>>Emerson: All right, good afternoon everyone and welcome to another Distributed Generation Interconnection Collaborative, or DGIC Webinar. This is Emerson Ryder, coming to you from National Renewable Energy Lab, and today we're presenting our third webinar of 2017 on plug and play solar system. I'll go through quick agenda here, and some quick updates on DGIC activities this year, and mention a couple of our upcoming webinars on electric vehicles and aggregation of DER. Then we'll plunge into the heart of this webinar for today on plug and play solar systems and at the end, take question and answer questions from the audience, and answers from our speakers today.

So just a bit of background on the Distributed Generation Interconnection Collaborative, or DGIC. So this is a program that's supported by the US DOE SunShot Initiative. It was launched following a stakeholder working group in 2013, and we've produced 17 webinars to date. And we have two main focus areas: the first is on practices and protocols, documenting best practices for interconnection and identifying replicable innovations in the process, and then the second area is peer exchange. So facilitating data and information exchange among stakeholders, and providing a platform such as these webinars for peer learning and outreach.

Our structure for this year focuses on these two topic areas in the following ways: we're developing case studies on leading interconnection best practices, executing data analysis on pre-application reports, and curating some of the cutting edge research on DG interconnection that's coming out of [inaudible] and other national labs. On the peer exchange front, we've developed a lessons learned document for community solar for municipal utilities. You also see a bit later about DGIC blog posts. We've updated our website for this year, and we're looking at now five webinars this year with utility and industry experts.

So last presentation, I covered a bit of a [inaudible] focus on case studies, so I wanna give an update on a different aspect of our work this year, which is pre-application reports project and analysis. And so the overarching goal of that project is to conduct analysis on the effects of pre-application reports in different states, and the impacts on interconnection of distributed solar in specific utility territories. But along the way, we've done some background research on the topic and put up a blog post on the DGIC website with sort of a state of pre-application reports across the state. And so this evaluates what states have pre-application report requirements, or regulations, and also the contents of those specific pre-application reports and how they line up with say, the FERC, Federal Energy Regulatory Commission's small generator interconnection procedures and the pre-application reports that are outlined there.

So, please go online and take a look at what we've put up there. You can access it through the DGIC Interconnection Insights blog. And our next phase of this project will be doing data collection and analysis with some utility partners on the effects of pre-application reports. So, stay tuned for more on this front. For upcoming webinars, just to keep these on your radar, in September 2017, we're looking at having a webinar on utilities and electric vehicles, with a focus on electric vehicle charging infrastructure siting, impacts on the distribution system. We've got some ongoing research here at NREL about balancing solar output with charging of electric vehicles.

So, that should make for a very interesting webinar. We're also looking at out in November to profile some case studies of utilities that are doing aggregation of distributed energy resources. So, dates to come on those. Please go to the DGIC website if you'd like to subscribe to stay up to date on when the final dates are announced for these two webinars. If you're already a subscriber, you should get a notification directly from us when dates and speakers are finalized. So, before we jump into the body of today's webinar, I'd just like to go over a couple of logistics. So everyone on the call is joined in listening only mode.

Please use the questions panel on the sidebar to ask questions at any time throughout the webinar. Feel free to enter those as they occur to you. We will hold them till the end, and then we'll post them to the two panelists as time permits. So this webinar is also being recorded and it will be posted to the DGIC website. You can go there to find both this recording and all of our past recordings, the slides and actual audio and visual contents from these webinars. So, with that, I'll jump into introducing our couple of speakers. First we have Matt Kromer of the Director of Grid Integration at the Fraunhofer Center for Sustainable Energy Systems. And Justin Woodard, Principal Engineer for the New Energy Solutions Group, New Grid Offerings at National Grid.

So they'll be speaking in that order. I'm gonna go ahead and provide a bit more introduction for Matt now, and then introduce Justin just before his presentation. So, as I mentioned, Matt Kromer is the Director of Grid Integration at the Fraunhofer Center for Sustainable Energy. His work focuses on how to cost effectively increase the hosting capacity of the power distribution system for distributed generation. He is the principal investigator on Fraunhofer's SunDial project, a DOE funded SunShot program that integrates the control of grid scale energy storage, distributed solar and demand side management. And, he was previous the technical lead for Fraunhofer's plug and play TV projects, about which he'll be presenting today.

