In the Matter Of:

ENERGY STORAGE FINANCING SUMMIT

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ENERGY STORAGE FINANCING SUMMIT

SEPTEMBER 22, 2020

Day 1

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MR. CHAUDHRY: We should get started. Good morning everyone, or for those on the East Coast, good afternoon everyone. I am Rohit Chaudhry.

On behalf of Kirkland & Ellis, I'm excited to welcome all of you to the 2020 U.S. DOE Energy Storage Financing Summit. These are unusual times and I wish we were all together in the same room, but we are nonetheless delighted to hold the first ever virtual addition for this conference. I am happy the Kirkland team can partner with all of you.

I would like to thank Richard Baxter for coordinating this event. It really wouldn't be possible to do it without his seemingly boundless energy. This is the third time Kirkland has collaborated with Richard on this event and the seventh or eighth time that our own Bob Fleishman has done so.

At Kirkland, I lead our energy and infrastructure debt finance practice, which along with our M&A and regulatory groups, advises on billions of dollars in energy and infrastructure deals every year.

Over the last few years we have seen a bigger and bigger focus on storage deals. The policy environment is becoming increasingly friendly to storage (inaudible), and we continue to see infrastructure funds, private equity funds, and other investors using energy storage.

Based on Wood Mackenzie's power and renewables Q3 2020 report, we know the storage deployments continue to charge ahead despite the massive destruction of COVID-19.

Over the first quarter of 2020 saw a 23 percent quarter-over-quarter decrease in U.S. storage deployments. The second quarter of 2020 saw a 28 percent quarter-over-quarter increase, and a 72 percent year-over-year increase. The second quarter saw nearly 170 megawatts of total deployments.

And the growth storage in 2020, so far, has shown complimentary contribution from front-of-the-meter and behind-the-meter deployments.

The big growth driver in the second quarter was front-of-the-meter segment, which experienced a megawatt increase of 400 percent quarter-over-quarter and 5X year-over-year.

But in the first quarter, it was behind-the-meter segment reboosted the storage market. When the U.S. market saw an overall decrease in the first quarter, behind-the-meter deployments continued to face with the residential side experiencing its fourth consecutive record quarter and the nonresidential side boasting its third strongest quarter ever. On the residential segment held onto the momentum and recorded it's fifth straight record quarter in this year.

The COVID-19 destruction will likely continue in the near term. But further out, the market outlook for energy storage is extremely positive. Woodmac projects total deployments to reach 7 gigawatts annually in 2025, which is approximately seven times the market growth compared to the projected deployments in 2020.

This large-scale deployment will, of course, require billions of dollars in investments, which is why I'm sure all of you are here, and we expect it will have a transformational impact on the grid.

The sense of urgency underlying the need for capital deployment is only increasing. Just last month, California suffered its first rolling blackouts since the (inaudible) energy crisis, and there's a broad consensus that energy storage needs to be a part of the solution.

On the technology front, Lithium ion batteries continue to dominate the market with a 98.6 percent share in Q2 of 2020, and price is expected to decline by more than 10 percent in 2022. But there's more work, of course, to be done.

The industry must continue to navigate this COVID downturn. Policy reforms are needed to improve the interconnection processes as RTO and ISO interconnection cues are becoming increasingly larger. And although the Court upheld the FERC order 841, many important details regarding the intersection of state and federal regulation need to be ironed out.

And ironing out the market rule for DER aggregations pursuant to FERC order 2222 is going to take significant time and resources over the next couple of years. And it's gatherings like these ones that are critical to ensuring that the industry remains poised to address these challenges and those lurking around the corner.

So thank you all for coming. I'm looking forward to diving into these issues more over the next few hours and during our session tomorrow. And, with that, I'd like to welcome you again, and I'm going to turn it over to Richard Baxter for his remarks.

MR. BAXTER: Thank you, Rohit.

Well, welcome everybody to, virtually, to San Francisco. This is our ninth Energy Storage Financing Summit series that we've had. This -- this one will be doing the workshop today and then the summit tomorrow.

This program is an outreach to the financial community by the Department of Energy's Office of Electricity Energy Storage Program. It's a platform to promote the daily programs and allows the DOE to engage directly with those shaping the industry.

Today's workshop is a way to compare some evaluation modeling approaches looking at different revenue recognitions and results from project analysis so that as the contractual nature of energy source projects, both on scale and complexity, we can -- the DOE is working to help promote a more sound analysis of the market themselves.

And so here, let me -- I will -- let's see, sharing the screen and --

So today, as I was saying, we were going to -- our first speaker will be Imre Gyuk. Head of the Office of Electricities Energy Source Program, and then we will be having the workshop moderated by Ray Byrne of Sandia National Labs.

So, with that, I would like to introduce Dr. Imre Gyuk and he will give the keynote address.

DR. GYUK: Okay. Great. Let me add my welcome from the Department of Energy. And I am Imre Gyuk and I direct the Energy Storage Research Program at the Department of Energy, Office of Electricity.

And today I'm going to talk about resilience and bankability. Resilience is what I want from my side and bankability is from your side. But, of course, if we don't get bankability, there will not be any resilience. So we are in accord, and bankability is what we are striving towards.

I have problems controlling my up and down.

MR. CHAUDHRY: You can just actually click on the slide if you'd like.

DR. GYUK: Just do next.

MR. CHAUDHRY: There you go.

DR. GYUK: Okay. Good enough.

So energy storage obviously has become a resounding success. You heard the figures for 2020. In spite of COVID, energy storage is forging ahead and an exponential future is obviously going to be coming towards us, but it's a little bit more complicated than that.

Exactly one week ago this happened. This beautiful 20 megawatt plant in England burnt to the ground. This is a shock, particularly after the fire in Arizona last year. And it's not one that we can simply disregard and say, Well, accidents happen. So the dominant technology is, of course, lithium-ion, but it raises a number of concern.

And these are in several categories. First of all, there's the problem of sourcing. Only a few countries provide the raw materials for lithium-ion energy storage, and that is not a good situation. There are ecological problems. The groundwater situation, for example, in lithium mining is not what it should be. It's highly exploitive.

There are sociological issues. It is not appropriate to have little boys in Africa to grabbing cobalt out of the ground. I have just mentioned safety issues. Even though that's not necessarily the technology, but might be the power electronics, but safety has to be one of our primary concerns, and along with it reliability.

And then we have the issues of re-use, recycling, and disposal. If we are going to be building energy storage plants exponentially, we're going to have waste exponentially. And, at the moment, there's really not very much that we can do with lithium-ion batteries when they are spent, even though institutions like Argonne and others are working very hard at trying to find a way of handling that.

So the DOE program works very seriously on safety and reliability. But we also work on developing new storage technologies that are safer and more cost-effective and environmentally acceptable to begin with.

One of the ventures that we are putting into effect is the Grid Storage Launchpad. This is a big $90 million or so venture at Pacific Northwest Laboratory, which will be devoted towards validating and testing new generation storage material, de-risking and speeding development of new technologies, and collaborating with industry and other institutions. It's going to be big; 70 to 100 work stations.

Ultimately, we would like to end up with a circular technology based on earth abundant and inexpensive materials. We have to put the supply chain and the waste stream into the design itself.

So here are some of the examples that we're working on. And I will not do them in detail, but zinc manganese oxide is one of them. Zinc manganese oxide as a primary battery are quite common. There are 10 billion units on the market at the moment.

The trick is to make those rechargeable, and eventually to get -- make them more energy dense. And as we do this, the price per -- the cost per kilowatt hours will go down and down, possibly as far as $20 per kilowatt hour. And, of course, both zinc and manganese are fairly earth abundant.

Another thing to work on is sodium. And the idea there is to basically replace lithium by sodium. If you look at the raw material, lithium cobalt price, while it -- lithium carbonate price, while it changes, is fairly expensive. Sodium carbonate, on the other hand, is fairly cheap. And, of course, fairly abundant. And we have been working towards making these more effective. And as you can see from the curve, it's now fairly flat for a fairly long cycle life.

We need to improve the energy density and the cycle life itself. And eventually this may replace lithium-ion batteries. Of course, they will probably not be as energy dense as lithium-ion, but for stationary applications, we don't really need that.

And, finally, Aqueous Soluble Organics. These are redox batteries. I particularly like them because instead of using materials that you buy on the stock market -- on the -- you rely on human ingenuity because these are organics and we can manufacture them, and they just use carbon and nitrogen and oxygen and hydrogen. And it's up to us to see how well and how cheaply we can make them. The curve shows that we might be able to go quite far down; whereas, with vanadium we are always stuck with the stock market.

So these things have to do with reducing cost. And that's not just the materials, that is also the greater safety and the reliability. But equally important is the value. We have to bring up the value as we bring down the cost.

Now, I notice that while projects are getting bigger indeed and duration gets longer, many of these projects really do not yet rest on a firm business case, which is to say a return on investment greater than one.

Too many of the projects are still pilots or they are based on mandates. In the long run, we cannot rely on that. Not if we're going to have that exponential future of energy storage.

So the DOE energy storage program works on building and validating business cases through innovative pilot projects. You're looking towards resilience, sustainability, and grid stability.

Very important is the use of tools for valuation. Modeling. And we have models developed at Sandia and Pacific Northwest Laboratories. The Sandia model -- and you will hear about it soon -- is particularly useful for deregulated utilities, and it allows you by using historic data to get a quite good idea of what return on investment a project will get you.

The tool at Pacific Northwest Laboratory, on the other hand, is particularly suited for vertically integrated utilities, though, it can handle other systems as well. And there, because it's a vertically integrated utility, you have to go more deeply into monetizing some of the characteristics that are not monetized as easily in a market structure.

So here's some examples, which I have shown before. A project in Sterling, Massachusetts, took three -- only three months to go from groundbreaking to commissioning. It started out as a pure resilience project, but by using our modeling tools, we showed how to actually profit and monetize this project extremely well.

And we could show that with arbitrage and reducing monthly and annual peaks, we could profit by about $400,000 a year. And this is how it devolved. You can see the monthly peaks, the monthly reductions; the yearly peak, and then the monthly ones and then the yearly ones. And as a result, after two-and-a-half years of running this project, we had avoided $1 million in cost to the system. And it's now become somewhat famous, and people from all over the world have visited the little town in western Massachusetts and learned how to do a project well.

Another example brought us up to Cordova, Alaska. They have a municipal system that is isolated from the grid. In fact, you have to fly there or boat there to get there. And they rely on 6 megawatts run-of-the-river hydro power, which means that they don't -- can't load follow that well. They have to throw in auxiliary diesel and keep spinning reserve.

But the diesel is 60 cents per kilowatt and the hydro is 6 cents per kilowatt. Obviously, you want to maximize the hydro, minimize the diesel. We did that by introducing storage. Here is the ribbon cutting, and this is the unit. And it was commissioned about a year ago in June of 2019. It does frequency regulation, load following, and provides emergency supply.

A project that uses the PNNL tool for modeling was an underground cable that was avoided for going to Nantucket Island. You can see the output of the tool, and it shows that using storage, rather than an underground cable, is a definite advantage.

So, again, the ribbon cutting, I like those because you have to get people's attention to these projects. And this is the unit. This one is by Tesla. And the return on investment here is quite good. 1.55, which is about as good as you can expect.

Now, we have a lot of these innovative pilots under development. One in Iowa. The Albuquerque Public Schools. Projects with the Rural Electrification people. One of them with the Air Force -- with an Air Force base. We have residential projects with the Navajo Tribal Utility Authority. We have another project coming up in Alaska. And we are taking off a really big bite from Puerto Rico, we are trying to get involved in a large microgrid for the five Central Mountain Utilities. And good luck to us.

There's something else we should mention, though. And that is, in many states, Public Utility Commissions are not as familiar as they might be with energy storage, and the regulatory environment is not yet as conducive to substantial build-out as it should be. So our program does a lot of policy research and a lot of outreach to Public Utility Commissions and other regulators.

Here is a number of workshops/tutorials, just from this year; New Mexico, North Carolina, Nevada, Utah, Iowa State together with MISO, a FERC tutorial will be tomorrow, and New Mexico PUC in November. So, as you can see, there's a lot of learning to be done yet, and a lot to be improved as the regulatory structure becomes more and more suitable for building out energy storage throughout the U.S.

To help this along, the energy storage program has developed an energy storage policy database, which is available for free. There is the URL. And it shows that not a few states now have regulatory structure in place.

Now, some of that, as, for example, in states like California, New York, and Massachusetts, is very extensive and very detailed. In other states, it is just a few notes on regulatory structure. But it's coming there, it's definitely in the works.

But along with this, an urgent situation is developing. Thirty states have set renewable energy goals, and some of these goals are very ambitious. Like total decarbonization by 2030 or maybe 2040. Overall, one can expect that we might be as low as -- as high as 50 percent in terms of renewable energy.

The point is that this will require longer duration storage. If you have that much penetration of renewable energy, you have to count on a rainy day, or the wind not blowing or whatever. And we have to look towards 8-hour storage, 12-hour storage, days, and perhaps even seasons.

The beginnings of looking into this are already there -- well, pumped hydro, of course -- but DOE-ARPA-E has the DAYS program. CEC has solicitations for long-duration storage behind-the-meter and elsewhere. And our energy storage program at the Department of Energy is seriously looking into long-duration storage.

Looking at current technologies that are currently underway. The cost goals -- and this slide is somewhat garbled by having been sent through e-mail -- are fairly good. Something between 300 and 125 can be expected, and if you look at zinc manganese, at low temperature sodium, at aqueous soluble organics, advanced lead should not be discounted, it might even go as low as $35 per kilowatt hours. So good things will be happening, but perhaps not sufficiently, not for a really long duration.

So we have to look at things on the horizon. So what's coming here.

Well, vehicle to grid is definitely in play. Not so much for individual vehicles, but certainly for fleets, such as school bus, postal, and military fleets.

We will no doubt see better, quote-unquote, lithium, I mentioned innolith, for example, which will eliminate some of the problems that lithium-ion technologies have at the moment and go towards even lower cost.

Non-lithium technologies, particularly flow batteries, under consideration, vanadium, zinc, zinc-manganese. These are all technologies that are suitable for longer durations. Other technologies, such as, Ambri, are in the work too.

Then there are non-battery technologies. You can always stack cement blocks. The ancient Egyptians did something much like it. There are little railroad carts that go up incline planes. There is one in Nevada that's going to have a groundbreaking early in October. Compressed air, pumped hydro, thermal systems, of course, ice, but also phase change material and systems such as Aesthus and Malta and perhaps liquid air.

So long duration energy storage, 8 hours, 12 hours, and days is coming. And, of course, you could always go with hydrogen or ammonia provided we are more effective in doing it in a more cost-effective way.

The Energy Storage Grand Challenge at the Department of Energy is trying to bring the various programs such as hydrogen, pumped hydro, and others together into a consortium, if you wish, to address this long-duration storage issue. And we have high hopes that we will be able to develop technology along those lines.

But the main question is still, even if we solve the technology, what is the business case? How are we going to justify having energy sitting around for weeks? Because mostly money is being made when you either put energy into storage or take it out of storage.

When it's just sitting there, it's there as -- for purposes of resource adequacy, but you don't really profit from it. So what is the business case? Who will pay for all of this, for these substantial amounts of energy? Are we going to have mandates, such as all renewable energy must guarantee storage? Are we going to have taxes? Are we going to look at higher rates? What is it? I leave it up to our policy people to work it out.

But whatever it is, it will require the fundamental reorganization of regulatory structure to enable this long-duration storage and to guarantee that we have enough storage to cover deep penetration of renewables. Thank you.

MR. BAXTER: Hello. Thank you very much. Dr. Gyuk.

Right now, are there some questions for Dr. Gyuk? I think there's a Q&A box at the bottom if anybody wants to put one in.

DR. GYUK: No open questions. I must have expressed fundamental truths.

MR. BAXTER: All right. Wait, okay. So here we go. A lot.

How long until the technology from the national labs becomes commercially available? So maybe, you know, just that process, in general, rather than -- or maybe highlight some specific issues.

DR. GYUK: Want me to throw out a number? Ten years, maybe earlier. It depends on how much money we have and how hard we work.

MR. BAXTER: Another question.

There's projects in (inaudible) areas, what do you think we need to see to have more activity in that market -- or that technology?

DR. GYUK: We need technologies with high reliability. There are a fair number of flow battery technologies out there, but either they have not been sufficiently tried or they have problems (inaudible). And we all know both the utility industry and the banking industry are conservative industry and they would prefer to have an absolutely sure thing, which means that it has to work and it has to be shown to work by numerous examples. So that's why, as much as we can, we like to prove out some of these technologies. We have had some failures.

MR. BAXTER: Okay. Thank you.

We've had a number of questions about long duration. So maybe taking a step back and talking about, first, the renewed interest in what really long duration means in some of the applications and then, again, touching on how some of those specific technologies fit those emerging needs.

DR. GYUK: Well, that's a separate lecture. But, basically, the thing is, while we all know that the sun don't shine at night and the wind blows where it will. In the short term, we have lovely technology, lithium-ion works well for four hours, maybe even eight hours, and it can smooth out renewables.

But, if we have a two-day rainy spell, then we need storage available. And that has to be massive because if we are going to rely a hundred percent on renewables, or let's say, solar, then we have to have an equal amount of energy for X days in storage.

MR. BAXTER: All right. Thank you. Question about the recycling and how it is incorporated into, I guess, the design and then the market uses of it -- of the systems.

DR. GYUK: Well, if you have a technology like vanadium redox batteries, the vanadium electrolyte that you have sitting in the battery is exactly the same after 20 years of use. It doesn't degrade.

Particularly, you can siphon it off, get rid of the containers and reuse the vanadium's solution, either for another storage unit or for industrial purposes. So in that case, you have reused your -- recycled your technology.

Lead acid batteries are something like 98 percent re-useable. The lead is smelted. The battery liquid is recycled, you know, that's the kind of technology we would like to have if we can have it. But having to continually bring in new resources through mining, et cetera, and having large amounts of waste accruing is just not the right way to go. Afterall, remember, we are doing all of this so that we can reduce the carbon footprint and by having a large amount of waste we are not helping the environment.

MR. BAXTER: Thank you.

And I guess a follow-up is the influence or educate customers and incorporating recyclability into the use of these products.

DR. GYUK: Actually, customers are really quite astute, because, in general, kind of organizations that are willing to use renewable energy and are willing to install energy storage behind-the-meter are already quite astute on a -- from an environmental point of view.

So they are, I think, very much on board with creating such technologies that are more circular and using them if and when they're available.

But, yes, education is going on and on and on.

MR. BAXTER: All right. And one final question talking a little bit more about the sodium batteries for the time frame of their development and how they might roll in to compete with lithium or lead.

DR. GYUK: Again, ten years should do it. Earlier might very well do it. Almost every -- almost every technology takes ten years to roll out. You know, you do not get technologies overnight just because you had a clever idea. A lot of technologies with such clever ideas have come out, gone to market even, and then have to withdraw their units because they just didn't work properly.

So you want to prove them out, increase in acceptability, and then go to full deployment.

MR. BAXTER: All right. Thank you. No other questions.

We're going to have our break now. So we'll put up a slide and then I think if everybody could come back at 11:00 o'clock Pacific, noon Mountain, 1:00 o'clock Central -- wait, yeah -- and 2:00 o'clock Eastern, sorry. And then we'll start with the -- the

Energy Storage Valuation Workshop.

Thank you very much, and we'll see you again in 15 minutes or so.

(Break in meeting.)

MR. BAXTER: Thank you very much for returning, and we'll be starting the workshop today.

So right now I'm going to turn it over to Ray Byrne of Sandia National Labs will be the moderator for the Energy Storage Valuation Workshop.

MR. BYRNE: Thanks, Richard. So my name is Ray Byrne. I manage the electric power systems research department at Sandia. And I also am team lead of the energy storage data analytics work.

And, first, I'd like to thank Dr. Imre Gyuk who has sponsored the majority of our work, as well as the work of many of the panelists in our session today.

But energy storage valuation is complicated. It matters where you're located. The rules and remuneration scheme are different if you're in a market area versus a vertically integrated utility versus a behind-the-meter application. The regulatory landscape is constantly evolving, so rules change and -- over time, and that can cause challenges for valuing energy storage. And there's still not really an agreed upon framework on how to value storage, which can be a barrier to widespread adoption.

So the purpose of this workshop is to talk about different methods for valuing energy storage, and talk about best practices that have been developed by the national laboratories and industry. So we have three different -- or four different speakers from three different organizations today representing Sandia National Laboratory, Pacific Northwest National Laboratory, and the Electric Power Research Institute.

So I'll turn it over to our first speaker Dr. Tu Nguyen from Sandia and he'll talk about QuESt, which is an energy storage valuation tool.

MR. NGUYEN: Hello. Let me share my screen first. Good morning and good afternoon. My name is Tu Nguyen of Sandia National Lab.

Today I talk about QuESt an open source of software tools that we develop for energy storage evaluation. I will give to you a brief overview of QuESt and how to obtain it in different application that QuESt provides. I will also provide some background information on behind-the-meter storage, and a case study evaluating the cost savings for a large hotel using battery together with the solar.

Software almost dedicate energy storage analytics team at Sandia under DOE energy storage program has been conducting evaluation studies for energy storage. And after developing a framework for conducting these studies, the team (inaudible) formulation that could be generalized into it, too. And in September 2018 we publicly release the first version of QuESt, which included market valuation application in addition to a data acquisition. In 2019 we also added QuESt behind-the-meter, and currently it is on the version 1.2 series of updates. The software code base is currently hosted on GitHub.

So the first goal of this effort was to create a Graphical User Interface, or GUI, to help users conduct analysis that is to evaluate revenue potential of energy source systems in different applications.

We also make it open source so that engineers and researchers can customize the back-end code and models to treat their own needs.

So, currently, QuESt has three built-in applications including QuESt Data Manager, manages the acquisition of ISO market data, utility rate structure data, commercial and residential load profiles.

In QuESt Valuation, estimates potential revenue generated by energy storage system providing multiple services in electricity markets of the ISO and the RTOs.

