

In the Matter Of:

ENERGY STORAGE FINANCING SUMMIT

VIDEO TRANSCRIPTION

September 22, 2020



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UNITED STATES DEPARTMENT OF ENERGY

STORAGE FINANCING SUMMIT

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VIA VIDEOCONFERENCE

ON

SEPTEMBER 22-23, 2020

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TRANSCRIBED VIA DIGITAL MEDIA BY:

VALERIE NUNEMACHER, RPR, CSR

1 ENERGY STORAGE FINANCING SUMMIT

2 SEPTEMBER 22, 2020

3 Day 1

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5
6 MR. CHAUDHRY: We should get started. Good
7 morning everyone, or for those on the East Coast, good
8 afternoon everyone. I am Rohit Chaudhry.

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

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

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

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

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

10 Over the first quarter of 2020 saw a
11 23 percent quarter-over-quarter decrease in U.S. storage
12 deployments. The second quarter of 2020 saw a
13 28 percent quarter-over-quarter increase, and a
14 72 percent year-over-year increase. The second quarter
15 saw nearly 170 megawatts of total deployments.

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

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

23 But in the first quarter, it was
24 behind-the-meter segment reboosted the storage market.
25 When the U.S. market saw an overall decrease in the

1 first quarter, behind-the-meter deployments continued to
2 face with the residential side experiencing its fourth
3 consecutive record quarter and the nonresidential side
4 boasting its third strongest quarter ever. On the
5 residential segment held onto the momentum and recorded
6 it's fifth straight record quarter in this year.

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

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

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

23 On the technology front, Lithium ion batteries
24 continue to dominate the market with a 98.6 percent
25 share in Q2 of 2020, and price is expected to decline by

1 more than 10 percent in 2022. But there's more work, of
2 course, to be done.

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

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

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

22 MR. BAXTER: Thank you, Rohit.

23 Well, welcome everybody to, virtually, to San
24 Francisco. This is our ninth Energy Storage Financing
25 Summit series that we've had. This -- this one will be

1 doing the workshop today and then the summit tomorrow.

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

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

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

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

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

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

1 the Department of Energy, Office of Electricity.

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

8 I have problems controlling my up and down.

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

11 DR. GYUK: Just do next.

12 MR. CHAUDHRY: There you go.

13 DR. GYUK: Okay. Good enough.

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

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

1 raises a number of concern.

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

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

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

24 So the DOE program works very seriously on
25 safety and reliability. But we also work on developing

1 new storage technologies that are safer and more
2 cost-effective and environmentally acceptable to begin
3 with.

4 One of the ventures that we are putting into
5 effect is the Grid Storage Launchpad. This is a big
6 \$90 million or so venture at Pacific Northwest
7 Laboratory, which will be devoted towards validating and
8 testing new generation storage material, de-risking and
9 speeding development of new technologies, and
10 collaborating with industry and other institutions.
11 It's going to be big; 70 to 100 work stations.

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

16 So here are some of the examples that we're
17 working on. And I will not do them in detail, but zinc
18 manganese oxide is one of them. Zinc manganese oxide as
19 a primary battery are quite common. There are
20 10 billion units on the market at the moment.

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

1 are fairly earth abundant.

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

25 Now, we have a lot of these innovative pilots

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

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

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

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

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

11 But along with this, an urgent situation is
12 developing. Thirty states have set renewable energy
13 goals, and some of these goals are very ambitious. Like
14 total decarbonization by 2030 or maybe 2040. Overall,
15 one can expect that we might be as low as -- as high as
16 50 percent in terms of renewable energy.

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

23 The beginnings of looking into this are
24 already there -- well, pumped hydro, of course -- but
25 DOE-ARPA-E has the DAYS program. CEC has solicitations

1 for long-duration storage behind-the-meter and
2 elsewhere. And our energy storage program at the
3 Department of Energy is seriously looking into
4 long-duration storage.

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

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

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

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

25 Non-lithium technologies, particularly flow

1 batteries, under consideration, vanadium, zinc,
2 zinc-manganese. These are all technologies that are
3 suitable for longer durations. Other technologies, such
4 as, Ambri, are in the work too.

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

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

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

24 But the main question is still, even if we
25 solve the technology, what is the business case? How

1 are we going to justify having energy sitting around for
2 weeks? Because mostly money is being made when you
3 either put energy into storage or take it out of
4 storage.

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

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

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

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

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

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

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

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

10 MR. BAXTER: Another question.

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

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

25 MR. BAXTER: Okay. Thank you.

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

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

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

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

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

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

6 Lead acid batteries are something like
7 98 percent re-useable. The lead is smelted. The
8 battery liquid is recycled, you know, that's the kind of
9 technology we would like to have if we can have it. But
10 having to continually bring in new resources through
11 mining, et cetera, and having large amounts of waste
12 accruing is just not the right way to go. Afterall,
13 remember, we are doing all of this so that we can reduce
14 the carbon footprint and by having a large amount of
15 waste we are not helping the environment.

16 MR. BAXTER: Thank you.

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

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

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

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

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

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

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

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

21 We're going to have our break now. So we'll
22 put up a slide and then I think if everybody could come
23 back at 11:00 o'clock Pacific, noon Mountain,
24 1:00 o'clock Central -- wait, yeah -- and 2:00 o'clock
25 Eastern, sorry. And then we'll start with the -- the

1 Energy Storage Valuation Workshop.

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

4 (Break in meeting.)

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

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

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

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

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

1 barrier to widespread adoption.

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

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

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

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

24 Software almost dedicate energy storage
25 analytics team at Sandia under DOE energy storage

1 program has been conducting evaluation studies for
2 energy storage. And after developing a framework for
3 conducting these studies, the team (inaudible)
4 formulation that could be generalized into it, too. And
5 in September 2018 we publicly release the first version
6 of QuEST, which included market valuation application in
7 addition to a data acquisition. In 2019 we also added
8 QuEST behind-the-meter, and currently it is on the
9 version 1.2 series of updates. The software code base
10 is currently hosted on GitHub.

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

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

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

22 In QuEST Valuation, estimates potential
23 revenue generated by energy storage system providing
24 multiple services in electricity markets of the ISO and
25 the RTOs.

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

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

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

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

18 So next I will talking about the QuEST
19 applications.

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

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

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

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

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

20 So one of the key component of QuEST is the
21 data manager app. For different types of analysis you
22 need to grab different types of data. And this app
23 helps you grab those data. Currently, you can download
24 market data, such as the local marginal prices,
25 regulation prices of the ISO and the RTOs, and the

1 utility rate structures and PV load profiles. We only
2 use publicly available APIs and posted market data, and
3 open source data.

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

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

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

24 So next I will give you an overview of utility
25 rate structure and how behind-the-meter can help

1 customers lower their bills. So as you may know, the
2 terms of front-of-meter and behind-the-meter often use
3 to specify the system locations.

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

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

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

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

23 The second charge is the demand charge. This
24 is the charge to the customers for their peak power in
25 kilowatt. This charge is often applied to large

1 commercial and industrial customers, but in some
2 utilities the demand charge also used for residential
3 also.

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

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

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

22 So in opposite to the fixed rate is the
23 dynamic rate and one of the main advantage of dynamic
24 rate is that it reflect the variability of the energy
25 prices -- of the wholesale electricity prices. And the

1 utilities motivation for dynamic rate include increasing
2 customer satisfaction with options to reduce energy
3 bill, encourage the load growth, and reduce the total
4 peak demand by load shifting of complying with the
5 regulatory mandate.

