PV Systems and Fire safety in Germany

Säkerhetsaspekter i solenergianläggningar

Karlstad, 2018-10-22

Marco Hernandez Velasco

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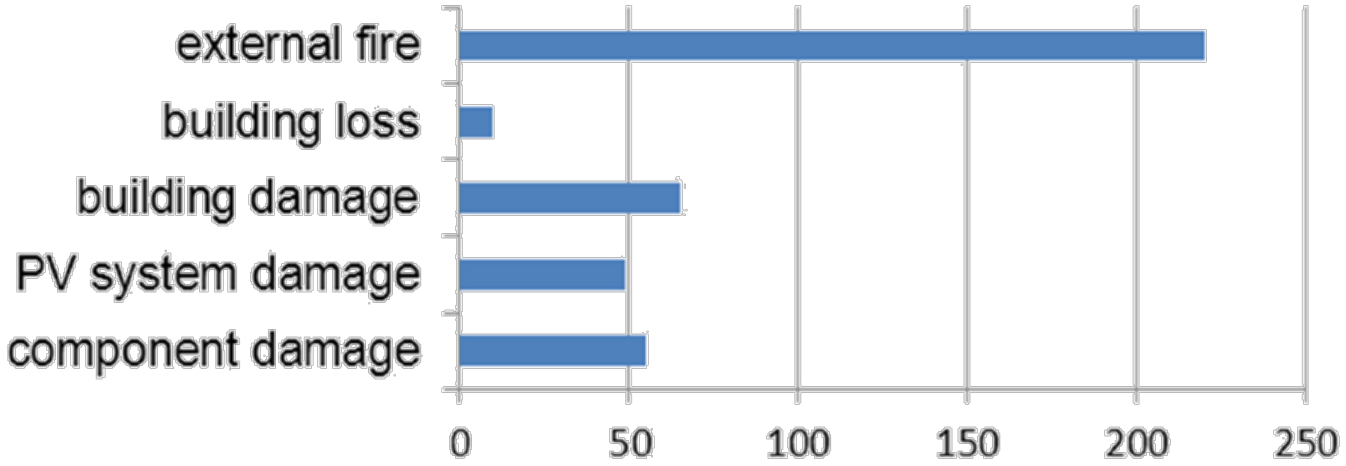
PV fire incidents collection for 10 years (until December 2012)

Around 190 000 fire fighting missions each year
(Deutscher Feuerwehrverband)

In this period, 350 fires reported, where PV systems had been affected

- in some 130 cases fires are attributed to PV systems
  - (some more 50 cases of heat damage to components)
- in some 220 cases PV systems were damaged by a building fire



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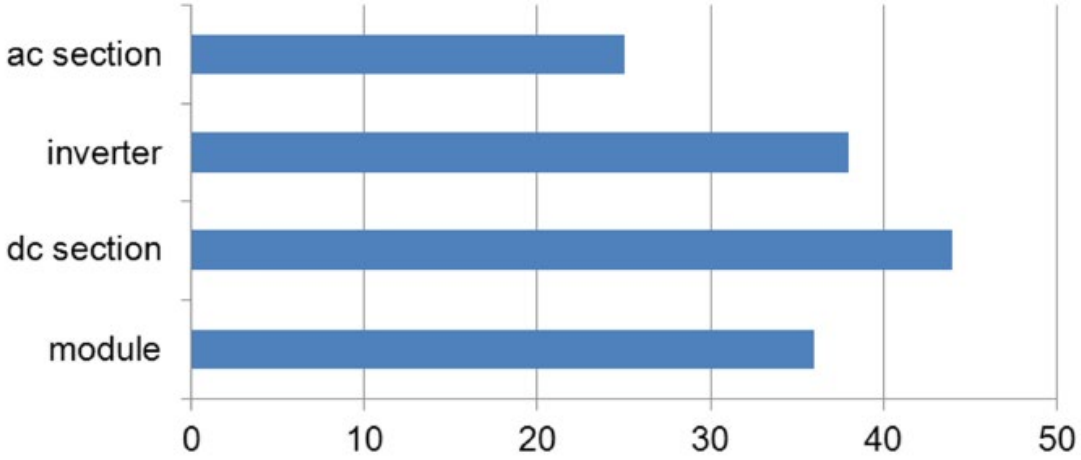
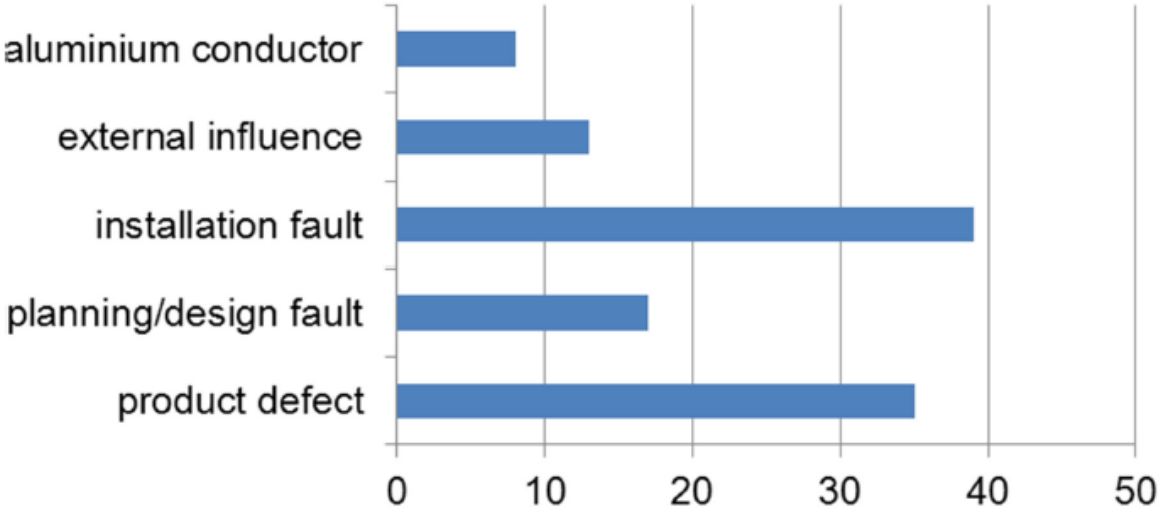
PV fire incidents collection for 10 years (until December 2012)



Location of incident – source of damage

Main root cause



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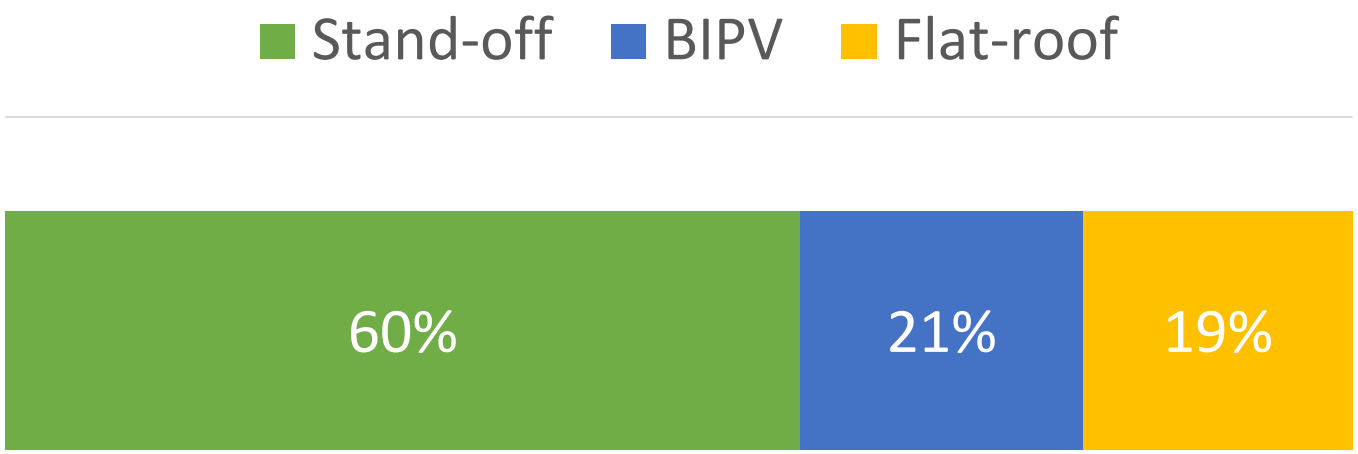
PV fire incidents collection for 10 years (until December 2012)

Cases of damaged buildings (63 cases)

- Stand-off systems protected by “hard” tiles (tiles)
- Building integrated systems (BIPV) exposed to fire hazard above average:
  - 1% of the systems but 20% of the damages



