NREL
NATIONAL RENEWABLE ENERGY LABORATORY

Sustainable Energy Resources for Consumers (SERC) – Solar Photovoltaics

Presenter:

Peter McNutt, NREL Engineer

October 20, 2011

Purpose

Assist SERC grantees and DOE project officers in monitoring SERC technologies.

This webinar will guide viewers through the technology monitoring checklist developed for completed SERC solar PV installations.

NREL PIX 15620

The webinar is intended to inform SERC grantees and project officers how to identify proper quality, functionality and long-term durability.

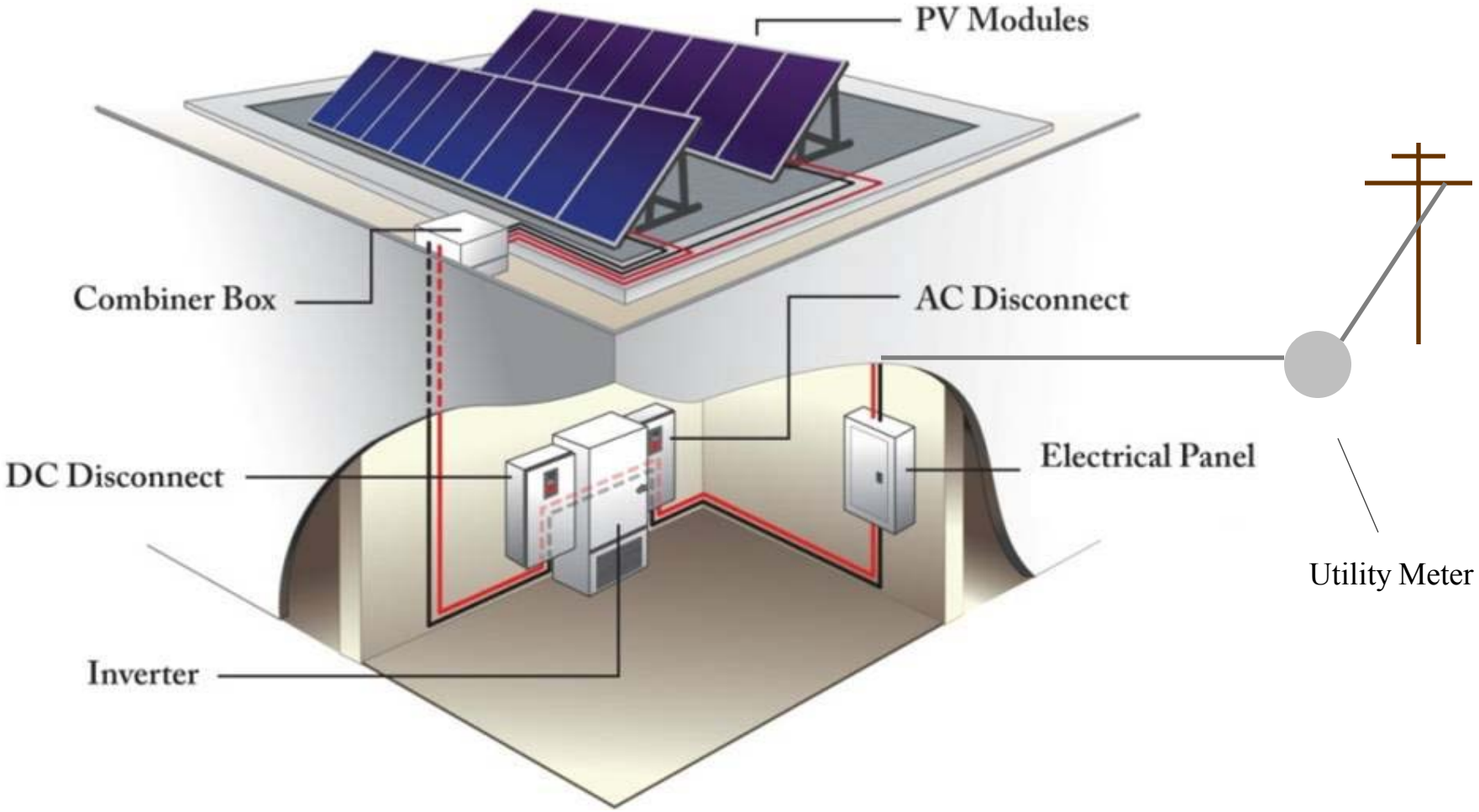
This will help a layperson identify problems, lack of function and/or poor quality.