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

12 They work as weekdays, weekends, holidays, and
13 month of years as summer and winter months. And this
14 picture shows example time-of-use schedule for Southern
15 California Edison, which the optimal hours are
16 10:00 p.m. to 8:00 a.m. every day, and peak hours are
17 from 2:00 p.m. to 8:00 p.m. every weekday and other
18 hours as specified as part-peak hours.

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

23 Besides time-of-use there are other dynamic
24 options including real-time pricing. Variable peak
25 pricing, and critical peak pricings. And all of those

1 are some variation of time-of-use pricings. For
2 example, the variable peak pricings is very similar to
3 time-of-use pricing, except that peak period prices
4 change daily to reflect the system condition and cost.

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

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

22 So to benefit the -- from the dynamic rate
23 structure, the customer must be able to charge the load
24 in the manner that lowers their electricity consumption
25 without -- sorry, that lowers their electricity bills

1 without interrupting their operations or sacrificing
2 their conveniences.

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

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

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

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

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

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

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

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

1 For example, the red blocks in the time
2 schedule, which are the peak hours from noon to
3 6:00 p.m. every weekdays in summer months, are
4 corresponding to the price tag No. 4 at 16 cents per
5 kilowatt hour.

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

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

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

21 And, finally, we will need to download the PV
22 power profile. In order to do that, we'll need to enter
23 the lat/long, the PV systems specification, and also
24 save the data. Once we're done with all that data
25 setup, we'll start using QuEST BTM or QuEST

1 behind-the-meter for the analysis.

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

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

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

19 Based on the calculations, the addition of the
20 energy storage system reduced annual charges by about
21 \$36,000 per year. This mostly due to demand charge
22 reduction. And, specifically, the peak demand each
23 month was reduced about 100-kilowatt in this case.

24 We can also create a summary report that
25 includes formulation details and the results. So we can

1 retry the wizard with different energy storage system
2 parameters, or we can try different PV and load profile
3 rate structure, and so on. Is energy storage system
4 worth it? In this case, it will depend on the financial
5 of operating it and acquiring it. But we will have an
6 estimate on its performance value potential.

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

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

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

25 MR. BYRNE: Thank you, Tu. So right now we

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

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

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

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

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

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

16 To date, we have worked on various
17 technologies. Lithium-ion is obviously one of the, you
18 know, most frequent technology that we work with.
19 Today, the largest system that we have worked on is a
20 6-megawatt, 8-hour battery in Nantucket Island, owned
21 and operated by NationalGrid -- Dr. Gyuk also mentioned
22 that project -- providing reliable service on the island
23 power system is the main goal, but it can also
24 (inaudible) various markets that exist. We also have
25 worked on flow battery systems, mainly in the state of

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

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

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

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

22 So I wanted to briefly touch on the various
23 value streams we work on. It's sort of evident by now
24 that energy storage benefits can be captured at various
25 locations within our electricity infrastructure starting

1 from generation, transmission, distribution, end use.
2 Also electricity market provides a good platform to
3 provide various services and tap into various revenue
4 streams.

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

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

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

22 If there are gaps between the value that we
23 identified and evaluated in the analytic evaluation
24 stage with the value that we are actually generating in
25 the field, what are the differences and why they are

1 different. The analysis of those aspects can provide
2 really good insight and can help enhance the value.

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

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

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

21 So how -- for a given project, how do the
22 various streams can be achieved. Identification of that
23 is really important. And while we do that, we engage
24 with a lot of, you know, really close engaging
25 discussion with the utility partner, so whoever owns and

1 operated the storage. So that kind of forms the really
2 fundamental sort of, you know, base of our valuation
3 work.

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

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

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

21 In terms of tasks, we are fortunate to have
22 kind of multiple valuation process. We establish a
23 preliminary evaluation based on a lot of presumptions,
24 particularly under technology, but then we have sort of
25 a, you know, testing period where we try to characterize

1 the technology and understand its limits, et cetera, and
2 then embed those aspects in the final evaluation.

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

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

18 Now, I just mentioned about the technology
19 characterizations, but I just wanted to say a few
20 more -- maybe share a few more things about that.
21 Actually, you know, there are things that we see in
22 technical specifications, but unless and until you
23 actually operate the battery in the field, you're not
24 able to understand that it's real limits or if there are
25 any operational challenges or, you know, the performance

1 characteristics that really relate to the particular
2 application that actually will be used in.

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

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

22 Typically the results are as, you know, as one
23 would imagine various benefit streams, here are the
24 numbers that are, you know, one of the kind of most
25 important results that we have from our valuation

1 analysts. But we also look at various (inaudible). For
2 instance, you know, how the various, you know, financial
3 outcomes of the battery or, you know, metrics, for
4 instance, or return on investment or benefits cost would
5 vary as the size is varied or the energy to power ratio
6 is varied.

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

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

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

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

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

23 I think Dr. Gyuk has already mentioned that we
24 have been working with regulatory entities in the state
25 and also at federal level for PNNL have put together

1 workshop to inform various regulatory entities on the
2 benefits, opportunities, and challenges of energy
3 storage, so that's a useful part of our work.

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

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

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

23 Thank you, Ray.

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

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

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

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

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

23 So some are done by Sandia, some are done by
24 PNNL, with the other lab providing input and reviewing
25 the analysis. So that helps, I guess, get everyone kind

1 of on the same playing field.

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

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

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

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

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

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

21 MR. BYRNE: Yes, we can see it.

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

25 I do the research work in areas of energy

1 storage analytics, building grid integration and
2 microgrid design. Today I'm going to provide an
3 overview of modeling and analytical methods and the
4 tools for energy storage valuation.

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

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

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

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

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

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

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

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

24 Constant-efficiency models are simple to use,
25 but they are several limitations. So let me spin the

1 idea of using this 1 megawatt/3.2 megawatt hour, UET
2 vanadium flow battery as an example.

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

8 As can be seen here, the charging/discharging
9 capability varies state-of-charge levels. The amount of
10 energy that can be extracted from this battery depends
11 on discharging power. For example, we can only obtain
12 2-megawatt hour when discharge at 800-kilowatt. Losses
13 also vary based on state of charge -- state-of-charge
14 level and also charging/discharging power level.

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

24 So how can we construct of nonlinear model
25 besides using data from manufacturer. We have test and

1 evaluating several energy storage systems in Washington
2 state, and here is an example for the two-battery system
3 in Snohomish PUD.

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

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

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

23 Allow an energy storage model, describes how a
24 system can be operated. Optimal (inaudible) is required
25 to determine the best way to operate the system and

1 thereby to maximize the potential benefits considering
2 two-dimensional (inaudible).

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

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

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

22 There are several methods to handle
23 (inaudible). One of them is the policy-based dispatch.
24 This method consists of two steps. The first step is to
25 determine energy storage is engaged or not on the

1 operation day based on the probability of the events and
2 also some predetermined thresholds. Once the dispatch
3 is triggered, the model for (inaudible) control will be
4 carried out using the expected values.

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

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

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

25 Scalarizing method can be used to convert the

1 problem into the single objective optimization problem.
2 Each can be solved by many existing software.

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

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

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

22 Here is something more about bi-level
23 optimization. So, as I mentioned, bi-level optimization
24 can be naturally applied to sizing problem as
25 illustrated in this figure. As well as the battery

1 sizes and the annual benefits you can dispatch
2 (inaudible) exchanged between two levels.