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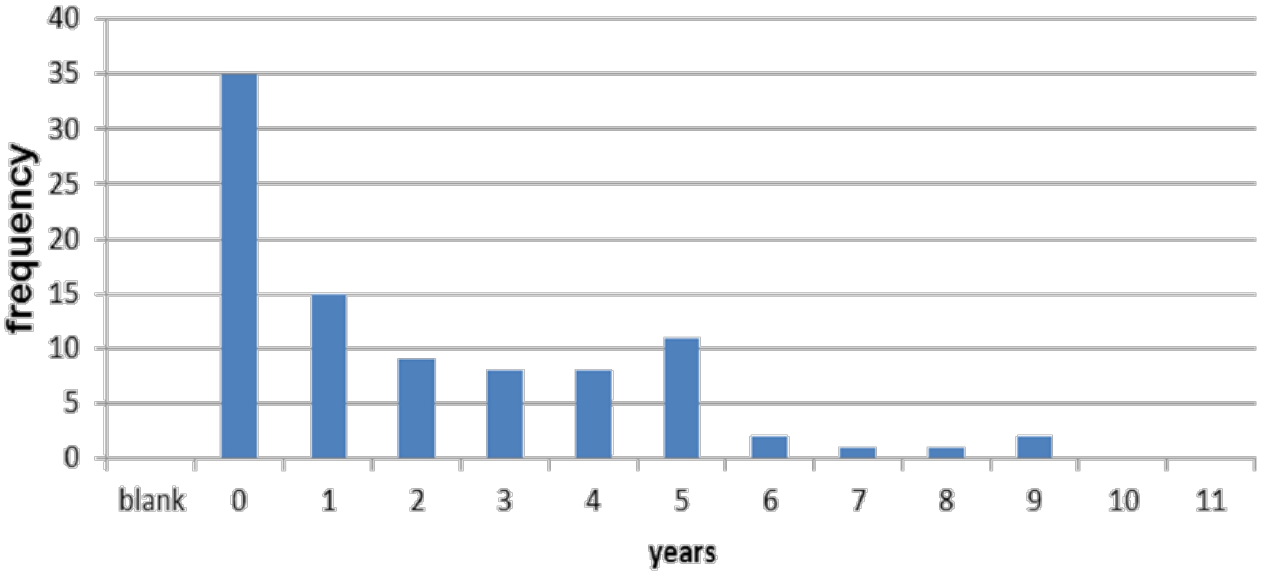
PV fire incidents collection for 10 years (until December 2012)

- Most incidents occurred during installation of first year of operation
- Probably many installation flaws
- Large fraction of electrical defects sparking a fire in general (not only PV) is to be attributed to failing electrical connections → poor contacts are predominant cause of fire!



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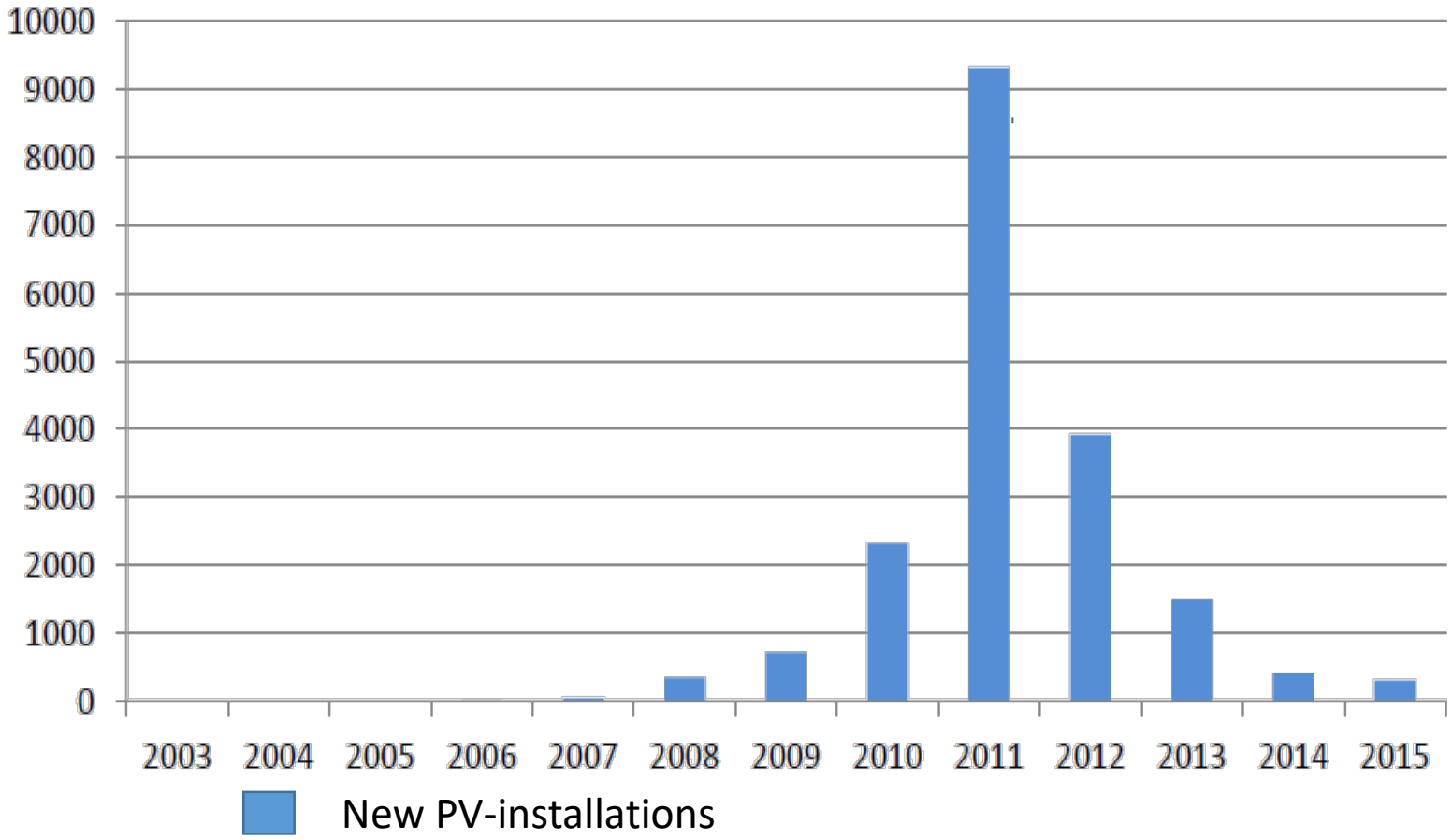
Fires in Photovoltaic Systems: Lessons Learned from Fire Investigations in Italy



Fiorentini, Luca, et al. "Issue 99: Fires in Photovoltaic Systems: Lessons Learned from Fire Investigations in Italy." *SFPE emerging TRENDS enewsletter* (2015).

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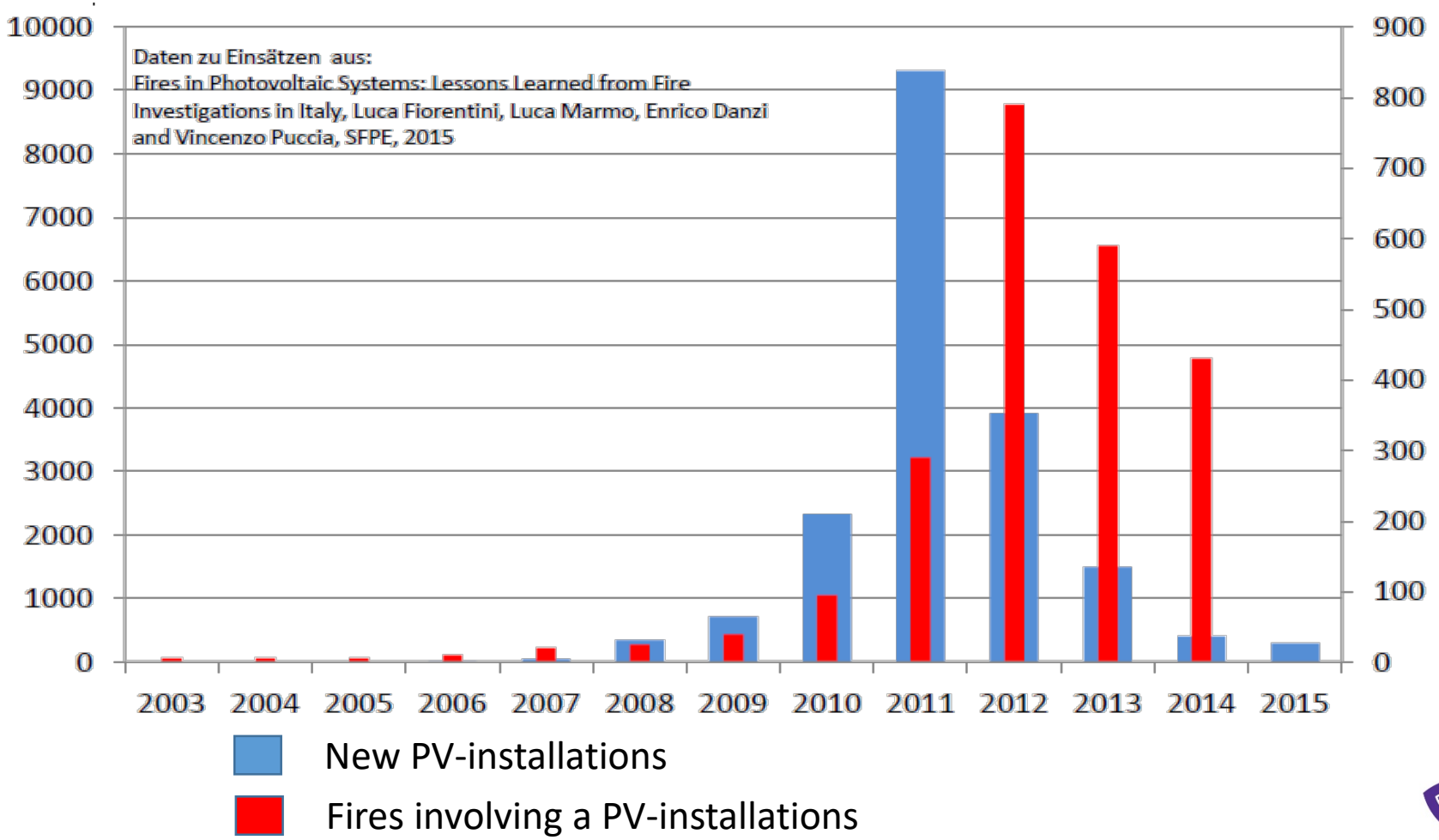
Fires in Photovoltaic Systems: Lessons Learned from Fire Investigations in Italy

Beware of too fast market growth!



