EPIC POLICY+INNOVATION COORDINATION GROUP

TRANSPORTATION ELECTRIFICATION WORKSTREAM – MEETING #2

OCTOBER 22, 2020 2:30 PM – 4:00 PM

Welcome everybody, we're going to get started momentarily.

>> Welcome everybody. We're going to get started in one minute.

>> Welcome everyone and thank you all for joining today. I want to welcome everybody here. As we discuss an important topic that is critical to the decarbonization effort of California. Electrification transportation and making sure we're overcoming the obstacles in getting us there. Time California public utilities commission consultant for the epic policy and innovation coordination group. This is the second meeting of the transportation electrification work stream of the epic policy coordination group. You are gathering insights and lessons learned from projects in the state and working to identify new opportunities for collaboration to accelerate innovation. I want to thank the other epi pick participants for joining us today including the epic program administrators, California energy commission staff and advisors, utilities and staff. I would like to point out Rebecca and Amanda will be providing helpful information in the chat. And q and a box as we go. If you have any questions for us on this process, please reach out to us. The goal is to discuss questions raised by the working group and the transportation electrification framework on technology, regulatory and market challenges to transportation electrification development and gain understanding of the cost effectiveness of different approaches. Last time we met we had an excellent discussion on the role of energy management systems in vehicle charges, particularly around fleets, medium and heavy-duty vehicles, infrastructure. Today the discussion will be focused on epi lick projects that can provide insight on the use of electric vehicles for backup generations, as part of grids and to provide grid services. It's been part of important conversations, regarding shutoffs. Looking at mobile batteries as part of the solution. Further these vehicles distributed batteries around the state connected to the grid serving as potential resources that may be able to provide grid services that support their owner or neighbors. This has been a key point of discussion in the working group in transportation electrification framework. I hope the conversation we will have today will gain insight for epic projects that have been working in this area to help further the conversation. I want to thank you again for joining and participating in this effort. Today's meeting two will include presentations from several folks who have been working on epic and rd and d projects. Throughout presentations today we've asked those representing to talk about a couple of core questions and topics. The first one is around the feasibility for backup generation when not part of the

microgrid which is a recommendation on final working report. Also, feasibility for backup generation as part of a multicustomer microgrid. We're going to have discussion around electric vehicle supply. Hopefully there is time for a q and a session. If you have questions for the presenters, please include them in the q and a feature that is included on the right-hand side of the screen. That q and a feature might appear after you look at the far right-hand corner of your window. It might be behind three buttons to find it further. You will find a live transcription of the events if you click on the box that opens the multimedia box. You might have to close the chat box and headers in order to see the transcription come through. We're seeing that come through now. There is a live Spanish translation you can link to in the chat that Amanda is sharing with the group as we go. If you have questions, please include them in the q and a section. This meeting is being recorded and will be available after ward at epicpartnership.org and will not be a quiz. I want to get into our first presenter we have here.

Welcome and we're going to dive right in. We'll be connecting this to the work we've been doing directly as it impacts these issues with the working group. We'll be answering the questions that are posed to the panel, so we'll stay focused on those. And one of the things I pointed out is focusing the aspect around evs. EV that are impacted mainly. I've been involved with projects for over a decade now. Our involvement has been to work directly with the automotive manufactures because we saw key deficiency early on in the programs setting up. Without these technologies migrating to the automotive products, there will not be any part in the development. And our focus has been on open standards. Number one develop standards and number two implement them with the providers and audience. The early programs in 2009 and 14 we focused on. There have been two projects funded 1406 primarily focused on ac. We worked with Honda to implement standards and focus around local facility and demand management aspects and use cases as well. And then it was demonstrated work ago long side EV project. The second project we have ongoing and the third one is epic as well. Is looking at the D.C. aspect of it and to integrate in terms of building management system. This is where we are relying on a device not only the electric grid functionality but also local, solar and storage in one power conversion and control system. So that hopefully is a cost-effective way to do it. And these ongoing projects, one key aspect is to look at impact of these services on the battery cycle life. Let's look at the issues the question in the context of the project we've been working on. EV's for backup generation without a microgrid, so we're looking at all of these programs are looking at how backup generation can facilitate without violating any of the foundation principles. The smart power integrated node designed for this purpose. How does it do it? It integrates local PV with V2G capable EVs. It can manage it locally or through the cloud. It's capable of take over local load management powering the household with combination of PV and electric storage. If