Mr. Kromer previously held positions at Satcon, TIAX and Draper Labs. He received his Bachelor of Science and Master of Science in Electrical Engineering from Brown University and received a Master of Science in Technology and Policy from MIT. So with that, I'll turn it over to Matt Kromer to introduce today's topic.

>>Matt: Thank you for the intro Emerson. So, today I'm going to be talking about a project originally funded under the DOEs SunShot program, on plug and play solar. So this is about how to reduce the cost of residential scale PV by making solar – residential PV systems much easier to install, and to standardize the workflows associated with getting a PV system installed. So before diving into the project in detail, I'm going to start with a short introductory video that will introduce the concept, and then we'll dig into some of the details after that. And I wanted to warn everyone, there's a little bit of a lag with the sound and so you'll just need to bear with us, we're having some technical difficulties. So, Emerson, if you could cue up the video right now, I'd appreciate it.

>>[Video]

[Music]

Solar is a critical power source of the 21st century. Currently more than one million solar systems have been installed in America. However, solar system installation remains expensive in the United States, and many homeowners cannot afford it. The high cost of residential solar installation is due to the length and complexity of the installation. Today it typically takes between 45 and 180 days between the decision to go solar and the day the solar system starts generating power. That is unacceptably long. Fraunhofer CSE and its partners from industry, utilities, university and government have developed plug and play PV systems that will be fast, easy and safe to install, thereby reducing the cost of residential solar systems dramatically.

Here's how it works: plug and play PV systems are easy to install. Almost as easy as an everyday appliance. Plug and play PV systems run extensive [inaudible] and are easy to inspect for safety. They can get [inaudible] forward to the local inspector to ensure code compliance, and installed plug and play systems can transmit key information to local jurisdictions and utilities to take care of all the approvals needed to permit, inspect and interconnect the system. Plug and play PV systems can use a variety of compliant technologies. For example, conventional solar panels fixed to a racking system… or alternatively, light weight solar panels that can be adhered to a rooftop. New technologies such as the light weight panels will be even faster and easier to install. Once homeowners decide to purchase a plug in [inaudible] PV system, the installation process is simple.

After the installer submits an interconnection application and receives approval, the next step depends on the type of installation. For retrofits, an electrician will install a meter collar with a PV ready socket on the side of the house. In the future, meter sockets installed during new construction can already be equipped with a solar ready connector, as shown here. The PV ready socket serves to connect the solar system to the residential wire. Installation begins with PV panels being installed on the roof. One technology developed for plug and play PV systems are light weight peel and stick adhesive modules, which can be adhered to asphalt shingled roofs. To begin installing the peel and stick panels, simply peel off the protective sheet, and affix the panel to the roof, pressing down with your palms flat along the panel for the adhesive layer to bond to the roof.

Other types of modules that can be used with plug and play PV systems conventional backed modules, as shown here. With plug and play PV systems, all cables have touch safe connectors. There is no bare cup. Pre-fabricated wiring and cable protection make the code compliant installation very simple. The home run cables are plugged into the inverter mounted on the side of the house. In this specific example, the system utilizes advanced technology which allows national electric code class two wiring to be used, further simplifying the installation. Here we have a system with micro inverters where a smart AC combiner is used.

Once either the inverter or the AC combiner are connected, the installer will simply plug the system into the PV ready socket. But the speed and simplicity of the rooftop installation isn't the only point that makes plug and play revolutionary. Plugging the system into the PV ready socket will be the first stride in this series of time saving steps. Once the system is plugged in, it will initiate a self-test, ensuring that the system is safely installed and meets code requirements. The installer can also take photos of the completed installation through a mobile app, to provide visual documentation of key aspects of the installation. Once the installation is reviewed and verified by the local jurisdiction and utility, it can be electronically approved. As jurisdictions and utilities gain experience with this process, it will enable them to wave onsite inspections, further speeding up the approval process.

Once approved, the homeowner or installer must power on the solar system at the home, where it can then start producing energy. With plug and play PV systems, the time it takes to install residential solar can go from as much as 180 days down to as little as one day. The plug and play PV framework, an industry wide collaboration, incorporates ease of installation, automatic self-testing, and simplifies jurisdiction and utility approval to the push of a button, helping to make residential solar affordable for all.