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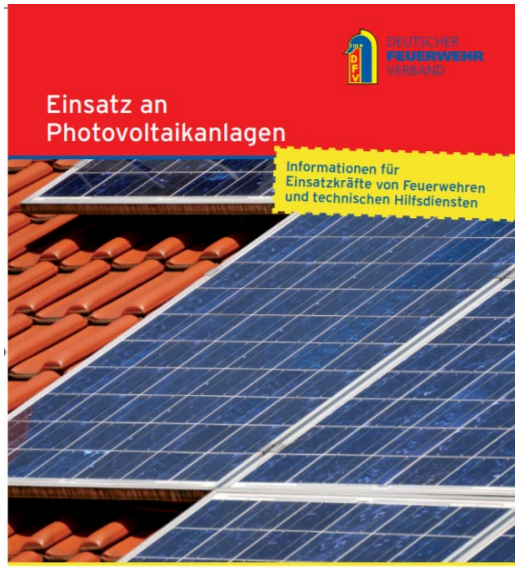
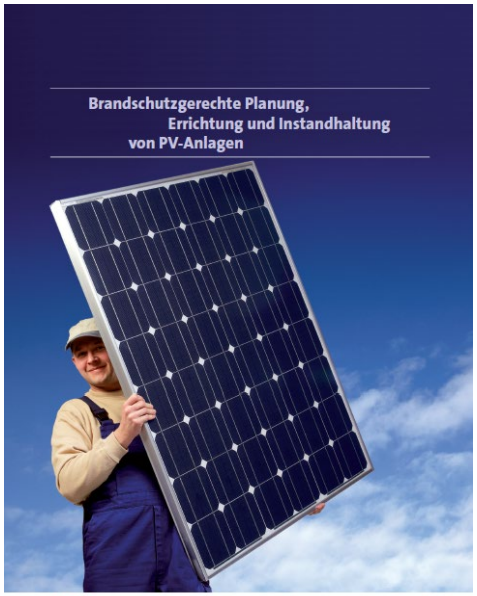
Fire of PV systems

- An undamaged PV-installation that was properly planned and maintained does not increase the fire risk more than any other electrical installation.





LEITFADEN

Bewertung des Brandrisikos in Photovoltaik-Anlagen und Erstellung von Sicherheitskonzepten zur Risikominimierung

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Fire safety concept – 4 basic rules

1. Preventing the onset of fire
2. Structural protection – preventing the spread of fire within the building and to neighboring buildings
3. Allow the rescue of people and animals
   - Information and signs for fire fighters.
   - Protection from exposed voltages in the building
4. External access for the rescue and fire brigade

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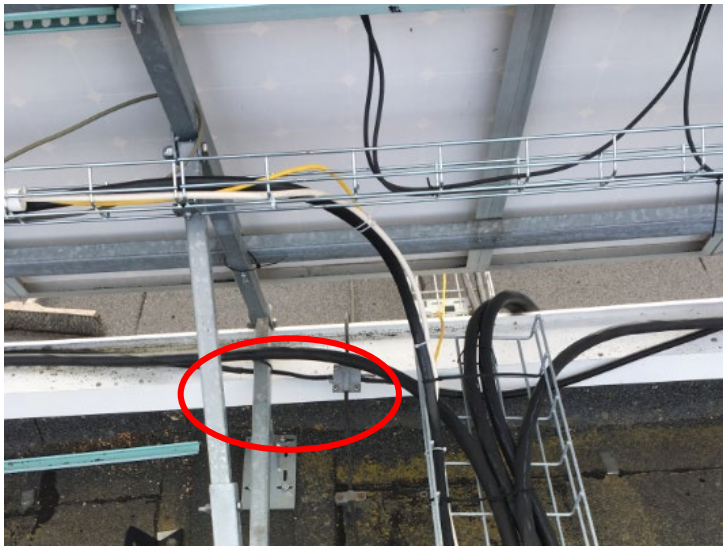
1. Preventing the onset of fire

- PV modules
  - Plan and build according to DIN VDE 0100-712
  - Avoid big induction loops
  - Consider wind and snow loads (and other loads) that can move the panels and set tension on the cables and connectors
  - Maintain and update lightning protection
    - Do not over-build!



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1. Preventing the onset of fire

- Inverters and combiner boxes
  - Do not install directly on flammable walls (e.g. wood)

    Metal plate over wood is not acceptable!

    → use e.g. a Calcium silicate plate of 15mm thick between the inverter and the flammable wall; keeping a circumferential clearance of at least 10cm around

  - Keep the immediate area clear of flammable materials
  - Avoid highly dusty places that can affect the ventilation system
  - Highly flammable materials must not be present in the room.

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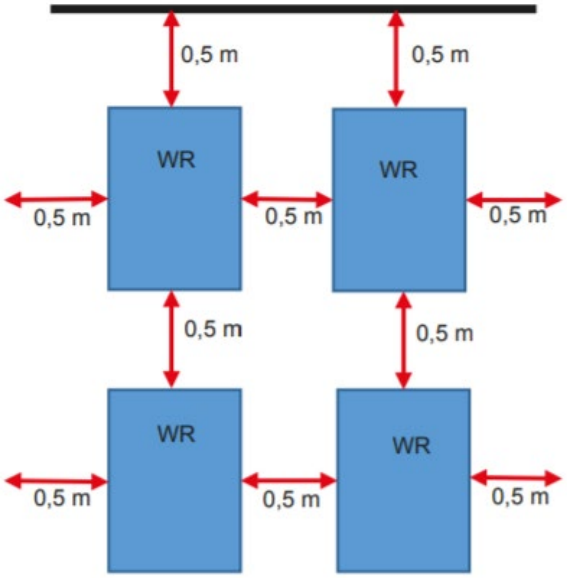
1. Preventing the onset of fire

- Inverters and combiner boxes
  - Enough space around for ventilation (follow manufacturers guidelines and Vds 3145)
  - Installation in the stairs and exit area of a single and two-family homes is to be avoided
  - Unprotected installation in stairwells of apartment buildings and auxiliary buildings is not permissible



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1. Preventing the onset of fire

- DC-cables
  - Avoid damage during installation
  - Keep bending radius
  - Use proper DC cables for PV-installations
    (UV and weather resistant → no cable is UV proof!!)
  - Cables should not be on the floor (water and snow)
  - Problems with Aluminum cables (crimping)

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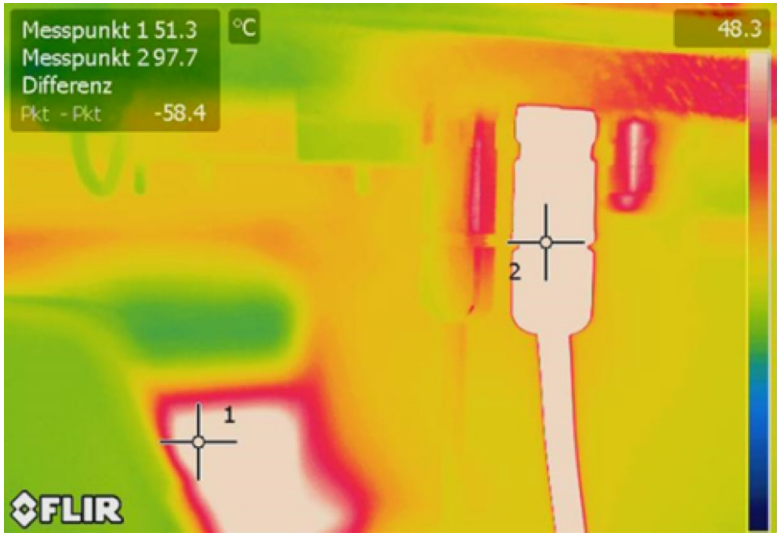
1. Preventing the onset of fire

- Connectors and switches
  - Use adequate DC-switches
  - Improper crimping or connection (lack of tool)
  - Avoid too much tension on the connector
  - Avoid mixed and incompatible connectors



