the grid. Like, what is the main benefit? And, you know, I say that you don't have to look very far to think about what the benefit is. So, it's kind of like your body. So, our bodies are perfectly harmonized. We have our own power system supply and demand of energy must always be perfectly balanced. If it wasn't you wouldn't feel very well and, thankfully, our bodies are very smart. We have these things called love handles. So, the tagline of this mini- story is learn to love your love handles, because if you did not have them, you would be a hummingbird and you would need to eat all the time. I mean, literally, just to make it to the Starbucks, you'd probably have to tank up right now to make that 200 foot walk; but because we have these love handles that energy is instantly available. When you eat a little more you can convert it and store it; and the same thing with our power sector. We have to always be perfectly balancing demand and supply. So, wouldn't a little inventory kind of help the whole system run a little more efficiently? So this is my simplistic, non-engineer analogy of how we would have an optimal electric power sector. Learn to love your love handles.

Trends. Okay, so one of the cool things that's happened, so, yes, we've used lead acid batteries for the last 100 years, things are changing; and one of the things that's changing is there's a lot of new types of storage that are being commercially deployed today; and some of them -- this is just one example, lithium-ion batteries -- the prices are falling very rapidly as demand increases, aided by other industries like consumer electronics, electrification of vehicles. This is Bloomberg New Energy Finance, the cost per kilowatt hour, which is the matrix of capacity in storage has fallen very steeply just since 2010 through now, through 2016; and it is projected to fall even further. So, one of the questions we have to ask ourselves as we think about this future, and this out-of-the-box question, of how do we use storage as a strategic energy asset? What happens if the stuff gets super cheap? So, that's what I want to orient people to think about is like the what-if in the future.

Another key trend is that -- and this is kind of supportive. I mean, these are newspaper clippings that have announced integrated solar plus storage projects, PPAs. So the first one that rocked the world -- 2016 -- Austin Energy made an announcement 14 cents a kilowatt hour combined solution. So, if there was talk yesterday about well, renewables can't be dispatched; well, they're starting to be. Hawaii announced a deal for 11 cents a kilowatt hour, and then most recently TEP announced they got something for under 5 cents a kilowatt hour. Will these projects be realized? I don't know; but they're talking about them in the news, and this is kind of an interesting trend.

So, I would proffer, and I have to confess, I am an advocate, so I'm allowed to say that storage is a game changing. In fact, we've even published a free educational video called Game Changers; but I'd be the first to say that storage is not the best solution for every application. And our challenge here today is to figure out what are the ones that may work in the future, especially with a little assistance from all of you and our federal government because, let's face it, what you focus on is what you get.

Some of the reasons I think storage is a game changer it's a huge broad asset class from really large systems to really small systems. The smaller ones can be modular, scalable; can be very low cost and getting cheaper; they're programmable so what you use it for today maybe not what you use it for tomorrow, and a software switch-out is a lot easier in my mind than a big hardware change out. Locally, they can produce no emissions; you can site them anywhere; it can go in mobile transportations, you can move them around; so there're a lot of reasons that storage can be a game changer in the power sector.

And then finally, the thing I want to bring up, and we talked about this yesterday. Storage is kind of like bacon. It goes well with everything. So, whether you hail from like a gas background, or a coal background, or a nuclear background, what storage represents is flexibility and the ability to make, whatever your starting point, even transmission, operate more efficiently. So, I say it's like bacon because if you notice there's like bacon jam, bacon donuts, bacon and eggs, bacon meatloaf. So that's the other perspective I want to bring is that we're not advocating for any one portion of the power sector, we're just saying just a little of this. Remember the love handles make the whole thing operate much more efficiently whatever your starting point.

And then, finally, this is the question that always comes up. Is it cost effective? Well, I'd say it depends on the application, but here my simple analogy is we all need to type letters, we do word processing, but I would say it's probably a pretty rare exception that somebody here is going to run out and buy a typewriter because you can instead get a laptop computer -- it's portable, you can do other things, you can run spreadsheets, you can have your kids watch movies -- same thing with storage. This is something that provides many different value streams, which we're going to talk about today; even though on a cost basis, it may not be the cheapest thing. So, you have to look at the benefits and not just at the cost. Just think about that in reorienting your box.

And so, finally, that's my overview of storage. What I want to do is just cover, again, what the objectives of today are. So, me personally, I'm here to learn. This is an amazing room. So, we're going to learn about grid vulnerabilities; recent progress in storage deployments; and also learn about all of your creative new ideas. We want to identify the role of storage. One thing you'll notice is we have this range of duration, so we're going to be coming up with vulnerabilities that may be addressable by storage and those time scales. What did you say, Merwin? That storage is the power flow -- help me.

MR. BROWN: It's a temporal power flow control device.

MS. LIN: Thank you.

MR. BROWN: Rather than a special power flow control.

MS. LIN: Which he says so well? Temporal power flow control device. We want to help solicit your input to help us identify gaps and then brainstorm solutions to those gaps; specifically, how the federal government can help, and so, I earlier went over the focus areas. We will have a session at the end of the day for discussion and prioritization. Your input on this is very helpful to our working group; but, generally, some of the questions to think about throughout the day, the over-arching question is, of course, how can storage support a modern and reliable 21st Century power sector? What are the resiliency challenges? -- that's going to be our first panel. What are the capabilities that are necessary to achieve to help in those areas? What are the medium and long-term challenges, because that's the orientation of DOE is looking longer term; and, you know, what can we do now to help address these challenges.

So, these are all the questions that will occur again and again today.

And then, finally, I'd be really curious if anybody learned anything new at the end. So, there you go. Ground rules, there is no such thing as a dumb question. Truly, like sometimes I think as experts in our field we get so focused at looking at one tree, it's hard to step back and see the forest. So, any question is a good question, and really encourage you to raise that question, speak out.

We do have a recorder who is going to be recording all the notes. We will be writing a public report, but we will not attribute any specific quotes to anybody, at least not without your prior written approval. So that's a pact that we can attest to. It's very hard for our stenographer to capture what everyone's saying, so, please, one speaker at a time; and I will do my best to facilitate that; and I really, really want to keep to schedule so that's why I'm going to wrap it up and next go on to introductions.

So, with that, perhaps, who wants to start? Richard; and we'll go around the room. So, name, organization and just a quick question you may have around storage.

MR. WALJE: Hello, My name's Richard Walje. I am the CEO of Magnum CAES, a compressed air energy storage project. I'll be presenting a little bit later today. My question is how should we value the stackable services that are available from storage, especially 15 years from now?

MS. PRAMAGGIORE: Good morning, Anne Pramaggiore from Commonwealth Edison. My question, or what I would be looking to hear about, is the articulation of regulatory hurdles to implementing storage and any unique or effective approaches to those sorts of hurdles. Thanks.

MR. FELLER: Gordon Feller from Cisco headquarters in Silicon Valley. My question is what do we learn from our competitors and potential partners beyond the U.S. borders? What can we learn, for instance, from the Chinese who are making large-scale energy storage investments, particularly around micro-grids in new urban centers that are being built as we speak?

MS. SILBERSTEIN: Good morning. I'm Pam

Silberstein from NRECA. I guess my question would be considering that our membership is rural electric cooperatives whose infrastructure covers a lot of the country, but that part of the country where not a lot of people live, what are the particular storage applications that would be most useful and helpful in that part of the country for not only reliability and resiliency but also affordability?

MR. ALMGREN: Ake Almgren. Orkas Inc. is looking at new added technologies. I'm also serving on the PJM Board where I chair the liability committee. My main interest today is where in the system will we expect to see most of the new storage resources show up?

MS. WAGNER: Thank you, Rebecca Wagner, Wagner Strategies. I'm an independent consultant in Nevada, and a former regulator. I happen to have a client in Nevada that manufactures batteries, so we have a lot of work to do incorporating a bunch of energy regulatory policies that were adopted in Nevada. So, my question is along the lines of Anne's with the nexus with the regulatory process and looking for ways to make that transition to getting regulators comfortable with an asset class that they're not familiar with.

MR. MORGAN: I'm Granger Morgan from Carnegie-Mellon University. It's hard to store electricity but, relatively, easy to store water. So, I'm interested in whether there are cost-effective ways to have variable generators that move back and forward between doing de-salinization and filling for variable and intermittent renewables?

MS. BROWN: I'm Laney Brown with Modern Grid Partners; and before I came to the meeting, I was talking with a colleague and he asked me, you know, is storage really of value. And, so, what I would like to understand is, you know, the perception of storage and how value can be articulated and applicability of that value?

MR. SHELTON: I'm Chris Shelton, the Chief Technology Officer at AES Corporation. My question for the panel is what one insight do you think speeds the awareness of value in the adoption of energy storage, in your experience?

MS. SANDERS: Heather Sanders, Southern California Edison. I'm interested in better understanding how, as we start to consider energy storage as an alternative to traditional infrastructure, how storage can be equivalent to a substitution for a regular wires alternative?

MR. BOSE: I'm Anjan Bose from Washington State University. My question has to do with the different types of storage. It seems that the conversation today goes towards thinking of storage of being batteries; and what is the status of other storages that are available?

MR. ADAMS: John Adams of the Electric Reliability Council of Texas. My question's similar to Anjan's in that at what cost of kilowatt hour do we expect the expansion of stationary storage to explode in megawatt hours installed; and what I'm thinking of is the early-2000s when the combined cycles just exploded across the country, and we had to, in the grid, accommodate it as best we could.

MR. BROWN: I'm Merwin Brown with the University of California, Berkeley, and my big question I asked in my opening remarks, actually; but maybe a more specific question, I'd like to look at is I'm seeing this tension in our system in which energy storage has to be deployed and its value recovered in either a regulated or a competitive market base; and I'm curious to know what kinds of barriers that poses, and what might be some of the solutions or workarounds on that?

MR. CENTOLELLA: I'm Paul Centolella. I have my own consulting firm and work also with another consulting firm in Boston. My question really goes to the topic of resilience, but also I guess, it has an impact for when we think about high renewable futures, and that is what are the technologies that are potentially available to do longer term such as multi-day storage of power in areas that may not have the geography for pump storage or underground compressed air; and what can be done to get significant cost reductions in technologies, whether it's load batteries, or liquid air, or something else that could begin to fill that need?

MR. ZICHELLA: Good morning. Carl Zichella, Natural Resources Defense Council. I think a lot of folks have already touched on things that I have questions about, but one of the issues goes to what Anjan was saying, is there are many different flavors of storage, there is not always a clear way to compensate for the services that the storage provides, and it creates a conundrum for us. Without this clear revenue stream we may not get storage that we need that can provide the kind of values that Paul was just talking about; and, you know, is it a transmission asset, is it generation asset; it's a question that doesn't seem to go away, and who pays for it and how it's compensated doesn't seem to be clear. I know of many large storage projects that can't get a power purchase agreement; they don't need a long-term contract in order to develop a large pumped hydro facility, for example, or a project like Rich's. You know, this is an issue that we have to solve.

CHAIR TIERNEY: My name is Sue Tierney. I'm from Analysis Group in Denver and I end up typically getting interested in public policy issues related to the electric industry. So, in that context, Janice has given us some overview of the arrival and entry of various types of storage, but, to my knowledge, we're really not at scale and we're not yet at a point where we could count on having storage across a wide range of functionalities and applications yet, and then to do that reliably on a large investment scale. So, given that we will have a lot of need for incremental investments in other things related to the grid, how do we think about the timing and pace of these different functionalities as we're adding, for example, new gas pipeline or other things, that eventually will end up competing and potentially look like stranded costs?

MS. JEREZA: Hi, Katie Jereza, Deputy

Assistant Secretary, Transmission Permitting and Technical Assistance, U.S. Department of Energy. So mine's a little -- got a two part to it -- so, my question is what game are we trying to change and what does DOE need to invent to help energy storage change that game?

MR. ROSENBAUM: Hi, I'm Matt Rosenbaum. I'm also with the Department of Energy. I'm trying to go outside the box with my question a little bit here. I did a lot of the emergency response work with DOE in my past days, and one of the most valuable things to getting the grid back up after a major hurricane or other things, was getting individuals back in their homes; nothing better than, you know, an unlimited workforce of people with their chainsaws out clearing stuff and stuff. So, my question is, you know, goes to the point of the role of storage in the home and how that could be used to get people back in their home after an event and what complications that provides for the utilities as they restore power after a major event?

MS. CARMODY: Hi. I'm Paula Carmody, People's Counsel for the Maryland Office of People's Counsel. I represent residential utility customers in that state; and so, my question is kind of -- given the enormous kind of scope, scale, and implications of storage, what top three recommendations would you give to state regulators and stakeholders in the state regulatory process from a focus on storage issues in the near to mid-term, given that we can't focus on everything?

MR. NORDSTROM: Good morning, everyone. I'm Rolf Nordstrom with the Great Plains Institute in Minneapolis. We're a nonpartisan, nonprofit there. I'm really interested in how energy storage either is currently, or could be, captured in the resource planning models that utilities and regulators use. So, in our neck of the woods, that happens to be strategists; but I know there are many out there. Does storage get captured in those models today and, if not, how might it and how might its value stack affect the way we do resource planning?

MR. MORRIS: Jeff Morris, Representative for Washington State, House of Representatives; and we have a similar comment, actually. I think our question is, we look at Hawaii as being an example of what we don't want to see happen, which is an active situation, would be ability leading to the most expensive CapEx solutions reacting to a problem. There's really a bad lack of data for looking at lifecycle costs to an integrated resource plan, which is like 70 percent deterministic, maybe 30 percent probabilistic, at the end when you're do an efficient crunch here; but when you look at DER planning, there's no data at all about where energy storage fits into more temporal value sets that are more situational, and how those would propagate out to have energy storage as a resource to build symbiotic relationships in the distribution grid as opposed to being a mission critical tool that's the most expensive one at the end. So, my question would be is there a horizon for those data sets and would they be in a form that, you know, people that participate in those planning processes really understand?

MS. CURRIE: I'm Phyllis Currie. I'm a former general manager of Pasadena Water and Power in California, and currently on the MISO Board and doing some independent consulting in California. My interest in storage is to see the range of applications that are possible from very small applications that might be suitable for a municipal utility that has a local, solar rooftop in their service territory, all the way up to, as a resource, that can be part of the energy markets.

MR. LAUBY:: Mark Lauby, Senior Vice President and Chief Reliability Officer of NERC. A couple of things -- one is, if you don't plan for it, it never gets built. That means you need to be able to make sure that you have the models, the simulation tools, etc., to see it as an alternative or one of the alternatives you can consider; and then given where we're going, and given the spectrum of technologies out there --

and this kind of really follows up with what Phyllis was saying and Paul was saying, is what's the status of that technology and technologies, and what kind of breakthroughs, if any, are needed to ensure that we got the technologies when we need them?

MS. BROWN: I'm Marilyn Brown with the Georgia Institute of Technology and the Tennessee Valley Authority. The State of Georgia has the second largest number of electric vehicles in the country, second to California; and my interest is on developing a business and governance model that would enable storage on wheels -- did you call it that Janice -- to help to provide some of the balancing requirements to the local distribution system -- in particular, I'd like to do a pilot in the city of Atlanta. So, anyone's interested; got ideas; please let me know. I hope you'll speak to something like that -- anybody on the panels, we'll be hearing from, who might have some expertise to help me out. Thank you.

MR. CASPARY: Good morning, Jay Caspary.

I'm with the Grid Operator in the Central U.S. Plains, Southwest Power Pool. I'm interested in market mechanisms to help us manage utility scale solar resources that are having excessive curtailments today.

MR. GELLINGS: I'm Clark Gellings. I'm an independent. I supposed you could call me a consultant. Most of my career has been with the Electric Power Research Institute, and I've managed research in just about every area of technology except nuclear. I want to be cautious here, a little bit. Would it be better to focus on conventional solutions; and what I mean by that are solutions that incorporate the use of technologies that we already are aware of that are much closer in costs and most closely competitive instead of focusing on storage. It seems to me that the improvements that we are making in storage are not rapid enough, and we might be better off focusing on power electronic applications, which in many cases can substitute for what would be a storage application.

MR. SCIANO: Damian Sciano. I'm a Director in Con Edison's Distributed Resource Integration Group. My group puts together the distributed system implementation plan that says how Con Ed's going to integrate all DER into the grid, and battery storage would, obviously, be an important part of that. I guess my question today would be, just learning, you know, benchmarking with other places like the UK and PJM and seeing what kind of market features they use batteries for -- you know, is it frequency control and things like that. I'm excited to see the boards with the different time frames of storage applications.

MR. KUMARASWAMY: Hi. My name is Kiran Kumaraswamy. I'm a Marketing Development Director with AES Energy Storage. My key question for today is also similar to what Rolf and Mark actually described with regards to modelling and analytics of all of the benefits that energy storage provides, and what has been done, to date, by DOE and the national labs? How can we make better use of all of those research studies, and what needs to be done going forward? Thanks.

MR. COLEMAN: My name is Terry Coleman. I'm with the Electrical Training Alliance, and representing the International Brotherhood of Electrical Workers and the National Electrical Contractors Association; so whatever you guys come up with, we're all in because we'll be putting it in for you; and that's my main concern. I'm curious as to all these systems that are being developed and a look towards a skilled worker's shortage. What do you guys see as needs for training opportunities, or training for a workforce that will install these systems around the country?

MR. IRWIN: Good morning. I'm Mark Irwin with Southern California Edison. I am in the Energy Procurement Group. I've been involved in a number of our storage activities in the company over the last six or seven years. I'm really here to learn from others and what others are doing in this space as opposed as to having a specific question.

MR. HASSENBOEHLER: Hi, I'm Tom Hassenboehler. I'm the Chief Counsel for the House Energy and Commerce Committee. Handle all of the energy issues and the DOE issues here at the committee. What I'm interested in is how storage can help bridge a gap that is desperately needed in politics right now on energy and climate issues; how we can, if we can have some discourse today about how to properly address and value storage in the markets, can actually bring about some technology neutral and less partisan ways of how to address climate and lower emissions. I think that will be a good thing to keep in mind as we talk into more a technical realm today. So, thanks.

MS. MCCORMICK: I'm Pat McCormick. I'm the Chief Counsel of the Senate Energy Committee, and my questions are variance on ones I've heard around the table. To be pointed about it, I think, given the significant challenges and the financial fiscal situation of the federal government, how can private capital be attracted to make the most of the opportunities in storage; increasing deployment; improving performance; lowering price. Can this be done with -- other than basic research support -- no support from the federal government; or, if the answer to that is no, what's the most efficient way and the lowest level of federal expenditure, whether it's a tax expenditure or direct expenditure?

MR. KUMAR: Good morning, everyone. My name is Puesh Kumar. I'm the Director of Preparedness and Exercises in the Infrastructure Security and Energy Restoration Division within the Office of Electricity. So, my questions today, throughout the day, are going to be more about the security resilience-side of things and emergency response. So, Matt, the question you had was going to be exactly what I asked is when you consider the Aliso Canyon example Janice gave and being able to use energy storage as a means for a liability after an incident like that, and a longer-term incident, what are the solutions for energy storage? But because you already asked that, I'll ask a new question. So, I'll pull on another thing that you mentioned Janice. You talked about the analogy between a typewriter and a computer, right. So, it made us more efficient, but it also opened us up to cyber vulnerabilities; and so, if we continue pulling on that thread we, obviously, know that was the right direction to head towards. So, when we're thinking about energy storage, are we looking into baking in security into those solutions so that - - from a security person's perspective, I'm seeing a lot of energy storage on the grid which means there are even more vulnerabilities on the grid. That can be a safety issue. So, let's address them right away. How are we doing that?

MS. DENVER: Jessie Denver, Energy Program Manager, City and County of San Francisco; and my question is for all of the attendees in the room, given that I am the only local government representative here, how familiar are you with local government activities and policies that are actually driving market transformation whether it should be at energy resources like storage?

MR. RUFFINE: I'm Tony Ruffine. I'm the V.P. of Renewal Energy at GAF Corporation. We have a variety of things we do in energy, solar, storage, that area, and I'm really trying to figure out the impact of storage in our overall funding program as for investing in overall energy systems, cost benefits impact on return. Maybe trying to get to the point of when do we go from accepting the storage and projects that we're funding to actually encourage the use of storage, and what's that tipping point of the things we should be looking for?

MS. LIN: Great, thank you everybody. That was an awesome list of questions. We got a lot of to cover today.

MS. SANDERS: Hey, Janice.

MS. LIN: Oh, Heather, go ahead.

MS. SANDERS: Sorry, I had two, but I thought someone would say my second one. I'm interested in the second use of energy storage and the recycling aspect of it. I didn't hear that at all, but one of my understandings is you build storage for a particular application but, you know, for a lack of electric vehicles, you know, is there a way to repurpose for a second use?

MS. LIN: You guys are awesome. I guess my question to DOE and EAC leadership is when can we do another workshop because we're definitely not going to be able to cover all of your questions today, but I think we'll cover a lot of them; and since we all heard everybody's questions to the extent that our speakers were -- or if maybe you personally have an answer to something that came up in the context of the discussion -- I encourage you to offer your thoughts. Any perspectives are valid here. So, I would just like to call -- you know, there's a lot of questions about international -- maybe Chris and Kiran, if you guys can cover some of the world views, since you guys are doing storage globally. Our utility friends, Damian, Mark, Heather, if you guys can cover some of the costs issues and where are things now; and, for those of you who don't know, Edison has bought, I think, like more than 400 megawatts of storage in the last two years, so they're probably super current on where costs are and looking at a range of technologies; and, I think, we're all going to try to answer the question of what is the game that we're trying to change, and what does DOE need to do.

With that I want to go right to our panel.

MR. MORGAN: Janice, could I have the clicker?

MS. LIN: Yes. Oh, you need the clicker. Sorry. I want to just -- to save time, I've asked each of our panelists to present on power sector vulnerabilities for all of our benefits -- we're lucky to have such experts here today -- in eight minutes or less, and we will be going right into discussions; and just so you know where I'm headed, I'm hoping that on these four things -- after you guys are done talking -- we can start brainstorming. What would it look like if storage was going to provide assistance in addressing vulnerabilities that last, in the seconds to minutes range; in the hours range; in the days and months; and seasons. And, again, just a reminder, it's the full range of storage. It could be storage combined with something else; so everything's fair game. And with that, we have Granger Morgan who is the Chair of the Grid Resiliency Committee of the National Academy of Sciences going first.

MR. MORGAN: So, I'm going to walk us through a range of sources of disruption that have occurred or could occur to the power system -- a set that are human induced, a set that are natural. I'm not going to talk about one of the issues we discussed yesterday; namely, the loss of gas supply. So, most causes of power outages are local -- they're things like lightning; they're things like squirrels; people driving into power poles -- actually, Clark pointed out that I should have included snakes and raptors on this slide -- and there are couple of standard matrices of these. These maps are a few years old. I'll show you more up-to-date data in just a moment; but our performance in this country for distribution-level disruptions is maybe not quite as good as highly dense places like Europe, but it's pretty good. There is, however, wide variability across the country. And I should point out that yesterday there were people talking about needing a matrix for resilience. Well, these matrices, of course, for interruption look back but many of the disruptions that could cause very large, high-consequence outages don't happen very often. Some of them haven't ever happened, and so figuring out how to do matrices there -- I mean, it doesn't make sense to report the frequency of [inaudible] events for solar storms or something; and so, matrices may not be quite as straightforward on the large disruption sides.