[Music]

[End of video]

>>Matt: Okay, so with that introduction, I'm going to dive into some of the project details. And, Emerson, I don't seem to have control right now of the mouse. Oh, there it is. So, first by way of introduction, just a quick word on who we are at Fraunhofer. So, we are a non-profit applied R&D laboratory. We're located in Boston, Massachusetts. We also have outdoor test facilities in Revere, which is local to our Boston offices, and a [inaudible] test facility in Albuquerque, New Mexico. We're around 40 people, and our mission focuses on accelerating the adoption of sustainable energy technologies. We have a number of research areas that we focus on, in particular we have a sizeable group that does work on solar module development.

The area I lead relates to grid integration and we do a lot of work on building energy sciences and specifically, we have a research area in building enclosures. And as you'll see as I go through this project, this – the plug and play initiative touches on all of those aspects, and so it's a really interesting… how it's brought together a lot of areas that we've focused on here at Fraunhofer. So, in terms of the plug and play initiative, mentioned before this was a SunShot funded project. Fraunhofer was the lead – the prime contractor on it. But this is a multi-stakeholder effort, so we've drawn in a lot of different folks from different places in the solar supply chain.

The overall vision for the project is to drive down the cost of residential solar PV through commercializing plug and play PV systems. And at a very big picture, this is about turning solar into something that looks a lot more like an appliance. So this is integrated [inaudible] PV systems that can be quickly, safely and easily installed by non-expert installers. So we had three specific technical targets we were trying to meet. The first has to do with an installation time of less than 10 hours. The second has to do with a reduction or elimination in the need for specialized labor qualifications during solar installation. And, so here we're thinking about making it so you don't need an electrician to install a PV system. And the third aspect has to do with developing and demonstrating a fully electronic process for doing the permitting, inspection and interconnection process.

And we call that the EPNPI&I process. And what we're really looking for is an ecosystem that fosters the adoption of plug and play solar. And so we at Fraunhofer, we're not a product company. So our end goal is to really foster the adoption of this system by – this concept by industry. And so that means multiple vendors developing systems that, within this context, that will be broadly adopted nationally with multiple utilities, multiple jurisdictions accepting their installation. And so we've thought a lot about how to set up a framework that would enable this, using a lot of different technical approaches that fit within the broad ecosystem of solar systems that are available today.

This slide lists some of the project partners on this. I won't go through all of them, but you'll see we've partnered with some names that I'm sure are familiar, such as Sun Power, we worked with them on developing an AC model version of a plug and play PV system. We've also worked with a number of smaller companies that have developed different innovative components that address different aspects of the solar installation supply chain. We've also collaborated on this project with utilities, notably National Grid and Eversource, as well as some of the local jurisdictions in the Boston area. So the City of Boston, and then the Cities of Falmouth and Dartmouth as well.

So at a very big picture, the cost of residential solar PV today in the US is driven primarily by what industry has termed soft costs. So these are the non-hardware costs associated with installing the solar PV system. And the data on this slide is a few years old now, so it's not – the precise numbers are not up to date, but the basic message is still valid. And that's that in the US, on a national average basis, to install a PV system on your roof, it's between $3.00 and $4.00 a lot installed. And if you compare that to other countries around the world, you'll see numbers that are half of that. So, in Germany you'll see an installed cost today that's less than $1.50 a lot.

And it's notable that this is the same basic hardware that's used in all these systems, and so what we're really looking at is a problem that's driven by the overall complexity of installing solar PV. So, on this project, what we've tried to do is take a big step back and design residential PV as a system to greatly simplify the installation process. So in terms of our approach to that, as I mentioned before, we wanted to avoid prescribing a specific set of technologies that one needed. So instead, we developed a framework that defines the requirements for a plug and play PV system. There's two very important components of this.

The first has to do with a standardized – a data standard, basically. So a standardized API that enables stakeholders to transact information in a standardized fashion. And this enables us to greatly streamline and accelerate the entire regulatory approval process. The second piece that fits into this is what we've called an electronic proof of compliance methodology. And so this is a way for a system to self-certify that it's been installed in compliance with the National Electric Code. And so we're talking about here is factory certified [inaudible] listing as a system for a PV system.

And the requirements for these two components have been defined in a draft standard that we've developed. And then based on that standard, we've done a couple of proof of concept implementations, and we saw two examples in the video, that use a portfolio of technologies in order to realize this concept. So, now I'm going to go into a little more detail on some of these specific ideas. So, the first leg of the proposed standard is this standardized data exchange framework. And what you see in this picture is a typical process for installing a residential PV system. And what we're trying to do is essentially automate anywhere that you see – in particular, as these lines cross boundaries between utilities and AHJs. So, AHJ is an acronym for Authority Having Jurisdiction.