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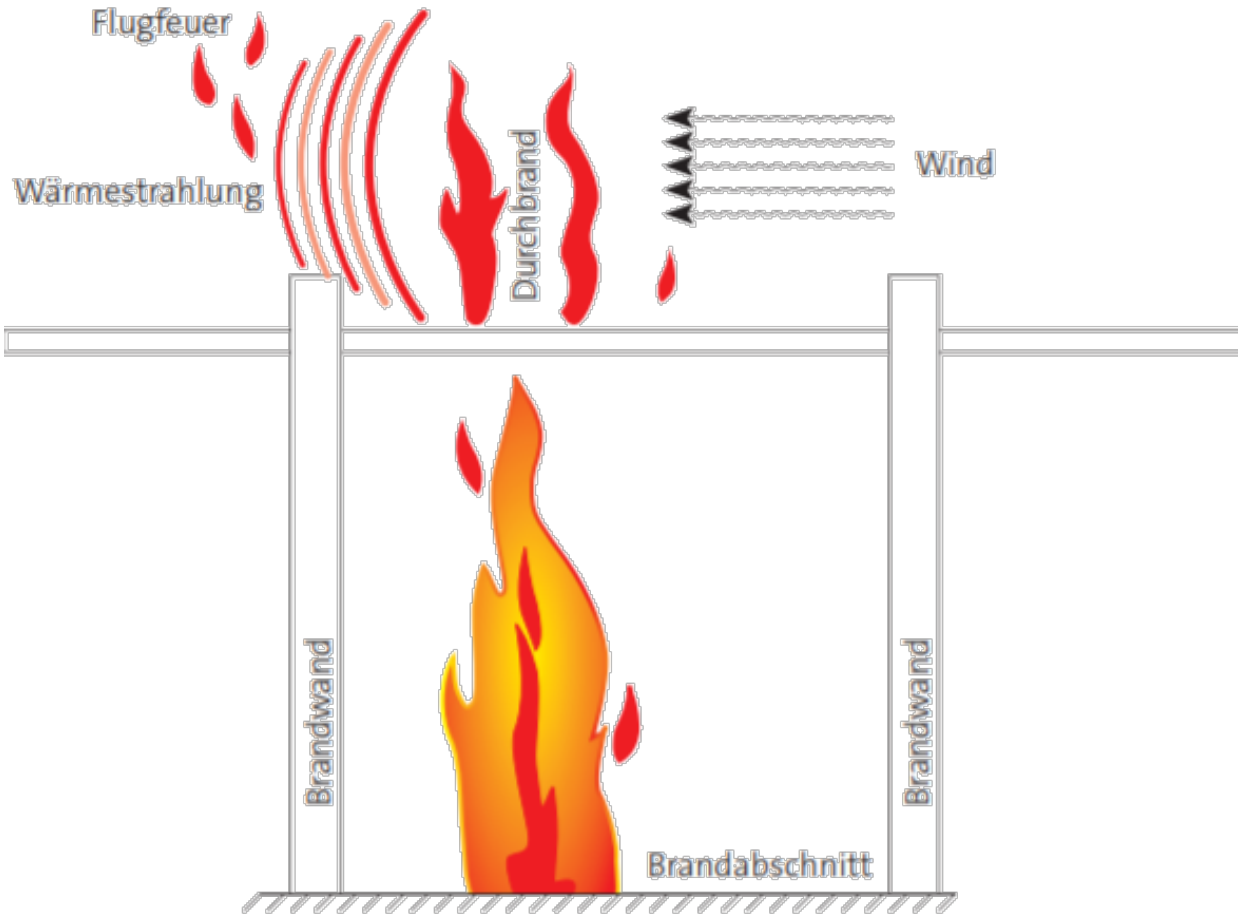
2. Structural fire protection

- The function of firewalls and building separation walls must not be diminished



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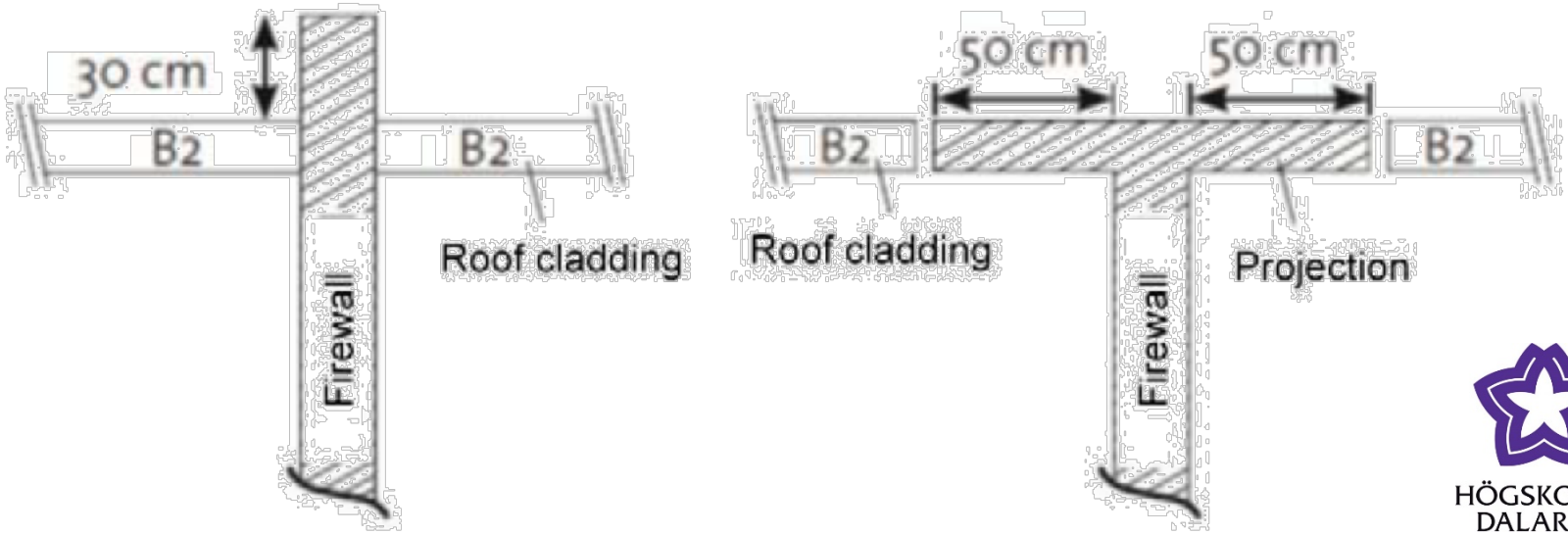
2. Structural fire protection

- Requirements form the building regulations: Characteristics of the “hard roof” (important for building integrated PV BIPV).
- As well as the use of materials with a classification of at least building material class B” “normal flammability” according to DIN 4102
- Spacing of roof structures to firewalls depends on their fire behavior
- Flammable materials should not bridge this areas



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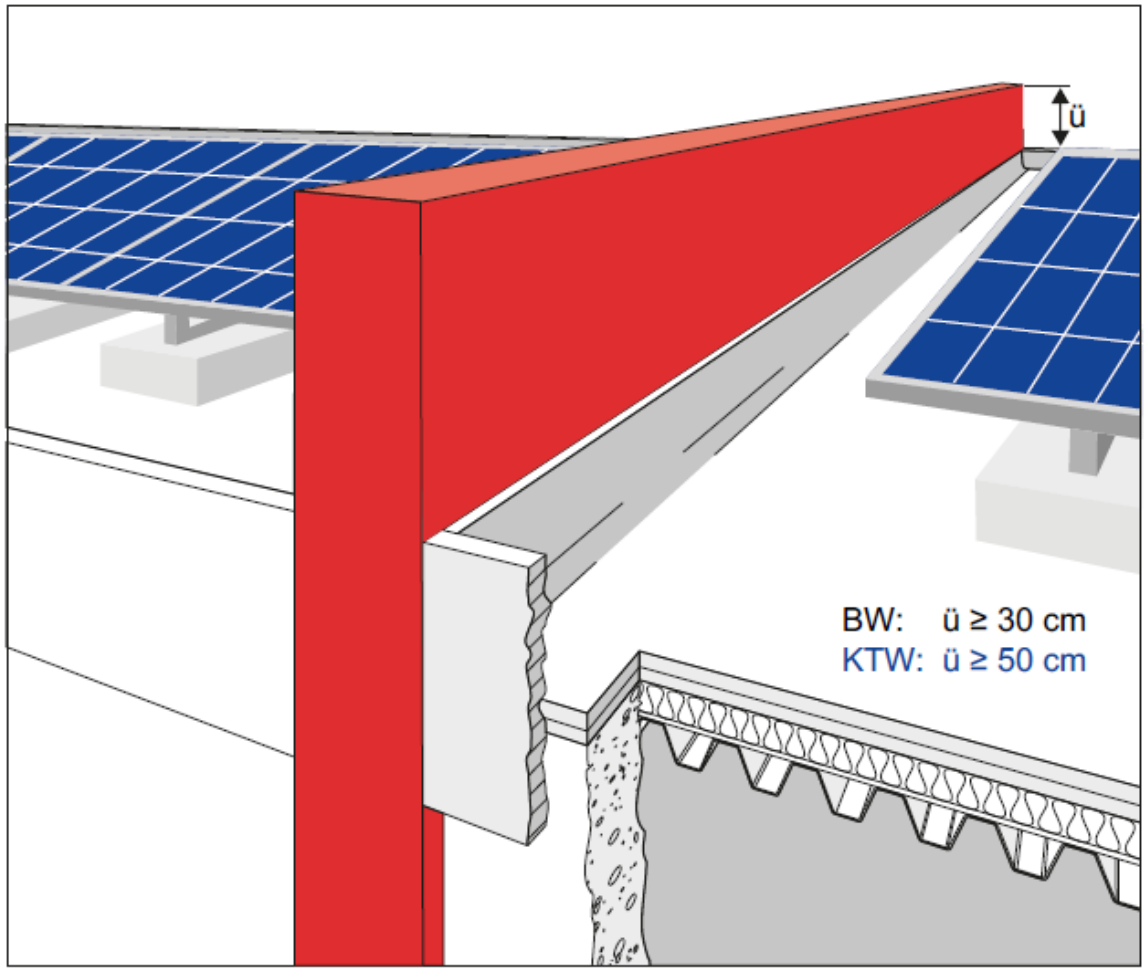
2. Structural fire protection

