Weatherization Assistance Program

Integrating Solar PV into the Weatherization Assistance Program

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Objectives

Quickly and efficiently assess a home's potential for PV during a WAP audit.

Understand the function of solar PV components and how site characteristics affect their output.

Identify and assess Quality Control (QC) touchpoints on a typical PV system.

Understand why promoting PV within the WAP is so important.

I went back and forth on what I thought we needed to get out of this session and I realized that solar is still a bit of a mystery to a lot of the people in our network. Most of the discussions to date have focused on how to get money to pay for solar, but very little has gone into how crews can start integrating this technology into their programs. So I came up with these 4 objectives. By the end of today I'm pretty sure you'll have a good idea of how to quickly and efficiently assess a home's potential for PV during a WAP audit. In order to do that, you'll need to have a basic understanding of the function of PV components and how site characteristics affect operation. And since this is Weatherization, I want you to leave here today with some QC touch-points for a typical PV system, along with an understanding of why promoting PV is so important for the WAP.

Why is Solar an Important Focus for WAP?

- **2021 Stats (Berkeley Lab, 2022)**
  - 59% of all PV installs are high-income (81% in 2016…so, progress…maybe?)
  - Only 12% of PV installs are low-income (identical to 2016 stats…so, no progress)
- **J40 Initiative**

  ~18% of US households are in Disadvantaged Communities (DAC)

  ~11% of solar PV adoption is in a DAC
- **Inability to participate in tax incentives**
  - 30% federal tax incentive (similar state incentives) don't work for low-income
- **Market decrease in Third Party Ownership models for PV**
  - This was the traditional way to reach low-income individuals

These data come from the Berkley Labs "Residential Solar Adopter Income and Demographic Trends: November 2022 Update

I think we can all agree that solar PV is a valuable technology, and everyone can benefit from having panels on their home. But right now, it's out of reach for low-income families. In 2021, 59% of all PV installs in the US took place on high-income homes. Just 5 years prior, that number was 81%, so it seems like we might be making progress. However, that gap was almost entirely filled by middle-income earners. In 2021, only 12% of PV installs were on low-income homes, an identical statistic to what we saw in 2016.

With the President's J40 Initiative, programs like ours are charged with putting an emphasis on Disadvantaged Communities (these are communities that have largely been overlooked – you can find the definition of a DAC on DOE's website). 18% of US households are in DACs, but only 11% of solar PV adoption. So, our current strategies are not putting PV in the right hands or into the right places.

Most of what drives PV uptake is in the incentives (30% federal and anywhere from 0-30% state incentives, depending on the state). Unfortunately, if you're low-income, you almost certainly do not have enough tax burden to take advantage of an incentive like this. And for whatever reason, we don't have a lot of data on this, there has been a market decrease in Third Party Ownership models for PV, which was one strategy working to get PV into the hands of low-income individuals.

WAP PV Discussions to Date

Grantee-focused Hurdles

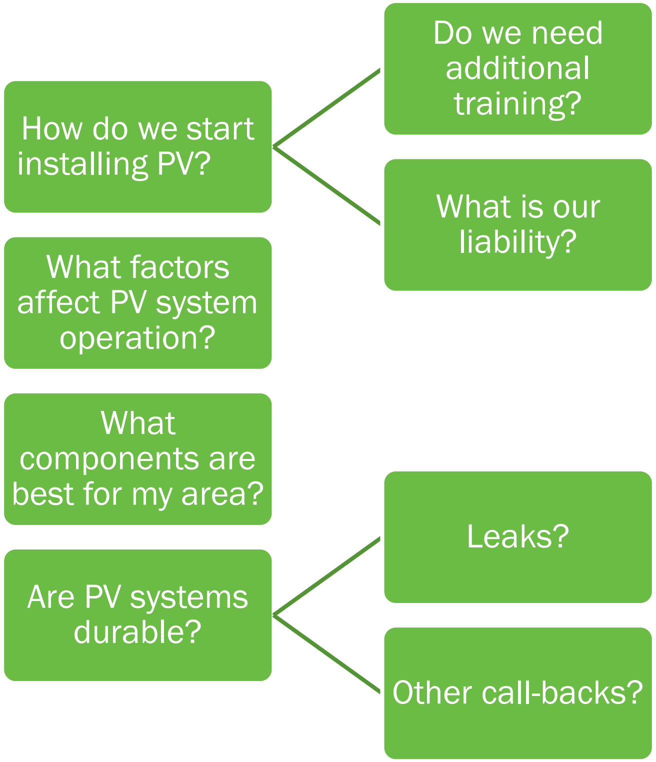
- How do we braid funding?
- Do we need DOE approval for PV?
- How does the approval process work?
- Do we need to run a pilot project?