I've listed here the fact that there is great variability across the country in terms of these matrices ranging from a very highly reliable system to systems that aren't quite so reliable.

So, let me first talk a bit about the upper branch here. So, the first point to make is that if you fit a distribution to modest scale grid interruptions, you get an exponential, which is sort of like that dashed curve, and you find that this is a distribution with a fat tail. That is, there are more, very large scale interruptions, than one might otherwise anticipate if you simply extrapolated from the more modest scale disruptions. Where am I supposed be pointing -- this thing, we had this same problem yesterday.

CHAIR TIERNEY: Granger, you told me you knew how to do it yesterday.

MR. MORGAN: No, I told you that it probably wasn't pointing at the screen.

MS. LIN: Point it at Chelsea, in the back.

SPEAKER: (Inaudible).

MR. MORGAN: Yeah, that's what I assumed. Okay, yeah, back there. All right. So, terrorism. We've been pretty lucky. I mean, other parts of the world have had major terrorist events -- people blowing up pylons, and so on. We've, with one or two exceptions, been very fortunate. You know we still have people who shoot out insulator strings, but we've not had any major event. This academy study, however, points out that if we had a major event, and it happened at a really awkward time, like in a cold winter or a very hot summer, not only could it have very large economic impacts, it could actually have resulted in hundreds or even thousands of deaths due to heat stress or extended exposure to extreme cold.

On the cyber side, I've quoted from the Quadrennial Energy Review. This situation is very uneven, and it's not clear that one could produce a physical destruction at the same scale that a terrorist event could, but you could certainly make life very inconvenient for a lot of people; and, as we discussed yesterday, with the growing sort of integration of cyber with the rest of the system, if you ever did get the system widely infected, figuring out how to disinfect and get things back up and running could become really quite a problem.

And then the last issue, of course, on the human side is operations or operational errors; and in that case, as we have become increasingly automated, one of the real issues that needs attention is how do I regain situational awareness if I'm sort of letting the automated system run itself and I'm sort of tracking it and then I suddenly realize, oh, my God, we've got a problem here. Getting back up to speed -- it's the same problem that pilots have when, you know, they become overly dependent on automated flight.

All right; so, now I'm going to quickly go through the natural events beginning with the one that, of course, causes by far the most disruption to power systems; but ice storms, of course, in some parts of the country can be also very serious. The extensive outages from the East Coast after Hurricane Sandy affected more than 8 million people. Economic losses were about 50 billion -- now, you know, many of those weren't related to the loss of electricity -- there were 147 direct deaths -- they, too, weren't all related to the loss of electricity, but the absence of electricity was just fine -- I was saying just fine to her who's holding up a two minutes sign.

The Quebec ice storm had similar sorts of consequences and could become -- predicting where ice storms are going to occur in the future turns out to be really difficult. Large regional storms are another source of disruption, and we've seen growing numbers of clusters of tornadoes. Now, a single tornado, of course, can take out a bit of a transmission line or a substation, but if you actually get a sequence like the one shown there that happens to track along a bunch of transmission corridors, you could have big problems. And then floods and storm surge and getting facilities sited away from areas that are potentially vulnerable to storm surge is another issue. Tsunamis, earthquakes, and volcanic events are three other sources that really need, perhaps, more attention than they have gotten; and then here's a few others, including pandemic, which, of course, could cause very major problems. The 1981 flu epidemic actually killed more people than the First World War; and if you had a serious pandemic of that sort, staffing the operations of power systems could be a big problem.

The last risk I wanted to talk about is space weather. Normal space weather events are not a problem, but we've never had a Carrington-scale event since we've become dependent on electric power, and as Lloyd's points out here, things could get really messy were that to be the case.

A final thought. Local storage can help with ride through for short-term local outages. If inverter designs and regulations are changed, local storage could also be combined with local PV to provide some limited resilience in the face of larger long duration outages. Many people with PV on a roof don't understand that when the grid goes down, they don't have any power; and central bulk storage can help both with short-term ride through on the bulk power system and with black start. With that I will say, thank you.

MS. LIN: Thank you. So, let's go ahead to Damian, and then we'll just -- and by the way, if anybody has a super quick question during the presentation, raise your hand, but like quickies. We want to get through our three presenters, and then we'll go to discussion.

MR. SCIANO: Okay. So, hello, again, I'm Damian Sciano. Part of what we describe in the distributed system implementation plan, which is like our strategic plan of how we're going to roll out the distributed energy resources, is we talk about this distributed system platform. It's probably going to be very IT-heavy, but it's going to be where we kind of pull all these devices together for both planning and operations, and eventually market transactions. So, if there's one take away I want to leave everybody with is, you know, from the utility's perspective, it's very important to own battery storage.

Carl mentioned, you know, can be a generation asset, and it has a lot of uses; and we understand customers are going to be using it etc., and so on; but, you know, we see it as absolutely critical to the T&D. Merwin used the term holy grail; Janice used the term game changer; we see it that way too. I can't think of really any other commodity, other than maybe telecommunications, where you have to deliver the product on demand; and Sue did such a nice job of explaining how challenging that is yesterday compared to a system where you can store stuff. So that would be a main point.

The second two points are, you know, we're still trying to find the use cases, and then this is going to sound like a piece of the first one; but the use case is going to continue to evolve. You know, I'm going to tell you about BQDM and how we used the battery there. Janice you mentioned Aliso Canyon. I think pretty soon, if we're successful with this stuff and we start to kind of flatten the demand curve, very quickly those big ones go away. So, then, what kind of follows it and what are pieces after that; and certain value stack has a lot to do with that. So, next slide. Oh, I've got to do this, sorry.

All right. New York State does have some pump storage. There are three pump storage plants in the state that are used for black start. So, during the 2003 outages, these are actually the devices that create some generation and then create what's called the crank path and start very slowly bringing things up to speed. It's very limited application because it's hard to find the land to site these big pumps. Reservoirs and, obviously, it's getting increasingly difficult to site those kind of things; so, not a lot of opportunity there. I just want to mention that. In the future, to the extent that smaller batteries we use for black start, you've got this tremendous amount of size that you've got to get to; so, it's hard to imagine that happening too soon.

MR. SCIANO: I wish I would have had under battery systems a mention of our substations. Obviously for decades we've had battery systems in the substation to make sure we have uninterrupted power supply. And I promised Janice I would look in that Ukraine cyberattack, in addition to simply taking control of the system and opening breakers and creating outages for something like six hours for 600,000 customers, my understanding, which I couldn't quite find online last night, I've got to be honest, was that they also were able to do some permanent damage to the UPS, the uninterrupted power supply systems and the battery. So I'm going to keep looking for that, but I think in any kind of inverter-based technology, if an outside person can attack it, and change the programming where it does some kind of high voltage and burn things out, I could imagine them doing that permanent damage. And I am pretty sure something like that happened in the Ukraine.

Anyway, even if it didn't, utility engineers lay awake at night dreaming about these things and worrying about them, so as we add more points -- so even that I've just told you it's not going to be possible to have one great big battery somewhere helping the system, as we add all these points, we worry about the physical security of them and the cybersecurity of them being hacked. And every time someone ties into our system, it's just one more vulnerability, you know, to where we are. We are looking at all different types of battery systems. We're working with the FDNY. New York City is kind of a unique case because of the density and the tightness of the building spaces, so it is a very big concern for the FDNY. And then, you know, I heard somebody mention air, airflow batteries. We're looking at supercapacitors, et cetera and so on.

So, again, very important to the utilities, and we would like to see more and more of it. I do want to call out to the REV explicitly, which says that utilities can own energy storage. Again, I know I'm repeating that point, but we can own the generation. We're vertically de-integrated. Since the '90s we sold off all our generation assets, but there was that carve out for energy storage. And, again, for the policy makers in the group, I think that's very important. It's a critical T&D asset. And you see why, not -- for capital, you know, capital efficiency, getting that nice needle peak that Janice mentioned moved over, and for security, reliability, and I'm sure a host of other things we'll think about in the future.

So I want to show you this next slide. It's kind of a time lapse of the New York City area. I probably won't be able to point to it, but you'll see New York City is kind of in the center of the city. It's the hub. It's the most dense. It's where you picture all the skyscrapers. And then, as you move out, you get more into the suburbs and things like that. And what you're going to see is, over the course of the day -- okay, so that' Manhattan, that little piece right in the center, and there's a blowup on the upper left. This is from midnight, six, seven, eight. You seen the load go from dark blue, which is like, 50% utilization, up to darker red, which is 100%. So, now, here it is 2:00, pretty good spread. People are working in Manhattan. You see a lot of density there. The part of Brooklyn you see highlighted there, we call it Downtown Brooklyn; it's got a lot of skyscrapers. Long Island City. And then White Plains, all the way north, is in Westchester, but it's still a pretty urban area.

So this is when solar would have the best benefit for us, and you can see some networks might get some advantage there in Manhattan. Now, as we move along, 3:00, 4:00, 5:00, this is our system peak where you've just got everything pretty high, even if it's not completely high. The solar assets, which is predominantly what we're seeing in New York City, they're already only at about 30% of their full rating and output. But then here's the interesting thing, as you go late into the night, and that load moves back to the bedroom communities, you can see a lot of networks hitting their peak at 9:00 at night. So a lot of takeaways. And then the Brooklyn-Queens one, which is the one I'm going to describe to you in a minute -- oh boy, I'm already getting two minutes, is the fastest growing one and things like that. So solar alone wouldn't be a piece of it. Battery storage is critical to that. And then we go through the night. So, again, you can see why it's a critical T&D tool, right? To defer costs in any of those networks, you got to actually do it at the time when it occurs. And some of them have very long-sustained peaks. And that's what you're going to see.

So here's Brooklyn-Queens. That's the dark red area you saw at 9:00. The bowtie in the center is what we're targeting. If we don't have a distributed energy resource solution, we're going to spend a billion dollars on a substation. Instead, we're spending $200 million to defer that. We're not saving 800 million. We're just deferring it. And we get a lot of optionality value out of that. Battery storage is a part of that. And I know I got to move this along. So here's what we're trying to accomplish there. Basically, that dotted black line at the bottom is what the substations are good for today. In three years we predicted it's going to go to that red line. The traditional utility solution would be to add a 250-megawatt substation, which would be up on the fourth floor, on that diagram, would give us nothing but headroom. Engineers love that. The BQDM solution is to put in all these little blocks. You know, some of it may be solar way over there at noon; 1:00, 2:00, 3:00 to meet that growing peak, because you can see it's a long duration that it's overloaded. But batteries are obviously going to be a critical part of that at the later peaks of the night, demand, response, energy, efficiency, and things like that. So it's going to be a big mix of those different assets, but it's going to allow us to defer that capital pretty significantly.

And this is just the asset mix. And I just wanted to highlight for you the batteries. So, here, look at that, charging and discharging. And then you've got energy efficiency and demand response. And this is one of the batteries that we're going to use. It's a 2-megawatt/12-megawatt hour battery. We did get it through the permitting process with FDNY. Just to give you an example, we used lithium iron phosphate, which has a very low, all right, I don't know if flammability is the right index. It has its own fire suppression system. Even still, the FDNY had us put in a standpipe system just to, kind of, have belts and suspenders. It's been much harder to get those permitted on the residential level.

So BQDM, very big success story. We tried this virtual power plant at the residential level. We're still kind of struggling with the FDNY coding on that. I think they've got some very legitimate issues, but it made it challenging for that project. And we've also put out a demonstration process for largescale storage demo.

Okay, I think, with that, I'm turn it over.

MR. LAUBY:: Good morning. I'm waiting for my slide to get teed up. There you go. So, we were going to go right past that slide and talk a little bit about reliability and why we think that, of course, a large-scale storage can be a real game changer. This is our classic definitions of reliability, both in the adequacy and now called operating reliability. And, of course, the adequacy is really about, is there enough supply. Operational reliability is, can the system operate under a variety of different conditions. And then, finally, you know, of course, is there enough supply at the operational reliability that can be controlled. And that's really how we define reliability at NERC.

So system dynamic characteristics are changing and I'm going to have a few examples of how those faint signals that we're starting to see now may be indicative of changes to the system and how, perhaps, storage and the variety of different technologies that are available can help us, you know, address some of those changes. I do talk a little bit about sensor reliability services here. That is, actually, those characteristics that, perhaps, you used to get with you when you calculated a reserve margin, which now we're disaggregating as we had more and more asynchronous type resource to the system. Asynchronous means those kinds of resources that are not synchronized to the system. The 60 Hz heartbeat that really is the driver of -- and, you know, the support of that frequency along with voltage. It really makes it all go.

So we'll talk a little bit about storage, of course, what is it. Yes, it's load. Yes, it's capacity. And, yes, it's transmission. And I guess that's, perhaps, one of the challenges is that, you know, it's dynamic. It can be what you want it to be when you need it to be that. And as a result, it's sometimes -- it can be helpful to support because it can be dispatchable against those resources that are not dispatchable. We'll talk a little bit about the actual flexibility and some of the, perhaps, range of vulnerabilities that storage can help us with. We can talk a little bit about the inertial and primary frequency response area, certainly with batteries, and that there is a need here for inertia replacement at some point. Inertia is that which allows to slow down or attenuate disturbances on the system. If you don't have it, you better have controls that are going the speed of lightning, or light, because it's going to go down. The frequency will go down very quickly and will not be able to be recovered. So batteries can help support that inertia replenishment, especially when you got a lot of asynchronous resources coming on your system.

Regulation, of course, we talked a little bit about that and how that can be supportive of the system. Voltage support, load following and ramping, and continuancy reserves, it's a -- my God, this thing's got to catch up with me here. I'm faster than a dog on a speed of light. And you can see the different types of technologies that can address different capabilities. So it's a matter of understanding, what is the issue, what's the problem I'm trying to solve, and then what are the types of alternatives in front of me here that I can use in my normal planning. Yeah, you better watch out. I could take that out in no time.

So, of course, when we talk about a central reliability of services, and we talk about load and resource balancing. That's extremely important. That has to happen on the distribution system, as well as on the bulk power system, supporting voltage, and then it's actually frequency support. And all that then really drives toward reliability. It used to be we'd get this with reserve margins. It's a multidimensional kind of a measurement, which 15% ultimate you got inertia. You got voltage support. You got frequency response. But now, not every megawatt is exactly the same, and as we disaggregate this piece of the puzzle, so that we can assure that we can continue to support frequency, we can support the voltage of the system, and that's actually one of the challenges in using battery storage and DER, when you have -- the system goes down, how are you going to keep -- what do you regulate this, or how do you get your frequency? Generally, especially with power electronics, it's actually using a phase lock logic, and it's actually, you know, using the frequency of the system to synchronize. If you don't have that frequency anymore, how do you do that locally? And then, also, when you restore, you can't just slap these things back in, because they'd all be out of sync. You know? You got to get everybody on the same heartbeat at the same time. So that's one of the challenges of using DER and batteries, but that doesn't mean it can't be done, it's just something we have to keep an eye on.

Frequency excursions, of course, happen across the system. They may start in one part of the world, then, kind of, you know, float across. So, you know, where is the right place to replenish the frequency response of the system and see that it is a large interconnected network. We can talk about the duck curve. I always like to talk about the duck curve because we actually thought that this was all going to happen by 2020 in California, and as you can see, (inaudible) our solar and, of course, our wind, and then the whole idea is, how do we match our ramping against the net load. And, of course, what we ran into here is that, though we expected, you know, perhaps a kind of a ramp by 2020, if I can get this guy to come up, 12,700 megawatts in three hours, we're actually seeing that now in 2016. In fact, there was an event earlier this year we had to go to interruptible load, which is okay. That's what it's there for, too -- because the generating clients couldn't ramp fast enough. Batteries, again, can support that, as well, so another good characteristic here.

Already heard about the Aliso Canyon. This, of course, is an area where we have intense interest in backup for storage. And, of course, batteries can provide that backup and allow that -- increase that flexibility of the system so we're not accounting for storage facilities which are, especially here, close to, you know, large metropolitan areas.

Let's talk a little bit about solar. This is what we see in the next two to three years as far the current, excuse me, the current solar penetration. We see that increasing over the next two to three years. Again, this is another area where storage can be extremely helpful so we can take, and perhaps spread out, the peak, as well as when you have unexpected cloud cover come up, again, you're going to have that for backup, as well. So let's look a little bit about where we are right now and how this whole control and system is changing, as we kind of lean more toward from a bulk power system generation to a distribution system that's generating, and seeing, of course, here that the disturbances are starting to permeate from the distribution system actually out of the bulk power system, and how to manage that, again, using storage as a key contributor.

So, in closing, and I know that you've been waiting for that comment for quite some time, we see profound changes to the bulk power system. There's certainly a lot of uncertainties of what that system might look like, and how do we manage that transition to ensure that we continue to provide a reliable system and, of course, reliability to the consumer. So with that, I yield the remainder of my 10 seconds.

MS. LIN: Thank you, you guys. So at this point I'd like to open up for questions in our panel. Any questions from anybody and the convention is you can raise your hand, turn over your name card, and we'll start with Phyllis. Go ahead, Phyllis.

MS. CURRIE: I guess my question is more directed towards Damian, although the other two might have responses. Living in an urban area for a long time, I think I witness a lot of residential and political pushback when you go to site large, you know, technical devices. And certainly looking at the picture of that battery storage unit that you showed, I would -- my question is, so how do you manage public acceptance and perception of having such kinds of devices in an urban area?

MR. SCIANO: That was definitely a big part of it. We actually met with the community a number of times. New York City has one mayor, but they've got 49 council members, and what's been really clear over time with any kind of disturbance on the electrical system, get to them early. The same thing with this. You know, we're putting it in a -- and you're absolutely right, right? There's going to be now, on a residential lot, probably not 10 feet from the people on either side of it, this construction, the containers going in, et cetera, and so on. So we explained to the community and the community leaders what the purpose of it was and all the benefits of it, and answered any questions that they had. I think we had at least two or three meetings. But it is very challenging and it changes very much area to area.

You know, part of the reason BQDM was successful is because it's so expensive to build a substation. That's why I say, it's not a billion dollars anywhere else, but we've got to acquire the lane, and then we've got to build, usually, architectural facades and kind of make it blend in or look even better than the thing. But, yes, a lot of lobbying and a lot of meeting with the community and working through.

MS. LIN: I have a question for everybody, so we'll go to Carl. Merwin, I ask that you be concise because I have a question for everybody that I want to solicit input. So go ahead, Carl.

MR. ZICHELLA: Okay, this is also for Damian. I know that the flywheel technologies had taken some root in New York. I guess it's on Long Island, there's about a 30- megawatt installation down there. Very fast, very short-term operation, mainly for frequency, I think, regulation. I'm just wondering, given, you know, the space constraints, that actually seems like a pretty nice application. And there's also some flywheel technologies now that have much longer operating timelines than just the few seconds that the first ones had. I'm wondering if there's any interest in or continued consideration of using flywheels to provide some of this grid service needs and modest load following.

I think I saw an article about flywheels that can now operate for a few hours at a time. Just wondering what your thoughts were. Beacon Power, I guess, had been the original originator of this technology and its applications. And it came out of your state.

MR. SCIANO: Yes. So, you know, the flywheel technology, we have a little bit of experience in our territory. There's this A train that goes from Queens over to Rockaway and there's a three-mile run where you're going over water, and it was, I think, a very good application in that case. I'm not sure how it's doing today, but that was 10 years ago. And it provided that momentary frequency boost for this big, heavy traction load to get through. So I agree with you. I certainly see some applications for it, but I must say, we haven't had a lot of flywheel vendors recently even come -- literally not, you know -- so it's kind of back in the R&D pocket at this point.

MR. ZICHELLA: And this goes to the question that I raised earlier about compensation. You know you have a great technology with a good idea, and it can't get paid for.

MR. SCIANO: Yeah. In addition to all the work we're doing on REV at the DER level, the New York Independent System Operator is building a DER roadmap and trying to see what products and services make sense in the future. My understanding is, PJM has a frequency market or something where a flywheel might get some better reserve capacity (inaudible). So I think part of what they're trying to do is come up with those value streams that make sense.

MS. LIN: Merwin?

MR. BROWN: Merwin Brown, UC Berkley. When we were around the table I raised the question about the fact that we're having to deploy, buy, and pay for energy storage in kind of a hybrid market situation in which there's competition. There's also rate-based regulation for the recovery of the investment and earnings. And I then look at the different applications that have already been addressed, something such as helping firm up solar energy or maybe more significantly frequency support means the asset probably gets used a lot, very frequently. I take it to the other extreme when we get into things like resiliency. I envision that the asset gets used very seldom because it isn't going to be needed, and also location matters where it may not matter so much when it comes to frequency.

So, I guess, given those complexities, I'm curious what you think. Does anything need to be done about this fact that we seem to have this tension between whether something is an asset that's rate-based or something that's participating in a market, can those live together in the same investment, or are we going to have to change those systems somehow, or is there another solution? Is there a technological solution that works around that problem? I hope that question's clear. It was kind of complex, but --

MR. SCIANO: So I certainly think it could be a combination of all of the above. You know? I would have argued that the battery and energy storage was the Holy Grail before any renewables. Now when you add these intermittent resources, I think it becomes even more critical for the utility to have control of that. That said, you know, totally recognize that a customer may want to put it on their side. There's some economies of scale to having the battery and the solar on the same side of the inverter. There's some benefit to only, you know, using the DC and converting it to AC once so you get some benefits there. We're just not seeing a lot of customers do it right now. And we've, you know, we have done that demonstration project with the virtual power plant where we were trying to combine a residential rooftop solar panel with the batteries. And we had some challenges with the FDNY, and also there's just not a lot of customers doing that. So from the utilities perspective, we want it right away. We're trying to move into it as quick as we can, but certainly they can coexist.

MR. MORGAN: And on the large distributed outage kind of problem, I'm not persuaded that storage is the central source of a solution. But you pointed to -- I mean, it can clearly help in certain settings, but in terms of some of the kinds of things that I talked about, storage is not going to be the major answer. At the same time, the point you raised is correct. There's nobody in charge. I mean, there's, you know, Damian has to worry about the, sort of, day-to-day kinds of stuff, and he's in charge. But for the large resilience issues where you could have very large scale, widespread blackouts, there's no -- I mean, you know, lots of players have partial responsibility, so we haven't figured out either how to make decisions or how to pay for the things, or how to decide how risk averse we want to be. And those are all big challenges.

MS. LIN: I think that your -- both of you have raised some really interesting issues that pertain to ownership, business models, who's in control, who controls the proverbial switch. We're going to get into more discussion about that on specific applications later in the day, but as facilitator, what I want to do is hear what everybody -- all of you are thinking. So we have given out these little stickies, yellow stickies to everybody. And I would like each person to take a minute, now, on your own, to write down the ideas from your knowledge and your subject matter expertise, because everyone in this room is an expert in their own right, from what you know of what's happening today, what are the vulnerabilities that you think, given what we've heard from our esteemed panel, that DOE should be more focused on going forward. And, of course, that storage could potentially, in the medium and long term, be a solution for, and I encourage you to think about these in the context of the duration. There's seconds, hours, days, and months. So what are those vulnerabilities? And then I'm going to collect them with Rachel and Chelsea's help. Then we're going to talk about it for just a few minutes. So just take one minute. Feel free to draw pictures, write really big.

