Amy Hollander: Good morning. I'm Amy Hollander with the National Renewable Energy Laboratory. Welcome to today's webinar on Monitoring Residential Solar PV Systems sponsored by the U.S. Department of Energy. I'd like to begin by thanking all of you on the phone for joining us this morning. We're broadcasting from DOE's National Energy Renewable Laboratory's brand-new, state-of-the-art, net zero energy research support facility in Golden, Colorado.

Our presentation today is designed to assist Sustainable Energy Resources for Consumers or SERCT grantees and DOE project officers in monitoring SERCTechnologies. Although the webinar can be useful to anyone inspecting residential solar PV systems the webinar is intended to inform SERCT grantee inspectors and DOE project officers how to identify proper quality, functionality and long-term durability of solar PV.

We are going to give our participants a few more minutes to call in and long on so while we wait I'll go over some logistics and then we'll delve into today's topic. First of all today's presentation will be posted online within 10 days to two weeks. You will be receiving a link at the presentation via email at the end of the webinar. But remember, the presentation will not be published for ten days to two weeks.

For now you have two options on how you can hear today's webinar. In the upper right corner of your screen there is an audio pane. If it is not visible to you look for the red arrow and click on it. This pane will allow you to choose whether or not you want to listen to the webinar through your computer speakers or telephone. As a rule if you can listen to music on your computer you should be able to hear the webinar. Sometimes the volume is louder through your telephone. The dial-in number and pass code are also in the box.

If you have questions during the presentation please go to the questions pane in the same box. There you can type in any questions you may have during the course of the webinar. We will then strive to answer your questions at the end of the webinar during the question and answer segment.

And with that I'd like to introduce today's speaker. Today we'll be hearing from Peter McNutt. He is an electrical engineer with the National Renewable Energy Laboratory, known as NREL. He has over 15 years of experience working with PV system and have spent many years deploying and monitoring PV systems from the top of Mount Evans in Colorado all the way down to the South Pole in Antarctica. Peter holds an MS and BS in electrical engineering from CU at Denver and he is a licensed professional engineer with the State of Colorado. With that I will turn it over to Peter McNutt.

Peter McNutt: Thank you Amy and welcome all. Today what we'll be talking about is how do you monitor a PV installation and determine if the installation has gone properly, if the installer has done a good job. And basically I'm aiming this talk today at SERCT grantees and the DOE project officers. So my hope is to guide you through the checklist that we have posted. I'll probably be making some modifications to that checklist in the next few days, but then also -- so with that I'll move on.

And so we'll spend a few minutes just going over PV system basics, when we'll spend the majority of the next 30 minutes or so going through the checklist and then I'll talk a little bit about PV system installers.

So a basic grid type PV system is going to consist of PV modules, and typically modules will be arranged in strings. And you're getting DC power from the PV modules. That DC power is then run into a combiner box. From the combiner box you run power down into a DC disconnect. The disconnect is just a switch between the PV array and the inverter. The inverter is what converts the DC power from the array into AC power that is then fed to the electrical utility. There's also an AC disconnect at the output of the inverter. This allows you to just complete isolate the inverter from the DC array and the AC utility.

From there then you run your power into the electrical panel; that panel then runs into a utility meter and the utility meter then runs out to the electrical grid.

A couple of factors that affect the cost effectiveness of PV systems are going to include the availability of sunlight. So this NREL map here shows the southwest is sunnier; you've going to have more sunlight. You're going to get more electrical energy from your array. But another big factor is how the price of electricity -- even though the sunny Southwest is going to deliver more power per day, places like the Northeast, which don't have a lot of good solar insolation, lot of good resource have high energy prices, making the payback on a PV system just quicker.

Before dong any kind of an installation a good installer is going to have tools for evaluating the site. They may be just a relatively inexpensive piece of equipment for evaluating this test site on up to a couple thousand dollar piece of equipment that does everything for you automatically.

The sorts of things that a site evaluation is going to include will be how far off your array is from an ideal orientation. The idea is you want to have your array for annual energy purposes you want to have your array pointing due south and at a latitude tilt. So from horizontal tilting the array up. So in this case -- this is Oregon, east of the Cascades; you're going to tilt your array up about 35 degrees. So what this represents, each of these circles represent about a 10 percent loss of electrical energy over the course of the year. So if your array is off by as much as 40 degree from due south you're only going to lose about 10 percent of your annual energy. And it can be as far as 60 degrees from due south and you're only losing 20 percent of your energy.

