Firefighting & PV Systems – Risks and Solutions

Presented by:
Overview of PV Systems

- Solar panels convert sun energy to electricity
- A solar inverter is required to convert the DC electricity generated by the panels into a grid-compliant AC electricity
The SolarEdge System

- Each panel is connected to a single power optimizer
- Power optimizers are electronic chips that maximize energy from each panel individually
- An inverter converts DC to AC
- Monitoring platform visualizes the performance of each panel
The Solution

1. Power Optimizer
   By connecting a SolarEdge power optimizer to a PV panel it becomes a smart panel. This allows:
   - Harvest of up to 25% more energy from each panel, compared to traditional inverters
   - Constant feedback on the performance of each panel
   - Designed to de-energize to a safe voltage upon grid or inverter disconnect

2. Inverter
   The SolarEdge inverter is simpler and more reliable:
   - Responsible only for DC to AC conversion, as all other functions are handled separately for each panel by the power optimizers
   - Extremely small, lightweight and easy to install
   - 99% weighted efficiency
   - Suitable for indoor or outdoor installations

3. Monitoring Platform
   By displaying real-time performance data, the monitoring platform allows:
   - Full visibility of your system performance
   - Automatic alerts on system issues
   - Easy access from a computer, smartphone, or tablet
Introduction

- Millions of PV systems are installed around the world
- Technology is relatively safe and reliable
- As long as the sun is shining, PV wires are energized with high DC voltages
  - PV installations can reach high voltages (600-1500VDC)
- Electric arcs are fire hazards
- Safety standards are being required by country codes or in tender specifications
Safety Risks
Under normal circumstances, PV systems are generally safe and pose no danger to people and property.

However, as long as the sun is up, PV wires are energized with high DC voltages.

PV modules typically have an output voltage of 30-60V. When connected in a string, voltage can reach 600-1500V, which can be dangerous to installers during system installation, maintenance personnel during O&M, and first responders during an emergency.

Shutting down the inverter or disconnecting the DC cables terminates current flow but increases the DC voltage level (from Vmpp to Voc) creating even higher electrocution risks.
An electric arc is an ongoing high-energy discharge, resulting from a current passing through a normally nonconductive media such as air.

When cables or connectors in a PV system are improperly connected or damaged, the electric current may pass through the air, causing an electric arc.

Arcing can electrify an installation, causing the mounting system to become electrified, potentially shocking anyone touching the unit, or cause fires.

Arcs generate heat which can cause fires and pose electrocution risk to those working near them.

Arc risk (while still low) increases with system aging due to connectors and cables degradation.
High DC Voltage – Ineffective Solutions

- Automatic DC breakers on the inverter cannot disconnect the voltage at the module level — solution adds cost without decreasing the risk.

- Covering PV modules during firefighting to block sun irradiance and eliminate production of high voltage:
  - Spray foam — has proven to be ineffective because foam evaporates or slides off the modules before the fire is extinguished.
  - Covering modules with opaque material — this method is not practical due to the prioritization of manpower and the availability of opaque material on firetrucks.
Hazards and Recommended Regulations
Scenarios: Firefighting Outside of a Building

**Hazard:** Risk of an electric shock
- Can be reduced by applying standard local protocols for firefighting powered electric generators
- Outside of a building all parts of the PV system are visible and can be avoided

**Recommendations:** Firefighters should keep a minimum distance from the PV system, e.g. in accordance with DIN VDE 0132 (Germany):
- 1 m – 5 m, depending on nozzle of fire hose, for extinguishing with water
- 1 m from (possible) live parts
- Procedure is identical to buildings without PV systems
Scenarios: Firefighting Inside a Building

Firefighters must avoid touching hazardous DC voltage inside a building during fire.

**Hazard**: Parts of a PV system (such as cables) might not be identifiable because of smoke or physical obstructions.

**Hazard**: Space constraints complicate safe distances to hazards.

**Recommendations**: Require a shutdown mechanism on all hidden conductors (not near the modules and inverters). Example of such regulation — USA Rapid shutdown in NEC 2014 (article 690.12):
- All live conductors that are >3 m from the array of inverter must be de-energized to <30V in under 30 seconds
- Central point to trigger shutdown that is clearly marked
Scenarios: Situation After a Fire/Disaster

- Firefighters have to perform follow-up tasks (e.g. searching for hidden pockets of embers)

- **Hazards:**
  - Risk of shock
  - Risk of having follow-up fires due to arcs in damaged DC installations

- **Recommendation:** Rapid shutdown regulation (as described above)

- **Recommendation:** Arc detection protection to avoid potential fire hazards similar to US regulations UL1699B
Scenarios: Flooding

- **Hazards** posed by immersed DC installations in case of flooding:
  - Water penetration of inverter — possibility of a short-circuit, but there is no risk of electric shock
  - Penetration of water into components of one polarity (e.g. connectors) may cause electric shock if a second fault is touched at the same time

- **Recommendation**: Ground fault and Residual-Current-Detector and shutdown in all inverters (regulations currently in place)

- **Recommendation**: Automatic de-energizing of voltages to <30V if inverter is shut off due to isolation faults
Scenarios: Rescue Operations Near/Inside a Generator

- Accident involving people in the area of a PV system, for example:
  - Car crashes into a building with integrated PV system
  - Structural collapse of a building with people (gas explosion, storm, roof overload...)