-- you one other detail. The reason there's a pad, one idea per sticky, because we're going to try to attempt to group them. Sorry about that. Key instruction. Thank you.

SPEAKER: Do you (inaudible) your card.

MS. LIN: Folks can just collect their thoughts, and I want to start with this end of the spectrum. Are there any vulnerabilities in the very short timescale that folks came up with? Just raise your hand. Damian, what was yours?

MR. SCIANO: I took, you know, ride through -- oh, I'm sorry, ride through for momentary events, and that could include switching and things like that. And I put soften the impact of intermittency, you know, to kind of be a shock absorber as the cloudy day or something like that.

MS. LIN: For solar and wind?

MR. SCIANO: For solar and --

MS. LIN: Okay.

MR. SCIANO: -- wind, yep.

MS. LIN: Does anybody have any comments related to that, because we're just going to sweep through and collect them all at the same time. Just hold them up. We'll gather them. No? Any other short-term vulnerabilities that you think storage could be a candidate for? Merwin?

MR. BROWN: Yeah. It was mentioned in the presentation, is the real time situational awareness or to put it in the (inaudible) barely stage is a lack of enough awareness to meet future grid operation needs.

MS. LIN: And when you say awareness, do you mean sensing and measurement, as well as the ability to respond?

MR. BROWN: How you get awareness is

through sensing and rapid --

MS. LIN: Right.

MR. BROWN: -- analysis. The response is another item.

MS. LIN: Thanks.

MR. BROWN: But it's really a --

MS. LIN: Help me stick these up in the seconds. Anybody else have any comments along those lines on the short response?

MR. LAUBY:: I had speed with a fast response, fast response with sufficient amounts of reactive and active power.

MS. LIN: Okay. All right. How about on the -- oh, great, go ahead, Heather.

MS. SANDERS: I think another one is about optimization over longer periods. So if you are relying on energy storage as an alternative and you're not optimizing over the longer period, you may find yourself not charged when you need it. Does that make sense?

SPEAKER: Mm-hmm.

SPEAKER: Mm-hmm.

MS. LIN: So that is a challenge that's missing of how do you optimize it. It kind of pertains to all these timescales (inaudible).

MS. SANDERS: Well, yeah, it does, but a lot of, you know, market systems will optimize over a day or sometimes two days, but a lot of your resiliency or your N-1-1s need more time. So it's a really difficult optimization problem.

MS. LIN: Would you say that's, like, a multi-day problem or a seasonal, monthly --

MS. SANDERS: Well, it depends on the application.

MS. LIN: Okay.

MS. SANDERS: It's both. It's all.

MS. LIN: So it cuts across.

MS. SANDERS: Absolutely.

MS. LIN: Great. We'll capture that one in its separate bucket. Do you have a short-term one, Paul?

MR. CENTOLELLA: It builds on what Damian said, but we have this, sort, of seven and a half minutes between dispatch, the development, and giving of dispatch signals where markets really don't function and, you know, how do you manage variability within that time frame?

MS. LIN: Mm-hmm, seven and a half minute problem.

MR. CENTOLELLA: Yeah, mm-hmm.

MS. LIN: Okay, definitely. Anybody have some --

(inaudible) go ahead.

MS. SANDERS: You should write frequency response, because that's what you're talking about, right?

SPEAKER: That (inaudible) --

MR. CENTOLELLA: It's frequency. It's voltage. It's, you know, it's everything related to disability of the grid.

MS. LIN: Yeah. Can you put that on your little note just so we can capture it later?

MR. CENTOLELLA: My note is already up there.

MS. LIN: Okay. Well, we got it. How about in the hours' time frame? Anybody have any vulnerabilities? And I'm waiting for the cyber comment to come up. Go ahead, Praveen.

MR. KATHPAL: Yes, Janice. I was thinking about, as more and more of the energy and services are provided by distributed energy resources when you have a hurricane hit, who's going to coordinate the recovery of the distributed resources with the bulk power system at the same time? When you have a --

MS. LIN: Good one.

MR. KATHPAL: -- when you have a hurricane now, that'll be another send linemen to Florida. You can send distribution transformers, and there's, kind of, a common understanding of how to restore the system. It's going to be more complex in the future.

MS. LIN: The system restoration with DERs, you put that in the hours category. That's a good one. Any others? Damian?

MR. SCIANO: (Inaudible 0:04:00.) Peak shaving for a T&D deferral.

MS. LIN: I know that's a hot topic for

you. Any other in the hours category? Go ahead, Clark.

MR. GELLINGS: Thank you, Janice. It may be more valuable to focus on distributed as opposed to central storage in order to gain value with the hourly basis.

MS. LIN: Mm-hmm, okay. We'll take that one. How about days? I want to get some --

Mr. PARKS: Excuse, Janice --

MS. LIN: -- (inaudible).

Mr. PARKS: -- could I ask a clarification from Clark?

MS. LIN: Yeah, sure. Go ahead.

MR. GELLINGS: How distributed? You know, what -- I'm actually, I'm thinking back to the stuff we did for Galvin and Motorola. You know? And it couldn't even be this distributed. Okay? So think about the power system as it might evolve at a basic end use level, and embed storage all along the chain, and I know that -- I can see the advantages to an investor or utility making investments in larger systems. I understand that very thoroughly. But, you know, from a societal perspective we might be better off growing the system if we can in increments such that it -- there's inherent storage all along the way.

MR. PARKS: Thank you, Clark.

MS. LIN: Looking at (inaudible).

MR. GELLINGS: And how are you, by the way, Bill?

(Inaudible 0:05:21.)

MS. LIN: We have a bunch of comments of here under months and seasons. So I also want to hear from the folks who offered those suggestions. Anybody want to volunteer their thoughts who put a sticky up there?

MR. MORGAN: Well, one of them is mine. And I argued that batteries and electrochemical storage and even pumped hydro aren't going to work on those sort of timescales. For those, sort of, timescales you got to make synthetic fuels or hydrogen or something like that.

MS. LIN: Mm-hmm. You look like you're about to say something.

MR. GELLINGS: Yeah, just that, Granger, permit me, but I could store longer term with thermal devices. All right? I mean, we've got technology work to be done, but in theory, I could do a pretty effective job with a thermal device.

MR. MORGAN: Yeah, I guess, I agree. And I didn't say we couldn't do thermal on that note.

MS. LIN: Okay, go ahead, Phyllis.

MS. CURRIE: Okay. The comment I asked is really, after listening to the presentations and stepping back, I think we need to ask ourselves, on balance, is storage adding to the overall support of the grid, or is it adding more vulnerabilities?

MS. LIN: Mm-hmm.

MS. CURRIE: And I think that, you know, we shouldn't assume that adding storage in and of itself is going to be a major plus. There are going to be problems, and I think we have to face those problems and be prepared to manage them overall.

MS. LIN: Yeah. Thank you for that comment because I think Damian brought it up on that recent cyberattack. I know it's a big issue for ISER, and I think that's the really big one, and it probably falls across the spectrum from very short duration all the way to long duration. Okay. Go ahead, Pam.

MS. SILBERSTEIN: Sort of a related question. I was very taken by the slides that Granger had about all the extreme weather, and certainly we do seem to be experiencing more extreme weather, and they are incredibly much more expensive events. The range of storage technologies that are out there, are there some that are more vulnerable to extreme weather? For example, a prolonged period of, you know, below zero temperatures or, conversely, are there some that are actually better suited in those types of situations?

MS. LIN: Yeah. I think that's a great question. When you think about storage as a potential solution, recognizing the risks, are there some that are better suited for different types of issues? Okay, this has been a great dialogue. In the interest of time, I want to cut it because I want to make sure you guys have a break -

MR. KUMAR: Sorry.

MS. LIN: Oh, I'm sorry, Puesh.

MR. KUMAR: I just wanted --

MS. LIN: Go ahead.

MR. KUMAR: And I'm jumping a little late. So just a reminder that the 2015 Ukraine incident, disconnected three substations for three hours. So it was ours.

SPEAKER: Yeah.

MR. KUMAR: Could there be potential? And I'm not saying that storage would be the silver bullet here to solve that completely, but could there be critical areas where you would want power back. And so you preposition yourself, and that actually translates into a larger discussion with natural disasters, as well, and something we certainly are looking at and working with MIT, Lincoln Laboratory, to look at pockets of critical lifeline functions that you would need following any type of incident, whether it's a natural disaster or cyber incident so that you can get those services restored for life safety immediately after an incident. So --

MS. LIN: That's a great one, and I think Jessie's going to have a lot to say about that later today. But I think you raised two issues. So one is, you know, this critical, you know, restorative function of islands of power, but the other one that I heard you say is, like, you know, there is this cyberattack, so if there is something like that, how do you separate yourself from the Internet and, like, physically shield, and is that a capability that we need to be thinking about on these thousands and millions of storage devices that are going to be deployed everywhere. I don't think anyone started thinking about that quite yet. So that'd be good if you could capture both of them and we're going to stick it up there. Thank you.

MS. LIN: Okay, thanks everybody. Let's take a 10 minute break and come back right at around 10:00, right at 10:00. Thanks. And there is coffee in the background.

(Recess)

MS. LIN: We are going to start. Change up the order a little bit. Please take your seat. Thank you.

(Discussion off the record)

MS. LIN: Okay. Our next session is called, Advances in Energy Storage for System Reliability and Resiliency, and one of the case studies we are going to be talking about in more depth is how storage was used to help support resiliency in the wake of the Aliso Canyon issue.

And so first up we have Mark Irwin from Southern California Edison; and then we are going to go to Fred Hoover from NASEO, and finish with Praveen Kathpal. Go ahead, Mark.

MR. IRWIN: Okay. Let's see if I can figure out how to get this to work.

(Discussion off the record)

MR. IRWIN: So, I'm not going to spend a lot of time. As most people know, in California we have a mandate for storage, our mandate is 580 megawatts, you can see it, it comes in over time. One of the interesting things about Edison's mandate is, we've bought almost no mandated procurement, almost everything we bought is because we had a separate need. And that's, I think, is what I'm going to focus on today.

So these are some of the places, well, key places we bought storage just to -- and I'm going to go through the details of them in a bit, but we issued a local capacity resources RFO in 2013, which really got us off to a sprinting start in storage, where we bought 260 megawatts. One of the important things that I want to touch on is, we've bought a lot, so we have a lot of experience in the procurement side. there is still very little online. So, you know, we are just starting to learn a lot of those online lessons now, and we'll talk about why.

We did do our first Energy Storage RFO

back in 2014, and bought a little bit, as I said, from when we were still in a need for compliance. In our Preferred Resources Pilot we bought quite a bit more, another 120 megawatts both behind-the-meter and in-front-of-the-meter, which was also local capacity was both behind-the-meter and in-front-of-the-meter.

And then more recently Aliso Canyon, and then we have some other ongoing activities now. I'm going to talk in a little bit more detail about each of these that are, I think are critical to what we are talking about today.

As Janice said, we bought over 400 megawatts, 485, and it doesn't all count towards our target because of some of the interesting rules around what can and can't count, but they are all procurements that we've made, because it was the best, outside of that 16.3 megawatts, it was the most cost- effective procurement within the rules we had for the RFO and our need.

All right, so some of the use cases. We actually had an RFO out in the market, and we pulled it back recently, we suspended it, we will shortly be probably proceeding with a newly-constituted RFO. The challenge is still the same, and that's what I want to talk about, is the challenge.

So, we have an area of our system, you know, we always talk about as Goleta, but everybody in the rest of the world thinks about it as the place that serves Santa Barbara. The substation happens to be in Goleta, which is the adjacent city. It's the end of our system, so when you think about the Central Coast, or the south end of the Central Coast in California, you don't really think about that as the end of anything, you think about that as the beginning of the way up towards Monterey.

Here's a picture of the area, but it's really the end of our system, and PG&E's system starts over the mountains, in there where you see on the upper left, Solvang is an area they serve. So, we are serving the coast all the way up towards Point Conception. We have one 220 set of towers, two 220 lines, so double circuit that goes up there, that's the big blue line, that has -- here is what we have an N minus 1 risk, and the N minus

risk, though is two lines but they are on one set of towers.

So it really, you can think about it as a single- tower risk, the smaller green lines are

KVA lines that go feed the area, but they don't supply anywhere near the amount of power that the area needs, so it's not really a backup solution with the current situation. So, one of the things you see, from the topography, you see mountains there, so we were subject to two risks here, one is a lot of alluvial soil, so when we have a lot of rain, we may have a slide. These are in remote areas, so if we had a slide, by the time we can even get temporary transmission up, may be as long as two weeks.

We also have an area that is subject to fire risk, where we have to shut down -- we've had to shut down these lines before, for a few hours for fire, but really the slide risk is the long-term risk that we are trying to deal with. So, the question then is if you have this area that's going to isolate the resources in that area, from the 66 KVA line, can only support a small portion of the need.

So how do we, effectively, when people talk about microgrids, effectively how do we turn Goleta -- and it's not a full microgrid but we need more resources out there. How do we do it? Energy storage is obviously one of the pieces to it. Interestingly enough in many situations we've looked at resiliency, energy storage can be the only solution needed. In this case it's not the only solution, because the need is so great in this outage, that we actually don't have enough to charge to storage to come back, so we can have storage be part of the solution, but not all the solution, but I think it will be a key part.

So that's an example of something we are working on now. Let's see. And one of the questions I heard earlier was on Rural Electric

Cooperative people talking about, you know, how do we think about storage, and you know, when you have -- so this is our other solution besides building DERs and having storage be part of that, is to build a new 220 line, through an environmentally sensitive area, through rugged mountains. Or, connect up our system with PG&Es, which is going to go over those same sets of mountains, and it's going to be an environmentally difficult situation.

So, those are the kinds of things you think about when you run into, I'm at the end of the grid, the wires gets really expensive. I think ConEd gave another example of the wire is really expensive, and we've also seen in some of the examples we've looked at is, where you have a smaller area, and you've got a lot of thunderstorms and things of that type, in isolated areas, to build a backup system may be really expensive because you have to go a long way and storage can, in some circumstances manage that. So that was just a comment to one of questions earlier today.

The Aliso situation, we've had some discussion about it today, but as has been described it's a large gas storage facility, it is used to balance out the need in the -- the unexpected need from gas plants as well as when the pipelines coming from out of state are insufficient. Being used for both of those purposes, the idea was to use storage to help balance the electric grid more. The size of the problem compared to the size of the storage procurement, the size of the problem was much larger, but the storage procurement could assist.

So we were ordered to buy in May, it had to be on line by December, so when people think about power plant construction, they don't think six months or seven months, they think about six or seven years, right. And in our state we think about 7 to 10 for permitting a gas plant, we think about it shorter then for alternative fuel. So, one of the big things was we were told to do this very quickly. Obviously the storage industry felt they could do this.

I think the utilities felt that there was an opportunity for this. We did not have a volume minimum, so there was no minimum and there was no maximum. There was, really, here is the price -- you look at price target which we came up with based on our past procurement, so it was consistent with past procurement pricing, what do you think you'll see, and where do you go when you get all those bids in.

We looked at it as broadly as we could. We looked at utility ownership, we looked at nine utility-owned projects to say, because we didn't have a volume limit, they didn't really compete with each other, they all competed with a price benchmark, and we found three contracts that we signed, with third parties, that end up, two came online, 22 megawatts.

The utility-owned facility, one facility that Tesla built for us, with two adjacent 10-megawatt projects, and the two GE gas turbines where we built an integrated system -- a system to integrate with the gas turbines, so instead of having a time to ramp for the gas turbine and the minimum that they would come up to, that was a much smoother ramp rate.

And so that was actually something that GE has been working on that product for a while, and that was a first opportunity to deploy that; it actually was economically positive, because it allowed the units to get into the spinning reserve markets, so some technical reasons why it was able to change its revenue capability.

The other comment that I heard today, that I wanted to comment on here with Aliso, when you are buying things for reliability, you don't really have an economic -- they are not cost benefit positive, because reliability devices don't run very often, and so when you are buying for reliability you have to look at what's the cost of the alternative reliability device.

So, again, I think that's lot of challenge people in the marketplace have with storage, is it may not be necessarily economic.

If you put it in the market and say, I can only get market ramps, but if you get into a space where it has actually providing reliability services which are compensated outside the market. You see that opportunity.

So, the last one I was going to touch on was DERs. We've heard some of this, we are looking at storage to defer our distribution resource. We ran RFO earlier this year, we had a number of locations, some of the challenges we found, so again, it was all DERs, but storage probably being the primary player.

You can see up in the upper right there is the profile of the overloads in it, it's by year, so I think we are actually missing the table that was with it, the legend. But each of those is a subsequent year, so that the need above the baseline what the system is capable of, and then the need, you grows over time. So, up on the right you saw a need that grows and gets quite long. And what we found in looking at the economics, is as these needs get very long, they get very, very expensive to satisfy.

And there also, the lower right chart is trying to show they had to be in very specific local areas, we found some of those local areas, we've got enough bid capability from third parties, we had a few that we did not, but we really found it economically challenging. So, if you look at some of these others, this is another site that we put out in that article; a much steeper needle peak, and that gave us much better opportunities. So, we saw those as better opportunities, and we are actually going to run another pilot later this fall, and all three California utilities are, Edison is the only one that did this particular one.

This is just showing you a local capacity that I talked about earlier. You can see the green is our system, we actually didn't do a good job here, mapping this out, we did it really fast, because there's a big donut in the middle of our system, that's L.A.

But the blue area was where we were

looking to buy resources. So, again, these were a system reliability standpoint, we need more local resources where the load is, and that's where we've signed over 1,800 megawatts, 100 megawatts in-front-of-the-meter storage, and 160 behind-the-meter.

And that's just a list of the substations that happen to be in that area. So I think a number of people have talked about, you know, Edison has spent a lot in this space. We've bought for a lot of different reasons, reliability has clearly been one of them, and you see we are trying to buy some more for reliability in Goleta, and we think storage is often a big part of the solution, in some circumstances it's not the only part, but I think when we go to procurement we look at what are our economic alternatives.

In our state preferred resources are often the driver, so we've been in a number of procurements where preferred resources were our only choice, and storage has performed extremely well there, and we expect it to continue to be a big part of our resource mix.

MS. LIN: Thanks, Mark. Any super-quick questions for Mark before we move on to Fred? Go ahead, Fred.

MR. HOOVER: Good morning. I'm Fred Hoover. I'm with the National Association of State Energy Officials, so we represent the 56 state and territorial energy offices, and NASEO advocates for their interest at the Federal level. State Energy Officials generate under the direction of their governors and the state legislatures, and they address a full range of energy issues.

They represent the interest of their states in promoting economic development, and the sound use of energy resources. State Energy Officials view the emerging technology of energy storage as presenting both economic development opportunities, and opportunities for increased resiliency of the electric grid.

Energy Officials in their states serve a role in energy emergency preparedness, resilience planning-- these are interdependent, requiring interdisciplinary expertise and cooperation among state, local leaders, federal officials and the private sector. State Energy Officials are responsible for carrying out critical energy emergency planning. Response to mitigation functions at the state level.

In the areas when it comes to liquid fuels such as gasoline, heating oil, they tend to be lead agency and in the areas of electricity and natural gas when it comes to energy emergencies they work with the public utility commissions. Most State Energy Officials serve the emergency support function 12, or ESF #12, a function that's out of the Departments of Energy's, Office of Electricity Delivery and Energy Reliability.

This is the primary interface with states as far as regarding expertise and experience in dealing with energy emergencies, and we rely to a great deal on the staff at DOE to aid states in responding, both in planning for energy emergencies, and also the direct response in providing federal support to states in energy emergencies.

Now, what I want to talk about is a small sample of state actions that have been taken primarily in response to severe weather events, looking to utilize energy storage as part of their energy emergency planning.

Starting off with Connecticut, after Hurricane Irene and a number of other traumatic weather events in 2011, which caused widespread and extended outages in the state, Connecticut embarked on a series of actions to increase reliability and resilience on their electric grid. The state created a program to provide grants and loans to develop a microgrid infrastructure starting in 2013. These grants and loans were available to municipalities, investors in utilities and private entities, to create microgrids to protect critical facilities including hospitals, police and fire stations, water and sewer plants, and critical utility infrastructure.

The state has provided tens of millions of dollars in incentives for the microgrid development, and has a well- developed microgrid across the state. It's a short step from microgrids to the inclusion of energy storage in the microgrids, and in 2015, Connecticut enacted an act concerning affordable and reliable energy, to authorize the state to solicit for long-term contracts for energy resources including energy storage projects in connection with renewable energy resources.

Turning to Maryland, Maryland had a severe electrical outage due to the derecho windstorm from a few years ago, which caused distribution system outages on the same scale as a hurricane, the big difference was, unlike a hurricane that gives you a lot of warning, the derecho literally blew through in an instant. The governor instituted a study to increase resilience and reliability on the electric grid, the recommendations included consideration of enhanced and directed recovery mechanisms, or investments by utility and resiliency measures, and stronger reliability standards.

The Maryland Energy Administration which is the state energy office in Maryland, recently provided a report to the Maryland legislature on the benefits of energy storage, expressing the view that energy storage has clear benefits for reliability, since it can keep load power during times of grid outages. Maryland has an incentive program known as game changers, where applicants are funded for demonstration projects of technologies or applications of technologies that are not commercially available.

Maryland funded its first microgrid project through this program, and its most recent grant solicitation for game changers seeks applications for commercially sited -- commercial-customer-sited electric storage systems integrated with the renewable energy, source which provides a quantifiable reliability or resiliency benefit. Maryland will continue to examine the opportunities for energy storage systems as a way of contributing to both resiliency and reliability of the electric grid.

Turning to New Jersey, as was mentioned earlier, Super Storm Sandy had a significant impact on New Jersey; 71 percent of the electric distribution grid was impacted with 2.8 million customers losing power. The storm damaged gas lines to the barrier islands; tidal surge, flooding and winds caused outages and the shutdown of petroleum bulk storage terminals, major refineries, and petroleum pipelines.

Over 70 percent of the state's gas stations were out of gasoline for a week, and those that were able to operate had supply problems. The Governor was forced to invoke a petroleum allocation system to distribute both gasoline and diesel for standby generators.

The widespread power outage affected many critical facilities including waste water treatment plants, hospitals, police and fire stations. Some were able to operate on standby generators, but the duration of the power outage affected their operations, and the state was overwhelmed with requests for temporary standby generators which exceeded the available supply.

Now, while Super Storm Sandy was the worst weather event causing power outages, New Jersey has suffered a number of significant weather events that have caused electric distribution grid problems similar to those seen in Connecticut. These recurring weather-related power disruptions convinced the state to make the electric distribution system more resilient, and attempt to harden the critical energy infrastructure.

The state examined the acquisition and deployment of more standby generators, but sought to install more resilient energy technologies on the grid. And so similar to Connecticut, New Jersey examined the increased deployment of microgrids throughout the state, the state's desire to create through microgrids, islands of power that could keep critical facilities operating during large power outages. New Jersey has established a pilot microgrid process to create microgrids in the counties and municipalities designated by FEMA, as vulnerable to storm-related outages.