Outline

- ❑PV System Basics
- ❑SERC Checklist
- ❑PV System Installers

NREL PIX 15620

Basic PV System Components



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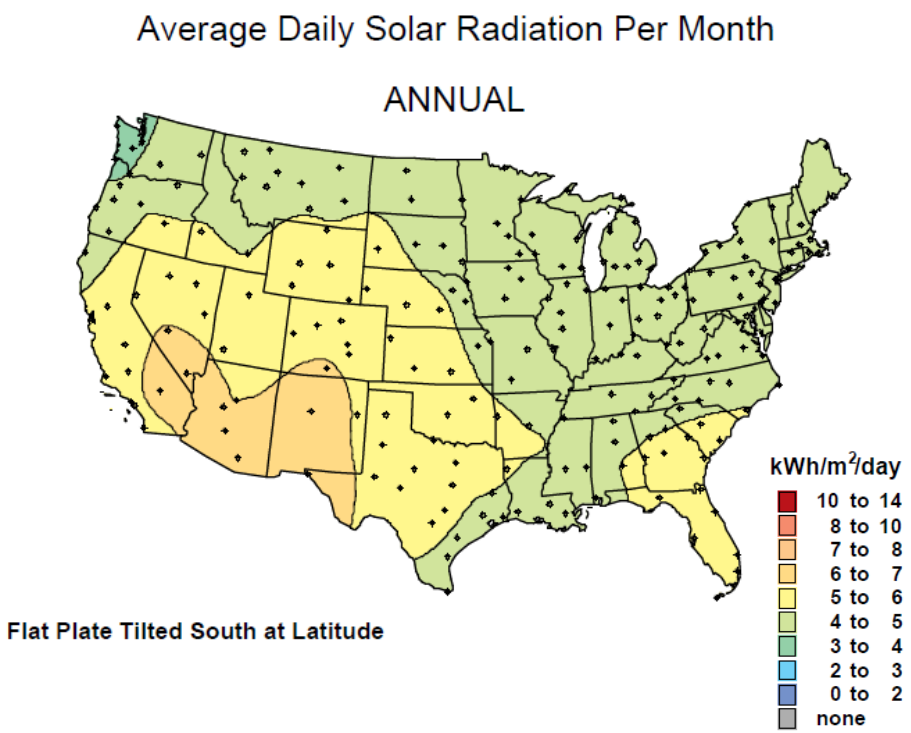
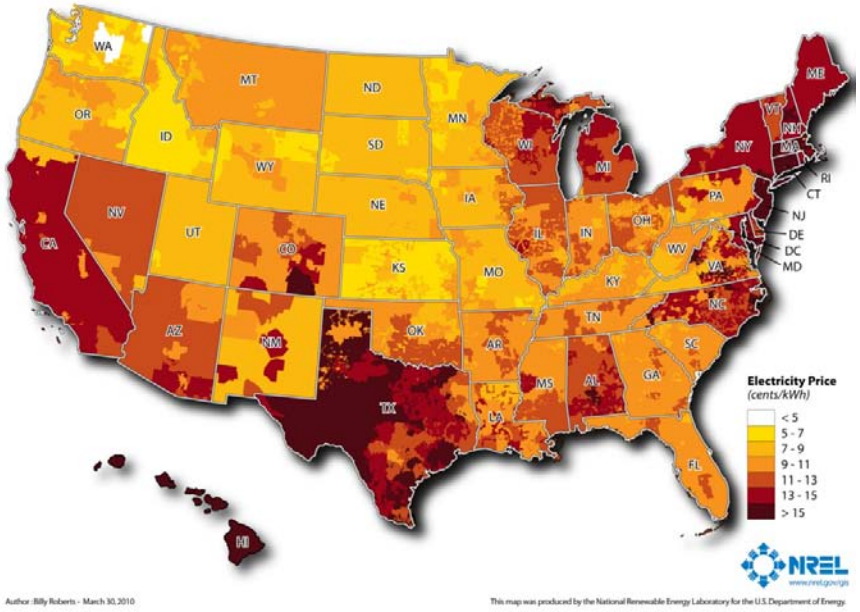
Factors Affecting PV System Cost Effectiveness