In QuESt behind-the-meter, estimate the cost saving for time-of-use and net energy to customer using behind-the-meter energy storage systems.

So we developed the Graphical Users Interface so that the users can easily start up and run the analysis and report the results. But at the same time we also building the API to help the power users better utilize QuESt by (inaudible) library.

So currently QuESt is available on GitHub. It runs on multiple platforms like Windows, Mac or Linux. The only add-on that you need to install is the software for optimization. We also provide the instructions for installation on GitHub page.

So last year for Windows 10 user, we have develop an executable version of QuESt, and that has a lot of installation process and -- but you still need to install the software for the optimization.

So next I will talking about the QuESt applications.

So this is the general workflow of QuESt. First, you have need to decide what type of analysis you want to do, then grab the appropriate data from QuESt data manager, and then select the appropriate application from the first step to do the analysis and see the results.

For example, if you want to do the evaluation of energy storage in the ISO/RTO market, you need to grab the ISO/RTO market data, then select the QuESt valuation and then run the analysis.

So estimation earlier market valuation is one of the current applications of QuESt. It answers the question how to maximize the revenue of energy storage providing services to electricity market.

Basically, you can select the ISO where the storage system is located, and then select the revenue streams you want and set up the storage from meters. Currently, we have a few default settings for a few battery technologies based on the data provided on the DOE's energy storage portal.

So after running the optimization, you will find the maximum potential revenue that the energy source system can make in this application. You can also find the results summary, and you can also generate the reports based on these results.

So one of the key component of QuESt is the data manager app. For different types of analysis you need to grab different types of data. And this app helps you grab those data. Currently, you can download market data, such as the local marginal prices, regulation prices of the ISO and the RTOs, and the utility rate structures and PV load profiles. We only use publicly available APIs and posted market data, and open source data.

So for downloading the market data, you will need to specify the market, the time period, the pricing node. You will need to sign up for an account to interface with the market data portal. And to download the utility rate structures, you need to search for the utility and then select the specific rate you want. You can also modify the rate to reflect your actual contract with the utilities.

And the building load data can also be downloaded through QuESt data manager. The data include different types of residential and commercial buildings provided by OpenEI database based on DOE building office preference data. Similarly, you can also download the PV data for your location.

And the last application I would like to talk about today is behind-the-meter applications. The applications help you to evaluate the cost savings that behind-the-meter storage can bring to utility customers. And I will talk about the details of this application in the example at the end of this presentation.

So next I will give you an overview of utility rate structure and how behind-the-meter can help customers lower their bills. So as you may know, the terms of front-of-meter and behind-the-meter often use to specify the system locations.

Behind-the-meter refers to system, but are located at customer sites such as homes, commercial, industrial facilities. Behind-the-meter are usually owned the customers and intended for customer use while front-of-meter owned by the utilities, and intended for (inaudible) services.

So whether or not can behind-the-meter energy storage have reduced customer's electricity depends on the utility rate structures, or, in other words, it depends on how the utilities charge their customers for the electricity usage.

And before talking about utility rate structures in detail, I would like to introduce some important terms here.

First term is energy charge. It is a charge to the customers for the energy in kilowatt hour consumed in a billing period. And this charge is applied to all customers including residential, commercial, and industrial.

The second charge is the demand charge. This is the charge to the customers for their peak power in kilowatt. This charge is often applied to large commercial and industrial customers, but in some utilities the demand charge also used for residential also.

So beside energy and demand charge, you always have some other charges that are independent of consumption such as a meter fee or some other basic customer's fee.

From the first rate structure, I would like to talk about today is the fixed rate and we all know that this is the most simple and probably the oldest rate structure used in the U.S. And sometimes it is called a tier rate.

And it is the rate where a constant price is applied to each tier of energy consumption. And this should be noted that the flat rate is actually a special case of tier rate, where only one tier is specified. The figure in this slide shows an example of PG&E's tier rate for California customers, in which the higher tier -- the higher prices are applied to the higher tiers. And, of course, different utilities have different prices and specifications.

So in opposite to the fixed rate is the dynamic rate and one of the main advantage of dynamic rate is that it reflect the variability of the energy prices -- of the wholesale electricity prices. And the utilities motivation for dynamic rate include increasing customer satisfaction with options to reduce energy bill, encourage the load growth, and reduce the total peak demand by load shifting of complying with the regulatory mandate.

So the most common dynamic rate is time-of-use pricing. In time-of-use pricing, energy and demand prices are set in advance for different time periods. In time schedules for time-of-use often classify as hours of day -- classify the hours of day as peak and part-peak and off-peak hours.

They work as weekdays, weekends, holidays, and month of years as summer and winter months. And this picture shows example time-of-use schedule for Southern California Edison, which the optimal hours are 10:00 p.m. to 8:00 a.m. every day, and peak hours are from 2:00 p.m. to 8:00 p.m. every weekday and other hours as specified as part-peak hours.

And you can see that the energy price varies during the day, and the difference in price settings for the week days and the weekends for summer months and winter months.

Besides time-of-use there are other dynamic options including real-time pricing. Variable peak pricing, and critical peak pricings. And all of those are some variation of time-of-use pricings. For example, the variable peak pricings is very similar to time-of-use pricing, except that peak period prices change daily to reflect the system condition and cost.

Other than the above rate structures, the utilities also introduced net metering programs as more and more customers owned roof top and on-site PV systems. These programs allow the customers who own renewable energy system to export the excess energy to the grid. And the net energy exported to the grid will be used to offset the customer's consumptions and at the end of the building period -- or true-up period, the customer will be charged or credited for the net energy usage, or surplus.

So general speaking, the longer the true-up periods are more beneficial to the customers, because the surplus energy in summer instead of being sold to utility at hosted price, can be used to offset the usage of some other months; however, that might not be true anymore. If the customer's surplus are paid at the retail electricity price as in Net Metering 2.0 program.

So to benefit the -- from the dynamic rate structure, the customer must be able to charge the load in the manner that lowers their electricity consumption without -- sorry, that lowers their electricity bills without interrupting their operations or sacrificing their conveniences.

So behind-the-meter can be used to provide the needed flexibility for the customers. For example, the net metering customer can increase their savings by storing the excess renewable energy when the load is low and use that energy later when the load is high.

And time-of-use customer can benefit by charging the battery during off peak and then charging them during peak hours. Time-of-use customer can also reduce their peak demand by discharging during peak hours.

So given the limitation of storage capacity and efficiency, the economic gains highly depend on the storage size and operation. And to justify the deployment of behind-the-meter energy source, it is very important to optimize these to maximize the outgoing benefit of the customer. And this is an optimization problem in which the objective is to minimize the total energy charge, demand charge and net metering charge, concealing the physical limits of the energy storage device and the inverter.

The decision variables of the problem are the charge and discharge power of the energy storage device at the tower.

And so now I will get you a case study that's step-by-step walk-through QuESt behind-the-meter application. And in this case study we can see a large hotel with solar and storage. And trust we need to use QuESt data manager to get the data we need. So for this analysis we will need utility rate structure, load profile, and PV power profile.

So let's assume a hotel is a customer of PG&E following rate structure E-19 for medium general demand time-of-use, secondary and voluntary. So the data manager give us the different options to find the rate structure including search by utility name, search by zip code, and search by state.

For example, in this case study, we search by the utility name. Once you find the utility, we can use a filter to narrow down the showed results to find the rate structure that you want.

So please note that we will need an API key for this tool, and for the PV profile downloader. There is a help prompt to get you started with that short process. So once you find the rate structure you -- we want, we continue to verify all the time schedules and prices. This screen show the time-of-use energy prices. On the left corresponding to the time-of-use -- time-of-use schedules on the right.

For example, the red blocks in the time schedule, which are the peak hours from noon to 6:00 p.m. every weekdays in summer months, are corresponding to the price tag No. 4 at 16 cents per kilowatt hour.

So if we find the differences in the downloaded data compared to the real contract, this screen also allows you to modify both prices and time schedule. So now we continue to verify the demand rate structure. In this case, both time-of-use demand and (inaudible) demand apply. Again, we can modify the data, if needed.

Now, we can finish up the rate structure setup by setting the net metering rate structure, and save the data for later use.

Next, we will need to obtain the load profile for our load. Since this is a large hotel we will select the commercial load profile. We will need to select the location and the type of load we want, and set the data for later use.

And, finally, we will need to download the PV power profile. In order to do that, we'll need to enter the lat/long, the PV systems specification, and also save the data. Once we're done with all that data setup, we'll start using QuESt BTM or QuESt behind-the-meter for the analysis.

And, first, we will use time-of-use cost savings wizard to set up the analysis. And proceeding to the wizard we will select the data that we have just downloaded, including the rate structure, and the load profile, and the PV profile.

Now, you can enter the energy storage system parameters. In this case study, our energy storage system is 400-kilowatt hour and 100-kilowatt. So we can enter that in. Once everything setup, we will click next and initiate the model building and solution process.

In the background, the specified data is being loaded. The optimization models are being constructed and the models are being solved. After a brief wait, a prompt will notify you that the computation is complete. We can now view the wizard report of results and view several summary graphics.

Based on the calculations, the addition of the energy storage system reduced annual charges by about $36,000 per year. This mostly due to demand charge reduction. And, specifically, the peak demand each month was reduced about 100-kilowatt in this case.

We can also create a summary report that includes formulation details and the results. So we can retry the wizard with different energy storage system parameters, or we can try different PV and load profile rate structure, and so on. Is energy storage system worth it? In this case, it will depend on the financial of operating it and acquiring it. But we will have an estimate on its performance value potential.

So this is -- if you interested in the formulation and mathematical framework, these are some publications that we published during the last couple years.

So for the future, we would like to include more applications under QuESt platform. That includes the degradation, valuation of any storage. We also want to integrate the planning tools and resilience tool into the QuESt platform. And very important we want to release the API and library probably this year. And we keep continuing providing the webinars, tutorials and workshop and we are welcome your feedbacks.

So, with that, I'd like to conclude my presentation here. Last, but not least, I would like to acknowledge the support and guidance from Dr. Imre Gyuk, the program manager of U.S. Department -- U.S. DOE-OE Energy Storage Program. With that, I conclude my presentation here. Any questions?

MR. BYRNE: Thank you, Tu. So right now we don't have any questions. If folks have a question, do you want to enter it now and we can take one or two before we do the next speaker? All right. Looks like there's no open questions yet.

So, with that, thank you, Tu. I'll turn it over to Dr. Jan Alam and Dr. Di Wu from Pacific Northwest National Laboratory, and they're going to give an overview of PNNL energy storage valuation efforts.

DR. ALAM: Well, hello, everyone. My name is Jan Alam. I'm from Pacific Northwest National Laboratory. Today, me and my colleague will talk about our energy storage valuation efforts. So I will try to give an overview of our valuation efforts and we will dive into some of the details on our modeling approach and methodology.

So both of us work at the energy storage program at PNNL. Have been working here -- I personally have been working in the program for about four years now.

So PNNL has been providing -- has been involved with energy storage valuation for quite a few years now. I think that earliest report that I remember to see was from 2013, that time, so pretty much the start of the retail storage application or at least that wide level -- or wide scale.

So most of the projects that we have worked on today, you know, they intend to look at various value streams, or various value streams of energy storage. Also, while we do that, we are able to kind of understand the relative importance of various use cases. I think Ray mentioned that in the storage evaluation is complicated. A lot of the things depend on where you are in which market structure or, you know, utility type that sort of thing. And if there are any particular use case or applications (inaudible) for a given region that will, you know, cancel out from our valuation. That is, we can obviously, you know, try to understand or explore various challenges in evaluation of benefits, and some of our studies were focused on understanding the market potential of some new technology.

To date, we have worked on various technologies. Lithium-ion is obviously one of the, you know, most frequent technology that we work with. Today, the largest system that we have worked on is a 6-megawatt, 8-hour battery in Nantucket Island, owned and operated by NationalGrid -- Dr. Gyuk also mentioned that project -- providing reliable service on the island power system is the main goal, but it can also (inaudible) various markets that exist. We also have worked on flow battery systems, mainly in the state of

Washington. And also working on a couple of pumped storage hydro projects.

Mainly, this project is owned and operated by various types of utilities, you know, starting from public utilities, electric cooperatives to really large investor-owned utilities. Some of the projects are also owned by private developers. Many of these projects are funded by, you know, grant funding and cost share.

And, as I mentioned, that quite a few of the projects are actually part of Washington Clean Energy Fund in the state of Washington. But there are also projects that are funded by the even more traditional (inaudible) or other traditional financing mechanisms.

This map here shows the projects that we have worked on to date. This is a little dated, by now I think we have probably more than 25 that we have worked on or are working on. So I just wanted to give sort of a, you know, background or an overview that, you know, as we talk about, we can kind of navigate various types of opportunities that we had and various types of lessons that we learned through this project.

So I wanted to briefly touch on the various value streams we work on. It's sort of evident by now that energy storage benefits can be captured at various locations within our electricity infrastructure starting from generation, transmission, distribution, end use. Also electricity market provides a good platform to provide various services and tap into various revenue streams.

I referenced the paper within this dashed box that we wrote a couple of years ago. It provides a good insight on various value (inaudible) and also some of the tools that are available for evaluating various benefit streams.

That goes to the various types of activities that one has to do to achieve a value from energy storage. The first one is logically the identification and analysis of value, which is mostly the valuation activities.

But it's also important to remember that, you know, proper sort of, you know, hardware, software, infrastructure, and control strategies are really important to be able to realize the value that we, you know, identify and analyze in the valuation stage. And it's also important to track how we are actually doing in terms of achieving the value that we have identified.

If there are gaps between the value that we identified and evaluated in the analytic evaluation stage with the value that we are actually generating in the field, what are the differences and why they are different. The analysis of those aspects can provide really good insight and can help enhance the value.

So I just wanted to mention the two points, although they're not really directly related to the valuation aspect, but also -- but that's really important in terms of achieving the value in the real world.

This slide basically talks about our sort of, you know, the approach and process of the valuation work that we do at the lab. I won't talk a lot about it because Di Wu will provide a lot of detail information and share maybe some of our modeling methodologies and approach.

I just wanted to say at a high level that as we just talked about in the value chain, that, you know, identification of the value streams and how the values accrue would be really important. As we know, the value could accrue as avoided cost or deferred investment or some sort of earned revenue by providing a service to a market.

So how -- for a given project, how do the various streams can be achieved. Identification of that is really important. And while we do that, we engage with a lot of, you know, really close engaging discussion with the utility partner, so whoever owns and operated the storage. So that kind of forms the really fundamental sort of, you know, base of our valuation work.

And then, based on that, we develop modeling and analysis methodology and then use various tools. So at PNNL we have BSET, Battery Storage Evaluation Tool, which Di will talk about. We have to model various constraint and have to incorporate various, you know, considerations, system considerations, technology limits, et cetera. And then, obviously, financial consideration.

So once we have, you know, preliminary set of results, we go through iterations with our, you know, utility partner or whoever owns and operates the battery and try to understand and interpret the results, you know, what we have come up to make sense or not.

That sort of reverse process, you know, kind of provides a really great learning opportunity in terms of understanding the value streams, and then we sort of finalize our valuation process.

In terms of tasks, we are fortunate to have kind of multiple valuation process. We establish a preliminary evaluation based on a lot of presumptions, particularly under technology, but then we have sort of a, you know, testing period where we try to characterize the technology and understand its limits, et cetera, and then embed those aspects in the final evaluation.

So that -- sometimes that can, depending on time available, it can go in multiple periods of testing, that way we can also, you know, try to under stand the degradation that, you know, that's related to this particular -- to a particular technology. And all those, you know, kind of are built into our final evaluation.

So it's not always easy to have that -- or, you know, maybe in all projects we won't have that opportunity to kind of do a, you know, technology characterization before the decisions are made. So in those cases, you know, previous work on a particular technology that has been done by others, you know, PNNL, Sandia, or other organizations, I think those could provide really useful information.

Now, I just mentioned about the technology characterizations, but I just wanted to say a few more -- maybe share a few more things about that. Actually, you know, there are things that we see in technical specifications, but unless and until you actually operate the battery in the field, you're not able to understand that it's real limits or if there are any operational challenges or, you know, the performance characteristics that really relate to the particular application that actually will be used in.

So in the past we have, you know, come in close situation or experience when we have sort of modeled the battery in our preliminary evaluation in one way, but when we run the test we found that the performance is really different.

In some instances we found there were reliability issues. The battery may not be available. It may face frequent, you know, issue or (inaudible). So all of those aspects are actually important. And, again, it may not be always possible to, you know, perform the field tests in evaluation work, but it, you know, other -- what others have done in terms of, you know, performing field tests that technologies can provide useful information and then at least, you know, keeping a provision in our valuation analysis or if it's reflecting on those aspects, could provide more accurate -- or more, you know, practical estimation of the benefits. I just wanted to share that aspect as well.

Typically the results are as, you know, as one would imagine various benefit streams, here are the numbers that are, you know, one of the kind of most important results that we have from our valuation analysts. But we also look at various (inaudible). For instance, you know, how the various, you know, financial outcomes of the battery or, you know, metrics, for instance, or return on investment or benefits cost would vary as the size is varied or the energy to power ratio is varied.

We know that value stacking is a very important aspect of energy storage, so battery can -- battery or (inaudible) can serve, you know, provide multiple service, then, you know, in a given time horizon, how this various, you know, services stack up, you know, and how much time a battery has spent in various services. How much time it was sitting idle. Very important point. How much time it was, you know, it was in using in recharging, that sort of thing. So those aspects come out from the valuation we do.

And also we are able to see how the battery is kind of, you know, operating in terms of, you know, providing charge and discharge power, so sort of the, you know, example or illustrative dispatch signal, and how the state of charge varies. So all of these aspects really deeper into the technical aspects, but it can provide some insight of, you know, how you can expect the battery to operate during the actual field operation.

And then -- and then if there are, you know, things that can relate to the, you know, financing and economic aspects then we can kind of, you know, take further action to understand those in further details. We just wanted to share that aspect here.

Now, today, the work that we have done on, you know, valuation of various storage projects, most of these are actually available in public domain. I had provided a link blow there where you can access the work and if you have any question we can talk further. I just wanted to mention that we feel that most of our works would -- could inform various communities involved in energy storage industry in one of the other way. First and foremost, I think, are the project-related entities like developers, owners, operators, you know, financing institutions.

Many of our, you know, project actually work on real field data from the market and follow the projects involve performing system analytics, so the bulk system entities like market operators and reliability organizations, like (inaudible), for instance, can benefit from the studies we have done.

I think Dr. Gyuk has already mentioned that we have been working with regulatory entities in the state and also at federal level for PNNL have put together workshop to inform various regulatory entities on the benefits, opportunities, and challenges of energy storage, so that's a useful part of our work.

And we also think the demonstration projects that we have been working on have created lessons that can also benefit the technology-related entities, the system integrators, the manufacturers, so they can kind of see how the technologies are performing in the field and what sort of, you know, challenges we are facing and how the technology needs to improve in the future for those aspects.

I think with that I'm at the end of my presentation. If there is any question, I'd be happy to answer. But I would like to acknowledge the support of Dr. Imre Gyuk from Office of Electricity, U.S. Department of Energy, for his guidance. And also, as I mentioned, a lot of our work is part of Washington Clean Energy Fund, so we would like to acknowledge the support of Bob Kirchmeier from Washington State Department of Commerce.

So thank you for the opportunity to talk here and share some aspects of our valuation efforts.

Thank you, Ray.

MR. BYRNE: Okay. Thank you. So we do have a question.

So how are Sandia and PNNL collaborating on these sorts of analysis tools? So do one of you guys want to answer that?

DR. ALAM: If you or Di would like to take that -- I'm happy to. As far as I understand that, you know, we have been working very closely and sharing various methods and approach that, you know, on energy storage valuation. Both of the labs have, you know, various tools that, you know, the user community can take advantage of.

How we can, you know, sort of collaborate more on, you know, bringing them on a single platform for user access, I think that's probably a discussion still to happen but, you know, I'd like to hear from you Ray and maybe Di, as well.

MR. BYRNE: Okay. So I think the best way that we're collaborating in the recent last six months or years, an example would be the NRECA analysis efforts. So we're working with NRECA and their co-ops to do analysis for different sorts of energy storage applications and deployments. And so we basically split up the analysis efforts.

So some are done by Sandia, some are done by PNNL, with the other lab providing input and reviewing the analysis. So that helps, I guess, get everyone kind of on the same playing field.

Tu, do you want to speak to how that's working?

MR. NGUYEN: Yeah, that is a great example of how we work together between Sandia and PNNL. And as Dr. Gyuk mentioned earlier, PNNL tools for (inaudible) integrated utilities and Sandia to dispute for market application and behind-the-meter. And that's kind of closely -- not close enough, but it's still there's some distinguished differences between the two areas -- the two areas that the lab working.

DR. WU: This is Di. I want to add one thing. PNNL and Sandia National Lab are regularly communicated to exchange experience, and also make sure we don't duplicate efforts. I think that's very important.

MR. BYRNE: Okay. So I think we can consider that question answered.

So, with that, I'll turn it over to you, Di.

DR. WU: Okay. All right. So, okay, we -- can you see my screen?

MR. BYRNE: Yes, we can see it.

DR. WU: Hello everyone. I'm Di Wu, a senior research engineer and team leader at Pacific Northwest National Laboratory.

I do the research work in areas of energy storage analytics, building grid integration and microgrid design. Today I'm going to provide an overview of modeling and analytical methods and the tools for energy storage valuation.

As Jan just explained, energy storage is capable of providing a vary range of services from bulk energy, ancillary services, and T&D, to customer services. We have collaborated these other national labs utilities (inaudible) and the universities to evaluate energy storage systems at more than 20 sites across U.S.

In this presentation, I will summarize these methods and the tools (inaudible) used in this project. I will start at high level, but provide references that contain detailed information.

Let's first look at modeling. To evaluate economic benefits of energy storage we need a set of equations and constraints, or tables representing operational flexibility and the physical constraints.