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

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

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

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

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

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

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

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

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

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

23 And the user can determine the optimal size
24 based on the selected of audio stream and the cost
25 parameters. And here are some screen shots of the input

1 and output of the GUI. So far this has been (inaudible)
2 to (inaudible) in the U.S.

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

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

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

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

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

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

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

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

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

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

23 So here is the website and our register
24 account. So here is my dashboard. So here are some
25 existing project analysis I have created. And to create

1 a new one you simply click either app and give it a
2 name, so you will generate a case.

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

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

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

21 And here are some example of the output.
22 Basically user (inaudible) sizing on the evaluation
23 results. These are on the DER sizes all the benefits
24 from different surveys. And you can use a check
25 different amounts of peak load (inaudible) near the

1 investment. And you can also check the detailed
2 operation of different assays. Are you consuming too
3 much or download the data, or select, unselect different
4 profile.

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

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

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

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

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

25 Would anyone like to enter some questions for

1 the previous two speakers -- or three speakers?

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

6 MR. DAMATO: Thanks, Ray.

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

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

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

1 to them as the rules update and change.

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

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

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

25 And I mentioned, you know, I'm going to talk

1 about how EPRI's addressing these challenges with
2 DER-VET, which the beta version launched back in April
3 of this year, and it's available for download now. And
4 we're targeting the beginning of 2021 for the full
5 release. So, you know, be -- prior to the end of the
6 first quarter 2021, and, you know, it rests on the
7 shoulders of the StorageVET tool, which EPRI released in
8 2016 as version 1 and released a second v.2 in 2019.
9 And, really, DER-VET does everything that Storage can
10 do, but also includes looking at a portfolio DERs, which
11 we think is really important to the modeling
12 environment.

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

19 So when you have a portfolio DERs you can also
20 look at addressing reliability and resilience. And that
21 can be, as you can see from the center of this slide,
22 either customer values, so those types of value streams,
23 or on the transmission and distribution are the utility
24 side of the grid, as well. So there's that
25 multi-perspective capability that was in StorageVET that

1 is now also in DER-VET as well in the EPRI tool suite.
2 And also you can look at a combination of those, as
3 well.

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

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

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

21 And also, you know, the third-party developers
22 out there, and the investment community like yourselves,
23 as well as, the utilities, for looking at energy storage
24 on the -- either on the utility side of the meter or
25 programs on the customer side of the meter, and looking

1 at that as a whole, and also community microgrids. And
2 then, of course, at the state level with commissions and
3 regulatory bodies, as well, including ISOs and RTOs.

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

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

18 And then on the right-hand side here you can
19 see some -- some outputs, you know, in terms of high
20 resolution of detail in tracking what the -- either if
21 it's standalone storage or a portfolio DERs, you know,
22 and this one is just focused on the storage here for
23 simplicity. But, you know, state of charge across a
24 whole year or multiple years of dispatch, what the
25 battery is doing in terms of services. So either

1 providing energy or providing capacity so you can see
2 that the -- the energy or the area under the curve there
3 in that second graph and the arrows are capacity
4 reservations for either providing regulation or spin or
5 nonspinning reserve.

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

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

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

1 DER-VET.

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

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

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

22 And, actually, we've done a few cases on the
23 customer side as well for some of the -- those utility
24 host members on that map. So, you know, it's -- it's
25 kind of a multi-step process, and DER-VET fits into this

1 in many ways. So on the transmission and distribution
2 assessment, so typically, you know, the utilities are
3 bringing in some sort of, you know, circuit model and we
4 use tools to help analyze that. And then we can
5 highlight the issues and we can kind of, as you can see,
6 you know, the red hot zones where there's potential
7 issues, maybe some potential issues later as load grows
8 or as PV increases on a feeder or a circuit in yellow,
9 and then maybe no issues.

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

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

22 And one example of this that I picked here is
23 in Los Angeles Department of Water and Power. I picked
24 this one, one because we were going to be in California
25 in person, but we're virtual. But also because it's

1 some details are -- and the report are publicly
2 available on a white paper, so you can look more deeply
3 into it if you'd like.

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

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

21 We're also kind of in the middle of helping
22 them more on a longer term project. Since they do have
23 a hundred percent RPS targets and aggressive energy
24 storage targets and some unique issues with -- in the LA
25 basin versus out of the LA basin and their service

1 territory, we're helping them with how energy storage
2 helps them address lots of different issues.

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

5 So this came out of what's called Senate Bill
6 801 in California and it required LADWP to look at
7 putting in energy storage. They've looked at solar plus
8 storage, and that's kind of one of the reasons why we
9 expanded StorageVET to DER-VET to include all DERs,
10 because this is something we see as a trend of, you
11 know, standalone storage is not something that we
12 necessarily look at a lot in isolation. We're always,
13 you know, comparing it to multiple alternatives, or
14 maybe a combination of alternatives like this particular
15 example.

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

20 And you can see in the top right, there are
21 many different cases that we took a look at in terms of
22 what services it would provide, and seeing how that
23 would impact the valuation of the project. It went, you
24 know, we included energy time shift and spinning reserve
25 for all the cases. We also looked at restricting

1 charging from the grid, you know, based on the ITC
2 restrictions and also some other potential services
3 unique to LADWP as to when it could discharge and charge
4 and also providing frequency response for the basin -- I
5 should say for the LADWP service territory.

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

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

1 know, that's one of the reasons why LADWP moved forward
2 with that project and it's in execution now.

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

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

21 And then, you know, once we understand the
22 objectives of what kind of DERs we want to look at, then
23 we can go into the sizing and operations. So in this
24 case in a microgrid, you typically have a primary
25 objective of resilience or reliability. So being able

1 to cover an outage, for example, and stay up and running
2 and what's your probability of being able to do that
3 based on the outage length.

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

13 So, you know, I mentioned that, you know, we
14 looked at in this example some military installations.
15 They have a very -- obviously, a very high reliability
16 target. They need to be up and running no matter what
17 the potential issues. So they had -- and also a very
18 long reliability or resilience target of 168 hours, so a
19 7-day target.

20 And also, you know, what we had to do was make
21 sure that the -- when we looked at a storage enabled
22 microgrid versus the conventional diesel generator, we
23 had to make sure that the -- first of all, that the
24 reliability or resilience was equal to or greater than
25 the conventional solution. And also look at the total

1 life cycle costs and compare those.

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

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

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

19 So this is just, you know, you can see a
20 military base typically is a pretty large load, although
21 it does vary from site to site, just like anywhere else.
22 But this example is a 14 megawatt load with a 4 megawatt
23 critical load. They had 7 diesel generators and
24 50,000 gallons of diesel available. They also had
25 830 kilowatts of PV on-site. And other than the

1 resilience objective, we were looking at, you know, what
2 can we do in terms of bill reduction, and also
3 participating in the market.

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

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

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

25 So here you see the running DER-VET. We were

1 able to reduce the number of gensets for that 7-day
2 outage down to 5, and install a 4.3-kilowatt, 4-hour
3 battery -- I'm sorry, 4.3 megawatt, 4-hour battery. And
4 also be able to do bill reduction as the secondary
5 services, as well.

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

13 And then you can also see we looked at
14 costs -- or net costs, I should say, and you can see
15 total NPV of the net cost. So by net cost, I mean, that
16 we're netting out any reductions in bill savings, et
17 cetera. You can see that the solution was about
18 \$4 million cheaper over the 20-year project life. And
19 also just the metric of annual dollar per kilowatt peak
20 of critical load. We used that as well. You can see
21 that it was left to serve that each kilowatt of critical
22 peak load, as well, using the storage-enabled microgrid
23 solution.

