PV Installation & Quality Assurance
Best Practices

Daniel Hytowitz
Field Trainer

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Overview

• Effective and simple designs are best
• Equipment selection
• Installation work day & efficiency concepts
• Site prep and install processes (ground prep with clips and roof layout marking essentials)
• Install quality as you work and reviewed after (share a SR audit or self assessment detail)
• discussion and misc question time
Simple & Effective designs = productivity and profit

Goals = increase productivity and profitability

• Less complicated designs result in faster installations

• Typically more reliable performance
Simple & Effective designs = productivity and profit

How?
• Avoid mini array “islands”
  (an array with only one or two modules)

Why?
• Lots of penetrations per module
• Lots of cabling and conduit runs
• More design challenges depending on inverters used
• More complications in predicting system performance
Simple & Effective designs = productivity and profit

How?
• Avoid overly challenging sites

Why?
• A skipped opportunity is a lot cheaper than a site that costs you money
• Liability on challenging roof types from leaks or damaged materials or excessive engineering and equipment costs
• Time spent to close the sale, design and build this one system could have been used on three other conventional sites. aka “opportunity cost”
• Reduced safety issues and mistakes.
Equipment Selection

Goals?

- Cost, be sure to include labor with your calcs
- Installation speed / productivity
- Reliability & performance
- Reduced callbacks
- Referrals
- Safety

- Modules
- Inverters
- Racking
- BOS
Equipment Selection: Modules

Modules

- Reliability
- Warranty
- Price
- Efficiency?
- kWh per KW or per square foot
- Crystalline Silicon poly vs mono / thin film
- Anything else?
Equipment Selection: Inverters

Inverters
- Reliability
- Warranty
- Price
- Efficiency?
- String / Central inverter vs Micro inverter?
- Hybrid inverter string with optimizers (Solaredge)
- Which is best?

- (per site, tailored clothes shoots vs boots also for your business)
- Anything else?
Equipment Selection: Racking

Racking
• Reliability
• Warranty
• Price
• Efficiency?
• UL2703 a system approach (not just UL tested parts)
• (per site, tailored clothes shoots vs boots also for your business)
• Anything else?
Equipment Selection: Racking

Racking continued...
• UL2703 a system approach (not just UL tested parts)
• Briefly it includes
  – Mechanical
  – Bonding/Grounding (EGC)
  – Fire

• What else is important on and around racking?
Racking continued...

- What else is important on and around racking?

- CABLE MANAGEMENT (& CONDUIT management)

Good racking choices should:

- Be UL2703 listed (mechanical, integrated bonding, fire)
  - Misc perks no weebs & less copper
- Include cable management and essential accessories
- Install quickly with few tools

- Effective total solution that manages overall costs
Racking LAB:

- Briefly review several racking types
- Roof attachments and flashing typically used
- Cable management solution?
- pros?
- cons?
Equipment Selection: BOS

BOS balance of systems (everything else)

- Junction boxes
- Flashings (stay away from rubber boot based)
- ChemLink next gen “pitch pocket” low slope solution
- Wire splices
- Sub panels
- Meter mounts
- Switch gear
- DC disconnects needed? Odd site or PV location?
  IMO industrialcontrolsdirect.com
- Conduit supports? Conduit bonding clamp (gec clamp)
- Anything else?
Industry standard, a PV install in one day is typical

How?
- Good design
- Right equipment helps, especially if its mostly pre assembled
- Man hours per kw is still important
  eg: nine person crew installing 5kw in one day is likely more expensive than three person crew taking two days...
Installation Work Day: Plan and Communicate

Planning ahead of time and communicating with homeowner is essential.

- Before work starts communicate a plan with your team.
  - Even drawing out pv stringing on a scrap can be a timesaver.

- Set clear goals
  - “By 10 am break all racking footings should be in”
  - “before lunch all racking should be installed and leveled”
  - “we should be laying glass after lunch and testing the system by 3pm...”

- Complete as much work as possible at your warehouse or on the ground
  - module wire management with wire clips
  - prefabricate sub panels
Installation Work Day: Plan and Communicate

Misc

• **Work like a machine (or an assembly line)**
  – One person drills and applies sealant to holes, another follows with L feet/standoffs and flashings
  – If there is a bottleneck redirect or rotate to other items then resume assembly line

• **Try to stay out of the house (garage) if you can**
  – Gear can usually be installed quicker and more readily serviced
Installation Quality

Why does quality matter?

- Performance
- Safety
- Liability
- Pride & morale
- Reliability
- Service costs / call backs
- Referrals
Installation Quality

Check quality while you work and when system is completed...

• It’s best to maintain quality as you work rather than returning to correct something

• If documentation is needed, it may be best to collect while installation is underway

• Sometimes a 2\textsuperscript{nd} opinion can provide a better solution

• It’s best to promote high quality not just pick on mistakes
  – Friendly competition and positive reinforcement can promote productivity and morale. Take pride in your work.
Installation Quality

System assessment when complete, the following is from Sunrun installation quality program.

