



Storage Batteries

Fisuel Seminar – 07-08 of October 2026

Rome - Italy

Abundant, often surplus, generation

French Case:

92.3 TWh

exported in 2025: all-time record
(17% of generation)

≈ 95%

low-carbon electricity (nuclear,
hydro, wind, solar)

~ 6 %

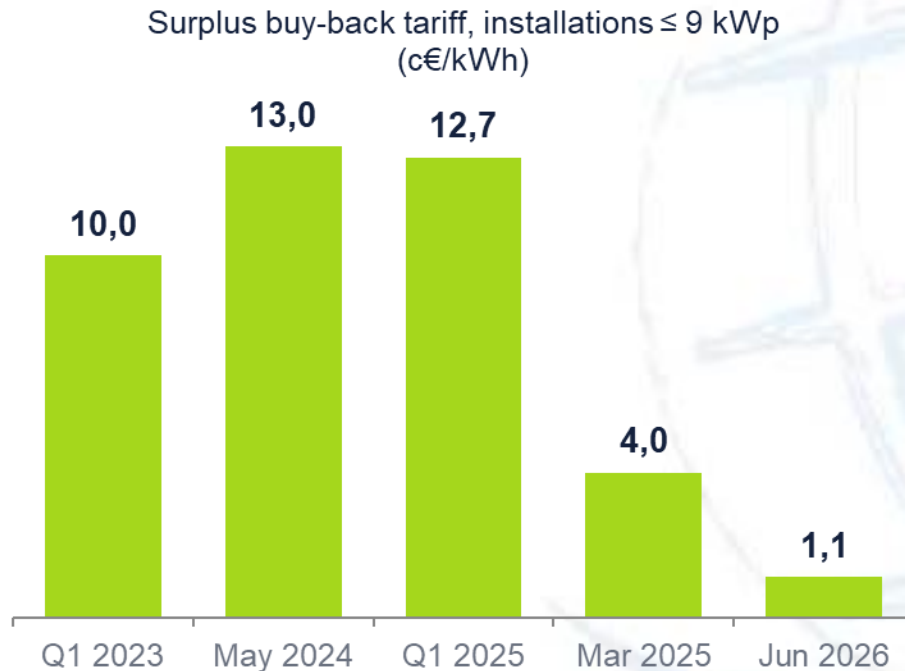
lower consumption than pre-crisis
levels

Hours with negative spot prices in France



Sources: RTE, 2025 Electricity Report and H1 2026 Report.

Falling buy-back price per kWh



× 18

A self-consumed kWh (20 c€ saved) is worth about 18 times a kWh sold (1.1 c€)

- € Order of 1 June 2026: single tariff of 1.1 c€/kWh up to 100 kWp
- € Self-consumption bonus abolished
- € Quarterly CRE revisions discontinued

Sources: CRE / photovoltaïque.info (S21 tariffs); orders of 26 March 2025 and 1 June 2026; EDF Blue Tariff base 6 kVA as of 1 August 2026.

Consequence: from selling to self-consumption



Yesterday: generate to sell

- Attractive buy-back tariff guaranteed for 20 years
- Surplus fed into the grid without constraint
- Profitability driven by sales