So that's the – typically your local wires inspector. We're trying to automate anywhere that you see these swim lines crossing the boundary between these different entities. A little more detail on how we do that. So, when I do say standardized, I guess I'd like to stress that that's not a one size fits all approach. This is a configurable process, so a particular utility or jurisdiction can set up exactly what their process looks like, and then they can set up what the requirements are within that process. But we define the API broadly enough that there's a lot of flexibility about how that is done. And so we use this API to configure the approval processes, and then to basically create track and process submittal packages for a project.

And so, this is done by organizing a PV system into a set of data models that capture different aspects of a PV system installation. So that would include an electrical single line diagram. It would include things like the customer information related to their utility account. It would include information about the premises electrical and structural information, and so on and so forth. So the second leg of the proposed standard is a framework for what we've called an electronic proof of compliance. And so this is a methodology for a PV system to self-inspect that it's been installed in a code compliant fashion. And there's a number of different ways one can do this.

So, for example, one could imagine designing a PV system so that it eliminates all the exposed metal on the roof, and so in that sense by design, you've made it so that there's no need for a grounding conductor. Another way is verification by self-test, and so for example, if your system is able to electronically interrogate the as built system, we can use that to map the system and make sure that it's compliant with the permitted system that the AHJ has approved. And the last method that we've identified is what we call visual documentation, and so this entails taking digital photographs that can be submitted with an inspection report, or an interconnection request, that document how the system has been put together.

So, just a few examples running through some of the approaches that we've explored on this project. Here's a little cartoon of a PV system, and we can see a lot of different – there's a lot of different components here. So, starting with racking concepts, we saw in the video that we explored adhesively mounted PV modules. There's also a lot of technologies using conventional racking that are much simpler than what's available now. And one can also imagine this approach applying to building integrated PV. So, BIPV. In terms of cabling, we've looked at how can we pre-fabricate cables so that a user never needs to actually be exposed to bare copper, and that greatly reduces the expertise needed to install a PV system.

We've looked at doing – in terms of electronics, both microinverter systems and stream inverter systems currently exist in the solar market. And so, we've thought a lot about how we can make both – this concept work with both kinds of systems. And then in terms of connecting to the premises wiring, we worked with a company called Connect ER that's developed a meter collar that fits between your meter socket and your electrical meter. And we've integrated a premises side connector into that. So you could look – think of this like an electric vehicle charging adaptor. So, that you can essentially plug in the – plug your solar system into this meter collar.

We've also looked at different ways to integrate that solar connection device directly into a meter socket, or into a subpanel in your house. And this is always together with a provisioning controller that can basically run the self-test and communicate with the various approval authorities to actually provision the PV system. I'm not going to go into details on these next two slides, but we did do – we saw in the video there's two example implementations, and this slide is basically going through for the big buckets of things that an inspector would look at, how the different aspects of National Electric Code compliance would be accounted for in the system. So, just a couple of examples, I talked about no exposed metal in the system.

We pre-fabricated all of the conductors. There's a provisioning controller that can map the PV system on the roof. We've integrated all of the required over [inaudible] protection within the kit, and so these things can all be very easily verified. Similar set of – similar list, but this time for an AC module based system. We worked with Sun Power on developing an AC sub combiner that's a little hard to see in this picture. This was a prototype for this project, but it basically integrates all of the over [inaudible] protection for an AC module system in a single enclosure. And that can, again, connect directly to a pre-installed premises wiring system.

So, that gives a brief summary of the project. In terms of where we are now, so our DOE funded work has concluded. We have quite a lot of ongoing work, and I should say to begin that no entity has yet committed to commercializing a turnkey plug and play PV system as I've described it here. And that has a lot to do with – there's – no company is currently organized to deliver systems in this way, and so that's been a big challenge. And so what we have done is worked a lot on a lot of the different enabling technologies that we can push some of these ideas into the marketplace in a more incremental fashion.

And so for example, on the adhesive mounting front, there's one company we worked with that has taken a light weight product to market. Internally at Fraunhofer, we've actually been developing technology that lets us do adhesively mounted solar modules using a conventional framed – frame module. And we actually just had a SunShot award announced that's given us some funding to pursue that at a larger scale than we've been doing. I mentioned Connect DER has developed this meter collar concept, which is commercially available and is – currently they're working to have this accepted at different – in different utilities across the country.