[Image of a checklist titled "Solar Home INstallation Evaluation and self assessment"]
System assessment when complete, the following is from Sunrun installation quality program.

### Site Details

<table>
<thead>
<tr>
<th>Site/Cust Name</th>
<th>Address</th>
<th>Date</th>
<th>Time</th>
</tr>
</thead>
</table>

| 2 | Remaining life of roof should be at least 15 years | Array installed per design plans with correct modules within 10° tilt & 10° azimuth (N, S, W, E) module brand and model, wattage. |
| 3 | Racking is installed properly, standoffs, splices, span distances correct equipment and steps, no mismatched hardware, span spacing per design | Modules are supported properly module clamps must be within designated areas per manufacturer, quarter points are typical. |
| 4 | Array EGC (Equipment Grounding Conductor) sized & installed properly min size #10. Exposed min size is #6. Secured/protected (no zip ties) in conduit or under modules. | Racking and modules are properly grounded some modules can bond / ground via racking systems with bonding clamps. |
| 5 | All roof penetrations are properly flashed and sealed includes racking standoffs, conduit supports, conduit roof penetration | comp roof flashings need to be overlapped by 2 courses of roof material. All holes in roof must be flashed and sealed. Tile roofs need double flashing unless hooks are used. |
| 6 | Cables are managed properly, less than 1” sun exposure, not in contact with roof, adequately supported and secured & no sharp bends Cables should not be seen below rail, should be well secured and protected so that it cannot be easily damaged by sun or surfaces. It should not be able to come loose. |
| 7 | Junction box mounted correctly. Wiring transitions are done properly via cord grips and enclosed splices are WET RATED, if metal box it must be grounded. | Junction box must be mounted at least 1” above roof, must have small drainage weep hole. (please install under modules) all wires must enter via cord grip, all splices must be wet rated. |
| 8 | Conduit is well supported, routed properly and fittings are rated for the environment, if metal grounded PVC for salt air or underground, EMT for high temp above ground dry areas, rigid if required. Outdoor fittings, supported every 5’ EMT every 3’ PVC. |
| 9 | DC disconnect is appropriate for environment, wired correctly, grounded. Ungrounded conductors broken & grounded conductors unbroken. | DC disconnect is appropriate for environment, wired correctly, grounded. Ungrounded conductors broken & grounded conductors unbroken. |
| 10 | Wire types and colors are appropriate for all locations and are easy to understand | Wire types and colors are appropriate for all locations and are easy to understand. |
| 11 | Grounding Electrode Conductor GEC is a min #8 and continuous or irreversibly spliced, larger size and protective jacket should be used where exposed | Grounding Electrode Conductor GEC is a min #8 and continuous or irreversibly spliced, larger size and protective jacket should be used where exposed. |
System assessment when complete, the following is from Sunrun installation quality program.

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<tbody>
<tr>
<td>12</td>
<td>The inverter and other BOS (meters, switches etc) are installed in a logical fashion compliant with manufacturer instructions and easily serviceable. Follow manufacturer instructions, always try to install equipment out of direct sunlight, please consider future serviceability.</td>
</tr>
<tr>
<td>13</td>
<td>If the site uses module level electronics (Enphase, SolarEdge) the monitoring system is installed and registered.</td>
</tr>
<tr>
<td>14</td>
<td>If applicable PV meter is installed between the AC disconnect and inverter/s, meter is secured with ring and lock tag. This allows the meter to more safely &amp; easily be de-energized and serviced, be sure the meter is secure and locked.</td>
</tr>
<tr>
<td>15</td>
<td>AC disconnect is appropriate for environment, wired correctly, grounded. It must be a blade style unit. Ungrounded conductors broken &amp; grounded conductors unbroken. Land inverter output on bottom load side. No light switches. IMO makes good choices.</td>
</tr>
<tr>
<td>16</td>
<td>If interconnecting system with a supply side tap the AC disconnect must be fused and rated for 60 amps. When you are using tags before the main panel or bus.</td>
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<tr>
<td>17</td>
<td>At interconnection / main service panel equipment grounding conductor is connected to ground.</td>
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<tr>
<td>18</td>
<td>Inverter overcurrent protection (fuses or breakers) are sized to 125% of inverter max continuous output (per string with Enphase).</td>
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<tr>
<td>19</td>
<td>Load side interconnection PV breaker is as far away from main source breaker, SUM of PV breakers and main breaker does not exceed 120% of bus bar rating.</td>
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<tr>
<td>20</td>
<td>Work site is clean, no tools or items are left behind, ensure that no hazards or damage has occurred.</td>
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<tr>
<td>21</td>
<td>PV system has been tested and was left in a safe operational state (leave off til PTO).</td>
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</table>
Thanks for attending!