- **Braiding is necessary – WAP isn't enough**
  - SIR based on DOE contribution
  - NREL's SIR tool can help
- **Approval is necessary - now streamlined**
- **WPN 23-6 outlines approval**
  - Optional Solar PV Initial Request Template
- **No longer requires a pilot project**

Most of the discussions surrounding implementing PV into the WAP have centered around the Grantees. How do we braid funding, do we need approval from DOE, how does the approval process work? Do we need to run a pilot project. Although there's still a lot to work out, we do have answers to these questions. Yep, you most certainly need to braid or leverage funding to make PV work within the program. Yep, approval is necessary and the process is now streamlined in WPN 23-6. Nope, a pilot project is no longer a requirement for approval. So hurdles at the Grantee level have been minimized, though states are still left with the task of leveraging funding. Luckily, there seem to be a lot of programs available.

Today's Session

Subgrantee-focused Hurdles



✓**Assessments**

What do you look for to give a quick thumbs-up / thumbs-down?

✓**PV Components**

What does each part do and how are they different? How do site characteristics affect your choices?

✓**Quality Control**

What are the big QC touchpoints? (We are not becoming experts!)

But very little discussion has taken place at the Subgrantee level. These are the folks who are on the ground making things happen. They need to have a nuts and bolts understanding of the process. How do we get this program going, do we need additional training/certifications, what components are best, do we own the roof once the job is complete, how typical are leaks and call-backs, what else can go wrong?

So let's switch gears and attack this problem from the standpoint of the Subgrantee. If the Grantee has already gone through the proper steps with DOE, how can someone new to the game, get started incorporating PV into their WAP homes?

The easiest approach is to address three main areas with your in-house staff: Assessment, Learning the Components, and Quality Control. And keep in mind, no one in WAP is really an expert on this subject, so this really is just the start of the conversation.

Solar Site Assessments

The unfortunate truth is that many of the homes that are currently unsuitable for PV, house the families who need WAP's help the most. Yes, we now have Weatherization Readiness Funds (WRF) and these funds can certainly be used in this case. However, given the very minimal uptake of Solar PV in WAP thus far, it is most prudent to focus on starting a PV program with homes we know will work. Once subgrantees have an established, well-oiled, PV program, they turn their efforts to applying PV technology more broadly. The rest of this section on Assessments focuses on quickly and easily finding suitable candidates for a roof-mounted PV installation.

Site Characteristics

Your Area

- **Latitude: determines the "best" angle to set panels**
  - Less slope maximizes summer production, more slope maximizes winter production
- **Altitude: Higher = More production**
  - More irradiance = More current
- **Temp: Cooler = More production**
  - Low temps = Higher voltage
- **Weather: snow, dust/soil, hail?**

The Structure Itself

- **Roof Access: Easy = Cheaper**
- **Shading: Partial shading analysis**
  - Shooting from the hip can get you close
  - Simple tools like the Solar Pathfinder increase accuracy and they're fun to use

When your auditor arrives at a home, they should be looking at two things: the area itself and the structure on which you're putting the PV units. Low-hanging fruit means we're looking at roofs and the general suitability of the area to get an idea of how much energy we can produce over the course of a year. Ground mount systems are great and they have some advantages, but let's walk before we run.

Starting with some things you'll know before arriving at the house:
V x A = Power
Power over time = Energy

Latitude…matching angle of array with latitude is "generally" the most efficient angle over the course of a year.
Altitude…8-10% increase in irradiance per 1,000m of elevation. Standard irradiance is 1,000 W/square meter – higher irradiance increases current
Temps (climate)…Standard temp is 77F – Lower temps increase voltage
Weather…Hail can be an issue – microcracks can lead to panels failing early
And then the specific structure – roof access is key. If access to the roof is difficult, expect to pay more. Focus on homes with a clear and easy path to the roof.

