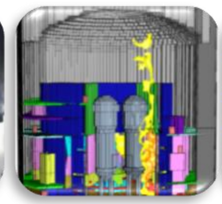

SMART GRIDS AND PV IN BUILDINGS: IMPACTS IN TERMS OF FIRE SAFETY

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CONTEXT

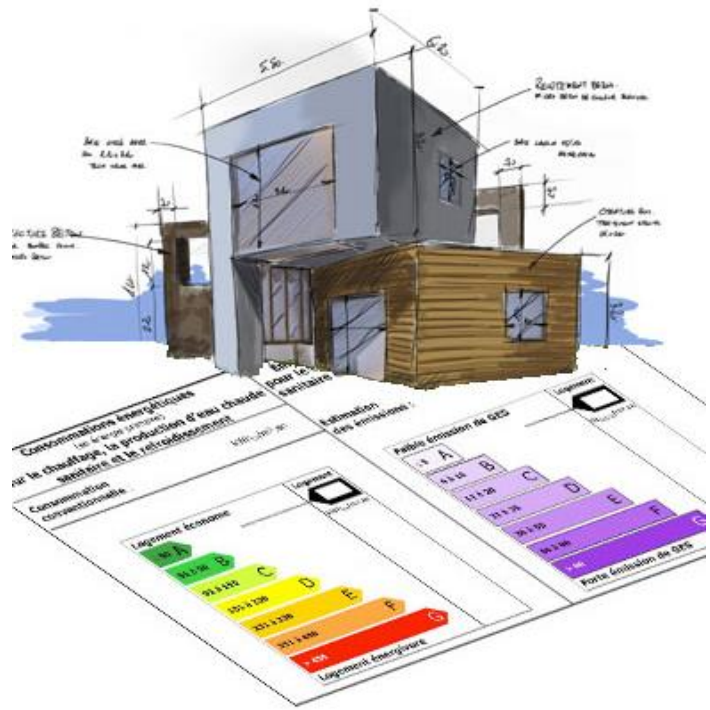
Building sector represents 40% of the total energy used in European Union

- Reduction of energy needs in buildings
  - European directive 2010/31/EC on energy savings in building
  - National regulations, i.e. French Thermal regulation RT2020
- Slow renewal of housing/building stock
- Need to improve thermal performances of existing buildings

CONTEXT – EXTERNAL THERMAL INSULATION OF BUILDINGS

There is a need to increase thermal performances of new and existing building

- Solutions include a better insulation, energy savings and production, auto-consumption, etc



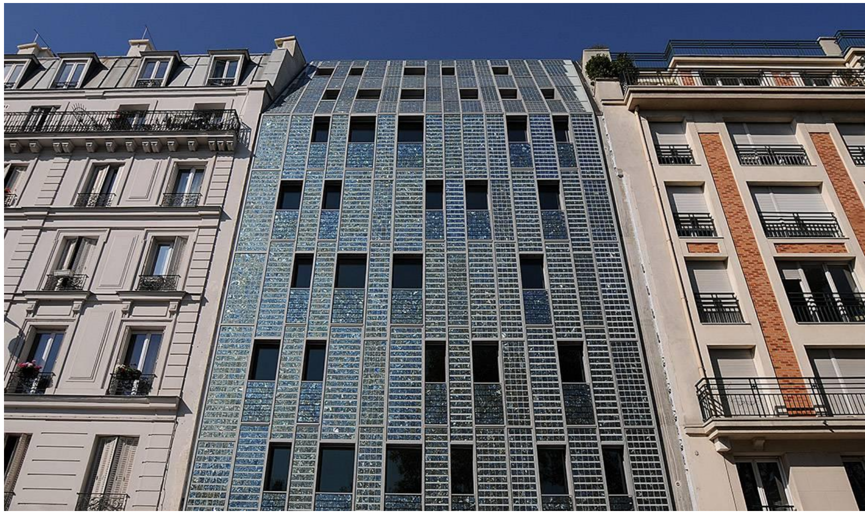
CONTEXT - ARCHITECTURE

- ❑ Architects develop more and more complex systems:
  - Curtain façades, glazed façades
  - Nonplanar façades
  - Decorative panels, e.g. on balconies

CONTEXT - NEW PRODUCTS AND NEW FUNCTIONS

- ❑ Zero-energy buildings:
  - PV panels on facade (BAPV) and as facade (BIPV)
  - Other functionalities added

- ❑ Carbon footprint reduction
  - Wood construction
  - Biobased products, e.g. insulation
  - Vegetalized facades



BIPV facade, Paris

Quai Branly Museum, Paris

PV PANELS

DEFINITIONS

- Photovoltaic (PV) modules and systems are yet covered by a series of European harmonized standards established jointly between CEN and CENELEC, known as EN 50583 parts 1 and 2

- BIPV (Building Integrated Photovoltaic modules)

- BAPV (Building Attached photovoltaic module)

BIPV tiles on a roof

BIPV

- BIPV are defined as providing a function in a building as defined in the European Construction Product Regulation.