Some people that go to a lot of work to install their arrays at these due south may be subjecting themselves to a lot of extra work and also annoying the neighbors. Plus the other thing you have to watch out for is wind loading. Also, part of the site analysis is going to include looking at the shading. So what this little graphic here represents is each of these boxes indicates you have a one, a two or a three. If you have a tree shading up into this box you're going to lose -- you're losing less energy than if you have a tree shading up into this box. It could be a tree or a building shading into this box. But a good site analysis, a good contractor will know all this; they'll take care of this for you. This shouldn't be something that you have to worry about at this stage~~; tolerate the~~ ________.

Anyway, and another thing to keep in mind is that small trees grow into tall trees, so if you're setting up the site and you're doing landscaping keep that in mind -- you want to keep plants away from the front of the array where they can shade and cause future problems.

So the system commissioning essentially serves three purposes. One: that the contractor met the contractual requirements of the contract, so they do everything they said they were going to. Second: is the system's safe, and that's what we'll be talking most of our time here is just trying to figure out how you can determine if the system has been installed safely. And then thirdly: is the system generating the power that you would expect it to?

I'm going to be referring to a couple of different documents. One is an excellent document by Bill Brooks. And you'll notice at the bottom of all the slides I'll have sources for the picture, your documents I'm working with. But Bill Brooks put together this field inspection guidelines for PV systems. The thing I like about it is the way he describes it his intent is to consolidate the most important aspects of an inspection into a process that can be performed in as little as 15 minutes. It has lots of excellent photos and lots of explanations and also has a one-page checklist. This is available for free on the internet and I do have a list of references in my talk so you don't have to worry about writing anything down at this point.

Another excellent document, although it's aimed at decision makers it has an excellent checklist at the end for solar screening, project design and then system commission. This is procuring solar energy and it's a DOE document. And again, this is available for free online.

So before you get into the commissioning process these are things that already should have been taken care of, so all the permits have been signed off, the utility has given you permission to interconnect the system to the grid, you've gotten all the appropriate structural and electrical engineering stamps, you've got the one and three-line drawings of the system, you've got a layout of the system, and that'll include a lot of information like how the modules are going to be laid out, how they're wired, the various components disconnects and the wire and conduit specifications.

You also want to know which modules you're going to be using. You need to know the inverter specifications and then the combiner box specs.

There are several different mounting options; you can have rooftop, you can have a canopy, you can have ground mount and another canopy. What I'm going to start doing at this point -- I have like a little checklist items denoted by a little check here. Basically when you're mounting a ground mount system you've got to make sure that people can't walk up behind it and access the wiring too easily.

Another problem, not in this case but I've seen it done where wiring's hanging down low enough, you have rabbits munching on the grass down below the ground mounted array and they start chewing on the insulation on the wires. So that's a recipe for disaster. In red I'll have things to look out for; in this case the wiring is a little too accessible.

In the case of the canopy here the wiring's up and you really can't do it'; they've done a good job of tucking away the wiring, so they've done a good job of making the wiring inaccessible and it's also high enough that people shouldn't be able to access it too readily.

Some things to look out for: check for protective fencing and make sure you've got the proper enclosures installed. So one solution for a ground mount system might be to put fencing around it, but of course that's going to add cost to the system. Before mounting a rooftop array you want to make sure you have a structural engineer's stamp, sign off on the structure. You want to make sure that the roof can handle the added weight -- again, the structural engineer'll be able to help you there.

You also want to look at the age and condition of the roof. The roof like this, you probably just want to replace the roof and then put your array on it -- roof looking like this is in good condition; probably don't have to worry about it. But you need to check these things.

Also be aware that certain funds may be used to improve the roof directly under the array but not necessarily replace the entire roof. So you need to be aware of that.