And Shading. Generally we can shoot from the hip and get a pretty good idea of site suitability, but you'd be surprised how many things can partially shade a panel, so a handy tool is something like the Solar Pathfinder. They're about $250, so it's not a large investment and it can significantly increase your accuracy when determining shading on a site. Plus, Weatherization people like tools – anything that keeps someone interested in and continually learning in their job is probably worth it in the end.

Roof Surface – Sloped Roof

Exterior Roof Characteristics

- Roof Condition: Will you get 20 more years out of the roof?
- Roof Orientation: Does it need to be south facing?? – NO!
- Roof Slope: Close to latitude is best, but not necessary – match the roof for aesthetics
- Protrusions? – plumbing stacks, vents, etc.
- Roofing material: Asphalt (easy), screw-down metal (additional liability - avoid), standing seam metal (easy), tile (difficult)

We're still just starting with PV in WAP, so stick with the low hanging fruit:

- Look for a roof in good condition. It's difficult/expensive to remove a PV array to re-roof, so let's start with a good, usable surface.
- The orientation and roof slope do NOT have to be perfect! Check PVWatts to see how these factors make "minimal" differences in overall output. No need to wait for perfection in these areas if everything else looks good.
- Look for minimal protrusions in the roof which could physically prevent PV installation or they may add up to significant shading on the array. Is there enough free area for a good sized array?
- Asphalt makes for an easy install with minimal concerns regarding leaks – same is true of standing-seam metal roofs (there are quick clamps that require no additional penetrations). Although it can be easy to install PV on a screw-down metal roof, most installations already leak a bit due to improper torque of gasketed screws. Adding holes for a PV array will add to your liability…so let's stick with the easier roofing surfaces while we are still building the program.

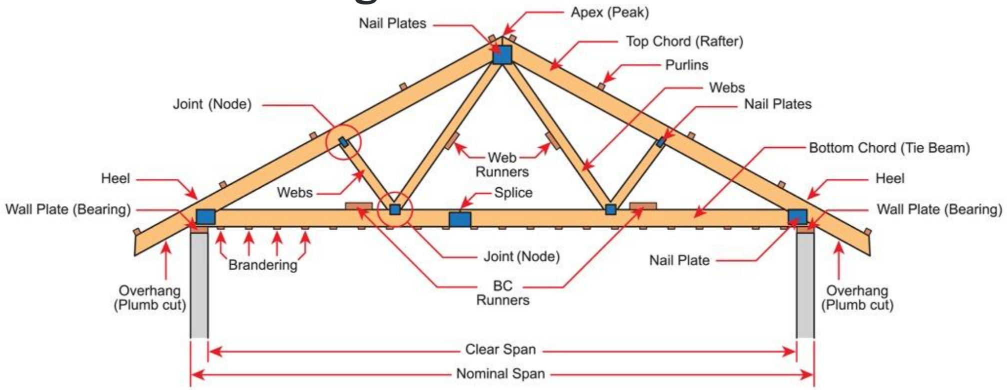
Roof Framing

PV Impact

- VERY little impact on static load (maybe 3-4 lbs/ft^2)…but it's still a concern
- Generally decreases snow load on sloped roofs
- Uplift is more of an issue than point load, use appropriate anchors for racking

Framing Types

- Engineered Truss: generally just fine for all solar installs
- Rafter: "likely" fine for solar installs
- Spacing/size: too wide, uneven, weird?
- Single Wide Trailers: Nope



Most of the PV impact on a roof is due to uplift, not weight. As we are just starting this program in WAP, stick to what we know will work: Engineered trusses on site-built homes will almost always be fine. Rafter construction is also almost always ok, but look for inconsistencies or "weird" framing. If it looks sketchy, maybe it's not a great candidate to sign off on right away.
Single wide mobiles will not work with roof-mounted PV. Double wide mobiles "may" be ok, but again, let's stick with what we know will work to ease into our programs.