you have a switch, you can switch back and forth. Some of the use cases looking at is minimizing back feed and self-conduction and other things. What are the challenges and opportunities that we are seeing with this project? One of them is DC V2g standards process. So, we have a way to interrupt both systems. The second is battery degree days, what is the impact of this on batteries. If you use electric vehicle batteries for backup power occasionally. It's looking promising so far. We will so v some very important results later part of this year, early part of next year. That is one aspect. The backup generation is part of multicustomer microgrid. How do you implement EV backup generation? EV for one thing to understand is that EVs by themselves no matter how good the battery size is having limit to extend capability of backup power. It is consumed by the battery itself. With EV it can be extended quite a bit. An existed is likely to have microgrid integration. We have had architecture in which there is microgrid control they're allows nation of this. The second so the second thing is that we are looking at capable EV. Provide the energy backup. Two Mike grow grids are the same. We need to make sure the interface and upstream systems need to be seamless and we rely on the communication standards to facilitate that. How can we use electric grid as sources? One of the things that is important to know is that EVs and electric vehicle owners need to have the mobility and electric vehicle owners' priorities around how they want to use the grid, whether they want to on the in or out need to be factored in. We have provisions for that. Keeping the driver informed and keeping them in the loop is important. The second thing is use cases around these that we worked on are related to the grid services we implement. If we want to manage multiple vehicles in a facility connected back and forth from the grid, you need to make sure service capacity aren't violated. One of the use cases we implemented was around that. The second thing is absorbing oversupply. As long as there is visibility into this aspect of signaling, we should be able to have the electric charging to excess over supply. Which is a nice feature of EV as complement of over generation. And the information around hardware. We can't get into the hardware and software cost specifics only because these are one off experiments at this point. There is sufficient information available now what the components are going to be to create models. I can answer very important aspect we need to study many details. And the second part will be the more you can standardize the packages that are capable of interconnecting with utility system, that will help speed up the process and streamline the cost and interconnection aspect as well. Thank you very much and that's all I have to say. >> Thank you. I appreciate a lot of projects you were trying to get through there. We'll dive a little deeper into them when we get to the q and a session. If folks have questions around his presentation.

>> Hello. Program manager here. We are a green energy technology company. We have commercially deployed option worldwide. Where our platform is essentially optimizing the distributed energy resources, particularly EVs in order to leverage their

potential to provide services to the grid. I'll be speaking to the invent project that is taking place on the 42-megawatt San Diego microgrid. You see on the screen the partners that we have that have been contributing to this project over the last few years. I'll note that we're at the very tail end of this project and are going to be releasing a final report in early next year, so you can keep an eye out for all the details at that point. Ultimately goal of this project was not only to demonstrate but also quantify real world benefits of technology and EPA the way for commercialization here in California. To give you an idea of what this project was doing, we essentially this is the architecture in which we were operating. The two main things I want to call people's attention to here are the two input into the aggregation platform. One the s the signal for one of the four different services I'll talk about in a moment. As mentioned it's the driver transportation need, and this is the crux of making this work in a way this not only satisfies the drivers needs but also brings value to the grid. Leveraging the architecture, I showed you on the past slide, we essentially used that to demonstrate three buckets of services. First being vehicle to building, which is charge math and renewable time shifting. Trying to align charging with on cytosol large intestine production. Frequency regulation and third we have demand response. I'm going the walk you guys through results of each one of those different use cases that we worked on over the last few years. Charge management, we manage the charging profiles of five different electric vehicles that were at a parking garage in San Diego. The graph you see is the calculated cost savings we were able to realize through manipulating the charging profiles to reduce the demand charges for those vehicles. Over the course of a year. So, based on that year of operation, ultimately, we were able to show we were able to reduce the annual build for this parking garage by $4,600 which came down to a 9% reduction on a monthly basis for this standard parking garage that had charging added. For renewable energy timing, we managed the profiles between four to six vehicles. Another parking garage on the uc San Diego campus over the course of 7 months. We'll have more by the end of the project. We managed these vehicles with a dual objective in mind. One is the attempts to as I mentioned correlate the vehicle charging with the on cytosol large intestine generation for this particular parking garage. And the other was to reduce the monthly bill. The results you see on the screen tell a clear story of the additional value add of the vehicle two grid component. That additional value was realized because the ability to discharge when the solar was ramping up in the morning and ramping down in the evening. Frequency regulation was the one-use case that under the invent project we did not decide to quantify value for. That was largely because we would have been replicating efforts that would have been completed under the vehicle storage project which we collaborated on as well as a few others. Instead of going through the evaluation process for frequency regulation after collaboration it was determined that we would instead focus specifically on the performance c component settlement. Really the goal for this was to allow to us get a better feel for how diverse range of

