Safety in PV Systems – SolarEdge Solution Overview
Session Objective

- Evaluate the safety risks in Solar PV Systems
  - Electrocution-related risks
  - Fire-related risks
  - Case studies
- Demonstrate the SolarEdge solution
  - SafeDC™ technology explanation
  - Firefighter Gateway
PV Safety
Background
The Photovoltaic Effect

- Solar Photovoltaic (PV) modules are composed of solar cells
  - Cells contain one or two layers of a chemically coated semi-conducting material, mostly Silicon, one of the most abundant materials on earth
- **Electric Field** - created across the cell when exposed to light
- **Current** - proportionate to the intensity of the irradiance and even low lighting conditions are enough to generate an electric current
Conversion of light to Electricity in a Traditional PV System

1. Photovoltaic modules
2. Inverter DC/AC
3. Feed-in electricity meter
4. Consumption meter

Source: EPIA
Various Applications of Solar PV Systems

Utility Scale PV Plant

Residential System

Roof Integrated System

Commercial System
Safety Risks in Solar PV Systems

- PV system installations involve physical, chemical and electric risks. **Electric shocks are the major concern**
  - PV modules generate DC voltage when they are exposed to light (even when physically disconnected from the grid)

- Residential and commercial PV installations include:
  - Dozens to hundreds of PV modules
  - One or more PV inverters used to invert the current created by PV modules from DC into grid-compliant AC
  - Typical PV modules produce 20 – 40V
    - 8 – 15 PV modules are typically connected in a series (string) and produce a total voltage of 150 – 1000V
Solar energy systems have been in commercial use worldwide for many years

- High safety level through strict manufacturing quality standards
- Risks to system owners, installers and skilled firefighters are defined by experts as: **low risk**
- Due to fast growing installation rate and the inevitable degradation of existing installations, there is a growing need for:
  - Thorough safety trainings
  - Consideration of new technologies
Risk of Electrocution

Risk to installers and maintenance personnel:

- 120V = Safe outdoor voltage
  - 3-4 active modules produce a dangerous voltage for a person touching exposed wires
  - Safety precautions need to be employed
  - The high voltages remain even if the inverter is disconnected from the modules/AC grid and the risk remains even after installation is completed and during maintenance

DC Voltage up to 1000V
Risk to firefighters:

- False assumptions can lead to disasters
  Firefighters commonly cut off electric grid supply to burning buildings as a precaution procedure before extinguishing the fire. They assume there is no risk of electrocution once the grid has been disconnected, allowing the spray of water and pouring of holes in the roof to allow the emission of smoke and heat. Unfortunately, this assumption is not true in case of a PV roof system.
To conclude - No Way to ‘De-energize’ Traditional PV Systems

- PV systems are always energized when exposed to sunlight
- Traditionally, rooftop PV systems operate at up to 1000 VDC
- Opening disconnects interrupts current flow
- Hazardous voltages remain even with disconnects open
PV Safety Case Studies
In February 2010, fire broke out in a residence in Schwerinsdorf, Germany. The firefighters, aware of the PV roof system, were concerned by the risk of electrocution and decided not to distinguish the fire directly, but to wait for the complete burning of the roof and destruction of the modules.

"All we can do is wait until the panels have burnt completely"
Case Study – Warehouse, Germany

- The flow of events repeated in a fire in a warehouse in Hohenaspe, Germany
- The existence of a PV system on the warehouse’s roof delayed the firefighting procedures, as the firefighters preferred to only keep the fire from spreading from a safe distance
A fire broke out in 2 separate locations on the roof of a department store in California.

Damage to two connectors of a 380kW system resulted in an electric arc that led to the heating of cables and the burning of 9 modules.

The firefighters had to manually disconnect each of the system’s 56 breakers individually, until they could start putting out the fire.
A fire broke out in a private residence in Arizona due to an overheated cable in a bedroom (unrelated to PV)

A 3kW PV system was installed on the roof. Although the roof was disconnected from the grid according to the standard procedures, damage to another cable that was connected to the PV system, resulted in the electrocution of a firefighter that touched the metal banister at the entrance to the house.
PV Safety
SafeDC™
- Module level optimization
- Fixed voltage – flexible design
- Module level monitoring
- Enhanced safety solution
SolarEdge Power Optimizers

- Per-module Maximum Power Point Tracking (MPPT)
- 99.5% maximum efficiency, 98.8% weighted efficiency
- Advanced, real-time performance measurement
- Automatic module shut-down for installer and firefighter safety
- Embedded by module manufacturers, or connected by installers to c-Si and thin-film modules

250W-400W Module add-on
600W Module Add-On for Commercial Installations
300W Module embedded

* Available H2 2013
PV Safety
SafeDC™
In traditional installations, DC voltage reaches up to 1000V during installation.

