Sustainable Energy Resources for Consumers Webinar on Photovoltaics for Residential Buildings

The following is a transcript of a Webinar recording about using solar photovoltaic (PV) systems to provide electricity for homes. The Webinar was presented on Jan. 25, 2011, for Sustainable Energy Resources for Consumers Grantees and sponsored by the U.S.Department of Energy. Watch the video recording.

Amy Hollander: Hi. Thank you for attending this SERC Webinar. My name is Amy Hollander, and I work for NREL which is the National Renewable Energy Lab in Golden, Colorado. We have as our guest today for this webinar on Photovoltaics, we have as our guest Otto VanGeet. And Otto's worked for the National Renewable Lab for quite some time. He is a senior engineer, and most of his work is with the Federal Energy Management Program, but he is also supporting the San Diego Solar America City project and has supported other municipal and state agencies with projects and planning.

Mr. VanGeet has been involved in the design, construction, and operation of energy efficient research facilities as well as office and general use facilities. His experience also includes renewable screening and assessment, passive solar building design, use of design tools, Photovoltaic systems, and design for _____ applications. He also does energy audits. Mr. Van Geet has also authored many technical reports and conference papers, and has been recognized with many awards from professional associations, including the 2007 Presidential award for leadership in Federal Energy Management.

On a personal note, Mr. VanGeet and his family have an off-grid passive solar system with a 1.2 kilowatt PV/wind/hybrid power system, and a solar water heating system that he designed and built twelve years ago. Thank you very much for attending the webinar.

Mr. VanGeet is going to focus on solar residential applications for these SERC grantees. Feel free to type in your questions using the Questions sidebar. It should be at the top of your screen. Mr. VanGeet will probably check questions halfway through, or he may wait til the end. At the end of the webinar you will all be unmuted so that you can certainly ask any questions verbally as well. Thank you for attending, and thank you, Mr. VanGeet, for the webinar.

Otto VanGeet: Thank you, Amy. So this is Otto VanGeet, and I'd like to go ahead and get started. Today's talk will be about PV for residential buildings, and then related to the SERC program that Amy had just discussed.

I'd like to on the order of forty-five minutes or so, and then leave fifteen minutes for questions and answers at the end by myself, and Amy, and Tyler from DOE. So I'm going to go ahead and get started here.

And you should be seeing a cover slide, and this slide is an image of the National Renewable Energy Lab's campus. The reason I use this image is you'll notice, this is an artist rendering obviously, but several of the buildings on our campus do have roof-mounted solar, and we certainly see that the future holds that every roof of every building should be capable of having solar and I believe will have solar installed on it. We're actually broadcasting from one of the buildings in this image. So I'm going to go ahead and get started on the webinar, and again, you can type in questions if you have them, or we'll answer questions at the end.

So the objective of today's course is to provide you, the grantees, an overview of photovoltaics systems, and to establish a foundation for implementing PV projects at your sites.

Again, we're going to start with some motivations. Why renewables make sense, a discussion of renewable technologies, and then this will be kind of the course outline. Site considerations. Resource maps. Technology overview and schematics. A little bit on cost, and then a case study, and then we'll finish out with information resources and questions and answers.

So why renewable energy? This is a nice rendering of renewable energy on the horizon, and I'd argue that it's actually here. And some of the reasons we're going to do this are there's a lot of talk about greenhouse gases, which is primarily driven by energy use, and then primarily by fossil fuels used to make energy. Renewables are carbon neutral, or carbon free if you want to call it that, so this is starting on the left.

Efficient. Obviously they use currently available renewable resources. Today's focus will be on solar, so since we're talking about solar, it's solar systems used currently available solar energy. Diverse. Obviously solar is available everywhere in the world. Jobs. We're going to talk quite a bit about jobs, both local and within the U.S. Jobs are certainly a very important subject. And the case study at the end will talk about jobs, and how you might be able to help with that.

Low impact. Obviously very minimal impact environmentally. Affordable. Again, you'll be giving out grants to low-income housing from affordable. Then secure. That refers to secure energy. It's not energy that's imported from say the Middle East or other unstable portions of the world.

So some other motivations for renewable energy especially for low-income residents is the energy cost savings. Once you install the solar on the roofs of low-income houses, the energy costs that they pay to the utility should come down. Potentially another benefit, though this won't be a big one in today's talk, is avoided cost of infrastructure. For example, my house is off the grid, so we didn't need to extend the power lines to power my house. Reduced environmental emissions. I just talked about that, but greenhouse gases is avoided by using renewables. Reduce volatility. You'll notice on bills that there's a fuel adjustment charge, but reduce volatility and sensitivity to fossil fuels. Same kind of thing for hedge against rate increases. Fuel supply shortage and interruptions. Redundant energy supplies. Then the second bullet from the bottom, this becomes a really important one for all states and locals is employ local trades for O&M, and the installation of the solar in this case. And then balance of trade issues, which I've already discussed.

But those are some of the motivations for renewable energy. Again, we can talk about any of these later on if you'd like in more detail.

So to actually get into the material, the core material of this course, I'm going to spend a moment discussing PV technologies for the next several slides actually. But what's happening with PV, which is short for photovoltaic, and I'll be using PV from here on – is you're taking the energy of the sun and converting it into DC electricity. DC electricity is like the electricity that you get from a better. Direct current is what that stands for.