vehicles charging stations could provide regulation up and regulation down as they start to wrap their head around how do we incorporate this type of resource into that market on the wholesale level. Then last but not least, we spent the last year digging in deep into the response and demand response option make niche. What you see here on the slide is essentially overview of the players and the different resources that have been involved with us actually being able to leverage our assets on the microgrid to participate in the demand response mechanism and wholesale energy market. So really the two things to point out here on this slide is that what we had control over under the project was our resources and then a stationary storage battery that the university had that they wanted to try to use the leverage into the market. We aggregated both of those, all those assets together to provide demand response and low production in the market. What you see here is essentially a summary of our actual market results over the last few months. Dram 2020 started back in June. We had capacity of 1.8 mega Watts which was largely attributable to that storage battery. About 200-kilowatts from the vehicles we had on campus. June and July were straightforward months. All the snow on the lines and crazy in the energy narcotic due to the heat wave we were having. The preliminary results or August and September, we just got our August result this is week after I had to submit these slides. The capacity came in for August was closer to $50,000 and energy payments were positive in the realm of $8,000. That was largely attributable to the spike of people we were seeing in the market during that month. More importantly it is a nod to the dynamic of managing a few resources within a broader microgrid and having the settlement and baselining occurring at the microgrid level. You can see on the bottom line of that table that are demonstrated capacity that led to the payments was far greater than what our original capacity was and that was due to the overall microgrid taking action to further reduce load which was really good for the grid during that time of stress. This last slide summarizes some of the bigger picture items of the fun we've been dealing with trying to figure out how the provide demand response. We're only in control of two mega Watts. Lots we can go into further, so I'll leave it at that. As I mentioned we're at the tail end of this project. We will be submitting our final report in early of next year. That final report will include a cross benefit analysis that will address some of the cost questions that I know many on the phone are interested in. Keep an eye out for that analysis early next year. I don't have the numbers unfortunately at the moment to share. But they are forthcoming. And I got the last and final slide just contact information for myself and my colleague for any other questions that meme might have following this. Thank you very much for the time and we'll look forward to answering questions at the end. >> Thank you. I appreciate it. As we move off this slide, would you put your email and address in the chat box so if they want they can grab it.

>> Yes, I will do that now.

>> Thank you. We have several follow-up questions me for that. And I've had a few come in to chat. If you have questions for Kelsey directly, feel free to put them in the A and A box. It may be hind three dots. Next, we are going to go to Jordan Smith with southern California Edison. Jordan, I welcome you are a repeat performer here. I look forward to hearing what you have to say.

>> Thanks Andrew. Thanks for inviting us to participate in this forum here. Happy to talk about one particular epic project here. Also, very appreciative of the program itself in being able to participate and enjoy the benefits. I'm a consulting engineer with grid eng innovation group. One of the main functions of that group is managing our epic demonstrations. So, if I could go to the next slide please. So, I've just listed here three what we call transportation electrification focused epic projects. There is actually a fourth project that was reported on in another work stream by which smart city project which has some EV charging elements. These three projects are really mainly transportation electrification focused. And so, we have service center of the future, vehicle to grid project and a distributed charging resources project which I presented on at the 9/24 workshop. Service center of the future is really very interesting concept and has developed into a position where it has quite a lot of potential for providing value to the utility and the industry. The original idea was that was really more focused along electrification of our fleet and all the 6,000 vehicles in the fleet. And looking at all of the bases for those vehicles and bringing in all the infrastructure and all of the elements to those facilities that we would need to fuel all those vehicles. But the other thing that we were looking at there was the distribution of those centers throughout our service territory, throughout the 50,000 square miles. And noticing that they would be potential there as the basis for supporting the distribution system. That was the original idea. Now workening to fleet and heard some of the announcements that came out in the press about our fleet electrification, we continue to work on that steadily and republish some goals there. But what we found working with our customers and supporting the charge ready program was that parts of the medium and heavy-duty truck industry were progressing faster than the utility states which have a lot of specialized vehicles. In support our activities consulting our charge ready program group. In support of a major customer there in the charge ready transport program we pivoted to a fleet customer site. So, this particular customer working with L.A. metro on electrification of their bus fleet and the more than 2,000 electric buses and we're working together with L.A. metro on their first full depot electrification which they call division nine. And so, as we work together with the charge ready transport projects on defining and designing this depot for full electrification, we thought it was a very high potential for us to be able to host the service center of the future technology. Just to give you an idea of the sort of the nature of the challenge, this particular bus depot host as of today more than 200

conventional buses. As L.A. metro moves toward phallic will be, on paper these types of things are popping up conceptually around the territory. As you go to full electrification, you sudden I have bubbles arising of potentially large power and high energy. We thought this was a great place to look at application of this technology. I've listed the elements here. I will mention we just launched this project earlier this year. So, we're designing the system at this point and so we expect to come back again at later conferences such as this and present our results. Pretty much in design phase right now. I will mention also that at the same time we're working on these epic projects, we're working separately on implementing a new grid management system with a DER management system incorporated. And so, one of the things that the epic project is doing is it's helping us work out interfaces between the control systems. We're standing up a utility microgrid utility front of the meter energy storage system that we're in design phase now, but we think will be on the order of several mega Watts and probably a four-hour battery. And integrating with a Mike controller. We're in the process of acquiring this system and will used a cross several microgrid projects. On site here, we're doing a building electrification on this property this means we're bringing in electric, HVAC and electric water meeting with a building system that will interface with the microgrid controller and we are interfacing with the bus charging management system which will be primarily operational and economic controls and so one of the challenges here is to blend in inputs from the grid side into that charge management system. Without disrupting any operations try to optimize economically from the customer and grid perspective. We've also got submetering elements in the project where we'll look at submeter technology for each of the EV Chargers and all the back-office communications. We're going to wrap up here. I'm not going to go through all the use cases. I'll list the outlines here. Demand response from a grid perspective, how do we support the local grid again and renewables on the local grid, EV charge charging, support the whole system. We can support voltage issues as well as capacity issues. We're looking at resiliency, how do we support the vehicles in the event of a grid outage? I have v listed out the challenges and value we expect to be delivered from this project. I'll go to the bottom line. We see this as a potential alternative service option. So, the ultimate bringing in high voltage sub transmission and customer substation. We'll do this with storage and controls in a way that might be more economical and efficient. We hope to use the learnings here to help support the building out of transportation electrification at large scale.

