FIRE RISKS OF PHOTOVOLTAIC SYSTEMS

Milan Bělík

ABSTRACT

This article deals with fire risks of photovoltaic systems mounted on buildings and roofs. The aim of the article is to explain the fire progress in building, fire rating and performance of photovoltaic system and possible ways of extinguishing. Specific dangers for acting fire units are described in detail. The article is also targeting on secondary hazards for surrounding objects and people during and after the fire.

6. INTRODUCTION

Photovoltaic systems have reached large number of installations in recent few years. There are, in basic, two types of installations. Large systems (with installed power up to 38 MW) are usually built on green fields or brown fields. Smaller systems (with installed power usually up to few kW) are mounted on roofs or side walls of buildings. All these systems could be affected by fire or could fire initiate itself.

Goal of this research is to define main risks of these systems, explore progress and results of a fire and suggest some ways of extinguishing.

First type of installations (large systems) is not included in this research. Panels are installed on stand alone constructions that could not affect progress of the fire. Also results and costs of the fire are practically assessed by panels, wires and / or inverters. There are no additional interacting objects. Secondary hazards, ways of extinguishing and dangers for the fire units are similar or lower to the second type of installations.

Small systems installed on buildings interact with the building itself (during fire). Fire performance and fire rating of the system is defined by features of the panels and features of the roof (or side wall). Also progress of the fire depends mostly on features of the building and very lowly on the panels. Next, the dangers for acting fire units are higher, because of indistinguishable and unpredictable features of installed photovoltaic system and its wiring.

Tasks of the experiment:

- Dangers for the fire units
- Fire rating and fire performance of PV system
- Ways of extinguishing
- Secondary hazards of PV system
- Progress of fire in building with PV system

7. DANGERS FOR ACTING FIRE UNITS

Entry into the object affected by the fire is the crucial task for acting firemen. First step is to switch off the electricity. In case of building with installed PV panels only AC could be switched off, while the panels still produces DC.

Main issues during the entry:

- Unknown architecture of the system (grid on, grid off)
- Configuration of PV strings
- Location and configuration of switching devices (AC)
- Cable ways (DC, AC)
- Location of inverters
- Location and configuration of accumulators (grid off)
- Configuration of accumulator breakers (grid off) – if exist

The entry itself is usually led in two separate ways. First crew tries to enter through the main door and / or windows in ground floor, while the second crew tries to go directly through the roof to minimize the time of fire localization. The roof team uses hand axes and chain saws to break the roof tiling and during this action could hit or cut DC wires from PV panels. Both teams could get into contact with exposed or over burned wires. Voltage depends on configuration of the system and can reach up to 1000 V. Current depends on configuration of the system and on incident solar radiation and can reach up to 10 A.

Main dangers for acting fire crew:

- High DC voltage
- DC current

8. FIRE RATING AND FIRE PERFORMANCE

Fire rating of PV panels could affect progress of the fire. The panels are in fact additional layer on the roof or side wall. Experiments have shown good fire resistance of PV panels. Short exposition to temperatures up to 200 °C has no detectable effect on panels or their production. Longer expositions harm structures of the panel and higher temperatures (above 600 °C) locally damage the panel, while unaffected cells still produce electricity (depending on panel design).

Fire performance of single PV panels is very low and actually doesn’t affect progress of the fire. Both features and progress of the fire defines final damage of the device.

Figure 1 – Fire rating and fire performance of PV panels.

9. WAYS OF EXTINGUISHING

First ideas focused on extinguishing agens, what can affect (decrease) production of PV panels. It means, that agens suppresses the fire and makes non-transparent cover on panels. Extinguishing

foam and extinguishing powder were discussed. Both agens failed, because the covers were rapidly gravitated or flown down. Also the non-transparency of the cover was non-homogenous and production of panels was only decreased but not stopped. Disadvantage is also relatively high price of these agens.

Different way is use of thin black plastic sheet. But application and manipulation during real action is very difficult and this method is not used any more.

The best way to extinguish in these cases is usage of low pressure water or high pressure water beam while using additional isolation devices (isolation gloves). Application is easy, agens is cheap and reasonable and results are reasonable.

10. SECONDARY HAZARDS OF PHOTOVOLTAIC SYSTEM

Secondary hazards are additional risks for surrounding objects and acting fire crews depending on features of the photovoltaic system. Except possible step voltage and touch voltage is the main issue sparking on exposed or cutted wires and cables.