I think there's been a trend towards increasing integration of PV systems. So, two particular concepts that really help this out are the sub combiner that I mentioned that's now on Sun Power's – they're developing – continuing to develop that internally. As well as module level power electronics that can – such as required for the rapid shutdown requirement, that can help with electronically interrogating a streamverter system. There is a number of initiatives related to developing a data exchange standard, such as the Orange Button initiative. That overlaps with the work that we've done, although I'd say it's necessary but not sufficient, data models that they've developed.

And then the last point I'd highlight is that we've done some work here at Fraunhofer on basically a mobile automated commissioning tool that lets you basically do an after-market version of the proof of compliance methodology that I described here. And so that can give either a utility or jurisdiction a lot of comprehensive information about interconnected DG. It allows them to validate an as built system in a very structured way, and it gives a tool to automatically route interconnection requests and approvals. With that, I'll wrap up. In summary, we've shown proof of concepts of how a plug and play PV system can be realized.

We've installed these systems – both systems were installed in [inaudible] of one and a half hours with a couple of novice installers. And the requirements for the plug and play system is defined in a draft technical standard. This is posted on our website, along with the video that you've seen. And we have reference implementation of this system, and I think the – my bottom line is that this $1.50 installed cost in the US is eminently achievable. This is not a technical challenge at this point, this is much more about bringing together the right collection of stakeholders to really realize this vision. And with that, I will turn things over to Justin. Or, back to Emerson I guess.

>>Emerson: All right, thanks Matt, I'll jump in here. I'd like to introduce our next speaker, who will be Justin Woodard. Mr. Woodard is the principal engineer in the New Energy Solutions Group at National Grid. His current area of focus is on company owned solar and storage development in Massachusetts. Mr. Woodard is a licensed professional engineer in Massachusetts, has received a Master's degree in electrical and computer engineering from Worcester Polytechnic Institute. His areas of interest include power quality and the integration of renewables. So with that, I'll turn it over to our second speaker, Justin Woodard.

>>Justin: Excellent, thank you Emerson. So, again, Justin Woodard from National Grid. You know, I'm gonna talk a little bit about our involvement with this program and helping to frame why we feel plug and play is such an important step in the evolution of residential solar. So a little bit more about National Grid. We're an investor owned utility, and our New England or [break in audio] should say, our US based service territory includes New York, Massachusetts and Rhode Island. About 13,000 employees and just over 3 million electric and gas customers. And I included some pictures or some graphs here of the interconnection applications that we've received.

So you can see that in Massachusetts, we've had a lot of growth of renewable generation. This graph was into 2016, so you know, we've broken the 1,400 megawatt mark, clearly. By the trajectory of growth… when we dive into the actual applications, you know, based on market signals and whatnot, the number of applications has decreased slightly, just because we're between different solar incentive programs. But, just to kinda frame your National Grid view into this, you can see, you know, 8,500 applications. You know, last year, compared to a little bit – you know, down to 7,400 applications.

And you can see the number of megawatts is actually decreasing, so these systems are trending to smaller systems. And we see that [inaudible] residential scale solar, our smaller systems are becoming more and more prevalent. One thing to note, smaller systems are starting to trigger larger upgrades. So, as we move from – you know, this is a slide that [inaudible] came up with, but I think it's a great illustration of as we move from the traditional grid that we think about where generation flows through the grid to our customers. And you have this more integrated grid, where different devices are communicating, we're relying more on distributed generation, we have to look at the distribution system and ensure reliability.

So as I was saying, that some of these smaller systems are actually triggering larger studies for us. Because we do have to ensure that the system is operating in a safe and reliable fashion. But we see – you know, tying this back to plug and play, that for the small residential systems, there is a lot of potential to help streamline that process. And when we get into certain areas and looking at different distribution circuits in advance will allow us to say there's areas that we know it's real easy to interconnect. And getting that information out and allowing customers to then say, okay, I wanna do this. Go into the system, start the application, commit to the system, and know that they won't have to go through a lengthy process or pay for an upgrade.

So, we're trying to balance that need for reliability in operating a system that delivers all the normal expectations that our customers come to be accustomed to. You know, when you flick the light switch, you expect the lights to go on. And balancing that with trying to help our customers be able to easily adopt the PV or distributed generation. Distributed generation, it's not new to National Grid or Massachusetts. There was a piece of legislation in 2008 which allowed regulated utilities to own – in this case, 35 megawatts of solar generation. So National Grid's actually developed solar generation. Mainly larger sites, [inaudible] megawatt scale, starting in 2009.