Most power systems in most houses or most residence use AC or alternating currents which is the electricity carried from the grid. So the energy that the DC solar panels produce goes through an inverter, the second box, moving from left to right in the diagram. The inverter takes the DC and coverts it to AC energy. An important thing is these inverters are grid-following, meaning if there's a grid outage, that they'll shut down instantaneously. That's part of the requirements. So there is no hazard if the grid fails. The solar fails, also.

Solid-state electronics. No moving parts. That's true for all of it. In fact, the PV panels are extremely reliable. They come with warranties of twenty-plus years – standard is twenty-five. What the standard warranty says is that it'll guarantee the initial rating or 80% of the initial rating after twenty-five years. That's a very impressive warranty. We actually at NREL do a lot of research into photovoltaics, and actually have the first photovoltaics that were invented by Bell Labs over fifty years ago, and they still work. So very robust technology.

The PV panels are wired in series to increase the voltage for what the inverter wants to see, and then groups of those are wired in parallel called strings to meet the current requirements. So the PV is connected to the inverter. A very important part of this – and I'm going to talk about this several slides later – is a meter to measure how much energy the PV is producing. Leaving the meter, the energy would go and power the residence, or if there's excess energy on a good sunny day, certainly like today in Colorado, you can back-feed the grid. That's called net metering, and I'll talk about that in some future slides also.

So a really brief diagram on the photovoltaic effect. Basically it's a solid-state device, sort of like a semiconductor, and it's got a PN junction in there, and I'm not going to explain the details here. We can talk about it in questions and answers. But essentially the incoming light, a photon of light, is converted to a free electron. That's the upper part of the diagram. And that produces useful electricity, that makes a circuit as shown in that diagram. The text which, for some reason, is cut off at the bottom of the slide – no materials consumed in the process. Could continue indefinitely. Again, we have over fifty-year old PV. So that's the actual PV effect.

And then some terminology. PV is modular. Starting on the left again, a PV cell is an individual cell that's manufactured and then the cells are manufactured into a module, and then the modules – so we talk about PV modules, the modules are assembled into groups called arrays. So what you'll see on top of houses or on top of the buildings in the first image is a PV array, which is a group of modules. Modules vary in size, but they're nominally 200, 250 watts each, and then the PV array is put together in building blocks of modules.

So looking at an entire PV system, a grid-connected system, which is all I'll be talking about today, this will be typical of what you might be installing on the low-income housing you're working on. These PV modules will be mounted on the roof, typically sloped at some angle facing south, which is where the maximum solar is. And you've got positive and negative wires leaving the PV array on the roof going into what's called a combiner box, basically just gathering all the parts of the PV array going down. Now typically within the building, there'll be a DC disconnect in case you need to turn the PV off. Then there'll be the inverter I talked about. It could be 120 or 240 volts, or even 208 volts, depending on the residence. There'll be an AC disconnect to separate it from the grid.

Typically there won't be a transformer in your projects, but there could be in bigger ones. Then the AC energy leaving the inverter is typically fed into an electrical panel which is the standard electrical panel in the house. It's actually fed typically into a spare breaker into the panel. And then again, it offsets the load. This diagram doesn't show the meter, but there will be a meter also. And it offsets the load first in the residence, and then spins the meter backwards so to speak, and feeds the excess into the grid on good sunny days.

So now to take a little bit bigger picture. We talked about the individual PV systems. This is an interesting diagram about states that are leading in solar energy development. Some of you on the call are in some of these states. And it's not obvious exactly why some of these states are on here, so I'll get to it in a minute. But by far the leaders install PV, this is actually for 2008 in this diagram, but in 2010 it looks pretty much identical. The leader by far is California by several factors, in fact. That's not a big surprise. Big state, lots of people, and good incentives. That's going to be part of the answer. The next one is a surprise. So in California obviously there's good solar resources also.

The next one is New Jersey. Kind of a marginal solar resource. Not bad, but certainly not like the desert southwest. It's because they have good incentives that New Jersey is second. Colorado somewhere in between. We have good solar and good incentives. And I won't read the rest of the list to you, but you can see if there.

This diagram is an NREL map of the U.S. solar resource, and it's just as you would expect. In the desert southwest, deserts of California, Arizona, Nevada. New Mexico is the best solar, the bright red on this diagram. On the bottom right-hand side you can see a key. We measure solar by kilowatt hours. That's the unit of energy per square meter per day. The darker the color, the better.

The real reason to put this in here is twofold. You can see, for example, New Jersey in the upper right. It's not nearly like the southwest, but they still have the second-most installed PV in the country. Again, Oregon is another example, and there's some people on the call from Oregon. You know, not as good a solar resource, but it's still very high on the list.

The other real reason I wanted to put this on here is from best somewhere in the desert southwest, to the worst being somewhere say Seattle or Washington area, is less than a factor of two difference. So PV works everywhere, properly sited PV works everywhere, and it's not that it doesn't work in the northwest or northeast. It's just there's more solar available in the southwest.

Now we're getting into some financial considerations. There's this very nice website called DSIRE, the Database for Solar Incentives for Renewable Energy. There's a link right there. I encourage you to look at it later. In the next few slides I'll be talking about information available from DSIRE. But incentives can fall into many types of categories, and I'm just going to read through them, but there can be federal, state, local, or utilities.

The first more common one is tax incentives . Next would be grant programs like the ones you guys are administering, and the DSIRE site will list all the different grant programs. Then there can be all these others listed here. Industrial recruitment incentives. Trying to get say PV manufacturers into your state. Leasing programs. Loan programs. Production incentives. That's if, for example, in Colorado we have a production incentive that the utility provides incentives for renewable energy generated. That's a subset of other kinds of rebate programs. Then there might also be a renewable energy certificate sales. Again, all of these are available on DSIRE. You might be able to in coordination with your grant to actually have other incentives leveraged for your programs.