- Availability of the solar resource
- Cost of energy



http://rredc.nrel.gov/solar/old_data/nsrdb/redbook/atlas/serve.cgi

Electricity Price Map - 2010



http://en.openei.org/wiki/File:Electricity_Price_Map.jpg

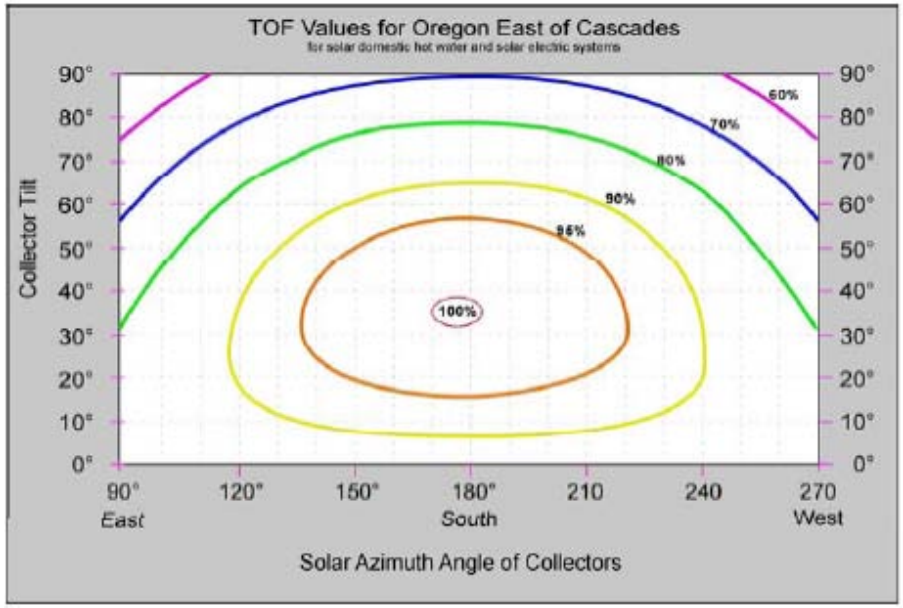
Solar Site Evaluation Tools

Solar Pathfinder

Solmetric SunEye

Solar Access

- ✓Array tilt & azimuth angles
- ✓Structural engineer's stamp for array wind loading



Tilt & Orientation Factor (TOF)

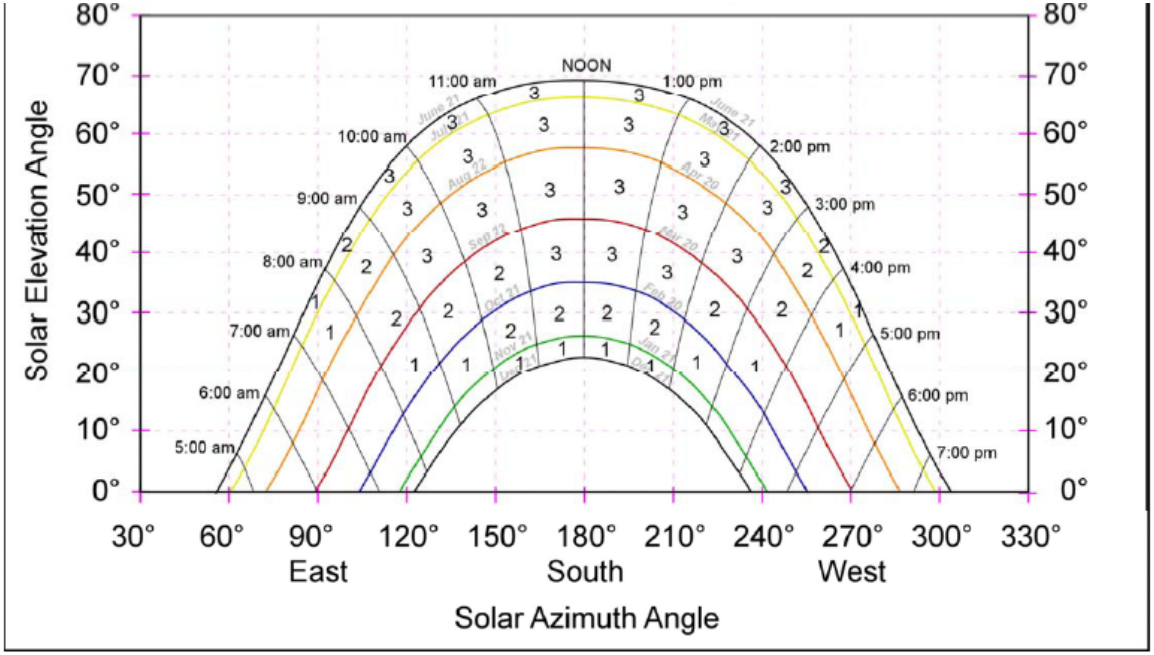
Aesthetic & wind-loading issues

www.oregon.gov/ENERGY/RENEW/Solar/docs/SunChart.pdf

Inspecting PV Systems for Code Compliance. Bill Brooks

Solar Access

✓Shading analysis prior to installation (remember – small trees grow into tall trees)