SolarEdge power optimizers automatically limit module voltage to 1V, until the string is connected to an operational inverter.
Unsafe Firefighting & Maintenance with Traditional Inverters

- Shutting down the inverter, string DC disconnect, or AC breaker does NOT shut down voltage on the roof

![Diagram showing Dangerous DC voltage with Traditional Inverter and AC breaker]
Safer Firefighting & Maintenance with SolarEdge SafeDC™

- Power optimizers shut down DC voltage in modules and string wires immediately when the inverter is turned off, or when the AC breaker is disconnected.
- In addition, inverters and power optimizers shut down when exposed to extremely high temperatures or electric arcs.
Firefighter Gateway

- In addition to the SolarEdge automatic built-in SafeDC™ mechanism, SolarEdge Firefighter Gateway can be connected
- Firefighter Gateway enables system DC shutdown:
  - By pressing the emergency stop button
  - By receiving an alarm from Fire Alarm Control Panel (Unit)
- Real time indication of system DC voltage for safety assurance
- Remote indication of PV system status
The Firefighter Gateway is connected to the Fire Alarm control panel (unit) which is optional.
Certified to meet the relevant IEC and VDE standards as a DC disconnect mechanism between a solar inverter and a PV generator*

- IEC 60947-3:1999, DIN EN 60947-3; VDE 0660-107:2006-03
- “Low-voltage switchgear and controlgear - Part 3: Switches, disconnectors, switch-disconnectors and fuse-combination units”
- IEC 60364-7-712:2002-05, DIN VDE 0100-712:2006-06

More than just DC disconnect:
- Increased safety compared to DC switch, due to safe DC string voltage
- Built-in and eliminates the need for a separate disconnect device – time and cost saving

* Installing SafeDC™ instead of a DC Disconnect should be verified with your local inspector/utility
Certificate of Compliance

Applicant: SolarEdge Technologies Ltd.
Abba Eban 1a
Hertzlia 46725
Israel

Product: Disconnection device for PV generators
Model: Safe DC disconnect mechanism

Use in accordance with regulations:
Disconnection between a solar inverter and a photovoltaic generator

Applied rules and standards:
In accordance on:
- DIN EN 60997-3: VDE 0690-167:2006-02
- "Low-voltage switchgear and controlgear - Part 3: Switches, disconnections, switch-disconnectors and fuse-combination units"

and
- IEC 69364-7-712:2002-05
- DIN VDE 0100-712:2006-06
- "Electrical Installations of Buildings - Part 7-712: Requirements for Special Installations or Locations - Solar Photovoltaic (PV) Power Supply Systems"

The safety concept of an aforementioned representative product corresponds at the time of issue of this certificate to valid safety specifications for the specified use in accordance with regulations.

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PV Safety
Remaining Challenges
Increasing Risk Exposure

In the absence of a proper solution to electrocution risks, the exposure of installers, maintenance personnel and firefighters to these risks is expected to increase:

- **Increasing number of PV installations** - with the PV market growing, so does the probability of fires breaking out on roofs equipped with PV systems (even if PV-unrelated)

- **Installation aging** - the majority of PV installations are still relatively new. But as these systems grow older the likelihood of a cable or connector damage increases, and with that, the risk of electrocution, electric arcs and fires
Refine Regulations

- Multiple committees are continuously working on establishing refined regulations and procedures for safer installations & firefighting in the PV environment

- Regulatory requirements change slowly by nature
  - Fast changes in requirements would cause overreaction
  - Long lead times are needed to allow manufacturers to develop solutions

- The PV industry is evolving faster than the regulatory process can adapt
Challenges Remaining – Placards

- Need for first responders to be able to identify between systems with safety voltage functions
  - Labeling needs to be standardized (same label for different safety solutions)
  - Differing hazard levels must be readily identifiable
  - Should be developed in cooperation with first responders
  - Widespread training will be needed
Summary

- **Ability to disable DC voltage is vital**
  - Inability of traditional inverters to provide safe DC voltage
  - Growing demand for the ability to disconnect the DC voltage of each module, or at least the ability to limit it below a safety threshold
  - This can only be achieved with module-level power management such as power optimizers