24 And this occurred across four of the five
25 other sites, as well. So you can see here each one of

1 these groupings shows the baseline case with just diesel
2 gensets and/or PV -- or I should say not and/or; some of
3 them had PV, some of them didn't on-site. And then the
4 investment case of including storage and reducing the
5 number of gensets.

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

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

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

24 And of course looking at the financials as
25 well. Sorry about that. So SCE helped us with finding

1 this feeder, they came to us with the question. And
2 they picked it, as I said, there were a lot of PSPS
3 events because of wildfire mitigation, and these
4 customers, 137 of them, with a total of 2.2 megawatt
5 load were experiencing a lot of outages. And this was
6 mostly commercial/industrial circuit, not residential.

7 So we took a look at the solar irradiance to
8 help us with what's the probability of covering those
9 24- and 48-hour outages. And looked at what the upper
10 limit of how much land that we had to work with or
11 surface area. And then also we were told we could
12 curtail the PV if we had to, and we looked at options
13 where we did and didn't. And then also some assumptions
14 about the operation and energy storage and being ready
15 for the PSPS events, which are called -- so you have a
16 head start notification.

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

24 So the top one is a hundred percent. You
25 assume you get a hundred percent of the PV and then all

1 way down to 0 percent as the PV output for that 24-hour
2 event. You can also see that it changes dramatically.

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

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

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

24 And you can see, you know, we had other
25 financial inputs as well. And then, in summary, you

1 know, this when out to RFP at the beginning of 2020, but
2 SCE decided to hold off and put out this RFP again in
3 2021 because the costs were pretty high to cover this
4 24-hour outage, so to be continued on that. So with
5 that, I'll stop there and see if there are any
6 questions.

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

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

11 MR. DAMATO: Yes, there definitely is.

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

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

25 So that's how they link together. And there's

1 actually a module in DER-VET that helps with passing
2 that information back and forth, and some other tools,
3 as well, not just Open DSS.

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

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

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

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

23 MR. DAMATO: I can jump -- I could jump in and
24 just talk about our experience with DER-VET and
25 StorageVET, is that we have done backward, you know,

1 historical looking cases and we're adding to that list
2 all the time of, you know, looking at what DER-VET and
3 StorageVET would predict without the future information,
4 and then backtasking and comparing it to what actually
5 happened and what was achieved.

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

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

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

19 DR. ALAM: So I just wanted to briefly mention
20 that although the particular project or example that I'm
21 talking about was not really to understand the
22 performance of the tool, but what we, you know, really
23 wanted to, you know, see what the benefits that we talk
24 about and when we actually go into the field and operate
25 the system, you know, with all the practical

1 constraints, how far we can go with achieving the value.

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

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

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

21 MR. NGUYEN: Yeah, I would like to add that
22 the model tools usually provide possible saving. In
23 other words, that's kind of the maximum potential. And
24 how that revenue is realized in practice depends a lot
25 on forecasts, on energy (inaudible), and controls

1 strategies of specific system. So we try to provide the
2 maximum potential revenue and now we are also like to
3 provide some kind of average and lower end of the
4 revenue too. So it's kind of like bouncing between
5 the -- between the lower end and upper end, so that's
6 what we trying to do.

7 MR. BYRNE: Okay. Thank you.

8 So do we have any other questions?

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

14 MR. BAXTER: Thank you.

15 So this is finishing up today's -- the Energy
16 Storage Valuation Workshop, and we will be continuing
17 the Energy Source Financing Summit tomorrow at
18 10:00 a.m. Pacific, 11:00 a.m. Mountain, 12:00 p.m.
19 Central, and 1:00 p.m. Eastern.

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

22 (End of video Day 1.)

23 --oOo--

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1 ENERGY STORAGE FINANCING SUMMIT

2 SEPTEMBER 23, 2020

3 Day 2

4 --oOo--

5
6 MR. CHAUDHRY: Hi, I think we're going to get
7 started. We have a number of attendees who already
8 signed up and I know we expect many more to join soon.

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

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

23 We follow these two keynote panels with
24 further remarks from Richard and then that will lead
25 into two panels that we have today. We have a market

1 outlook panel that's going to be moderated by Bob
2 Fleishman at Kirkland & Ellis, and then we have a
3 capital providers panel which is going to be moderated
4 by Brian Greene of Kirkland & Ellis.

5 As I mentioned in my remarks yesterday,
6 there's been a tremendous surge of energy storage
7 projects already in 2020. There was a Woods Mackenzie
8 study which projects that by 2025 the total deployment
9 capacity of energy storage projects is going to be about
10 7 gigawatts, which is seven times -- a seven times
11 increase of the level of energy storage capacity
12 projects to date. Which, of course, will require a
13 tremendous amount of investment, which will make today's
14 panels and today's presentations extremely interesting.

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

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

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

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

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

25 Here is the outline of generally what I'm

1 going to say, you know, in the report, you know, looking
2 in the operations and trying to define a little bit more
3 of the market roles and the operating expenses.

4 Basically for a lot of other people who are not experts
5 in the industry to give them a basis for conversation
6 when they talk to some of the other people who have more
7 knowledge.

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

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

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

25 For this, and to give us to detailed, first

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

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

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

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

20 MR. BAXTER: You are good to go.

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

24 Okay. Give me just a second to get that one
25 slide. There we go. Okay. My apologies. I got this

1 technology thing down. So I just want to kick us off
2 this morning with a little bit of California context.
3 And, as you all know, we have been experiencing quite a
4 bit of wildfire and we've had some extreme weather
5 events with our August lightening siege here in
6 California.

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

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

23 So, in California, what we're trying to do is
24 make our way to a hundred percent clean energy standard.
25 And our policy requires renewable energy and zero carbon

1 resources to supply 100 percent of electric retail sales
2 to end-us customers by 2045. The California Energy
3 Commission is working in coordination with the Public
4 Utilities Commission and the California Air Resources
5 Board as well as with the California Independent System
6 Operator to complete a joint agency report that
7 evaluates the 100 percent zero carbon electricity
8 policy. And that report is underway and it should be
9 completed by January of 2021, so please do also keep an
10 eye out for that.

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

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

21 We're also looking to address affordability
22 and equity challenges to ensure that all Californians
23 are participating in and benefiting from our clean
24 energy future and making sure that we're not leaving
25 communities behind as we make that transition. We're

1 also working to build a more resilient energy system
2 where we can better anticipate the risks that we think
3 are coming, and also ways to look to manage the risks.

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

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

15 I oversee our research program, which is
16 called EPIC. It's the Electric Public Investment Charge
17 program. And the EPIC program has invested about
18 \$60 million in energy storage and related projects, and
19 we did that prior to 2020.

20 This year, in 2020, we invested an additional
21 \$40 million in new research grants for energy storage.
22 So, in total since the program has begun, we've invested
23 about a hundred million dollars in advancing these
24 energy storage technologies.

25 And, as I mentioned, some of the things that

1 we're looking to the invest in is looking at storage for
2 resiliency, we're looking in longer duration storage,
3 and all types of things that help us get to that
4 100 percent clean energy standard.

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

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

19 We're also looking at the price projections.
20 And price projections for lithium-ion storage continue
21 to decline. We have seen prices come down about
22 85 percent over the last ten years, and it's decreasing
23 at a much faster rate than forecasted a decade or so
24 ago.