Couple other things to check for with rooftop mounting: any roof penetrations must be weather proofed and the array must be fastened and sealed according to the plans. Here you can see the flashing is installed correctly; the upper shingles cover the top of the flashing so that any water running down isn't going to get into the penetration, whereas here they haven't installed the flashing properly: tucked it under the shingles above it, so water and snow may be able to start seeping in here. You many have problems with your roof and if you have problems with the roof then you're going to have to remove the array in order to fix the roof. So it becomes a real problem. So be aware of that.

During your field inspection you want to make sure that the

Amy Hollander: We're having a technical interruption of a broadcast; we'll be with you in one moment. In a few minutes you'll be hearing an emergency test and some alarms, in which case we will mute the webinar and then return. So please be patient. That will probably occur in about one minute.

Peter McNutt: Sorry about that. So one thing you want to make sure is that from the plans or drawings that you have --

Amy Hollander: [Off mic conversation].

Peter McNutt: Like I said, you want to make sure that the number of modules in the module type match the plans. It's not uncommon for the plans to state one module and then later on the installer might get a better deal on another module, so the module type may change slightly but it shouldn't change radically. Also you want to make sure the layout of the array meets the plans.

Also during your field inspection electrical boxes should be accessible and installed permanently and suited to the environment that they're installed in. Then also the array wiring should be 90-degree C wiring, and should be UV rated. Any wiring that's up on the roof is going to have to withstand very rigorous conditions for 25, 30 years, so it's got to be good wiring. You want to make sure that the installer used good wiring.

Here you can see a good installation where you've got the DC disconnect and the AC disconnect from the inverter mounted about eye level so it's easy to access and easy to see. Here you've got a weatherproof but not waterproof box that's been mounted up on the roof. It should be mounted vertically to be weatherproof. Also they've installed a switch disconnect up on the roof, which isn't readily accessible. That's something to keep in mind as you're looking at various installations.

At this time I also just stuck in this slide. You might hear about string invertors and micro inverters. Micro inverters are essentially just small inverters mounted with or even on the back of modules and from those you're taking the DC and converting it directly into AC and then running everything into the utility with the AC current. The advantage of this is you don't have to deal with a DC components, which tend to be a little more expensive and a little bit -- the installers have to know how to deal with them. But also it might increase the cost slightly. So there are tradeoffs but there's no right way or wrong way; if an installer says they want it installed, micro inverters or string inverts, just ask them, "Why are you doing that? What are the differences, the pros and cons?" They should be able to tell you the differences.

Another thing to look for: DC string fuses need to be DC rated. Here you can see a fuse that's DC rated. Typical glass fuses that used to be installed in cars are not UL listed for PV system as a rule. So you want to make sure your fuses and breakers are sized properly. So a string fuse should not be bigger than the rating on the module. Every module's going to have this fuse rating; if you see that a string fuse or breaker is bigger than this number that means you have the potential to burn out modules. What you want to do is have the fuse burn out before the module burns out. So if this fuse is too big it could lead to potential problems. I've seen this recently where someone installed a 15 amp fuse on a module that was rated for 12 amps they have the potential to burn out the module before they burn out the fuse. It's a lot cheaper to replace the fuse than it is to replace the module. So it's something to be aware of; you should be able to ask the installer and they should be able to tell you what the fuse size is.

Another important thing is grounding. The PV array has to be grounded properly and you might ask why is it important to ground the system at all. The main reason is in the event of a fault; if something happens where a conductor should happen to touch a metal surface, you want your fuses and circuit breakers to trip before you start causing a fire or burning out modules or inverters. So that's a reason grounding is very important.

So you want to make sure your PV array is grounded properly, all metallic surfaces in the system should be grounded and dissimilar metals should be electrically isolated. Here you can see a piece of copper wire -- well, I'll start over here. This one's installed properly; they have a proper grounding clip and the copper wiring is running properly. Here you've got the copper installed directly up against the aluminum of the frame. This can cause galvanic corrosion. So basically you'll get corrosion between the copper and the aluminum and that can cause the grounding to fail after years. Like I said, if you have a failure of your grounding you have a higher risk of shock and fire danger later.

This part of your inspection you ought to look to see if the array conductors are neat and professionally installed and also the conduit should be installed properly. Here this is a flexible conduit that's not supported properly; you should have conduit clips along the length of the conduit and here you've got wires in direct contact with the roof surface.