- **Hazard:** Cells and modules are still operating due to ongoing irradiance

- **Recommendations:**
  - Rapid shutdown regulation (as described above)
  - Arc detection protection to avoid potential fire hazards similar to US regulation UL1699B
SolarEdge Solution
SolarEdge – Enhanced Safety

- The SolarEdge solution meets advanced European and US safety standards
  - The SolarEdge SafeDC™ safety feature is certified to meet IEC 60947 as a disconnection means between a PV inverter and a PV generator, and VDE 2100 for safety in cases of firefighting or maintenance (EU)
  - Rapid Shutdown functionality available for NEC 2014/2017 690.12 (US)
  - Integrated Arc Fault Protection (Type 1) for NEC 2011 690.11 (US)
With SolarEdge SafeDC™ feature, whenever AC power is off, DC wires are designed to de-energize in order to protect installers, maintenance personnel, and firefighters.

- Power optimizers are designed to drop to 1VDC in any of these cases:
  - A building is disconnected from the electrical grid
  - The inverter is turned off
  - Insulation faults for example in cases of flooding or structural collapse (ground fault or RCD will trip the inverter)

- Thermal sensors in power optimizers of each module detect temperature over threshold (85°C)
SolarEdge — Arc Fault Detection

- SolarEdge inverters with CPU version 3.19xx and higher comply with UL1699B arc detection requirements (US).

- Two modes of inverter reconnection after an arc detection event:
  - Manual reconnect: According to US standard compliance — the system must be manually restarted on site following inverter shut down.
  - Auto reconnect: In order to avoid costs associated with false detections due to site visits for manual reconnect, this mechanism reconnects the system automatically a certain period of time after an arc detection event. If the arc detection persists, the reconnection time will increase progressively (not available in US).
SolarEdge — Advantages for Firefighters

- When using third party safety devices such as a dedicated Rapid Shutdown solution that has no monitoring:
  - If the device is installed incorrectly or fails, there is no indication of the failure and the device does not function as needed.
  - Maintenance has to be carried out frequently to verify proper operation.

- With SolarEdge:
  - System does not start up unless it is properly connected (in terms of polarity and string design).
  - If a power optimizer fails, the error is reported on the monitoring platform and can be repaired.
  - A failed optimizer is designed to go into shutdown mode until repaired.
Safety Standards
The National Electric Code, NEC 2014 and the more recent NEC 2017, requires rapid shutdown of PV Systems on buildings. DC voltage in circuits running more than a certain distance from the array (10 feet for NEC 2014, 1 foot for NEC 2017) to the inverter has to be lower than 30VDC within 30 seconds of rapid shutdown initiation. NEC 2017 also requires that the voltage on the conductors within the array be lower than 80VDC within 30 seconds. The SolarEdge solution complies with these requirements.
Rapid Shutdown of PV Systems — EU

- VDE AR 2100-712 and OEVE R-11-1 contain additional requirements for fire safety.
- A rapid shutdown is one of the possible, but not the only accepted measure.
- Systems with module-level shutdown can fulfill all requirements of these standards.
- The SolarEdge SafeDC™ feature is certified in Europe as a DC switch disconnector, which fulfills the requirements of IEC/EN 60947-1 and -3, and is certified according the safety standards VDE AR 2100-712 and OEVE R-11-1.
This protection is intended to mitigate the effects of arcing faults that may pose a risk of fire ignition under certain conditions if the arcing persists.

DC electric arc according to UL1699B standard:
- Photovoltaic systems operating at 80 volts DC or greater (between any two conductors) shall be protected by a PV arc-fault circuit interrupter or equivalent protection.
- The system shall detect and interrupt arcing faults resulting from a failure in the intended continuity of a conductor, connection, module, or other system component in the PV system DC circuits.

NEC 2014/17 sec.690.11 & 690.12 requires the ability to detect and terminate arcs through inverter shutdown.

The system must remain shut down until an installer has checked the site and replaced any components, if needed, only then can the system be manually restarted onsite.

SolarEdge US inverters have been UL 1699B certified since the standard came into effect.
Arc Detection in Solar Applications — EU

- Currently, there is no EU standard for arc detection
- SolarEdge does however offer the functionality according to the US standard per its certification
Cautionary Note Regarding Market Data & Industry Forecasts
This power point presentation contains market data and industry forecasts from certain third-party sources. This information is based on industry surveys and the preparer’s expertise in the industry and there can be no assurance that any such market data is accurate or that any such industry forecasts will be achieved. Although we have not independently verified the accuracy of such market data and industry forecasts, we believe that the market data is reliable and that the industry forecasts are reasonable.