>> Thank you. If you have questions for Jordan, please put them into the Q and A feature. We have some in the chat function. If you want to ask a question to any of the panelists, put it in the Q and A box. Next, we have Tim from UC Berkeley to talk about our next presentation. Welcome.

>> Good afternoon everyone. Thanks to everyone for inviting me to participate in this session. Very excited about this topic. Some of you may know I've been studying vehicle grid integration for over 20 years now. This has been a topic I've been really interested in thinking about how electric vehicles and the grid work together. I've been involved in three epic projects related to this project. Two main ones. The one I'll talk about now. This spring we concluded another one with BMW and one that involves 400 households in the bay area. Maybe you'll hear about that project in a future event. I think we know about the problem where we're getting both the belly of the duck problem and the neck of the duck with the steep ramp and how vehicle grid integration can address potentially both of those problems. So, there is a couple of different strategies here. And I won't go through slide in detail. There are strategies which was the premise of this workshop. There are also EV centric strategies. We were working on the building of the unit and extension of the building another load that could be controlled in the context of the building as the operational unit. I want to show there is a number of different strategies. Also, on the right different emerging standards and protocols that can help to facilitate this. This project we call XBOS-V. It was at UC Berkeley. A dream project for me because I got to work with a number of faculty I had wanted to work with for a number of years. The idea is to use this platform we developed at Berkeley designed for building load controls and extend it to EV S. It's readily extensible open code, open architecture platform. A lot of what we're trying to do is demystify what charging code is ability. Making code available. Showing a low-cost platform to enable this. This is kind of from the proposal of the project, not the greatest slide but there are four key tasks in this project. I won't have time to talk about all of them. The ones I'll focus on are task three which was the platform itself and a little bit on task five where we did some sophisticated modeling to look at particular think ability of EVs to address the belly of the duck problem so that renewables an reduce curtailment which we see being a big problem over the next several years. This is kind of the theme. It's called the extensible building operating system. What we're doing here is thinking of another controllable load associated with the building but one that is more flexible. There are thoughts of turning off lighting or letting thermostats drift. Before you do that, you could look to the parking lot and if people are parked for a long time you could interrupt their charge if ways that don't interrupt their comfort. This is what our test bed looks like. This is the vehicle we were using to test it. Level two charge area long with level one charger that we could control through wifi. Then we had a sophisticated power device on the right to see how quickly we could send signals, how quickly it would respond, quality issues and so forth. This is a geeky computer programmer slide. This shows the common message boss that devices will communicate to the system. As long as we can access the API to these devices which we were able to open up for the EV Chargers, we can put them on a common message bus and develop a hierarchy for what we control. This shows one of the questions which was how this can be low cost. Not the prettiest

picture but what we can do with this platform, we can have a very low-cost computer for about $100. And then we upgraded the charge we are about a $50 wifi board. Started with a rasp berry pie. Ended up with a slightly more capable one that is about $50. A $50 snap in addition. If they don't have wifi, typically allow for that with a simple upgrade. And then a simple internet switch is all you need if you were controlling the EVS E. These are all now becoming standard low-cost devices, easy to implement. This shows what we were trying to do here where something in the building would happen like a thermostat, heater would turn on or refrigerator would turn on, we could complicate sate by adjusting the power level of the EVSE quickly. We could adjust from 6-amps to 30-amps fast to compensate for what was going on in the building or turn it off. The task five is looking at future for 2030 of buildouts of millions of EVs is which is the state plan. This will take a lot of work but that's what we're hoping for. You can see this is the curtailment in these different cases. Focus on the center 3.3 million EV, with no EV we see up to 10 terra watt hours. Unmanaged hours will reduce that a little bit. You will have some plugged in during the day with excess wind or excess solar which helps a little bit. You can reduce curtailment. We can't solve the problem. But we could wrap a couple of terawatt hours that are going waste in these vehicles. We see this equating to 10-$60 million per year in grid cost savings by 2030. 10-$30 per megawatt hour. 72 tons by 2030. That's the forecast of greenhouse gas emission savings because you are soaking up renewables you'd have to replace with natural gas generation in the evening. These high-level recommendations. We knead anyway senate hearing in the spring. We need to get more daytime charging going. Time rates to get more dynamic pricing to encourage people to charge at the right time. And then of course building EV market so we can get to millions of vehicles that will unlock all of this potential. Thank you very much. I'll put my email in the chat. An I look forward to the discussion.