Like I said, the roof can get very hot, and in the desert Southwest you can get temperatures approaching 200 degrees Fahrenheit. So they can get very hot. The wires have to be able to withstand the rigors of that environment for 25, 30 years, the lifetime of the modules. So you want to make sure they're not touching the hot surfaces; you want to keep them -- protect them from those high temperatures. You also want to make sure that the conductor and conduit size and ratings match the electrical drawings that you have.

Bill Brooks has an excellent quote in his document referenced here: "Wire management is one of the quickest ways to read the competence of a contractor installation team." So if you start seeing wiring that looks like this, the wiring is hanging down where squirrels, rabbits might be able to get it or that you can trip over it's probably a sign that they're not doing the best job possible. So these cables, just look for loose or exposed wiring; it should look neat and well tucked away; that's usually a good sign that they've done a good job.

Here we have the bending radius is very tight; they've basically doubled the wire back on itself; you can't do that. So conductors have to be neatly and professional held in place.

Here are some good examples: the wires and conduits should match the plans. Also you want to make sure there's no potential for wire damage. Here you can see how the conduit is properly grounded with a grounding bushing. They also have the bushing in here to protect the wires from being scraped as they were fed through the conduit. And then also you've got cable glands that are designed for two conductors coming up into a combiner box.

Another really important part of the system's longevity is knowing if it's working properly. Monitoring might be as simple as just watching the inverter display. Nowadays it's easy to get remote displays and you can even get internet monitoring. Nice thing about the internet monitoring, it's going to show you hour by hour and day by day, month by month the amount of energy that your system is delivering.

Another thing to look for is there's some way of knowing that your system has failed. This inverter here actually has a failure indicator on it so that you can look at it and easily tell if there's been a problem.

As part of the commissioning process system performance testing is very important. This may be done by the installer; it might be done by an independent third party to come in, but it may be as simple as just using a clamp on DVM with voltmeter to measure such things as short circuit current or the open circuit voltage. You might be able to compute the maximum power of the array using the clamp on meter. Or you might spend a few thousand dollars; they might have an IVcurve tracer, which will go through and actually sweep out a curve to show you how the system is performing.

So the system performance test might include measuring VOC or open circuit voltage and short circuit current of each string and perhaps the entire array, verifying that the inverter starts and operates and actually disconnects from the grid correctly, measuring the maximum power, the voltage at maximum power and the current maximum power of each string and perhaps the whole array, confirming that the power meters that you have are displaying accurate information and then verifying that the system power production is accurate and delivering what it should under actual conditions.

Something that you as an owner might be able to do is have a quick check is on a clear day, near solar noon, if you know the size of your array you should be able to get a number that comes out near the rated power output of the system. So if you have a one kilowatt system and you go out on a sunny day near noon you should expect to get something around 1,000 watts. Here in Colorado we can actually get numbers higher than that; if you're in an area that has a lot of haze you might expect a number slightly lower than that.

Another real important aspect to this or that is important for system inspection is labeling. You want to make sure that your PV source circuits or DC circuits and disconnects are labeled. You want to make sure that your AC interconnection points are also labeled. So there should be clear labeling on all the system components. And the labels should be robust enough to stand up to many years of -- if they're outdoors, standing up to being outdoors for many, many years.

At the end of the commissioning the owner should get a manual that provides the following information: the operation maintenance instructions, including what the homeowner is responsible for, if the homeowner is responsible for anything, the electrical drawing and plans that the system is built to, the actual as-built drawings, so how the system was actually built versus what was intended in the plans.

Another important thing is a system warranty. So the modules may be warranted for 25 years; the inverter may be warranted for ten years. But what is something happens to the system within the next 90 days? Who's going to be responsible for that? You want to have the contractor install or be responsible for warrantying the system. You also want to have a system warranty that's essentially what the contractor warranty is. Like I mentioned, manufacturer module inverter manufacturers will have their warranties.

You also want to have the permits that the contractor hold on the system to make sure that everything was done correctly, and you also want to make sure there's a parts and source list so if you have to buy something down the road where do you pick it up? And another very important thing is the emergency contact information, so if something goes wrong or if there's a major problem who do you call to take care of it? And that should all be part of the owner's manual.