- The BIPV modules must be able to perform one or more of the following functions:
  - mechanical rigidity and structural integrity;
  - primary weather impact protection: rain, snow, wind, hail;
  - energy economy, such as shading, daylighting, thermal insulation;
  - fire protection;
  - noise protection.

- BIPV take parts for the integrity of the building's functionality. If an integrated PV module is dismounted, it would have to be replaced by an appropriate building component.

BAPV

- BAPV are defined as when the PV modules are mounted on a building envelope and do not fulfil the criteria of a BIPV for building integration.
- The integrity of the building functionality is independent of the existence of a building-attached photovoltaic module.

BAPV module on tile roof

PV panels

IGNITION SCENARIOS AND PHENOMENOLOGY

IGNITION SCENARIOS

- Causes of electrical fire ignition: overload and short circuit
  - Quality of mounting – qualification of installers
  - Mitigated by respect of national electric codes

- Internal sources to PV components and systems
  - Arcing
  - Hot spots. A hot spot on a PV module produces localized heating on the back sheet of the module that could ignite and start a fire.
  - PV cell misalignment or the used of reverse currents in a module (both called mismatch) are responsible for another mechanism of fire ignition.
  - Lack or bad connection among modules, strings (a series connection of two or more modules) and inverter could generate enough heat that could start a fire.

- External sources (PV modules promotes the fire spread or the fire risk).
  - Include classical building fires such fire from windows, through facades and roofs, but also external ones such fires from adjacent buildings, fires from wildland areas, etc.
  - Ignition can be caused by direct flame impact, heat transmission across materials, etc.
  - Ignition can occur from radiation, combination of convection and radiation or firebrands.

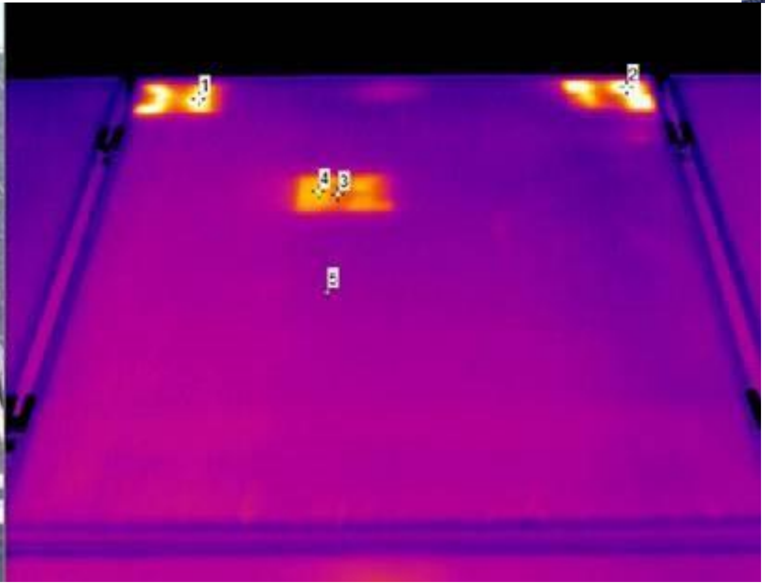
- Indirect risks: DC dwelling electrical network, ESS (batteries)

IGNITION SCENARIOS - HOT SPOTS

Damage to the module can cause internal cracks that are not easily visible. Microcracks can lead to hotspots in the cell, which then may lead to fires. The cracks are points of high resistance in the cell and can lead to hot spots.

Cracks and microcracks in the cell can be caused by:

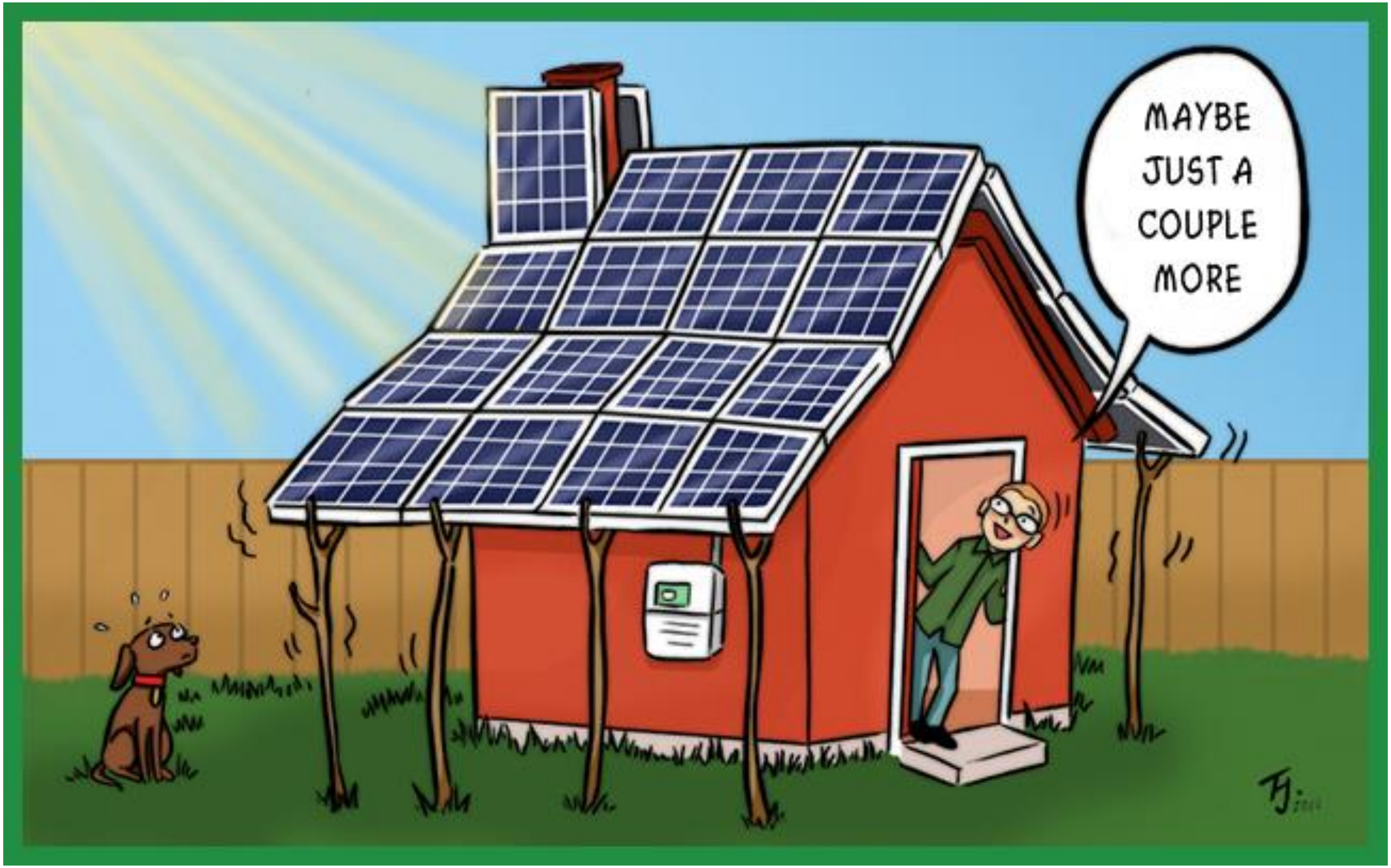
- Smashed module (e.g. golf ball, hail)
- Earthing lugs installed against backsheet causing abrasion
- People walking on modules/improper transport
- Improper cleaning



IGNITION SCENARIOS - INSTALLATION

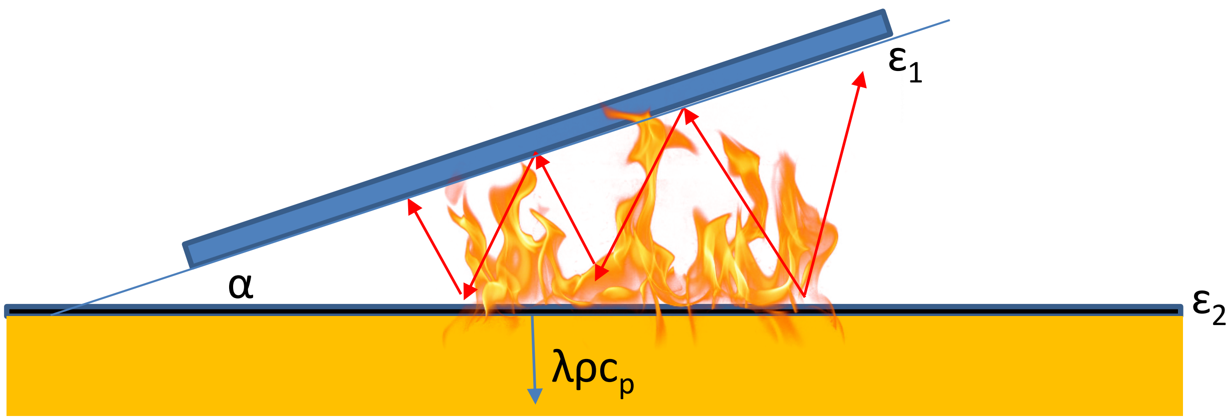
- ❑ Earthing lugs
- ❑ Improper connectors
- ❑ DC cables pinched
- ❑ Improper installation of connector boxes