In many cases it's a black-box or gray-box model at system level without component-level details. (Inaudible) is as important as fidelity, as the model will be used for formulating a lab organization problems that could involve (inaudible) decision variables and the constraints.

These models describe technical characteristic of energy storage from two perspectives; operational flexibility and degradation effects.

Constant-efficiency model is a simple and popular method to characterize operational flexibility. It's a linear (inaudible) system that resembles a simplified dynamics of energy state characterized by charging/discharging power (inaudible) and (inaudible) and efficiencies. These are round-trip efficiency or one-way efficiences.

High Fidelity model generally more complicated but provide several advantages as I will explain later. When modeling degradation effects, because (inaudible) some degradation cost associated with energy storage charging and discharging operation.

It can also be a more complicated state-of-health model that is basically capture a loss of battery life and a degradation in performance such as (inaudible) capacity increase their losses. A (inaudible) and integrated model is preferred in storage evaluation study. I won't to be able to cover all these models today. I will talk a little bit more about high-fidelity models next.

Constant-efficiency models are simple to use, but they are several limitations. So let me spin the idea of using this 1 megawatt/3.2 megawatt hour, UET vanadium flow battery as an example.

And here are the actual performance curve. And horizontal is the state of charge, SOC. The Y axis is the change of state of charge per hour. And the red (inaudible) are for charging and the blue one for discharging.

As can be seen here, the charging/discharging capability varies state-of-charge levels. The amount of energy that can be extracted from this battery depends on discharging power. For example, we can only obtain 2-megawatt hour when discharge at 800-kilowatt. Losses also vary based on state of charge -- state-of-charge level and also charging/discharging power level.

All this performance characteristics cannot be fully captured by constant efficiency models. And here are the general models that battery represented the capability of energy storage. It can be either some analytical (inaudible) or table. We compare the two models in evaluating energy upcharge with energy (inaudible) profiles in the Northwest region. Here is the comparison results as can be seen. The difference is quite significant in this case.

So how can we construct of nonlinear model besides using data from manufacturer. We have test and evaluating several energy storage systems in Washington state, and here is an example for the two-battery system in Snohomish PUD.

This picture shows the first system, which is the 2 megawatt/1 megawatt hour lithium system. And there is another battery system which is a 2.2 megawatt/8 megawatt hour UET system. We have collected testing data all (inaudible) seasons to evaluate a performance and the (inaudible) and performance into (inaudible).

The collecting the data include the power measured at battery on a grid-coupling point. Battery on direct current and voltage, and also state of charge. The gradient boosting maching algorithm was used for ranking predictor importance and determining co-efficients.

This feature compares the root-mean-square deviation of nonlinear and linear high fidelity models based on measurement of performance. As can be seen, the nonlinear model generates smaller (inaudible) and it can more accurately describe the performance especially for the (inaudible) tool, the flow battery system.

Allow an energy storage model, describes how a system can be operated. Optimal (inaudible) is required to determine the best way to operate the system and thereby to maximize the potential benefits considering two-dimensional (inaudible).

The first is the (inaudible) value streams as different services compete for limited capacity. The second is the intertemporal (inaudible). For example, discharge more energy per hour, less is available in the next hour. More frequent operation in (inaudible) year, reduce the cycle in future years.

(Inaudible) to formulate an (inaudible) optimal dispatch problem for determining storage operation and estimating potential benefits. This feature shows how energy storage can be dispatched today considering different boundary and services. A general evaluation tool is generally required to define technical achievable benefits.

To optimal (inaudible) on a dispatch storage system, information such as load and energy prices are required. In real world, we don't have (inaudible); therefore, operational (inaudible) need to be considered in evaluation studies to a (inaudible) maintain the benefits.

There are several methods to handle (inaudible). One of them is the policy-based dispatch. This method consists of two steps. The first step is to determine energy storage is engaged or not on the operation day based on the probability of the events and also some predetermined thresholds. Once the dispatch is triggered, the model for (inaudible) control will be carried out using the expected values.

(Inaudible) is proud of performance of different thresholds and identified optimal (inaudible) to maximize the net benefits.

Normally, in evaluation studies, we ultimately dispatch energy storage to maximize benefits. These are for energy storage owner. All for (inaudible). There was an interesting case, the (inaudible) utility on a U.S. Army base, how (inaudible) project. The Army lease the land to utility. In return, the utility will install (inaudible) energy storage and used them to benefits (inaudible) utility Army.

Since, in this case, there are two objectives. There does not exist a single optimal solution that simultaneously maximize both objectives. The goal here is to approximate a Pareto front as illustrated in this picture. The blue dots on the Pareto front are all good solutions. As (inaudible) objective cannot be further improved without compromising the other. The blue dots in this red circle are not good solutions as the benefits can be improved in either direction.

Scalarizing method can be used to convert the problem into the single objective optimization problem. Each can be solved by many existing software.

For optimal sizing problem, there are three kinds of approach. The first is to formulate a large optimization problem with size as decision variables. The second is bi-level optimization. In this method, the lower level is the evaluation for given size of storage system, and the upper level will be some algorithms searching for the optimal size based on the return to benefits from the lower level.

The searching algorithm can be some gradient based method (inaudible) algorithm of (inaudible) optimization.

Finally, analytical methods can also be used to determine the optimal size. The method can also have (inaudible) to identify key factors that will affect economic sizing. For example, this figure shows (inaudible) space can be divided into different divisions with different cost (inaudible). And this figure is (inaudible) battery cost of space for (inaudible).

Here is something more about bi-level optimization. So, as I mentioned, bi-level optimization can be naturally applied to sizing problem as illustrated in this figure. As well as the battery sizes and the annual benefits you can dispatch (inaudible) exchanged between two levels.

There are also some other valuation studies that (inaudible) fall into battery optimization, but it can be restructured for use in this technique to speed up solution process. So, for example, integrating state-of-house model into evaluation. We have a super large optimization over multiple years. This is challenging to solve.

We can't restructure the problem as the bi-level optimization with the state-of-house boundary conditions of a period and also retain the benefits of a single period is changed between the two levels.

Two-stage stochastic programming is a framework for optimization that involves uncertainty, and can be using for sizing problem.

The first stage is to make here and now decisions before the realization of uncertain parameters is known. After the second stage, making a decision after the first stage and after a random event occurs we make a decision for the best outcome.

To solve the problem numerically, probability distribution and a finite number of possible realizations can be used to generate -- to generate a deterministic equivalent of the stochastic problem.

Based on this framework, (inaudible) a stochastic sizing method for microgrid (inaudible) including not only this patchwork (inaudible) distributed (inaudible) but also energy storage. Considering not only system resiliency, but also the cost and also the potential economic benefits.

So (inaudible) problem, the first stage is the planning stage to make a decision on investment with (inaudible) say some load renewable generation, starting time on a duration and so on.

The second stage is the operating stage depending on DER size. Ultimately, this patch is carried out in each of scenarios, in both grid-connected and island mode.

So we have developed a number of tools at PNNL. I will (inaudible) in this presentation.

The first event is Battery Storage Evaluation Tool or BSET. This is a desktop application originally developed in to (inaudible) searching as Dr. Imre Guyk explained it (inaudible) multiple value stream, especially for (inaudible) integrated utility environment.

And the user can determine the optimal size based on the selected of audio stream and the cost parameters. And here are some screen shots of the input and output of the GUI. So far this has been (inaudible) to (inaudible) in the U.S.

During the past few years we have improved these (inaudible) these individual capability, such as (inaudible) energy storage modeling, state-of-house model, under these (inaudible). We are currently working to develop a wide based (inaudible) with the improved (inaudible).

So here is tool called Energy Storage Evaluation Tool, or ESET. This is a platform consist of set of (inaudible). It based on modular structure that facilitates maintenance and expansion. We also adopted encapsulated environment-based docker, as illustrated in this picture.

We have docker for modeling and automization (inaudible) per application. We also have generic docker for the information exchange (inaudible). With the docking environment we are able to eliminate the need for customer sizing.

We also separate -- separated data and application to improve the data security. Finally, the dynamic GUI provides an interactive interface for easy configuration and settings.

So the two is currently hosted on the PNNL server and here is the address of the tool.

There are currently two applications within ESET; MASCORE and the P2G. As I mentioned, the web-based ESET and BSET is under testing and should be available in October.

MASCORE is a tool to allow energy manager for large industrial and institutional customer to select size and operate on a microgrid asset to enhance both resilience and economic performance of the system. The (inaudible) was developed based on the stochastic sizing method as presented earlier.

But the other app is for evaluating power to gas system, into (inaudible) for gas production and transport while providing ancillary services and demand response considering potential clean energy incentive.

Models are added to capture operations associated with the production, compression, storage and methanation of hydrogen (inaudible) economic assessments.

So these apps are created straightforward to use, no need to install anything. So maybe I can spend a couple of minutes quickly show you how to use the tool.

So here is the website and our register account. So here is my dashboard. So here are some existing project analysis I have created. And to create a new one you simply click either app and give it a name, so you will generate a case.

So let me quickly open, for example, MASCORE project already created. So in its case, users can either try to maximize (inaudible) given the budget constraints. I will try to maximize the net benefits given the (inaudible) constraints and we put some default value, but user can easily modify those values and there many different options.

For example, you can choose to either enable the intra-hour variable modeling. Whether you enable an active load in greater economic mode, so if you have higher demands you will see some additional information on each field. Users can use default value. Are they saved on the server or they can upload some they are customized the (inaudible).

The (inaudible) different configuration of microgrid (inaudible) configuration, like, they can, for example, exclude distributed generation, and (inaudible) automatically exclude that from the input and output.

And here are some example of the output. Basically user (inaudible) sizing on the evaluation results. These are on the DER sizes all the benefits from different surveys. And you can use a check different amounts of peak load (inaudible) near the investment. And you can also check the detailed operation of different assays. Are you consuming too much or download the data, or select, unselect different profile.

So here is the example for P2G, which is more complicated because we have so many inputting information, and also financial analysis parameters need to be considered. As I mentioned, as you can see there are two general pathway. If a user is only interest in one of them, they can also uncheck those pathways and the input interface become a little bit cleaner.

So for the output we have detailed economic analysis results, like, for example, including the (inaudible) along different pathway or transportation fuel benefits. We also have the operational cost for different component throughout the year.

So, please, give it a try and your comments and feedback are welcome.

Finally, we are thankful to Dr. Imre Gyuk and the Bob Kirchmeier for providing the financial support and the leadership. So thanks for your attention and your questions and comments are welcome.

MR. BYRNE: All right. Thank you, Di. Right now we don't have any questions.

Would anyone like to enter some questions for the previous two speakers -- or three speakers?

Okay. Lacking any questions, we'll turn it over to Giovanni Damato from the Electric Power Research Institute and he's going to give us an overview of what EPRI is working on as far as energy storage valuation.

MR. DAMATO: Thanks, Ray.

All right. Well, today I'm going to be talking about EPRI's work in energy storage valuation similar to the last three speakers in the workshop. And I'm going to focus on EPRI's new DER-VET tool, which if some of you were at the previous few summits, I mentioned it briefly, but I'm going to go into more detail with some additional case studies with the DER-VET tool.

So I always like to start out with some of the challenges to modeling. I think a lot of these were addressed in one way or another in the past few conversations before me, but, you know, it's important to point them out, because I think the tools need to consider these issues and address them as well.

So No. 1, you know, a lot of the rules and the regulations -- they're still in flux and they're going to be for the foreseeable future, so the tool needs to be flexible enough to address those -- those issues as they come and be extensible and flexible enough to add to them as the rules update and change.

The other big thing and we saw this before, you know, we hear the buzz word of benefit stacking or service stacking, a lot, but, you know, a key issue to address when modeling storage is really, you know, how do you practically stack those benefits, you know, when those systems are deployed in the field, and how do you reflect those practicalities in the modeling tools.

So, yes, you know, there's a lot of buzz because more services for energy storage likely mean more value, but on the other hand, more services also mean more requirements, so we like to really focus on how those requirements can be satisfied if they can be. And then that's reflected in the modeling results.

Another issue -- and we've seen this throughout this hour is that to do energy storage evaluation, you really need site specific values and data to be able to come up with accurate project level results, so that adds some challenges to the modeling. And then everything needs to be co-optimized together, so it's kind of a complex exercise in the modeling between all the technology constraints, the service constraints, and the objective that you have, either economic or reliability, et cetera.

And I mentioned, you know, I'm going to talk about how EPRI's addressing these challenges with DER-VET, which the beta version launched back in April of this year, and it's available for download now. And we're targeting the beginning of 2021 for the full release. So, you know, be -- prior to the end of the first quarter 2021, and, you know, it rests on the shoulders of the StorageVET tool, which EPRI released in 2016 as version 1 and released a second v.2 in 2019. And, really, DER-VET does everything that Storage can do, but also includes looking at a portfolio DERs, which we think is really important to the modeling environment.

So just a little bit conceptual overview of DER-VET. You know, there was some key drivers behind it. One of them was it was funded by the California Energy Commission. So that's how EPRI is expanding StorageVET in all DERs, and also has a microgrid component.

So when you have a portfolio DERs you can also look at addressing reliability and resilience. And that can be, as you can see from the center of this slide, either customer values, so those types of value streams, or on the transmission and distribution are the utility side of the grid, as well. So there's that multi-perspective capability that was in StorageVET that is now also in DER-VET as well in the EPRI tool suite. And also you can look at a combination of those, as well.

So, you know, if you're sided on the customer side of the meter, there's certain services that a customer sided storage project or set of DERs can also address for the utility side of the meter as well.

And again, you know, for more background on the tool in terms of documentation, and then also the download instructions and help links and the -- to help with the user group and the asking questions and things like that, you can go to der-vet.com for more information on that.

So this just -- this slide gets into a little bit more detail. I mentioned most of it, but down there at the bottom I think it's important to talk about the target users. So it's everybody from individual customers, you know, a community of customers; that could be like a community microgrid or a co-operative utility, et cetera.

And also, you know, the third-party developers out there, and the investment community like yourselves, as well as, the utilities, for looking at energy storage on the -- either on the utility side of the meter or programs on the customer side of the meter, and looking at that as a whole, and also community microgrids. And then, of course, at the state level with commissions and regulatory bodies, as well, including ISOs and RTOs.

And we have a pretty good representation of all these types of users for both DER-VET and StorageVET.

So I mentioned that I'm going to do a focus here in the last part of this deck on case studies using DER-VET. But here are just a couple of screenshots of kind of what the tool looks like, so there's a -- for DER-VET there is a GUI in the beta version that's available to the public now. It's kind of a web browser based doing, the final version will be a little bit more feel like an app and easier to install, so we're looking forward to that. But, in general, it will hopefully be pretty straightforward for the user, like I said, to install and use.

And then on the right-hand side here you can see some -- some outputs, you know, in terms of high resolution of detail in tracking what the -- either if it's standalone storage or a portfolio DERs, you know, and this one is just focused on the storage here for simplicity. But, you know, state of charge across a whole year or multiple years of dispatch, what the battery is doing in terms of services. So either providing energy or providing capacity so you can see that the -- the energy or the area under the curve there in that second graph and the arrows are capacity reservations for either providing regulation or spin or nonspinning reserve.

You can look at the price signals as well and also if there is a load that you're looking at, it will also address that as well either on the customer side of the meter or if you're trying to do a T&D upgrade deferral.

So here's just a few more ways to get involved now, with DER-VET and also StorageVET. I already mentioned those links. But we also have the energy storage integration council, which is a couple thousand participants strong across the industry in lots of different stakeholder representations and it's free to participate. And if you aren't already on the distributions list, you can do that here at the top and send an e-mail to esic@epri.com.

And, you know, I mention that because we have a regular monthly meeting -- task force meeting where we focus on DER-VET and StorageVET. Talk about new features, how to use the tool, answer questions and things like that. So it's a great way to get started and stay engaged and help us craft the next versions of

DER-VET.

So, actually, I will go back one and just mention briefly that, you know, this is a publicly available tool. So just like ESIC, you know, free to join, DER-VET and StorageVET are also free to the public and open source as well.

Now, let's move into some case studies. So I have one transmission case study to mention and then a couple of microgrid case studies; one behind-the-meter and also one in front-of-the-meter. And all of these are energy storage enabled case studies.

So, first of all, on the transmission and distribution side, so in EPRI for the last couple years, we've had an energy storage analysis project going on with 14 different hosts across North America and also including South Africa, where we've looked at using DER-VET alongside with other tools, like power flow analysis, production cost modeling, things like that, to help answer site-specific energy storage project questions, either on the transmission side or the distribution side of the grid.

And, actually, we've done a few cases on the customer side as well for some of the -- those utility host members on that map. So, you know, it's -- it's kind of a multi-step process, and DER-VET fits into this in many ways. So on the transmission and distribution assessment, so typically, you know, the utilities are bringing in some sort of, you know, circuit model and we use tools to help analyze that. And then we can highlight the issues and we can kind of, as you can see, you know, the red hot zones where there's potential issues, maybe some potential issues later as load grows or as PV increases on a feeder or a circuit in yellow, and then maybe no issues.

And we help the utilities to figure out, you know, pinpoint locations where energy storage or a combination of energy storage and other non-wire solutions can address the problem.

And then we dive into the details of how energy storage could address that particular need, by, first of all, meeting or exceeding all the requirements to provide those services and address the issues. And also, you know, what are the economics of the alternatives, as well. So, typically, we look at what's the conventional solution compared to installing energy storage or energy storage plus other DERs.

And one example of this that I picked here is in Los Angeles Department of Water and Power. I picked this one, one because we were going to be in California in person, but we're virtual. But also because it's some details are -- and the report are publicly available on a white paper, so you can look more deeply into it if you'd like.

So we're really doing two major projects for them. One of them is market service participation with energy storage plus solar PV, and looking at the market services of energy arbitrage, or energy time shift, frequency regulation, spinning reserves, and resource adequacy capacity.

So you know, this particular case we're going to focus on today. One, because it's, like I said, the details are in a publicly available white paper. And also it has, you know, LADWP and EPRI work together and based on, you know, the analysis we did with StorageVET and DER-VET to help them understand the project, it's now in execution mode, so it went into RFP, the (inaudible) project, which is one of the largest solar plus storage projects in the world, so it's kind of exciting to see that start helping from the beginning and getting that through to the execution phase.

We're also kind of in the middle of helping them more on a longer term project. Since they do have a hundred percent RPS targets and aggressive energy storage targets and some unique issues with -- in the LA basin versus out of the LA basin and their service territory, we're helping them with how energy storage helps them address lots of different issues.

Now, let's just dive into the solar plus storage project.

So this came out of what's called Senate Bill 801 in California and it required LADWP to look at putting in energy storage. They've looked at solar plus storage, and that's kind of one of the reasons why we expanded StorageVET to DER-VET to include all DERs, because this is something we see as a trend of, you know, standalone storage is not something that we necessarily look at a lot in isolation. We're always, you know, comparing it to multiple alternatives, or maybe a combination of alternatives like this particular example.

So this looked at a 100 megawatt, 4-hour battery paired with a 200 megawatt solar system. And we also needed to look at capturing the Federal Investment Tax Credit for both the solar and the storage.

And you can see in the top right, there are many different cases that we took a look at in terms of what services it would provide, and seeing how that would impact the valuation of the project. It went, you know, we included energy time shift and spinning reserve for all the cases. We also looked at restricting charging from the grid, you know, based on the ITC restrictions and also some other potential services unique to LADWP as to when it could discharge and charge and also providing frequency response for the basin -- I should say for the LADWP service territory.

These are some of the outputs, you know, just diving into some of the weeds on those different cases. This is just a day in January where you can see, you know, with storage not having kind of -- only having simple constraints on when it can charge, and then -- on the left, and then on the right you can see a much different outcome for the same day, same set of data when we restrict charging from the grid, as well. So it's only charging from the PV profile and it's following that PV profile. So it's kind of a simple example that gets into the details.

And then you can see here kind of broken down by start year, so LADWP asked us to look at, okay, did this PPA project, the (inaudible) project, although we didn't know it was them when we were doing this, but if the bidders started their PPAs in 2021, 2022, and 2023, you know, based on cost projections of the energy storage and PV also adjustments for the benefits, so the service prices. We saw that starting in 2022, all the cases had a benefit-to-cost ratio of over one, and, you know, that's one of the reasons why LADWP moved forward with that project and it's in execution now.

So now I'm going to talk about a couple of storage enabled microgrid case studies. One of them being on the customer side of the meter, which happens to be military installations for -- with some DOD projects, and the other is in Southern California Edison territory, which was a utility side of the meter microgrid.

So the first one we'll talk about is the DOD microgrid, but, in general, you know, we look at with DER-VET, the -- obviously, the technology mix we're interesting in. So DER-VET can look at a whole range of DERs. In this particular case we looked at energy storage plus solar, and energy storage plus solar plus diesel gensets in islanded mode, and -- but, in general, DER-VET can look at, you know, demand response, electric vehicles, other types of distributed generation, either fossil fuel, or renewable fuel generation, wind, et cetera, controllable load.

And then, you know, once we understand the objectives of what kind of DERs we want to look at, then we can go into the sizing and operations. So in this case in a microgrid, you typically have a primary objective of resilience or reliability. So being able to cover an outage, for example, and stay up and running and what's your probability of being able to do that based on the outage length.

And then also, typically, there's economic objectives. So for the, you know, 99 percent of the time it's blue sky days, how can I reduce my electric bills or participate in other programs to make money, and looking at the cost effectiveness of doing a cost-benefit analysis of the entire project from the capital expenses to the operating expenses, replacement costs, et cetera, and bringing that down to a net present value, CBA.

So, you know, I mentioned that, you know, we looked at in this example some military installations. They have a very -- obviously, a very high reliability target. They need to be up and running no matter what the potential issues. So they had -- and also a very long reliability or resilience target of 168 hours, so a 7-day target.

And also, you know, what we had to do was make sure that the -- when we looked at a storage enabled microgrid versus the conventional diesel generator, we had to make sure that the -- first of all, that the reliability or resilience was equal to or greater than the conventional solution. And also look at the total life cycle costs and compare those.

These are the five -- we actually looked at five sites. You can see on the map here. I'm going to just do one particular example to get into the details.