Also at the end of the day the owner should be educated on just understanding how the system operates, basically, how to read the meters and interpret what the inverter's doing, understanding what maintenance is required to perform. Maintenance might be as simple as just making sure grass and trees in front of the array are kept trimmed. As I said, who are they going to call in the event of any kind of emergency? And then of course just how do you turn the system off safely and bring it back online.

Something to realize is most of the inverters are available today have to turn off immediately if the grid disconnects and it may take them up to five minutes to reconnect to the grid.

Spending the next few minutes just talking about installers. There's a North American Board of Certified Energy Practitioners, NABCEP. It's basically a voluntary certification that provides a set of national standards for PV installers to just establish good skills and determine the experience they have working on PV and solar thermal type systems.

So it just gives you a sense of confidence that the installer you're working with is competent and can do the job well. But it doesn't necessarily prevent you from getting a poor system installation but it certainly helps. So you can find out who's registered in your state by referring to the website here at the bottom of the paged.

Something to keep in mind too is NABCEP is relatively new; I think it's in the last ten years it came into existence. So for example there are some states that have a lot of good installers but aren't necessarily NABCEP certified. There are some states that don't have any NABCEP certified installers; Mississippi didn't have any yet. Anyway, keep that in mind.

So keep in mind you want to work with a reputable contractor and installer, definitely answer references; a good installer will be proud to show off past work. It's also really important to have some sort of a system commissioning after the system has been installed. Monitoring the system is real important to making sure that it keeps working down the road, so it's important for the owner to keep an eye on that. And if you don't know what to do ask the installer or contractor.

So with that I'm going to open it up for any questions that you have.

Amy Hollander: Thank you, Peter. That was really informative and interesting. It looks like we did not have the test fire alarm yet; we may still have it and if we do it should only take a few seconds so we'll just pause, but maybe we'll get through the whole webinar without the test fire alarm.

The first question comes from the field and it's regarding a grounding, which is slide 21. The question is that -- and I'm assuming that the audience member who wrote the question is referring to this slide: "It appeared the copper grounding wire was in contact with the rim of the panel -- dissimilar metals. What would you suggest to isolate this point of contact for a permanent correction?

Peter McNutt: In this case here there's supposed to be some stainless steel hardware that'll go behind the copper wire and prevent that corrosion from happening. So all the modules should have either hardware with them or the installers may have to go out and buy special hardware, depending on the module.

Amy Hollander: I'm wondering if Tom is referring to the correct grounding.

Peter McNutt: Oh are you talking about the conductor placement? I think there's actually a gap in between there, and this is very stiff wire in the array, the modules in this case are going to basically -- the stiffness of the wire will prevent the copper from coming in contact with the aluminum frame.

Amy Hollander: Should they come upon the incorrect copper wiring what would you recommend for a correction?

Peter McNutt: In a case like that they're going to have to go back to the installer and say, "Is this done to code?" And if it isn't done to code it's going to be up to the installer to correct it. And I've known installers that have been caught on such issues and they've had to spend hundreds of dollars correcting their mistakes. But it's critical the grounding be done correctly because this array is going to be producing power for 25, 30 years; you want to make sure it's safe.

Amy Hollander: Thank you Peter. The next question refers to the inverter slide, which is slide 19. The question is what happens if the inverter does go bad and is tied to the grid? Does the grid then kick back to the system to provide power to the homeowner or do they lose power completely?

Peter McNutt: In most cases the inverter's going to be operating in parallel with the grid, so if the inverter stops working you'll notice that your utility bills will start going up but you'll continue to have AC power from the grid. But that's why it's real important for the homeowner, the system owner to monitor either the inverter display or monitor internet connection that tells them how much power and energy their inverter is producing. But no, they'll still have power but they won't get the benefit of power from their PV array.

Amy Hollander: Okay, thank you very much. The next question is also from the audience. "Should the system's performance test be a part of the installation and should there be a written performance report in the client file that we should be looking for?"

Peter McNutt: I think it should be a requirement, yes. That way you know that the system was installed properly and you have a written record that on day one it was producing power as intended and as expected.

Amy Hollander: The next question is also from our audience, a simple question perhaps. It says, "Please define payback."