Again, this is from DSIRE, and this is a diagram about net metering. Luckily everybody in all the states that received these grants, and you guys on this call all have net metering in your states. Again, what this allows is that on good sunny days, the PV system can literally spin the meter backwards. When that happens you're sort of crediting yourself for the energy generated that day.

You can see all of your states on this diagram, and what the net metering policies are. For example, since I'm in Colorado, in Colorado there's no limit on net metering, meaning that no matter what the size – it could be ten megawatts, the net metering would still apply. But also in Colorado if you're a co-op or a muni, they're limited at ten or twenty-five kilowatts depending. You can see the same kind of thing for your states.

This is another diagram from DSIRE, and this actually relates to the previous one, but it says renewable portfolio standard policies with solar/distributed generation provisions. And in this case, if there's an RPS in your state, and the RPS has a solar set aside or DG set aside, that would be the case. I'll use Oregon in this example, but twenty megawatts of PV by 2020, and in Oregon you get double credit for PV systems installed. Again, several of your states on this call are on this diagram, and the reason they have it is here is that again, you might be able to leverage multiple incentives with your grants.

Now we're going to actually change gears a little bit and get into PV project planning, and what the approach that you might be using for your sites. The first step is to look at the actual facilities that you're considering, and collect relevant data for your PV study. That'll start with the energy characteristics. That's the energy use, and the energy cost. And then also very importantly to the physical characteristics. That's the physical attributes of the building or the site. For example, the address may be the latitude, longitude. The characteristics of the building. You know, is it a single-story? Is it high-rise? Orientation. Those kinds of things.

Then the bolded third bullet down is really, really important. You'll hear this many times. The age, condition, orientation and type of roof. I'm going to have several other slides that are going to talk about this. But that's very important if you're considering putting PV on the roof. You might also look at surrounding grounds, and is there somewhere that might be appropriate for PV. And then very importantly, what is the status of this address, of this physical site? Is it owned? Is it leased? Who owns it? Those kinds of things.

This is sort of an overall priority slide. This is sort of my take on where to install solar. And the first place to install it is on the built environment. In other words, like buildings or the environment that's been modified by people. So on the built environment, where unshaded. PV is very shade intolerant, so you'll have to determine what areas are unshaded to start with and then you size it to the capacity and to the load. Meaning that the generation, the system size, shouldn't be any larger than the annual load. Again, I'll have some more slides to talk about that. And then on 1A, this is the focus of this webinar. On existing building roofs that have an expected life of at least fifteen more years and can accept the added load, meaning the added weight. A side benefit of that is it does reduce the solar load on the building. The solar ends up hitting the PV and not the building roof instead.

If you're a public entity and you have to comply with the NEPA requirements, this would be a categorical exclusion because it's an existing roof. I'll go through the others quickly. 1B is a takeaway that anytime you're building new buildings, you ought to make them at least PV ready, and hopefully actually install the solar with the building. There's a link to a nice document that some coworkers of mine wrote that actually talks about how to make buildings solar ready.

Third on the list would be any other part of the built environment, like parking lots. PV covered parking is a nice amenity and generates energy, also. If you can't put it on a built environment, putting it on compromised land, such as landfills, brown fields, et cetera, would be next in the list. And then last, if you couldn't make it work anywhere else, is on a green field. If you put it on a green field, you certainly need to minimize site disturbances, plant native low-height vegetation, et cetera.

So more on roofs as promised. The ideal installation is you install the PV on a new roof, require the PV and the roof to have a twenty-five year warranty. And often we encourage the two of them be bid together, so the contractor puts on the new roof, and installs the PV so you have one point of contact for the roof and the PV system. That's in the perfect world. But as part of some other weatherization work, you may well have had some recent new roofs, or you might be planning the roofs, if you can combine the two, that's great.

An acceptable version is installing the PV on a roof with at least fifteen years of expected remaining life. Next bolded note is roof must be able to accept the added weight and wind load of the PV. That's typically somewhere in the order of two pounds per square foot, but it has to be able to handle that. The last bullet is cautionary is don't install PV on lightweight roofs such as mobile homes, or roofs in poor condition. You're just asking for trouble.

So now to give you some examples. This happens to be a coworker of mine here at NREL. The upper left image is the house before this project. The bottom right is the same house, but after he's put an addition on, meaning he also has a new roof, and as part of that happens to be a standing-seam metal roof which is a very nice roof. He's also put solar on there. The bottom image on the left has what's called a peel-and-stick solar, so it's literally stuck on in between the standing-seam webs of the new addition. The solar on the right is more typical of crystalline solar, but it happens again to be on a standing-seam metal roof that's attached by clips. If you look closely, you can see the clips that hold the PV onto the roof. So this is a really nice example of a PV system on a new roof, all installed together.

So racking on roofs, more roof details. This happens to be an image from a nice magazine that you might consider subscribing to called Home Power. Very practical home power things focused on solar and other renewables. You can see a bunch of images about appropriate roof penetrations, if needed. The previous image was a standing-seam metal roof so there was no roof penetrations. That's as good as it gets. Most of your houses probably have hopefully in good shape shingled roofs. And starting in the upper left you can see a nice shingled roof. Starting on the upper left you can see a nice roof flashing detail, where the flashing is tucked underneath the shingles, this nice boot on top, and then the solar racking is attached to that.