You know, we looked at the base -- or the military installation conditions. So the load shape, the size of the load, the critical load shape, the solar, and the other assets available and some of the other conditions. Then looking at the, you know, blue sky days of the secondary services of helping them reduce their electric bills, and also, in some cases, depending on which of the five sites participate in wholesale markets, and look at the, you know, the trade-offs and the rules amongst those five sites.

And the storage technology that we looked at, at least in the example slides here, is lithium-ion; although, we also looked at flow batteries, as well, for this project.

So this is just, you know, you can see a military base typically is a pretty large load, although it does vary from site to site, just like anywhere else. But this example is a 14 megawatt load with a 4 megawatt critical load. They had 7 diesel generators and 50,000 gallons of diesel available. They also had 830 kilowatts of PV on-site. And other than the resilience objective, we were looking at, you know, what can we do in terms of bill reduction, and also participating in the market.

So I mentioned, you know, we focused on lithium-ion as the base case technology, and we also looked at flow batteries, but we weren't able to put those in the slides here today, but it was a similar exercise as well.

You can see kind of some typical assumptions here for the -- for the lithium-ion batteries. And then we had performance objectives based on the base case. So this curve on the left shows, you know, the probability of covering X number of hours. So you can see that with diesel generators as the outage gets longer and longer, the probability of being able to meet that outage drops. On the right you can see kind of the numbers there. How the probability changes. And also what the costs were for the baseline to cover the load. That's all the -- the CAPEX and operating and maintenance cost of the diesel generators.

So now moving forward to the storage-enabled microgrid. We want to take a look at how do we achieve -- meet or exceed the technical reliability requirements and also can we reduce cost.

So here you see the running DER-VET. We were able to reduce the number of gensets for that 7-day outage down to 5, and install a 4.3-kilowatt, 4-hour battery -- I'm sorry, 4.3 megawatt, 4-hour battery. And also be able to do bill reduction as the secondary services, as well.

And then you can see on the reliability side, in terms of the probability of outage coverage. This blue line I showed you before with the lithium-ion, you can see that it's a much hire probability of covering those outages. So that met that objective, as well, and these come out of -- these are outputs from DER-VET, as well.

And then you can also see we looked at costs -- or net costs, I should say, and you can see total NPV of the net cost. So by net cost, I mean, that we're netting out any reductions in bill savings, et cetera. You can see that the solution was about $4 million cheaper over the 20-year project life. And also just the metric of annual dollar per kilowatt peak of critical load. We used that as well. You can see that it was left to serve that each kilowatt of critical peak load, as well, using the storage-enabled microgrid solution.

And this occurred across four of the five other sites, as well. So you can see here each one of these groupings shows the baseline case with just diesel gensets and/or PV -- or I should say not and/or; some of them had PV, some of them didn't on-site. And then the investment case of including storage and reducing the number of gensets.

So we also looked at, you know, cases using DER-VET on not the customer side of the meter, but on a community level microgrids or utility microgrids. And in this case in Southern California Edison territory, or SCE, we looked at focusing on, you know, a solution of being able to mitigate high public safety power shutoffs starting in 2019 in this area in Southern California where they had multiple days where they were shut down because of wild fire mitigation.

And they also -- SCE didn't want -- needed to follow the guidelines in California pushing for microgrid solutions that would be renewable-focused and reduce GHGs and not just be diesel generator solutions.

So what we did was we looked -- we brought in DER-VET to help with, Okay, what would be the optimal storage plus PV mix to satisfy a 24-hour outage at this utility feeder with a group of customers, and also a 48 hours, and I'll zoom in to the 24-hour solution here.

And of course looking at the financials as well. Sorry about that. So SCE helped us with finding this feeder, they came to us with the question. And they picked it, as I said, there were a lot of PSPS events because of wildfire mitigation, and these customers, 137 of them, with a total of 2.2 megawatt load were experiencing a lot of outages. And this was mostly commercial/industrial circuit, not residential.

So we took a look at the solar irradiance to help us with what's the probability of covering those 24- and 48-hour outages. And looked at what the upper limit of how much land that we had to work with or surface area. And then also we were told we could curtail the PV if we had to, and we looked at options where we did and didn't. And then also some assumptions about the operation and energy storage and being ready for the PSPS events, which are called -- so you have a head start notification.

So, you know, here's some of the results. So you can see, you know, this kind of shows how the model was -- the workings in the model internally of DER-VET of co-optimizing the size of the battery and the PV system, so you can see these curves on the left and the lot -- different color lines assume different dependability of the PVs.

So the top one is a hundred percent. You assume you get a hundred percent of the PV and then all way down to 0 percent as the PV output for that 24-hour event. You can also see that it changes dramatically.

There's the knee points there of when you reach the amount of energy -- or the amount of PV where more doesn't help you, and you start curtailing and that's on the far right.

And then here you can kind of see here zooming in on the peak day or one of the worst days kind of what the load and PV profile is and then also the state of charge, the energy storage at the bottom there. You can see how it's charging during the event, and then discharging down to zero.

And, you know, we took into account several different inputs from SCE, as well as, kind of conservative assumptions based on a typical lithium-ion battery system and PV assumptions, as well, for costs. And had the objective of assuming with the storage-enabled microgrid that you would be able to ride through a hundred percent of the 24-hour outage, and then -- and then also on the blue sky days be able to participate in the (inaudible) market for energy time shift and frequency regulation, as well as, other ancillary services.

And you can see, you know, we had other financial inputs as well. And then, in summary, you know, this when out to RFP at the beginning of 2020, but SCE decided to hold off and put out this RFP again in 2021 because the costs were pretty high to cover this 24-hour outage, so to be continued on that. So with that, I'll stop there and see if there are any questions.

MR. BYRNE: Thanks, Giovanni. I do have a question for you.

So is there a close linkage between DER-VET and EPRI's distribution modeling tool Open DSS?

MR. DAMATO: Yes, there definitely is.

And when I talked about the T&D example. Typically, we run Open DSS to help with understanding the issue and characterizing it and getting, you know, constraints and requirements for providing a T or a D service, so that depending on, you know, if it's on the distribution system, Open DSS; if it's on the transmission system some other power flow tools.

In working together then with DER-VET to understand, okay, these are the requirements, let's put those constraints into the DER-VET model, and then optimally size the storage both for capacity and duration, and then see, you know, also what its state of charge is, impacts to degradation, things like that.

So that's how they link together. And there's actually a module in DER-VET that helps with passing that information back and forth, and some other tools, as well, not just Open DSS.

MR. BYRNE: So for the transmission level analysis, can you speak a little to what types of tools you interface for that problem?

MR. DAMATO: Right. So PSSE is one of the primary examples there. And also EPRI has a tool called the Transmission Hosting Capacity Tool that's -- that members can use that helps with running PSSE to create, you know, time series data and things like that out of -- out of the conventional power flow tools to help us with characterizing the constraints and the requirements for a storage project.

MR. BYRNE: That's really cool. Okay. So let's open it up to questions. If you have a question please enter it into the Q&A box.

Okay. So the first one from Frank Petricelli is: Are there case studies to compare savings predicted by these modeling tools with actual achieved savings? In other words, what's the performance record of these modeling tools?

MR. DAMATO: I can jump -- I could jump in and just talk about our experience with DER-VET and StorageVET, is that we have done backward, you know, historical looking cases and we're adding to that list all the time of, you know, looking at what DER-VET and StorageVET would predict without the future information, and then backtasking and comparing it to what actually happened and what was achieved.

So we are actively doing that and we have some projects in 2021. Two of them, I think, that will look at market participation and also the customer side of the meter as well.

MR. BYRNE: Okay. And then for the Sandia side, I guess one good example for us is the Sterling Municipal Light Department project that Imre mentioned in his presentation, but there's an IEEE PS general meeting paper from about 2016 that discuss the analysis, and the actual results were very close to what were predicted.

So Di or Jan, do you all -- do you guys have any examples you can pull from your research?

DR. ALAM: So I just wanted to briefly mention that although the particular project or example that I'm talking about was not really to understand the performance of the tool, but what we, you know, really wanted to, you know, see what the benefits that we talk about and when we actually go into the field and operate the system, you know, with all the practical constraints, how far we can go with achieving the value.

And we found that, you know, on certain days and not being able to predict the performance of the battery (audio glitch) including those in the control strategies can, you know, impact the benefit and, you know, the benefit that we evaluate or analyzed at the client in actual operation.

So that we have observed those type of things, you know, as I mentioned in my presentation, as well, as what's the difference between, you know, the evaluation stage and the actual operation stage, and sort of analyzing those differences and feeding that back into the sort of into the implementation stage and also analysts stage. So we have observed that -- that sort of, you know, aspect. Not exactly from a tool performance (inaudible), but sort of the controlled study and user information, that's from that point on (inaudible).

MR. BYRNE: Okay. Tu, would you like to comment on that?

MR. NGUYEN: Yeah, I would like to add that the model tools usually provide possible saving. In other words, that's kind of the maximum potential. And how that revenue is realized in practice depends a lot on forecasts, on energy (inaudible), and controls strategies of specific system. So we try to provide the maximum potential revenue and now we are also like to provide some kind of average and lower end of the revenue too. So it's kind of like bouncing between the -- between the lower end and upper end, so that's what we trying to do.

MR. BYRNE: Okay. Thank you.

So do we have any other questions?

All right. With that, I would like to thank our esteemed panelists. I think this has been a great session. Energy storage modeling evaluation is a key technology to enable wider deployment of energy storage, and, with that, I'll turn it over to our host Richard.

MR. BAXTER: Thank you.

So this is finishing up today's -- the Energy Storage Valuation Workshop, and we will be continuing the Energy Source Financing Summit tomorrow at 10:00 a.m. Pacific, 11:00 a.m. Mountain, 12:00 p.m. Central, and 1:00 p.m. Eastern.

So thank you very much, and we look forward to seeing you again tomorrow. Thank you.

(End of video Day 1.)

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ENERGY STORAGE FINANCING SUMMIT

SEPTEMBER 23, 2020

Day 2

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MR. CHAUDHRY: Hi, I think we're going to get started. We have a number of attendees who already signed up and I know we expect many more to join soon.

My name is Rohit Chaudhry at Kirkland & Ellis. And I'm delighted to welcome you to the second day of this virtual conference. We have a great lineup of speakers for this conference today.

The first day of this conference was yesterday, and yesterday we focused largely on valuation issues for energy storage projects. Today, Richard Baxter will kick things off with an overview of an energy storage financing study. That we have two distinguished keynote speakers who will be presenting today. We have Janea Scott who is the vice chair and commissioner of the California Energy Commission and we have Eric Hsieh, who is the Director of Grid Systems and Components at the U.S. Department of Energy.

We follow these two keynote panels with further remarks from Richard and then that will lead into two panels that we have today. We have a market outlook panel that's going to be moderated by Bob Fleishman at Kirkland & Ellis, and then we have a capital providers panel which is going to be moderated by Brian Greene of Kirkland & Ellis.

As I mentioned in my remarks yesterday, there's been a tremendous surge of energy storage projects already in 2020. There was a Woods Mackenzie study which projects that by 2025 the total deployment capacity of energy storage projects is going to be about 7 gigawatts, which is seven times -- a seven times increase of the level of energy storage capacity projects to date. Which, of course, will require a tremendous amount of investment, which will make today's panels and today's presentations extremely interesting.

With that, I should mention, as a technical matter, that this session -- all the sessions today are going to be recorded, so everything is on record today. And, with that, let me turn it over to Richard Baxter for his welcome remarks.

MR. BAXTER: Hello, and welcome to Day 2 of the DOE Energy Source Financing Summit. As Rohit had mentioned, yesterday was the workshop day. Today is our summit -- or the panels. And so let's start a few things here. So let's see, okay. So here we go. And -- well, that was Rohit, and this is me.

So a little bit about the summits -- or the financing studies. What we're trying to do is figure out a way as the Department of Energy has been working to develop the technology and improve that helping with the commercialization requires both taking that technical analysis of the different technologies and then market analysis to figure out a way to show the commercialization -- the bankability for the commercialization.

So, you know, reducing the barriers to entry for both new technology, but also new groups wanting to come in at various points throughout the industry. This also includes, especially for energy storage, helping to understand and providing greater transparency for both the technological performance issues and the project risk.

And so as we had mentioned, the studies they kind of break down into three parts; that we have the workshop and the summits, and then we pull them together into a full report. And, as you can see, this is the fifth report that we've been working on. I've been working on. And as we have done it through the years looking at the different issues that are big challenges for the industry and promoting conversation.

Here is the outline of generally what I'm going to say, you know, in the report, you know, looking in the operations and trying to define a little bit more of the market roles and the operating expenses. Basically for a lot of other people who are not experts in the industry to give them a basis for conversation when they talk to some of the other people who have more knowledge.

And then looking for the strategy, the cost and revenue impacts, performance implications, and then based on the research, based on the -- especially the interviews and conversations I had with people in the industry, such as you, we can figure out a role of what night be needed to help promote more and better operations and strategy for the industry.

Again, here we just had the summit. This is actually the 9th summit that we've done, and we've usually been trying to do one in San Francisco in the fall, and then New York in January.

And let's see. So today I said we're going to talk a little bit about the cost and revenue, you know, how -- issues about operating systems and how the evolving markets are going to be impacting what type of roles the different technologies and different projects can operate.

For this, and to give us to detailed, first we're going to start off with two keynotes to get some incites into both California and Department of Energy, so vice chair Janea Scott from the California Energy Commission, and then Eric Hsieh from the U.S. Department of Energy will be the keynote, and we'll be following along like this pattern here.

After Eric is having his keynote, we'll take a break, and then we'll come back for panel 1 and panel 2.

So with that, I would like to stop sharing my screen. Okay. And there we go. And turn it over to Vice Chair Scott.

MS. SCOTT: Excellent. Well, good morning everyone, or good afternoon depending on where you're dialing in from. It's nice to see everyone, and I'm really happy to be back for a second year in a row to talk to you all. Let me pull up my screen share for you to go through our slides. I hope I picked the right one. Share. Okay. And hopefully someone will jump in with the comments if I did not do that appropriately.

MR. BAXTER: You are good to go.

MS. SCOTT: You can see me? Okay. Great. Is my very first slide is just to say again good morning and how happy I am to be here with all of you today.

Okay. Give me just a second to get that one slide. There we go. Okay. My apologies. I got this technology thing down. So I just want to kick us off this morning with a little bit of California context. And, as you all know, we have been experiencing quite a bit of wildfire and we've had some extreme weather events with our August lightening siege here in California.

So Governor Newsom has asked the members of his administration to look into accelerating California's efforts to decarbonize. And this effort continues apace. It's been ongoing all of this time. And actually from a press release that I saw just this morning, there may be some announcements coming almost simultaneously here with my talk. So please do keep an eye out on Governor Newsom's press web page to see what will be going on in California.

But one of the things that we all know is energy storage projects are going to be critical in supporting the resilience that we need in California, and also the continued operations of infrastructure and equipment across our grid. We also know that developing energy storage will not just strengthen the grid, but it can do so at a lower cost and a lower carbon footprint.

So, in California, what we're trying to do is make our way to a hundred percent clean energy standard. And our policy requires renewable energy and zero carbon resources to supply 100 percent of electric retail sales to end-us customers by 2045. The California Energy Commission is working in coordination with the Public Utilities Commission and the California Air Resources Board as well as with the California Independent System Operator to complete a joint agency report that evaluates the 100 percent zero carbon electricity policy. And that report is underway and it should be completed by January of 2021, so please do also keep an eye out for that.

My next slide here shows some of the goals that we are looking to help advance. I oversee the Energy Commission's research program. And within that we are working to help advance some of California's clean energy goals and we're doing that through a few different efforts.

One is we're looking at decarbonization and that includes advancing our clean energy supplies and ensuring that the grid is able to accommodate the clean energy supplies with things like load flexibility.

We're also looking to address affordability and equity challenges to ensure that all Californians are participating in and benefiting from our clean energy future and making sure that we're not leaving communities behind as we make that transition. We're also working to build a more resilient energy system where we can better anticipate the risks that we think are coming, and also ways to look to manage the risks.

So the Energy Commission has a long history of researching new and innovative energy storage technologies, and our efforts have really supported seeding California's storage industry.

The research that the Energy Commission is carrying out focuses on a range of storage from all kinds of sizes all the way from utility scale down to residential, and we're looking at a variety of technologies like lithium-ion, flow batteries, flywheels, compressed air, thermal, and also at some advanced battery chemistries.

I oversee our research program, which is called EPIC. It's the Electric Public Investment Charge program. And the EPIC program has invested about $60 million in energy storage and related projects, and we did that prior to 2020.

This year, in 2020, we invested an additional $40 million in new research grants for energy storage. So, in total since the program has begun, we've invested about a hundred million dollars in advancing these energy storage technologies.

And, as I mentioned, some of the things that we're looking to the invest in is looking at storage for resiliency, we're looking in longer duration storage, and all types of things that help us get to that 100 percent clean energy standard.

So I wanted to mention a few of the trends. I'm sure you all are familiar with this but it seemed remiss to not have it in the presentation. As you can see here, Bloomberg's 2019 outlook is projecting 122 time increase in energy storage by 2040, and that cost will be about $660 billion of investments around the globe.

Also, globally, the energy storage market is growing. And currently there are ten countries leading with nearly 80 percent of the market. Most of this anticipated growth is being attributed to the electric vehicle market. Another market's projection show a similar future growth similar to what we're seeing on the Bloomberg slide that you can see here.

We're also looking at the price projections. And price projections for lithium-ion storage continue to decline. We have seen prices come down about 85 percent over the last ten years, and it's decreasing at a much faster rate than forecasted a decade or so ago.

The prices have dropped from over $1,000 per kilowatt hour to about $150 per kilowatt hour from 2010 to 2019. And Bloomberg is projecting that the prices will continue to decline reaching closer to about $100 per kilowatt hour by 2023. These cost reductions are largely attributed to economies of scale. And, again, most of that's being driven by the electrification of our transportation system, along with technology advances that include higher energy densities, and those have nearly tripled over the last decade.

And cost productions I don't need to explain to you, are incredibly important because right now it costs more to store energy than it costs to make energy. And we need both of these systems to work well together to integrate the level of renewables that we're talking about for our decarbonized future. So to get to that clean energy system -- 100 percent clean energy system we got to have storage at prices that are closer to what it costs to generate energy as well.

So this slide here is showing you the growing need for energy storage in California. And in 2010, some legislation in California, which was Assembly Bill 2514 sent energy storage procurement targets for California. And since then, we really have been a leader in the nation when it comes to addressing the use of energy storage to help support our future energy goals.

As a result of that legislation, over the last decade, California utilities have installed or improved installation for more than two gigawatts of energy storage.

Given our energy goals and looking out to 2030, 2045, and beyond, there is still a growing need for additional energy storage as we continue to integrate increasing amounts of renewables onto the grid, and move toward our goal of the hundred percent clean energy future.

Here you can see from the California Public Utilities Commission, 2019-2020 Reference System Portfolio, that they're projecting a need of almost 10 gigawatts of energy storage by 2030. And that's about 9 gigawatts of battery storage, and 1 gigawatt of long-duration storage. That's where the breakdown is right now.

In California, the investor in utilities are currently at about 2500 megawatts, so we've got some work to do. 90 percent of that procurement is lithium technology, and that has four hours or so of duration. Moving forward, we need to look at technology diversification, and also at longer duration storage.

And just as a side note, that four hours of storage duration is driven by the California Independent System Operator requirement that we have at least four hours for the system that we could use as a resource adequacy asset.

All right. So I also wanted to talk to you a little bit about the Energy Commission's research strategy here. So as we look to the future and plan for storage we are projecting that will be needed, we got to think towards the long term. We believe that the State should not rely on only one technology and that we need a diverse portfolio of possible energy storage solutions.

So we're mapping out a storage research investments. We're taking kind of a three-pronged approach that you can see here. We're looking to diversify, we're looking to demonstrate, and we're looking to derisk.

So in the diversification space, the energy commission is looking at a suite of storage technologies, and most recently we have focused on non-lithium alternatives. The Energy Commission is also looking at projects, and we always are, that will demonstrate performance and improve the functionality of storage. And we continue to explore opportunities to derisk storage by reducing costs and ensuring safety.

And some of these systems are also looking to be ruggedized. So that if they're deployed in places where we anticipate wildfires, they might be able to withstand that and continue to provide the storage that we're counting on.

2020 is proving to be a pivotal year for research on energy storage, at least I think so, at the energy commission. Some of the priorities for the Energy Commission and the State this year including evaluating the performance of a variety of storage technologies in various microgrid applications.

We're looking, as I mentioned, to diversify by supporting non-lithium ion technologies. We're looking to demonstrate longer duration energy storage technologies. And with some of the increases that we're seeing in transportation electrification, we're also looking at validating the capability and cost-effectiveness of second life batteries.

And, finally, as I mentioned, we are doing an assessment of long duration energy storage deployment scenarios that will help show how we can meet California's 100 percent clean energy goals.

So let me walk you through a few of the different types of technologies that we are funding.

So the storage-related solicitations that we have out right now resulted in over 15 new projects. And these solicitations focused on developing non-lithium ion storage, long-duration storage, and residential storage that will be compatible with our building standards, so in California that's the Title 24 building standards.

And also to some funding that help support the development of long duration energy storage scenarios. So we're really trying to understand what parts of the system do you need long-duration storage. When do you think we might need it. Where do you think we might need it, right? So trying to do some assessments for what the grid of the future is going to look like.

And I think it's almost important to note how important equity is and diversity in this state. It really is central to our program as we develop our solicitations. We're always -- a friend of mine, had to make sure we bring low income, rural, tribal, disadvantaged communities, along with us. We can't get where we're trying to go on 100 percent clean energy standard if we don't have every community engaged with us, and we have solutions that is work in all communities.

So as I go through some examples you'll be able to see that in the projects that we've funded.