And really what I wanted to touch upon here is in 2014, we started a program that is helping us integrate, not just interconnect renewables. And part of the benefit there is leveraging some of the advanced inverter technology, or the technology that's inherent into distributed generation inverters where they can provide VAR support, low frequency ride through, low voltage ride through. So they can start – you know, these systems can start to be better stewards of the grid. And the plug and play methodology really is encouraging to help us understand and be able to move to a position where we can come up with settings and then be able to – based on, you know, almost real time, send those to the system through this process, so that the system can then take the correct setting and run with that.

So that's some of the research in the phase two program. And then phase three, which just started last year, is building upon that with additional, what we call enhancements. So carports, canopies, energy storage and tracking. So, another benefit of continuing this research is understanding tracking is great for getting more total watt hours, or kilowatt hours in a day. But it's also important to us because it allows that energy to be there when we need it more. So in the afternoon on most residential feeders, when the system peaks, you know, the tracking system would produce a little more energy later.

Now, tying this all back to that advanced inverter aspect, there's a ton of benefits that the inverters can actually help with and this is another slide from EPRI, Electric Power Research Institute that kind of starts classifying some of the inverter functions and the benefits. So this is good to just give you a picture of how communication to these inverters would allow us to potentially leverage those functions. In addition, that communication and that dialogue is key because there's a lot that goes into the settings for advanced inverters. You'd have to look at the feeder characteristics, and you have to try and change ramp rates and set points to really optimize interconnection and really increase penetration.

So, being able to study those and be able to get that information out to a large number of small systems is really beneficial. And here's a slide that just talks about – or shows, I should say – the results of Volt/VAR, for example. This is an actual circuit in our Massachusetts territory, and you can see the voltage one day, without the advanced inverter function and Volt/VAR specifically, off and on. And there's a very distinct improvement with voltage regulation. So this is just an example of one area where you know, if you get all of those steps right and picking the right function, getting the right settings, communicating to the right device, you can really get a pronounced impact and benefit.

Getting back to the actual process, for most of our smaller residential customers, they're gonna fall into what we call the simplified process. So that is for systems 15 kilowatts or smaller, single phase. And normally, that's a fairly easy process, meaning that there's not a lot of system upgrades, versus when you get into our larger applications, it requires a more detailed review. And then even our larger systems, 500 kilowatts and above, requires a detailed study and usually requires some form of system modification in able to – in order to support the distributed generation.

And the plug and play program I think really lends itself specifically to the simplified, although the same framework could be applied to some of our larger systems to help automate, you know, the process, 'cause it – there's a paper application. Or it can be done online, but it's not automated in the sense that when you submit it you can see where the status is. We're really working with legacy systems. A lot of our work management systems have been around for decades, and they weren't – no one thought of PV, you know, 15 years ago when these systems were designed.

So a lot of our work is to try and fit some of the new applications and the new demands that distributed generation puts on the company, and figuring out how to best work those into the existing work methods without having to completely revamp all of our existing systems. And as those systems become antiquated and we replace them, we'll obviously design for these newer systems. But, they're trying to integrate that, so right now, a lot of these systems are manual and require tie in to legacy systems and applications. But this gives you an example. You normally [inaudible] process for the application three days, review time ten days. Completing everything, so we're around a month. You know, 25 to 30 days for most applications.

To put that into like, the process and the flow, you know, the customer is filling out that app, sending information, we review it and then we can inform the customer and if any system upgrades are needed. And we really see that the plug and play process could help automate a lot of that and take something that takes upwards of a month down less than a week. As Matt said, you know, ideally less than a day. But we definitely see getting that month to a week as really feasible. Going to a day, I think it's a great goal, and it does lead us to the future of distributed generation. You know, some of the other areas that we're looking at, not just plug and play related, but identifying feeders.

So where can PV be easily integrated, and where can we do it for the least cost? Being able to provide that information, being able to forecast some of the adoptions so that we can plan ahead and understand how to better prepare our system for increased penetration. Obviously streamlining the interconnection process is really beneficial to our customers. And the Distributed Energy Resource Management System, DERMS as most people know it by, I think plug and play can fill a gap, as I mentioned, just being able to get those set points. So, thinking of it as being able to modify and set it up, DERMS really, to me, takes that to an additional level which provides more benefit to the operations of the grid.