The next image in the upper right is that same kind of detail, but the roof _____ actually put in and ready for the racking. The middle images are another competitive system. Again, integrated into the roof with a bolt sticking out to attach the racking. Similar on the bottom left, happens to be for a shingled roof. Wood shingles in this case, so you can do that. They also make systems like this for tile roofs. I don't think you guys will have many of those. And then the bottom right is probably the least desirable, but another way that can be done where it's just a piece of angle bolted to the roof, and then the roof racking attached to it. And the note that I have here is require engineered systems. An engineered system that's strong enough to resist all loads and does not leak. That would be part of a warranty that I'll be talking about soon.

So what you need to find out when you go do the site assessment is how much energy is being used. That's the annual kilowatt hours. Another key thing is install the PV after all efficiency upgrades are done. Again, as part of weatherization you might be installing better heating and cooling systems, better lighting systems, more insulation, et cetera, all of which will save energy. And the PV should be designed to meet most of that load after the energy retrofits. Also look at where if there's meter data for grabbing the utility meters, and where those meters are located. So this is for determining that annual kilowatt hours.

So now we're actually going to talk about some tools for when you go out and do the site assessments. I call this screening, and this is preliminary screening. There's a lot of free online tools. I'm going to talk about a couple of them from NREL. I'll talk about in my backyard, and there's a few slides on that. And then another very handy one that you'll see in a few slides coming up is called PV Watts, and there's a link right there. These are both web-based software tools that estimate the electricity produced by a PV array.

Important when you're evaluating bids further down the road, and we can potentially help with that, that they use realistic derate factors. In both of these there's a derate, meaning the derating of the PV, the DC energy to the AC energy. There's a default of .77. Unless bidders can justify a higher one, you want to make sure that the derate factor is spelled out.

Another nice tool in our suite of tools is called RET Screen. It's actually out of Canada, the Canadian equivalent of our Department of Energy here, but a nice suite of tools including Photovoltaic tools. Then the bottom link is a listing of all the available tools.

So now from a PV Watts, I'm going to talk a little bit about orientation, and the top of this slide says orientation and slope matter. The optimal orientation is south-facing sloped at latitude. For example, here in Colorado we're about 40° north latitude here in Denver, so we would ideally put the PV at 40° north latitude. I use an example here since Nevada is one of the people on the call for Las Vegas. And Las Vegas happens to be at 36°, so the columns on the left are the orientation, the middle column is the slope, and the right column is the annual production. And the units that are used here is kilowatt hours for each kilowatt of installed PV. So the optimal orientation south at latitude would produce 1,664 kilowatt hours for each kilowatt, meaning 1,000 watts, of PV that you install.

What's more, it's probably unlikely to have a roof sloped at 36°, but it's quite likely to have a roof sloped at 20°. You can see the dropping from thirty-six to twenty produces very little difference. It's still 1,621 instead of 1664. Same kind of thing if the roof is sloped at 10°, 1,539 annual. Or even 5°, 1480 annual. Those are all pretty decent numbers.

Also, if you orient the building, the roof to the southeast, you can slope it at 20°, you can see it goes down to 1,563. So not quite as good as south-facing, but still pretty good. Now if you were to go further and put it on the east side of the roof, you can see that number drops. Still sloped to 20°, but if it faces east, that number goes down dramatically. 1,393 in this case. And the same story if you rotate the array to face west. Southwest you can see is still pretty decent, 1,543. But if you face it due west, it's even worse – 1,365. If you just laid it horizontally on your roof, you can see it's down to 1412 annual. This happens to be – it's actually far worse if you get far north to say Oregon or some other people on this call. Having it flat on a roof produces much less energy.

So the suggestion for your grant programs is to require the PV to each produce at least 85% of optimal if calculated by PV Watts. Again, the link is in the previous slide to receive the grant. That's, of course, up to you, but you want to make sure your grant hours go as far as possible.

Now I'm going to show you another similar tool called In My Backyard. It's a Google map web interface. It estimates the PV system size based on suitable area. Pretty easy to learn – very easy to learn, and it actually has the PV system output plus simple paybacks based on incentives, and the link is here on this slide.

This just happens to be a random diagram that I've drawn on a site. You can see the blue rectangle kind of in the middle right-hand side of this slide, standard Google Earth. You draw a rectangle on here, and then you just hit – first you hit draw, and then you draw the rectangle. And then it'll actually say based on this rectangle and some assumptions, the assumptions being that it's sloped at 40° in this case and a .8D rating, and it faces south, let's see what would happen. So we'd hit run, and then we'd end up having this output screen. And this output screen estimates the energy production, the value, meaning dollars based on the assumed electric rates, some assumptions about rebates and tax incentives pulled from the DSIRE database that I talked about before. And then you could also play some what-if scenarios here. For example, what if I was to change the tilt angle from forty to twenty, like in my previous slides.

So the right-hand side is the size of the PV. This is just a random output. The rebates, the tax credits. An assumed cost in the dollars-per-watts which is what we talked about with PV. 8.11 in this case. And the other economics and the payback. System input is the bottom left, and that's where you could play some what-if scenarios. Then the system outputs is the diagram on the right-hand side, and it shows the expected monthly output in value, and then summarized by the annual output at the bottom.

