Safety of Photovoltaic Systems

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Agenda

PV Industry view

Key safety research in the PV sector

Standards & Harmonization

Safe installation of PV systems
PV Installations in the US

Figure 1.1 Annual U.S. Solar PV Installations, 2000-2014
PV Market Highlights

• The US installed 6,201 MW of solar PV in 2014, +30% over 2013, making 2014 the largest year ever in terms of PV installations.

• More than 1/3 of all cumulative US PV capacity came on-line in 2014.

• 20 states now have >100 MW cumulative operating solar PV installations; California alone is 8.7 GW.

• 32% of all new US electric generation came from solar in 2014.

• 2015 forecast: PV installations will reach 8.1 GW in 2015, +31% over 2014, with growth in all segments.

• 2014 was the largest year ever for concentrating solar power, with 767 MW brought on-line, including the 392 MW Ivanpah project.
PV Systems

- Photovoltaics (PV)
- Concentrator PV (CPV)
- Concentrating Solar Power (CSP)
  - Building Integrated PV (BIPV), Stand-alone system
  - Centralized Generation, large users or utilities
Solar is approaching a tipping point in many segments.

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<tbody>
<tr>
<td>1 Off-grid</td>
<td>Applications in areas with no grids (eg, India, Southeast Asia, Africa, and parts of the Middle East)</td>
<td>0 10 20 30 40</td>
<td>15 20</td>
<td>Now</td>
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<td>2a Residential and commercial, good sun conditions</td>
<td>Developed markets in sunbelts (eg, California, Spain, Italy, Australia)</td>
<td>0 10 20 30 40</td>
<td>150 250</td>
<td>Now</td>
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<tr>
<td>2b Residential and commercial, moderate sun conditions</td>
<td>Developed markets with moderate solar yields (eg, Germany, Netherlands, Denmark, United Kingdom, Canada)</td>
<td>0 10 20 30 40</td>
<td>65 120</td>
<td>2012–13 and beyond</td>
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<td>3 Isolated grids</td>
<td>Small, local grids mainly fueled by small diesel generators; large latent demand (eg, Africa)</td>
<td>0 10 20 30 40</td>
<td>25 30</td>
<td>Now</td>
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<td>4 Peak capacity in growth markets</td>
<td>Growth markets; large power investments (eg, India, Middle East, Africa, and China)</td>
<td>0 10 20 30 40</td>
<td>150 170</td>
<td>2013–14 and beyond</td>
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<td>5 New large-scale power plants</td>
<td>Growth markets; large power investments (eg, India, Middle East, Africa, and China)</td>
<td>0</td>
<td></td>
<td>Marginal</td>
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<td><strong>Total</strong></td>
<td></td>
<td>~400–600</td>
<td>Compared with 2011 installed base of ~65 gigawatts</td>
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1Photovoltaic.
2Adjusted for implementation time.

Demand forecasts for global PV installations still very strong despite short-term uncertainty

Growth in solar PV may transform power markets.
Cumulative capacity additions, 2012–20, gigawatts

- Off-grid
- Residential and commercial
- Isolated grids
- Peak capacity
- Large-scale power plants

North America
- 80–130

Europe
- 85–150

Middle East
- 50–60

Asia
- 135–180

South America
- 30–40

Africa
- 35–45

Solar could potentially see total investments of $800 billion to $1.2 trillion over the next decade


1 Includes 10–20 gigawatts of regulated utility pipeline in the United States.
2 Includes Mexico.
Incidents
Dietz & Watson fire – September 2013

Source: NBC Philadelphia
Moving forward to leverage learnings

Understanding root causes – partial shading, environmental stresses, etc.

Developing mitigating strategies – fire classification, PV arc fault protection, grounding, installer qualification

Supporting improved tactics – first responder research and training
Solar ABCs / UL Research Project

The Solar America Board for Codes and Standards (Solar ABCs) in partnership with UL, designed and conducted specific tests to characterize the effects of stand-off mounted PV modules on the fire rating of Class A rated roofing systems.

Acknowledgement: This material is based upon work supported by the Department of Energy under Award Number DE-FC36-07GO17034.
Assessing Fire Hazards to Buildings from installed PV systems

Background

• Fire service and building code officials concerned about adverse impact of PV installation on roofs to fire rating of roof covering materials

Objectives

• Determine how PV panels impact fire growth on roofs
• Develop data on the correlation between PV fire ratings and its impact on fire rating of roof materials
• Share research with building codes for revising code practice

Outcomes

• New PV/mounting/roofing coordination system requirements
Roof mounted PV panels increase the thermal exposure to roof materials by factor of 3
Dept. of Homeland Security PV & Firefighter Safety Project
How to safely tackle fires with PV power generation?