25 The prices have dropped from over \$1,000 per

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

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

19 So this slide here is showing you the growing
20 need for energy storage in California. And in 2010,
21 some legislation in California, which was Assembly Bill
22 2514 sent energy storage procurement targets for
23 California. And since then, we really have been a
24 leader in the nation when it comes to addressing the use
25 of energy storage to help support our future energy

1 goals.

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

6 Given our energy goals and looking out to
7 2030, 2045, and beyond, there is still a growing need
8 for additional energy storage as we continue to
9 integrate increasing amounts of renewables onto the
10 grid, and move toward our goal of the hundred percent
11 clean energy future.

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

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

25 And just as a side note, that four hours of

1 storage duration is driven by the California Independent
2 System Operator requirement that we have at least four
3 hours for the system that we could use as a resource
4 adequacy asset.

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

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

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

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

6 2020 is proving to be a pivotal year for
7 research on energy storage, at least I think so, at the
8 energy commission. Some of the priorities for the
9 Energy Commission and the State this year including
10 evaluating the performance of a variety of storage
11 technologies in various microgrid applications.

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

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

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

25 So the storage-related solicitations that we

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

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

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

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

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

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

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

25 And then last is the energy -- Indian Energy

1 project, which will examine multiple storage technology
2 configurations, with the mix of zinc hybrid cathode
3 battery, a vanadium redox flow battery, and a mechanical
4 flywheel. This project is going to be located at Camp
5 Pendleton and will provide both the Navy and the Marines
6 with an opportunity for hands-on experience with several
7 different non-lithium ion technology demonstrations.

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

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

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

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

4 So GRID Alternatives is planning to install a
5 50-kilowatt hour or 500-kilowatt -- I'm sorry,
6 50-kilowatt or 500-kilowatt hour vanadium redox flow
7 battery, and an off-grid generation system to enable
8 that the Soboba fire station to provide the community
9 with complete and critical services during emergencies.
10 In addition to providing critical resilience to the
11 community, the project is also expected to provide
12 energy cost savings for the tribe.

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

20 We also had some funding that was specifically
21 targeted towards low income and disadvantaged
22 communities in California. And there is a California
23 Enviro Screen system and it takes a look at communities
24 and it looks at any number of factors, and then it kind
25 of pops some of them up at places that have been

1 over-burdened. And those sometimes show themselves to
2 be disadvantage -- that's why they call it disadvantaged
3 communities.

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

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

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

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

24 So we had in California a Senate bill. It was
25 Senate bill 1369 and that defined green electrolytic

1 hydrogen as energy storage. And it asked the Energy
2 Commission to consider the potential uses of the
3 screened hydrogen for an energy storage solution in
4 California.

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

11 And, again, these all go back to demonstrating
12 that kind of that longer term storage and that type of
13 thing. So the first project is the Dash2energy project.
14 And they are integrating a green electrolytic hydrogen
15 system with power generation from a one megawatt wind
16 turbine within a microgrid at the Palmdale Water
17 District.

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

23 The second program is the T2M Global project.
24 And T2M global is going to evaluate a green hydrogen
25 system that can produce hydrogen through electrolysis as

1 well as recover dilute hydrogen from waste streams such
2 as biomass conversion, flue gasses, and ammonia.

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

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

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

21 So the UC Riverside project will develop a
22 site level test and demonstration program for optimal
23 coordination of a network of autonomous plug and play
24 behind-the-meter solar battery units, not only to
25 perform demand side management, but also load shifting,

1 maximizing the solar self-utilization and backup power
2 and providing new developed grid services.

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

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

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

23 Finally, I wanted to mention to you all that
24 last year the Energy Commission launched our Empower
25 innovation platform. And I want to encourage anyone

1 that's interested in applying to an Energy Commission
2 EPIC grant, or really that you're just interested in the
3 storage and clean energy innovation, this
4 entrepreneurial space, to join our Empower Innovation.
5 It's the newest tool in our innovation eco-system. It's
6 an online platform that is designed specifically for the
7 cleantech community. And it provides a great networking
8 opportunity for individuals and organizations for
9 exploring our funding opportunities.

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

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

23 So I think I have maybe three or four minutes
24 for questions, which I'm happy to take. I do a lot more
25 of the policy and the strategies, so if it's a specific

1 question on the technology, I can certainly put you in
2 touch with the experts at the Energy Commission who can
3 really talk through, in detail, some of that. But I
4 look forward to your questions.

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

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

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

23 Eric is the Director of Grid Systems and
24 Components with the U.S. Department of Energy, and I
25 want to say welcome to Eric, but before we do that maybe

1 let me pause and see if there's a couple questions for
2 me.

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

5 MS. SCOTT: Okay.

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

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

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

14 MR. BAXTER: All right. Good answer.

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

21 MS. SCOTT: Yep. So that's a fantastic
22 question as well. Typically, what we do at the Energy
23 Commission is we have what we call a pre-solicitation
24 workshop. And so our staff spends, as you can imagine,
25 quite a bit of time thinking through, reading papers,

1 talking to experts in the field, what is it that we need
2 to -- how can we make our investments the smartest
3 investments, right? Is there a challenge we can help
4 solve? Is there a technology question that people are
5 looking for answers to and that we can help put some
6 investment in that space?

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

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

24 The other thing that we do is an investment
25 plan for the EPIC program. So that's a nice place, too,

1 as we're kind of thinking through the broader goals of
2 here's the types of things we're planning to invest in
3 over the next three to five years making sure we're
4 hitting -- and, you know, there's a little bit of
5 flexibility in that space as well, of course, because
6 technology is changing really quickly and we want to
7 make sure we don't miss things by preplanning too much.

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

20 And then last I would certainly encourage that
21 Empower innovation platform. That's just a great way
22 for -- if you've got a great technology and you want to
23 demonstrate it in the community and you're looking for a
24 community, you can find that match there. If you're a
25 community and you would love to have someone come and

1 demonstrate a technology, the same thing, it's really
2 kind of a matchmaking for entrepreneurs and folks who
3 are looking to pilot different technologies and places
4 to pilot it and also some additional expertise, right,
5 like you're looking for some financing expertise. If
6 you're looking for manufacturing expertise. All of that
7 is kind of within that Empower Innovation. So hopefully
8 that helps.

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

11 MS. SCOTT: Yes.

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

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

24 So a lot of times if you have -- if you're an
25 entrepreneur and innovator in this space and you've got

1 some DOE funding, if you're part of one of the programs
2 where the DOE and Energy Commission are working together
3 that's great, right, so then we're, like, Okay, DOE is
4 taking you technology readiness level 1 to 3, the Energy
5 Commission is going to pick it up and take it from 4 to
6 6, and then maybe it goes back over to the DOE. We work
7 pretty closely to try to compliment one another in our
8 funding in that way.

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

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

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

24 You had shown, I think, some Bloomberg and
25 other market information. Do you guys use that when

1 you're trying to predict the scale of the market going
2 forward? Do you have some internal demand or internal
3 need estimation about -- that helps you guide what type
4 of technologies or deployments to evaluate?

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

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

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

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

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

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

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

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

20 MR. HSIEH: Great. Thank you, Richard.

21 And it's a pleasure to follow Commissioner
22 Scott. I'm a former Cal Bear, so I'm on the other side
23 of that rivalry. I've always been impressed by how the
24 State blends creativity, technology, and equity issues.
25 And the CEC demonstration projects that she went through

1 are exactly the kinds of innovations that DOE hopes to
2 accelerate as part of the Energy Storage Grand
3 Challenge.