New Jersey has also looked at incorporating energy storage systems, and in 2014 the state issued and RFP for renewable energy storage program for behind-the-meter energy storage systems tied to renewable energy sources. The storage system had to include a reliability benefit in order to be funded.

New York was alluded to earlier, but the New York energy office, known as NYSERDA, has recently issued a funding request for field demonstration projects of commercially-distributed energy storage systems. And while the proposed projects are looking to integrate renewable energy into the grid, one of the factors for a successful application is the ability of the Energy Storage System to increase grid resiliency.

Washington State through its Clean Energy Fund, has provided grants to utilities and research institutions for demonstration projects to show how to improve reliability through energy storage, dispatch energy storage resources through utility control rooms, as well as use commercial building systems and loads as a way to store energy.

Washington State funded two utilities to create battery-based energy-storage systems and it funded a third utility to create a modular energy storage architecture for a set of design and connectivity standards for energy storage control system integration and optimization.

Washington State has also joined with the Pacific Northwest National Lab for a study to analyze the technological -- the technical and financial benefits of energy storage, and the role of energy storage in delivering value to utilities and citizens.

And then finally, Massachusetts, who, in September of last year, issued a comprehensive report on the value of deploying energy storage - to grow the energy storage market in the state, and grow the industry in the state. Massachusetts also looked at incorporating energy storage systems as a way of increasing utility reliability.

The report discusses the various manners that energy storage can be used to create increased reliability and resiliency on the grid, and Massachusetts, as the other similar states, have created pilot programs to fund energy resiliency, storage projects throughout the communities of Massachusetts, allowing municipalities to incorporate microgrids and energy storage as a way of supporting their overall systems.

All of our members are keenly interested in energy storage as both a resilience technology and an economic development technology, and a lot of the efforts that our states put forward on this, are funded through the State Energy Program which is part of the Department of Energy's budget. That has provided resources to our members to enable them to engage in the types of programs that I've just described.

It also supports the states' efforts on energy resiliency, or energy emergency planning, energy emergency response and mitigation, and it's an effort that is a worthwhile investment by the federal government enabling states to pursue these types of policies that will hopefully bring energy storage to the rest of the country.

MS. LIN: Thank you, Fred. I think this morning, Praveen, you didn't have a chance to introduce yourself because you came late as well. So, our third speaker, Praveen Kathpal. If you could just take a minute to introduce yourself before you offer your perspective in

(crosstalk).

MR. KATHPAL: Sure. Thanks, Janice. My name is Praveen Kathpal, I'm a Vice President with AES Energy Storage. And within our storage business at AES, I'm with our Global Market Development Team, and also right now I'm the Chair of the Energy Storage Association Board of Directors.

So, the first message I'd like to deliver to you guys, is that energy storage is happening all over the world; all over the country and all over the world. So, over the past 10 years that AES has been working on utility-scale battery-energy storage, we have deployed storage in 9 states, next year it will be 10, and we've also deployed storage in five countries, and next year there will be at least six.

So, there are a lot of different applications, there are a lot of different regulatory structures, there are an untold number of environments where energy storage works in a business case, not as R&D. And these are continually reaching increasing levels of scale where we started by doing this at the 1 and 2 megawatt level, and then now, none of the projects that Mark referenced in his presentation, where we are deploying a project that will be 100 megawatts.

So, it's definitely an area that's grown up a lot, and what I'm going to do is try to give you guys some recent examples of the storage applications, and I'm hoping that will spur a lot of good questions forward. So, before I get into our most recent deployment, we have a video that shows how this was actually built, that I think would make this a little bit more real to you.

It's a time-lapse video -- if you could pull that up, Chelsea -- that shows over a period of about six months. This started off as -- basically a storage yard, for the utilities, for San Diego Gas and Electric, for one of their distribution operation centers, and they cleared that and moved the equipment somewhere else, and this is where AES worked with our local contractor partners and our global supply chain to put the system together over a period of six months.

(Video Playing) So, that's it. And I'm sure no one on

our Delivery Team will appreciate me saying this, but that's how easy it is to build (laughter) the world's largest lithium ion energy storage array. So, I say that, not to say that it's simple or easy, but it's eminently possible. And I think some of the comments that have already been raised this morning, help to highlight the advantage of in-planning flexibility, when we are used to talking about a timescale of multiple years, to be able to develop and deploy new power resources.

When you do end up in a situation where there's a conventional infrastructure vulnerability that's realized, and we need to act quickly, energy storage is there to fill that gap, and we've seen -- our company was able to do that to serve San Diego Gas & Electric, and a couple of others were able to do that to serve Mark's company, Southern California Edison, over a similar time period.

And we don't always know what those vulnerabilities are going to be. It's not always going to be underground natural gas storage, but it's also not always going to be in California. And I think that's a really important lesson for the rest of country is, you know, California was in a specific situation where there were storage-supported policy, and then there was a sudden nuclear retirement, and then there was the more recent issue that caused some of these deployments.

And as those other issues occurred, it was an environment of utility and a regulatory environment that was used to looking at storage, procuring storage, and deploying and operating it, which is why California was able to move quickly.

MR. KATHPAL: And I dare say that the rest of country is severely underprepared to solve similar challenges with energy storage the way that California was, because if it's brand new, if it's a first of its kind, it's much harder to do it quickly, but because California had the familiarity, because the institutional infrastructure was there, it was able to move quickly.

And this is the 100 megawatt project that I mentioned, this was selected in Southern California Edison's Local Capacity RFO. It's not due to come online for a few more years, but this is a great example of the level of scale that energy storage has reached. This is 100 megawatts, four hours duration. It's truly substituting for having to build a new gas-fired peaking plant to meet local capacity needs.

And so when we look at the benefits of that, a lot of that is in the asset utilization that Janice mentioned at the beginning of the day, where the rest of the fleet can be used much more efficiently, and much more often, because you have a resource like this that's synchronized to the grid 24/7. And also a lot of the value of this comes in meeting the adequacy of supply needs, that Mark from NERC mentioned on the previous panel.

We've seen some independent analysis that points to a need of tens of gigawatts of capacity needed in this country over the next decade, and when you look at that, that's probably in the $25-35 billion of peak in generation, which is part of our reliability infrastructure. And those get put in, you know, when you look at most of what's happening in storage in the past few years, where it's been in the tens of megawatts, we are talking about generation that gets put in, normally 50 to 500 megawatts at a time, and storage has now reach a scale where it can compete at that level on an economic basis.

Moving to the other end of the spectrum, this is a system that we delivered to Arizona public service in the Phoenix area. This is a 2-megawatt unit that's installed on a distribution circuit that has high solar penetration, and because of the unique stability and variability issues, when you have really distributed solar penetration, this was where the utilities decided to take a position to really become the middle of this new energy network, where you have consumers producing, and you have the utility trying to maintain reliability, and you have other uses emerging, and so storage is one of the tools that AES is using to manage that as their network evolves.

And then this was also an example that Janice mentioned, one of our sister companies signed a PPA deal on the Island of Kauai, to deliver solar and storage, 28 megawatts of storage -- of solar with 20 megawatts of storage at 5 hours for $0.11 a kilowatt hour. And this is going to give an island the ability to maximize the use of locally- produced renewable energy, and reduce its reliance on fuel oil that has to be shipped in for their power generation needs.

And this is a trend. It's very easy to say that, okay, well, Hawaii, they have a unique situation, but we are seeing this trend increasing, where solar and storage together are able to meet the energy needs of an increasing set of the U.S. energy system, at a cost that's less than that of the fuel cost of conventional generation.

And so we have been talking to people all over the country and all over the world about this opportunity, and this is turning into a wakeup call for a lot of utility mangers, especially in the integrated space, that the way that they serve their customers needs to evolve. And so we expect to see an increased adoption of structures like that, it's just as solar and storage together become the lowest-cost option; less than the cost of burning fossil fuels.

I will leave it at that, as I just got the 30-second flash card. I look forward to your questions on the panel.

MS. LIN: Thank you very much. I'd like to kick off our discussion with the three of you and everybody around the table. Coming back to our President's Executive Order on cybersecurity, and we have the perspective of the state, the utility and California.

Praveen, your experience around the world, and I'd just be curious how each one of you is thinking about this, and it also relates to Puesh's comment earlier, how do you hinder

(phonetic) these hacks, and

Damian's issue before: how are you

planning for this, and are there

any best practices from around the world in dealing with this, when it comes to storage deployments for that range of applications you've all spoken about?

MR. HOOVER: Well, I'll start. From the state's perspective, I mean, one of the things we've looked at when it comes to a cyber event, and we actually recently participated in an exercise last December with the Department that visualized a long-duration cyber event affecting -- starting in Philadelphia and affecting the states going to the north, was the, you know, widespread impacts that would have, not just to the electric grid, but to all other related sources of energy.

I mean, it would cause impacts on pipelines, petroleum supplies, and in this situation the outage was happening in December, and so you actually had a situation where people were physically migrating from the outage area to other parts of the state and the region to get away from the lack of electricity for want of a better word. And that would cause all sorts of impacts.

So, you know, from a states' standpoint, there is just a multitude of problems that a cyber event is going to cause over and above what it's doing to the utility itself. And the states are going to have to respond in coordination with local governments to come up with solutions to that, for relocating people to come up with access to critical facilities and things like that, and so states are, you know, convening large, multi-agency groupings, to sort out how to look at how to deal with this.

And then at the last part of the problem was the whole communication issue which is, you know, in traditional storms, you know, states and local governments provide information to citizens about what's happening, and things like that. Well, now with social media you have the situation where you could have information being spread about that's erroneous. Now some of that may be malicious, some of that just may be misinformed what states and local governments are going to have to be prime to respond to that, to try to allay social unrest, which is the fundamental problem- seems to be- that a large cyber event that caused an outage of a long duration, could lead to significant social unrest.

MR. IRWIN: So, Janice, to be honest with you, I'm not familiar with our cyber planning activities. As you know, kind of our -- we have, kind of, two levels, one level is, what are doing at the ISO, and what are we doing at the PUC from a demand standpoint. And I'm not familiar with any studies that have been done there. I also think there is a broader activity, I know there's a broader activity with the federal government, but I'm just not close to that to know what we are -- exactly what we are doing there.

MR. KATHPAL: Similar to Mark, I can't give you a lot of the technical details on our cyber preparedness plans, though that is something that we actively work on, and what I can tell you is that the way that people think about cyber attacks manifesting into a physical vulnerability, and especially with respect to the electric grid, storage provides what we believe is an inherently more resilient architecture because of its modularity.

And so it really reduces the single points of failure, and it's also vastly more controllable, and creates more opportunities to put in safeguards where, if it appears that something -- that the equipment is being used in a way that it shouldn't, it's much simpler to disconnect it without affecting the rest of the system.

MS. LIN: Just in surveying, for folks who have their cards up, who has a question on this particular topic, on cyber security, anyone? Go ahead, Carl.

MR. ZICHELLA: Excuse me. Carl Zichella here, NRDC. My question is related to security, but not necessarily cyber security, too. We heard earlier from Damian about the profound concerns that are being expressed by the New York Fire Department about lithium ion chemistry. I'm just curious about physical security concerns, and the extent to which those are being factored into both siting and construction of these facilities, going on.

We are seeing, especially at substations, I think a fairly alarming number of events that have been occurring at these places. So, battery technologies, especially, you can locate them in urban centers, there's vulnerabilities that come with that too, that could ripple through the system, but also create other problems related to fire and significant disruption.

MR. IRWIN: So, I think, Carl, the question is: are we doing more to secure -- I mean the way I think about responding to you, are we doing more to secure a storage device than we are doing to secure anything else? I mean, that's kind of what it comes back to at the end of the day, as far as I'm aware of.

So first of all, we have two levels of deployment here. We have a lot of third party deployment, the third party deployment we are handling contractually, contractually we lean very heavily on industry standards, and a comparable operator of a comparable type of device in the industry. We also have additional safety standards in our contracts.

In the utility-owned side, the deployments to date, of any substances have been either near or adjacent to an existing asset, we've had a couple of deployments -- one deployment in a substation and it was substantial. But in a substation in the carved off area of the substation, another adjacent to a substation, the other two integrated with gas turbine facilities.

I'm not aware of all the details of the later deployments; I was involved in the first -- in the (Inaudible) project. We did not have any more security there than we would have had at another asset in that particular location. We do have, obviously, secure buildings, et cetera, we have fire suppression systems, we have all the types of things we feel we need to manage the resource if it gets out of control. I think you are describing another reason why it might get out of control, but we haven't -- as far as I'm aware we haven't created additional measures.

MR. ZICHELLA: Thank you for that. You know, the concern is just how much is enough and, you know, we had to learn sort of the hard way that substations which seem pretty secure, really, maybe weren't, and we had to bolster some aspects of their security; just a thought here as we begin to implement these things more broadly and a larger scale.

MR. IRWIN: I think the real issue becomes, and I think that's a really good example, so the substations we did need to secure, and there's a process to secure them, are really large substations that are very -- the grid is really reliant upon them. One of the nice things about storage systems and many of the systems we are purchasing, they are not of the size and scale that they create the, you know, the real size risk, that does.

Now, the 100 megawatt AES facility starts to get to where it matters, but even then, and if you think about N minus 1 and N minus 2 risks in the grids, they are up in the thousands of megawatts or high hundreds of megawatts, not down, and 100 being a huge station and a lot of these 10s and 20s.

MS. LIN: Thank you, Mark. Could we go to Puesh and Patrick next, and then we'll catch you guys on the side, over here.

MR. KUMAR: So, my question is more focused on the resiliency side of things. So, I know on the last panel we discussed energy storage from a transmission reliability perspective a lot, which is great. And I know from SCE, has considered that as well from the distribution side, and Fred, a little bit to your point of working with the local communities, states, could you talk about the interaction. How does that play into decisions of where to put energy storage for critical lifeline functions if an emergency were to happen?

MR. HOOVER: Well, I think what the states are doing, and it's mainly been in response to, as I discussed earlier, the significant weather events that have caused, you know, these widespread outages, is to look to siting both microgrids and energy storage systems as a way to bolster overall resiliency and reliability of the grid.

I mean, most of these things have been predicated on fairly in-depth studies, almost after action reports from the outages related to the storms that created the legislative and administrative programs at the state level to examine microgrids, and now storage as a way of trying to harden the grid, because I think most states realize that, you know, their economies are more dependent on reliable electricity supply, citizens expect, you know, the electricity to come back on as soon as possible, whenever a weather event has occurred. So, they are looking for mechanisms and means to harden the grid, harden critical infrastructure, and increase resiliency.

MR. IRWIN: So, I think it's always interesting to thing about the East Coast versus the West Coast. The East Coast has a lot of these storm events that tend to -- from a planning perspective tend to be really critical. Our big critical planning event is an earthquake that we don't know where it's going to be. And so, you know, we have emergency response plans, generally, with all our local communities, but it's really initially about restoring the transmission system to the distribution system, and the generation systems, individually.

I think that I have seen an example in California of the microgrid for a resiliency standpoint, and it's actually quite an interesting one. I heard a description of it about four years ago, which is at Apple (phonetic) Headquarters, and it's not because they are worried about earthquake, it's because they are actually worried about a couple hour interruption causing -- they looked at their whole chain, and their decision and their development process, and how many billions of dollars losing a week or two would cost them.

And so they went out and decided to create an entire microgrid, obviously storage being a big piece of that. Again, we haven't seen those events. I've seen, again, a number of projects in the East Coast where it made a lot of sense. You see these local clusters, and you can understand what the restoration process would look like, and it makes a lot of sense, but again, in our environment we haven't seen that need.

I think that's one of the most interesting things about storage, it's kind of like, you migrated to what that need is, we've also seen in the resiliency standpoint DoD, another example of a place that, they've looked at microgrids a lot. Again, customers of ours, we have a number of major bases. You know, our service territory we've talked to them about microgrid structures.

We continue to be in conversation with them about how we could do that. We've also seen again, on a military base -- at a military facility that is a local or a regional response area that we would look at putting a microgrid in for that local response area.

So, we've got a few, but I wouldn't say it's as pervasive as a lot of the projects I've seen along the East Coast, but we do have a few examples out there, where it's really a situation specific of a particular customer or a particular need that says, okay, I need this resiliency for whether it's to be an emergency op center that will continue to work, or whether it's the government saying, I can't deal with any interruption when I'm doing potential mission preparation.

MR. McCORMICK: Thank you. Your answer there is a perfect segue into my question, which is listening to the AES and the Edison presentations I came away with the impression that storage is here commercially, that there's a commercial case to be made; albeit perhaps a niche case. And I just wonder if either one of you could elaborate on that. Am I right? Am I wrong? What is it that the project finance and just regular commercial operations brings us by way of new opportunity for storage?

MR. KATHPAL: Sure. I'll take a crack at that. So, on a technical basis we have mature storage technologies that are obviously able to be deployed in significant scale, and that relies -- mostly what we are doing is with lithium ion that relies on upstream from a significant manufacturing and R&D that came out of the automotive and consumer electronics spaces. So that's there on a technical basis.

There is, I'm sure still technology increments, and technology shifts to occur for other types of storage media, and I think that may be a role that DOE has to play in the R&D related to that. Well, one of the points that I think you are taking away is that continued technical milestones aren't a precursor to large-scale use on the grid. I think the other hurdles that we see are more in the commercial and the regulatory side, that essentially center around the adoption curve in the utility industry, where we've seen -- you know, we've seen more forward-leaning customers within the U.S., like PJM, like Southern California Edison, like San Diego Gas & Electric, come out there and really embrace this.

And I think that's the beginning of a domino effect that we need to see play out, because the technology is here, the economics are here, commercial mechanisms are here, and it's really about accelerating this adoption rate and that is going to involve a multitude of stakeholders. When you look at us having 3,000 electric utilities, plus or minus, across the U.S. that means that for each one to adopt it needs to look at some of these references and say, yes, that makes sense as a business case for me here.

As well as their regulators, whether that's a State Utility Commission, you know, a County Board, a City council, there are so many different regulatory structures as well. And so it's really on getting that message out, and identifying the existing needs, and the existing commercial structures that we can adapt for the adoption of storage.

MR. IRWIN: I also wanted to address your, yeah, really good questions, Patrick. So, let's step back and say why is California doing what California is doing? We are doing it because the state had a vision of a future that was very high renewable and needed storage in the future. And when we needed storage in the future, the only way to get, and I think Praveen described it really well, but I'd say that commercial DNA and the operational DNA to do what we are going to need to do in large scale in the future was to start doing it.

And that's a decision our state made. So, what do we need to do to make it so preparing for the future wasn't in the DNA and you see broader adoption across the country, some big areas that we've got going on now in California is market rules, how do we get market rules for multi-use devices, multi-use systems. I don't know what the DOE's role is, certainly you wouldn't talk about the FERC's role, and other regulatory process roles in that.

So I think market rules is one big area that we are working on in California hopefully that will be able to be -- proliferate across the rest of the country. You know, everybody has their tweak on market rules, but generally they have the same principles.

The other areas, though, that I think are really critical; is to continue to see the cost reduction drive and the innovation in the space. One of the things, so I used to work in R&D space at Edison around energy storage R&D, and we were actually, you know, the (Inaudible) Project was an aero (phonetic) project. And being familiar with the space a little bit, some of the investments that had been made, and been made in a very public way, and things get shared publicly around cost-reduction drives, I think are very helpful.

And we've seen some, you know, some of the work that's been done in looking at, you know, what's the best technology for the future. For today it's lithium ion, for tomorrow we don't know what it is. And I think that, you know, when you get some of the smartest minds in the world around that, trying to push that forward, there is real value there. And whether that's technology, whether that's been supporting technology, we've really seen DOE do great things there.

The other thing besides cost is size. One of the things we find with the utilities, ConEd is a great example, we are a great example, you may drive to low-cost technology, but the footprint that you can get and it really matters, and when we are in very urban environments, a small footprint has landed so precious, not just from a, can you find it, but also from a cost perspective.

In urban environments that the size of the devices and what's generally called in the space, energy density, become really critical, so those are areas we've really -- I've seen in my experience, DOE really do great things there, and we would love to see that continue. Because I think that will really, you know, the earlier question: what's the tipping point for price?

The answer sadly is, I don't know, but that's because: what's the application using if for? Every application has a different spot where it now clears the market, and as the prices draw down, and you clear the market with more applications you get more volume in the space and prices keep coming down. And I think that's what we've seen, obviously that's why lithium ion is there, because it's relied on auto and consumer electronics to get that scale, and the question is, you know, are there other technologies that can get to that scale. We've got to develop more applications that are in the money, and that's about cost, right.

MS. LIN: Thank you.

MR. HOOVER: Actually, and just one

follow up to that. As he mentioned California is one of the leaders, as is New York, but many, many states are taking close examination of their energy markets. Looking at the energy resources they have, and the way that they use energy and are trying to figure out policies and programs to help to develop the energy markets in their state in order to serve the needs that they have both economic and environmental.

MS. LIN: Thank you. That was a great question. I just can't really see who is over here. Does anybody have a comment or question on this issue of, you know, gaps, because that's what we've been chatting about for the last few minutes, challenges or gaps. Laney, do you have one?

MS. BROWN: Thank you. The institutional infrastructure, I think you had commented as an example, and I'm wondering if you can build off of that in terms of, if you were going to provide advice to another state in terms of building institutional infrastructure in preparation for storage, what would those key things be?

MR. IRWIN: So, it starts with, let's see, so there are two legs to that, one is how do you use the device in the organization, what are you trying to use if for, and what can you gather from how other people have done something similar. So, that's really a technical side. That often takes time, but to be honest there's probably lots of examples, and if people are interested in the space and the utility is interested in the space, you know, EPRI is a great place that that information gets shared. There's other industry space that that gets shared.

They can obviously talk to folks like DOE about: who should I go talk to. So, I think that technical side is one thing to overcome. The other is the commercial side, so the commercial side is, you know, in California we have a lot of experience in the contracting space generally, because we've had a state policy of buying from third parties, buying, I'd say, energy and capacity services from third parties.

That's been something we've done for a long time. But we would never have gotten Aliso done in the speed we got it done if we hadn't had a contract we had used two or three times before, negotiated with counterparties in the marketplace, found it acceptable to the project finance enterprises; if you didn't know you had all those things.

So I would guess that most of the people that we did third-party contracts with did not project-finance their projects because there wasn't enough time. But they had to be confident that after the fact they could do that, well, the way they were confident was, they had seen a contract like ours, like the one they were going to sign with us, get financed in the past.

So, that's all about commercial experience. And it's throughout the chain, it's the utility, it's the counterparty, it's the financing institutions. All those things take time. So that's the two legs I would talk about there.

MR. KATHPAL: And in terms of that process of building the institutional infrastructure, I think it mainly went through three steps. One was defining the needs- which jobs that already need to be done in the electric system can be done by storage. Because that begins to inform, you know, which commercial structures that already exist, right. If it's capacity, do you already have a PPA, or if it's transmission can you fit it into the same rate-recovery structures.

The second is familiarizing with stakeholders because it's not just a matter of a -- usually of one decision being made through resource planning or system planning. You know, that usually involves the PUC and NGOs and other players. And then the last thing is just committing to action, and I think that's obviously the most important part that, the step that California took.