Peter McNutt: Payback is the amount of time it's going to take for you to recoup -- if you paid so much for your system how much energy, the cost of energy it's going to take in number of years to recoup your losses because of the offset from the energy from your system, your PV system. So basically it'd just be the system cost -- I'm getting myself into a little hole here. Basically what it is is just the cost of energy that's offset by your PV system. That's a simple way to put it

Amy Hollander: And do you recommend people reference payback on a monthly basis or an annual basis?

Peter McNutt: Typically for net metering it's done on a monthly basis and you will get a check on an annual basis if you do get anything at all back.

Amy Hollander: Probably varies from utility to utility.

Peter McNutt: Yeah, so it's going to depend.

Amy Hollander: Thank you. We have another question from the audience: "Should the DC connect be mounted outside or nearest to the entrance of the dwelling for safety purposes?

Peter McNutt: Yes, it's supposed to be outside where if firefighters had to come in and go into the home it's as close as possible to the system but outside where firefighters could access the system and disconnect the DC from the inverter.

Amy Hollander: Does it need to be covered from the weather?

Peter McNutt: I needs to be rated for the weather. So if it's a case of the NEMA 3R, NEMA 4, those are weatherproof or waterproof boxes that can be mounted outside as long as they're mounted in the case of the 3R box it has to be mounted vertically, yes. So they can be mounted outside.

Amy Hollander: Thank you Peter. How much shading does it take to disable a PV array?

Peter McNutt: Actually I happen to have a slide here at the very end. This is just a simple experiment I ran several years ago where basically you can see the IV curve of a particular module when it's unshaded, and you can see the power output curve of the unshaded module. But by placing a single piece of cardboard over the bottom row of cells in the module you can see the seven percent shading of the modular resulted in a 93 percent drop in its output power; that's what the dashed lines are here at the bottom.

So modules are getting better at dealing with shading but still in the case of PV a little bit of shading can really hit you hard with a dramatic drop in the output power. So it doesn't take much. If you have one module go out in an individual string that can take out that entire string. So it doesn't take a lot of shading to cause big problems.

Amy Hollander: And does the PV array have to point perfectly south?

Peter McNutt: That's something that I talked about in an earlier slide. Let me find that real quickly. As I pointed out here, this is a tilt, an orientation factor. This is something that the government and State of Oregon provides on their website. But you can see that for the State of Oregon the tilt up doesn't have to be perfect to be within 10 percent of 100 percent output. They can be off by as much as 40 degrees on either side of that from east to west and suffer less than a 10 percent drop in the output. It does have to be perfect, and the other thing to keep in mind is you'll see people mounting their arrays going through some real hoops to try to get their arrays facing perfectly south. It's probably not worth it and then you have to worry about wind loading and also annoying your neighbors. So good question.

Amy Hollander: Can PV modules withstand hail damage and should they be able to withstand wind damage?

Peter McNutt: They should and do. One thing: any UL listed module will have gone through a qualification test so their laboratories that go through and test the modules and make sure they can withstand a one inch hail ball fired at several spots around the front of the module without any breakage of the front cover glass or the cells underneath the glass. So yes they are designed to withstand hail.

Amy Hollander: Could you talk about lightning arresters?

Peter McNutt: Typically lightning arresters suppress the electrical surge that occurs when lightning strikes nearby. on this system here you can actually see where they've installed a lightning arrester at the DC combiner box and also on the AC combiners so that any lightning coming in from the array or any lightning coming in from the utility would be diminished in these lightning arresters and hopefully not damage the array or the inverter. So yeah, there are these products available and they're usually installed either in a combiner box or in the disconnects.

Amy Hollander: How do you make sure you have the proper and latest training for the system installation, or is this done by the city and county inspectors?

Peter McNutt: Probably the best thing would be to make sure your installer is NABCEP certified. There's actually a study guide for PV system installers that's put out by NABCEP. It's very technical but it's an excellent resource, giving you kind of the latest information that the installers need to be aware of. So that might be a good place to start. Also I'd say early in the process of installing a system talk with your inspectors to make sure that you're living up to the latest codes and you have the proper permits and you're doing everything to what they expect. Because another thing: basically the bible on PV installations is the National Electrical Code or NEC Article 690. And this again, it's very technical, but it's updated every three years. So the latest version is 2011 but your local inspector may be working off the 2008 or 2005 version, which may have different requirements. So it's really important to early on talk with your local inspector, find out what version of the NEC they're dealing with and work with them to get your system installed to that. And if there are differences between what the installer is doing and what the inspector is requiring then you need to have the inspector and the installer talk to each other.