QUALITY OF MOUNTING



AFTER IGNITION - PARAMETERS GOVERNING FIRE GROWTH

- ❑ Geometry of cavity, e.g width, slope, closing cavities
- ❑ Nature of materials in both sides (roof and panel) in terms of:
  - emissivity,
  - heat transfer,
  - ignitability
- ❑ External conditions, e.g. wind, inital temperature



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TESTING - MODULES

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PERFORMANCE REQUIREMENTS – MODULES – IEC/EN 61730-1

- The modules may have to comply to IEC/EN 61730-2. In this standard, the fire test MST23 could be performed only if requested by the manufacturer of the PV modules.

- The MST 23 test is carried out according to the ANSI/UL 790 standard, and the fire performance classification of PV module ranges from Class C – "fundamental fire rating", to Class B or Class A – "highest fire rating". The standard also requires a minimum fire resistance rating of Class C for any building-mounted module.

- Furthermore, UL 790 Standard addresses two fire protection concerns: flame spread along the roof and fire penetration.

- The EN 61730-2 standard also states that the MST 23 test specifies fundamental requirements and may not be sufficient to satisfy the needs for a module intended for building applications according to local or national building fire code requirements.

PERFORMANCE REQUIREMENTS - MODULES - IEC/EN 61730-1

- ❑ MST 21 Temperature test ANSI/UL 1703:2015
- ❑ MST 22 Hot-spot endurance test – MQT 09
- ❑ MST 23 Fire test – ANSI/UL 790
- ❑ MST 24 Ignitability test ISO 11925-2
- ❑ MST 25 Bypass diode thermal test – MQT 18
- ❑ MST 26 Reverse current overload test ANSI/UL 1703:2015

TESTING - PRODUCTS

PERFORMANCE REQUIREMENTS - PRODUCTS

- EN 50583 series refers to the EN13501-1 standard, having a minimum requirement of Euroclass E
  - Category C façade PV elements as defined in EN 50583-2 should be performed according to EN 13501-2 and EN 13501-5
  - Category D requires only EN 13501-2 Fire classification.

- For PV flexible plastic and rubber sheets, the fire performance could require B_{roof} classification according to EN TS 1187 and EN 13501-5 (testing options T1, T2, T3 or T4 depend to the national requirements).

- BIPV glass in façade: both the IEC certification for PV products and the certification in accordance with the EN 14449, which covers both fire resistance according to EN 13501-2 and reaction-to-fire E class according to EN 13501-1.

- Other provisions may be included in local or national building fire code requirements.

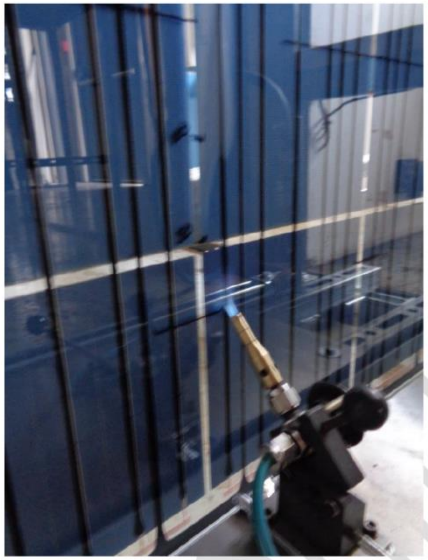
TESTS - EXAMPLES

- CLC/TR 50670
- Normally on dummy inert roof
- May be also used to check at the interaction betwen roof complex and PV module

TESTS - EXAMPLES

- EN ISO 11925-2 and EN 13823 (Euroclass) tests
- Requested in France through Certisolis for modules certification

certisolis
TEST - CERTIFICATION PHOTOVOLTAÏQUE



EXAMPLES - FRENCH PROTOCOL

- B_{roof} T3 (EN TS 1187): firebrands + radiation + wind

EXAMPLES - BIPV FACADE

- BS 8414-2 test

SOME OTHER CONCERNS

SMART GRIDS

- PV panels or any other intermittent source requests other components:
  - DC network – new risks of ignition
  - BESS = big battery
  - Direct use or converters DC→AC

- Promotion of self-use of energy

BESS fire test failure

ANY QUESTIONS?