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

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

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

22 I'll go through the long-term vision for
23 energy storage here. Look at one example of a use case
24 that we're considering and go through the drivers and
25 indicators of change within that use case. I'll talk a

1 little bit about energy storage at OE, but also across
2 the department and how we bridge the gap to
3 commercialization.

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

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

21 We've really been given the directive to align
22 all of the different levers that DOE has to accelerate
23 this industry. And whether you're a Zoomed-out
24 executive, or a impetulant TikTok influencer, we've
25 boiled down the ESCE into six words. For your

1 convenience, it's innovate here, make here, and deploy
2 everywhere.

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

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

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

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

19 Next is tech transition. How do we accelerate
20 these technologies to market? Part of this initiative
21 is an explicit recognition that DOE strength in R&D is
22 not enough. We are also developing tools for -- to
23 assist those in the policy and valuation space. And
24 I'll speak a little bit to that. And, finally, domestic
25 manufacturing, supply chains, and workforce development,

1 I've alluded to before, and they will also be key in
2 assuring U.S. leadership.

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

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

12 MR. HSIEH: Can you see my slides?

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

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

19 MR. HSIEH: Sorry about that. So drivers and
20 indicators of change. One of the things that we're
21 doing different. A little novel for DOE within the
22 Energy Storage Grand Challenge is to introduce a user
23 focused R&D framework. So instead of just chasing a
24 dollars per kilowatt hour or efficiency metric, we've
25 been identifying representative use cases for electrical

1 needs over the next 10 to 30 years. These use cases
2 span everything from industrial facilities to remote
3 communities to entire balancing authorities.

4 And then once we've identified some functional
5 requirements that helps us fill out an R&D strategy.

6 Now, I'll use our first use case Facilitating an
7 Evolving Grid, as an example.

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

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

22 In 2020, the vast majority of the grid are
23 here to the bottom left, and as we get to higher
24 penetrations of DERs you might see things move towards
25 the distributed side of the graph. At the same time as

1 we have asynchronous resources, like wind and solar or
2 anything inverter based, they may move towards the top.
3 And then, finally, you might get to this stage on other
4 end of the quadrant where you have grids that look and
5 behave much differently than they do today.

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

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

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

23 So I'm going to borrow some back of the
24 envelope numbers from ARPA-E's program. Today's best
25 available solution if you're talking about flexibility

1 and it's dominant thermal capacity being constructed is
2 a combined cycle unit. And we're rounding things out
3 for simplicity, so we'll assign that a proxy price of
4 \$50 a megawatt hour for dispatchable energy.

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

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

23 The battery-based solutions today are up here
24 in the top right corner, certainly in the higher cost
25 category. And so to get to longer durations, we might

1 need to look at storage media where the incremental cost
2 of adding more hours is a couple of order of magnitudes
3 lower, like sodium, air, rocks, or water.

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

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

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

1 And so we're envisioning a scenario where
2 these use cases represent sort of the -- are
3 representative of how storage is being used and they
4 feed this multibillion annual U.S. market, and that
5 would likely be split into some number of firms. So at
6 \$20 billion or \$30 billion, you know, 60 firms gives you
7 half a million dollar annual revenue, which is pretty
8 healthy for a smaller company or business unit.

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

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

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

1 components of energy storage systems.

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

8 (End of video part 1, Day 2.)

9 --oOo--

10 (Begin video part 2, Day 2.)

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

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

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

1 were presented earlier.

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

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

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

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

1 industrial, and institutional customers.

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

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

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

23 So, from our perspective, that opens up a
24 bunch of different markets for us primarily in the
25 western United States, including California, ERCOT, and

1 some markets with (inaudible) and we continue to focus
2 in New York, New England and Ontario.

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

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

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

22 And outside of California, and the western
23 mainland U.S., the big focus on solar plus storage, the
24 interconnection queues are really packed with that. In
25 fact, even California's interconnection queue, there was

1 almost zero PV without storage entering the queues in
2 2019.

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

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

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

23 Because the CCA is taking a lot of the
24 procurement responsibility away from the investor-owned
25 utilities, that created a -- that's why the IOUs are

1 very long on their contracting of RPS. And so the CCAs
2 are -- they are the big game in town for buying solar,
3 and now the California market because they're such high
4 solar penetration. Storage -- there's very little solar
5 without storage procurement going on. It's really
6 driven by solar plus storage.

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

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

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

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

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

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

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

20 So I didn't really answer your question, so I
21 would say let me come back to your question. We look
22 at, in our group, technologies at readiness level 6
23 through 10. So vanadium redox flow batteries might be
24 in a 6 or a 7. Might have sodium sulfur batteries in a
25 7 or 8 stage, so they're more proven in the marketplace.

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

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

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

15 MR. STOUT: I think there's --

16 MR. FLEISHMAN: Okay. Go ahead, Mark.

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

21 MR. FLEISHMAN: Let me turn to Nick.

22 Nick, with the first round of fire codes being
23 developed and product standards continuing to evolve,
24 what's your view on the safety challenges that remain
25 for energy storage going forward and what impact on

1 markets does safety issues and related reputational risk
2 have in your view?

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

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

25 There are thousands of these systems that

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

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

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

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

25 MR. GOLDIN: So I'll speak on behalf of the

1 work we're doing with several vendors of low batteries,
2 we see those as nonflammable. They have other risks
3 associated with them. They take more maintenance to
4 keep them running, but they won't burn and they won't
5 generate sort of incidents that we've seen.

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

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

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

23 Challenges have always existed. The fire
24 service has always learned to deal with them in time;
25 maybe not as quickly as we'd like. But I think

1 ultimately what we'll find is that, you know,
2 lithium-ion battery failures are going to be inevitable.
3 If we can get those down to a number that's manageable
4 and reasonable. And if we can make the overall
5 magnitude of those failures manageable and get the fire
6 service trained to a point of handling them, a lot of
7 these safety risks were start to subside.

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

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

15 MR. FLEISHMAN: Go ahead.

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

18 MR. FLEISHMAN: Of course, yes.

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

24 So along with that, there's a wide array of
25 mitigations that can be added to the best system in

1 order to make -- to manage the risk as best we can.

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

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

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

21 But more importantly with some of the
22 (inaudible) we've deployed already, we're working with
23 some of the OEMs to actually go back and retrofit some
24 of the existing assets that we have so we can bring them
25 up to code to avoid some of the issues that we're

1 seeing -- that we've seen in the U.S. and in the U.K.

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

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

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

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

1 code.

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

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

13 MR. FLEISHMAN: Okay. Go ahead.

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

21 On the residential systems, there's probably
22 10,000 -- or I don't know what the current count is.
23 Those would not be economical to retrofit those systems.
24 Safety will be implemented via software on those systems
25 for better monitoring and visibility.

1 I'm curious what Moe has to say.

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

3 (Talking over one another)

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

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

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

25 We got impact of regulation in the market and

1 the FERC's energy storage rule order 841 has been on the
2 books for a little while and -- with respect to the RTOs
3 and the ISO's. And the compliance filing process has
4 worked it's way through. New York now says they're,
5 quote, fully compliant and so forth.

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

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

12 MR. FLEISHMAN: Okay.

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

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

17 MR. STOUT: That would be great.

18 MR. FLEISHMAN: Yeah, yeah.

19 MR. GOLDIN: So I'll comment about we see the
20 FERC order in the U.S. and we see other regulatory
21 structures emerging in California and Australia and
22 Germany, everywhere. It adds a lot of complexity in
23 understanding how the batteries will be used. So
24 systems that have been put into place with a certain
25 daily use model now can profit from more aggressive use

1 to capitalize on the value stack or 841 revenue streams.