So once you've done some screening with say PV Watts, and you've looked at some potential sites, now you might want to actually go do a real site assessment. On this diagram on the left-hand side is a resource tool called the Sun-I, and it actually is measuring for each location the available solar resource for the whole year. The reason this might be important or would be important is that PV is again very shade sensitive. For some reasons, we can talk about during questions and answers if you want. I'm going to hold questions til the end here. What you're looking to do is estimate the size, the annual production, and maybe verify if this is an appropriate site.

So now I'm actually going to jump into some other resources. This is probably the best – or this is the best of the resources that I'm going to talk about. This is an excellent guide put together by solar America cities, or they're now called solar America communities. It's called Solar Powering Your Community, A Guide for Local Governments. And it's a very nicely organized slide and provides policy and program descriptions, implementation tips and options, and a lot of real life examples from a lot of cities around the country. And it's organized in the bullets listed there, but the intent is to accelerate demand through policies and incentives. Talk about engaging and enforcing local rules and regulations, meaning building codes, et cetera, which I'm going to talk about soon. Engaging utilities, creating jobs and economic development. Accelerating demand with outreach and education – again, which you guys will be very interested in. And then there's a lot of examples. The link is listed there at the bottom, and it's scheduled to be updated any day now. I'd encourage you to browse through this. Again, I think it's the best of references that I'll be talking about.

Another useful reference is this Procuring Solar Energy, A Guide for Federal Facility Decision Makers. It's obviously geared towards much larger installations, Federal installations, as you can see from the picture on the cover. But it's actually got a lot of good guidance for planning and executing solar projects, and that guidance is same whether you're a Fed, or a state, or a local, or nonprofit, et cetera. It's another nice reference that we've been able to put together just so you have it there and know it's available.

Now once you actually get to installing PV systems, there's this group on this slide that I'm currently on called the North American Board of Certified Energy Practitioners, or NABCEP. And they are an organization, a nonprofit, that certifies energy practitioners, and they've got a specific certification program for solar installers, and even a specific one for PV installers.

It's a nice thing to have in your PV installers. If your state is mature in the solar market, there'll be a lot of NABCEP certified installers. If not, you can certainly encourage that. This is just a screenshot from their website, and describing the need for certification. I believe it is important to have certified installers. It shows competence that they know how to install solar systems, and deal with code issues. There's also a whole bunch of other nice resources they have in the link that I have at the bottom, including a study guide for what it would take to become a certified installer. I encourage you to explore that site a little bit, and see if that might help.

Once you install your systems, you'll want to know that they're actually working, and by far the most common way to do that is with web-based monitoring. You could verify their operation by going out to each facility and looking, and going through the inverter and seeing the performance, but typically it's better if available to do web-based monitoring. It can sometimes be done even through a phone line. But a suggestion is to require the installer to provide, for five years as part of the PV installation contract, this web monitoring service.

You might consider standardizing on one vendor, and there's a lot of them. But if you had one vendor, then all the solar systems that go in in your district, you could monitor the performance of all of them on one site, which would be very nice.

One of the issues with solar, one of the few issues is that if it's not working, you don't know it. It still just looks like a PV panel sitting up there, unless you actually go look at either the meter or the inverter. I've included a screenshot from one of these vendors called Fat Spaniel Technologies. They happen to be the biggest, but there's a whole bunch of others that are certainly equal. And you can see what it does. It's another nice website here. It walks you through a nice bunch of diagrams showing the panels, the inverter, and the meter. How it feeds into an electric panel, then the data acquisition system, and then how it feeds through the internet. Then you see an output as shown on the screen there. The amount of energy you're currently producing, you produced for the last day, week, year, et cetera. So I'd encourage you to include web-based monitoring.

The last note there is that monitoring may be available for free from inverter manufacturers. Most of the major inverter manufacturers offer free web-based monitoring for buying their inverter.

So now what I'd like to do is go through, for the next couple of slides, a case study, and then I'll work on wrapping it up and getting to questions. This happened to be a project that we were lucky enough to be involved with called Northeast Denver Housing Center. It's low income housing in Denver. And there's a bunch of pictures on the right-hand side of some of the final systems that I'm going to talk about in these new few slides.

What we did is, similar to you, we went through. We had as part of this Northeast Denver Housing eighty-six rental properties that were considered. By screening, looking for things like orientation, roof condition, et cetera, we narrowed that down to thirty-eight rental units. Then we gathered utility data for those thirty-eight units. The PV was sized to meet 85% of the average annual energy use in those units.

A key thing here is all the systems were bid together. There is definitely an economy of scale with PV, and you'll get better bids if you bundle many of your buildings together. So in this case, it was bundled together that we wanted somewhere on the order of two kilowatts of PV for each of these thirty-eight rental units. Then there's some more detail at the bottom notes there. They were all single story, roof sloped at 22° facing south, with shingle roofs that were in good condition. This is the kind of thing you'll want to be looking for in your cities.

In part, some other things that were able to do this Northeast Denver Housing is to use it as training. So Northeast Denver Housing and Groundwork Denver provided training for several low income community members, people living in these units, on photovoltaic design and installation. The images on the right are the professional installer, and some community members installing solar on some of these roofs. The request for proposal, the RP, required the selected solar contractor to include, in this case, up to five trained community members on its crew for this PV installation. The trainees' pay and Workman's Comp was covered by Groundwork Denver in this case. So the PV contractor was able to get free labor, and the community member was able to get a skill in trade for this. So on-the-job training.

In the proposal we also required the contractor to indicate how they plan to integrate these trainees into their workforce, and describe any similar projects that they'd worked on with these trainees. And this is an installed and operating group of housing that worked out quite well.