>> Our last presenter here is Maria. If you have questions along the way, pop them in the Q and A box. I will take them if you chat them to me but it's helpful if you put it in the Q and A box for everyone to see them.

>> Welcome.

>> Hi. Thank you for having me. I really appreciate the opportunity to talk to you. Everyone is really exciting and really interesting topics. Thank you so much for having me. I am PG & E lead. I'm electrical engineer and I have ten years of experience in microgrid ability and integration. Most of my experience is in Germany. These last few years here if California which is a pleasure. Today I'm going to give you a brief overview of two of our pilots. One of them in collaboration from another point of view BMW charge forward project with real drivers. And the second someone going to be epic project that is focusing on vehicle to home combined with a

smart converter. I will start with BMW pilot. The results of the latest stage of charge forward. This is the second phase of the pilot. And it was in May 2020 so really new out there. In the phase of the pilot, we had around 400EV owners participating. It is smart charging program with real drivers. And they provided real life experience on how to do smart charging and help us learn more about our customer behavior. This project aimed to maximize integration of renewable energy, reduce customer bilker learn more about away from home charging. Something that is very important to us. And help us understand better the role of incentives. Like financial and non-incentive. Informing people about events. We thought that was a way of incentive. Participants were provided with digital tool. They could see their information. And they were informed about the optimal charging window for their particular needs. And BMW incentives and some events happened around the process of this pilot. Calculated the information from the utility and vehicle and balanced them and provided that information to the customers so they could react to that and have an optimal charging as I mentioned before. When the grid needed more con storage align renewable generation with the consumption of the vehicle or when the electricity was less essential. As part of this charge forward pilot, demonstrated that customers were willing to change their behavior when it came to charging. When given incentives and messaging. We can see an example of that in the graphic on the right side of the slide. There you have a comparison between the normal charging during the week of our participants and the week that we called earth week where basically the customers received more information from the utility and from BMW educating them on what needs to be charge in the middle of the day, why is it good, why is it more renewable. By understanding that and also thanks to BMW giving some incentives we had a very good response having more than double the amount of people charging in the middle of the day, basically charging much more renewable. And even some of them charging 100% renewable. We had 73% more electrical charging utilizing renewable energy which was a very interesting result. Incentives not only in incentives but the right messaging and educating people, bring ago ware is something important that had an effect and positive response. With regards to the integration of renewable energy , the pilot demonstrated managing load can reduce -- charging during the day and this increases the renewable used energy used during middle of the day. That's the graphic you can see on the lower part of the slide is trying to represent. Good amount of electrical vehicles participating did shift and this meant we had much more renewable energy charging there. This pilot brought lessons learned. A key part of is it could help increase participation. That is something I will improve in the next stage now. And there were other learnings from the program. Some of the aspects the participation of household base line, visibility and electrical vehicle can be aggregated and then 100 kilowatts minimum capacity that they have to provide, and that data would have trouble getting certain hours, especially today. And with this slide an over view of the second pilot. This pilot is vehicle to home demonstration. It was part of

the epic 2.3 assessment. This project was expanded to include a project that included vehicle to home demonstration focused on charging of electrical vehicle in last setting and responding to events. To give you -- to clarify this considers the home to be a portable system to a solar system in a home shared with a management system. As you can see on the graphic on the right side that is the basis, that is the home and what this pilot considered is different configurations to test which one of the technologies would be more cost efficient, more feasible and have more benefit to the customer. One of the configurations that we see is the electrical vehicle together with storage only -- sorry the house together with the storage only, the house together with the vehicle only or the house together with the vehicle and a storage. And what we measured was the feasibility, customer engagement, how many people would participate in this program. Different cost benefit analysis test and then we did a comparison to see which one it was best. One of the things we also -- one aspect not listed on the objectives, but we also tested was in the scenario how many days could different configuration provide. The lower part of the slide is very interesting because it is the 50% capacity of the electrical vehicle battery and still you have 13 days that the vehicle is totally able to provide energy to this home with portable panel. And what we also see is very interesting consideration of storage with electrical vehicle able to provide 31 days of supply without a grid. This is all connected with solar panel as we. It adds a significant value by having the electrical vehicle with a storage. Even without storage electrical vehicles in this demonstration were able to provide services for functionality. This pilot really has a lot of that. It has a lot of numerical which I think is very valuable. I will leave that link there, so you can check it out. The high level the findings we had from this pilot were that feasible but not commercially available. We'll have to see how it develops before it can be provided in a commercial setting. As I mentioned before PG & E conducted a survey with customers. There was high interested in emergency cases. However, the customers were discouraged by the high cost. And then challenges because it's not available everywhere or not every vehicle has the ability to V2 H. From program administration standpoint, that is a factor I will be look at. When the system was taken by government. We identified the pilot and one of them customers up front cost. And the unclear path. We think with time and the market it will change. Below you can see the test for the EV only configuration, from the program administrator point of view and from the customer point of view. And a result from the program administrator point of view and the cost is the one that makes the participant test. And with that I am done with my presentation. Thank you so matchup for the time and I'm glad to take your questions. Thank you.