So here are a few examples of projects that are funded, and let me walk you through them. So the first one is with the Rincon Band of Luiseno Indians. And they're demonstrating a vanadium redox flow battery combined with a flywheel. Their system will be connected with solar PV to provide resiliency and cost savings to local facilities including wastewater treatment plant, a gas station, a convenience storage, an office building, and the Harrah's Casino and Resort, which also served as an emergency operations center when it's needed.

This project will achieve multiple advancements, we hope, including reaching historical scale for both flywheels and flow batteries, demonstrating grid forming functionalities from a flow battery system, and integrating two separate forms of long duration energy storage into a single commercial microgrid.

The second project is Form Energy. And Form Energy will develop and demonstrate the performance of an aqueous sulfur sodium air system for long duration energy storage that can provide up to 100 hours of energy. This system will be built and evaluated on the UC Irvine campus.

And then last is the energy -- Indian Energy project, which will examine multiple storage technology configurations, with the mix of zinc hybrid cathode battery, a vanadium redox flow battery, and a mechanical flywheel. This project is going to be located at Camp Pendleton and will provide both the Navy and the Marines with an opportunity for hands-on experience with several different non-lithium ion technology demonstrations.

Again, a lot of these demonstration projects are really important to us at the Commission, because tribes, a lot our military installations are often at the end of the transmission line, but it's places where it's incredibly important to make sure that we keep the power on. So looking at these type of storage solutions in the places where they're needed most is really hopefully quite impactful.

I mentioned earlier that we're working on equity, and that's one of the key priorities of our EPIC program, and it's central to the investments that we're making. So in this storage solicitation, we had a specific carve out for tribal communities and here's a couple of the resulting projects.

These projects had smaller system requirements than the ones I just talked you through and those requirements were at 50 kilowatts for ten hours. For the first project is with the Soboba Band of Luiseno

Indians. Where they live is often impacted by unplanned outages, and also by planned public safety power shutoffs.

So GRID Alternatives is planning to install a 50-kilowatt hour or 500-kilowatt -- I'm sorry, 50-kilowatt or 500-kilowatt hour vanadium redox flow battery, and an off-grid generation system to enable that the Soboba fire station to provide the community with complete and critical services during emergencies. In addition to providing critical resilience to the community, the project is also expected to provide energy cost savings for the tribe.

The second project I highlight here is with Indian Energy. And they're going to be installing a flywheel that will use -- pump water for the Viejas Band of Kumeyaay Indians. And this project is expected to advance the current technology readiness level of kinetic energy storage technology from technology readiness level 6 to technology readiness level 8.

We also had some funding that was specifically targeted towards low income and disadvantaged communities in California. And there is a California Enviro Screen system and it takes a look at communities and it looks at any number of factors, and then it kind of pops some of them up at places that have been over-burdened. And those sometimes show themselves to be disadvantage -- that's why they call it disadvantaged communities.

So we're working to get the benefits of these programs into those communities to really help alleviate some of those concerns, and also to make them a lead as we make our transition to the clean energy future.

So these projects are projects that are in communities. And, again, these are the smaller systems. So like the ones I was just talking about at the tribe. So it's 50 kilowatts at about ten hours. The first project here is the Antelope Valley project. And it's demonstrating pumped hydro at an aquifer to provide support for groundwater storage facility at the Willow Springs Water Bank.

While pumped hydro is a proven technology, this project will include retrofitting existing wells to provide a smaller and more flexible version of pumped storage hydro.

And then I also want to take a look at demonstrating the generation of green hydrogen through electrolysis and converting this hydrogen into electricity.

So we had in California a Senate bill. It was Senate bill 1369 and that defined green electrolytic hydrogen as energy storage. And it asked the Energy Commission to consider the potential uses of the screened hydrogen for an energy storage solution in California.

So we have two examples of projects here that I wanted to walk you through. And I know this is a lot of projects, so I'm just trying to give you a snapshot, a look into the types of things we're investing in. The innovations that we're trying to push in California across the storage sector.

And, again, these all go back to demonstrating that kind of that longer term storage and that type of thing. So the first project is the DasH2energy project. And they are integrating a green electrolytic hydrogen system with power generation from a one megawatt wind turbine within a microgrid at the Palmdale Water District.

The wind energy will be used to produce hydrogen, and then the hydrogen will be used to provide electrical resiliency with long duration storage, high reliability, price stability, new business case models and at a lower cost for the Palmdale site.

The second program is the T2M Global project. And T2M global is going to evaluate a green hydrogen system that can produce hydrogen through electrolysis as well as recover dilute hydrogen from waste streams such as biomass conversion, flue gasses, and ammonia.

So most of the electrolyzer systems require purified water as an input. However, under certain modes of operation, this electrolyzer may be able to generate water as a by-product, and then the project will test and validate system performance in a laboratory setting and use the results to develop designs for a commercial scale system.

All right. And then, finally -- and, again, like I mentioned, this is just kind of an overview just -- and then a quick dip into some of the projects that we're funding in these spaces. I mentioned that we're also looking to help fund storage in residential applications, so that's what this shows.

So we have UC Riverside, BoxPower, and EPRI. And they will all be using commercially available residential storage systems to demonstrate the value of energy storage combined with PV solar for residential customers at their homes.

So the UC Riverside project will develop a site level test and demonstration program for optimal coordination of a network of autonomous plug and play behind-the-meter solar battery units, not only to perform demand side management, but also load shifting, maximizing the solar self-utilization and backup power and providing new developed grid services.

BoxPower is looking to yield an integrated hardware and software platform that will be compliant with California's building standards, and it is projected to be scalable to about 10,000 units by 2025.

And last we have EPRI. EPRI is working to model project site homes for compliance and total energy use. And they're working with builders and storage providers to understand the control and implementation of energy storage operations, and they will use measured data to evaluate how energy storage units help provide grid harmonization.

So anyway, as I mentioned, I know I ran through a lot of projects in a really short amount of time. But I just wanted to highlight the breadth of the storage research that the Energy Commission has been kicking off this year. And I'm really excited to see how these projects get going, how they get up and running, how they're implemented. And especially I look forward in a couple of years to seeing what the results from these projects are.

Finally, I wanted to mention to you all that last year the Energy Commission launched our Empower innovation platform. And I want to encourage anyone that's interested in applying to an Energy Commission EPIC grant, or really that you're just interested in the storage and clean energy innovation, this entrepreneurial space, to join our Empower Innovation. It's the newest tool in our innovation eco-system. It's an online platform that is designed specifically for the cleantech community. And it provides a great networking opportunity for individuals and organizations for exploring our funding opportunities.

On Empower innovation you can find a community of cleantech entrepreneurs, developers, technology adapters, and community-based organizations, and you will also be able to see the latest funding announcements from the Energy Commission.

This platform also includes a "Find a Partner" feature. And that allows you to announce your interest in a specific funding opportunity and to view other interested parties to find potential partners in a trusted environment. And if you are excited to find it, you can see right here on the slide it's at empowerinnovation.net. So you can just go to empowerinnovation.net, and take a look there.

So I think I have maybe three or four minutes for questions, which I'm happy to take. I do a lot more of the policy and the strategies, so if it's a specific question on the technology, I can certainly put you in touch with the experts at the Energy Commission who can really talk through, in detail, some of that. But I look forward to your questions.

And I really want to thank you all for letting me share a little bit about what we have going on at the Energy Commission. It really is an exciting year for us, and it's just an exciting time, as you all know, to be working in this clean energy space.

And storage, as we make our way to a decarbonized system and 100 percent clean energy system is just an incredibly important foundational component for how we get there. So digging in to kind of long duration, how do we get it into more residences and things like that, I think, and then also looking at a broader set of storage technologies, in addition that can compliment lithium-ion is really important.

So that's what the Energy Commission is doing in this space. I really want to say thank you to you all. Like I said, I think I have a couple minutes for questions, so I can do that and then I'll also tee up for you the next speaker who is Eric Hsieh.

Eric is the Director of Grid Systems and Components with the U.S. Department of Energy, and I want to say welcome to Eric, but before we do that maybe let me pause and see if there's a couple questions for me.

MR. BAXTER: Yes, hi. This is Richard and we have two questions.

MS. SCOTT: Okay.

MR. BAXTER: So far. And if anybody has additional questions, on the bottom there's a Q&A button that you can select.

AB-87 established a climate catalyst fund for California. How is that being employed?

MS. SCOTT: Wow, that's a great question. I'm not sure that comes through the Energy Commission, so I don't have an answer to that one. I apologize for that.

MR. BAXTER: All right. Good answer.

Let's see, I happen to (inaudible) gather the information of these projects and then disseminate those. And, I guess, maybe talking about how you're doing the projects, what are the steps involved, and then how gathering the information, and dissemination about the results.

MS. SCOTT: Yep. So that's a fantastic question as well. Typically, what we do at the Energy Commission is we have what we call a pre-solicitation workshop. And so our staff spends, as you can imagine, quite a bit of time thinking through, reading papers, talking to experts in the field, what is it that we need to -- how can we make our investments the smartest investments, right? Is there a challenge we can help solve? Is there a technology question that people are looking for answers to and that we can help put some investment in that space?

So in these pre-solicitation workshops they hear from experts around the field to hear what types of things we really ought to be directing our funding towards, and that's how they work to develop the solicitations.

And then, you know, once the solicitation is out there, you can participate in the solicitation workshop. That's where people ask any questions that they have about what's in there, what are we looking for, why are we looking for it. And then we kind of go into the dark period where, you know, we're waiting for applications to come in. At that point we're not talking to potential applicants. And then, you know, they go through and they score all of the proposals. Everything is typically a competitive solicitation through the Energy Commission for those funds. So that's one way to get engaged.

The other thing that we do is an investment plan for the EPIC program. So that's a nice place, too, as we're kind of thinking through the broader goals of here's the types of things we're planning to invest in over the next three to five years making sure we're hitting -- and, you know, there's a little bit of flexibility in that space as well, of course, because technology is changing really quickly and we want to make sure we don't miss things by preplanning too much.

But those are two places to really help engage with us kind of what we're looking at, why we're looking in -- to understand why we're looking to invest in certain spaces. And then typically each year we post an EPIC annual report. And the annual report is a great place to find out some more details about the different projects, right? So it will be a write-up of all the projects that are there, and that's a nice place to get some information. And also on our web page. On our web page you can click through and there's a lot of information there about the different projects and technologies as well.

And then last I would certainly encourage that Empower innovation platform. That's just a great way for -- if you've got a great technology and you want to demonstrate it in the community and you're looking for a community, you can find that match there. If you're a community and you would love to have someone come and demonstrate a technology, the same thing, it's really kind of a matchmaking for entrepreneurs and folks who are looking to pilot different technologies and places to pilot it and also some additional expertise, right, like you're looking for some financing expertise. If you're looking for manufacturing expertise. All of that is kind of within that Empower Innovation. So hopefully that helps.

MR. BAXTER: Okay. Great. Thank you. And then the slides will be shared later.

MS. SCOTT: Yes.

MR. BAXTER: Well, since this is a DOE conference, can you talk a little bit about how you coordinate and work with the DOE on project -- demonstration projects?

MS. SCOTT: Absolutely. So DOE is a great parter with us at the Energy Commission, so I appreciate that very much. We do have a memorandum of understanding with the ARPA-E program. And oftentimes what will happen is we have two -- we have several mechanisms; one of them is called Bridge, one of them is called the Ramp Program, and then we also have a federal cost share program.

So a lot of times if you have -- if you're an entrepreneur and innovator in this space and you've got some DOE funding, if you're part of one of the programs where the DOE and Energy Commission are working together that's great, right, so then we're, like, Okay, DOE is taking you technology readiness level 1 to 3, the Energy Commission is going to pick it up and take it from 4 to 6, and then maybe it goes back over to the DOE. We work pretty closely to try to compliment one another in our funding in that way.

And we also -- within the federal cost share if people are looking to apply for a settler grant, but they need some additional, like, state funds or other funds, they kind of match up together. So you can apply to the Commission, and that funding is contingent on if you get the DOE grant then you get the Energy Commission funding and off you go. And I think DOE does that with some of our programs as well.

So we work very hard to try to complement one another and really help move these technologies from where it's an idea in an entrepreneur's head all the way up to the level where it's ready to go out into the market.

MR. BAXTER: Okay. Great. And I think one more.

You had shown, I think, some Bloomberg and other market information. Do you guys use that when you're trying to predict the scale of the market going forward? Do you have some internal demand or internal need estimation about -- that helps you guide what type of technologies or deployments to evaluate?

MS. SCOTT: Yeah, so we certainly use Bloomberg, information from EIA, IEA, right, all of the, you know, the robust and known data sources.

We also have an analysis shop within the Energy Commission that does some pretty cracker jack work I think in this space as well, so when we're looking to analyze where California is going and what we think is needed, we can do quite a bit of that analysis in-house as well and kind of, you know, okay, go back and see What's Bloomberg showing? What's EIA showing? What are we showing? Kind of get that data circle going to help inform what we think we need.

And then, as I mentioned, when I was talking -- and I know I talk really fast, I'm sorry about that. I'm happy to share slides with anybody or follow up in more detail.

Some of the things that we do with our EPIC investment is to invest in analyses, right? So one of the analyses we're doing is this long term -- is an analysis of where long-duration storage is going to be needed within California's grid.

So we -- and I think that one went to EPRI. And so what they'll do is they'll do an analysis for us. What does the grid look like? Where do we think that makes the most sense to put some of this long-duration storage? Is ten hours going to be enough? Do we need more? Do we need less? Where should it go? Why should it go in those places, right? And so sometimes we also put out solicitations to have folks help us do that analysis as well. So A few ways to come at it.

MR. BAXTER: Okay. Great. Well, thank you so very much. We appreciate your time and your insight and, well, hopefully at some point in the future we'll see you in person.

MS. SCOTT: See each other in person. Thank you so much for having me. I was delighted to be here.

MR. BAXTER: Excellent. So now we're going to be turning over to our next -- our next keynote. It's Eric Hsieh, the director for Grid Systems and Components of the Department of Energy's Office of Electricity.

MR. HSIEH: Great. Thank you, Richard.

And it's a pleasure to follow Commissioner Scott. I'm a former Cal Bear, so I'm on the other side of that rivalry. I've always been impressed by how the State blends creativity, technology, and equity issues. And the CEC demonstration projects that she went through are exactly the kinds of innovations that DOE hopes to accelerate as part of the Energy Storage Grand Challenge.

So just as a little bit of background. I have the coolest jobs that I'm qualified for at the Department. (Inaudible) one as Director of Grid Components and Systems. I oversee the hardware R&B portfolio for grid technologies that include power electronics, robotics, and storage.

I, myself, before coming to DOE, I used to be at A123 battery company. Helped grow their stationary storage business, and stayed on through the bankruptcy and emergency -- emergence from chapter 11. So I appreciate the risks and obstacles to nurturing technology in this field.

Day job No. 2 is what I'm going to go through in more detail here. I'm one of the track leads for the Energy Storage Grand Challenge. And my job here is to create a long-term R&D strategy for these technologies on behalf of the Department. So that's what you'll see today.

I'll go through the long-term vision for energy storage here. Look at one example of a use case that we're considering and go through the drivers and indicators of change within that use case. I'll talk a little bit about energy storage at OE, but also across the department and how we bridge the gap to commercialization.

So Energy Storage Grand Challenge was launched in January of this year by Secretary Brouillette, and we have a vision and mission statement generally to become the world leader in energy storage utilization technology and exports. And we are aiming to create a comprehensive program that accelerates the development and commercialization of next generation energy storage technologies.

One of the things that is more expansive about this initiative compared to previous ones is that this is truly DOE wide. From basic science in the Office of Science, to ARPA-E, to the Applied Energy Offices like mine and ERE, where you'll find wind, solar, hydro, buildings, vehicles, as well as, nuclear and fossil energy. And then to the near commercial offices like LPO, Loan Program's Office, and the Office of Tech Transitions.

We've really been given the directive to align all of the different levers that DOE has to accelerate this industry. And whether you're a Zoomed-out executive, or a impetulant TikTok influencer, we've boiled down the ESCE into six words. For your convenience, it's innovate here, make here, and deploy everywhere.

So for innovate here, we want to see how the U.S. can lead energy storage R&D, and we'd like to make sure we get a return on the IP that's developed here.

Next stage is make here. Of course, we want to lower the cost of impact of manufacturing and strengthen domestic supply changes.

Finally, deploy everywhere. Of course, we want to make sure that there are robust markets here for energy storage deployment, but we want to make sure that the kinds of technologies that we develop are widely applicable and scaled.

So the way we're achieving innovate here, make here, and employ everywhere is through five tracks. The first track is the one that I lead. Technology development. That's an -- that's essentially creating a long-term R&D strategy.

Next is tech transition. How do we accelerate these technologies to market? Part of this initiative is an explicit recognition that DOE strength in R&D is not enough. We are also developing tools for -- to assist those in the policy and valuation space. And I'll speak a little bit to that. And, finally, domestic manufacturing, supply chains, and workforce development, I've alluded to before, and they will also be key in assuring U.S. leadership.

So this is a snapshot of the status from this past summer, so we released the draft road map in July of this year. The comment period just closed at the end of August, and we are now visually sorting through all of the wonderful input we got from many of the people on this line, and we out later this year.

MALE SPEAKER: Eric, can you share the document? We are not seeing the document. Can you share it? Share your screen.

MR. HSIEH: Can you see my slides?

MALE SPEAKER: No, we're not seeing your slides. If you wouldn't mind just sharing your screen, that would be great. Let's try that again. Thank you for the -- all right.

MALE SPEAKER: We're good now, yes. Thank you.

MR. HSIEH: Sorry about that. So drivers and indicators of change. One of the things that we're doing different. A little novel for DOE within the Energy Storage Grand Challenge is to introduce a user focused R&D framework. So instead of just chasing a dollars per kilowatt hour or efficiency metric, we've been identifying representative use cases for electrical needs over the next 10 to 30 years. These use cases span everything from industrial facilities to remote communities to entire balancing authorities.

And then once we've identified some functional requirements that helps us fill out an R&D strategy. Now, I'll use our first use case Facilitating an Evolving Grid, as an example.

So this use case covers both the power and distributions systems and one of the biggest drivers here is the increasing proportion of variable energy resources. In part due to economics and state policies. DOE will achieve success if we can deliver cost effective technology solutions as the underlying drivers accelerate.

So what might these drivers look like? If we go little bit technical and back to first principles, there are a couple axis on which you could consider how the grid has evolved. So on the X axis is whether a system is centrally controlled versus distributed and the Y axis is whether the resources are synchronous or asynchronous.

In 2020, the vast majority of the grid are here to the bottom left, and as we get to higher penetrations of DERs you might see things move towards the distributed side of the graph. At the same time as we have asynchronous resources, like wind and solar or anything inverter based, they may move towards the top. And then, finally, you might get to this stage on other end of the quadrant where you have grids that look and behave much differently than they do today.

And I want to clarify that we're not looking at a single grid, right? So if you look at all of the EIA utility entities and their evolution. They have not evolved the same way. So in 2004 we did a quick metric to see where they were. And the vast majority of them were in this lower left quadrant with large centralized power plants that were synchronous.

Fast forward to 2019. There are many utility entities that have made significant changes in the way they generate electricity. So this evolution is not just futuristic, in many cases it is happening today.

And this map shows the geographic distribution of utilities by quadrant. You can see the indicators of large scale wind in the Midwest, large solar in the Southwest and potentially -- I think it's small scale solar in specific states like New Jersey and North Carolina.

So I'm going to borrow some back of the envelope numbers from ARPA-E's program. Today's best available solution if you're talking about flexibility and it's dominant thermal capacity being constructed is a combined cycle unit. And we're rounding things out for simplicity, so we'll assign that a proxy price of $50 a megawatt hour for dispatchable energy.

So to be cost effective, any new technology has to beat that number for a comparable service. So long-term wind and solar generation are likely to approach $25 megawatt hour in wide swaths of geographies. And for this analysis, we're just going to assume that half of that output needs to be storable in order to be fully dispatchable. So each cycle through a battery if it adds 50 megawatt hours or less -- $50 per megawatt hour or less, then we can get to combined cycle competitive numbers.

So how do we get to lower cost storage. This graph also from the same program shows the relative costs on an energy and volumetric basis of various storage media. So the diagonal lines signify similar energy densities, so you can see rocks, air, salt, can all store about the same amount of energy per unit of volume, and they're all a little less dense than lithium.

The battery-based solutions today are up here in the top right corner, certainly in the higher cost category. And so to get to longer durations, we might need to look at storage media where the incremental cost of adding more hours is a couple of order of magnitudes lower, like sodium, air, rocks, or water.

In the medium term, there's still a lot of work to be done on these new chemistries. So in 2019 PNNL estimated present and 2025 costs for a variety of storage technologies. And if you could build pump hydro anywhere and finance it for 25 to 50 years, it would be lowest cost solution for large scale applications.

But sometimes you need things on a smaller scale or closer to load, like data centers or hospitals. And that's why a diversity of technology portfolios would be useful. While R&D reduce the cost of the storage medium is important, the next largest cost component is construction and commissioning, so C&C on this chart, or EPC costs. And just like solar and wind in the past, we're working on activities to help shave costs there, too.

So bridging the gap for commercialization. I appreciated the questions about market projections for California for Commissioner Scott. In some -- according to some -- depending on which projections you're looking at, the annual cap per spent for energy storage in the U.S. could be multibillions, tens of billions in the U.S.

And so we're envisioning a scenario where these use cases represent sort of the -- are representative of how storage is being used and they feed this multibillion annual U.S. market, and that would likely be split into some number of firms. So at $20 billion or $30 billion, you know, 60 firms gives you half a million dollar annual revenue, which is pretty healthy for a smaller company or business unit.

And, in turn, presumably these firms would have their own new technologies that would have to be derisked. And, in turn, those technologies would span the gamut of bidirectional and electrical, chemical and thermal, flexible generation and load.

So we're trying to assemble any ecosystem where technologies can accelerate from foundational science, materials, R&D, all the way to commercial validation, high value deployments and wide bankability in as little time as possible.