Point of Connection

Load Side

- Generally less expensive
- 200 Amp Service – why is this necessary?
  - 120% rule likely can accommodate 32-56 A inverter output
- Access to the electrical panel – easy access means a lower install cost
- Requires less coordination with the utility
- Common

Supply Side

- Requires extra coordination with the utility
- Less common

It's important to consider the point of connection for Solar PV. Typically, installers will want to install on the load side of the system (user end) rather than the supply side (utility side). Load side connections are less expensive and easier to coordinate for the installer. The catch is that load side connections must account for the max service installed and all loads drawing on that service. As an auditor, there's no need to be an electrician, but it's easy enough to give a quick check of the electrical service to determine if the home is a good candidate for PV. Though a 100 A service might be enough for a small PV system, it's unlikely suitable for the typical 4-7 kW residential PV systems. So look for 200 A service and easy access to the panel where a PV installer will backfeed a breaker to tie into the home.

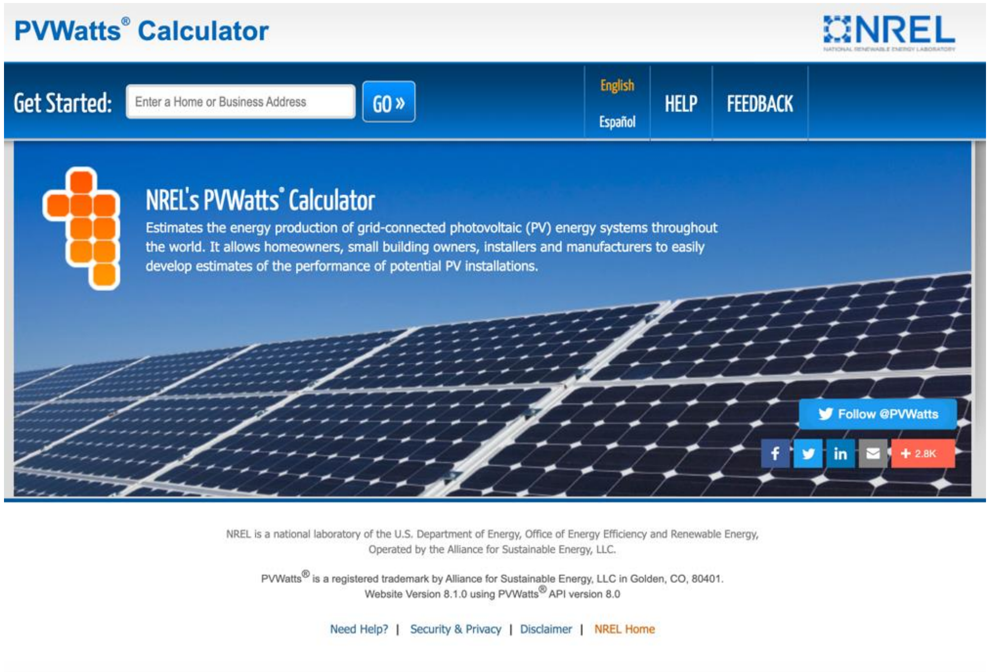
Assessment Recap – Look for Low Hanging Fruit

- General area – climate and weather greatly affect production and longevity
- Home site – accessible roof and limited shade?
- Exterior roof characteristics – good condition and close to south is best, but not necessary, note the roofing type and avoid screw-down metal and tile
- Roof framing – truss frames are easiest to approve, avoid mobiles for now
- Point of connection – easy access and 200 A

Here's a quick recap of the things to look for on a home to ensure quick and easy installation of rooftop solar.