• Shock hazard due to presence of water and PV power during suppression activities

• Shock hazard due to direct contact with energized components during firefighting operations

• Emergency disconnect and disruption techniques

• Severing of conductors

• Assessment of PV power during low ambient light, artificial light and light from fire

• Assessment of potential shock hazard from damaged PV modules and systems
Some key findings

• Isolation requires special consideration: Unlike a typical electrical service, a PV array has no single point of disconnect; tarps offer varying degrees of effectiveness to interrupt the generation of power from a PV array, independent of cost. Firefighting foam should not be relied on to block light.

• When illuminated by artificial light sources such as fire department light trucks or an exposure fire, PV systems are capable of producing electrical power sufficient to cause a lock-on hazard.

• Damaged PV arrays are capable of producing hazardous conditions including electrocution from new and unexpected circuit paths.

• Firefighters’ gloves & boots afford limited protection against electrical shock, provided the insulating surface is intact and dry.

• Responding personnel must stay away from the roofline because modules or sections of an array could slide off the roof.
Firefighter Safety and Photovoltaic Systems

Under the United States Department of Homeland Security (DHS) Assistance to Firefighter Grant Program - Fire Prevention and Safety Grants, UL examined fire service concerns of photovoltaic (PV) systems and the potential impact on firefighting operations. These concerns included firefighter vulnerability to electrical and casualty hazards when mitigating a fire involving photovoltaic (PV) systems. The need for this project is significant due to the increasing use of photovoltaic systems, growing at a rate of 30% annually. As a result of greater utilization, traditional firefighter tactics for suppression, ventilation and overhaul have been complicated, leaving firefighters vulnerable to potentially severe hazards. Though the electrical and fire hazards associated with PV systems have been known for some time, a very limited body of knowledge and insufficient data exists to understand the risks to the extent that the fire service has been unable to develop safety solutions and respond in a safe manner.

This fire research project developed the empirical data that is needed to quantify the potential hazards associated with fire scenarios involving PV installations and provides the basis for the development of firefighting operational practices to reduce firefighter death and injury.
PV Standards

• Our PV standards date back to 1980s, built out of NASA’s Jet Propulsion Laboratory’s work on PV technology

• Dozens of new PV equipment, PV system, balance-of-system and energy storage system standards have been developed in the last several years to advance safety of this critical technology

• Our work has been used as source documents for IEC standards through IEC TC 82, which can then be used for North American harmonization
PV System requirements

- PV Junction box: UL 3730
- PV Wire: UL 4703
- PV Wiring Harness: UL 9703
- PV Connectors: UL 6703 & 6703A
- PV Fuses: UL 2579
- Fuseholder: UL 4248-18
- PV Breakers: UL 489B
- Combiner Box: UL 1741
- DC side isolation switch: UL 5081
- Inverter: UL 1741 & 62109; PV Arc Fault Protection UL 1699B
- AC side isolation switch: UL 98B
- Energy Storage Systems: UL 9540
- Solar Trackers: UL 3703
- Concentrated PV Assemblies: UL 8703, Safety UL 62108, Performance
- UL 1741 & 62109; PV Arc Fault Protection UL 1699B
- UL 5081
- UL 1741 & 62109; PV Arc Fault Protection UL 1699B
- UL 9540
- UL 62108, Performance
- UL 8703, Safety
Development of Code requirements

- The National Electrical Code (NEC®) requirements continue to evolve significantly to address PV
- Requirements for PV arc fault protection, rapid shut-down, and installation by qualified personnel are notable examples of this evolution
- Work in ongoing for the 2017 NEC to address large scale PV plants, potential refinement of the rapid shutdown requirements, and other important topics.
Training

In the past, PV systems could be installed by people who may not have understood the unique potential hazards, for example roofers, carpenters or handymen.

PV Installer training and personnel certification programs help meet the needs of the broad user community by establishing confidence in the safety of the installation and the installer’s knowledge of the technology and applicable Code requirements.
Summary

Based on its characteristics, PV is an important component of the renewable energy portfolio going forward.

PV systems will continue to be deployed at a significant rate in the US and globally.

Safety of PV systems must leverage established standards, Code requirements, and support for the broader safety community.
Thank you.

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