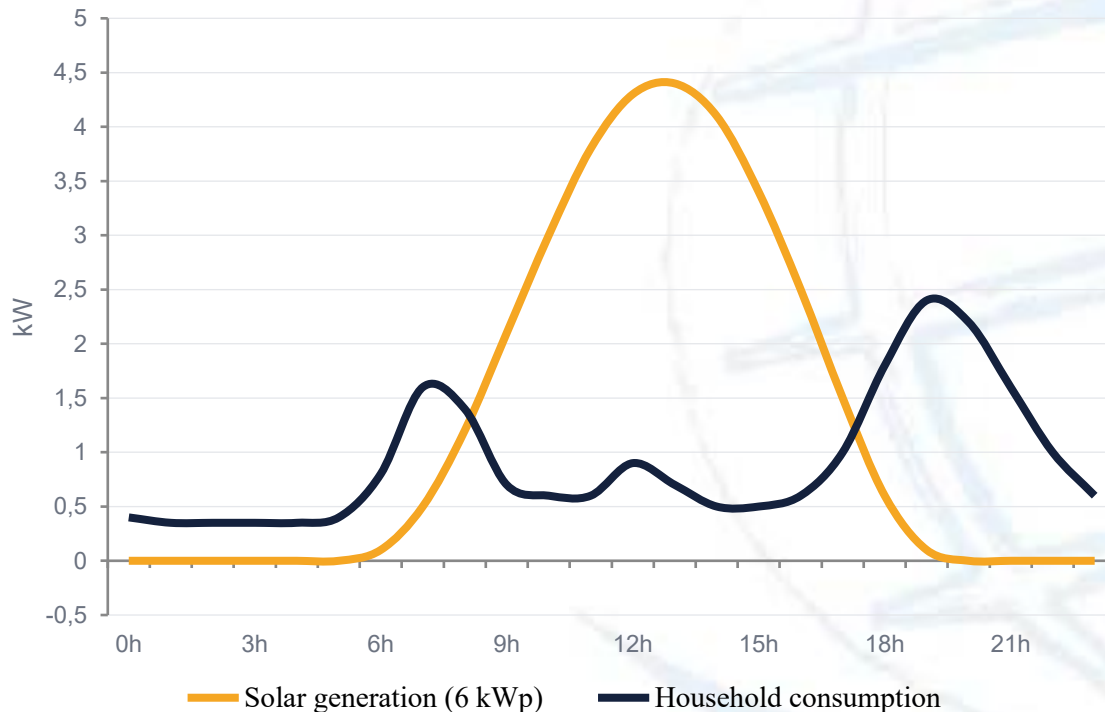


Today: generate to consume

- Maximise the self-consumption rate
- Shift usage to daytime (hot water, electric vehicle, appliances)
- **Store the surplus: the battery becomes a key component**

The regulator supports this shift: the off-peak hours reform (TURPE 7) is gradually moving them to the afternoon, when solar is abundant.