Site Impacts on Energy Production

PVWatts

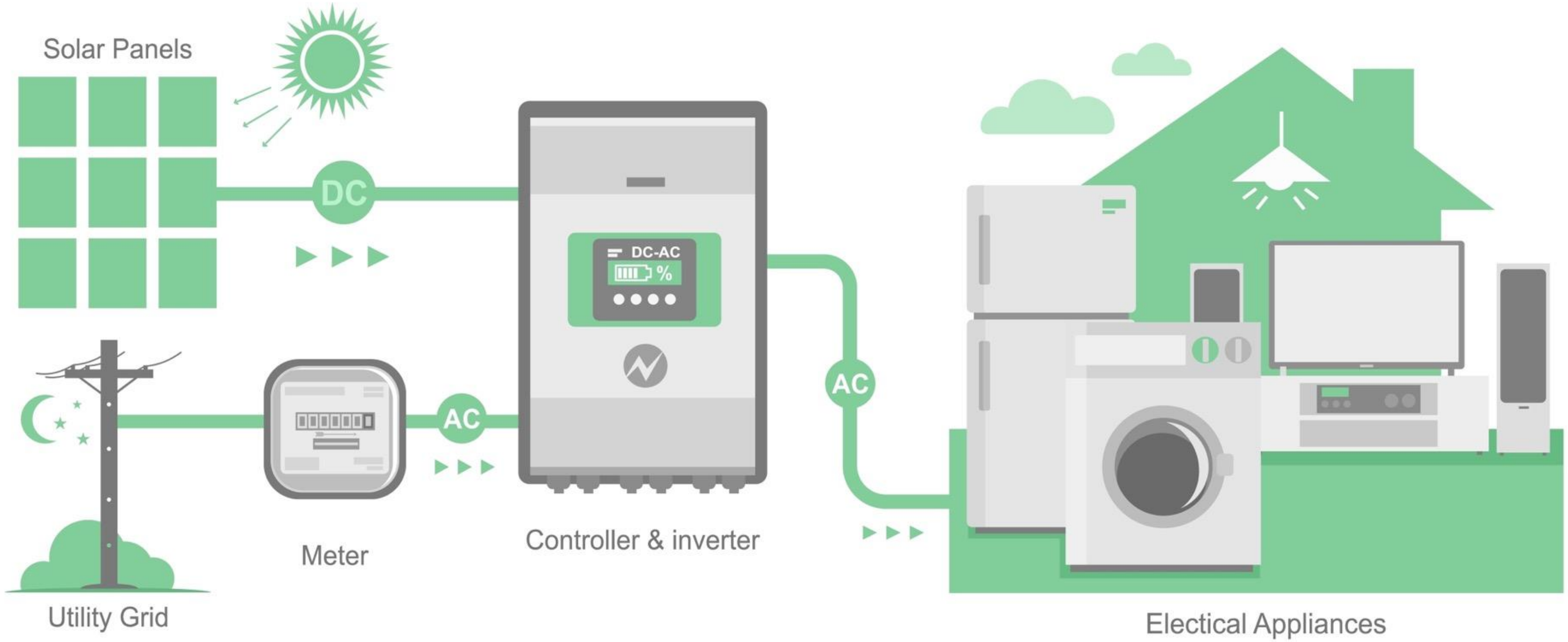


FLOWCODE

PRIVACY.FLOWCODE.COM

PVWatts is an excellent, free, professional tool that anyone can use with just a few minutes of practice. Walk through some examples. Try changing 1 variable and see what happens. Note that slight changes in roof aspect or slope may not make much of a difference in overall output.

Components



Let’s switch gears to learn about PV components. Knowing the common components of a PV system and how they interact with home/site characteristics will help facilitate an understanding of why installers choose some options over others. Know how things work so you can carry an intelligent and competent conversation with PV professionals working in your Weatherization program.