VdS 2234:2012 - Firewalls And Complex Partition Walls



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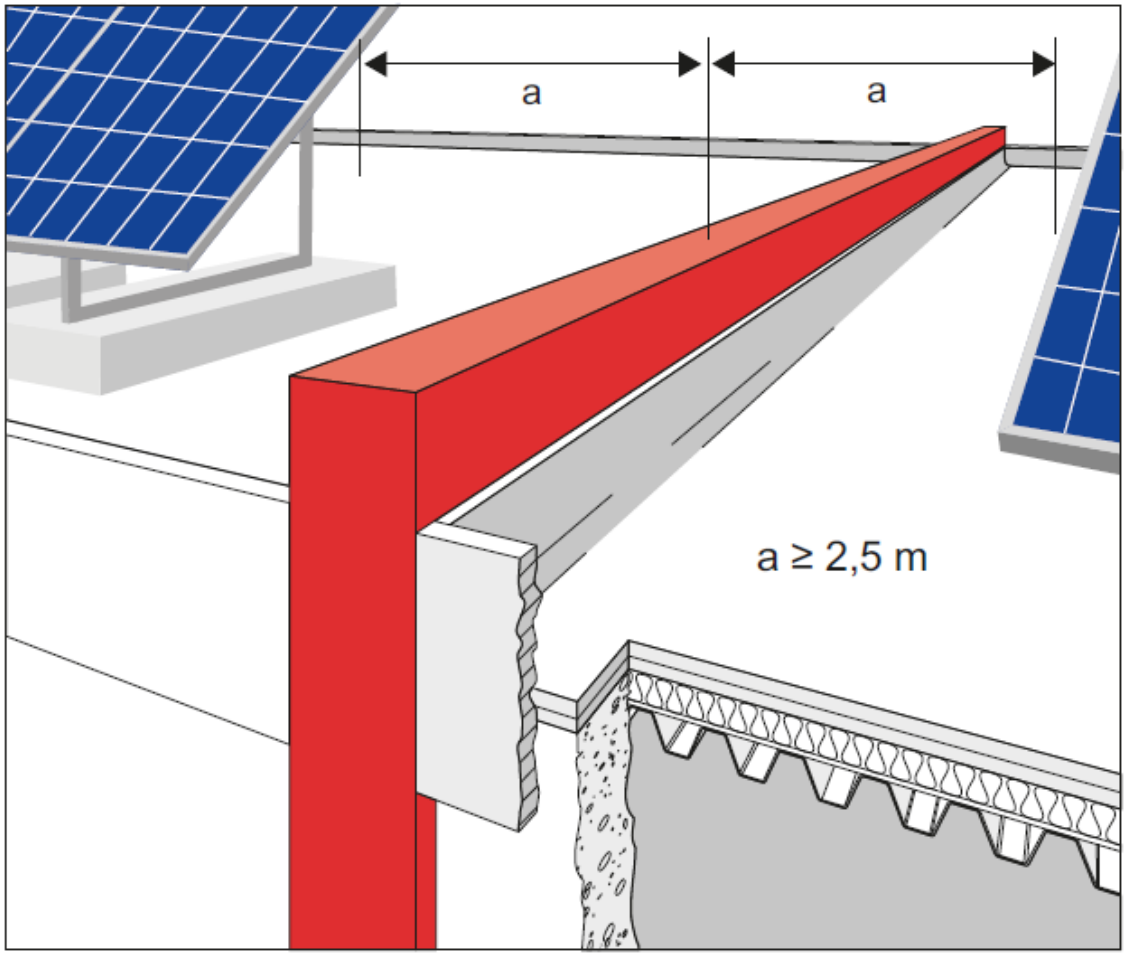

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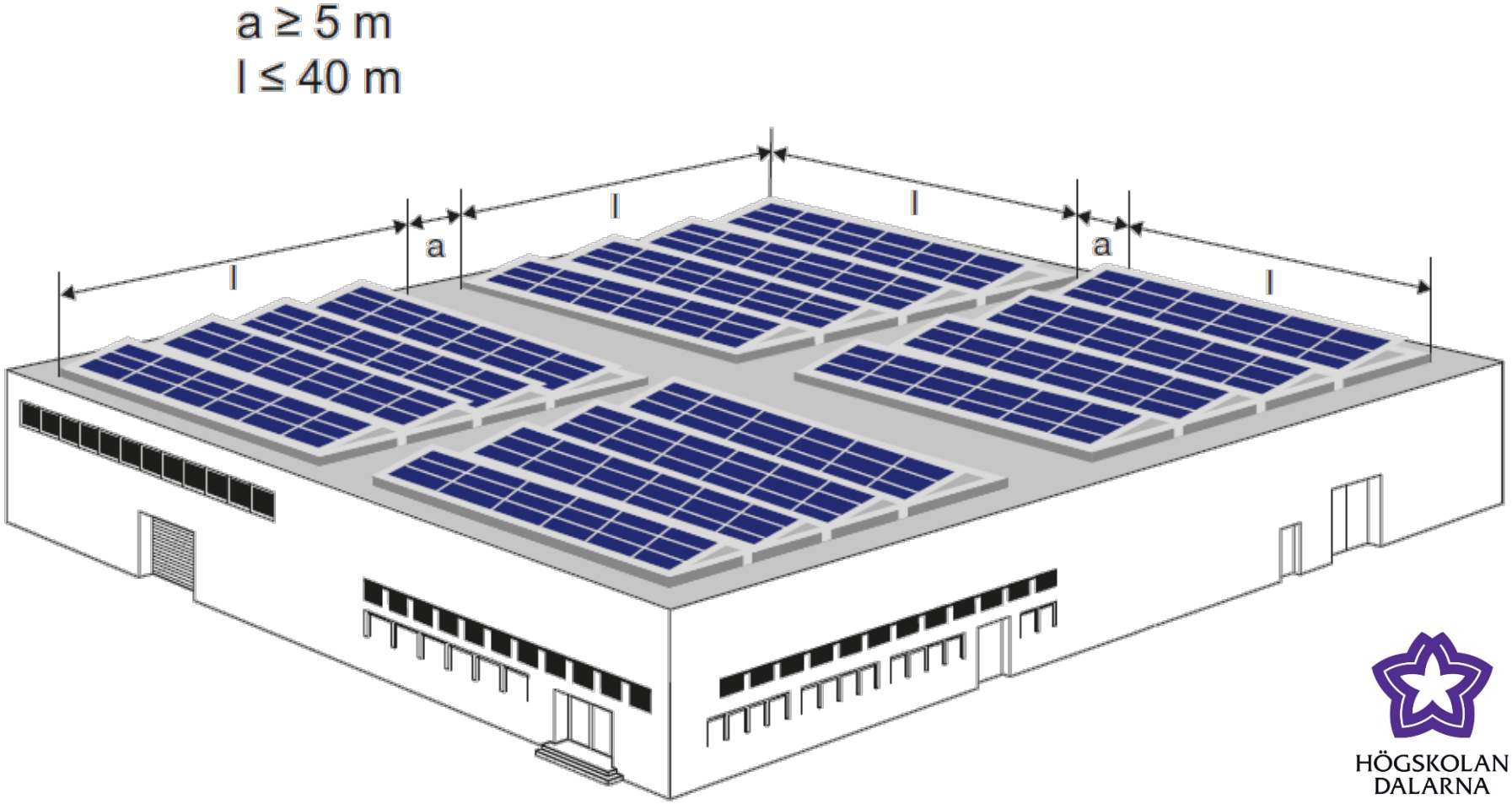

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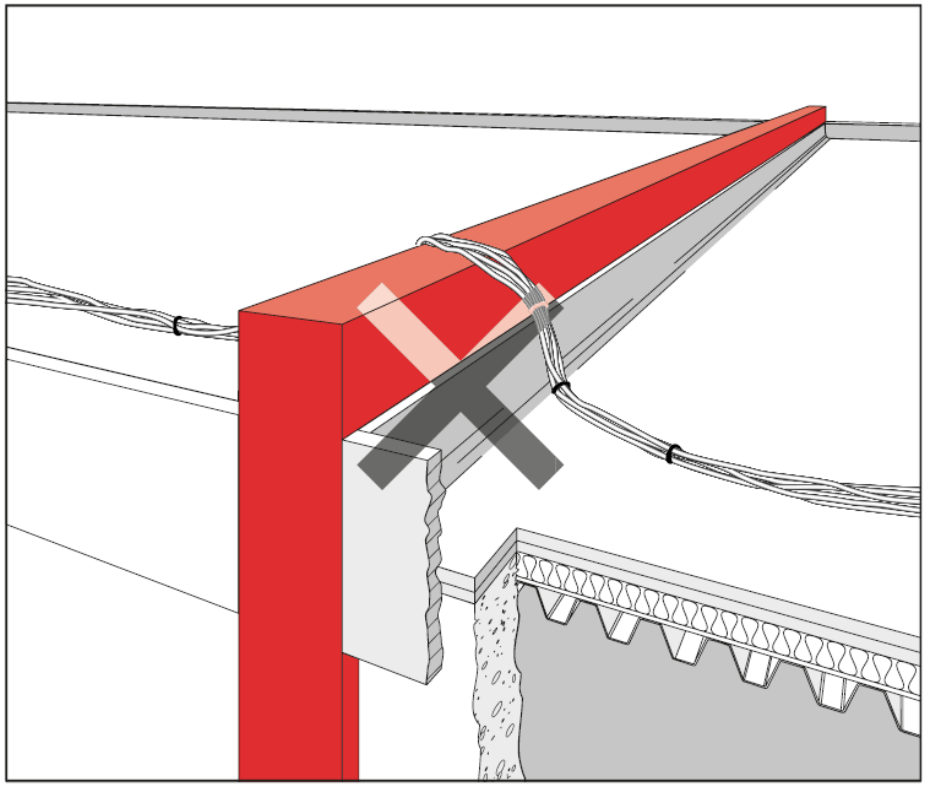
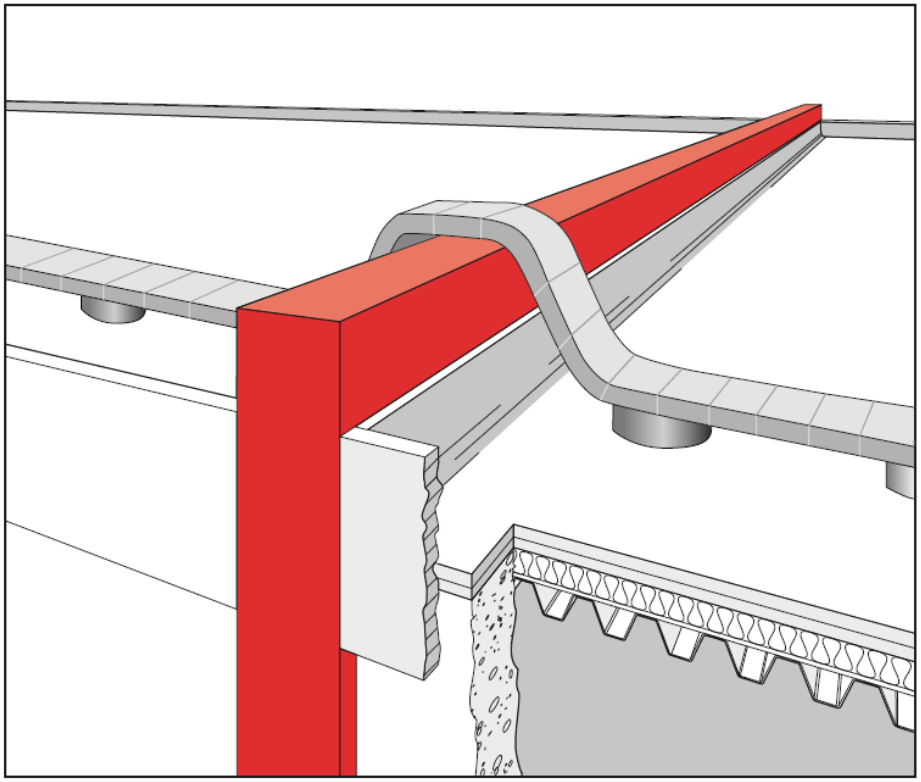
2. Structural fire protection