And I really want to highlight that in

California, you know, there's often talk that it required state-level legislation, but the story that often isn't told is that some of this can be done at the state commission level, where basically the local capacity RFO that Mark referenced, it was like about a 2000-megawatt capacity need that was authorized by the Commission, and what the Commission said was, do at least 50 megawatts of storage, 50 out of 2000 is a relatively small bite. And then, you know, once they committed to that, and they looked at the economic analysis, it turned out that it made sense to go get 260 megawatts of storage out of that.

MR. SHELTON: Janice, let me just add a comment here, because I think it's the air, the air you breathe in California, right, that's all-source procurement, it's very simple, but a lot of states don't do that. So, I mean, like very basic, all-source procurement, don't narrowly go to market and say I want to buy a peaker plant, you should go to market and say, I have these needs, I want to hear any solution, and maybe you can't afford to evaluate every crazy solution, so you have to put -- you know, put some things narrow. But I feel like it was present in what you were saying, but, you know, it's not completely obvious from the comments.

MS. LIN: Yeah. Thank you for those.

MS. SANDERS: I have a follow up.

MS. LIN: Okay. A quick follow up, and then we are going to go to Granger, and then we are going to wrap up, and I'm going to touch base with you, too. Yeah. Go ahead.

MS. SANDERS: So, you started to hit on this, and it was really, you know, what had to be in place to do this in six months. You talked about the commercial terms, but what about aspects, you know, interconnection, and so forth, and now is this the new expectation. So, we went out, you know, it usually take two years, three years, seven years. I mean, now is it the expectation that we can do this in six months in the future?

MR. IRWIN: So, I think that's fair, Heather, because the bill in California to build more Aliso storage got out of Committee last week. So, I think the expectation is, regulators think that this can be done, but I think you raise a good point, about Aliso. So, from an interconnection standpoint it's fair that usually takes a couple of years and that's pretty common, so the question was, who was going to be able to respond to Aliso?

And one small project, small projects can generally get through the interconnection process faster, but we had to jump through a ton of hoops, so one of the projects was new, it was

megawatts, our Distribution Planning people have done a lot of work before they had to do what they could to expedite not this project, but anybody else wanting to connect for Aliso. But CAISO had to accelerate their process for new resource integration; the bigger project, the 20 megawatt project that was a third party, was an existing interconnection, so they didn't have to go do brand studies, et cetera, because it wouldn't have happened otherwise. So when we talk about -- you know, when we do these ultra-fast it is doable, but we narrow down the number of market participants because of the conditions.

The conditions really said, you needed to be either small on a distribution system, which is actually what the two utility -- the two Tesla projects were on a distribution system. Or you needed to be in an existing interconnection, one of those others, and our two enhancements of our gas turbine again were with an existing interconnection and they weren't raising the amount that was going to happen there.

So you are right, the expectation from regulators and policymakers, is we can do it fast, the challenge with doing it fast is we know the market. When we know the market we get less competition. The good news for us in that particular case was we didn't have a minimum, and we had a price benchmark so we could manage it. But if we had been given a minimum and not given a price benchmark, it would have been much more difficult if the minimum was quite large.

So, I think those are really conditions, you are right, the expectation is that we can do it, but when you get into the gory details, there is more in the gory details as to what can actually happen that fast.

MS. LIN: Thank you.

MR. KATHPAL: And just on the speed, I just wanted to add, if it needs to be done, this comes back to identifying the needs, if it needs to be done, it can be done. And that's what we saw in our rapid deployment experience in the San Diego area, obviously what really helped us working so collaboratively with the utility there, because they were able to identify which locations on their network had the ability to add these resources, you know, both from a space and an interconnection standpoint, as well as fit within an existing permitting envelope, so that it could be done quickly. That's not universal, it won't be true of every single site, but there's a lot of low-hanging fruit out there.

MS. LIN: Thank you. I'm hoping, Granger, that you'll take us back to resiliency and reliability, but --

MR. MORGAN: Fred, I was --

MS. LIN: But hold on. But before you go there, I want to give everyone a heads-up, after this question I'm going to ask the three of you for your top recommendations of what our federal government can do to help address some of the litany of challenges that you guys had mentioned, and also to take volunteers from the crowd, for suggestions, of very specific things that we could do in the future. So, go ahead Granger.

MR. MORGAN: Fred, I was pleased to hear you talking about islanded microgrids as a strategy for dealing with resiliency. And that of course makes a lot of sense if I've lost bulk power, on the other hand, if the distribution system has been flattened as it was in the Jersey Shore or as it is after an ice storm, you've got a real problem. And for places like the Jersey Shore, where you are also likely to have several feet of water on the ground, undergrounding may not be an adequate way to make the distribution system resilient.

Would you talk a little bit more about what folks are doing in that space, since you've got to have an intact, distribution -- unless you are going to do things at the individual customer level, you are going to have an intact distribution system to do an isolated microgrid.

MR. HOOVER: Well, I think the states that have kind of explored this in more detail, Connecticut and Jersey, you know, have tried to strategically look at the critical infrastructures and the critical facilities that would be impacted by a significant storm. And you know, both the reports that they wrote in response to that, discuss the fact the largest outages tend to bring related outages.

And so I think what they were looking at was creating microgrids tied to, in a lot of places, you know, renewable, or located power sources that would help create the effect of creating some ability for some of these critical structures to come back on before you get a chance to put all the poles and wires back up, because yeah, when the distribution system is wrecked, as it usually is from a hurricane, or in an earthquake situation, I mean, you are looking at a long-term project when it comes to putting it back up.

So I think their thought was to try to figure out a way to incorporate localized places of generation incorporated with microgrids, and now storage is a way of trying to create some semblance of societal normalness in these areas.

MS. LIN: I think (crosstalk).

MR. MORGAN: I mean, the point of course being that even for a microgrid I've got to have a grid of some sort, yeah.

MS. LIN: And we have a whole session on microgrids coming up later, which we'll talk about that much more. But I'm wondering if there are suggestions from anyone in the crowd. We've heard about some of challenges are size, cost and innovation -- I've taken notes here -- Commercial structures, market rule, managing peak for a sort of assisting capacity need, figuring out the best technology for a future optimization, temporarily from, you know, optimizing this resource.

Another issue is, that Phyllis left, but a... storage, does it included other risks from the cyber issue. So, I'm curious, folks, if you could take a minute to everybody think about: what are like the top three items, that you think ideally should be looking at in the future if storage is to help with this range of potential threats to our grid? And then we'll collect them, and I want to hear last thoughts from each one of you too, briefly.

(Off the record)

MS. LIN: Do you want to start with some thoughts?

MR. HOOVER: Sure. Well, as I mentioned in my remarks, I mean, the states already have a well-established role of the Department through the State and Energy Program, which provides resources, expertise, training, to our members in three areas. Overall energy planning, you know, how states go about trying to figure out what's the best way to manage their energy resources and their energy usage.

Examining new technologies. States are, you know, it's stereotypical to say that the states are the laboratories of these things, but as was shown in my discussion, states have been looking at trying to create demonstration projects of these new technologies, microgrids being one, storage being the next, to try to figure out what's the best way to apply these things in the overall system, that can lead to, you know, state initiatives to work with regulatory commissions and other state agencies, to help provide for the commercialization of these things.

And then finally, you know, from the resiliency standpoint, the department has a large role in working with the states when it comes to energy emergency planning, and mitigation and response to energy emergency. So, increased in that area particularly given the fact that states are trying to wrestle with this cyber threat that's out there, that someday is going to occur here, and working with the Department can aid both of us in trying to respond to that.

MS. LIN: Okay. Anybody else have thoughts or comments around that issue and I just want to collect them. It's interesting for us on the Committee to see the quantity of that. So, we'll just collect it. And if you have anything to add, anything different, okay we can read these later. This is awesome. Thank you. Harvesting ideas.

SPEAKER: (Inaudible)

MS. LIN: Yeah. Thank you for helping me. So Mark, your thoughts.

MR. IRWIN: I think I shared those really, a cost reduction and I think technical innovation. DOE has done a great job of supporting both of those, and I think the demonstration projects is that I'm not going to pile on to that, but it's a good way to get people used to it from a technical standpoint, but I think the cost reduction and the technology, you know, technological innovation, and I particularly focused on, you know, footprint reduction. But I think there's lots of things in the space that the DOE has been supportive of, and that that stops things from being as commercially private as some of the companies developing these things on their own.

MS. LIN: Thank you. Any thoughts to add to that before we go onto Praveen? Just a quick show of hands. No? Okay. Praveen, go ahead.

MR. KATHPAL: Thanks. So, I first of all agree with all my fellow panelists have recommended, and I would say that there is a role -- there is a potential for DOE to play a role in the acceleration of adoption, that can come in a form other than the basic R&D and demonstration projects, and we see some of that happening right now.

We think this is needed. We've already seen the Energy Storage Association has begun unveiling a vision of how gigawatts of storage can be beneficial to the U.S. by 2025. And for us to get there, I think some of the things DOE could do, is assessing the identification of the needs, we talked about tens of gigawatts of peaking capacity that supports the reliability in the form of adequacy of supply.

We think there is work that can be done similarly to identify the transmission and the distribution investments, that could be met the needs in those areas, that could be met with storage, and then once those were identified, to study the economics of them. We've see some really good system level modeling work that's been done out of NREL, and I think we would encourage more of that, that is targeted and matched to the needs that are identified, because that's where it can motivate actions.

It's if you match that analysis to the

needs. And then of course part of that change process of adoption, is bringing stakeholders together again. That needs to be done on a state and a regionally targeted basis, to drive the commitment to action that we think will improve the preparedness, that institutional infrastructure that I was talking about. It's once the need and the economics are put together, and people are bought along in that change process, that's where we converge on a commitment to action.

MS. LIN: Thank you. I wish we could spend more time to talk about all those great ideas, but what I'd like to encourage you all to do, is if you've written down your ideas, please hand them over, because we'll read them, and we really want to know what you are all thinking. It's very helpful to our Committee, so I'd say, the category that Praveen introduced is this acceleration of adoption, and there is a whole nest of issues.

So if you have ideas please give them

up. We are going to give you 30 minutes to go out and secure your own lunch. There are several places. We did this intentionally so we would be early and there wouldn't be huge lines.

Please, please come back in 30 minutes, so that is at 11:55, because we are going to get started with our Microgrid Panel, and looking at behind-the-meter applications. So, thank you. We want your yellow stickies. And please feel free to bring your lunch back here, and eat during the meeting.

(Recess)

MS. LIN: As you'll notice we are building a wall of ideas, and it's titled: What Can DOE Do? So if you had a hot- burning suggestion that you didn't get to voice, please feel free to put it on that wall, because our Subcommittee will go through each one. Feel free to put your name on it, if there are questions we know who to follow up with.

(Discussion off the record)

MS. LIN: Thanks everybody for coming

back on time. I really appreciate it. We have an amazing session for you focused on microgrids and behind-the-meter storage with a really diverse set of folks to share their experiences and perspectives. One of the things as I said earlier is we have here, we are building up on this wall behind Tony, a list of ideas of what DOE can do.

I wish we had two days to do this workshop because we could hear from all of you and all of your ideas early, but we don't have time, so feel free to put your name, put your idea, the name is helpful, so if we have questions our Subcommittee knows who to follow up with, but just stick it up there as we go through the day. Okay.

So, with this we have our next session is storage and microgrids, new applications, Paul Hibbard from the Analysis Group is going to give us an overview of what storage behind-the-meter and sited close to load could mean, what are the benefit steams.

Mark Vanderhelm is the VP of Energy from Walmart, just a small energy user in this country, I think only second to Department of Defense. So, we've got 1 in 2, at least on the commercial side, number one, and then largest user is Department of Defense, so this is probably like a huge amount of our energy consumption in the whole country.

Jessie Denver from San Francisco Department of Environment to talk about what their city is doing with respect to resiliency and energy storage, and Dr. Ariel Castillo, from the U.S. Department of Defense who oversees 500 military bases all around the world.

So, I've asked each person to elaborate a bit on their backgrounds, especially the folks who didn't introduce themselves this morning, and then they each have 8 minutes for remarks, and then we are going to dive into discussion as before. So, go ahead, Paul.

MR. HIBBARD: My name is Paul Hibbard. I'm a Principal with the Analysis Group out of Boston Mass, but I've spent about half my life in State Government at the Department of Environmental Protection in Massachusetts, and the

Public Utilities Commission, most recently as Chairman of the Commission. So that means I'm one of at least four recovering rate regulators in the room. So, that may flavor my comments a little bit.

Janice mentioned I'll give an overview of some of the value streams, I thought what I would do to do that, is go over a pilot project that we have in the State of Massachusetts funded by the state, by the Massachusetts Clean Energy Commission, related to trying to figure out: what is the optimal way to configure storage with renewable resources in a microgrid application? What are the potential benefit and value streams? What are the other benefits that go even beyond the microgrid itself?

The project that I wanted to use for that purpose is one where the largest Military Base in Massachusetts, the Joint Base Cape Cod is probably one of the larger users of electricity in Massachusetts, and they also are one of the largest holders of renewable resources in

Massachusetts. So, the Joint Base is about a 20,000-acre property on Cape Cod. They have a peak load on the base itself of about 4 megawatts, about half of that is really for mission-critical operations.

And it's really a classic microgrid, they own the distribution system on the base, they have two points of connection to the utility, the base itself is the location for the radar, the monitors, essentially, the whole East Coast, so it has some extremely important operations. It's also on Cape Cod, which, for those of you that can picture it in your heads, sticks out into Massachusetts Bay and gets hit a lot by the storms that were being discussed about in the last panel.

And it has a relatively -- it's sort of at the end of one of the utility distribution systems, so it has a relatively weak, and hopefully knowing from the utilities in the room, but has a relatively weak distribution, and there are a lot of outage issues out there.

So, the base itself is, as I mentioned,

they own and operate the distribution system. They own approximately -- I think as of now, or shortly, they'll have over 10 megawatts of renewable resources, solar and wind on the base, and that compares to annual consumption on the 40 gigawatt-hours; peak load of about 4 megawatts.

So, it's an interesting matching of the level of renewable capacity with the base peak load. It also has a significant amount of diesel generation, as you can imagine, on site, because they need to support the critical-mission operations, mission-critical operations throughout the year. And so they need to have that level of redundancy, quality of power supply, reliability of power supply is extremely important, but it also -- the economics are also important, they spend an incredible amount of money every year, on electricity.

So all of these things were really the subject and the focus of what role could storage play, given the existing renewables on the base, and given the mission-critical functions, the need for reliability, the extreme cost to the Military of operating the base. How could storage help do that? So, we did an analysis with them. The model, the storage model that we are using is one of a Cambridge-based pre-commercial storage technology, Ambri- it's a liquid metal battery developed out of MIT, and we essentially took the technical specifications of the battery and the hourly loads, and the hourly renewable generation profiles on the base, and conducted and optimization analysis.

And the idea was really to figure out: what are the potential value streams to the base, what would be the optimum size of storage on the base, and ultimately what are the challenges associated with capturing some of those benefits over time. So, the questions were really: how can the base reduce cost by minimizing the cost that they paid to local distribution utility, but also minimizing the cost that they pay for a wholesale energy supply services?

Massachusetts is in a fully competitive

wholesale market region, and all customers chip in to the cost of energy and capacity and reserves, ancillary services in the region. Again, they are very curious about how storage could help assure the reliability of the base on the one hand, but actually probably more importantly, reduce the amount of diesel generation that they use in order to maintain reliable operations, and have sufficient power available during potential outage scenarios.

Also, another important goal of the analysis was to identify how to optimize the renewable generation that existed and was expected to be developed on the base. Again, a mix of solar and wind, a very large amount. And the optimization could either be for the purpose of reducing what they are paying to the distribution utility for all-in energy services, or for selling power in the wholesale market in New England.

So the analysis that we did ultimately looked at all of these different value streams, estimated how you would optimize the use of the

Ambri storage technology in order to capture each one of these value steams, and try to figure out really, what would be the best use of the batteries from the perspective -- from the reliability and cost and revenue perspectives of the base.

And then a secondary focus of the analysis was really to figure out, okay, well, given this potential microgrid application in Massachusetts, how does that facilitate the energy and the environmental goals of the state itself, and achieving both climate goals/ carbon dioxide reductions, and spurring the development of renewable resources within the state and region?

So, the model that we used is really -- it's essentially an optimization once you select the criteria that you are trying to optimize. We did not try to optimize across all of these different potential value streams, but looked at them individually, and in the end the answers are fairly obvious, and not anything new that hasn't already been discussed here today. There is the base with -- well, let me tell you the quantity, that what we modeled were -- was a storage -- a level of storage equal to 16 megawatt-hours, 4 megawatts.

And again, a reminder, with just over -- I think it was 11 megawatts of renewable generation, 4 megawatts of peak in the base. So, putting 4 megawatts, 16 megawatt-hour- storage on Ambri cells on the base ultimately, how would you optimize across each of those value streams? And so the -- essentially what we find is that what it means to the base in terms of reducing the electric cost that they currently pay could be

(inaudible) of 5- to $10 million per year. And which is about a quarter -- or over the lifetime of the battery, which is about a quarter of what the Base's expenses for electricity is.

So, a significant light down there. The actual potential wholesale market value in the region of, instead of really trying to use the renewable generation to reduce consumption on the base, but sell it into the wholesale energy capacity, and the ancillary services markets, was actually in excess of that. It was in the order of $20 million.

So, it raises interesting questions that the -- I have 30 seconds, so I'll go through this really quickly. The Base itself was not very interested in the complexity of becoming a wholesale market participant, and using its renewable storage optimized product to sell it into the wholesale markets. And in part because there are, not only would it be difficult for them to actually go through that process, but it raises issues with the local utility.

As you can imagine, it's a significant portion of the fixed revenue recovery for the local utility, and so there were questions about whether or not the base could separate itself entirely from the local utility and be participating in the market and as wholesale market participant.

And then the other, I'll just finish up with one more comment. I think this is a really -- it is a confusing -- as a former rate regulator, and when you think about some of the issues that we've seen at least in the wholesale market region; we found that it's difficult to decide really what the optimum use of the storage technology is in that context.

Is the focus simply for maintaining reliability on the base, is the focus for optimizing wholesale market sales, or simply for rate reduction. And it raises issues that this is a sort of the next level of detail, but it really raises issues in terms of cost allocation, cost recovery, and the distribution of cost against different -- across different rate payers, when you have a major user of electricity, either dramatically reducing its consumption, or even moving off-grid entirely.

So I just throw that out there as a rather complicated rate question that that's something that we haven't heard from this morning, and that I think becomes important as you get to the point of actual installations. So, I'll stop there.

MR. VANDERHELM: I agree with that last comment for sure. So thank you for giving me the opportunity to speak in front of the Committee. Mark Vanderhelm. I lead the Procurement Function for Energy and Utilities at Walmart. As Janice mentioned, it happens, unfortunately to be a significant usage of electricity in the U.S., second only to the federal government.

So, in terms of my responsibilities, it's the U.S. fixed assets, so stores that we all go visit. The distribution centers and the other home offices and so forth, responsibility for reducing the amount of cost associated with that. Along with that, Walmart has fairly significant sustainability goals, and execution of those goals fall -- or two of the three major ones fall to our team. The one most significant here, is a commitment by 2025 to reduce our carbon footprint by 18 percent, so that's an updated goal, that's a sites based target, and you really get that in two different ways.

You use less energy and use more renewable energy, and now we are starting to focus in on storage. The critical element associated with that is a lot of people, without thinking about it in the context of renewable storage, it doesn't necessarily always translate to using less energy, it just comes around to efficiencies. Anyway, in terms of additional comments, I'm just going to go through what we've done in terms of storage, the what and a bit of the why.

Basically the why in my mind really starts with the economics, overall for us is it's reducing that cost, and that's really what I refer to is that lily pad that gets you moving further down the path.

The next step for us in terms of why, the storage enables renewables, and it enables renewables in the sense of now thinking about a distributed asset that is more consistent with what the grid can manage at a local level. So, we seek drive down, and partner with folks on projects, and integrating storage with solar as an example, or you do it with other technologies as well. What that does also across the industry, is create more competition in that electricity space, which I think makes us all do our jobs better.

The third bucket is this concept of reliability, fortunately we don't get necessarily compensated for that reliability, but if you think about it from a Walmart perspective I think there are some questions here, about would we actually go down to the customer level. It turns out that in many of the conversations at the national level, Walmart set the table, specifically around conversations with (Inaudible), and so forth. You think, you know, once you get past the concept of, you know, having available water, you get to this concept of available food, and provisions, and so it happens that after 4- to 500-some-odd locations throughout the U.S., fairly well-distributed into major township, that becomes fairly relevant. So, we often are a part of that initial response team for communities in terms of thinking about bringing communities back from disaster situations.

So, we continue to look at those types of benefits for how we deploy storage. In terms of what we've actually done in California, unfortunately predominantly California, hoping to do something in Massachusetts, so far it's been -- we started with two allocations, we did

kilowatts, it was really just around peak shaving and energy moving from on peak to off peak. We then scaled that up to another 11 locations, we did 30 kilowatt batteries, and most recently we, last year installed at six locations, something now more at scale, 200 kilowatts scale for us relative to the size of our store; 200 kilowatts, 400 kilowatt-hour type batteries.

And we've looked at a number of applications, not only for the basic economics, which is what it gets paid for in terms of peak shaving and energy move from on peak to off peak, but also looking at it as backup and integrated with our solar facility. So that we normally do take advantage of the ITCs associated with that in terms of capital. We are also able to look at scenarios based off of switch gear we have in place, where when we do lose power we drop down to the required loads in the store, first and foremost being lighting, to make sure that customers are safe.

The second one is around refrigeration, and trying to protect some of the product for as long as we can, and hoping to essentially because batteries would only, you know, theoretically at full power get us two hours, stretch that out to four to six, and then we are able to, hopefully, run in some sort of backup generation, if we don't already have it in place there at the store.

So, it's really, again, chipping away at this concept of additional reliability, and thinking about it in terms of, certainly not full microgrid, that won't imply that at all, but getting towards microgrid from the perspective of taking steps that are economic the whole way down.

So, that's the thought process for the Walmart, it's one where we definitely have scale. We are always looking to partner with folks, we don't necessarily have a whole lot of capital out front, but we've got the biggest laboratory in the world, for us to partner and try out new technologies and do concepts. And we have a track record of doing it. So, appreciate your time.

MS. DENVER: All right. Jessie Denver, Energy Program Manager siting in the County of San Francisco. And San Francisco we some pretty audacious goals around climate action, and we are working to reduce our climate footprint 80 percent below 1990 levels by 2050.

And so we've been making significant investments in energy efficiency, and renewable policy over the last 10 years, which has not come at the loss of economic prosperity or growth. This is new data that we've just published, and in fact we have seen our population increase 19 percent from 1990 to 2015. Our GDP has gone up

percent, and we've reduced our

greenhouse gas emissions 28 percent. And we are not alone in these numbers. All of our neighboring cities, other cities in California, and other vanguard cities across the United States have the same kind of numbers to report.