One of the things we're doing in the short term to help with this effort is helping everyone get on the same page with vocabulary. So, for example, we're looking at standardized component definitions and metrics. So you see here on the right is how we're proposing internally within DOE to -- to develop common ways to track the cost and performance of different components of energy storage systems.

That will help us make sure numbers are comparable, especially as we comparing things that may feed into different chemistries. It may also help us prioritize R&D areas. So one of the things that we've seen in the comments that are (inaudible) is that thermal management systems can present a common point of failure for energy systems. So while HVAC might be a mature technology for its current applications, a lot of systems aren't subjected to the reliability requirements of utility needs.

So this might be a place for some coordinated chemistry (inaudible) activities; crosscutting and cross (inaudible). And in turn that will help us accelerate validation, testing, and safety standards.

I did want to -- I explored just the wide diversity of storage technologies and pathways that are included within the storage challenge. Here you see along the X axis is continuing from basic materials researched to components and devices, all the way out to investment finance, operations, markets and value.

And so you see flexible generation and loads, there is a lot of contributions there from the Building Technologies Office, thermal and chemical. You start to see ARPA-E, solar, advanced manufacturing, the Field

Sales Office. And then bidirectional electrical storage includes both electrochemical and electromechanical technologies.

At the end here we are aiming to leverage and coordinate work from as diverse as the Vehicle Technologies Office, Office of Electricity, Office of Science. And I'll also note that as you get out into the higher levels of integration, in operations, the issues become much more crosscutting.

So the market and evaluation issues that the pumped hydro unit might face aren't that much different very long duration electrochemical stores. And that's why coordinated work across DOE and with the industry is going to be really important.

So in alluding to that policy an evaluation, DOE also has a role in providing analytical capabilities to decision-makers in order for them to make -- to incorporate the benefits of new technologies in the most effective ways.

Our policy and valuation work within the Energy Storage Grand Challenge is intended to be targeted, systematic, coordinated, and objective. So we are not making policy, but we are offering policymakers the tools to most effectively meet their own policy and regulatory goals.

And finally, you know, delivering them in a way that is relevant to the use cases that are facing and the kinds of decisions they have to make. So whether it's PUCs or project developers and retail consumers. We want to assemble data, feed them through models, and then provide the analysis that is most relevant and transparent to them.

So I think we're getting to the end of our time, so I will close out by saying DOE is formulating it's long term vision through Energy Storage Grand Challenge. The use case framework helps us to validate how end user needs can be met through storage, and identify diversity of technology pathways that can achieve these storage functions.

And there are a wide number of -- large number of offices across DOE working with industry to support an ecosystem of capabilities to accelerate innovation in the space.

So thank you very much, again, for inviting me here. And I'll hand it back to you Richard in case we have any questions.

MR. BAXTER: Sure. All right. So for everybody, if you look down at the bottom you can see the little Q&A button and so you can type in your questions there.

We have one. How is the DOE utilizing data from Green Button for energy consumption, and Orange Button for energy production for planning measurement and monitoring -- or just analysis? So information from the Green Button and Orange Button for market analysis.

MR. HSIEH: So I'm aware of the Green Button program. It's actually in a different part of the Office of Electricity. I know there are -- there are projects in place to develop better algorithms or methods of control and monitoring technologies that could improve the operations, especially at the distribution level. I can't speak to more specifics, but would be happy to follow up offline.

MR. BAXTER: Okay. Let's see, not -- are there any other questions? Okay. Wait, yes.

Does the DOE see thermal energy storage as high probability achieving economic deployment by 2025?

MR. HSIEH: That is certainly the goal. And it's not -- it's not so much thermal energy storage specifically, but if there are applications for -- or use cases for which a -- those technologies are well-suited, we are trying to accelerate the data which these technologies become cost-competitive. And, of course, economically driven deployment is the ultimate way to scale these things quickly.

MR. BAXTER: Excellent. Okay. One more minute. Any other questions? Okay. Well, Eric, thank you very much. And I think what we're going to do is -- we're a little ahead of time, but to make sure that every -- that everybody is able to -- can you hear me? Back on. There we go. So since -- so thank you for everybody's time right now I --

(End of video part 1, Day 2.)

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(Begin video part 2, Day 2.)

MR. BAXTER: Hello. Welcome back everybody to the 2020 DOE Energy Storage Financing Submit, Panel 1. And we're going to have Bob Fleishman of Kirkland & Ellis be the moderator, so I'll turn it over to Bob.

MR. FLEISHMAN: Thank you, very much. It's a pleasure to be here again. I've lost track of how many I've done of these.

Today we have a very distinguished panel. Have Jay Goldin, who is vice president of Green Tech Solutions at Munich RE America. We have Nick Warner, who is a founding principal of Energy Storage Response Group. Mark Stout with Viridity Energy Solutions. He's director of business development in the western region. And also Moe Hajabed at AYPA Power. He's their CEO. The fuller bios are in the package of materials that were presented earlier.

And we're going to run this panel, and the next one as well, by Brian Greene, also from Kirkland. The way we've done them in the past. They're not going to be PowerPoints or long canned presentations. They'll be questions that I pose to each of the panelists to begin. And then we'll have some follow-up and maybe some conversation amongst the various panelists and then we'll open it up to questions. We've got the Q&A chat function here as well. And it would be best to use that as we did today earlier and also yesterday rather than trying to speak.

So with that, let me ask the first question of Moe. NRStor, which you were instrumental in creating, was acquired by Blackstone Energy Partners recently.

Could you just talk briefly about your focus and expansion plans, and what that tells us about markets both here in the U.S. and in Canada with respect to energy storage?

MR. HAJABED: Thanks, Bob, for having me, and thanks, Richard, for having me today. So as you said, Aypa Power is formerly NRStor C&I, which is a company that I founded. And NRStor C&I and Aypa Power are both customer centric organization. So when we think about what we do, we focus primarily on commercial, industrial, and institutional customers.

And what we brought to the Ontario market specifically and the Canadian market is distributed storage and we became the largest developer owner-operator of storage assets in the Ontario market, primarily over the past 40 years.

Following the Blackstone acquisition, we've extended our footprint significantly beyond the northeast into the California and ERCOT markets. And what we're trying to do and what we're focused on is basically bridging behind-the-meter and front-of-the-meter models.

So a big focus today is working on utility scale projects, primarily focusing on commericial, industrial, institutional customers across North America, but providing them with solutions that focus on value that can be brought in through virtual power purchase agreements, as well as, coupling that with -- coupling that with behind-the-meter solutions that can provide them with reliability, resiliency, and expand on the business model in terms of economic value for some of those customers based on their needs.

So, from our perspective, that opens up a bunch of different markets for us primarily in the western United States, including California, ERCOT, and some markets with (inaudible) and we continue to focus in New York, New England and Ontario.

MR. FLEISHMAN: Thank you. Let me turn now to Mark. Mark Stout, who will talk a little bit, I think, about western markets. What energy market trends -- energy storage market trends do you see in the western U.S. at this point?

MR. STOUT: So over the last five years, I think there's been quite an evolution in market opportunities in the western U.S., you know, going back to the earlier 2010s, we had the AB2514 mandate in California, which everybody said, 1.3 gigawatts, huge mandate. Which really did get things started, and that was big. And that was almost exclusively standalone storage-focused.

And over time, we're seeing -- I'd say currently we're moving more towards, in the California market, storage is typically paired with solar, and solar plus storage, and procurement's largely driven by CCAs since the investment in utilities are typically long on RPS credits.

And outside of California, and the western mainland U.S., the big focus on solar plus storage, the interconnection queues are really packed with that. In fact, even California's interconnection queue, there was almost zero PV without storage entering the queues in 2019.

So it's really gone to dominant technologies are solar plus storage and standalone storage in California and then solar plus storage outside of California. Hawaii, you know, a lot of procurement on the way to 100 percent renewables by 2045. And it's a mix of solar plus storage and standalone storage across the islands that eco has really been driving that.

MR. FLEISHMAN: So following up on that. By CCAs in California, you're referring to Community Choice Aggregators. How significant is their role in the solar and storage market at this point, let's say, over the last year or two, and where it's headed in the short term.

MR. STOUT: The CCAs are currently serving over 25 percent of the gigawatt hours in the California grid in terms of loads served. I think that's quickly heading somewhere to 40, 45 percent in the next few years is there's a lot of CCAs that are, you know, currently going through implementation plans and formation.

Because the CCA is taking a lot of the procurement responsibility away from the investor-owned utilities, that created a -- that's why the IOUs are very long on their contracting of RPS. And so the CCAs are -- they are the big game in town for buying solar, and now the California market because they're such high solar penetration. Storage -- there's very little solar without storage procurement going on. It's really driven by solar plus storage.

MR. FLEISHMAN: And, Moe, is that what you're seeing in California, as well?

MR. HAJABED: Yep. We are seeing the same thing in the California market, so we're working with the CCAs primarily to be able to promote some of the projects, the hybrid projects that we're working on. And we're seeing a need for constant CCAs for hybrid projects. But also they're looking at more local projects to be able to meet the capacity needs. And we're also seeing the same needs come up from commercial/industrial customers in the market.

MR. FLEISHMAN: Let me ask the next question to Jay.

And, Jay, thank you for being on this panel, again. We ask different questions of you each of the times, it's not always the same thing. So what technologies does Munich RE consider to be bankable in today's markets? I think it's probably changed over time.

MR. GOLDIN: Thanks again, Bob, for having me. And I want to thank Richard and the Department of Energy for hosting the event.

So I will look back to the conversation that the CEC speaker had -- Janea Scott, and the DOE speaker. They talk about technology readiness levels. So if you all aren't familiar with technology readiness levels, it's basically from the concept through to fully commercialized product. And a lot of lithium-ion energy storage projects are highly bankable, highly known. They're at full readiness commercial level 9 or 10. But just because they're at 9 or 10, it doesn't mean that the performance obligations are well-understood by the people who are going to be writing $100 million checks.

So even if it's a technology that's well-proven in the marketplace, the investor class, especially if you go to infrastructure funds, they want further assurances of the technology and of the balance sheet of the system providers.

So I didn't really answer your question, so I would say let me come back to your question. We look at, in our group, technologies at readiness level 6 through 10. So vanadium redox flow batteries might be in a 6 or a 7. Might have sodium sulfur batteries in a 7 or 8 stage, so they're more proven in the marketplace.

And some of the flywheel technologies are at an earlier stage. So that would be used for pilot projects that the CEC supports or grants support, but we have not yet support them.

So it isn't really a question of what we consider bankable. It's really a question of what do the project finance committee consider as investment grade? Because if they plan to secure (inaudible) projects or sell them onward, they're looking to have an investment grade project to get an investment grade rating. And there's a few way to do that, insurance is one vehicle, me and some others might be (inaudible).

MR. FLEISHMAN: Great. Anyone else on the panel have thoughts and reactions to what Jay just said?

MR. STOUT: I think there's --

MR. FLEISHMAN: Okay. Go ahead, Mark.

MR. STOUT: I'll say, I think there's a lot of interest in the developer community in the sort of projects that Jay and Munich RE can offer. So I'll leave it at that.

MR. FLEISHMAN: Let me turn to Nick.

Nick, with the first round of fire codes being developed and product standards continuing to evolve, what's your view on the safety challenges that remain for energy storage going forward and what impact on markets does safety issues and related reputational risk have in your view?

MR. WARNER: Thanks, Robert. I think they're kind of two issues now as we start to finally move forward into a better regulated world with respect to energy storage. Obviously, you all have done a great job with the standards and continue to evolve in a way that I think will promote innovation and continue improvements to safety energy storage systems. We'll never be able to complete avoid failures and incidents.

They hopefully won't occur at a rate greater than any other incidents we see with grid tied power electronics and power equipment, and they'll be manageable in a way that fire service and stakeholders can handle. I think as we move to that future, though, it might be kind of time to turn our attention back to the systems and the fleets that have already been deployed, the systems, you know, just last week we had an explosion in Liverpool in the U.K. of a system that was installed precode. And I can't speak to what's in place in regard to codes and standards in the U.K., but I know when the system was deployed, there had been no codes adopted the U.S. nor any codes adopted in the U.K. for these systems.

There are thousands of these systems that already out there. And thousands more that will probably be installed in states outside of California and New York over the next couple of years before they get a chance to -- before these other states, rather, get a chance to catch up with codes.

I think it's probably time now, again, to kind of look back and make sure that these systems are out there, don't have an opportunity to cause problems. They're going to be felt down the road even as the new stuff starts to come online, and make sure that we don't kind of overreact if these safety issues do continue to come up on these systems, we don't over react going forward. We seem to be on a regulatory path now that I think is going to be sustainable and cost-effective for everyone. Let's make sure that we can stay on that path.

MR. FLEISHMAN: And I guess following up on that, we've got a question from someone who's here saying -- virtually here, I should say:

With the increasing instances of lithium-ion battery fires, in reference to the Liverpool event last week, what efforts are being made to various organizations to try to pursue what this speaker refers to as nonflammable technologies?

MR. GOLDIN: So I'll speak on behalf of the work we're doing with several vendors of low batteries, we see those as nonflammable. They have other risks associated with them. They take more maintenance to keep them running, but they won't burn and they won't generate sort of incidents that we've seen.

However, there's a place for the lithium-ion batteries, and there are controls that will be placed on them to make them safer and visibility it will add. And Nick's got a mechanism -- a fast response or a better situational awareness, so cars -- automobiles are unsafe things; we have bumpers, we have signal indicators, we have seat belts to make them safer. I think the same logic might hold true for the lithium batteries.

MR. FLEISHMAN: Any others on the panel on that question.

MR. WARNER: Yeah, I would just echo what Jay said. You know, the fire service, the code world, they handle risks, they handle challenges on the built environment on a daily basis. You know, open a PA magazine at any point in the last couple of years, and you'll see the challenges that arise in the built environment across the board.

Challenges have always existed. The fire service has always learned to deal with them in time; maybe not as quickly as we'd like. But I think ultimately what we'll find is that, you know, lithium-ion battery failures are going to be inevitable. If we can get those down to a number that's manageable and reasonable. And if we can make the overall magnitude of those failures manageable and get the fire service trained to a point of handling them, a lot of these safety risks were start to subside.

Because, quite frankly, as Jay alluded to, most of the things we do on a daily basis involving just simply walking out our front door in the COVID age, come with some inherent risk.

So managing that, I think, is as important as developing new technologies and new approaches to existing technologies themselves.

MR. FLEISHMAN: Go ahead.

MR. STOUT: Do you mind if I add on to, Nick? Thank you, Bob.

MR. FLEISHMAN: Of course, yes.

MR. STOUT: So just totally agree with what Nick is saying. And as a developer in IPP, there's a lot focus during the environmental permitting and then construction permitting phase for every project, and the fire safety and the battery systems is very important.

So along with that, there's a wide array of mitigations that can be added to the best system in order to make -- to manage the risk as best we can.

MR. FLEISHMAN: And when you all are developing projects or, you know, signing up new customers and the like, how important is the representational risk associated with safety concerns?

MR. STOUT: I think it's pretty huge. And if lithium-ion batteries in general are considered a risky technology that can't be -- can't have the risks managed and mitigated then -- there's -- there's always concern that that would slow down the market, or we'll wait for an alternative technology that has -- its traits might not be as positive as lithium-ion, but it might be safer, you know. There's always concern.

MR. HAJABED: I would echo what Mark said here, and from a reputational standpoint, obviously, and a safety standpoint, both are extremely important. So throughout engineering and technology groups and some of the consultants that we work with, we monitor what new technologies are out there from a fire mitigation and safety standpoint.

But more importantly with some of the (inaudible) we've deployed already, we're working with some of the OEMs to actually go back and retrofit some of the existing assets that we have so we can bring them up to code to avoid some of the issues that we're seeing -- that we've seen in the U.S. and in the U.K.

So I think both are equally important revisiting some of the assets, that I would care to avoid any future problems but also look at new technology and new code, and make sure that the technology and engineering groups are implementing that when it comes to procurement and execution of projects.

MR. FLEISHMAN: How widespread, following up on that, do you think the practice is of having OEMs try to help out with respect to retrofits? You know, projects that were built before certain standards and codes went into effect? Is that pervasive? Is that episodic? Is it a growing trend? What do people think?

MR. WARNER: We haven't seen much of it, and most of what we have seen are people bringing us in shortly after the system is built having us do kind of a third-party review of the system. This is mostly in states where there is no fire code, and how they can kind of bring the system up to a level of safety as in line with the code as possible.

To be entirely honest, in a lot of cases, the way the containers were built pre-code, it's not going to be cost effective to retroactively make them compliant with code or refit them in a way that's going to achieve the same level of safety required in the code.

It doesn't mean that the systems can't be made safe in other ways, though. Mostly on the operational and engineering side, by creating controlled distances by making sure all the stakeholders understand clearly what needs to happen during emergency event that the fire department knows how to respond.

It may result in a loss of more of a system than would have happened otherwise, but from a perspective of preserving life and property, it doesn't need to be catastrophic as long as everyone understands what happens.

MR. FLEISHMAN: Okay. Go ahead.

MR. GOLDIN: I think it's also early days, so there aren't that many systems out there to be retrofitted. On the large utility scale projects, they're really just coming to fruition last year, this year, and the next couple of years. So people have been acting as if the codes were there, or they may retrofit them because there's relatively few.

On the residential systems, there's probably 10,000 -- or I don't know what the current count is. Those would not be economical to retrofit those systems. Safety will be implemented via software on those systems for better monitoring and visibility.

I'm curious what Moe has to say.

MR. HAJABED: Yeah, on some of the --

(Talking over one another)

MR. HAJABED: On some of the 2 to 10 megawatt systems that we've deployed already, there are ways to retrofit those systems. There are some cost-effective ways to basically retrofit those systems. I wouldn't say it would get them up to 55 completely, but it will get them close enough where (inaudible) and you can control some of it through software. So from the discussions that we've been having with OEMs, again, its early days, I think in certain instances, we're posing some of the questions for the first time especially as it relates to retrofitting.

In other cases, they've been asked the questions before and they're trying to wrap their heads around it themselves to do it in a cost-effective way and that's what we're working on with some of the installations that we have today. We're just starting and we just got a report completed through (inaudible) and we're following some of the recommendations that are in it to get the systems up to code.

MR. FLEISHMAN: Got it. Let's turn a little bit to some regulatory things.

We got impact of regulation in the market and the FERC's energy storage rule order 841 has been on the books for a little while and -- with respect to the RTOs and the ISO's. And the compliance filing process has worked it's way through. New York now says they're, quote, fully compliant and so forth.

To date, what's been the impact of that energy storage rule in the markets you all are operating in or ensuring or involved with?

MR. STOUT: And, Bob, do you mind if -- I'd actually like to talk about other California regulatory impacts.

MR. FLEISHMAN: Okay.

MR. STOUT: If we only want to talk about the FERC order, we can talk about the FERC order --

MR. FLEISHMAN: Yeah, let's talk about the FERC, and then let's go back to California.

MR. STOUT: That would be great.

MR. FLEISHMAN: Yeah, yeah.

MR. GOLDIN: So I'll comment about we see the FERC order in the U.S. and we see other regulatory structures emerging in California and Australia and Germany, everywhere. It adds a lot of complexity in understanding how the batteries will be used. So systems that have been put into place with a certain daily use model now can profit from more aggressive use to capitalize on the value stack or 841 revenue streams.

That makes it harder for us to model how the battery is going to be used and how long it will last when we're looking at the reliability case for the batteries. So I think that adds complexity to -- it adds profit incentive -- profit cases for the system owners, and complexity for the vendors.

MR. FLEISHMAN: Okay. Others on the impact that they're seeing of the FERC energy storage rule?

MR. GOLDIN: Still early.

MR. FLEISHMAN: Still early, right. Right. Well, Mark, what's California doing with respect to regulations and implementation of its various mandates and policies, and what could we be doing better?

How about that as a lead in to the California question? Does that work?

MR. STOUT: That works great.

MR. FLEISHMAN: Okay.

MR. STOUT: We are very excited about in the fall the CPC had a decision that all the load-serving entities throughout California would procure a total of 3.3 gigawatts resource adequacy, which, by and large, is going to be energy storage and demand response as the lead technologies.

So really no -- no significant fossil

contributions of the 3.3 gigawatts. And it's -- it's definitely kept us busy. There's a lot of procurement going on. It's -- we call it the RFP tsunami and it keeps coming, and so very exciting times on that. And that's really just getting us started, 3.3 gigawatts, and also the CPUC, as a result -- as a bill-out of the legislature to kind of look at some more of the long-term RFP perspective. You know, they're, I think, currently looking at more like 16 gigawatts total storage procurement in the not very distant future.

So, anyways, that's been going great. I don't know, that's been so -- that's been so big I think anything negative I could come up with would pale in comparison, so I'll just leave it at that.

MR. FLEISHMAN: All right. Anyone else on the California, what are they doing well, what could do they do better question?

MR. HAJABED: Yeah, Mark, I tend to agree with you. I think the only concern that we have is some of the procurements that are happening specifically for storage and standalone storage is disadvantaged by obviously not having the ITC is that storage is being co-located to solar systems that are in the middle of the desert, as opposed to having the majority of those storage systems in the load centers where they're made to solve problems.

MR. STOUT: Good point, Moe. Yeah, that was -- the whole -- so (inaudible) ran a -- they opened up this big material modification assessment opportunity late last year, I think in November. And so if you had PV plants -- these are all the way from online to in development, and it would be online in time for August 1st, 2021, COD. That was the magic date. If you were online by then by co-locating storage by either existing or very mature developed solar, and it was -- there was a lot of gigawatts of MMAs, Material Modification Assessments, done. And I know the SEC procurement was highly oriented towards that, the most recent buys.

It was really if you looked at what was in the queue for standalone storage, that was project sites that were in urban load centers that were, you know, good sites for standalone storage, there just -- I don't know if there was enough capacity for them to get the, you know, they needed -- all the load-serving entities 50 percent of the 3.3 megawatts by August 1st, 2021. And, you know, I think the utilities had to get creative.