But, being able to just get that set point out there and even though it's not an automated system in the sense that it's almost a real time into our energy management or control center, it fills a gap that's definitely there today. And as far as the future of solar, the goals of our program are really to try and make interconnection easier, so this ties very well. Lower interconnection costs for the customers, increase the renewable generation within our service territory, and I think a takeaway question here is how plug and play solar aligns with utility goals. And I believe it aligns very well, 'cause [inaudible] Matt laid out, and it aids in the increase of renewable generation and the cycle time of installing that generation.

It allows us to better track and understand and update our systems based on those applications. And, adding that altogether, we feel that it adds more options for our customers and better value to our customers. So with that, I'll turn it back to Emerson.

>>Emerson: All right, thanks Justin for that great presentation. So, I think we'll move onto the question answer segment. I've seen a lot of questions come in already. Folks, if you still haven't submitted them and have a question for our speakers, please go ahead and submit using the questions pane in the sidebar panel for the [inaudible] webinar. But, drawing from a couple of these, maybe I'll start off with perhaps a couple of more straightforward questions. So, one question that came in, and I think this is geared towards Matt, for the plug and play systems, how does a plug and play type system meet utility AC disconnect requirements, if there are any?

>>Matt: Yeah, thanks for the question. So, first of all, that is – the AC disconnect requirements, the specifics of it vary by location. So, the systems that we saw there had an integrated circuit breaker in the – in that meter collar. So, that meets the requirements some places. Some utilities want to see a visual disconnect. So, another option would be the actual plug that we have that can be obviously disconnected, so that would be a visual disconnect. And then a third option would be you know, basically a standard AC disconnect, and if I were sort of plug and playifying that, then I basically would connecterize the interfaces to it, and let you basically put it in series between an inverter and the premises wiring.

>>Emerson: Okay, great, thank you. And then another follow-up on the kind of systems considered for plug and play. Was there a specific size in terms of capacity? You mentioned the goal of installation in under 10 hours, but was there a specific capacity size? It sounded like – or looked like from your images, they were generally smaller residential sized systems.

>>Matt: Yeah, so we focused on this project on 10 kilowatt and below systems. That's… and there was a few reasons for that. One is I think the… the acceptance for the concept would be greater for those types of systems. A lot of utilities and jurisdictions already have different degrees of streamlined processes for small, residential PV systems. A second reason is that the soft cost issue actually is a lot less dramatic as you go to larger and larger systems. So, there's nothing intrinsic about you know, could all the ideas that we discussed be scaled up to 25 kilowatts. The answer is probably yes.

Once you're talking about 100 kilowatt system, it's – the soft costs really aren't so much of an issue, and you really probably do want some skilled labor designing and installing the system.

>>Emerson: Okay. I'm gonna jump over to a question for Justin here, and this is sort of a hypothetical. But, suppose kind of all of the applications you're seeing come in in

simplified, were overnight transformed into plug and play applications type systems, what changes do you think National Grid would have to make to switch from processing traditional applications to this plug and play type of system?

>>: Justin: Oh, really good question. It's one that I think keeps some of us up at night. You know, I don't think, if the plug and play system's there, it's really more of an IT upgrade. In order to get the right infrastructure tied into the existing legacy systems. But, the same people are really reviewing that, and actually, by automating the system, it'll really allow those reviews to happen quicker. So if that same number of interconnection applications was coming in all through plug and play type systems, the turnaround and – we could really help streamline that process. And then you really start to get into just the need for distribution upgrades or finding ways to mitigate the increase in penetration that's really not an application issue anymore, it's an engineering grid constrain issue.

>>Emerson: Okay. Thank you. Let's see, jumping through the list of questions here. So one that came in – and this may not have been part of the scope of the original plug and play initiative, but how might the addition of battery storage or some type of energy storage, integrate with a plug and play rooftop solar system?

>>Matt: That's a great question. I actually – I – on the ongoing work slide, I actually had forgotten to put in a bullet point that said storage. So I'm glad someone brought that up. So, storage was outside the scope of our DOE project, but we – I think we've had it in the back of our head the entire time. And so it's a similar set of issues that we're going to see with these more complex, more integrated systems. And so the overall framework fits very neatly in with energy storage. So one can imagine, you know, the same idea of connecterizing storage. A lot of the premise side connector concepts fit very well with a storage based system.

So, it sort of fits within the framework, but it's not something that we've – we haven't, for example, demonstrated it.

>>Emerson: Okay. Next question is coming in for – let's see, I think this is for Justin. Let's see here. So you mentioned a couple of times the ability to send set points with sort of a prime attraction of the plug and play system. Can you talk about how that's different from your more traditional rooftop solar system? And how plug and play provides the incremental benefit.