All right. So, around renewables we have some near- term goals, and then some longer-term goals. Our first goal is 50 percent renewable energy by 2020 to all customers in the city and county of San Francisco, and 100 percent renewable energy by 2030. And our 100 percent renewable energy goal is not just electricity supply, that's also looking at transportation fuels, and thermal decarbonization.

How do we get natural gas out of the system, a number of the cities who have big climate goals will get to those goals, if we don't start to think about natural gas, and therefore moving towards the built environment that's fully electrified, we need to consider storage. Today in San Francisco, between our two utilities, our grid is 44 percent renewables.

So, I'm going to share with you a few applications for storage that we are currently focused on, the first of which is very applicable to this audience and it is a Department of Energy Grant. And I just want to mention, Department of Energy Grant, you know, this grant enables us to really have this intersection between our climate action goals and our resiliency plan.

In San Francisco resiliency is basically synonymous with functionality, and this Department of Energy Grant is enabling us to identify facilities through the city that will serve the community in time of emergency, and that pair solar- plus-storage for critical loads. And San Francisco's anticipated disaster of course is a major earthquake, but we are also surrounded by water and very concerned with sea-level rise.

So this is the Lifeline Council, they've studied how long it would take the electricity and gas system to be fully restored in a 7.9 magnitude earthquake. The Y axis and the numbers in the bubble show percent restored. And what they estimated was that electricity will be restored 95 percent after one week. So, in our grant, we are planning for a three to seven-day grid outage at the facilities that we've identified that will serve the community in time of emergency.

Interestingly enough back to the thermal decarb piece is that this chart also shows it will take six months for the natural gas system to be restored.

So, some steps that we took in our grant project in identifying these sites with the Department of Energy funding, we figured out the kinds of facilities that are best suited for solar-plus-storage systems. We identified how those buildings would be used in time of disaster, and the types of devices that would be needed. And we then worked to size the solar-plus-battery storage systems accordingly. And then document, in a roadmap, how other cities can replicate this process.

So, we work with a lot of different stakeholders, both internal and external to identify the sites that we ultimately selected, and these included our Departments of Emergency Planning, Neighborhood Empowerment folks, and identified all of those buildings that have had seismic upgrades, and that building that are not in areas of liquefaction, or in danger of potential impacts from a tsunami.

And so we narrowed the field of potential sites to sites, and there is one in each of the supervisor's districts, and they are circled there in the red. So, I know you can't -- it's a little tricky to see, and I do have another one that kind of narrows down the math, but essentially it's the ones that are circled there in red.

So, there is one in each of our 11 districts, and one thing that I should note is that we took a page from the Hurricane Katrina playbook, and we didn't focus on facilities that are first-responder facilities, that we originally envisioned. What the communities impacted by Hurricane Katrina found, was that the neighborhoods themselves were the first responders.

And so we are really looking at facilities to have these types of characteristics. This is the typical site for us, a public building that can serve as a shelter, like a school or a rec center. A communications hub, like a library, health clinic, and basically places that have an open area where people will gather. And then, obviously, enough room for the solar and battery systems to be sited.

I should note that we did intend for this to be a microgrid project. As I previously noted, San Francisco has two utilities, a municipal utility and an investor arm utility, and when we got started on this project what we found was that due to the additional cost and complexities that are tied to the fact that most of these buildings are served, the power served by our municipal utility, but we use the Investment & Utilities T&D system, it would just cause a lot of extra cost.

So, not one-size-fits-all in every city under every circumstance when you are talking about microgrids, and that's why we paired our project to a solar-plus-storage project. So, we saved these systems again, to address the critical loads of the site so libraries, for example, will have an increased electricity usage, because more people will be there using computers, checking into to Facebook, letting their families know that they are okay, charging cell phones, and what not, then on an average day. Plus refrigeration, coffee- makers, that kind of stuff.

And then we developed this solar-plus-storage sizing tool, and this tool is now available nationwide to any building owner. It's the first of the kind in the country, and it's not just to size solar-plus-storage at buildings for resiliency, you can also use this to address demand charges, it has functionality to be able to incorporate diesel generators as backup, et cetera, et cetera.

So, we are on a road show right now

disseminating information out about this tool, and I would be happy for my team to set up any sort of webinars, or just calls to run through the tool, with anyone who is interested.

All right. So, I've got to run through this pretty quick. So, with regards to just distributing energy resources, generally, moving from out solar-plus-storage project as an application for how we are looking at storage. You know, the utility industry as we've talked about today is in the early stages of this profound transformation, and both of our utilities in San Francisco recognize that this is really great opportunity to plan accordingly for DERs.

And in San Francisco we have over 6,000 rooftop solar installations, so a next step for us is looking at, how do we incorporate storage into those, because we do have an early-adopter community? And I don't know if you are familiar, but in California there is a piece of legislation making its way through the process, SB700, that would essentially set up a California Solar

Initiative, like incentive program for behind-the-meter storage.

If this passes, this is going to be the game- changer, and San Francisco and other local governments in California will be the ones driving that change.

So the last think I just want to mention quickly, is that California is the largest market for electric vehicles, and similar to Janice's analogy about baking, electric vehicles and storage are like peanut butter and jelly. They are both good on their own, but so much better together, to address demand charges we need storage in the built environment.

In San Francisco we are the home of the ride-sharing economy so we started the day off talking about Uber and Lyft. Their drivers, there are 45,000 drivers in San Francisco on the Uber and Lyft platforms, and if we want to electrify those vehicle miles that they are traveling, they need DC Fast Chargers. DC Fast Chargers need storage to make a business model that actually works.

So, I think that the last thing that I'll mention is that in San Francisco we do have something called the Community Choice Aggregation where the city has become the default electricity provider, using the investor-owned utility, transmission and distribution system, to deliver renewables that we are procuring.

And on a utility perspective, we are also looking at storage, and we'll be issuing an RFO this summer for additional capacity for our CCA. We anticipate by mid-2019 to have over 300,000 utility accounts on our CCA program. And in that RFO we'll be asking developers of renewable projects to include what storage looks like in their bids for renewables as well. All right. Thank you.

(Discussion off the record)

MR. CASTILLO: All right. So, thank you for the invite today. My name is Ariel Castillo. I work for the Office of the Assistant Secretary of Defense, Energy, Installations, and

Environment. Specifically I work out of our Installation Energy Office. I'm one of about eight people that manages 500 military installations, and policy and oversight across those military installations.

Our portfolio is pretty broad. We also have energy efficiency, onsite renewable energy, as two other areas. So, I am the Energy Resiliency Program Manager, steers integration between all those elements in some form or fashion, but I'm much more focused on delivering affordable solutions to our military installations that meet our mission requirements across those 500 military installations. And I'll let you know a little bit more, specifically what that means.

So this is my one-slide cheat sheet. This is everything I do on one slide, or that I have done in the last five to six years. You know, it's nice to just show kind of the broad perspective, and then I'll go from strategic to tactical, and specifically to storage. As I move on a little bit, I only have four or five slides.

So, how do we look are resilience? The first thing I'd mention is that we are at a different point now, where we were in the past, and resiliency to us is in a disruption state, not in a steady state anymore, where there's stress conditions in the environment. You know, largely for us, that means that commercial rate is down, and how do we solve that problem. So we are much more focused now on identifying critical loads on our military installations, identifying what our critical energy requirements, and even starting to quantify what our resiliency level is for those critical loads, and what our mission requirements are.

We've already published policy on energy resilience, in our DoD 4170-11, we've published guidance on operations, maintenance and testing, and now we are getting into guidance on energy resiliency metrics, and also the definition and quantification of critical energy loads and energy resilience for our military installations, that will broadly impact 500 military installations.

If you want more information, it's located at that website, that definition has been official now for a few years also. So, we have been pursuing this, like I said, for four to five years, and we at are the point where we are not implementing projects.

Okay. Just conceptually, so how do you operationalize the strategy? We are accepting risks, the commercial electric grid is down, like I said, so resiliency is stress fashion, disruption has occurred, and so how do we prioritize and now start making a determination. It's not a one-size-fits-all solution for us. We are technology agnostic when we approach the problem, and it's all hand on deck. We are looking at all possible solutions to include fuel.

We are very comfortable with fuel, delivering fuel, and we have storage capacity on our military installations that are already in place for field storage. We are also comfortable moving fuel around. I mean, if you saw in Sandy, the 249th did a pretty darned good job in moving fuel around to relieve bottlenecks.

Mobile gen sets, we did that too. Where we see a lot of penetration for storage is in UPS, I do have critical sites with a lot of uninterruptible power supply which usually gets me about 45 minutes, max. But it is, like the person who mentioned (Inaudible) space constraints right now, especially when I'm looking at storage near the point of use, and especially when I'm looking at it in a resilient state of mind; where there's a disruption that occurs, and I need to make sure that my critical sites have continuous power for at least a day, which is kind of how much fuel I have right onsite.

So, I'm doing that trade space comparison and I'm saying: okay, if I have this much fuel, then how much storage do I also need to make that comparison and to meet my requirement as I'm looking at it -- quantification and added a little bit to -- what else? When I am thinking about resilience, I am not looking at increasing my surface area. I am actually looking at decreasing my surface area; that's very important to me because I don't want my adversary to have more capability or a bigger... wider surface area to attack. I want to be flexible, I want to be mobile. I want to understand that it's not just about fixing infrastructure but if something happens to my primary power source or my backup power source, how can I mobilize? How can I recover quickly and adapt quickly also?

Distribution systems, right? So, how do I play into the distribution risks also of delivering fuel? How do I deliver storage at that capacity? Those are all the tradeoffs that we're making right now. It's easy to quantify when you compare fuel to storage and then you can have something tangible to kind of make a comparison over and that's kind of what we are doing right now. We are doing that baseline comparison because we have a lot of gen sets.

There are easy things that we can do like not put gen sets on non-critical loads, right size the gen sets. These things may sound familiar to you. There are some efficiencies there and just the baseline that we can do better on too that are some very near term things that don't cost as much money as investing R and D into.

So what did we do? We actually commissioned the study that was published in October of 2016 and we did four site visits. Big bases, and we applied the model to come up with alternative solutions to the baseline which was backup generators and what we tried to do is create a trade space and trade-offs between 48 different energy designs, identifying the critical loads at those sites and then comparing both life cycle costs and availability of all those solutions at those sites, sized appropriately to the critical load so we did that with MIT, Lincoln Labs. I think they are actually going to publish the source code on it; it was in MATLAB so they actually requested if they could publish and I said fine, you know? The more the merrier. You guys can play with it if it gets out there.

What I wanted to try to do because people are important, right? At the installation, I have public works officers, electricians, engineers, but thinking about the problem is really hard when your day to day is doing O&M and I wanted to get them a tool in their hands that they can do cross checks. They can look at different designs and they can make those comparisons very easily so that's what we are moving towards and some of the projects that are coming out of this tool are actually -- we are looking to fund too and I had also mentioned that the military branches have adopted the tools also and they are doing more site visits now and doing more assessments in terms of doing resiliency and the trade space comparison.

So, I stole these from my MIT friends this week. So, the other thing that I thought was really important that was mentioned previously is the cost, the economics of storage versus my present solution. We are making the comparison against different solutions when we look at resilience. We are technology agnostic so we are looking at both the cost associated with all potential solutions and we are looking at the availability we plan to achieve at those critical loads with all potential solutions. That's important to us. We don't want to overpay for resiliency if we don't need it so we are taking a very hard look at what those potential options are.

The thing that generally has worked out in the previous slide in terms of microgrids is actually just consolidating generation, meaning bigger generators near the point of use. And then I can actually buy down risk by just storing more fuel on site. And then with the savings, I can probably put more mobile gen sets on my military installation so I am making those types of tradeoffs.

I used to work at DARPA with storage, fuels and batteries. I am not investing R and D dollars. I am trying to maximize our operational budget when I look at my military installations.

The other issue is size. There are constraints at the critical sites and when I am looking to reduce the vulnerabilities and in terms of lower surface area of attack, I don't know where to put the capacity for storage that competes with my storage now. That is a big deal for me. I would run scenarios to kind of flush these things out and we are running scenarios. I need at least a day, if not more. We are going up to like seven days, 14 days and trying to -- if I need that much capacity, what does that look like and how much do I need? That's really important to. Right now I can get (inaudible) in buildings for 45 minutes but times that by

(inaudible), plus there is a lot of storage that I would need to conduct missions. We also do emergency response and life, health and safety but you know, just to end, I have mission owners in my military installations that can't afford disruptions so if I am

performing national security
emission, I have satellites in
space. I am doing ISR. I am doing
ICBM detection. You can ask me
what those acronyms means but
that's what you have to understand
and appreciate when you work with
DOD is kind of what does that mean?

I can't afford a disruption over a day and I want to limit those disruptions at those critical sites that I am reviewing right now and that concludes my presentation. I look forward to questions.

MS. LIN: Thank you for each of your very interesting perspectives and I will just kick of this discussion by saying that customer sited storage, I wasn't the one who said this, but many people have said that it holds the promise for the greatest potential of asset sharing. You have the potential benefits to the host. You have potential benefits to the utility, the distribution system, the system as a whole. Each of you has a very unique perspective. Maybe it depends on the applications. Maybe there are some resiliency applications where you don't want to do anything but just back up to get to your five nines or whatever you need to power the ICBMs but I am just curious from your perspective, when we think of this promised land of how do you tap into those multiple benefits, what are the challenges? I am wondering if you can comment on that.

MR. VANDERHELM: I think the -- I was a little bit late this morning but we must have talked about the factors, ten to fifteen, twenty value streams associated with the storage device. None of them, unfortunately that you can tap into simultaneously and unfortunately, the regulatory structure outside of places like California hears what we value, the regulatory value for that asset. You guys go out and find the rest of the value to go and make this make sense but again, potentially Massachusetts is going down the same path. Unfortunately, you've got this situation where you've got a technology that is not well positioned to take advantage of the multiple value streams that could be there and it just comes down to regulatory construct. I know obviously that(inaudible) they are asking the (inaudible) to rethink that but that's one of the biggest challenges.

MR. McCORMICK: I am Pat McCormick with the Senate Committee on Energy. Could you follow up on that? What do you mean -- are you talking about ISO and RTO market rules? Are you talking about the plethora of regulatory jurisdictions there are for electricity? I can think of some but perhaps you can be more specific?

MR. VANDERHELM: Yeah, I apologize, so the specificity is a storage device that can provide that reliability to the grid. Where you can defer larger capital items. That's not traditional T and D value streams that need to be captured. At the same time, whilst providing that reliability, it can participate at the local level of reducing and operating to reduce peaks and take advantage of some of the more wholesale energy components associated with it so there's this concept of a regulated entity that has its source of benefit associated with it but can't take advantage necessarily of the wholesale energy component. It's just a fundamental break between what we made competitive and -- it's just as relevant in fully regulated environments but in places where you dereg energy components, the generation component, that's where you end up with this challenge. I think the NOPR from FERC is seeking to make sure at least within the wholesale energy environment, that there are explicit rules and thinking through, seeing it as its own unique asset but that -- still that challenge of the split revenue streams won't be solved by then.

MS. LIN: Yes, go ahead, Mark. I imagine you'd like to talk about market rules.

MR. IRWIN: So I think that Mark raises a really interesting point, which is we've got market rule issues. The other issue we have on top of that, which we will see how that plays out in California is we may be in the position where if one party is buying all the services from a device, that they are able to capture -- say we set up the market rules, they can capture them all but if you purchase only part of the device's capability and put that to the owner of the device to try to capture the remainder, that may also be so maybe, when we solve the market rules, there may be also commercial structure issues around, do you really have to -- does one party have to be able to own the capability of the resource or can multiple parties -- or does it depend which markets they are. I think that's another challenge that's out there to kind of add to that leg of it.

MR. HIBBARD: If I can just jump in. It's a great point. Just take as an example if a distribution utility were to make an investment in storage in order to reduce or defer capital investments, they would need to make overtime. If they were in a wholesale market region, they can't simultaneously use that and sell the peak production value into wholesale markets. There are jurisdictional issues and in a lot of these states you can operate something like this as a generation source and so that's one of the fundamental challenges is actually getting the full value factored into the investment matrix which is difficult to do in those settings.

MS. LIN: We're lucky to have a couple of operator people in the room. I think it would put it in perspective?

MR. ALMGREN: I have a different question. I guess(inaudible) 16,000 units sold each month. That equals 600 megawatt hours of storage. 7. 2 gigawatt hours added per year. Do you see that as a potential resource or just another complication?

MS. DENVER: I mean definitely a resource that factors into the solution. All the utilities see EVs are a way to increase the load which helps develop new business models when they see loads being shed from efficiency and onsite renewables so storage is key to this and in

California, in the bay area, there are some parts of San Francisco where electric vehicles represent five percent of all new vehicle registrations and in the bay area 25 percent of all new vehicle registrations and if California has a goal of 1. 5 zero emission vehicles on the road by 2025, storage is a key part of that so I don't -- I see it as a solution to be able to manage those demand charges, to be able to smooth issues on the grid and going back to this previous conversation, there are a lot of electric vehicle charging providers who are also very interested in storage because in California you can own storage at multiple sites, aggregated and participate as an asset in the wholesale market and so they also see that as a way to create a revenue stream within their business models so there are a few things happening in there. I am just going to add one more thing, I noted that in California we have community choice aggregation programs and there are four that are active, San Francisco's clean power SF being one of them and a new one that's just come online in the Bay area. By 2020, 60 percent of California's population will have access to a CCA program and all the CCA programs are developing demand side programs like storage incentive programs that are paired with electric vehicle charging that actually incentivize customers to curtail their charging and pay them to do that for the CCA to be able to tap into the storage so these are all emerging business models that you'll see a lot of activities around in the next couple of years in California.

MS. LIN: And having gone through the exercise of looking at siting storage in these resilient community centers, I am wondering if you have additional challenges that you want to raise?

MS. DENVER: Our number one challenge -- well I mean the large scale kind of issue, I don't know that that is as big of an issue for us because our investor and utility would be siting large megawatts worth of storage probably elsewhere, I mean we are looking in commercial businesses and we have a number of commercial sector partners that have already integrated storage into their operations but I think for us, the Con Edison presentation, the number one thing that we need to tackle between now and the end of the year, especially if SB 700 passes, is working with our fire department to make them comfortable with the different types of technology. The New York Fire Department, our colleagues, they worked on that, they also were part of the DOE grant that we are a part of and initially, New York Fire Department said no lithium ion and they worked with them to educate them and have a number of stakeholder meetings and they changed their minds but taking a page from the solar playbook circa 2007, we know that state fire marshalls, local fire officials can really close down an industry if they don't feel that it is in the best interest of the state and the health of the public so we need to ensure that we have streamline permitting and inspection processes that are in line to help the industry reduce those soft costs and deploy technology faster.

MS. LIN: Thank you. Ariel?

MR. CASTILLO: Actually to piggyback on that because that's a good thought. So when you think about me, you think of me as a public works officer that's on a base who is trying to build infrastructure for tenants so I am like a mini utility (inaudible) that's trying to make everybody happy on a base just on a micro scale than on a larger grid and I have mission operators that have requirements like (inaudible) safety functions and different things that I talked about before so we are really trying to understand those requirements. Understanding what their down time tolerance and the risk tolerances are for their missions and then we can bring them the technology and show them exactly how it benefits them.

I'll piggyback also on some of the demand response comments. I also have to then convince those same people that it's okay to participate in these revenue streams and show them how I will not interrupt their mission while I am doing that. That's another important thing and it's just because you go out and create a market and do demand response -- I may not be able to participate in it because of my mission requirements at some of these sites so that's something that's very important when you are doing analysis is that you really have to figure out what the mission operator can tolerate and that's what we are really driving towards right now. We are having very focused discussions on individual missions, what their risk tolerances are, what their mission requires and driving towards metrics so that we can understand what is the possible at those sites.

MS. LIN: We have some questions here. Are your questions about challenges or comments? Just while we are on this topic in general?

MS. BROWN: It's probably related to value streams. When you had mentioned the IOU or your T&D company having sited storage, I am wondering if any of you are aware of kind of integrated planning around storage needs with a community level plus a utility level to kind of optimize either from the grid side or from a community say critical infrastructure area where you can look to optimize opportunities and locations.

MS. LIN: Edison is here as well and they can probably speak to their resource planning but in California we have this IDR proceeding that is setting up the new rules and all of the investor owned utilities are looking at just that and at a local level, I think that we don't have a specific plan around that but that between now and 2020, when we update our last iteration of our climate action plan, you will see something to that effect.

MS. DENVER: That brings out another good point. While I can't give you specific examples, I am familiar with the Cape Cod and what they are doing there and when you do that, it also raises some security concerns so from our standpoint, if we are going to do that, then we have certain requirements on a security side like cybersecurity requirements that we have to figure out and understand how to apply those cybersecurity requirements, that's why we are trying to lower the surface area, right? Because then if we can control that and don't have to go through those procedures, it makes for a much more executable project but if there is benefit to us, then I would acknowledge that and I would try to work an arrangement out to try and figure it out but it does bring that cybersecurity type of element once we are starting to share resources back to base.

MS. LIN: Anybody over here have a comment about these multivalue stream challenge -- go ahead, Paul.

Mr. CENTOLELLA: You touched on monetizing the value of storage in the wholesale energy markets and I know FERC has done a lot of work on that front, issued a few orders. Can you share your perceptions on the current market design and what you think needs to change in the wholesale energy market construct that more appropriately values storage and kind of facilitates the deployment?

MR. CASTILLO: I think that varies significantly by market. Ultimately storage has to offer something -- if you look at the individual markets, what it ultimately comes down to is the pricing and the ancillary services markets primarily and the ability of a distributed storage facility to actually participate in those wholesale markets and that's essentially what FERC is busy trying to figure out and see whether or not the different regions have actually accomplished that or not.

MR. Morris: Jeff Morris from Washington state and I have some basic questions for Jessie and Mark. Jessie, a lot of times we see (inaudible) for success for initiatives by state energy officials or cities and so forth. There are always these numbers about greenhouse gas reduction and the buildout of storage. Do you have a good -- or have you found a matrix that lets you differentiate the ambient organic activity versus what's actually a result of the initiatives you undertook in your space?

My question to Mark is that I always like hearing from customers (inaudible) what is the motive, in the end for entry into this space? Is it a good business practice? Is it a year energy edge against demand charges? Is it an altruistic reason? Is it to access worldwide markets that require a certain amount of renewable generation? If you can kind of speak to what you see as the motives from this developing customer collapse that wants to participate?

MS. DENVER: So to answer your question, each city has their own way of kind of creating a dashboard of how they are doing against what's actually getting done and that's something that all cities have asked how do we standardize that process so we are all kind of speaking the same language and presenting the same information so the answer would be no, we don't have a good standardized methodology but there are ten cities across the United States, we are just getting started on this effort through the member network called the Carbon Neutral Cities Alliance and CNCA is a project of USDN which is the Urban Sustainability Directors Network and through this effort, we will be developing 2050 zero net carbon action plans and those action plans will prepare each of our cities with near term policy objectives that help us look at how do we get natural gas out of the system, how do we integrate storage? How do we create net zero carbon buildings in each of our cities to get us to our goals and a piece of that is developing that standardized kind of dashboard to measure how we are doing.