But you can buy this publication, the NEC, at this website. And all the references above here are free online. This book, PV Systems, by Jim Dunlop is an excellent resource; you can buy that too. Some other good references, especially for sizing your system can be found here at the bottom of this references page.

Amy Hollander: I'm getting another question regarding lightning arresters. Diane Jones from the audience is from the Detroit area and she's saying that most arresters she's seen have been loaded directly to the array. So her question is instead of the lightning arresters being loaded directly near the inverter they've been installed directly on the array.

Peter McNutt: Lightning protection will help; I mean you want to have lightning protection around the array to hopefully draw the lightning away from a direct strike. A direct strike will destroy whatever it hits but this is going to help. The lightning arresters are basically going to prevent a surge from coming into the inverter and destroying a multi-thousand-dollar piece of equipment. So that's the purpose of them there. But on the array itself you're going to have to have some sort of lightning rods to try to draw the lightning away from the array.

Amy Hollander: So a typical system, that's a typical installation is to have --

Peter McNutt: Right. And the grounding will help -- good grounding may help to try to draw that away. But like I say, if lightning strikes anything directly it's a safe bet it's going to be toast at that point. The surge arresters or lightning protectors are really protecting you from the surges of nearby lightning strikes, not a direct strike.

Amy Hollander: Okay that was an excellent question, though; thank you, Diane. It looks like we have one final questions and we have a few more minutes left in the webinar. I don't know if you can answer this question but from the audience, again, this person's wondering how do RECs factor in. And I'm not sure if the person is asking about within the SERCT program or in general. So why don't you just talk about in general -- we do have a question on recs that we forwarded to DOE and we're waiting for their answer on how the recs can work with the SERCT program but can you talk a little bit, Peter, about how they work with the general public in residential?

Peter McNutt: That's really not my area of expertise. It would be better to talk with somebody that's a little bit more knowledgeable of that.

Amy Hollander: That's fine. We will try to get back to the person who's asked that question; we'll try to email you since we do have a record of your email when you registered.

So Peter are there any more final comments or thoughts you have that you'd like to close with?

Peter McNutt: Most important thing is that you want to make sure the three critical things for any PV system: we're going to be making sure that the system was designed properly, that the system was installed properly and then also making sure that the owner of the system is using it correctly. So it's real important to have these to cover all these facets of the system, so make sure it's going to be successful. There are thousands and thousands of systems out there nowadays that are running well and every day there are more and more installers coming up through the ranks that are available to help you install a system correctly. So do a little bit of homework but you should end up with a good system in the end.

Amy Hollander: Thank you. I do have one more question from the audience: is there any rule that states how far the PV array must be mounted from the roof's edge or the ridge of the top of the roof?

Peter McNutt: I'm not sure there's anything that explicitly states that but I think from a structural engineering standpoint if you have the array above the ridgeline you're going to be more susceptible to higher wind loading. So I think at that point it's probably very important that it have either a structural engineer or somebody with many years of experience installing the systems -- talk to them. You're going to have to work on a case-by-case basis to really figure that out.

But something to keep in mind too is when you're working on a system can you walk around the system? Can you get up above the system? Can you work down below it? Accessibility to modules and if a module does fail after a number of years is there some way to access that modules and remove it and replace it? You want to keep those sorts of things in mind..

Amy Hollander: Okay thank you very much. And with that we'll conclude our webinar. I want to really thank the audience for those very interesting and engaging questions. We had some excellent questions from the audience; probably more questions than I've ever had at a webinar so congratulations.

If you have any other questions for our speaker today please be sure to email Peter at any time and Peter if you want to go back to your email at the end that would be helpful. Again, the webinar will be posted in ten days to two weeks at the link that you will receive when you close your webinar.

And with that I hope you have a great day and thank you again for joining us.

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