Cells and Panels

Cells

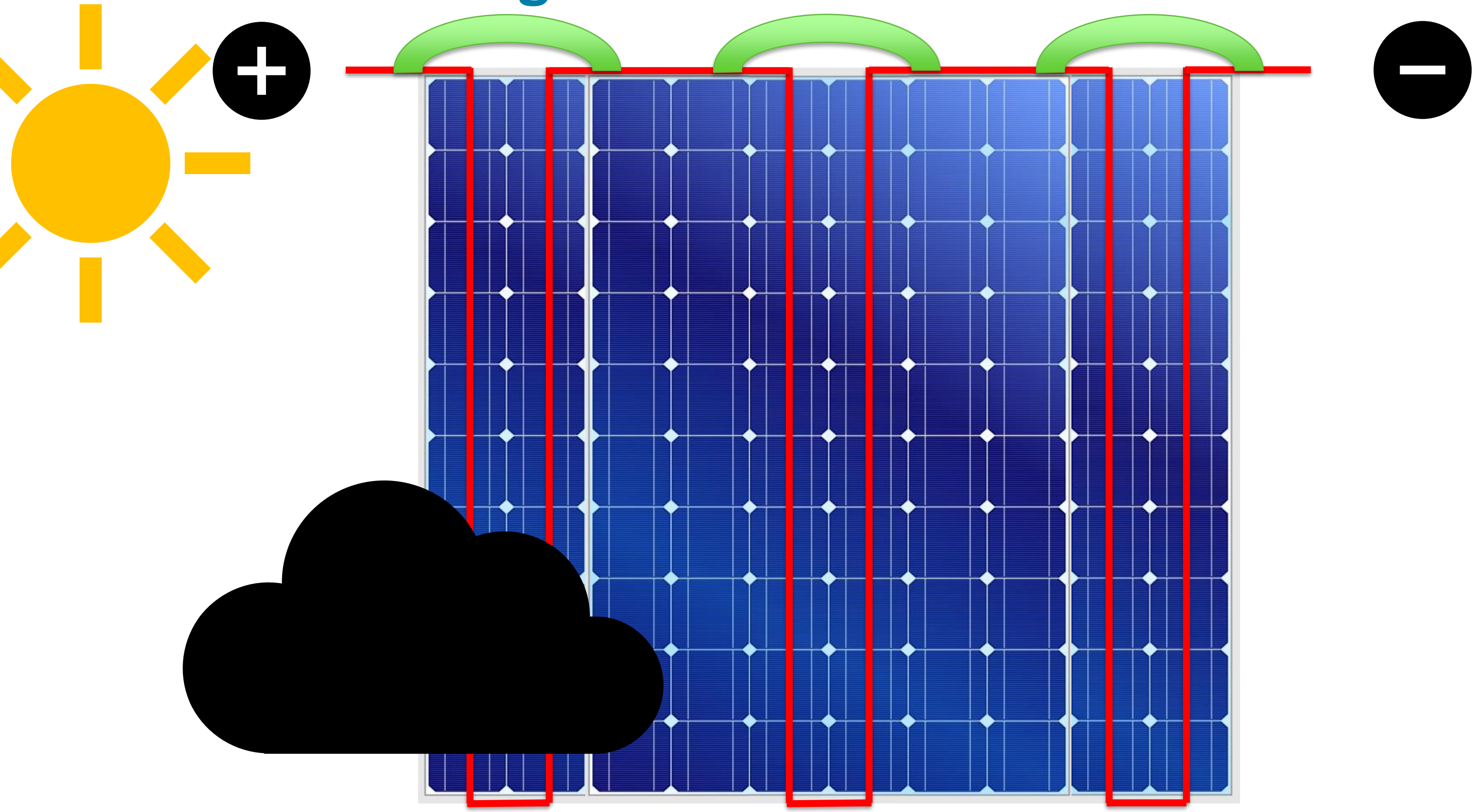
- 60 or 72 cells per panel
- ~0.5 V / cell
- Cells are wired in series (building voltage)

Panels

- 39” x 66” - 60 cell panel
- 39” x 77” - 72 cell panel
- 3 Bypass diodes separating groups of 20 or 24 cells (depending on panel size)

Cells are the components collecting energy from the sun (these are the squares you see on a panel). Cells produce DC electricity. Typical residential panels are either 60 or 72 cells (6x10 or 6x12) and 39”x66” or 39”x77” respectively. Cells are wired in series (one after another) so blocking one cell could theoretically stop the entire panel from working without the addition of bypass options. Modern panels have 3 bypass diodes separating groups of cells along the vertical axis of the panel (see the following slide for an animation of how bypass diodes work).

Panels and Shading



Think about electricity like water flowing through a pipe. Without any shading, electricity would flow uninhibited through the red circuit shown here. If shading “blocks” the flow of electricity, that resistance creates heat that could damage the cells or even start a fire. To safeguard against overheating, panels have 3 bypass diodes shown here in green. If shading blocks part of the panel, electricity “jumps” across using the bypass diode, effectively cutting out that section of the panel. Not only does this help prevent overheating, but it also allows part of the panel to produce energy even when partially shaded. This is important for things like snow accumulation, bird droppings, dust/dirt, passing shadows, and any number of items shading panels in your array.