MR. FLEISHMAN: Let me follow up on the regulatory front. Last week the FERC issued a very significant order -- well, I'll call it significant -- order 2222 dealing with the aggregation of distributed energy resources and they defined DER, distributed energy resources, among other things, energy storage, demand response, energy efficiency, microgrids, and so forth. And there will be, you know, a long compliance process with the RTOs and ISOs as there was with 841 and energy storage.

Just stepping back, though, what are folks views on how significant the ability to aggregate and bid distributed energy resources into the organized markets? How significant will that be in this space? Recognizing it's very early to tell, and it's a long order and all that. But at a high level of policy view, market view, what do you think?

MR. HAJABED: Maybe I will take that given that we're in the distributed space to a certain extent.

We think it's a big win for the industry, the energy storage industry as a whole, because some of those systems can provide additional benefits for the end user, and being able to (inaudible) front-of-the-meter markets or in front-of-the-meter revenue streams, would make the use case or the business case stand on its feet. But we've yet to see the compliance plan and the proposal and how it's going to get implemented, so we're cautiously optimistic.

MR. FLEISHMAN: Others on that question?

MR. GOLDIN: I expect it's significant, but I think there is a thing that could be of greater significance that is still missing.

MR. FLEISHMAN: What is that?

MR. GOLDIN: In tariff building or in value recognition. So the value of resiliency of energy storage is just not well characterized. So the value of backup power to a energy customer or the value of resiliency, it could be that the -- a microgrid tariff for microgrids that are attached to the grid. So perhaps this 2222 flows through and there can be some recognition of value of resiliency and --

MR. FLEISHMAN: So following up on that, are you thinking that, you know, there are a range of ancillary services at the wholesale level that do different things.

Do you think some of those need to be reshaped or additional ancillary service products need to be developed that would focus more on the resilience benefits of energy storage?

MR. GOLDIN: That sounds like a 3- or 4-year theoretical exercise.

I think the first question that industrial or residential or government customers need to understand is what is the cost to them of having the power go out. So if I were here in California, the power went out because of grid imbalance issues, and it's going out due to fire safety issues in a few days.

So what is the value of keeping the lights on?

MR. FLEISHMAN: So you're focused -- you're thinking more about the immediate issues, important significant issues, wildfires in the west, and impact, and what things could be done to help that situation much more near term?

MR. GOLDIN: It's true. And I think that there are research efforts and there are commercial companies trying to put some value on having the backup and resiliency, and energy storage is a key part of that. And insurance -- you can insure against a grid outage, it's not a common type of insurance. It's not the type of work that my team does, but it's just a poorly understood value. And I think the DOE is leaning on it with large -- Berkeley National Lab has some work on it, and (inaudible) has some work on it. I think that value is of a higher order than some of the ancillary services revenue to the grid that have to work through several layers of regulation.

MR. FLEISHMAN: All right. Any others with thoughts about how the increasing amount of wildfires is impacting empty storage markets and consumers and resilience concerns?

MR. WARNER: I think the challenge from the safety perspective is going to be to make sure we don't create a circular loop where wildfires knock out power, people go out and buy batteries, they install said batteries on their homes of the Urban-Wildland Interface, which two years later causes a fire, which knock out more power, which prompt more people to buy more batteries, ad nauseum.

I think we need to make sure we understand whether it's residential or small commercial systems, but the manner in which we install these units are going to create their own safety hazards and we're properly regulating the residential market, especially those that live at the Wildland-Urban Interface, which is, you know, a big chunk of the state at this point. Don't further create their own safety concerns trying to get away from the grid itself.

MR. STOUT: We're primarily in front-of-meter but just in terms of, I think, the public safety shutoff -- the whole program that has been going on in California about the IOUs, it's definitely created quite a large market for residential solar plus storage. I mean, I think that's one segment that sales are really strong, and some of the residential installers they're almost like residential IPPs have taken advantage of.

So it -- you know, it's a no-brainer. You've got -- you've got so many people getting blacked out so often that aren't in the Wildland Interface, but they're -- the transmission lines serving them are going through the wildfire regions.

MR. FLEISHMAN: I guess following up on that, FERC has been focused on, and many in the industry are focused on for a lot of reasons; hybrid resources, solar and storage, wind and storage, and such.

As between the various kinds of generating resources being paired with storage, what's the future or what's the market for wind plus storage as contrasted with solar. A couple of times we hear folks talk about solar and storage. How about wind and storage?

MR. GOLDIN: It's a real opportunity. We're seeing it in Texas, where there's a heavy wind market, and dramatic price swings for energy. So wind plus storage is growing in Texas. And as offshore winds starts to appear, the opportunity really comes for longer duration storage. So moving power from the weekends to the weekdays, because the wind blows on the weekends and on the weekdays.

MR. STOUT: I agree with Jay. LBL did a recent study. Kind of put up on their website around that research, and the interconnection queues are full of hybrids including very strong wind plus storage, particularly out in the Western U.S.

MR. FLEISHMAN: And just generally following up on the question of queues in the various, let's say, the organized markets. How significant or not are the interconnection queues and the length -- and the size of them as it relates to hybrid resources? And I know it's region by region, but if we can just have some general thoughts about interconnection queue and impacts on hybrid resources, getting the market, getting -- projects getting built? Any thoughts on that?

MR. STOUT: Sure, sure.

MR. FLEISHMAN: I'm not just looking at you, Mark.

MR. STOUT: I'm happy to yield.

MR. FLEISHMAN: That's fine.

MR. STOUT: Anyway, just like we saw with the (inaudible) having the huge, I think it was like 10 gigawatts of storage added to existing solar positions last year. You know, that -- that is a good way to kind of like -- if there's existing solar applications, it's a good way to move ahead in the queue and really accelerate interconnection of storage.

And I'll just -- I mean, in general, hybrids oftentimes just make a lot of sense. You can -- you can take advantage of interconnection capacity and share the cost, and there's just a lot of synergy all around. I would say that you could even -- there's other renewable technologies you can add storage to. I know GE was big on adding storage to the fossil plants. Not our thing, but, you know, that's interesting.

MR. GOLDIN: Yeah, Mark, that's exactly right. I think energy storage to fossil fuel generation sites makes sense for some. But it also -- there's a way to accelerate interconnection by re-purposing fossil generation sites. A lot of coal plants retired. We're seeing -- there's going to be fossil fuel plants retired. The value is the location where the -- our generation is and the interconnection.

MR. STOUT: Right -- in fact -- go ahead, Jay.

MR. GOLDIN: There might be a way -- we're not just been in that process, but if there could be accelerated interconnection queues for re-purposing those interconnections, I think it would accelerate the energy storage market.

MR. STOUT: So just to follow on to that. We -- in July, we acquired a 20-megawatt operational battery plant from AltaGas that was built at -- they had, I think, a 43 megawatt single cycle gas turbine, which was part of the sale process they decommissioned and removed.

So now, you know, we basically have a larger capacity existing interconnection in a 20 megawatt operational battery, so there's -- you can do a lot with that.

MR. FLEISHMAN: We have time for a few more questions. I see one that's come in asking generally:

How are you all financing both merchant storage and solar plus storage projects? Merchant storage and solar plus storage projects.

Any high level thoughts on that? They're different.

MR. STOUT: I'll wait. Let me know when I can go on that.

MR. FLEISHMAN: Jay, Moe, any thoughts on that one?

MR. GOLDIN: I think Mark and Moe, you're the ones who are actually owning and financing.

MR. HAJABED: Maybe I will touch on that. I think financing (inaudible) are evolving as investors are getting a better understanding of storage and the different revenue streams that you're capturing when it comes to storage, especially as it comes down to merchant. And what revenue streams are investors willing to underwrite when it comes to merchant in the first place. In our early days a lot of our financing was done through equity and now we're starting to see more project level financing being put in place where there is a portion of the contract of revenue streams or for (inaudible) of revenue streams that finance is willing to underwrite based on operational experience, and track record and the curve that you're actually underwriting.

So for (inaudible) things are certainly heading in the right direction when it comes to energy storage, and the general understanding of energy storage by investors -- or by the investor community. And, again, we were acquired by Blackstone earlier in the year as a result of them digging in and understanding merchant markets -- or understanding how energy storage can participate in merchant markets a little bit better.

MR. FLEISHMAN: Any further thoughts on that question?

MR. STOUT: Sure. Yeah, so I see Brett Simon had actually asked about financing merchant solar plus storage projects.

MR. FLEISHMAN: Right.

MR. STOUT: Really, I don't see anybody doing -- I mean, it's pretty rare. I think First Solar did a merchant solar with no storage project, but that's a unicorn. That's -- so what you see are solar plus storage projects are, by and large, fully contracted PPAs with revenue streams from the offtaker.

Standalone storage projects, at least in, certainly, in California, tend to be heavily merchant, but many of them, I would say most, have a resource adequacy contract with load serving entity, you know, kind of for a minority of the revenue. So, you know, over 25 percent, but less than 50 percent of the revenue.

MR. FLEISHMAN: Right.

MR. STOUT: And so -- so that kind of gives a fixed component. You know the money's there, and then the rest of it is all -- I guess there's -- there's, you know, enough comfort with the forecasters, and there's a lot of people doing forecasts.

MR. FLEISHMAN: Yep.

MR. STOUT: You know, that -- that between the minority, the revenue that's kind of more secure coming from the RA contracts, and the merchant revenue, that that combination -- to get project financing you might need to have a higher hurdle than if it was like 100 percent contracted, like, a tolling agreement. You could probably have a lower hurdle rate, but, you know, you just have a high hurdle rate. But there's enough money to be made in the merchant market that you can sustain that higher hurdle rate.

MR. FLEISHMAN: Okay. Last question. And this is another in the evolving opportunity bucket.

Recently, MISO has gotten approved the ability to have storage be considered a transmission resource with respect to certain expansion projects.

What are your all views at the wholesale level, if I may, the opportunity to associate with storage as transmission? Last question. It's not quite a lightening round, but last question.

MR. GOLDIN: I suspect that's a good question for your next panel, Bob.

MR. STOUT: Bring on the RFPs.

MR. HAJABED: Yeah, but it makes sense.

MR. FLEISHMAN: Well, I guess that's a good transition to the next panel because we're just about at 3:30 Eastern.

And let me now introduce Brian Greene, who is also a partner at Kirkland & Ellis. He will be moderating the next panel on capital providers.

And, with that, I'm going to go totally on mute. And thank you all panelists.

MR. BAXTER: Hi Brian, you can go ahead now.

MR. GREEN: Okay. Can people hear me and see me on the screen?

MR. BAXTER: Yes, I believe so.

MR. GREENE: Okay. Good.

So my name is Brian Greene. I'm an infrastructure finance partner here in the DC office of Kirkland & Ellis. This panel is capital providers. We really have, I think, an all-star lineup here.

We have an investment banker, two of the premiere investors in the storage -- the solar plus storage space, and a developer who has backing from preeminent -- excuse me, private equity firm.

So without ado, I'll just give a brief introduction to each of them. Our first panelist is Patrick Norton from Javelin Capital. Patrick has experience originating and executing in U.S. renewables energy storage, energy efficiency, and energy technology. He has -- he previously worked at Energy Foundry and Maritime Capital.

Our next panelist is Caleb Waugh. Caleb is the vice president in Macquarie Capital Green Investment Group, and he works in the global energy technology and solutions team. Team focuses on project and equity level investments and good scale energy storage, distribute energy resources and electrical vehicle storage and mobility. He was previously at Lockheed-Martin.

Our third panelist is Tim Larrison from Primergy Energy. Tim is the CFO at Primergy Energy. He has 25 years of experience in the corporate and finance experience in energy, water, and telecommunications. And the past 14 years he's been CFO of a number of different organizations, including, most recently, he was the CFO of ENGIE Storage, which is formally the Green Charge Network.

And our last panelist is Benoit Allehaut from Capital Dynamics. He's the managing director. He's on the Clean Energy Infrastructure team in New York. And he's been involved in a lot of very high profile deals, recently including the Eland project with 8minute Energy and the Switch project in Nevada.

So with without further ado, I will just begin kind of asking our panelists some questions and, you know, we'll let the conversation go from there.

So my first question is to Patrick and the question is this:

If a developer, who is kind of new to the storage space, say they have a solar plus storage project with a big storage component. They come to you and they ask what they need to do to get an investor in their project or their platform. What's your advice to them?

MR. NORTON: Thank you, Brian. Thank you everybody, excited to participate.

I think really the -- you have to -- I would not not try to answer their question with a question, but when you look at solar plus storage or standalone storage, it's easily to group them together. In reality, solar plus storage, there's actually three distinct business models, and some revenue models. And some of them look and feel very similar to a solar project without storage.

And, yes, there's some nuance and, yes, there's some technical considerations, but it should and is financed similarly to how a solar project would be financed. So that's one end of the continuum. You go all the way to the other end of the continuum. And then there's solar projects and storage projects that just really happen to have the same point of interconnect.

And those ones you can -- the solar project and storage project acting independently of one another, the storage project would have -- would it or would it not be eligible for IPC, it's an ongoing question with a lot of nuance. How does the storage side of the equation make money? In all likelihood, it's probably in the ancillary real-time day ahead and capacity markets, which are much more merchant.

And you start to blend those two, and you have the traditional solar investors that like -- that prefer and have underwritten several times the standard revenue that's highly contracted utility or corporate type PPAs, and then you have another bunch of revenue that's merchant, and investors that underwrite those.

And you look at that as a (inaudible) diagram, there's not a huge overlap, so it does take a lot of time and consideration from the very beginning as a developer of thinking about your revenue strategy, how that would be perceived, and where there's overlap between those two, in most cases, mutually exclusive investor sets.

MR. GREENE: Actually, I think what you're talking there is kind of the complexity of a solar plus storage project where there are a bunch of different revenue streams.

Benoit, you know, I'll ask you, you know, you've been involved in a number of pretty high profile deals recently. Can you talk a little bit more about how a storage plus solar project with a big storage component or a standalone storage project is different and more complicated than just a, you know, just a typical solar project?

MR. ALLEHAUT: Sure. So, you know, we have seven projects on the construction right now, and we have nine project in development in a partnership with Tenaska, so roughly 2.9 gigawatt hours on the construction and eight gigawatt hours in development.

We started three years ago with the interest in really understanding inside out how storage works. And what we saw and the organization we built was really beefing up significantly versus what we see in solar. As an organization, we have almost 100 people, but there's a lot of work being done on storage because the first effort is really scaled up integration. And especially when you have solar and storage linked up, you need to have the two components talking to one another, so that you don't exceed your interconnection point limit, which is a giant no-no.

In solar, you're relatively passive as a producer; in storage you're not. So the integration with the energy manager -- and we work really closely with Tenaska on that, and being able to take decision on charging and discharging is pretty critical.

And then the reality is that storage is an equipment that needs to be operated with really, really careful operating parameters. State of charge and cycles and the likes, but then even in the design, you know, we've seen all kinds of technologies, all kinds of chemistries. You have to look at ESG and the question of cobalts. You have to look at whether you work with a system integrator or not. You need to look at credits, you know, for as much as I love Tesla, they burn a lot of cash, but we bought a lot of megapacks. What kind of battery augmentation strategy.

So we're massive investors in solar and we're going to have a very large portfolio in hybrid plants as well as standalone plants, but it's really all hands on deck in terms of putting it together.

MR. GREENE: Okay. Tim, I think Benoit started to talk about the energy managers and the wraps and the kind of track record and experience of the contractors and manufacturers.

You began your career working on thermal projects back in the '90s. How have you applied the lessons that you've learned on those deals to your new career as a battery storage developer?

MR. LARRISON: You know, the biggest thing for me is not what should you do, it's what you shouldn't do. And my experience, and I think a lot of people who have those, you know, who have a lot of energy experience would say, Don't make too big of a bed out of aggressive merchant curves.

And I think a lot of people are talking about, you know, standalone storage, and these are merchant assets. They're like old gas peakers, but they're more complicated. And, Brian, as you and I discussed, they're old gas peakers that are more complicated without Siemens and GE standing behind those assets for 25 years.

And then you layer on top of that this concept of SCADA or energy management systems in the new parlance of energy storage, which is, you know, a wildly complicated piece of software to make these things operate. And if you're participating these in the energy markets and the wholesale markets, layering very complicated software on top of an unproven asset with, you know, a lot of companies don't have the compliance teams that the banks or, you know, the old merchant energy companies had. It takes a lot of care.

I joke that if you don't have a couple people from Enron on your team and you're thinking you're going to participate these in the wholesale markets, you should -- you should think long and hard about it.

MR. GREENE: Just a couple days ago, Wood

Mackenzie came out with their third quarter 2020 report, and it had an interesting comment that I'm going operations and maintenance contracts, as well as, preventative maintenance, service key differentiators for integrators. Those who can take on more risk and mitigate it through hardware and software expertise have a leg up over their competition.

You know, given what both of you said there, at this point in 2020, what value do developers and investors put on a wrap, or is it something that, you know, you think still -- you know, the companies are still rep developing a track record in a couple years before that is kind of one year, you know, primary considerations in determining whether to investment or go forward with the project?

MR. LARRISON: I've got -- when you talk about wrapping a battery energy system, it's, you know, obviously the devil's in the detail on it and what the wrap looks like. But it also comes down to, you know, the balance sheets of suppliers right now and integrators.

As I said, there is no GE or Siemens in the market today. So it's kind of, you know, can you get a wrap from a big EPC that actually covers your risks, you know. In many cases I take the balance sheet of the EPC over many of the suppliers on the market today, but that's from our perspective.

MR. ALLEHAUT: I'll just add a few things. First of all, there's Siemens on the market, that's, I think, (inaudible) would agree not to be recognized for that. There are additional wraps available. We've put (inaudible) on quite a few of our projects, on top of Tesla.

I think, overall, long-term contractual service agreements are preferable from prudent investors. A lot of the battery is really very careful design up front, where you overbuild the project. It's part of the ITC strategy. So the reality is that you are at 115, 120 percent and your sell towards a capacity decline that you'll change after a couple of years.

But to echo what Tim said, you have to be very careful around Ts and Cs. We spent an entire year writing the contracts. So we didn't accept what we come out of the market we wrote it, and we ran a very, very comprehensive RFP.

You know, at the same time I hope we don't live in a world of GE. I've worked for GE. I have GE equipment. It falls all the time. You know, I would rather not have the technicians come on a regular basis. So we are looking at, carefully, at performance. And, you know, truth be said, the availability of a megapack right now based on available data is pretty good.

But, you know, it is still emerging technologies and it requires a lot of oversight.

MR. LARRISON: I'll take your point on Siemens, it's a fair one. You know, having come from a company where we operate a lot of these systems, you know, over a period of sort of six or seven years. They break down, is what I would say. And, you know, it -- a lot of technicians in the field, a lot. And, you know, again, it's a new technology as you said, but it's --

MR. ALLEHAUT: There is -- there is, though, one thing that is quite interesting with batteries, and it's something quite similar to solar, and that's the modularity aspect. So I own wind, and, you know, when one single wind turbine goes down, it takes an entire string. And it's really, really aggravating.

When you have a single sort of panel that goes down on a field, you don't even seen it. For the very simple reason of the DC/AC ratio overbuild. On the storage side, you know, the maximum modular we see is 3 megawatts. So when you have a very large system, you will potentially have individual failures, but it's not like you're taking down an entire 7FA gas turbine.

So the (inaudible) aspect is something that is often not quite picked up. And it's interesting as well to think about storage system with inherently some overbuilts within these batteries, and being able to supplement through software an individual module going down.

But, again, there's a lot of nooks and crannies, and it will require a lot of oversight. But I also recall when I started in solar and everybody was afraid of it, and, you know, it was an experienced curve and it's pushing down best practice.

MR. GREENE: Caleb. Question for you.

What are the key challenges for energy storage at this stage in 2020? You know, both in terms of regulatory and technological challenges and what's holding you and other investors from making a -- more of an investment in energy storage or solar plus storage at this point.

MR. WAUGH: Yes, certainly. Thanks, Brian.

I'll probably just focus on challenges largely from a financing standpoint. I think Tim hit on it pretty well. There still is quite a bit of challenge getting comfortable with the nature of project level risk and merchant risks because fundamentally it is a different type of merchant risk and exposure than solar.

When you're betting on forward curves around batteries, you're primarily betting around ancillary service value and future energy price volatility. That's quite different than just betting on, you know, average energy prices, you know, on or off peak hours as, you know, you might with a solar project. And so that continues to be -- to be a large challenge.

I think that it just takes time to get comfortable with, and it really takes time to really quantify those challenges and understand them. So I think there is a need to reduce or better understand the nature of that risk, so that it can be, you know, properly -- properly, you know, valued and evaluated, you know, when you're looking at project economics.

I think that's true on the grid scale side, you know, certainly for large, you know, scale batteries or standalone batteries or batteries paired with solar. I think in some ways it could also be true on the distributed side. Many of those projects you're making bets around abilities to reduce customer's demand charges.

You do the paper exercise. You do the analytics. You know, you show all the peak shaving, it looks like great. When it comes time to who's actually going to stand by and back whatever that savings might be, oftentimes a customer may want some sort of savings guarantee, then the project owner/developer is trying to sell that, would rather, you know, that risk be on the customer side, and so there's -- I think there's still some -- I'm figuring out just how to address that on the distributed side.

From technology, there's certainly still, I think, some growing pains with lithium-ion, but I think, by and large, investors are fairly comfortable with a lot of the tier 1 battery providers and integrators. You know, still some things to be ironed out, but we're, I think, in a fairly good spot.

I think the biggest challenge there is there's a lot of emerging new storage technologies, both batteries and others, that can be very competitive and address a lot of future applications we see for batteries, especially around long-duration storage.

And I think a biggest challenge from the technical side is that those developers -- those technology developers are going to face is really getting to a point of technology bankability. And so you may have a technology, it works great, you prove it in a lab, it's been operating a year. Taking that next big step to really bring in large amounts of project financing to back that technology when the business case is depending on its last, you know, 10, 15, 20 years, I think that's going to be the next big challenges from a technology standpoint.