Sun Chart

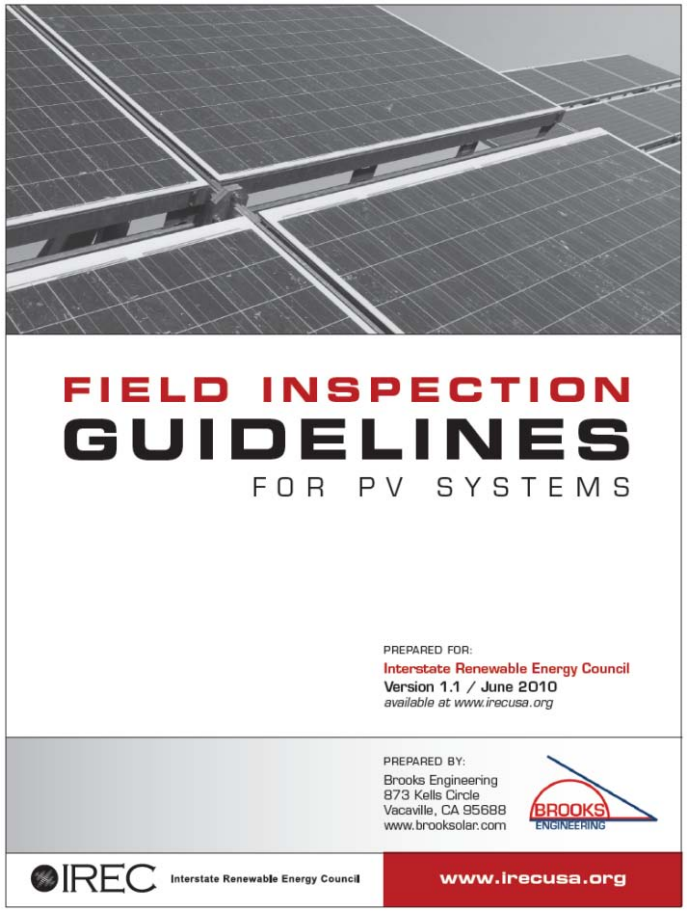
www.oregon.gov/ENERGY/RENEW/Solar/docs/SunChart.pdf

PV Commissioning

PV system commissioning serves 3 purposes:

1) System meets contractual requirements
2) System is safe (field inspection)
3) System generating expected power

IREC Field Inspection Guide

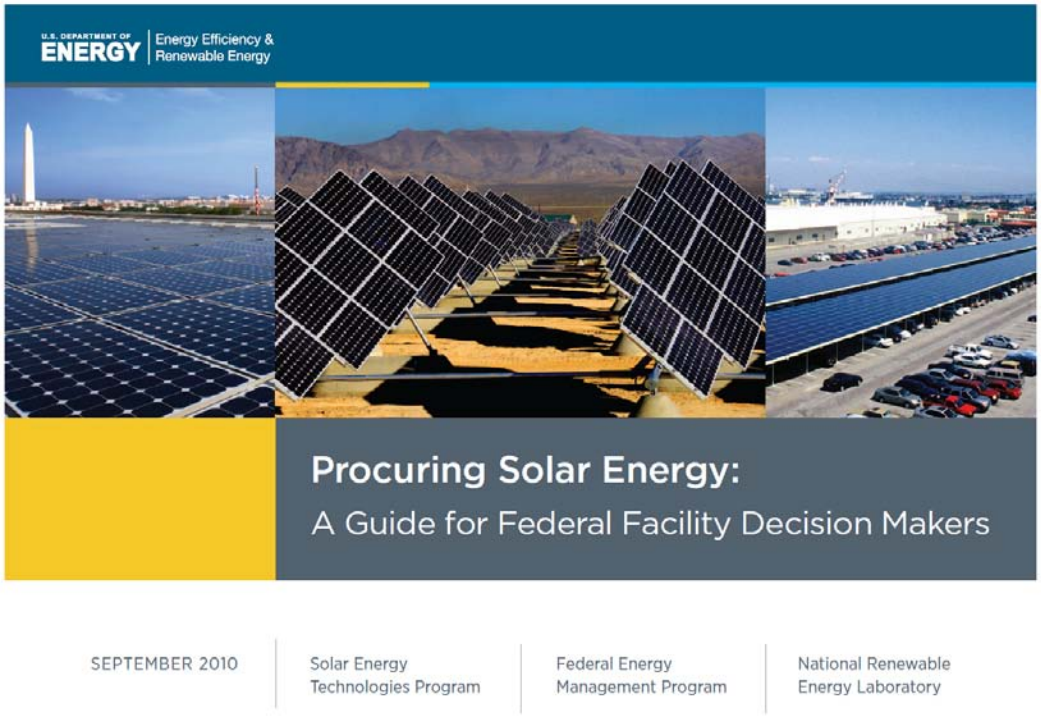


" The intent of this guide is to consolidate the most important aspects of a field inspection into a simple process that can be performed in as short as 15 minutes." Bill Brooks

- ❑ Photos and explanations to help an inspector
- ❑ One-page field-inspection checklist

Field Inspection Guidelines for PV Systems. Brooks Engineering. IREC June 2010.