VdS 2234:2012 - Firewalls And Complex Partition Walls

- It should have at least the same fire-resistance class
- Should be weather and UV-resistant

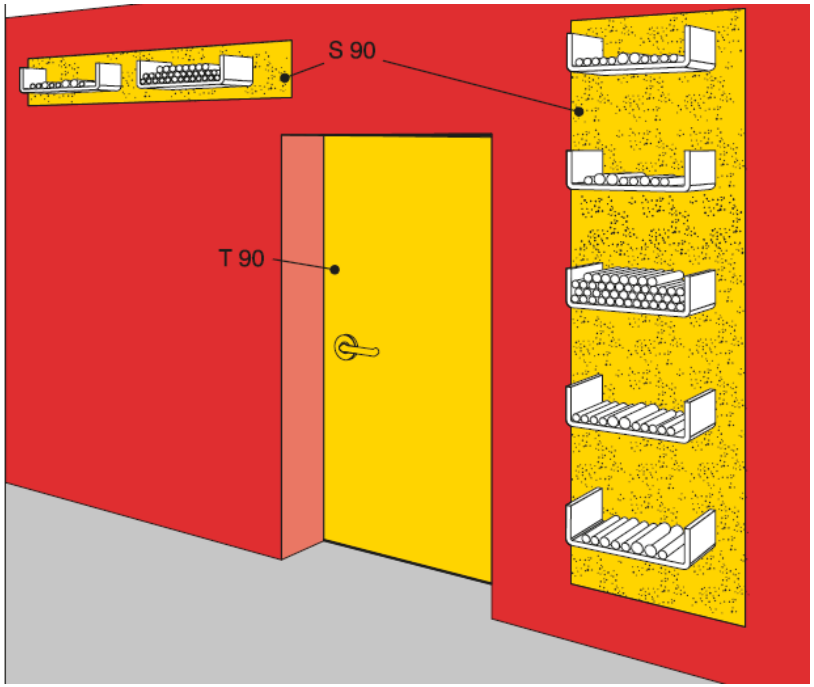


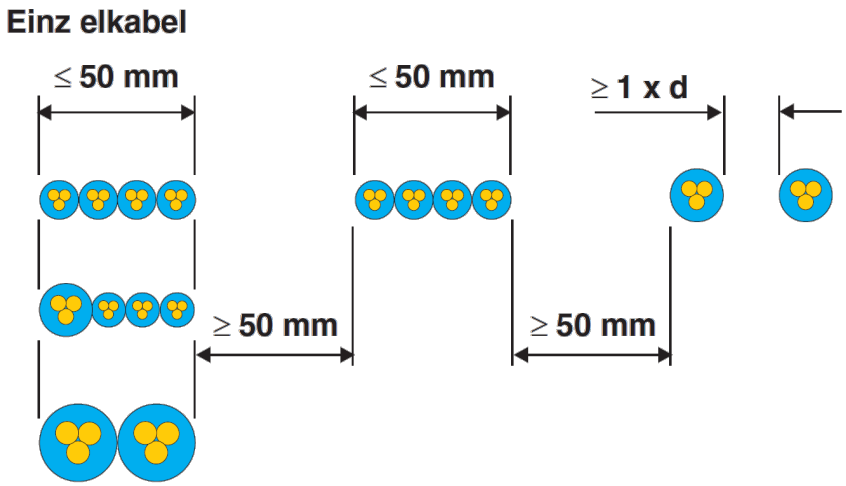


2. Structural fire protection

VdS 2234:2012 & MLAR

- Sealing of fire walls penetrations after cable installations





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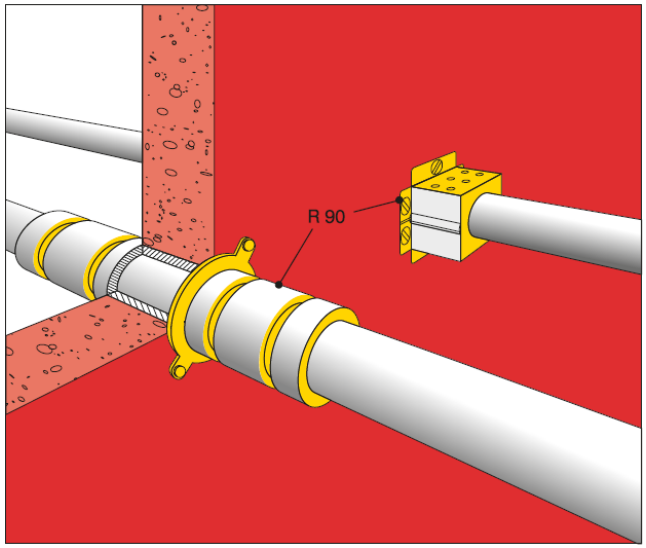
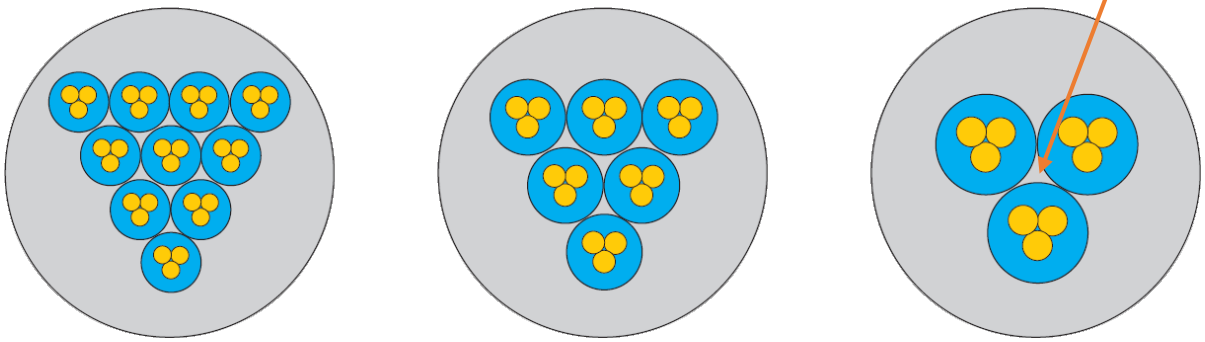
2. Structural fire protection

VdS 2234:2012 & MLAR



- Max 60% of the channel should be filled with the cable bund
- The rest has to be re-sealed to at least the same fire-resistance class



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2. Structural fire protection

- Do not cover heat and smoke vents
- Enough space should be left for maintenance and use in case of fire
- Important to take into account since the planning

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3. Protection from exposed voltages in the building

Organizational measures

- Warning sign in the house junction box
- Cabling plan for the fire brigade
- Update of the fire fighting plan