So we're just about to wrap up and this will be some of my last slides, but some other considerations that I hadn't talked about specifically, if vandalism is a concern, it requires theft-resistant hardware, or a mount where nobody can easily access it. Again, that can be a concern. These are fairly high valued systems. So take that into account.

Just like in my last slide, training. If you can get some low income community members trained, and they'll learn a useful skill on how to install and maintain PV systems, that's great. That's really leveraging and helping your community a lot.

When you're actually evaluating and awarding these proposals, you should be selecting the ones that provide the lowest dollars per kilowatt hour, meaning the most generation for your given grant level as determined by PV Watts are equal. Again, remember that derate factor I talked about. And meet all the other requirements for your project such as roof warranty. Making sure we don't violate a roof warranty. Training. Using a certified installer. All those kinds of things.

Upon request NREL could provide a sample RFP that, or DOE could provide a sample RFP. Again, we'll give you contacts here in the next slide. Let us know if we can help with that.

This last one is a point of confusion on solar systems. It's called the Buy American Act, and this applies only to public housing. If it is public housing, it's got to be either the cells or the modules, or portions of them, need to be made in the U.S. The inverters and batteries must be made in the U.S. Batteries won't apply in this case. And all incidental items – racks, cables, et cetera – there are no requirements. If you have questions on this, there's a link below, or you can contact Tyler, who will be on the questions and answers about additional requirements.

Here's the slide I was looking for which was a duplicate. Again, this note is here. Check with DOE if you have questions about this. The rest of the slide is what I just covered.

And then a summary slide which is available training and contacts. There's several here. I won't read through all of them, but all good information on all these links. And then at the bottom is my contact information, and my coworker Amy, who's also going to help me with questions. Her contact info. And with that, I'm going to look at the questions, and open up the phone also.

Amy Hollander: Thank you very much, Otto. That was very interesting. While Otto looks at the questions, I'm just going to contact the operator and have them unmute so that some of you can ask your questions verbally, so please hold.

Otto VanGeet: So we should be on interactive speech, and I've got some questions that were submitted. The first question is from Douglas, and the question is, why couldn't laminated solar be installed on mobile roofs? I assume that means mobile homes, and it potentially could be. That was sort of like the image that I talked about for standing-seam metal roofs. You do have to be careful with that. If it's a new roof that's in good condition, that's possible. Ideally we'd like to have it all kind of facing the same direction, so orientation does matter like we talked about, but that's possibility. Even the laminated solar, it's not much. It's on the order of a pound per square foot, but that's a peel-and-stick product, so it's got to be on a clean roof where it can be adhered and stay on there for twenty-five plus years.

Is Douglas on the line? Does that answer that question?

Douglas: Yeah, I think so. I know Uni-Solar has them you put on a EPDM so you could put the rubber roof over like a metal mold roof, and then the laminate is actually adhered right to that.

Otto VanGeet: Sure, and you could potentially do that. In fact, the image I'd shown was Uni-Solar and you can, like you said, adhere that to an EPDM or TPO or one of those types of roofs, and put it over either commercial or potentially a mobile home roof. Again, remember that these systems will be operating for twenty-five plus years, so make sure that the building and the roof will be in place for that long.

Douglas: Yeah, that's the one thing. With a manufactured home, it might be gone tomorrow. You never know. That's the problems.

Otto VanGeet: Exactly.

Amy Hollander: Okay, the next question is can the monitoring service estimate water heater solar as well?

Otto VanGeet: The focus of today's talk was on PV, but those same monitoring companies, if you explore that website and many others, yes, you could monitor solar water heating performance. It turns out to be slightly more difficult for solar water heating, but yeah, it's a good idea to monitor your solar hot water systems, also. That was by Tiff, I believe. Tiff, does that answer your question?

Tiff: Yes.

Otto VanGeet: Okay.

Amy Hollander: The next question is from Albert Weiss. What sort of maintenance requirements – and are these cost allowable under the SERC grant? This might be more of – regarding the last part of the question, are these cost allowable for the SERC grant, Tyler, are you on the line?

Tyler: Yeah, can you hear me?

Amy Hollander: Yes, we can.

Tyler: Okay, great. As far as the allow ability of maintenance costs, we touched on that in our Q&A that we sent out, and it's on the website. I don't have it right in front of me, but basically it follows the same guidance as what we issued for weatherization assistance program, which is that DOE funds don't pay for maintenance agreements, or for callbacks, or rework. But if you are contracting the work out, you can put things like guarantee of workmanship, et cetera, into your contracts.

Otto VanGeet: This is Otto from NREL. I just wanted to add a little bit to it. Maintenance and first performance verification certainly is required. What you might consider doing is as part of your RFP, require a five-year parts and labor warranty for the system to at least get around the first several years of this. The amount of maintenance required is minimal, but it's not zero. You do want to make sure connections are tight and that things are working as appropriate.

Somewhere fifteen years down the road, something like that, you might have an inverter failure that you would need to address, but that's way out in the distant future. So the maintenance is minimal, but you should take that into account.

We did skip one question. The question is, will these slides be available for download, and Amy will answer that.

Amy Hollander: Yes. The slides will be available for download on the SERC website. I think all of you probably have the link to DOE's SERC website. It may take five working days to get those slides, but we will attempt to do that as quickly as possible.

And we have another question from Margaret. What about solar panels on poles?