MR. VANDERHELM: So great question by the way and I get that question quite a bit. I think the first thing is(inaudible) and his commitment that he put out there and he timed it specifically before the actual election so the message was regardless of the administration, we are doing this. The second one is I am in a procurement function and it turns out that this stuff makes sense economically. The concept of sustainability is actually our future. It's the path. If we commit to it, it will make economic sense. It's just a matter of speed, it already does in certain areas. You have to split incentives that aren't split but fundamentally it is the long term economic plan as well so luckily for me I am still employed because it works in both spaces. Obviously there is a benefit to it broadly in terms of being a leader in the industry space as well.

Unfortunately Wal-Mart ends up being the poster child for the things that all of the corporate world does but in the sustainability community, I'll have people walk up to me from NGOs all over the country and shake my hand because I know what Wal-Mart does so it's a bit of a -- we're a bit quiet about it but as it turns out it makes businesses sense and for the environment for the industry to lead.

MS. LIN: Thank you. We are going to go to Paul and I have the same question for you guys and everybody on this question of given all these challenges, what can DOE do and we are not going to have to have a chance to hear from anybody but we do want to capture your ideas. Go ahead, Paul.

MR. HIBBARD: So I want to take a portion of that question that Janice just posted and post it back to you based on your experience and that is as I think about what DOE could do, one of the things it could do is develop methods and tools for actually beginning to value resilience so I'd like for you to think about what are the metrics that you would use for valuing resilience?

We know from the work on reliability that different customers and different end uses have very different values for reliability but all of that value of lost load work is based on surveys that only go out eight hours in terms of outage length and we are talking about potentially longer outages when we think about some of the resilience questions and it also occurs to me that resilience is somewhat dynamic in that different kinds of events may make different kinds of loads critical and so I am curious based on the work that you guys have done up until now, can you provide any suggestions, insights, directions to the Department as it thinks about how to develop more general methods and tools for putting a value on resilience?

SPEAKER: Would you also comment on how you define resilience for whatever your entity or client is and what metrics you have for evaluating that and what you might be interested in for DOE and developing metrics that are relevant?

MR. CASTILLO: So I had a definition out there and I will just read it to you. Energy resilience is the ability to prepare for and recover from energy disruptions that impact mission assurance on military installations. So when I think about resilience, I think about the core purpose of an organization, whether it's DOD, whether it's industry, what is your core purpose and how do you continue and maintain that function in the face of disruptions so that's how I think about resilience and I think that's kind of generally how resilience is built through the literature also. I am also a systems thinker so it even goes as far back as systems thinking too so that's kind of how I structure resilience.

Recovery is a big part of it so downtime is a big part of it too, so we are collecting downtime metrics. Unserved energy is just down time right? How much energy am I getting to those core functions and core purposes and how much risk? Risk is also another big issue, how much risk am I willing to tolerate in the face of disruptions. We're not looking at just ours anymore so we are running scenarios in groupings. This is how I am setting up the guidance on metrics, when you start and it's important to set up the scenarios to define your system boundaries so if you look at a zero to three day outage, things may look different in terms of criticality then the three to seven day outage, than a seven to fourteen day outage.

So what I want to do is then assess the tradeoffs in those scenarios and then when we are looking at those tradeoffs, then different system solutions come out. That's how the tool was built at MIT, the whole philosophical construct behind the tool was based on that so you can run different scenarios within the tools and different outages. You can input critically based on those outages and it will spit out the right solution for you.

When we got to 14 days plus, the interesting thing, and I want them to kind of be more active in publishing this, the solutions didn't really change, right? We're looking at a six month outage, you're talking about things that are happening at six months that you may not be at the site anymore so you'll probably have a contingency plan in place that you are going to move it. I think this came out already in terms of building the infrastructure up too much for a catastrophic event so at that point, we're thinking after 14 days or a month, you're moving missions now and we have the capacity to do that as DOD. We have CO-OP plans in place, continuity of operation plans, like I said, we can mobilize generation if we needed to but you do have to run the scenarios and then make a risk-informed decision on how you want to act and that's a big part of resilience.

Ms. DENVER: And I would add on, for San Francisco, resiliency is synonymous with functionality and that's during and after an event but also on a day to day basis. For the DOE, you don't have to start from scratch. There are efforts to define resiliency and create resilient standards and that spans from LEED. They have some pilot credits for resilience. There are some other standards like REDI, FORTIFIED, I am happy to talk about them and others afterwards. The one area that I am interested in and I actually put this up on a comment earlier is having DOE look at how we work with the insurance industries to start to put value on resilience and how that factors into the return on investment through potentially appraisals, loans, discounts for folks who are doing resilience on their premiums. Earlier, when we heard that some of these natural disasters, hurricanes, cost 50 billion dollars or more, there is a value there to the insurance industry and they should be engaged and I know that the national institute for building sciences is attempting to kind of assess the returns on specific technologies that are tied to resiliency and have a keen interest in also trying to figure out how do we connect the insurance industry to this conversation to help with the financial piece.

MR. VANDERHELM: So I'll look to not only answer the questions very simplistically measuring resiliency from the Wal-Mart perspective. It's a process of closing a store and inventory and waiting for truck to bring in new things. I think fundamentally if you want to get down to a concept as universal as impact on either loss of life on wellbeing or some concept of economic development, economic dollar impact essentially to communities as you have less resiliency. I don't know that you get any more granular than that. I think you end up in debates but the thing it actually suggests is try to build on the point of my initial comments was you might get into a challenging debate around the costs associated with some of the resilience components but if you focus your energy on the things that make sense or are close to making sense today in terms of making those economics, you won't have to push storage, storage will get pulled by making those environments real so the comment this morning around storage really becoming economic based off of other industries continue to work with electricity regulation, with the technology and help it be economic in some of its traditional value streams will then enable it to be there for resiliency. The one thing I always throw out there is I have resilience due to back up generation but I put it in for free. I get it for free because the business model allows working with the utility and garnering the capital through participating with that local utility so local utilities have the right incentives in place, create the revenue stream for that person putting the capital up and oh, by the way, I now have resilience in the back end of it where I get the first call in emergency situations so there are situations, there are business models out there. You make the other revenue streams work and resiliency comes along with it.

MR. HIBBARD: The only thing I'll add to this conversation is that I feel like we've had three definitions of resilience and that's what makes sense. On a customer by customer basis, how that customer defines and puts a value on resilience and that's the value that that has to them. It's going to be extremely different based upon their economic model and their function. I think a separate question which I sort of came up through your question, Paul, by mentioning value of lost load is how do you define resilience of the bulk power system? How should NERC and the RTOs be thinking about resilience and how do you quantify the value of that from the standpoint of having storage technologies distributed? I think these are all extremely different definitions and that's one thing that DOE could really help do is sort through those and sort through helping us from a standpoint of designing market rules and from the standpoint of bulk power system operators actually building resilience into this system that doesn't always exist. That would be extremely helpful to think through. To some extent, I think a lot of what power systems will do -- they have plans for restoring services as fast as possible. They have various reliability services built in to try to avoid outages even in the face of catastrophe so I think that's where there is a lot of confusion at the bulk power system level. What is resilience and how does it compare to the reliability function of these system operators?

MS. LIN: Great comment.

MS. DENVER: Can I just add some things really quick? The one thing I would add to DOE and I have to take this opportunity is to continue to fund local government projects. We are the living laboratories of your use cases and collecting that data that you need and so applying for grants is something that we rely on and we've had close relationships with DOE for years and have been able to do really good work through that so I would encourage funding.

MS. LIN: Thank you. So will all of you please write down your additional ideas because I bet each of you have great ideas on things that DOE can do and we want to collect them while we thank our panelists, thank you very much.

Richard is the CEO of Magnum and we are going to learn all about bulk underground compressed air as our third application for the day.

MR. WALJE: Well thank you, Janice and thanks for the opportunity that the committee is providing me to talk about compressed air energy storage in two ways, specifically about the project I am working on and then in general. So Magnum owns and controls and underground salt body 130 miles south of Salt Lake City. This picture shows you its location and the blue spider web are transmission interconnections to this location and the icons demonstrate that it also allows us access to the cornucopia of renewable energy in the western United States all the way from New Mexico to Southern California solar.

So a site layout, this is a (inaudible) set of circumstances that this salt body, that's the light blue shaded area literally abuts the inner mountain power project. It's a coal fire generating plant in Utah, 1900 megawatts. The department of water and power announced the intention to close that plant by the mid 2020s and replace it with 1200 megawatts of combined natural gas generation. There are multiple transmission lines facing the IPP substation. There is a 500 KD DC line that runs from the location down to the Los Angeles basin. There is a 230 KV line that flows to Nevada and 2345 KV lines that leave the plant and interconnect in the pacific system in central Utah so very propitious location for the salt dome.

The salt dome is very large. We've

actually hired a consultant to lay out multiple businesses there. We've already stood up the natural gas storage business. We've created four underground caverns successfully. We have plans to install natural gas storage as well as perhaps crude oil and et cetera. My project is to use these caverns that are created by drilling through 3,000 feet of earth. The top of cavern -- the top of the salt body is about 3,000 feet underground. It is a mile thick so we have the capability of creating over 100 caverns at this location.

The other thing that's fantastic about this location is there are two gigawatts of proposed (inaudible) solar projects literally abutting our property in some instances so this convergence of assets is unique in the west because we are unaware of any other salt body. Interestingly, I think our technology is closer to the combination of battery and LM 6,000 then storage in general and the reason I say that is we actually take renewable energy and we are going to use solely renewable energy to run our compressor motors to maintain a better environmental footprint for our project. You run them through a compressor and you store that energy in the cavern as compressed air. The operating pressure in the caverns is between 2,000 and 2,200 PSI. Our current design is 22 million cubic feet which would allow us at 48 hours of storage so when we talk about resiliency and the ability to bring the grid back up, we'll have I'll call it almost a binary fuel system where we take the compressed air and then we add a hydrocarbon fuel in this case -- people default into thinking it's natural gas but we are seriously reviewing whether we can use biomethane or other biofuels to make this a non-emitting resources-- so whether that's feasible or not, we don't know but particularly since we wanted to do business in California and other states as the world evolves, we want to be able to portray this as an environmentally responsible project. From a depleted cavern, that means down to its limit of 2,000 pounds per square inch, we can store 7,680 megawatt hours of electricity and because we can build multiple caverns and this is a modular design, we can continue to add modules over time, over 1,000 megawatts of capacity here.

Now one of the things I should have mentioned when I was showing the transmission lines is we don't own those transmission lines. There are multiple parties that own those lines so our ability to gain access is very much related to our ability to set up contracts, purchase power agreements with parties and that project or gain some of the access. One of the things that I also didn't mention is that there are 300 megawatt wind projects that connect to the inner mount power plant substation that has firm rights on the D.C. line on a capacity factor in the 20s so there are 300 megawatts of firm rights that aren't being used efficiently and one of the things that we could do is levelize the output of all of those renewable assets to get 100 percent utilization of the transmission systems so again, a very unique set of circumstances so what differentiates this case?

Case potential like pump hydro storage, PHS is based on geology and geography and I guess I should also say climatology because in our case, where we intend to use primarily PV solar to run our compressor motor, we need to be on a place where the sun shines a lot. Fortunately, we have good radiance at our location and as I pointed out, we can stand up some cost competitive solar for sales into the west and then of course, you need geography, the other advantage of our site is that it's flat land, it's a brown field site. There is qualified labor there already and a support infrastructure. There is a big chicken ranch, pig ranch and turkey ranch and that's where we are thinking about getting our biomethane through bio digestion from those. Because these are expensive, lots of capital cost, they have to have some regularly fairly large size in order to accommodate the ability to spread the cost and benefits over multiple units so therefore they are not widely deployable. If you think about the opportunities to do compressed air energy storage, it's vital that you get very little or no leakage of your compressed air, otherwise you're driving down the highway with this leak in your tire and you never get there. Very similar to pump hydro where your reservoirs also need to be essentially water tight so you can use some constant pressure, variable volume case projects that are being proposed now where you use hydrostatic pressure by putting a bladder underwater and that increases the availability of case. I've also thought that you should be able to take a retired oil tanker, weld it up, put the pressure in it, park it in a dock somewhere and use that as air storage for caves.

It's not that there are no other opportunities. There are other salt domes as well. We consider ourselves not to be a direct competitor with lithium ion batteries primarily because our output is essentially defined. We cannot build it in smaller building blocks. In our case, it's 160 megawatts, that's the most economic size. The duration, the cavern size is variable, the caverns are created by how long you pump water down into the salt. The salt makes you pull the brine out, then you sell the salt and make some money there but you can size the cavern for use and the other thing about our design, the compressor and the generator operate independently so you can be operating the compressor the same time that you are operating the generator and one would ask why would you ever do that but there might be times when the value is in regulation up in spinning reserve but there is still low cost renewable energy available that you want to capture.

You can run ancillary services off both sides of this project. Now the equipment capability doesn't deteriorate over time-- of course it needs maintenance-- but the two existing plants have 30 years plus of experience with minimal failure and no catastrophic failures.

The capacity is not affected by the operating range and frequency, we can move it up and down every day, every hour without impact and here is where the thing gets more interesting so this is the only project I know of besides the LM 6,000 battery combination where you are actually putting two forms of energy into the process so when you add the heat, and let's just use natural gas, into the expander because it's not -- isothermal project, you add natural gas to increase the expansion and basically you are supercharging a turbine. Some of us are old enough to remember muscle cars, that's essentially what that is.

Well I get you a heat rate for 4230 BTU per kilowatt hour which is almost a third of a peaking plant so it does have a much lower carbon output. It can do all of the actual ancillary services. I am not going to go through these. We talked about stacking them up or when you talk about resilience, what we believe this is an ideal machine for resilience as well as the energy imbalance market and the development challenges, while each state treats the environmental aspects of generation in the system differently, you have to do a lot of extensive and expensive engineering before you can get into contracts and final pricing; modeling thermodynamics and design capabilities is atypical for utility integrated resources planners and engineers. We think we can qualify this project for investment tax credits. We need to maintain the renewable energy credit value in California. I can go on and on about the evolving market structures.

I am actually meeting with the FERC staff tomorrow to follow up with comments we made on the storage NOPR. I think anybody who is doing one of these projects wants some recognition of the capacity value of their project in some form. The problem we have, it's a transmission asset, it's a generation asset, it's actually both so it's' hard to categorize and put into a bucket and I just mentioned the FERC. The biggest challenge for our project, there is no western US transmission for the entire grid. There is no RTO. CAISO takes care of California or most of

California but the rest of the west is not under a place where you can even set up market rules so activities we have underway are just related to all of that. I would just say in the end, I'd like to portray this project as in the west it's called the Leatherman of IM or utility projects or the Swiss Army knife of technology. Those are my quick comments.

MS. LIN: Thank you, Rich. Do we have any questions for Rich? Go ahead, Mark.

MR. IRWIN: So I saw one of the values that you talked about was multi day storage and I know we heard about that a little bit earlier today and I know that LADWP and SCPPA who are owners of a lot of the transmission rights may be able to do multi day planning, et cetera and you are talking about spreading the markets around west but in the (inaudible) market, it doesn't have a way to recognize, at least that I know of, a multi-day capability. How do you think that's going to happen and if you're trying to move to have more of the market be open in the west, how do you see recognition of that value?

MR. WALJE: Very good question. One of the reasons we do multi-day is so we can capture the renewables multi-day. Right now, many times a day, you can have somebody pay you to take their renewables. There were 80,000 megawatt hours of voluntary economic curtailment of renewable energy in the(inaudible) in March so there is some transmission access issues but our assumption is the reason we are going to gather up all that renewable energy is that so it doesn't go wanting and the people who make the investments in those assets have a better chance to assure themselves of some value rather than that -- I am a participant in something called fix the grid and part of that is to see if there is a way to build on the work that Pacific Corp and the CAISO started for a broader ISO in the west and see if that is some way to start evolving these market opportunities.

MR. IRWIN: If you are thinking that you are going to get people to think that getting the energy imbalance or the curtailment avoidance is going to give you a revenue stream when the value is being spread across all sorts of people on the grid -- so I think about this the same way I think about the PJM ancillary services market, it's great as long as there aren't too many participants. Once there are too many, it's not worth anything to anybody so any way a market player can be there is under a long term contract. How do you see that capability to get enough people in the market to come together to create that long term contract saying I am sharing in this value but I am not actually going to see it on an hourly basis.

MR. WALJE: so that's an excellent question and the gist of our business model. So our sales job is a lot easier if you are vertically integrated entity where in essence, I can make the pitch that if you invest in this asset or you enter into a 20 year purchase power agreement that power cost is going to go down or at least be no worst. When you are not a vertically integrated utility, LADWP and most municipalities still are, you have the better opportunity by participating in this -- it was stated earlier that there is kind of a mixture of megawatts in the old system where you had a portfolio and all of these ancillary services were sort of inherent in your generation fleet. Well now they are being differentiated. Differentiation creates one set of challenges but it also presents another set of opportunities.

MS. LIN: Sue and then Carl.

CHAIR TIERNEY: I am interested to know not only about the caves technology but perhaps some of the other ones that have been discussed. The extent to which the principle barriers are these institutional financial instruments, regulatory or things like the price of natural gas or other things that are tremendously affecting the values that can come off the electric system and others can address that as well.

MR. WALJE: That's an excellent question and I guess one of the things -- full disclosure, I worked for Pacific Corp for 30 years and I actually, the last 10 ran the Rocky Mountain power operating utility in Utah, Wyoming and Idaho so I am very familiar with what you just said. It used to be that your planning was where is the nearest coal seam or gas supply. You build the transmission line and you're done. That's the thing you can't do anymore so I think we are in a transitional evolutionary period in time where we're all somewhat feeling our way and my view is some of these things, we stated yesterday the grid is a public good. One of the reasons that I used to like to go to work at Pacific Corp, our office was called the public service building so one of the things for projects like ours, it's probably worth trying some of these things just to see if they are going to deliver on the promise and the premise under which you are taking them. We are an equity investor finance project so we have yet a whole another set of issues. We are taking a bit of a flyer that people are going to see the value of this but it's going to be long term.

What are ancillary services going to be worth or cost you in 20 years, with all of this evolution going on. I've heard people say they are going to be zero to Mark's point but wait a minute, they are going to go up and ERCOT, you're actually seeing some of the ancillary services go up, not the same as the west but who knows for sure?

For us, we need a 20 year revenue stream basically to get the financing to build our project. It's something that we are dedicated to doing but there is no clean answer I think we are going to learn along the way.

MR. IRWIN: So Sue, one of the challenges we have is -- let's use southern California as an example. We no longer do an integrated resource plan with transmission and procurement together. Transmission is done by the CAISO but the CAISO just studies where I need to build transmission for power to move. They don't actually say where do I want something. They recently did a study on three pump storage facilities. Three potential pump storage facilities because people are saying what about pump storage, shouldn't there be room made and they said for each of these, they added some value but they had some challenges. Market participants come to us and tell us where you want it. Well for distribution we do, like I talked about our distribution referral but for market based resource, it's really we are not favoring anybody. You can put it in one place and it's going to have some impacts. You put it in another and it's going to have something else but we don't do that centralized planning.

We just do the procurement based on a CAISO need in a region or something of that type. The integrated resource plan in California will be interesting to see if we migrate to location but I am not sure we are going to and I think part of the challenge of storage, people say well I want storage and solar together. Well for us, a lot of our big solar is out in the middle of the desert and if we had to say where do we want storage, do we really want it in the middle of the desert so I think those are some of the challenges that I am not sure there is a clear path through them at this point but it's certainly a challenge that I think for California is kind of the next phase beyond.

We know how it works, we are getting it to be more economic but then to manage it where do we want it and how do we go through a process of revealing that to the market without giving anybody a market preferential position -- you want competition, how do we find that process to work and that's something that we still have to go through in California.

MS. LIN: Do you think that's something that DOE for example, could help on a national basis?

MR. IRWIN: Yeah, I think that it is probably in the -- it is in federal jurisdictional but it's probably in the area of doing reliability things and state jurisdictional, I don't think it's a DOE because that to me is a little operational for what I think DOE's general mission is and then somebody has to rely on it for procurement and things of that type.

I think there are possibilities around the area. I think DOE has done a lot for solar. When you get up to the big macro piece, it's a bit more difficult.

MS. LIN: Why don't we go to Carl and then I just want to take a check in. We had planned to go straight through and this next session that we are transitioning to is intended to focus on discussion and prioritization and what are the top areas based on what you've heard all day that we should be focusing on from a federal government standpoint. I'd like to propose that we just keep going and I'll try to corral us into a set of priorities. So Carl and then Patrick.

MR. ZICHELLA: Mark, you just put your finger in something that NRDC has been advocating very strongly in California for a long time is a track record of success. You can look at the CREZ

(Competitive Renewable Energy Zones) Process in Texas as an example of locational development of transmission. The REDI process in California had a similar focus. Looking at grid needs versus short term incremental justifications, projects like Rich's are going to have a hard time getting justified if we just look at how we are going to meet the next few percentage points of additional load. We have nine gigawatts roughly of solar potential in the San Joaquin Valley on a land we can't farm anymore.

We have a great ability to maybe take those resources and help our neighbors with low cost renewable energy to offset some of their thermal resources which leads me to the question that I wanted to throw to Rich is I previously had heard and we've talked about this project before Rich that there is a bidirectional component to this and some of the surplus energy in California could get parked in these caverns as well. Is that still the case?

MR. WALJE: Technologically it's very feasible but jurisdictionally it may be more difficult. There is only one transmission line between the LA system to CAISO. There are some transmission constraints there so that this very conversation, if we were really looking at the grid at large and all of the renewables available, somewhere, and this is where I feel for state regulators in particular because they are at the face of all of this change, taking care of retail customers as well as all the other stakeholders who participate trying to sort this out. If it were me and I was just sitting there planning, I'd say one of the priorities for moving renewables all around the west, including in and out of California, I would increase the transfer capacity between the LA system and that DC line and that would have great public good but if you are the people who invested in those original assets and you don't know how you are going to get the revenue stream to pay for them, if they are not going to be embedded in rates somehow or recovered in the market, it really requires a different level of thinking about a western grid that is organized and planned as a western grid. There is no way out if, we are all in it together. We are going to atomization. We are not going necessarily in the right direction. Our plan really does depend on us being able to move excess renewable energy out of California whether it's wind or solar because if you think about our project, we absolutely need some wind because there may not be enough energy available in any form, strictly relying on solar to allow us to put enough air in our cavern to dispatch the generator in the most optimal fashion for everybody's benefit so a whole other aspect of this is looking for renewables beardly across the west.

MR. ZICHELLA: I think DOE does have some areas where they can help and there has been some effort in recent years to sort of unlock some of the obstacles getting some of this transmission done. There has been this effort to do pre planning for NEPA for example.

I would hope the new administration would maintain a great coordination that has developed between federal agencies and siting for example, of transmission but also the biggest obstacle is the differences between states, how they regulate and deal with transmission. Everything from state planning authorities in Wyoming to every single county in Colorado having jurisdiction over interstate transmission. This is where DOE can maintain its leadership and help to solve some of these coordination issues and I hope we won't go backwards on those because that was a massive effort, very bipartisan. Governors from all kinds of states participated in those conversations as I did and I think that there is -- we don't want to lose that. It was just beginning to get to the point where we might take some delivery on it and it will be -- if we don't have to do it, we will do it again anyway.