Racking

On a Sloped Roof

- Cheaper and faster to mount panels vertically
- Stronger to mount panels horizontally and marginally better in snowy areas due to shedding and bypass diodes

Racking is the assembly of metal rails and flashed stand-offs that attach panels to the roof and provide attachment spots for wiring and electronics. It takes fewer pieces of racking to mount panels vertically, so it's become more of the standard in the US. However, it's stronger to mount panels horizontally and it's marginally better for production in cold climates due to snow sliding to the lower edge of the panel, uncovering groups of cells separated by the bypass diodes explained earlier.

Array

- Panels mounted together in a single system (may work independently or in strings)
- ~12-15 watts/square foot for estimating (10 watts/square foot if you want to get closer to what you'll "actually" produce)
- Setbacks are determined by AHJ
- Typically mounted 4" from the deck
  - Temperature and uplift concerns

An array is just a group of panels. When assessing a roof for PV, using 10 watts/square foot will get you close to estimating output. Always check local setback requirements. In most cases, you'll need 3' of unused space on the gable ends and 18" of free space from the peak for code. Again, this will be different in some locations. Typically, arrays are mounted 4" from the deck of the roof. Any closer and panels will heat up, greatly decreasing productivity. If an array is mounted higher than 4" off the deck, you'll risk creating too much uplift, and it simply looks displeasing as well.

String (Central) Inverter

- Converts DC to AC
- Sized to your system and the number of strings in your array
- Allows monitoring of individual strings
- Can be mounted inside or outside (out of the sun is best)
- Once a common failure point, quality is much better now
- On its own, shading of one panel will cause the entire string to stop working

A string inverter (sometimes called a central inverter) simply converts the DC electricity produced by the panels into AC electricity used by your home. Modern inverters will typically allow for 2 or more separate strings of panels to tie in and work independently, allowing for independent monitoring and efficiency during shading events.

MLPEs

Module Level Power Electronics (MLPEs)

- Most residential installs now employ MLPEs
  - Microinverters
  - DC Optimizers

Module Level Power Electronics (MLPEs) are no employed on most residential PV installs in the US. They’re mounted to racking, just behind panels and allow panels to work independently of each other (or sometimes in groups of two) so the shading of one panel will not affect the rest of the string. Microinverters and DC Optimizers are both examples of MLPEs.

MLPE (Microinverter)

- Generally 1 per panel
- Allows monitoring of individual panels
- Works independently to minimize shading shutdown
- Converts DC to AC at the roof
- Wired in parallel (builds current ~ 1 A)
- Serves as a rapid shutdown for fire safety
- Often better warranties than central string inverters (20+ year design life)

Drawbacks

- More complicated wiring on the roof
- More inverters to fail (though current warranty periods are excellent)
- Typically more expensive upfront than a central string inverter or string inverter with DC optimizers
- Partial shading of a panel may cause the entire panel to stop working (min Voltage)

Microinverters convert the panel's DC electricity to AC electricity. They generally work for a single panel and panels using microinverters build current as they are linked together in strings. Shading of one panel will not affect the other panels in the string. However, partial shading of a panel may drop the voltage of that one panel enough to prevent the entire panel from working due to the minimum voltage requirements of the microinverter (recall our discussion of partial shading and bypass diodes). Using microinverters is typically more expensive than using a string inverter or even a string inverter with DC optimizers, but many installers still go with this option. Many of the better microinverters on the market now have design lives of 20+ years, so warranties may match nicely with lifespan requirements for WAP measures.

MLPE (DC Optimizer)

- Generally 1 per panel
- Allows monitoring of individual panels
- Works independently to minimize shading shutdown
- Serves as a rapid shutdown for fire safety
- Wired in series (builds voltage which can allow smaller/cheaper wiring when compared to building current)
- Often better warranties than central string inverters (20+ year design life)

Drawbacks

- More complicated wiring on the roof
- More units to fail (though current warranty periods are excellent)
- Still requires a central inverter
- Partial shading of a panel may cause the entire panel to stop working

DC Optimizers look a lot like microinverters, but they do not convert electricity to AC so a string inverter is still needed for a residential PV grid-tie installation. DC Optimizers function much like microinverters to minimize the impact of partial shading on an array.