DOE Procuring Solar Energy



- Solar screening, project design, & PV system commissioning checklists

Procuring Solar Energy. DOE September 2010.

Before Commissioning

These items should be completed or available at the site before commissioning :

✓ All permits have been signed off

✓ Utility has given permission to operate system

✓Electrical engineer's stamp

✓ One or three line drawing of system

✓ System layout drawing (shows module layout, location of balance of system components, disconnects, and wiring and conduit specifications)

✓ PV module specifications

✓ Inverter specifications

✓ Combiner box specifications

Procuring Solar Energy. DOE September 2010.

Mounting Options

Rooftop

NREL PIX 07521

Canopy

NREL PIX 12346

Mounting Options

✓Protective fencing & enclosures installed

Ground Mount

Wrong – wiring (too) easily accessible

Canopy

Correct – wiring not accessible

Field Inspection Guidelines for PV Systems. Brooks Engineering. IREC June 2010.

Before Mounting Rooftop Array

- ✓Structural engineer's stamp
- ✓Roof can handle added weight
- ✓Age & condition of roof

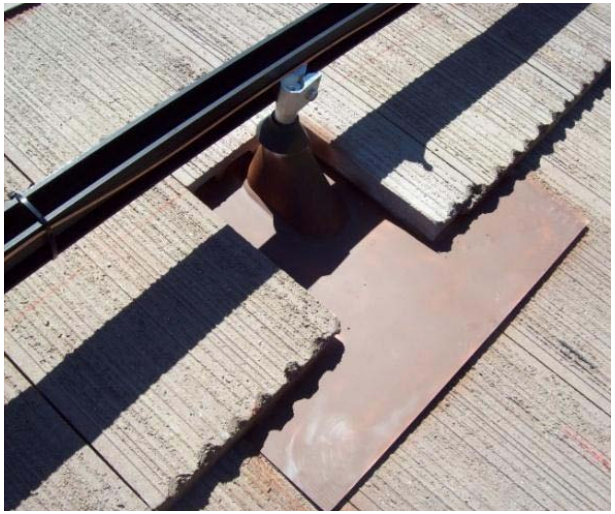
SERC funds may be used to improve the roof directly under the array, but not to replace an entire roof.

Poor Roof Condition

Good Roof Condition

Rooftop Mounting

- ✓Any roof penetrations must be weatherproof
- ✓Array fastened & sealed according to plans



Correct flashing

Wrong – flashing not installed properly

Field Inspection Guidelines for PV Systems. Brooks Engineering. IREC June 2010.

Field Inspection

- ✓Number of PV modules & model number match plans
- ✓Modules permanently installed

Verify number & type of modules

Field Inspection Guidelines for PV Systems. Brooks Engineering. IREC June 2010.

Field Inspection

✓Electrical boxes are accessible & suited to environment

✓Array wiring 90 degree C & UV-rated

Good – electrical boxes suited to environment & accessible

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Wrong – NEMA 3R box not mounted vertically & disconnect mounted on roof

Field Inspection Guidelines for PV Systems. Brooks Engineering. IREC June 2010.

Inverters

string inverter

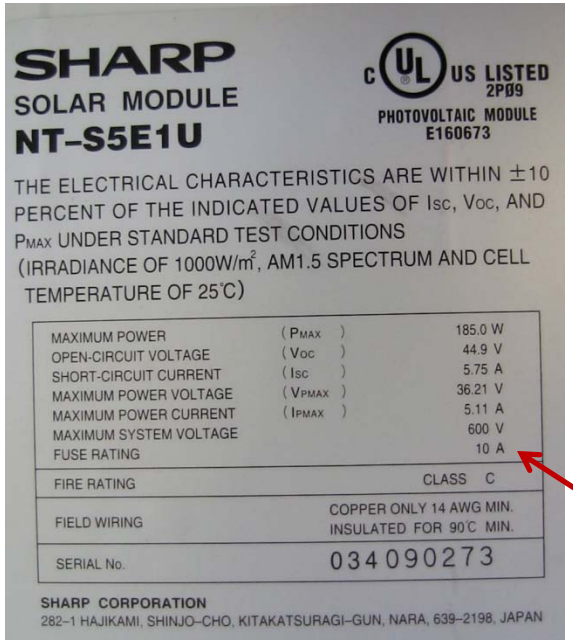
NREL McNutt

microinverters

NREL PIX 04476

Field Inspection

- ✓String fuses are DC-rated
- ✓Fuses & breakers sized properly
- ✓Fuse rating not larger than that on module name plate