>> Thank you. Well come all the presentations. I gave presenters a range of five to six minutes to talk. They had no range anxiety whatsoever. I find it very informative I have a lot of follow-up questions coming off the slide and information. I want to defer

over to some of the questions we got here that have come through over the line here. Reminder, if you have questions for any of the presenters. Please submit them in the Q and A feature. I'm going to first start, and this is a question for anybody that wants to answer here. There has been a lot of talk of a range of EGI and grid services that is going to be provided by vehicles. At this point based on these projects you have done, what is near term, what is vapor, what is too far off or has too many obstacles to overcome right now.

>> It's pretty interesting. There is a whole bunch of different things an electric vehicle could do for the grid. There are straightforward ones. Then you get to power quality. Frequency response for example. There is voltage support. There is reactive power support. A bunch of things. I think clearly the biggest near-term opportunity is simply managed charging. Shifting the timing of charging. We day whole bunch of use cases. In the project looking at what can you do in the context of a household over 24 hours. If you can expand it to a workplace and think about shifting charging not just across time but across space as well. So that you can capture those midday periods where there are excess powers at certain times of the year. That translates lathes into customer bill savings. That is kind of the most straightforward the smart charging. It's easy. It doesn't take a lot of technology. There is just a lot of value there. It's a value that as we get more renewables on the grid and more EVs, that opportunity will continue to grow I believe. Some of the other things like frequency regulation are more constrained confined markets that may saturate fairly quickly. You may have value at the beginning. It's a supply and demand thing. The value of frequency regulation may drop, and value may dissipate. You have to think about how big the markets are. Are they going to grow over time or are they easily saturated? And the working group I believe we come one hundred of kind of value propositions. So, there is just a ton out there and I'd encourage those interested to look at that work where we started with started with thousands of cases and then a few hundred more interesting ones and 30 or 40. Smart charging figuring out V2G has a lot more value. V2G can unlock a lot more value.

>> A reminder. If other of the panelists want to ask questions, you can raise your hand or just pop on video and I'll pass it over to you. Does anyone else want to answer that question?

>> I'll add some thoughts. Think fray private company business model perspective what real right is now in California is behind the meter. Kind of along the lines of what Tim was saying in terms of load shifting is the low hanging fruit right now. We could talk about V2G bit I want to point out the medium heavy-duty side of things. We are involved with school buses and they are going to be hitting the road next year. Those are going to be a game changer in terms of what we're talking about being able

to harness and take advantage of some of the other value streams and things we know that the grid needs, and we've been having conversations about they are trying to figure out in real time.

>> Going into that, I think you touched on it and I'll pass it over to Ben for his question. You touched on this in your presentation around some of the limitations participating in frequency regulation markets. Maria you touched to obstacles to individual customers participating in the VR program, what is standing in the way right now. What are the obstacles that limit the near-term adoption of some of these services or is it just those two?

>> I'll speak to regulation. So, the frequency regulation right now is the fact that we don't have a viable way to set it will retail and wholesale settlement. We're actively having conversations with Edison to try to figure out how we can do this in one of our school bus projects. It's not something standardized and not something that is going to make a business model anyone that paid attention to the airport project.

>> All these things along with my fellow panelists here involved with the working group. We've all talked a lot about these potential value propositions and use cases. They are all interesting right. I think that's what we agreed upon is they are all interesting. And they have there is sort of a scale of I guess kind of difficulty or potential in the different use cases. But they are all interesting. We have some that have technical issues that we're working on. There are tools that are coming on board that are going to help was those like I showed, I talked about our determines platform, utilities are implementing advanced dms and platforms that will enable capabilities here that are important to realize some of these functions. And so, some of the things we're working on that have challenges. I agree Tim that kind of what can we focus on now as the market sort of expands and we should -- I think we should be working on embedding certain capabilities or certain not even capabilities but certain settings and configurations right now that enable people to easily incorporate things like following the TLUs, that is one of the tools we have today and can we provide people with simple systems that are easily implemented that don't require intervention that automatically follow these types of signals. Simple DR for load. You get into things like complex things like getting into wholesale market services. Those are things that are going to take us a little bit of project work and epic is a good forum for that and we have projects focusing on these things to work through those. It's going to take long tore work through those to realize capabilities there. I don't think we should focus on those exclusively as those are a needed step right at the moment. We'll get those capabilities when we can accomplish what we need to accomplish and get the tools that we need.