Otto VanGeet: Yeah, so that's a good question. If vandalism is not an issue, solar mounted on top of a pole, I didn't include in the images like that, but a pole meaning like a 4" or 6" steel pipe with solar mounted on top of it is certainly a very viable option. What's kind of nice is you can actually adjust that seasonally. If you want to get some more output in the winter you make it steeper, or you make it flatter in the summer for more output in the summer. So it's another viable option. If there's no vandalism concerns, and especially if there's a location where the pole can be that's unshaded. Yeah, that's a viable option. Does that answer the question, Margaret?

Margaret: Yes. Hi. And that was one of the reasons, is there's a lot of trees on the property.

Otto VanGeet: Yep, and if you can get a pole located south of those trees where there's no shading, that is potentially a viable way to do it. And again, shading on PV is – you definitely need to avoid it. It dramatically reduces production. It's more than proportional to the shading. The systems essentially shut down if they're partially shaded.

Margaret: Right. Okay. Thank you.

Amy Hollander: We have another question, and this question is requesting examples of RFPs and request for qualifications for SERC projects. And NREL does have a template. For example, RFP for photovoltaics. So that template I believe is available on the SERC website, but if it's not, I'll put it up there. Also, I will be happy to mail a copy of that to Sidney Shaw, and I believe I can – actually I can't get your email unless you put – if you type it into another question I'll be able to address that later, Mr. Shaw.

Sidney Shaw: Yes, I'll do that.

Amy Hollander: Thank you.

Otto VanGeet: And both of our contact info's are on this last slide that's up here also, and it's pretty easy. It's amy.hollander@NREL.gov or Otto.Vangeet@NREL.gov. That's the last of the questions submitted through the emails, but we can also take verbal questions at this time.

It's 1:00 so we've been going for about an hour, but if anybody would like to discuss anything related to PV systems, just through either the internet questions or through the voice here, please ask us.

Ruth: Yes, I have a question. I'm Ruth from Indiana. I have gotten several quotes and they all use the Enphase micro-inverter. I wanted to know what your opinion of that was.

Otto VanGeet: Yeah, so for people on the call, a great question, Ruth. The Enphase micro-inverter is an inverter that actually sits on the back of the PV panels. One inverter per panel typically. And it's a great product. It actually – we see it a lot for residential applications. It's also a great product if you have a partially shaded site. Then only that one panel is affected instead of the whole array. I think very highly of the Enphase product. It also has a nice monitoring option where you can – there's an annual fee for this, but where you can go online and monitor the system. Somewhere there's a web-based monitoring that I was talking about. So yeah, great product, and I would encourage that.

Ruth: Is there a way to monitor it from the home? Do you have to pay a fee online to monitor it?

Otto VanGeet: Yeah, that's a drawback to the Enphase product is that you cannot – you do have to pay some fee, and I don't know what that is, to Enphase for the web-based monitoring. I don't believe that they offer any options for in the home. So comparing that to one main inverter that might be mounted on the wall near say your meter, then you can actually go look at, you know, the kilowatt hours produced that day, what's happening at that moment, et cetera. You could ask Enphase that, but as far as I'm aware, there's no in-home monitoring without paying for that web-based monitoring. Have you asked them that question?

Ruth: I've been getting some different answers from different people, so that's okay. I'll figure that part of it out. I just thought that for low-income people, that's kind of silly to ask them to pay a yearly fee.

Otto VanGeet: Oh, absolutely.

Ruth: Yeah, $9 a panel per year.

Otto VanGeet: How many? What'd you say?

Ruth: $9.

Otto VanGeet: Yeah, that's something that you as the agency might want to do to monitor the performance, but to ask the tenants to pay is probably not reasonable.

Ruth: Right.

Otto VanGeet: Do we have some other questions?

Male Caller: I was wondering if the output charts that you put on there took into consideration heat, overheating.

Otto VanGeet: Yeah. So the web-based tools. What this question refers to is that PV systems like to run cool. They're all rated at room temperature, and as they sit in the sun and heat up, their performance goes down. Temperature degradation we call that. All the web-based monitoring tools like PV Watts, In My Backyard, et cetera, take that into account as best possible. It's based on a typical system, but yes, what actually happens behind the scenes is there's a weather file for your location that's run, and based on the temperature, the degradation of the PV is taken into account. We monitor lots of PV systems, and the estimates from those monitoring tools is pretty close – modeling tools I meant to say. Does that answer that question?

Male Caller: Yes, it does. That might mean that even if you're not in the southwest, your panels may work better. Is that true or no?

Otto VanGeet: The modeling tools at PV Watts et cetera take that into account. Whether you're in Las Vegas, or say in Portland, Oregon where it's much cooler. So that's already taken into account when you're estimating the annual production. And you're right. When they run cooler, the ideal is a very good solar resource with a cool climate. But the tools take it into account either way.

Charlie: Hello, Otto. This is Charlie out at DOE right across the road from you.

Otto VanGeet: Oh, here in Golden?

Charlie: You bet. How are you?

Otto VanGeet: Good, Charlie. How about you?

Charlie: Good. Hey, you know the life expectancy and reliability of inverters has been kind of variable over the years. Has that settled down, and what sort of lifespan do you expect from typical inverters? Whether it's, you know, SMA or Sunny Boy or Fronius or whatever. Any comment on that?

Otto VanGeet: Absolutely. So inverters again will take the DC energy and converts it to AC energy, will come with a standard warranty. The model RFPs, when you look at it, we typically suggest that they require a ten-year warranty. Many of the manufacturers are coming with that. We also monitor the performance of inverters and see sort of a meantime to failure of on the order of fifteen years.