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

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

10 MR. GOLDIN: Still early.

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

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

17 MR. STOUT: That works great.

18 MR. FLEISHMAN: Okay.

19 MR. STOUT: We are very excited about in the
20 fall the CPC had a decision that all the load-serving
21 entities throughout California would procure a total of
22 3.3 gigawatts resource adequacy, which, by and large, is
23 going to be energy storage and demand response as the
24 lead technologies.

25 So really no -- no significant fossil

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

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

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

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

1 to solve problems.

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

15 It was really if you looked at what was in the
16 queue for standalone storage, that was project sites
17 that were in urban load centers that were, you know,
18 good sites for standalone storage, there just -- I don't
19 know if there was enough capacity for them to get the,
20 you know, they needed -- all the load-serving entities
21 50 percent of the 3.3 megawatts by August 1st, 2021.
22 And, you know, I think the utilities had to get
23 creative.

24 MR. FLEISHMAN: Let me follow up on the
25 regulatory front. Last week the FERC issued a very

1 significant order -- well, I'll call it significant --
2 order 2222 dealing with the aggregation of distributed
3 energy resources and they defined DER, distributed
4 energy resources, among other things, energy storage,
5 demand response, energy efficiency, microgrids, and so
6 forth. And there will be, you know, a long compliance
7 process with the RTOs and ISOs as there was with 841 and
8 energy storage.

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

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

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

1 get implemented, so we're cautiously optimistic.

2 MR. FLEISHMAN: Others on that question?

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

6 MR. FLEISHMAN: What is that?

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

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

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

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

25 I think the first question that industrial or

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

6 So what is the value of keeping the lights on?

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

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

25 MR. FLEISHMAN: All right. Any others with

1 thoughts about how the increasing amount of wildfires is
2 impacting empty storage markets and consumers and
3 resilience concerns?

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

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

21 MR. STOUT: We're primarily in front-of-meter
22 but just in terms of, I think, the public safety
23 shutoff -- the whole program that has been going on in
24 California about the IOUs, it's definitely created quite
25 a large market for residential solar plus storage. I

1 mean, I think that's one segment that sales are really
2 strong, and some of the residential installers they're
3 almost like residential IPPs have taken advantage of.

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

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

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

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

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

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

15 MR. STOUT: Sure, sure.

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

18 MR. STOUT: I'm happy to yield.

19 MR. FLEISHMAN: That's fine.

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

1 accelerate interconnection of storage.

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

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

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

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

24 MR. STOUT: So just to follow on to that.
25 We -- in July, we acquired a 20-megawatt operational

1 battery plant from AltaGas that was built at -- they
2 had, I think, a 43 megawatt single cycle gas turbine,
3 which was part of the sale process they decommissioned
4 and removed.

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

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

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

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

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

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

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

22 MR. HAJABED: Maybe I will touch on that. I
23 think financing (inaudible) are evolving as investors
24 are getting a better understanding of storage and the
25 different revenue streams that you're capturing when it

1 comes to storage, especially as it comes down to
2 merchant. And what revenue streams are investors
3 willing to underwrite when it comes to merchant in the
4 first place. In our early days a lot of our financing
5 was done through equity and now we're starting to see
6 more project level financing being put in place where
7 there is a portion of the contract of revenue streams or
8 for (inaudible) of revenue streams that finance is
9 willing to underwrite based on operational experience,
10 and track record and the curve that you're actually
11 underwriting.

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

20 MR. FLEISHMAN: Any further thoughts on that
21 question?

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

25 MR. FLEISHMAN: Right.

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

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

14 MR. FLEISHMAN: Right.

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

20 MR. FLEISHMAN: Yep.

21 MR. STOUT: You know, that -- that between the
22 minority, the revenue that's kind of more secure coming
23 from the RA contracts, and the merchant revenue, that
24 that combination -- to get project financing you might
25 need to have a higher hurdle than if it was like 100

1 percent contracted, like, a tolling agreement. You
2 could probably have a lower hurdle rate, but, you know,
3 you just have a high hurdle rate. But there's enough
4 money to be made in the merchant market that you can
5 sustain that higher hurdle rate.

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

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

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

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

17 MR. STOUT: Bring on the RFPs.

18 MR. HAJABED: Yeah, but it makes sense.

19 MR. FLEISHMAN: Well, I guess that's a good
20 transition to the next panel because we're just about at
21 3:30 Eastern.

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

25 And, with that, I'm going to go totally on

1 mute. And thank you all panelists.

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

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

5 MR. BAXTER: Yes, I believe so.

6 MR. GREENE: Okay. Good.

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

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

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

22 Our next panelist is Caleb Waugh. Caleb is
23 the vice president in Macquarie Capital Green Investment
24 Group, and he works in the global energy technology and
25 solutions team. Team focuses on project and equity

1 level investments and good scale energy storage,
2 distribute energy resources and electrical vehicle
3 storage and mobility. He was previously at
4 Lockheed-Martin.

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

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

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

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

24 If a developer, who is kind of new to the
25 storage space, say they have a solar plus storage

1 project with a big storage component. They come to you
2 and they ask what they need to do to get an investor in
3 their project or their platform. What's your advice to
4 them?

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

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

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

22 And those ones you can -- the solar project
23 and storage project acting independently of one another,
24 the storage project would have -- would it or would it
25 not be eligible for IPC, it's an ongoing question with a

1 lot of nuance. How does the storage side of the
2 equation make money? In all likelihood, it's probably
3 in the ancillary real-time day ahead and capacity
4 markets, which are much more merchant.

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

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

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

22 Benoit, you know, I'll ask you, you know,
23 you've been involved in a number of pretty high profile
24 deals recently. Can you talk a little bit more about
25 how a storage plus solar project with a big storage

1 component or a standalone storage project is different
2 and more complicated than just a, you know, just a
3 typical solar project?

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

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

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

25 And then the reality is that storage is an

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

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

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

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

23 MR. LARRISON: You know, the biggest thing for
24 me is not what should you do, it's what you shouldn't
25 do. And my experience, and I think a lot of people who

1 have those, you know, who have a lot of energy
2 experience would say, Don't make too big of a bed out of
3 aggressive merchant curves.

4 And I think a lot of people are talking about,
5 you know, standalone storage, and these are merchant
6 assets. They're like old gas peakers, but they're more
7 complicated. And, Brian, as you and I discussed,
8 they're old gas peakers that are more complicated
9 without Siemens and GE standing behind those assets for
10 25 years.

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

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

25 MR. GREENE: Just a couple days ago, Wood

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

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

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

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

1 over many of the suppliers on the market today, but
2 that's from our perspective.

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

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

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

21 You know, at the same time I hope we don't
22 live in a world of GE. I've worked for GE. I have GE
23 equipment. It falls all the time. You know, I would
24 rather not have the technicians come on a regular basis.
25 So we are looking at, carefully, at performance. And,

1 you know, truth be said, the availability of a megapack
2 right now based on available data is pretty good.

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

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

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

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

25 So the (inaudible) aspect is something that is

1 often not quite picked up. And it's interesting as well
2 to think about storage system with inherently some
3 overbuilts within these batteries, and being able to
4 supplement through software an individual module going
5 down.