Module nameplate

DC-rated fuse

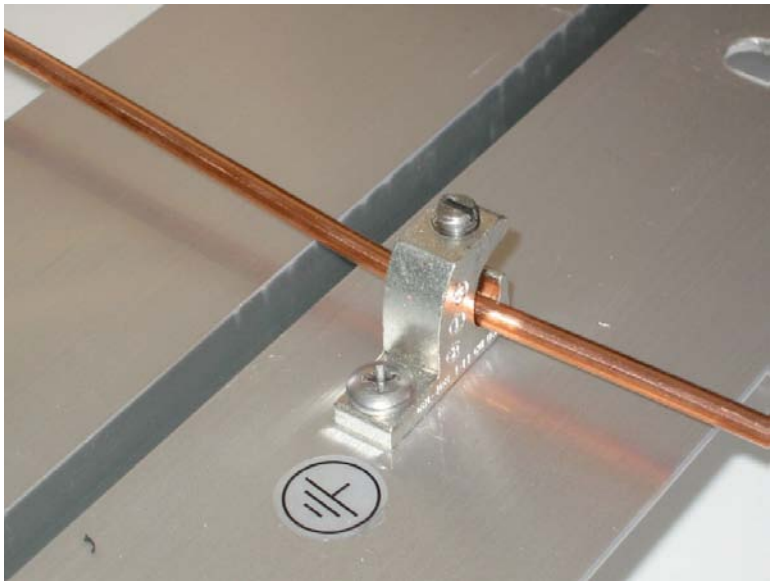
String fuse should not be bigger than the rating on the module

Photovoltaic Power Systems and the 2005 National Electrical Code: Suggested Practices. John Wiles. March 29, 2010.

Field Inspection Guidelines for PV Systems. Brooks Engineering. IREC June 2010.

Installation

- ✓PV array is properly grounded
- ✓All metallic surfaces grounded
- ✓Dissimilar metals should be electrically isolated



Correct grounding

Wrong – copper on aluminum will cause corrosion

Photovoltaic Power Systems and the 2005 National Electrical Code: Suggested Practices. John Wiles. March 2010.

Field Inspection

- ✓Array conductors are neatly & professionally held in place
- ✓Conductor & conduit sizes & ratings match plans

Wrong – wires touching roof surface

Wrong – flexible conduit unsupported

Field Inspection Guidelines for PV Systems. Brooks Engineering. IREC June 2010.

Field Inspection

"Wire management is one of the quickest ways to read the competence of a contractor or installation team." Bill Brooks

✓Wiring completed – not loose or exposed to damage

Wrong – cables not properly supported & exposed to damage

Field Inspection Guidelines for PV Systems. Brooks Engineering. IREC June 2010.

Field Inspection

✓Array conductors are neatly & professionally held in place

Wrong – bending radius too tight

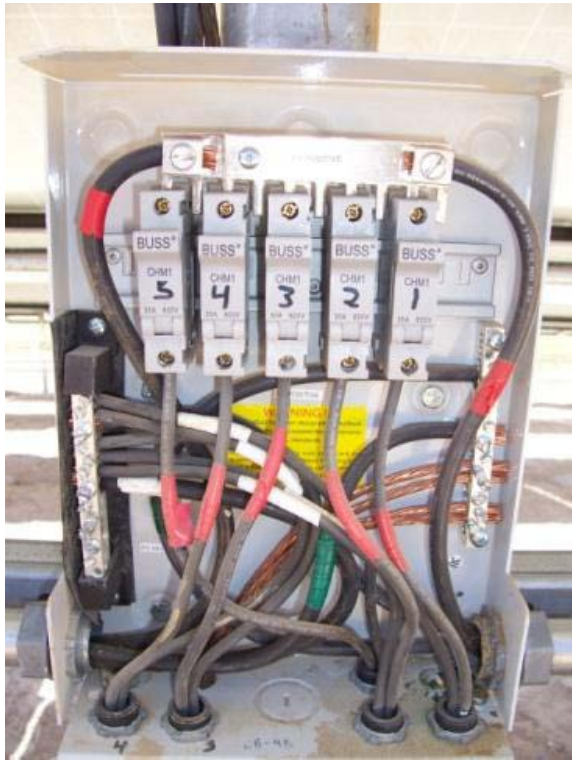
Field Inspection Guidelines for PV Systems. Brooks Engineering. IREC June 2010.