That keeps getting better and better. That used to be one of the weak links in PV, and modern inverters get better and better, but they will fail sometime in the future. And again, an estimate would be say year fifteen. That varies depending on where the inverter's mounted also. Ideally you'd like to keep the inverter out of the sun. Heat is what eventually kills the inverters. So if you can install them on say the north side of a building, that'll certainly increase its life. The bigger issue in hot climates and cool climates.

Charlie: Right. Are there any name brands you want to stay away from? I know, you know, we at DOE or NREL, you know, usually can't recommend or not recommend a product, but any names crop up that either positively speak of or negatively speak of?

Otto VanGeet: No, honestly not. You know, all the inverters, you named several of them – SMA, Fronius, Xantrex, et cetera – all make really good products. I'd require one, if I were to use it, it had a ten-year warranty, but they're all good products. So I wouldn't discourage or encourage one more than the other.

The other part that you should look at when you're evaluating inverters is the efficiency of it. That'll be part of the nameplate data, and all things being equal, the higher efficiency is certainly better.

Charlie: You bet. Okay, thanks a lot, Otto.

Otto VanGeet: You bet, Charlie. Do we have any other questions on the phone? I just got a question through the internet from Dan Elliott. Are manufacturer warranties good enough? Do you have the second half of that question?

Amy Hollander: Sorry.

Otto VanGeet: Oh, I'm sorry. In your experience, are the additional third party performance agreements ever necessary? So there's two questions there. This is related to inverters I believe. Is that correct, Dan?

Dan: Yeah, that's correct.

Otto VanGeet: Okay, yeah, so it's an inverter question. Are the warranties good enough? You can actually buy extended warranties if you're really worried about this. Typically it's not going to be worth doing that. Sort of save the money and if you're worried about it, put it into like an escrow account or a savings account.

The inverter manufacturers have been very good about honoring their warranties. There has been failures at times, and in all cases the manufacturer, at least as far as I'm aware of, has honored the warranty.

And then the second question is, in your experience are additional third party performance agreements ever necessary? Could you elaborate on what you're asking there, Dan please?

Dan: Yeah, I'm just trying to figure out if there's like – I think you answered it with the first one. They offer extensions on their initial warranties, and that's probably what I would be interested in initially when looking at the warranty that they would be offering.

Otto VanGeet: Okay, and again that's up to you. If you're really worried about it, you could pay for it, but it's sort of adding to the upfront cost of your system.

Dan: Exactly.

Otto VanGeet: It'd be better to take that money, like I said, and put it in a savings account for somewhere down the road if and when the inverter fails.

Dan: Yeah, and that's what we've been looking at right now – an escrow of some sort.

Otto VanGeet: Excellent. And that would be the preferred option. It's a much simpler route, so in that way the money is in the account, and hopefully this is never the case, but say the inverter manufacturer goes out of business, you still have the money. So I'd encourage the escrow account approach.

So are there any other questions on the phone or through the internet?

Susan: I have one more SERC question.

Amy Hollander: Tyler, are you still on the line?

Tyler: Yep.

Susan: Hi, this is Susan calling from Maine. I was just wondering about the monitoring piece. Is that allowable under the SERC grant paying for that? I know we're not wanting clients to pay for it.

Tyler: So paying for the monitoring of energy savings?

Susan: Yes.

Tyler: My take is yes, because it ensures that the equipment is performing as expected.

Susan: Okay. Thank you.

Tyler: How many years in the future? I don't know. That's probably a good question, too, is for how many years in the future is it allowable? I'll try and get clarification.

Susan: Okay.

Otto VanGeet: Just to repeat what I had said about monitoring, I would encourage you and your RFP to require they provide monitoring for the appropriate period of time. Five years, ten years, whatever the case may be.

Susan: What would be the parameters for needing a longer period of time, or a shorter period of time? Could you elaborate on that?

Otto VanGeet: So my answer to it, and Tyler gets to answer it next, is that the longer you can include it with the initial RFP, say five or ten years, then you won't have to be answering this question in the future about how to fund the monitoring. Tyler, do you want to add to that?

Tyler: Yeah, I think that's the right approach is if you're doing an RFP and you're contracting this work out, then it's to your discretion as to what you consider, you know, a quality job and quality workmanship. And if that means them monitoring and guaranteeing it for ten years, then that can be part of your RFP when you solicit the bid.

Susan: Okay, so you'd start out with your ideal window being ten years out.

Tyler: Yeah, well I'll defer to Otto on what he thinks the ideal is from a technical perspective.

Otto VanGeet: Yes, ten years is what I would typically – in the model RFPs that you'll see, I have typically been requiring a ten-year monitoring period.

Susan: Okay, well that's good to know, that there's a precedent for that. I appreciate it.

Otto VanGeet: Okay. So we have time for maybe one more question. Alright, so if we don't have any further questions, I'd like to thank you all for attending, and again remind you that contact information for Amy or I is in the presentation, and I think y'all know Tyler's contact info also.

Amy Hollander: Thank you very much, Otto. We had fifty-one people on the webinar today, and I just wanted to wrap up by saying that we're going to have another webinar on February 8th and we have not selected the topic of that webinar, but it will either be on cool roofs, or on high efficiency hot water heater systems, or on home energy monitors. So watch your email for those announcements. It will be on a Tuesday, same time, same place. And thank you very much for joining us today.

Tyler: Thanks, Otto.

Susan: Thank you. Bye-bye.

Otto VanGeet: Thank you all. Bye.

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