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

11 MR. GREENE: Caleb. Question for you.

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

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

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

25 When you're betting on forward curves around

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

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

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

21 You do the paper exercise. You do the
22 analytics. You know, you show all the peak shaving, it
23 looks like great. When it comes time to who's actually
24 going to stand by and back whatever that savings might
25 be, oftentimes a customer may want some sort of savings

1 guarantee, then the project owner/developer is trying to
2 sell that, would rather, you know, that risk be on the
3 customer side, and so there's -- I think there's still
4 some -- I'm figuring out just how to address that on the
5 distributed side.

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

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

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

1 think that's going to be the next big challenges from a
2 technology standpoint.

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

13 MR. WAUGH: Yeah.

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

25 MR. WAUGH: Absolutely. And I think one thing

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

6 And, yeah, I mean, it can be, you know, 30 to
7 50 percent. But at least you have some basis upon
8 which, you know, you are benchmarking that against a
9 much cheaper cost of capital. And, certainly, yeah,
10 you're open to taking on some of that merchant risk,
11 you're certainly open to kind of taking on that
12 exposure. You're probably going to discount that value
13 quite a bit until you get fairly comfortable with, you
14 know, it's going to be a much higher return of
15 expectation on that.

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

22 MR. ALLEHAUT: I think the important piece
23 is -- and Caleb you touched upon it -- the word merchant
24 is slightly misleading; the right word is really
25 volatility. And the interesting aspect in markets like

1 (inaudible), is that the retirement of thermal is just
2 adding tremendous volatility.

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

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

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

1 (Talking over one another)

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

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

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

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

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

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

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

17 MR. NORTON: Definitely.

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

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

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

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

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

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

22 Like today being primarily driven by ancillary
23 services with the expectation that over time that will
24 shift more and more to kind of an energy market. So I
25 think the biggest challenge today is that if you are to

1 do kind of a project which is merchant, you are kind of
2 bet on a couple things.

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

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

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

22 MR. WAUGH: Absolutely, yeah.

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

24 MR. WAUGH: Absolutely.

25 MR. GREENE: Our last panel question for this

1 panel which is the future of energy storage is
2 transmission.

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

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

20 So I think it's very nascent, these value
21 proposition are, you know, being whispered. But in
22 places where you have some of these congestions that can
23 be addressed by shifting, you know, some of the
24 transmission usage, it really becomes interesting.
25 Because I remember him saying when you start a

1 transmission project, you know, your kids will finish
2 it. That's pretty long. So situations where you can
3 address it, you know, with storage, it's really
4 beneficial to the overall market efficiency.

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

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

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

22 MR. LARRISON: The regulatory environment I
23 think is very, very challenging right now. And I
24 don't -- I don't think that various regulators have
25 fully thought through the implications of storage. You

1 know, I think there's tremendous work going on and that,
2 you know, we'll eventually get there, but, boy, it -- I
3 think there's some battles ahead in how -- you know, how
4 batteries are going to work for transitioning assets,
5 and hopefully they do get rate based and in the
6 appropriate places, but I think there's a real battle
7 that needs to be fought going forward in the various
8 markets across the country, because the regulatory
9 environment is not -- it just isn't there yet.

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

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

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

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

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

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

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

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

24 I wanted to see if anyone had any kind of
25 immediate thoughts on that and whether that would kind

1 of help further bolster the market.

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

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

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

25 MR. NORTON: So on the standalone, I think the

1 standalone's third project -- and we have very recent
2 experience of this -- is the level of interest is
3 exceptionally high. But you should anticipate that your
4 batting average is kind of in the Randy Johnson range,
5 so it's going to be quite low, the number of folks that
6 can put through a qualified bid.

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

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

21 As an industry as a whole, operating end value
22 will increase, IE reports authored will increase, and
23 more and more capital will come in, and it will become
24 more well-known over time. I can't say with certainty
25 it will be a lower cost of capital, but there's a -- I

1 think a lot of signs pointing towards that and that just
2 comes with competitive tension that's here, and here and
3 live and standalone -- and just solar. And so I think
4 that's -- it's coming and there's a lot -- no shortage
5 of interest that there can at times be a shortage of
6 qualified interest.

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

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

24 MR. GREENE: Couple times in this conversation
25 people have touched on the energy manager role which,

1 you know, for, you know, a solar project either doesn't
2 exist or is minimal in battery storage, it can be very
3 poor. And so maybe you can -- someone can talk about
4 kind of what part energy manager role plays, whether
5 there are certain, you know, companies that build a
6 track record, and kind of the, you know, different
7 factors that you look for in a project, you know, where
8 that weighs with other things like, you know, the wrap
9 or, you know, other kind of critical risks in how you
10 structure a deal.

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

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

25 You know, there was a good example this summer

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

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

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

25 If you invest in -- directly in a project or

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

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

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

18 MR. ALLEHAUT: The one thing I'll say,
19 Patrick, is that, you know, the market has some kind of
20 natural inefficiencies that everybody benefit from. You
21 know, the reality is when you have intermittency when
22 you look at particular cycles of spring, you know, with
23 a lot of intermittent resource, but at the same time,
24 you know, a thinner load. You basically start to see
25 periods where everybody -- you know, you have to be

1 really, really, really bad, you know, not to generate
2 some revenues.

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

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

20 You know, there is a trend that over, you
21 know, the last three years that some of these -- the
22 amount of revenue captured versus, you know, what one
23 thinks optimally is available has improved over time,
24 and some of those have been projects where they actually
25 are not using algorithmic trading. It is, you know,

1 kind of traditional trading, but there is trading kind
2 of against both, you know, (inaudible) in real-time
3 market.

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

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

19 (Talking over one another.)

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

25 And now suddenly you add all of these

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

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

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

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

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

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

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

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

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

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

25 So I think, Brian, it's a great idea that we

1 let everybody here have their final points, and then
2 I'll close it out.

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

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

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

1 crossroads that we're at.

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

11 So there's a lot of opportunity out there. It
12 just takes a lot of time, creativity, and to get up to
13 speed, but I agree that this is -- this is here, and
14 it's going to only grow.

15 MR. WAUGH: Yeah, I think that sums it up for
16 me. We're in the trees for all of the kind of near term
17 challenges, but I think we're still going through
18 growing pains was one does in a new and maturing
19 industry. 30,000-foot view, though. All the market
20 fundamentals are sound, and we'll just continue
21 improving.

22 MR. BAXTER: Great. Thank you very much.
23 Actually, Brian, did you have anything you wanted to
24 add?

25 MR. GREENE: Turn it over to you, Richard.

1 MR. BAXTER: Okay. All right. Well, thank
2 you very much for staying with us here.

3 Sort of our next steps. After this we'll be
4 sending out in a little bit the -- an e-mail to everyone
5 with the slides and a link to the video. We'll also
6 have -- we're going -- this is the -- so right now we're
7 all in San Francisco.

8 In January, we'll be having our New York
9 conference. And so we'll be sending out the Save the
10 Dates for that one as well very soon, and so you can
11 look for that and then follow it for the registration.
12 And then afterwards, you know, a lot of this what we're
13 trying to do is -- what I've been trying to do with
14 these is to -- exactly what we've seen here: Provide a
15 platform for people to showcase what's really important,
16 and not necessarily everybody saying I have the right
17 answer. No one has the right answer. And if you do
18 wait until tomorrow, it will be different.

19 So what we all need to do is just figure out
20 some really interesting lessons learned and I'll be
21 reaching out to a number of you for further insights,
22 and so I look forward to seeing everybody again in
23 January. And this -- I know you can't hear me, but I'm
24 going to clap, and say thank you very much to everybody
25 who participated.

1 (End of audio file.)

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12 Dated this 2nd day of October, 2020.



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