>> I was going the respond to your question with regards to what was said in the panel, the low hanging fruit is load shifting through price signals. That seems to be something that is the next step. Let's do it right and let's make it work. But we need to work with other use cases. For example, to your question with regards to the limitations of PR, what happens people have been working with people communication directly from the app and sometimes it's a little strange to have a person to involve along and that they can participate with their electrical vehicle in the program if they have a portable system. The enrollment challenge was there. When it came to participation, what was missing was flexibility. The market is designed for static things. A stationary storage there is that there and the vehicle moved. It is not possible the aggregate so much for certain hours in the day for others working specifically with electric vehicles for example. The base line continues to be the household. Another topic that we had that we know also they have to be available for the whole window. It goes from one to nine. But they have to be available the whole time. If that could be more flexible it would help. My sans flexibility and continue doing demonstration to understand better what is necessary and what are the key principles that would work.

>> I have some follow-up questions. I wanted to toss it over to Ben. You had a question to pose to the group. Welcome Ben.

>> Really appreciate it everybody. I'll try and be quick and want to turn the focus to a little more on the by directional capabilities that some of you folks mentioned. I'd be curious and appreciate the panels comments maybe around two broad areas that we've been thinking about on the emI and cec side a little bit. That is where are costs today. Some of you guys talked about some new products whether it's NUVVE or spin products. Where are costs today and where can they get to 1234 are where are the real opportunities to reduce them related to cost is your thoughts on real technology gaps or need that need to be further explored whether it's standards or starting to demonstrate these capable outside of Mike microgrid and aggregating. If Chelsea, nuvve is ready to start doing larger projects outside microgrids and ramping up. And also, if anybody wants to talk about their interactions with OENs and the sentiment of the automotive makers in participating in this and on vehicle technology requirements or cost requirements whether they are an issue. Any of those. Thanks for the great discussion.

>> I'm going jump in here first. In terms of cost, I think there are a number of ways to look at it. One is needing to look at it from the entire perspective of the hard and soft costs implementation cost and installation and then upkeep and maintenance. And need to look at total life cycle cost. The other thing is we need to look at the systems of integrated system, so we don't want to create functions in multiple places. So, if

you are adding cost in one place and taking it out of the other. The second part in value equation we need to maximize the opportunity here as well from using the system. I would say that on the hardware side primarily one way to whether the cost of the vehicle or infrastructure. One way to look at it is saying I think there is a question about whether the vehicles need to be equipped with any special equipment. You can take the system off board and you can have a V2G which is what we tried to do. You are not adding cost to the vehicles. Any ccs capability will be able to provide V2G capability. That's what we're developing. That is advantage of ease of interconnection. If the vehicle mobile, then it is not ought to mat that I can it connects and carrying it's the outlet is capable of accepting the out flow. There are some advantages that the systems bring. And if you heard yesterday, you may be familiar we're combining multiple functions. We are combining all of that in one box. That is one way to implement that. This thanksgiving is the cost side of it. I think the other part of interconnection and integration of cost. Standards are important that also removes the standard affect. We don't have the supply, vendors go out and we don't have access that are left unattended. So that is one thing unused. I think that in terms of overall programs, there are opportunities to streamline the entire administration operation of the programs itself. We've been lucky with auto makers. For the last eight years they've been look at the entire industry around manage charging program platform. I think manufacturers perspective is that as long as they are heavy to add the cost of the vehicle's hardware software as long as there is values available to the customer. They want to pass the value to the customer. Any features cut cost on the vehicle side and parts and labor, so they want to make sure the cost adds value to the customers. As long as the cost are minimized more chance these technologies will get out to the end customers the scale. The second part of the opportunity streamline process around interconnection and coordination of standards. We are as much as possible these things are interacting. Those are the things that are important.

>> I got to speak to the cost of V2G charging stations. We're looking at $1 per Watt of charging stationing's. The medium heavy-duty stations are shipping now. Mid next year we're looking at light duty stations that will be rolling off the line in 2021. All the good stuff come pattle. That's fray cost and time line perspective in terms of that technology becoming a reality and being deployed in California. In terms of your question of us being interested in work outside of a microgrid and aggregating things across sub lapse and working on a larger level, we are already in talks in terms of doing that with other partners on the private side of things. That is in the works and it's something that we have several partners interested in on that front. And the last point I'll make is that DONs in particular it's been a test meant to their interest in the space not nonterms of participation they've had in these projects but in the integration council which has been a good way for them to start entering more into the policy and

regulatory fronts. I think that actions speak louder than words showing they are interested, and they are listening.

>> Any follow-ups?

>> That's very helpful. Appreciate it.

>> We have some other questions. You talked about solar combined with an EV providing 12-31 days of resiliency. There was a clarification question going back 20 one of the initial topics of providing a backup source. What was included? I think I saw in the picture there was a critical load panel. What was included in terms of [inaudible] you were powering for 12-31 days there?