>>Justin: Sure. So, it's – really, it's with that automation of the system doing self-check and being able to report out, and having that communication via – we talked about different formats and the transfer mechanism, I don't think is crucial to this, but the idea that the system goes out and can notify and say, here I am, ask the utility can I actually interconnect? Can I generate? And then some kind of communication that goes back and says yes you can, but you need these settings. And that we know that that system will say all right, here's these settings, I plug them in, I can do my own self-check and ensure that they're correct and everything is gonna work. And then go and generate.

So it's that idea of being able to do that in a more automated fashion. You know, I think today if we were doing that, it's a matter of rolling out a tech and getting a laptop and connect it to the system and downloading set points. And then getting verification back that those set points are enabled, and if we just see that to move towards that direction, that rolling some – a truck roll to change those settings, or to set up to that, to set up the settings [laughs] maybe cost imperative for a small residential system. Where, in this system, or automation, it could be a very easy additional step.

>>Emerson: Okay, and a couple of folks had more specific questions. I think it's a technical audience, so maybe the mode of communications might actually be of interest to folks. But what mode of communications might be viable between the plug and play system and the utility?

>>Justin: Yeah, Matt, do you want to talk? I know we talked about a few different potential communication modes, and you might be a little better positioned to answer that.

>>Matt: Yeah, and so it depends on the – what specifically you're trying to communicate. And the work that we focused on is… we've somewhat constrained what the – what types of things one would communicate. And so what we're using is basically a secure but cloud based protocol that one would use for basically… one time commissioning set up of the system where one could transact information between the stakeholders. And so that somewhat alleviates some of the security requirements. So for example, a – different types of cyber-attacks would be greatly constrained in what they could actually do to a… a utility's system.

Now, if one wants a more secure communications link that's behind, you know – sort of isn't within a utilities firewall, I mean, one way to do that would actually be through something like the… meter collar has – or, a oncoming skew of that device has a, I think a silver [break in audio] networks adaptor. You know, so it can be inside the firewall for a more secure communications link if you're more worried about operational information. But, our focus has primarily been on trying to basically have something that a lot of utilities could use without having extensive deployment of any sort of AMI.

>>Emerson: Okay, got it. Thank you, that's really helpful clarification. I think there are a whole bunch of questions [break in audio] mostly for Matt about the adhesive panels. Folks have questions about one, heating between the roof and the panel, given there's no kind of air flow behind them as in [break in audio]. And then durability for extreme weather, whether it's hail or high wind speeds, etcetera. So, I was wondering if you could comment on that for some of the adhesive panels.

>>Matt: Yes, I can. So, in terms of the yield impact and the heating effect, that is a real impact. We did some ongoing outdoor testing of the specific modules that you saw in the pictures, with the flush mounted approach. And we saw a yield impact on the order of a couple of percent. I don't have the exact numbers in front of me, but it was a measurable impact. That's actually been one of the reasons we've also been exploring an adhesive –

the adhesive mount approach with a conventional module, where we can have some air spacing. And that would presumably address that issue. With regard to the environmental testing, these modules have been put through the same certification tests that a standard module needs to go through. And so we've tested up to – I can't remember the number.

It might be 150 mile an hour wind. The failure mechanism was the roof deck, not the module. They have a Class A fire rating. As I understand it, there's less – there's no chimney effect, so it actually – they perform very well with respect to fire. And then they've undergone you know, the different hail tests and so forth. Now, I should caveat all that with we don't have sort of 15 years of operational experience with these modules. So, whether the market accepts all the things that I just said is another question entirely. But they have been certified to the relevant test standards.

>>Emerson: Okay, great. I think we're at the top of the hour, or just a little past, so we'll leave it there for today. I wanna thank everyone for joining us for today's DGIC Webinar. And I also really wanna give a special thank you to our guest speakers Matt Kromer and Justin Woodard. And as always, thank you to DOEs SunShot initiative for funding this work. Remember to visit the website to sign up for informational alerts, find past webinars and slides, and catch up on the latest from the insights blog. We hope to see you for our next webinar sometime in September for utilities and electric vehicles. Stay tuned for the exact date and registration, which will be sent out in a DGIC e-mail. This is Emerson Ryder signing off from the National Renewable Energy Lab in Golden, Colorado. Thanks so much for joining us, and have a great day.

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