Sparking itself can repeatedly initiate secondary centres of the fire, above all in areas with present flammable materials. This issue is most serious in attics and garrets, where many easily flammable materials are present (old papers, textile, hays, dry wood of the roof, etc.). The issue is increased with every present metal construction or object (gutter channels, lightning conductor, tubes, cross rails, grills, etc.).

Next effect of sparking is ionisation of air, what supports origin of a DC arch evoked with relatively small currents. High temperatures of the arch can again initiate secondary centre of the fire even on hard ignitable materials.

Finally, DC current could cause electrolysis of water with generation of explosive compound of hydrogen and oxygen (with presence of sparking).

Danger of step voltage and touch voltage is dramatically supported with wet ambient and with anti-static shoes used by fire units.

Figure 2 – PV panels powered DC arch (0,75 A) and fire initiation.

11. PROGRESS OF FIRE IN BUILDING WITH PV SYSTEM

Progress of the fire was experimented on an old building in ex military area intended for demolition. Roof of the building was modified to carry 3 types of tiling to decide influence on fire progress (tile roofing, sheet roofing and felt roofing). 3 photovoltaic arrays were installed on conventional constructions – one array on each tiling. V-A characteristics, panels and tiling temperatures, solar radiation were periodically measured during the fire and progress of the fire was captured on 2 cameras and 1 thermo camera.

Felt roofing demonstrated poorest fire rating, while tile roofing showed best endurance. Panels on felt roofing were completely destroyed in first stage of the fire, sheet roofing collapsed 10 min after fire initiation, while panels on tile roofing survived almost unaffected.

Production of panels was affected only by heavy smoke, not by rising temperatures (panels were cooled by strong air circulations).

Typical fire progress in building:

- 0. min: fire ignition (mostly chimney)
- 2. min: fire detection
- 3. min: report to fire department
- 5. min: departure of fire units
  average distance 10 km (= 10 min)
- 15. min: initiation of fire action

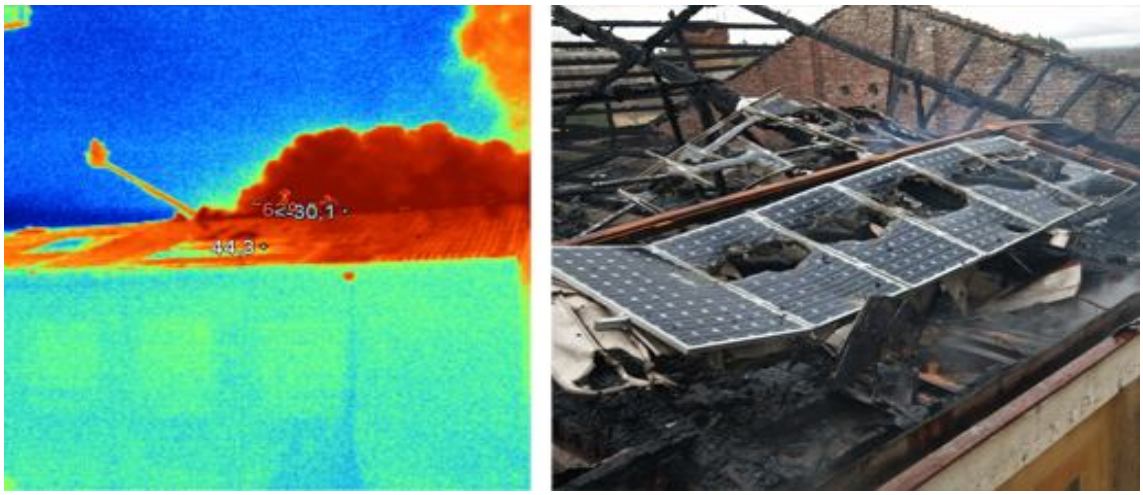

Figure 3 – Fire progress (infra view) and fire results on roof and panels.

12. CONCLUSIONS

Experiments helped to define and quantify main dangers for fire units acting on a fire of building with installed photovoltaic system and to choose usable ways of extinguishing of these fires.

Secondary hazards during the fire of photovoltaic system seemed to be more important for evaluation of overall situation than fire rating and fire performance of the system.

Fire progress in a building with installed PV system and fire results on devices are mostly affected by roof materials and potential additional phenomenon initiated by secondary hazards.

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AUTHORS:

Ing. Milan Bělík, Ph.D.
University of West Bohemia
Department of Electrical Power Engineering and Environmental Engineering
Univerzitní 8, 306 14 Plzeň, Czech Republic
E-mail: belik4@kee.zcu.cz
Tel: + 420 377634315
Fax: + 420 377634302