Utility Connections, Safety, & Code Issues
1. Grid Interconnection and Relationship to the Utility
2. Codes, Standards, and Structural Design Considerations of Basic PV Systems
3. Electrical and Fire Fighter Safety
4. Rooftop PV System Fire Classification Requirements
Relationship and connection to the electrical utility grid

Photo credit: NREL
Inverter: connection to the electrical utility grid

<table>
<thead>
<tr>
<th>Specification</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rated output power</td>
<td>3200 Watts</td>
</tr>
<tr>
<td>AC nominal voltage</td>
<td>240 VAC</td>
</tr>
<tr>
<td>AC operating limits</td>
<td>211–264 VAC</td>
</tr>
<tr>
<td>AC maximum current</td>
<td>14 Amps</td>
</tr>
<tr>
<td>AC trip current</td>
<td>20 Amps</td>
</tr>
<tr>
<td>AC operating frequency</td>
<td>60Hz</td>
</tr>
<tr>
<td>AC frequency range</td>
<td>59.3–60.5 Hz</td>
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<tr>
<td>DC max voltage</td>
<td>500 VDC</td>
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<tr>
<td>DC operating limits</td>
<td>230–430 VDC</td>
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<tr>
<td>DC maximum current</td>
<td>15 Amps</td>
</tr>
<tr>
<td>Operating temp range</td>
<td>-25 to 40°C</td>
</tr>
<tr>
<td>Enclosure</td>
<td>Type 3R outdoor use</td>
</tr>
<tr>
<td>Built and tested to</td>
<td>UL1741</td>
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</table>

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UL LISTED

Utility Interactive Photovoltaic Inverter
Inverter: connection to the electrical utility grid
Anti-islanding
Advantages to grid connection

Net metering and value-of-solar tariffs can offset a customer’s electricity usage costs
Advantages to grid connection

Grid-connected PV systems do not require a battery system

Photo credit: CSE
Codes, Standards and Structural Design Considerations of Basic PV Systems
The ICC codes are the basis for the code ordinances adopted by most jurisdictions.
Structural design considerations of basic PV systems
International Building Code (IBC)

• Structural
• Wind
• Seismic
• Gravity
• Roof Penetrations
• Fire Classifications
International Residential Code (IRC)

- Structural
- Wind
- Seismic
- Gravity
- Roof Penetrations
- Fire Classifications
International Plumbing and Mechanical Codes (IPC & IMC)

- Solar Heating & Cooling (SHC) aka “Solar thermal”
- ST panels
- Storage tanks
- Heat exchangers
- Roof anchors for fall protection
International Fire Code (IFC)

- Fire department access
- Fire safety requirements
- Requirements for PV markings
- Equipment location and spacing
- Location of DC connectors
International Energy Conservation Code (IECC)

• Minimum design considerations
• References ASHRAE Standard 90.1
• Mandatory and enforceable language
• C406.5 On-site renewable energy
• Solar-ready appendices
Solar-Ready Appendix

• Show solar-ready zone on construction documents

• Show roof loads of system

• Minimum area required

• Free from obstructions

• Pathway to electrical service

• Reserved space in main panel

• Certificate near panel
• Minimum requirements for energy efficient designs
• Prescriptive path
• Performance path
American Society of Civil Engineers
Minimum Design Loads for Buildings and Other Structures
IgCC and ASHRAE 189.1

- Total building sustainability guidance
- High performance green buildings
Materials Standards

IBC 1507.17.1 (IRC R905.16.2) Material standards. Photovoltaic modules/shingles shall be listed and labeled in accordance with UL 1703.
The dead load of rooftop PV systems, which includes the racking support systems, must be identified on the construction documents.
Design Roof Loads

Dead loads

Live loads

Graphic credit: NREL
Design Roof Loads

Racking only
3 lbs./ft²

Ballasted mounted
4-6 lbs./ft²
Snow Loads
Wind loads
Testing and Commissioning

Importance:

• Ensures safe installation
• Minimum procedures
• Output and performance
Electrical and Firefighter Safety
2014 National Electrical Code
NEC and Solar PV

- Art. 690 Solar Photovoltaic (PV) Systems
- Art. 705 Interconnection of Electric Power Production Sources
- Art. 250 Grounding and Bonding
About the electrical calculations

How it works:
VOC and ISC
String Voltage:

- Number of modules connected in series multiplies the module voltage, or VOC
System Amps:

- Series of strings connected in parallel increases the module amperes, or ISC
EXERCISE: How much space is needed for a 10 kW system?

- Silicon monocrystalline modules @ 345 watt/panel
- 77" x 39" or approximately 21 sf per panel

10,000 watts (10kW)/watts per panel
10,000/345 = 29 panels
29 panels x 21 sf/panel = 609 sf
Array size approximation

Use calculator

- PV Watts
- System Advisor Model (SAM)
Firefighter Safety
NEC requires rapid shutdown of PV systems
Access and Ventilation

2015 International Fire Code (IFC)

- Requires clear space on roof for:
  - Access paths
  - Ventilation

- Different requirements for Group R-3 structures
Access and Ventilation

IFC: Access

• 6 ft. wide clear perimeter at edges of roof
• Pathways provided in both axes
Access and Ventilation

IFC: Smoke Ventilation

- Max. 150' x 150' array
- Min. 4' pathway with venting cutouts
Access and Ventilation

IFC:
Smoke Ventilation
(Group R-3)

Photo credit: Greentech Media
Rooftop PV System Fire Classification Requirements
IBC 1505.8

- Building Integrated PV Products
Fire Classification

IBC:
PV Panels and Modules
Fire Classification Is...

- For the system as an assembly
- Based on the type of construction and required fire rating
- Not based on the type of roof installed
Quiz and Discussion
Rapid shutdown of the PV system is required by the:

a) Building code  
b) Residential code  
c) Fire code  
d) Electrical code  
e) All of the above
Approximately how many pounds per square foot will the panels and racking of a solar PV system add to the roof of a building?

a) 1
b) 3
c) 8
d) 10
A roof mounted PV array is which type of load?

a) An equipment load
b) An accessory load
c) A live load
d) A dead load
e) All of the above