MR. WALJE: Because my last job with PacifiCorp was to get the gateway project built over 2,000 miles of transmission line. It took us literally 9 and a half years to get our BLM record of decision. So once that investment has been made, it would be criminal to not get those projects done for the public good.

MS. LIN: I am going to add this to the wall. Help with differences in transmission planning across the states.

MR. IRWIN: So, Richard, you described the challenge with the transmission and with being able to deal with the energy imbalance market in California and move it through the transition system. With LA joining the imbalance market in 2018, doesn't that help with some of that solution?

MR. WALJE: Yes, absolutely, in fact that is a very beneficial thing for our project and I will just add an aside that I didn't really touch on. Right now, we have had some very constructive conversations. I am pretty confident we are going to get our first one of these built. The challenge is nobody wants to take the full 160 megawatts of output. We have multiple people willing to take a piece.

I am thinking who is going to dispatch this and decide what kind of economic and contractual relationship will you have to get that done so that's what keeps me up at night. I actually think we'll get our project done because it has a lot of value intrinsically to potential off-takers but that's what I haven't quite figured out yet.

MS. LIN: We have that same problem for new pump hydro resources in California. One is too big for any one utility so contracts for book storage, I'll put that one down.

MR. IRWIN: That's an interesting one. One might be too big but is one even required? Those are the studies that are still ongoing.

MS. LIN: It's just isolating that issue. Let's go to Patrick.

MR. MCCORMICK: Well you asked -- one of the questions I was going to ask -- you just asked about the imbalance market. I will say speaking for myself only and not our senators, I agree with Carl's point about the work that's been done previously and not going backward on that work. I think that's important. My other question was -- perhaps it's a very elementary question which will show my ignorance but how many compressed energies, compressed air energy storage facilities are actually in service in the United States or in the world?

MR. WALJE: There are two similar to ours. There was one built in Germany in 1983 and one in Alabama at McIntosh in 1991 which is another one of our challenges. There have been none with our design because they are either charging or discharging. We decided to take the clutch out of the middle and replace the motor generator with separate entities with more flexibility and value so one of our other challenges is this is a proof of concept; unit number one if we could get this first one done, we could test out the value and then it's just a cookie cutter to take more advantage of the transmission and renewable is right there for instance.

MR. MCCORMICK: Is there any feasibility of a merchant DC transmission facility that might be done in tandem with the project?

MR. WALJE: We'll we've actually thought about that, that there probably does need to be some merchant type transmission built somewhere and in fact, APS, Arizona Public Service and Berkshire Hathaway transmission has proposed a merchant line that runs from the PacifiCorp system over to Nevada and not with the emergent plans so we are not in the transmission business but there have been actually a couple of merchant transmission lines built. They faced very much the same problem as storage does. They are big, they are expensive, there is not necessarily any formal way to assure investors that their investment is going to be returned so.

MR. MCCORMICK: One of the things you have around many parts of the grid around the country is that you have different planning regimes and the question is each one of those planning regimes you are planning in the best interest usually of the planning regime and you look at the adjacent planning regimes and see how you might believe they might react in the case with CAISO, they've looked at a very conservative view of what the transfer capacity is going to be. They often have. They have done some more recent studies where they've looked at a broader view of a transfer capacity but still maybe not as broad as they need to but you still have the owners of these transmission rights acting in their own self-interest as well so I guess the question in my mind is that somebody might be able to help with from DOE's perspective is how much money is there in it for the U. S. and whether that's in the west -- the west is an easy one because there are a couple of big projects like this in the west and you can really think about this is how much value is there in cutting through all these planning regimes and trying to do what's best for the U.S. which in this case you'd say what's best for the west and the west also includes Western Canada so that's also another challenge but that might be an interesting thing because I am not sure outside of a project sponsor, I am not sure who else is going to do the study and I loved your opening, Janice, which is you said you're an advocate.

A project sponsor is always going to be an advocate as well so even though they might do a study, whether anybody would actually believe the results would be kind of another issue so that might be a great role that DOE could have.

And I am not sure if it's the U.S. -- it could be regions of the U.S. that go beyond planning regimes. ERCOT is another one that they only plan for themselves.

MS. LIN: It reads what is the value of simplifying planning across the U.S. or even regionally?

MR. IRWIN: Study the benefit of simplifying planning. If there is no benefit, why push it.

MR. ZICHELLA: It does seem to me that WECC has played that role so far and has studied this particular project. A number of us there insisted that they do it. They almost didn't do it because it was proposed by an individual developer but the concept was so important that we are able to persuade WECC to go ahead and study that project. Also, there will be an opportunity through planning. The regional planning entities that have to do interregional planning are not actually doing an extremely good job of it right now. I am hopeful. Maybe I am being overly optimistic here that we can, by engaging with the states in those processes get them to do a better job of that. So there are some avenues to pursue, to actually have some of those studies done but I do think that some of the technical studies -- those would be more powerful studies, production cost, technical studies would be right up the wheelhouse of DOE.

MR. WALJE: Well in fact, if you don't mind me adding here, Janice, actually I approached the Pacific Northwest National Lab to do that study for us because so far, one of the things that people don't recognize is the person most likely to be able to study our project properly is a chemical engineer and not an electrical engineer because this is really a thermodynamic flow problem. In fact, I had to learn to think in terms of pounds of air because when I talk to the vendors of the equipment, they don't talk about BTUs or things. They say our compressor will capture 350 pounds of air per second and our expander will burn 400 pounds of air a second and everything that happens in between kind of is inconsequential to them. Then we have to translate that into BTUs, megawatt hours, the prices of those things so having that modeled properly -- and not just for our project but for any project to similar would be very valuable. WECC has actually said this would be a great societal project but there is not a place to go to the society and say help us get this project done and I would also add that we have done back casting using CAISO SP-15 prices with our project looking at ancillary services, energy differences and it's a money maker for the off taker but then they said (inaudible) what do we expect from your study, so having an independent voice at that level of detail because that's what the utility and CAISO planners do -- they don't do arm waving type studies, they really look at use cases and variability and analysis as well so --

MR. MCCORMICK: Picking up on that idea, something that DOE can do is encourage the national labs to sponsor such a study or a group of studies.

MR. WALJE: And you know, in defense of PNNL, they had the very best approach, I felt but they were more expensive then we could afford most of the time because when you are a development company, every penny is a prisoner but they are the entity that could do this the very best, I think, and I am on the strategic advisory committee of the(inaudible) national lab so I am familiar with their capabilities and we've been to

NREL as well so we've been around looking for that best capability and I thought PNNL had it.

MS. LIN: Thank you. Could I get volunteer from the ICF team to help run ideas to the Board and the reason that I want to put them up there is so after our meeting is done, whoever is here, if there is an idea you feel strongly about, put a sticky on it.

MR. SHELTON: There was a lot of excitement -- if you talk about a project, people get really engaged and you can see that here. Compressed air makes a lot of sense in a lot of places. Marketplaces are suffering because of a lack of analytics and this is directly in DOE's mission. We have to think more broadly about it in terms of the fabric of DOE.

MR. IRWIN: Think about PJM and New York and New England. Those are adjacent markets so they have some coordination. When you get down to ERCOT, how much planning is there across those markets. Maybe the Southeast is a better example of this.

MR. ZICHELLA: There is a lot of activity right now going on in Universities. We haven't talked about them at all. MIT, Stanford and Harvard all have advanced programs for storage. It might be a good role for DOE to create a clearinghouse about what we are learning there. This may take a while but there are some promising results for low cost materials.

MR. MCCORMICK: I want to second that idea. Basic research is heavily supported and this is important at universities and the labs.

MS. LIN: A four page paper was passed on a number of things that would be helpful for DOE to work on with regard to grid modernization and we did talk about the fact that the systems aspect of the grid, as it relates to different technologies hanging on it. We really pointed out that although that isn't basic research. It's the kind of research that nobody besides the federal government would support.

MR. PARKS: It's crucial, from our viewpoint, that these are public-private partnerships and that the entities bring different things to it. You want to bring all your strength to bear and we've had success in the past.

MR. CENTOLELLA: I was part of a national academy of sciences panel that issued its report late last year called the Power to Change which really -- it looks at how you create an effective energy innovation system and one of the things that we noted is that there is this kind of middle stage between basic research and commercialization which particularly in this sector where we are talking about hardware and an industry that is slow to adopt new technologies often where you get a period in the middle where you are moving from the left and trying to scale up and create systems that is very difficult for a nascent technology to move through.

(inaudible).

MS. LIN: Did I capture it? I drew a little picture.

MR. MCCORMICK: Can I ask a follow up question? One of the things that we've learned is that people who do really basic research, chemistry and physics, they would be critical of DOE in recent years for not allocating its research dollars as much to -- I am talking about really basic long-term research that we might not even know the benefit of. Is that accurate in the view of anyone here?

MR. CENTOLELLA: So I can comment on it briefly, recognizing that we did not, in our study, go all the way back to really looking at gaps in basic research. I guess what I would say is that this is an area that is important to our national security and national economy and we ought to be looking at innovation much more broadly. I think that there is however this notion of how you strike a balance and often time we go back to (inaudible) that we need to focus on basic research.

That was to a degree true after World War II because we took our scientists and put them on the Manhattan project and other applied research. I think there is a balance that one has to strike and if all you focus on is that very basic side, you run into the risk that you got really great ideas that come out and then they die before they get to commercialization so it's a matter of evaluating ideas at different stages as they come through, figuring out which are promising and figuring out what the right private-public partnership is that is necessary to move them to the next step.

MR. PARKS: I think it's crucial. This has been said by the department in the past but I think it's crucial that those are not absolute boundaries either. If you really want to be successful, even if you have a targeted application in mind, you go as far upstream in the research you need to solve the problems that you need to have and so if it becomes a thermal expansion issue, you go into basics. If it's materials that you find it new materials, you research it so you really go and pull from all of that even not specifically applied work to understand and I was on a national academy study once where we had a carbon expert. We weren't studying carbon but this guy had so many novel ideas that had a place in what we were discussing as well.

MR. CENTOLELLA: It is very much an iterative process so you might be looking, for example at an advanced nuclear technology and realize that your problem is basically a material sciences problem and you need to go back to basic research to begin to solve that.

MS. LIN: I do think that later stage focus is especially important in energy because this marketplace is so complicated. We have so many different jurisdictions. It's different even within one state, whether its investor owned, publicly owned, different market structures so it's just more complicated and harder and some of these issues are frankly potentially impossible to bust through without some kind of intervention, shall I say.

MR. SHELTON: I think some of those words imply deployment, demonstration, government funding, support grants but not necessarily. A lot of the comments are about system dynamic announcements and how that would inform policymaking and that's what we have been saying in a lot of our work here. That is kind of a uniquely central function.

CHAIR TIERNEY: Chris' point really underscores that the systems that are relevant are technical but they are also institutional, they are financial, they are a variety of things that are really the fabric through which change has to occur but they get stuck.

MS. LIN: Gordon, you had a point?

MR. FELLER: It may be a point for the EAC to consider, in the future when we talk about the DOE's role and the question about national priority statements from the secretary or from the President or from the Vice President that we haven't had for a while and hearing about a unique project like the Magnum project or more broadly about some of the other emerging technologies, it's clear to me that these are exciting breakthroughs that need to happen that there is a demand not just by local customers but by essentially those of us who care about national energy strategy and to the point that Paul was making about national security priorities and national strategy priorities, I guess the question is does the EAC want at some point to talk about what would be the value of a declarative statement from the DOE saying we want to do everything we can to enable experiments or full scale commercial deployments like Magnum to succeed and we want the federal labs to bring the benefit of their research to the table. We want federal customers like DOD facilities that are nearby to become early adopters, to pull as demand, as customers. We want other federal actions that don't involve what Chris is speaking to which is the potential for grants so assuming that's not going to happen to a project like Magnum, is there a way that the federal government can act to declare in a way that sends a signal and maybe even results in some concrete value to a developer of an emerging storage innovation that fills a need, that is innovative, that is hard to do, it's obviously hard to do and that's not a federal regulatory reality only. It's a local regulatory reality but there is some value to having the biggest actor in the system, the federal government make a statement declarative that these kinds of things should happen. We want to do what we can to empower the investors and their customers. I'll leave it at that but it might be something that the EAC wants to talk about in the future.

MS. LIN: I have a follow up question for you and maybe Mark as well. What are the ways that this public- private partnership -- what does that look like and what does a successful model of that look like?

MR. FELLER: What the private sector wants is some certainty that allows for 20 year planning because a lot of P3s involve at least two decades out of risk assessment, of value and of ROI and this is hard to do in an electoral system like we have. We could have declarative statements that are bipartisan that represent the best thinking in the country about energy and emerging technologies. The private sector cares about more than four years of certainty in this electoral system.

MR. VANDERHELM: Potentially very mundane elements. We do it every day. We are engaged with the labs on a daily basis especially NREL but PNNL as well. We are partnering on specs, developing new technologies. We leveraged the ESIF out of NREL to see how technologies integrate from buildings. They have facilities that can mimic this.

Thinking forward, I don't know how aggressive you want to get in terms of your recommendations, in terms of thinking about technologies, but I do know that (inaudible) outside of ARPA-e potentially a real practical framework for committing to different types of technologies and how you think about these. Most people that think about pocket they think about it in three different pockets. They think of lithium ion on one end and bulk storage case and pump hydro. In the middle, there are flow batteries. If you look at those three, they all have a different application. The flow batteries are critical, by the way. Is there a framework there where you are tackling a particular area. (inaudible) They are not trying to get 22 percent returns like other VCs but they are trying to get to an economic development metric.

(inaudible).

MS. LIN: What I did was I said it established a framework for evaluating storage technologies versus applications and investors' needs.

MR. WALJE: There is a strategy component in terms of how you tackle it and a financial model you use to evaluate it.

MS. LIN: We also had a lot of comments and questions about regulatory guidance. Folks who raised those questions, do you feel you had your itch scratched? Clark, I didn't see your sign up.

MR. GELLINGS: Thank you, Janice. With my sincere apologies, I have a word of caution about focusing more on technology development in the near term. The power system, as we know it today is based on some pretty traditional technologies, we all know what they are, conductors, capacitors and the like. There are other areas of science and technology that we haven't fully explored. Storage actually falls into that category as well as power electronics which we still really haven't fully explored. Digitization which we are now beginning to embrace to some extent in order to sense and control the system but again, we have just scratched the surface but there are areas in chemistry, SF6 replacements, for example. We haven't touched -- you know what I mean, there is a list of them. Coatings for insulators and on and on. What I suggest is that what we need in terms of research is a balanced portfolio that is variable in several dimensions but it has to include basic science and basic applied science and it doesn't mean that all the money goes there. In the end, you sort through which ones go through to the next stage.

MS. LIN: I got it. I want to bring up Phyllis's point from earlier in the day which is a really good one. I think if I recall you said there has been a lot of talk today about how storage can potentially help with resiliency and reliability and a lot of folks are deploying it but what if it's creating new risk areas and this kind of gets back to that cyber security report and is there anything specifically that we should be putting on the to do list to address that.

MS. CURRIE: I put a sticky up with regard to that and the thought was that when you look at the value of storage for resiliency, I think it's difficult to separate it from the rest of the electric system because if you have an event or have a disaster, it doesn't just hit the generation device. It doesn't just hit the storage device. It hits a wide area so your poles are coming down, your lines are coming down so everything that storage might be connected to could be affected so I just think that has to be thought about as you're trying to say what is the resilience value of any one component, whether it's storage or some other part. That was just a thought.

MS. LIN: And as a corollary, make sure when you look at cyber security that storage is one of the things that is in that basket of stuff that gets looked at.

MS. CURRIE: And that gets back, I think, to the earlier comments about we are always going to look at reliability, resiliency, safety, cyber when we look at any of these issues affecting the grid.

MS. LIN: Thank you. We are getting close to the end. Not seeing any more cards here. Please, Patrick?

MR. MCCORMICK: A point that Sue made and I thought it was implicit in the one that Clark made is that DOE might think about research activity especially if the government doesn't do it, no one else will because I think in today's political climate and given again the difficulties of the federal budgets generally I think that that will be a good way to focus attention and Sue, your sort of alluded to that and I thought it was sort of implicit in what Clark was saying and I think it makes a lot of sense.

MS. LIN: Thank you for that.

MR. WALJE: To build on one item that Mark got me to think about. We installed a flow battery 20 years ago and it worked okay but not really well so it needs to be improved but I was thinking about the legislation that had been introduced in the Senate that broadened the definition of storage that would be qualified for ITC and I don't know where that sits and our only view of that was we hadn't initially thought about it too much but if the storage types are used for basically the same function that a project qualifies for ITC, I think it should be broadened. Asking for more money is not what someone should be thinking about but I think in the sense of equity, it ought to be broadened into these storage technologies.

MS. LIN: Great. Laney, did you have a question? I was going to do a wrap up but ask your question first.

MS. BROWN: I was just thinking about the discussion and I feel like we haven't necessarily focused on the distributor behind the storage (inaudible) electric vehicles. We had some discussion about (inaudible) valuation with a specific focus on storage and what that might look like on a distribution system.

MS. LIN: Any comments on that?

MR. CASTILLO: I was going to raise that same point. Behind the meter it gets a little bit different. I also briefed Edison Electric Institute just last week. I said why can't you think about the grid the same way we are thinking about resiliency in the military installation. In terms of prioritizing in enclaves so you can lower the vulnerability and accept risk in some areas so that it doesn't have to be bigger and better so you can do more of a prioritized approach in terms of developing some resiliency model. It may work; it may not. There are different dynamics in that.

The other thing I had mentioned is there is a lot more talk about implementation. That's our next step. We have two ways of paying. One is appropriated funds. So a lot of my discussion was on my requirements, what I need to do, stuff like that. I put out an RFI close to about a month ago. Alternative financing for energy resiliency projects and the whole point of that is trying to see how the market is going to react when I give them my requirements so I was trying to structure projects to see if I can get him rated through a study to see if there is a market for the types of projects I am looking at and I think there are going to be a lot of lessons learned coming out of that because the way I perceive a project from a mission requirement standpoint may not be as attractive if I think about it from a financial perspective.

The whole point of that study is to see

if there is a market for these kinds of resiliency projects and we already went through a few years in terms of the point of renewable energy on a large scale of alternative finances so we are going to share some of those lessons learned into now this new energy resiliency space that we are trying to achieve.

MS. LIN: That was great. I have like four stickies. Adapt and develop the resiliency model for non-DOD applications and customers; help establish financial products for resiliency projects; and I wanted to capture your insurance industry one because it's related to that guy, involving the insurance industry and valuing resiliency. Did I capture your thoughts?

MR. CASTILLO: It was more the financial industry, so we are going right to -- whoever rates projects, infrastructure projects and we are -- basically I am going to try to develop a laundry list of our projects to get all the requirements done up front to understand our requirements well enough to say okay, are these bankable projects or not and then can I take advantage of the capital or not, right?

Now I have authorities in place and I don't know what does with the authorities. That's another thing I have to figure out. Can I use them to then take advantage of the capital?

MS. LIN: Thank you. So we are nearing the end of the day and I would like to just close out our session first by thanking everybody for your participation. You should all pat yourselves on the back and I'd like to just close with any volunteers who are willing to answer my question. I am just curious. Did anybody learn anything new today that they didn't know before and I'll start by volunteering my answer and that was I didn't know there was such a thing as space storms. Granger was the one who presented that. So thank you, Granger, for expanding my world in that way. Any other thoughts or reflections?

MR. MCCORMICK: I would like to just thank you all for inviting me. I learned quite a lot. More than I can say in this short time but thank you.

MS. LIN: Thank you. Mark, you look like you wanted to say something?

CHAIR TIERNEY: Well, Janice, I'll say something. The level of participation of our invited guests has been really extraordinary. Thank you for not popping in and out as many people are apt to do in situations like this for understandable reasons and I think that the range of subjects that we heard about-- the range of technologies, the range of challenges has been really, really helpful so thank you for rowing with us today on these issues.

MS. LIN: Thank you. John?

MR. ADAMS: Janice, this was (inaudible) aside but one of the things that I was really interested in is what is the level of fire risk with these storage units and in an inside conversation, through discussion, I concluded that the risk of one of those in your

neighborhood is less than that at a
gas station in your neighborhood
and to me that was a revelation and
I think that's important to
communicate.

MS. LIN: Thank you.

MR. WALJE: Janice, I just wanted to thank you for inviting me and I think you've done a fantastic job facilitating a meeting as effectively and efficiently as I've seen in a long time so thank you for that. (applause)

MS. LIN: Well you're not done yet because everybody, I have one last favor to ask of everybody. This will help -- if during the course of the day, if there was one idea that really tickled your fancy or you thought was more important than others, you can have as many dots as you want but frankly everybody has a bunch of dots but if it's up there, on your way out, stick a sticky on it. That would be very helpful to our committee and helping read folks' minds. If your idea is not up there and you want to stick it up there, please do. With that, I'd like to put an end to this energy storage session and thank everyone for coming and for your input. Thank you.

CHAIR TIERNEY: I know I can speak on behalf of the planning committee that I am indebted to you for the working planning session today Janice so thank you very much. It's now time to have public comment. Rachel, no one has signed up for public comment so that was a quick session of the agenda. Is there anything else that anyone else would like to reflect upon after this day and a half together? We've talked about a lot of different topics, we've got a lot of work products out for the committees and sub committees. Katie, is there anything you would like to say? You don't have to.

MS. JEREZA: Yes, I would like to because this has been a very informative discussion today and I'd say a key takeaway from me is that there is a tremendous amount of complexity around the storage and issues and especially when you are thinking about it from like a systems perspective and I think that's an important way to think about.

It's also complex because you have to think about it in fairness of the potential solution and different stakeholders across the country so that's one key takeaway. I also would like to say I really appreciate the thoughtfulness and the tremendous amount of hard work going on here at the EAC and the subcommittee members. I think it's been very productive. It was great to see the three papers that were presented today and I really -- I guess I want to say that I appreciate the energy that you put into it and the commitment that everyone has. This is clearly a very important -- electricity is very important to the country and I certainly believe in it and just want to say thank you very much for your time and attention today.

CHAIR TIERNEY: I am going to excuse everybody in just one more minute. The EAC really does, as Katie said, spend a lot of time and attention so thank you for your effort to get here and to really give everything between meetings as well. The DOE staff has been terrific and Katie, I mentioned to you yesterday that it's clear that everyone around the room really understands the importance of a vibrant, affordable electric system for the country and because you are now on point to address those things, we really wish you success in your new job.

MS. JEREZA: Thanks.

CHAIR TIERNEY: Anything else? Yes?

MS. LIN: I have a quick reminder. I wanted to thank also AES for volunteering to host this very nice reception for everybody here immediately following this meeting at 4300 Wilson. I am going to be there. I'd love for whoever is able to come on by and chat further.

CHAIR TIERNEY: And just to make sure that all of our protocols are in line, that was a personal buffer and suggestion by Janice and that was not an official statement of the Electricity Advisory Committee. Thank you, everybody. Safe travels home.

(Whereupon, the PROCEEDINGS were adjourned.)

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

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