Field Inspection

✓Wires & conduits sizes match plans

✓No potential for wire damage

Correct – cables properly protected, with grounding bushing

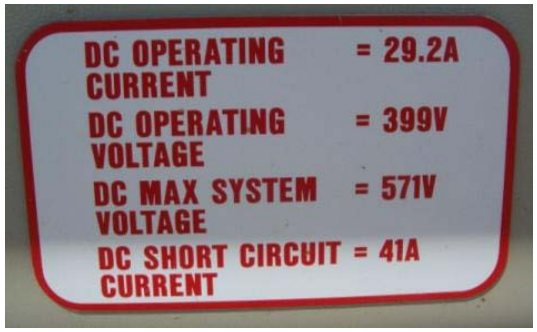


Correct – proper 2-conductor cable-gland inserts

Field Inspection Guidelines for PV Systems. Brooks Engineering. IREC June 2010.

System Labeling

- ✓Labels identify PV source circuits & disconnects
- ✓Labels identify AC point of interconnection



Correct labeling of the PV source circuit at the DC disconnect

Correct labeling of the AC disconnects

Field Inspection Guidelines for PV Systems. Brooks Engineering. IREC June 2010.

PV System Monitoring

inverter display

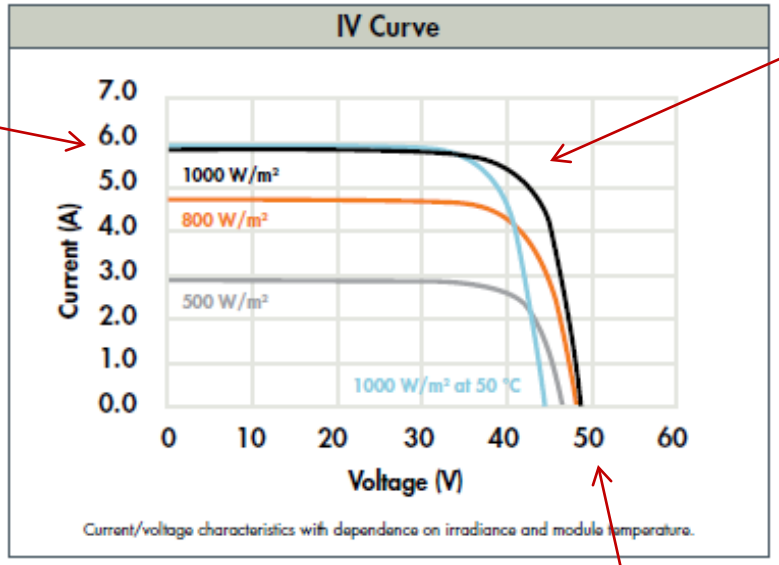
remote display

internet

SMA Americas

Measure System Performance

- System performance testing is an important part of the system commissioning to verify the system is generating the rated power
- May be done by the installer or an independent contractor

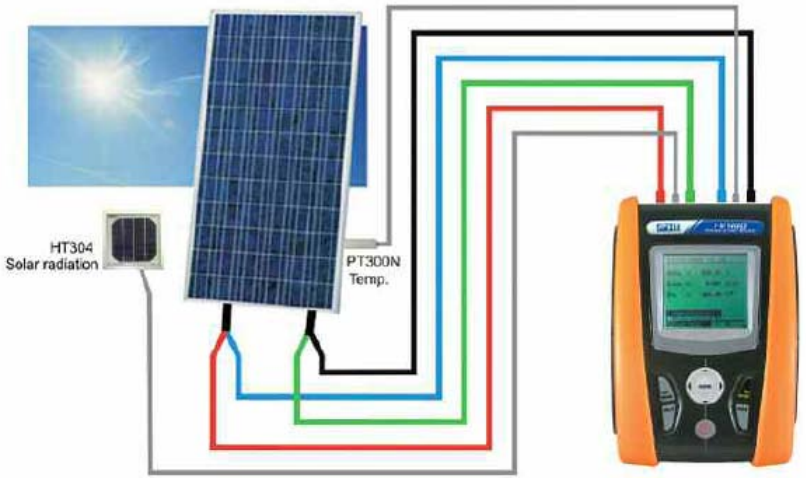


SunPower

clamp -on DVM

Extech

I-V curve tracer



Hukseflux

Measure System Performance

System performance tests should include:

- ✓Measure Voc & Isc of each string
- ✓Verify inverter starts and operates correctly
- ✓Measure Pmp, Vmp, and Imp of each string
- ✓Confirm inverter power meter displays accurately
- ✓Confirm system output under actual conditions

Performance Testing

System owner can do a quick system-power check:

Near solar noon on a clear day, verify the array power is close to the rated kW output of the system

inverter display

SMA Americas

System Documentation

Owner's manual must be provided & should include:

✓Operation & maintenance instructions, including homeowner's responsibilities (if applicable)

✓Electrical design drawings & meters

✓System warranty

✓Contractor warranty

✓Manufacturers' warranties

✓Permits

✓Parts & source lists

✓Emergency & maintenance contact information

Owner Education

Owner education should include:

- ✓Basic understanding of system operation
- ✓How to read meters & inverter(s)
- ✓Understand required maintenance
- ✓Who to call in case of an emergency
- ✓Proper system disconnect & safety procedures

Certified PV Installers

North American Board of Certified Energy Practitioners (NABCEP)

NABCEP PV installer certification is a **voluntary** certification that provides a set of national standards by which PV installers with skills and experience can distinguish themselves from their competition.