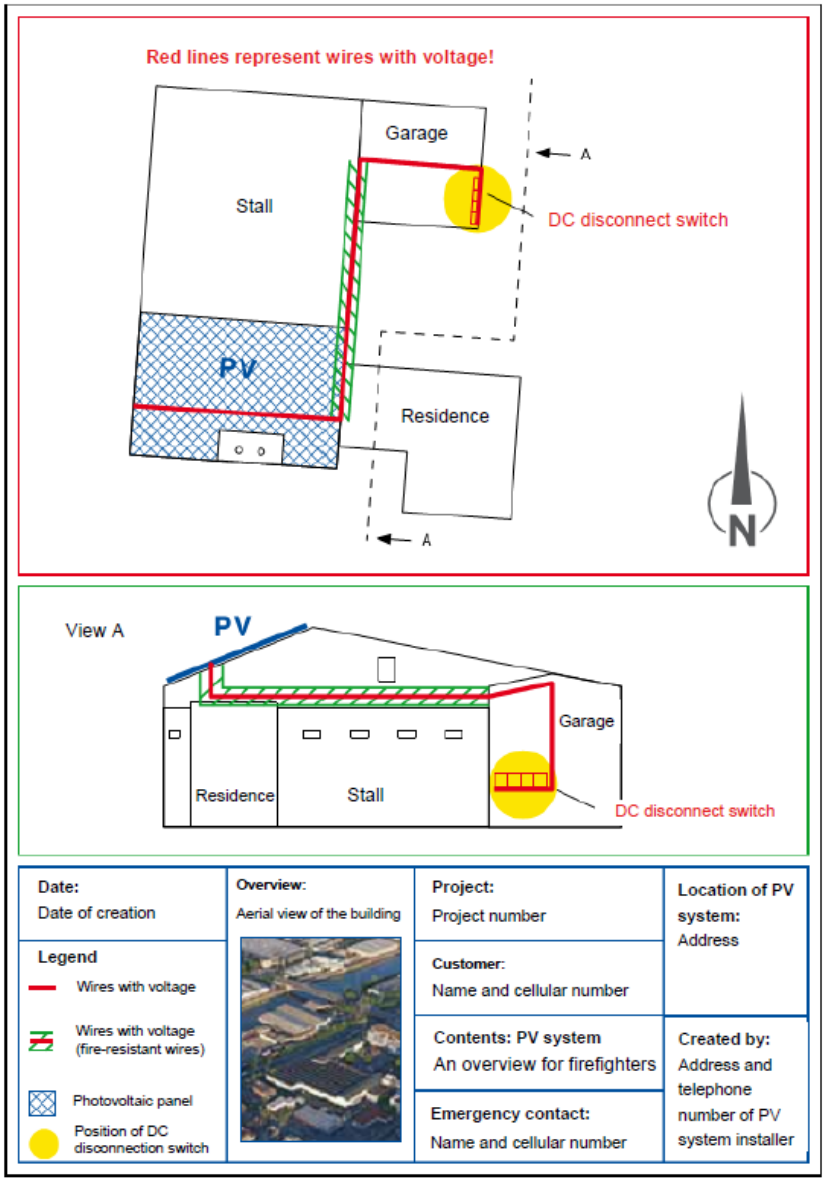
and construction measures

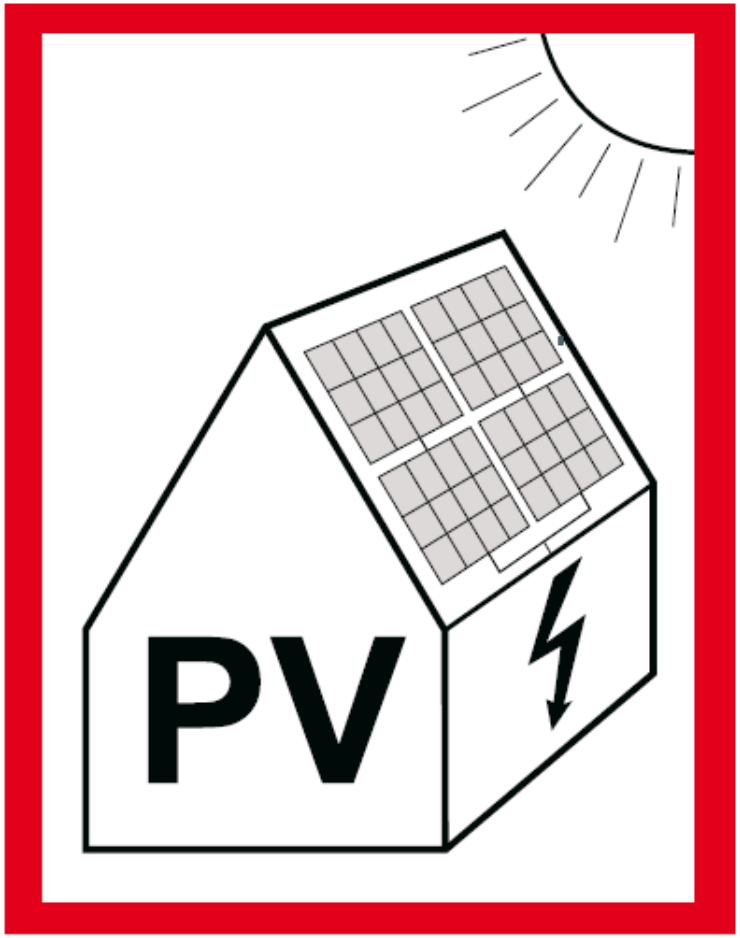
- Installation of DC-cables in fire-resistant ducts/channels
- Installation of DC-cables outside of the building (leaving only AC lines inside the building)
- Inverter and junction box outside of building or right at the entrance (IP class, weather/UV/direct sun protection

or technical measures

- Low voltage installation (<120 V, very unrealistic with PV)
- DC isolation switch:
  - Long-term reliability
  - Fail-safe behavior
  - Secured against restarting
  - Actuator on the house connection
  - Identification of the switch and its state
  - Risk of false “sense of safety”

3. Protection from exposed voltages in the building





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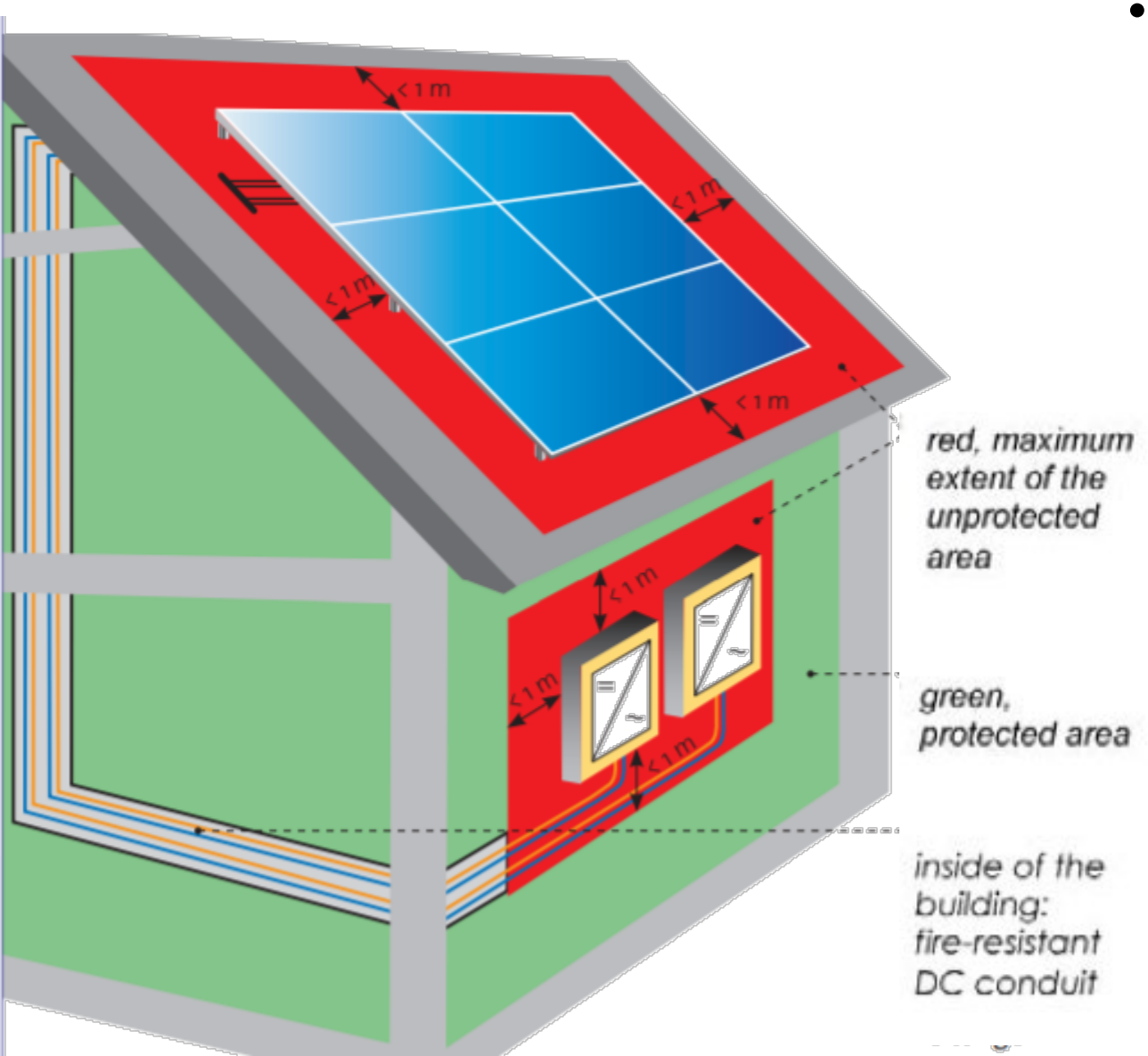
3. Protection from exposed voltages in the building

- Non-disconnectable DC-lines within a building longer than 1m should be installed within fire protection channel



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4. External access for the fire brigade

Emergency workers must have access to fire source

- Inside attack: Protection against exposed conductors inside the building
- Outside attack: Access to roof

- Escape routes
  - serve primarily as possibilities of escape and rescue
  - serve additionally as access routes for emergency workers
- Observe minimum requirements for access and clearance
  - Allow 1 meter safety clearance from electrically conductive components (in accordance with DIN VDE 0132)
  - e.g. size of "fire escape window": clearance width 90 cm and clearance height 120 cm