Quality Control

Common Touchpoints

Let's face it, unless you're a solar PV installer who has worked on systems for years, you're not going to be an expert. But, as a QCI in WAP, there are some touchpoints you can check out to determine if this is a quality installation.

Where to Look

Roof Components

- Most issues with longevity take place on the roof (string inverters are much more reliable these days)
- Most issues with longevity are due to poor installation and/or exposure to the elements
    - Check on-the-job and double check during the QCI

Panels

This is not Ideal...

- Difficult to see problems here
- Watch during the install for handling – stacking, walking or kneeling on the surface (on-the-job QC work is recommended)
- Microcracks have shown to greatly reduce longevity, even if they don't indicate problems in the beginning
- Initial test for proper operation

Panels may look and work properly in the beginning of their lives, even if they were damaged during install. Setting heavy or sharp objects on panels, standing or kneeling on them, or leaning ladders against them can cause micro cracks in the cells that deteriorate over time. To properly QC panels (aside from making sure they work in the beginning) watch the installation process. If you see rough handling or standing on the panels, you might not be working with a quality installer and those panels may fail sooner than you'd like.

Racking

Check on the Job! What's not great here?

- Proper flashing and installation of the base is the most important part

Racking should be torqued properly, though you won't be checking that unless there are obvious, missing fasteners. Look to the standoffs and flashing to determine if you are working with a quality installer. Note here there are caulked/tarred fasteners exposed on the base. This is a good indication the installer didn't know what he/she was doing. Proper flashing on a sloped roof should cover fasteners without resorting to tar and caulk.

Wiring

- Proper loops for strain relief (thermal expansion and contraction is substantial with wiring on a roof)
- No wires touching the roof
- No wires touching sharp edges
- Attachment points and bundling ties are appropriate (no white zip ties, preferably no zip ties at all)
- Clean installation of wiring indicates a quality installation of the ENTIRE system

This Looks Good at First…

Wiring is a big indicator of the quality of your overall installation. Well-run wires generally means a well-run install. Big issues include wires touching the roof, wires run across sharp edges, and poor-quality attachments such as white zip ties which degrade in the sun. Also look for strain-relief loops; wires on a roof are subject to massive swings in temperature which can cause extensive expansion and contraction. Wires that are strung without strain relief can rip themselves apart in just a few temperature swings.

Note in this picture that things seem to look good. However, there are a number of issues. The installer used zip ties that will degrade in sun within a few years. Additionally, this installer mounted the connector very close to the junction between two panels where water will drip. It's best to offset these connector points as much as possible to protect them from dripping water. (Even though these are waterproof connectors, it's still good practice to protect them as much as possible as they are considered a failure point.)

MLPEs

- Proper attachment - solid and in consistent locations (on-the-job QC is necessary to get a good look here as they are under the panels)
- Initial test for proper operation (apps are common and easy to use)

MLPEs will either work or they won't, so there's not a lot to QC. However, much like wiring, clean and consistent mounting can indicate you're working with a quality installer. As these are mounted underneath the panels, take a look at their installation during the job, prior to the installer mounting the panels to the racking.

Moving Forward in Your Program

- Meet with your Grantee and express interest in overcoming hurdles from the Subgrantee level
  - Work through the steps for DOE approval (Grantee)
- Attend WAP discussions that move the ball forward for PV
- Meet with your staff and gauge interest in Solar PV
- Find a company you trust and have an auditor or QCI shadow them for a day or two as part of your Specific Training
- Online courses offer a lot of information and can be a great way to learn during downtime
- Look at installations around your neighborhood/city

We’ve gone over a good bit about why we need to move forward with PV in WAP and how a subgrantee can incorporate a PV program into their daily routine. What is next? A great next step is to keep learning. There are numerous online and hands-on courses available, including some at our WAP Training Centers. And keep meeting with your program officials to express interest in incorporating PV into your program. It’s tough to get past that first step of starting a program, but once we get going, it will be a huge benefit to the network we serve.

Questions?

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