Certification provides a measure of protection to the public by giving them a credential for judging the competency of practitioners.

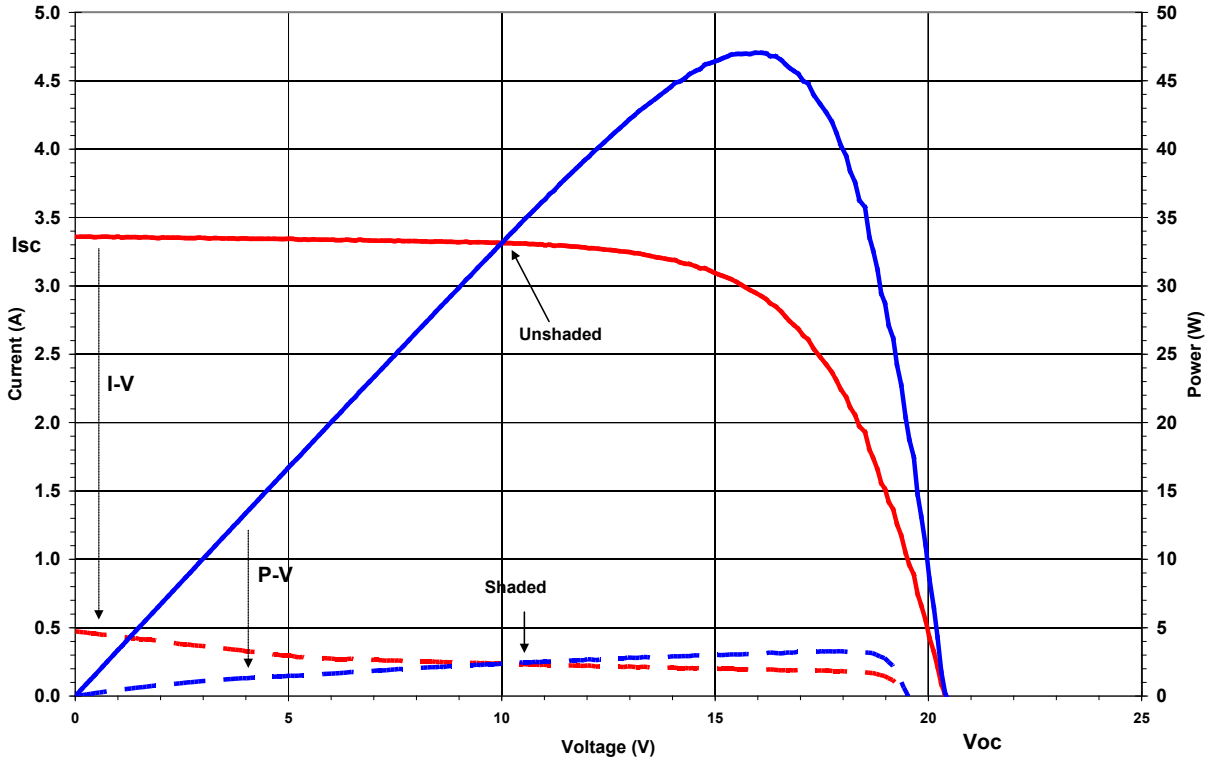
It is not intended to prevent qualified individuals from installing PV systems nor to replace state licensure requirements.

Contact information for installers can be found at:

http://www.nabcep.org/installer-locator

- ❑NABCEP is a relatively new certification so it may not be widespread yet
- ❑In Maine there are good installers, but only 19 are NABCEP certified in the state

PV Module Shading



I-V and P-V curves of an unshaded and shaded crystalline-silicon module - shading **7%** of the module area yields a **93% drop** in its output power!

Peter McNutt

References

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- State of Oregon - www.oregon.gov/ENERGY/RENEW/Solar/docs/SunChart.pdf
- Open Energy Info - en.openei.org/wiki/Main_Page
- Advanced Energy - www.aesolaron.com/SolarStringCalc.aspx

http://irecusa.org/2010/07/irec-releases-2010-edition-of-its-field-inspection-guidelines-for-pv-systems/

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