>> >> Who modes were you powering in the home?

>> We were testing at five will watt. It's in the slide. I don't know off the top of my head. I'll have to look at the slide again. Five-kilowatt mode. We had L2 charger. System was rated 5-kilowatt. All around the 5-kilowatts and that is basically this is what we have. The only thing they were doing is take a look at what it were difference between for example charging in summers, charging in winter and charging in the peak day for us which is 31st of July every year, that is the peak day energy demand basically and capacity. So, they were testing different levels of storage of each one of the different months and then this was the summer. I would need to look up again in the report what exactly else was there. That was what they were testing. I don't know if that answers the question. I can get back to you.

>> I think only other piece is it will be helping to feel get back. We'll pose that in the follow-up question to you round. We have time for one more question here. I want to go to some clarification questions that came through because I said I would ask them. Jose had a question around Tim your slides talking about curtailment. His question is if we have E Ps a need for more PD than exist now and yours is related to trying to preference charge. Clarify his question but then I have a follow-up to that one as well.

>> The short answer is yes there will be more. We have SV100 that says we have to have a grid by 2035. We're going to need inner solar and wind by 2030. In the scenarios I showed, I mentioned the modeling, that does simultaneously mod it will future grid and capacity expansion with more renewables as well as PDs. There is more bio fuel. The reason there is curtailment is that especially in the spring and fall months, there is a mismatch between load and generation. There are times when in the middle of the day also at night with all the solar it's not that hot in the spring and fall. You don't have the air conditioning load we have in the sum they're soaks up all this

midday renewable. In the summer we don't see a will the of curtailment. In the spring and fall we expect to see more. We don't have enough load those times unless we do a lot of load shifting there, is nowhere for that power to go as we get more and more solar out there or we could have storage out there. That is very expensive. There should be a better way to do it other than tons of storage.

>> My clarification in follow-up to that. How many consecutive hours or state of charge were you looking at for that shoulder month middle of the day period, how much were you charging on zero to full, were assuming you had two hours of charge time per vehicle, what were you looking at there?

>> What we would do is trunk Kate their charge in the night sometime, so they wouldn't have a full charge in the morning. If you have a full charge in the morning and drive ten miles to work, you don't need to charge. We curtailed their charge in the evening, so they had 50% charge depended on the length of their commute. They set. That I need this much buffer. And then you can play with the rest kind of. Typically, we were looking at vehicles 150-mile range. You might be able to charge them for two to four hours in the middle of the day until they were fully charged then.

>> The last question I have here I want to get to talk about the need for especially equipped hardware capability to enable V2 G. What does that look like from existing vehicle capability? What does the hardware look like from retro fit?

>> As of right now I think vehicles coming off the line are V2G capable period. You have chartable capable vehicle, chartable station, they are compatible. The V2G scenario for anyone listening to the interconnection working groups over the last couple of years have gone along with that ride. 1511 is not ready to do V2 G. It will be ready soon and there are parties figuring out how the make that happen as it is and current editions to make it work as well as just vcs. And for those that's the lay of the land right now. I'm sure others have more details.

>> Just to add quickly from utility perspective that interconnections is something we're focusing on demonstrating in another epic project. On the D.C. side, you know there seems to be a pretty clear path that was agreed upon for moving forward on interconnections. On the AC side there are other elements involved that are not quite ready for certification but it's being worked on through the auto industry. The EV supply equipment the equipment that connects to the grid is one of those components that needs some advancements as far as capabilities and certification. And so that is something on the AV side. It's the connections we're looking at where the exporter invert senator located. On the AC it's on the car. On the DC it's fixed on the ground. So that is where we are today. The other thing to keep in mind here as we close out is

we're talking about something like V2G, something that is not always equally considered, what happens, what do you do with the actual export and that is something that customers interested in V2G or aggregators need to have in mind. You need a plan of what to do. Maria went through an option of behind the meter and use that to home and facility purposes. If it's export it's a different path. It's another thing to keep in mind. After the interconnections it's what do you do with the energy from there.

>> We are at time here. There is a lot more questions I hoped to get through today. But I will send them to the panelist and try gain additional feedback over email and share the responses with the work stream. I want to thank everyone for being here today. Our panelists, our members of staff utilities, that were here as well as sad vice source that joined us as well. These are important topics. We're not going to be able to solve all of them. I participated in the epic symposium this week. There was a lot of information there. Our next meeting on this we touched on some questions in this meeting today that we're going to be talking about at our next meeting which will be on November 19th. At this meeting we'll talk a little bit about that customer engagement side, how do you get them enrolled in charging programs, what does it take to get them involved, whether they need devices on the desk or are there other obstacles to getting them involved in these programs. We're going to be talking about avoiding grid impacts with some planning around locations and other discussions around distribution system impacts from EV infrastructure. Thank you for participating. Look forward to talking to you next time. Have a good evening.