MR. LARRISON: Yeah, it's interesting, Caleb, when you talk about distributing and, you know, you can have the best software in the world and I know you guys had the MS portfolio for awhile, and I think you probably feel pretty good that there is an underlying contract with the LCR underneath it. Because when you start projecting out things like peak shaving for behind-the-meter storage applications, and thinking about financing that, it's a long stretch, right, it's --

MR. WAUGH: Yeah.

MR. LARRISON: You know, again, my previous life, you know, running hundred of those things. They're -- they don't really operate the way you think they're going to operate or the way the software engineers think they're going to operate. So I think it's a big challenge, I think, just for behind-the-meter. And then when you go in front of these larger utility scale and, you know, the punishment is not just missing revenue, but if you actually are in the wholesale markets and you miss windows in the wholesale market, you have bigger problems.

MR. WAUGH: Absolutely. And I think one thing

I found, if you're looking for kind of a blueprint for the type of structure you would like to see in a project, I think, in general, the most successful projects are one in which you have at least some basis of contracted revenue that you can raise debt against.

And, yeah, I mean, it can be, you know, 30 to 50 percent. But at least you have some basis upon which, you know, you are benchmarking that against a much cheaper cost of capital. And, certainly, yeah, you're open to taking on some of that merchant risk, you're certainly open to kind of taking on that exposure. You're probably going to discount that value quite a bit until you get fairly comfortable with, you know, it's going to be a much higher return of expectation on that.

But, in general, if you can find places where you can kind of pair at least a steady contracted cash flow enough, you know, to raise, you know, to raise debt against, I think -- I think there's enough comfort now to be fine taking on at least some level of merchant exposure.

MR. ALLEHAUT: I think the important piece is -- and Caleb you touched upon it -- the word merchant is slightly misleading; the right word is really volatility. And the interesting aspect in markets like (inaudible), is that the retirement of thermal is just adding tremendous volatility.

And that's really the big conundrum that on one side we talk about decarbonization, but on the other side of the ledger you have intermittency. And attached to the intermittency is climate change. And what was an exceptional year of fire becomes every summer a year of fires.

So when we worked with Tenaska on the acquisition of their development portfolio, all of these batteries are located on the coast. So it's really hard, I'll tell you, to acquire real estate in San Francisco or San Diego or LA, but what you have is a giant movement of what was thermal on the coast next to the load to renewable energy assets in the desert, and it all relies on transmission lines. And when these transmission lines have problems, you know, you basically see huge basis differential and volatility in the market.

And as you project yourself around compliance in (inaudible), you have to build a huge amount of batteries to start chipping at the (inaudible) curve. So that's some of the fundamentals are really driven by regulation, and I don't think volatility is there (inaudible) in California.

(Talking over one another)

MR. NORTON: I have a counter point to Tim and Caleb's piece of ideal structure being a little bit of debt and having a base of contractedness. So, yes, certainly, I think that is one of the business models. But I think the thing we think about -- or maybe lose sight of are two things with energy storage.

First, is it's not uniform. And there's not even -- there's tons of different revenue profiles, but even more fundamentally there's -- people can use them fundamentally differently. So, yes, there are resource adequacy type contracts, but they can also be financial option machines, they can be generation hedge machines, they can be a piece of T&D equipment.

So when you have that much variability in just the core use case, the revenue case then propagate from there, is we as an industry need to move past trying to shoehorn every energy storage asset as an infrastructure asset; they're not. The vast majority of them are not. They are uncontracted, volatility capturing, ancillary service machines.

And so I think that's the biggest issue I -- we see, is investors coming from renewables is trying to take their paradigm that worked in renewables, and apply it to an asset class that really isn't the same. And so

I think that's -- one piece as we get a lot of people on the line here is just to echo that point. Kind of consistently, we've been shouting it from the rooftops for three years now.

MR. LARRISON: It's a great point. Because -- and I think that the point, Patrick, is that there is no business model for energy storage. I wish -- just from my seat as the CFO, I wish that every project was like our Gemini project. Where it's 25 years of contracted revenue with NV Energy. It makes my life very easy to to (inaudible) 4 gigawatt hours of storage and 25 PPA with NV Energy, right?

But the reality is from my past years' experience is the business models are different from market to market, and maybe even locale to locale. So I think Benoit was getting at what --

MR. NORTON: Definitely.

MR. LARRISON: -- you need in Southern California is very different than what you need in western Massachusetts.

MR. ALLEHAUT: I just want to echo what Patrick said, because I'm just amazed that people do lessons learned from California and think it applies everywhere. I just -- we pass on every single storage project at ERCOT. I just don't understand. We know the

ERCOT market well. I don't understand the logic at all.

And, you know, maybe I'm wrong. I've been wrong, you know, in the past. But it feels like people are adopting blueprints and they think it's the same everywhere. And I agree with Tim, we have a whole bunch of tolling agreements. They're great. But you also have to build the project well. So that's what keeps everybody away, because build well, get in on time, good quality. That's already half of the journey.

MR. WAUGH: Yeah, I certainly agree with the point that I think every market certainly is very much different and introduces different market dynamics.

On the flip side, I think there are some things that we do see that are somewhat uncommon by markets. But probably, primarily, is that the highest value opportunities in most markets are always first in ancillary services, and then kind of second in energy, if you kind of look at a market specific (inaudible) for, like, revenue stack. And if you kind of do that, co-optimize exercise across the different revenue stacks, I think we would still see a lot of those.

Like today being primarily driven by ancillary services with the expectation that over time that will shift more and more to kind of an energy market. So I think the biggest challenge today is that if you are to do kind of a project which is merchant, you are kind of bet on a couple things.

You're betting on the time that it takes kind of those very shallow ancillary service markets to saturate, you know, very similar to what we had seen in PJM. And kind of the time that it takes for a lot of that volatility to potentially increase with the incorporation of renewables.

And then you're also making a bet against kind of the continued cost reduction of future storage build, that eventually will actually start depressing the kind of arbitrage spreads. So I think it's kind of in a high level, there's a lot of things we think about as far as kind of the type of exposure, understanding the way that those kind of trends unfold in each market will be very, very market specific and kind of dependent on its resource build.

MR. ALLEHAUT: And, Caleb, you were saying something very important. It's better to be in an environment where the return is a declining balance than the pseudo hockey stick, so...

MR. WAUGH: Absolutely, yeah.

MR. ALLEHAUT: I'll take that any day.

MR. WAUGH: Absolutely.

MR. GREENE: Our last panel question for this panel which is the future of energy storage is transmission.

You know, wanted to get your thoughts about that and what markets you might see that happen outside of, you know, maybe California. And, you know, second kind of everyone's seen a lot of activity in places like Hawaii, in the residential side in California and Nevada. What other states in the coming year or two do you see growth in energy storage or storage plus solar projects?

MR. ALLEHAUT: Brian, I think what's interesting is that when you do development and you see the type of transmission upgrades, in some places you have to face, for the time you have to wait until you get your transmission upgrade. You just realize that, you know, it's -- it's a problem. And the extraordinary potential benefit of storage is, you know, on the rate basing approach to unclog transmission and make its use more efficient.

So I think it's very nascent, these value proposition are, you know, being whispered. But in places where you have some of these congestions that can be addressed by shifting, you know, some of the transmission usage, it really becomes interesting. Because I remember him saying when you start a transmission project, you know, your kids will finish it. That's pretty long. So situations where you can address it, you know, with storage, it's really beneficial to the overall market efficiency.

MR. GREENE: Are there enough markets right now where there's the regulatory system will actually provide the right incentives or is that something that we're going to need to see develop over --

MR. LARRISON: I was going to say, Benoit, you need to answer the question of where you're going.

MR. ALLEHAUT: As I say, it's being whispered. You have to lead into here. No, but a good example is folks are talking about, you know, using storage in lieu of transmission in the Bay Area. So, you know, some of these short-term transmission lines are incredibly expensive. So there are these, you know, these opportunities as the grid changes, you know, you find yourself with natural transmission constraints. But, you know, anything that comes as a BTA or rate based, you know, it's always, you know, a long journey on the regulatory side.

MR. LARRISON: The regulatory environment I think is very, very challenging right now. And I don't -- I don't think that various regulators have fully thought through the implications of storage. You know, I think there's tremendous work going on and that, you know, we'll eventually get there, but, boy, it -- I think there's some battles ahead in how -- you know, how batteries are going to work for transitioning assets, and hopefully they do get rate based and in the appropriate places, but I think there's a real battle that needs to be fought going forward in the various markets across the country, because the regulatory environment is not -- it just isn't there yet.

MR. NORTON: And from my perspective, Brian, I that's a good question. I think there's going to be a much bigger fork in storage than there was in other forms of generation. In terms of there's going to be develop, build, transfer and the utility is the ultimate owner of the pole and line regulated utility. I think that's going to happen much more frequently.

There's a lot of -- there's 50 different PUCs, and each one will have a different view. I think a decent number of them will say, Okay, this is P&D, let's rate base it. And I do think there's people with their pen over the paper right now waiting for us to say a state, so I will, for the third-party owned. So I think other than the ones that are prominent now, and there's deals that are either getting done or in market now. I think Virginia, upper New England, and select parts of

MISO are the next waive of third-party owned projects.

MR. LARRISON: So I agree. And people don't talk about it enough, because I'll go out on a limb here. I think they are furthest along as far as regulatory environment on how to use batteries in the market, which could be debatable, but that's what I've been feeling that ISO New England has done a really bang up job in setting the regulatory plate for storage and solar plus storage.

Smaller markets, Caleb, as you said, I think some of the ancillary markets are super shallow, but it's a good one. Smaller assets but a good one.

MR. ALLEHAUT: And by the way, just when you have utilities sponsoring storage for EV charging, you know, in effect, it's a little bit like storage in New York transmission.

So it's interesting that, you know, they are pushing quite hard in that direction.

MR. GREENE: I don't know if anyone saw, you know, while we've been at this conference, Governor Newsom in California announced that there was going to be a requirement that there are no -- no gas cars or trucks after -- sold after 2035 in California.

I wanted to see if anyone had any kind of immediate thoughts on that and whether that would kind of help further bolster the market.

MR. LARRISON: It's a perfect -- just real quick, it's a perfect regulatory issue, right, to me. Which is let behind-the-meter storage assets, whether it be chargers or CNI energy storage assets export to the market. And if they can't export to the market, then you're leaving a ton of value on the table. And I think it slows down deployment for third-party owners.

MR. ALLEHAUT: I just recommend to everybody to look at the Tesla Semi. I mean, it hasn't come out, but really look at the Daimler Cascadia or the BYD, ATT, all of these things. It's coming super fast. It's pretty impressive. And we're going to see, you know, Class A, Class 7, Class 6. All of these things are coming. So the reason why he made that announcement is he knows it's coming.

MR. GREENE: Patrick, one more question for you. We had talked about kind of the universe of investors. You know, at this stage, compared to kind of the number of investors that you could go out to for a solar project, how many investors are interested in a, you know, standalone storage project in a, you know, solar plus storage -- you know, co-located or a very large battery?

MR. NORTON: So on the standalone, I think the standalone's third project -- and we have very recent experience of this -- is the level of interest is exceptionally high. But you should anticipate that your batting average is kind of in the Randy Johnson range, so it's going to be quite low, the number of folks that can put through a qualified bid.

Again, a lot of it comes from relative newness, a paradigm at which people used for the past kind of eight to ten years, the renewables, it's tough to transfer some of those. And then last is a lot of cases they have LP commitments, and those LPs have certain requirements on what they can and cannot invest in.

And so it just requires a little bit of evolution. So it's still -- even though the interest is high, the true number of equity, preferred equity, kind of corporate level investors, and senior debt, are improving. I'm actually impressed of how well particularly on the debt side, how much things have advanced in the past 12 months. But it will get there.

As an industry as a whole, operating end value will increase, IE reports authored will increase, and more and more capital will come in, and it will become more well-known over time. I can't say with certainty it will be a lower cost of capital, but there's a -- I think a lot of signs pointing towards that and that just comes with competitive tension that's here, and here and live and standalone -- and just solar. And so I think that's -- it's coming and there's a lot -- no shortage of interest that there can at times be a shortage of qualified interest.

MR. ALLEHAUT: Yeah, I think there's definitely less storage assets available than there is in solar. There's a lot of bad solar projects out there as well. Anybody can put an interconnection application, but very, very few people know how to do the procurements and the design of a battery, how to put an energy management contract.

So it's not surprising to see LS power, Vestra, folks like this, like ourselves, really, you know, right now have a pretty big footprint. There's a whole bunch of platforms for sale. You know, we see this with key capture and others. So people, you know, are thinking about that, you know, broader play, but individual assets available are few and far between for sure, and it's -- it's a very specialized set of investors who have scale and it's variance or some experience.

MR. GREENE: Couple times in this conversation people have touched on the energy manager role which, you know, for, you know, a solar project either doesn't exist or is minimal in battery storage, it can be very poor. And so maybe you can -- someone can talk about kind of what part energy manager role plays, whether there are certain, you know, companies that build a track record, and kind of the, you know, different factors that you look for in a project, you know, where that weighs with other things like, you know, the wrap or, you know, other kind of critical risks in how you structure a deal.

MR. ALLEHAUT: I'll start. It's really massive. You know, you have TPS, Tenaska Power Services, you have (inaudible). You have a bunch of guys, I think, that can do it. When you look at how revenue gets formed, you know, from scheduling in ancillary services, a lot of it is -- is power in the five-minute range.

So when you start in battery, you think, oh, I'm buying at 1:00 p.m. and I'm selling at 7:00. It's way more complicated than that. There's a lot of machine learning. This is not about a guy sitting at a desk doing trading. So, you know, it's -- but at the same time, as an owner, you also have to have the infrastructure to set uprighting limits.

You know, there was a good example this summer where, you know, the market was, you know, very, very high, and the real time market was horrible because PG&E, you know, moved out a huge amount of load. So it's something, you know, you have to monitor the person who manages on the energy side. You have to create the incentives and at the same time, you know, do that risk management.

MR. LARRISON: I would love to hear what Caleb says given the experience with AMS. But, you know, it takes -- Benoit, the risk management piece is critical, critical sort of old energy with new technology on it. The new technology, which is the software interface, is -- just cannot be understated, right? It is a -- I know, again, at my previous employer we spent seven years and had 20 Silicon Valley software engineers working all the time to build out that -- that -- that energy management piece. It is very, very complicated and costly. And once you make a bed, it's very hard to remove that software from the storage system.

MR. NORTON: And I would add that when you think about the energy management piece of an asset, that, air quotes, merchant, we use the term non-contracted, but that has exposure, market exposure, that it's really one of the critical pieces.

If you invest in -- directly in a project or you invest in a platform that owns and operates standalone storage projects with meaningful -- with not that much of contracted revenue, it's either the most or one of the most important aspects.

And the necessity or -- anything this is an industry early in the maturation cycle. So I think you can be good or pretty good at trading and still make a good amount of money. As it becomes more competitive, I think you have to be excellent to make any money on the trading side.

So having, you know, whether it's internally, probably internally, or externally, having that capability improving your algorithms, your system, your trading philosophy now, I think is a meaningful advantage that you can make a lot of money now, but importantly it will be a key defensive piece as more and more people move into the storage space.

MR. ALLEHAUT: The one thing I'll say, Patrick, is that, you know, the market has some kind of natural inefficiencies that everybody benefit from. You know, the reality is when you have intermittency when you look at particular cycles of spring, you know, with a lot of intermittent resource, but at the same time, you know, a thinner load. You basically start to see periods where everybody -- you know, you have to be really, really, really bad, you know, not to generate some revenues.

But to your point, then there is, you know, return, you know, getting some better return. The other issue is really on the software development. It's -- if everybody worked with the same software, then nobody has a competitive advantage. So, you know, you also have to have your own algorithm so that you're not turning into a passive investor.

MR. WAUGH: I would say what we've observed, the nature of software for trying to optimize against kind of peek demand charges and (inaudible) application is definitely quite different than if you're trying to optimize in a wholesale market. What we've seen at least kind of for wholesale market, there's a couple projects particularly in California now that are operational, you can go onto the FERC website, you can actually pull up, you know, operation, how well they performed.

You know, there is a trend that over, you know, the last three years that some of these -- the amount of revenue captured versus, you know, what one thinks optimally is available has improved over time, and some of those have been projects where they actually are not using algorithmic trading. It is, you know, kind of traditional trading, but there is trading kind of against both, you know, (inaudible) in real-time market.

So that's an interesting observation. I think there is something to be said that you can -- you can become over aligned on kind of computerized or algorithmic trading to the point where, you know, there is a need for somebody, I think, to oversee that and watch that and, you know, add that human element, you know, just -- there's some things that, you know, potentially algorithmic trading can't capture that you may want to think about.

But, yeah, I think in general we've seen kind of the ability of those platforms that capture value improving and it will be interesting to see what happens when you have many, many people competing for the same high price events collectively as you have more and more market entrance.

(Talking over one another.)

MR. ALLEHAUT: Sorry, I was going to say on the technical side, you know, hybrid plants are very interesting because what you have is a bunch of inverters that are solving to an MPPT with line losses to get to a point of interconnection.

And now suddenly you add all of these

inverters plus the battery that does injection and discharge. And I said it earlier, don't exceed your point of interconnection. Basically, now what you have is an oversized DC system with an oversized supplementary AC system. And it's going to be interesting to see if this is done well or if, you know, you find out that the software integration of solar and storage are, you know, comes with expensive hiccups because the fines are pretty substantial.

MR. GREENE: Tim, I think you and I talked about it in addition to the interconnection issue, there's your warranty and making sure, you know, how you're using the battery doesn't, you know, void your -- your warranties of the use case that was expected. So seems to me that's obviously another, you know, barrier in terms of, you know, possibility for --

MR. LARRISON: Yeah, and, again, this goes back to my initial statement. I appreciate that you, you know, it's difficult to work with (inaudible) make money from their -- their O&M agreements, but you knew they were going to be there. And, again, my experience with operating batteries. We use both integrators and we integrated ourselves, both models.

The inverters break down a lot if you don't operate the battery a certain way on tested technology.

Sometimes the batteries don't work. And if you don't have a good integrator, everyone's pointing fingers at one another, and it's -- it's an expensive problem.

Again, new technology and that the -- the need to have that performance guarantee over an extended period of time on a large investment, I don't know how you get away from it today. And long-term performance guarantees agreements, again, from my seat need to be backed up by a balance sheet.

And, again, GE was a pain in everybody's butt forever, but you knew they were going to be there. So I'm not quite sure who that -- that -- that partner is today in the energy storage business.

MR. GREENE: I think we've gone a couple minutes over here. I'll kind of let anyone who wants to give some final thoughts, you know, go ahead. Otherwise I know Bob have been kind of popping back up on the screen, and I don't know if he or Richard are planning on giving any closing remarks here.

MR. FLEISHMAN: Not from me, but I do pass the baton to Richard. He's the maestro here. Richard?

MR. BAXTER: No, I think this has been wonderful. We let it go because in person or on the web this has been a fantastic talk.

So I think, Brian, it's a great idea that we let everybody here have their final points, and then I'll close it out.

MR. ALLEHAUT: I'll just make one comment. I was at GE when we financed the largest solar project in the world in 1997 and that was Serpa in Portugal and that was 11 megawatts. So that was not a long time ago, and what amazes me being in this sector and even having this conference is the technology changed, how things changed is just mind blowing. So the reality is that you start in power and you're told you can't store power except for hydro, and what we're seeing right now is just a massive paradigm shift.

MR. LARRISON: I agree with that. The paradigm shift is tremendous and, you know, also living through the '90s when the energy markets were changing so rapidly and dramatically. It really, what's happening now, pales in comparison, and it couldn't be a more exciting place, dynamic industry to be in with the new technology that's being introduced and the amount of capital that's come into the market, and I believe will continue to flow into the market.

And it will take people building good projects to make sure that -- that -- the capital continues to flow into the market like we've seen, and, you know, I just -- I believe that it's -- it's a very exciting crossroads that we're at.

MR. NORTON: From my perspective, echoing everything that you guys said, this is a very interesting time. I think the fact that there are several different markets, each of which has a very distinct semi non-transferable business model, creates a lot of market dislocation. And whenever there's market dislocation, and whenever there's an industry early in its maturation cycle that should have a big light-up sign that says, "Opportunity."

So there's a lot of opportunity out there. It just takes a lot of time, creativity, and to get up to speed, but I agree that this is -- this is here, and it's going to only grow.

MR. WAUGH: Yeah, I think that sums it up for me. We're in the trees for all of the kind of near term challenges, but I think we're still going through growing pains was one does in a new and maturing industry. 30,000-foot view, though. All the market fundamentals are sound, and we'll just continue improving.

MR. BAXTER: Great. Thank you very much. Actually, Brian, did you have anything you wanted to add?

MR. GREENE: Turn it over to you, Richard.

MR. BAXTER: Okay. All right. Well, thank you very much for staying with us here.

Sort of our next steps. After this we'll be sending out in a little bit the -- an e-mail to everyone with the slides and a link to the video. We'll also have -- we're going -- this is the -- so right now we're all in San Francisco.

In January, we'll be having our New York conference. And so we'll be sending out the Save the Dates for that one as well very soon, and so you can look for that and then follow it for the registration. And then afterwards, you know, a lot of this what we're trying to do is -- what I've been trying to do with these is to -- exactly what we've seen here: Provide a platform for people to showcase what's really important, and not necessarily everybody saying I have the right answer. No one has the right answer. And if you do wait until tomorrow, it will be different.

So what we all need to do is just figure out some really interesting lessons learned and I'll be reaching out to a number of you for further insights, and so I look forward to seeing everybody again in January. And this -- I know you can't hear me, but I'm going to clap, and say thank you very much to everybody who participated.

(End of audio file.)

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COUNTY OF KOOTENAI)

I, Valerie Nunemacher, a duly certified court reporter, DO HEREBY CERTIFY:

That I transcribed the foregoing proceedings from an electronic recording of said proceeding and that the above and foregoing transcript is a full, true and correct record of said proceedings to the best of my ability, except where noted "unintelligible" or "inaudible."

Dated this 2nd day of October, 2020.

VALERIE NUNEMACHER, RPR, CSR

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