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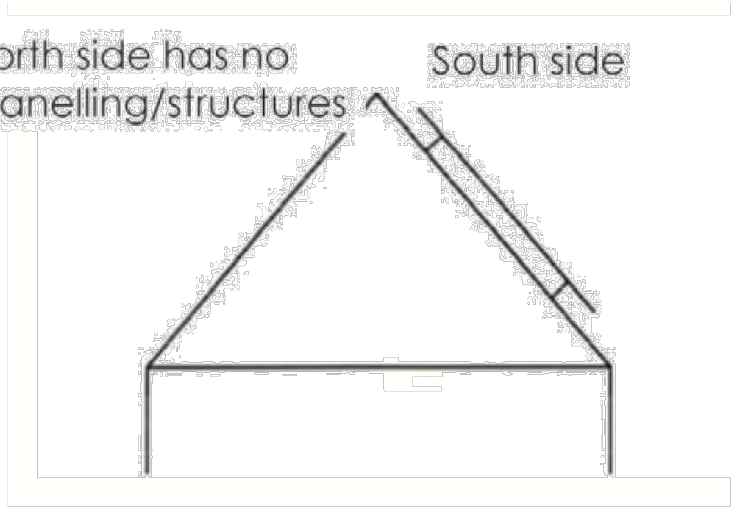
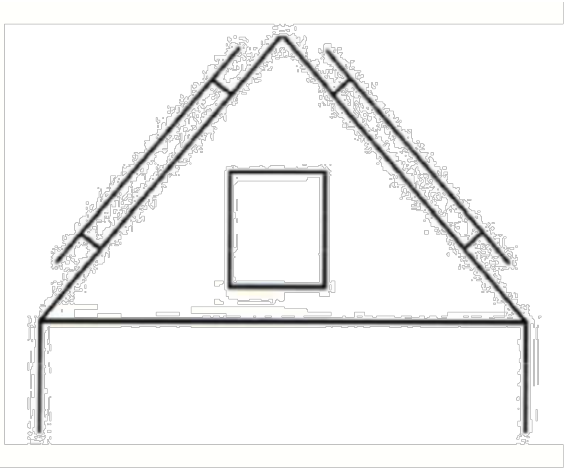
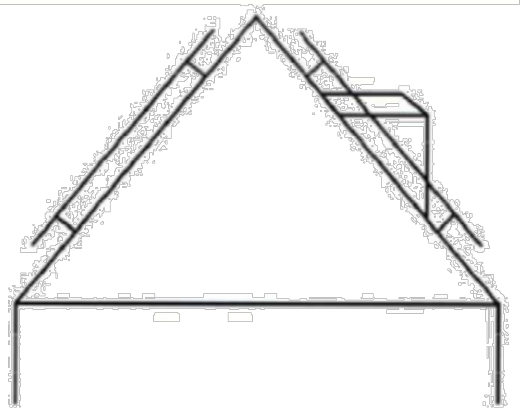
4. External access for the fire brigade



Go over the north side of the roof



Go over the front side "required window"



Go over the dormer

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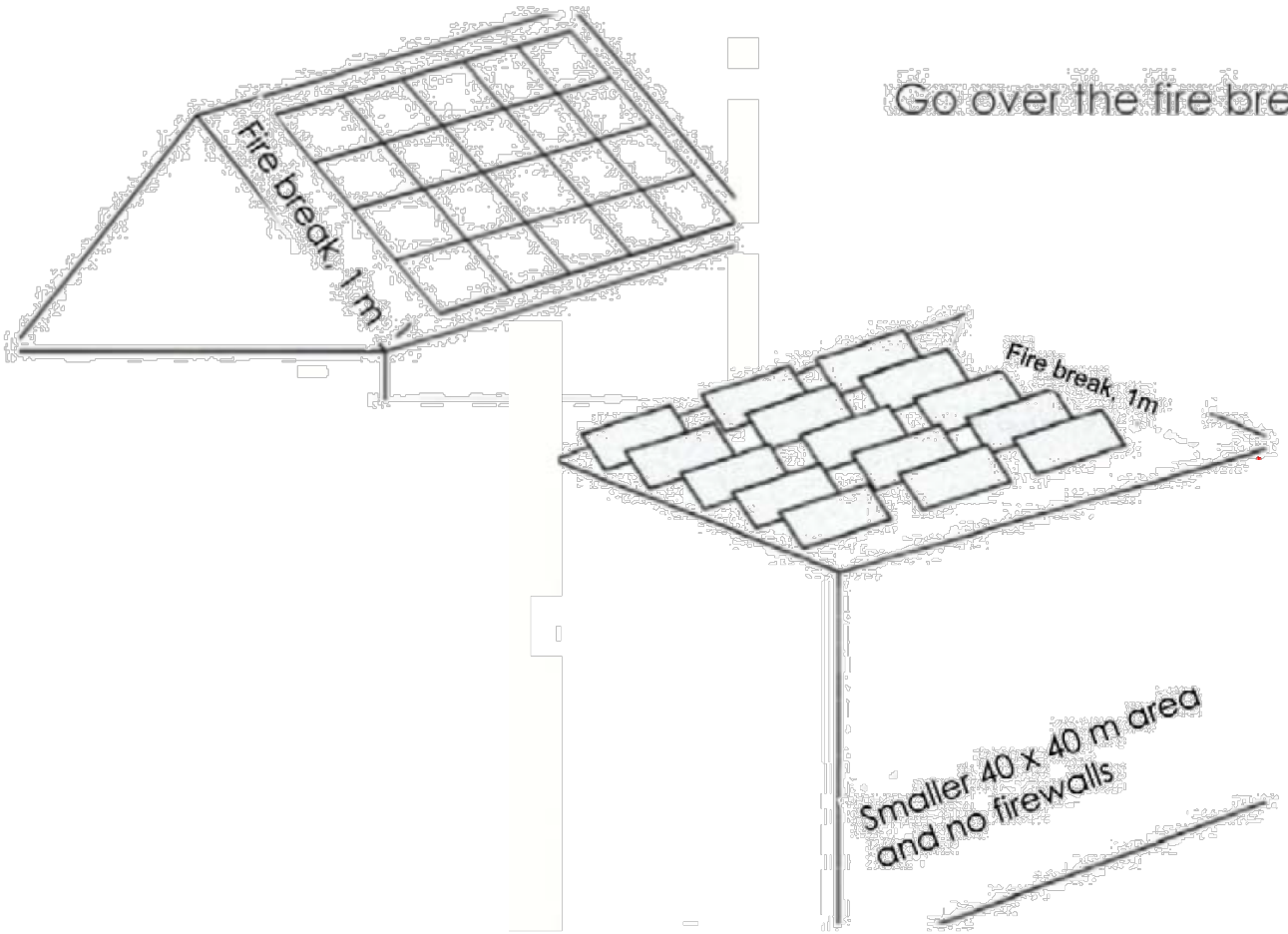
4. External access for the fire brigade

Panelling/structures on both sides of the roof with no other access option



Go over the fire break

Flat roof or mono-pitch roof without access options via windows, etc.

Go over the fire break

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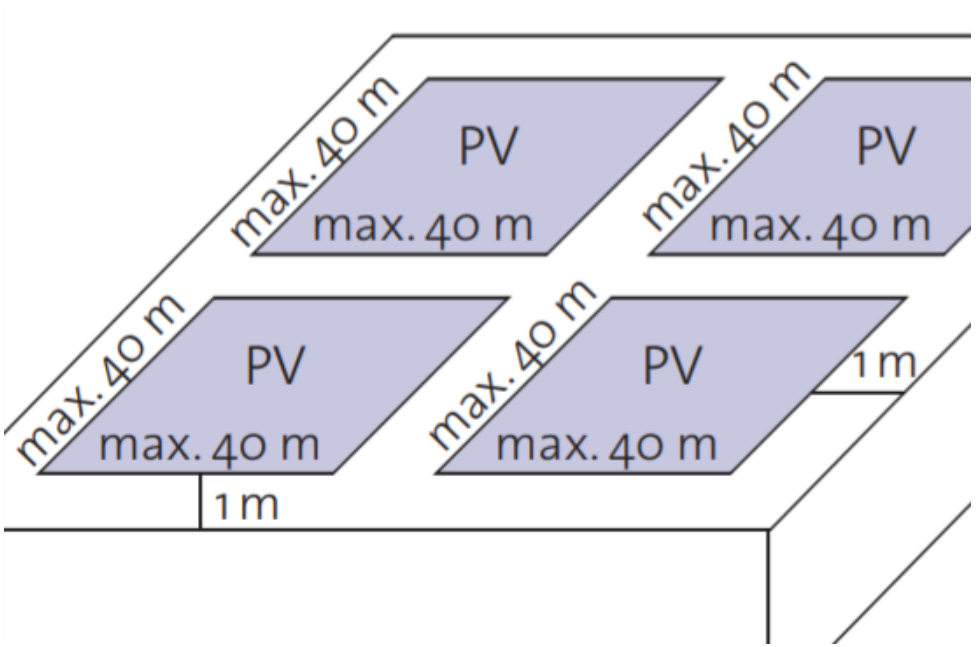
4. External access for the fire brigade

- For larger flat roofs, there should be an access point for each fire compartment (usually 40x40m) around the PV-generators. Route passage widths should not be narrower than 1m.



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Jet pipe clearance (DIN 14365-CM)

Jet pipe DIN 14365-CM	Low voltage (N) ≤ AC 1.0 kV ≤ DC 1.5 kV	High voltage (H) > AC 1.0 kV > DC 1.5 kV
Spray jet Full jet	1 m 5 m	5 m 10 m
Abbreviation	N-1-5	H-5-10

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Thank you for your attention!

Sources:

- PV-Brandschutz Webseite und Leitfaden/Kochbuch “Bewertung des Brandrisikos in PV Anlagen” www.pv-brandsicherheit.de
- DGS Leitfaden: http://www.dgs.de/fileadmin/bilder/Dokumente/PV-Brandschutz_DRUCK_24_02_2011.pdf
- BSW Merkblatt für Planer und Installateure “Lichtbogenrisiken an PV Anlagen reduzieren” www.solarwirtschaft.de
- VdS 3145 – Photovoltaikanlagen
- VdS 2234 - Brand- und Komplextrennwände, Merkblatt für die Anordnung und Ausführung
- VDE-AR-E 2100-712:2013-05 Measures for the DC range of a PV installation for the maintenance of safety in the case of firefighting or technical assistance
- DIN 4102
- § 30 MBO (Musterbauordnung) – Brandwände
- § 30 MBO (Musterbauordnung) – Dächer
- Muster-Leitungsanlagen-Richtlinie (MLAR)

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