The problem: generation and consumption are out of step



Midday: surplus

Fed into the grid and paid 1.1 c€/kWh



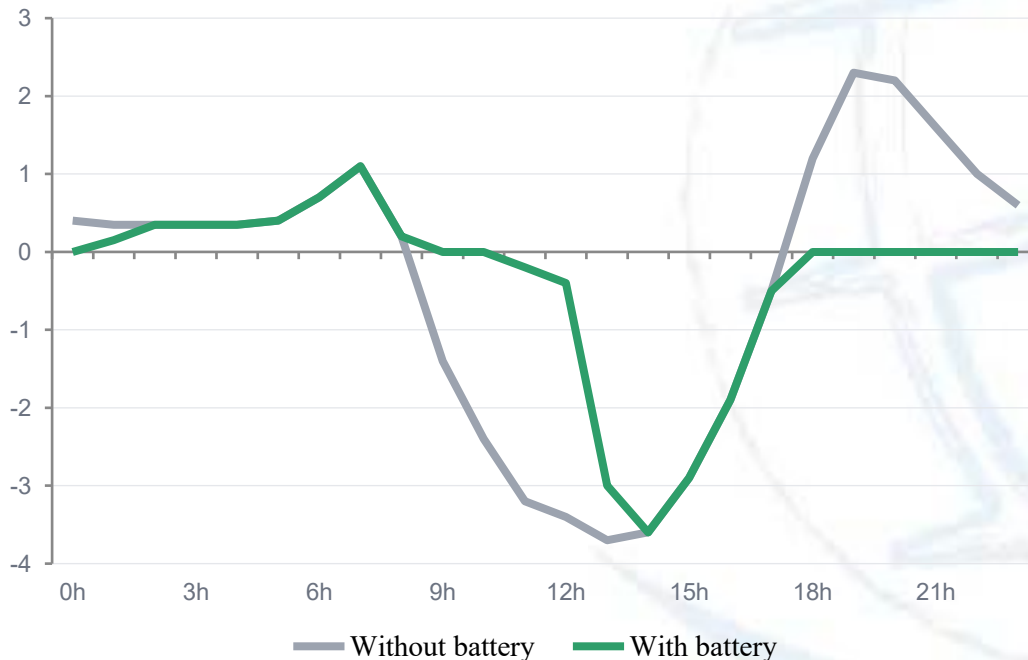
Evening: shortfall

Bought from the grid at about 20 c€/kWh

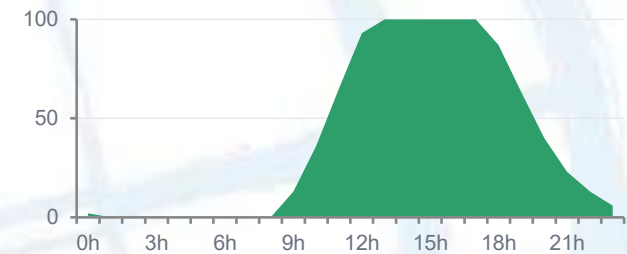
Illustrative profile of a single-family house on a sunny day.

The solution: the battery smooths exchanges with the grid

Grid exchanges (kW): + import / - export



Battery state of charge (%)



27 % → 61 %

Self-consumption rate of solar generation

13.1 → 3.6 kWh

Electricity bought from the grid over the day (-73%)

Illustrative simulation, same day as the previous slide: 6 kWp PV, 10 kWh usable battery, 3 kW, 95% efficiency.

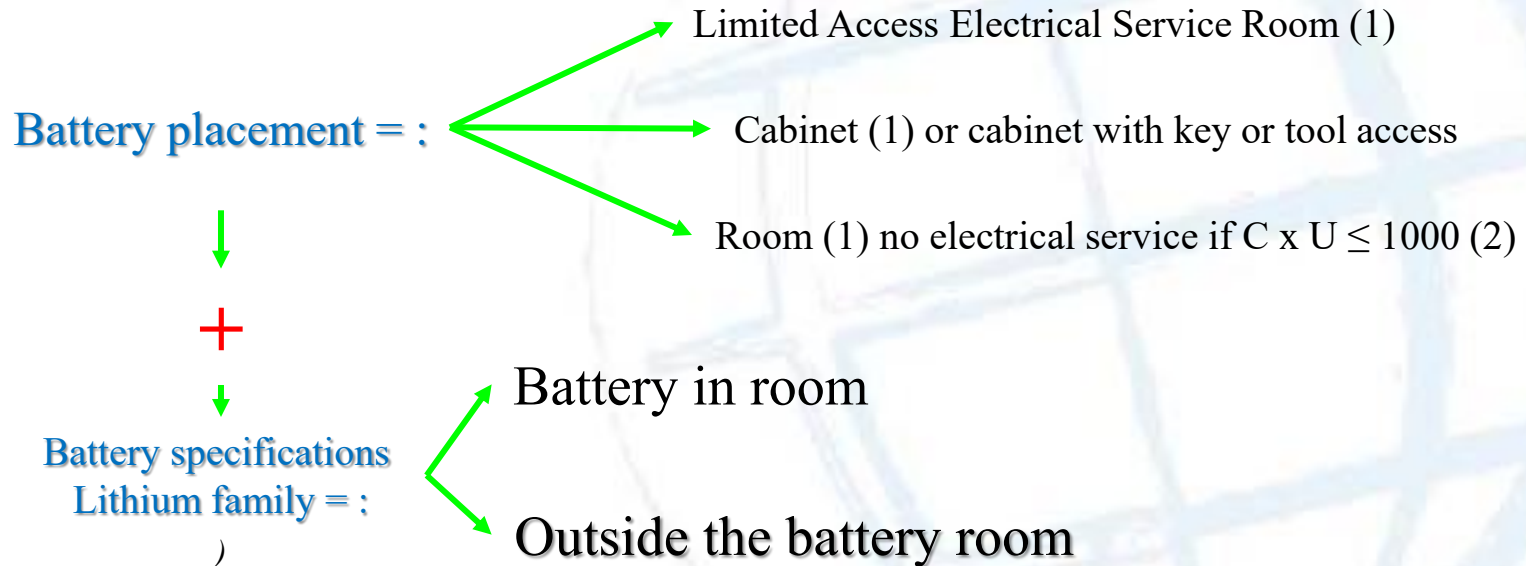
Components of a battery energy storage system

- Modules (containing the cells)
- BMS
- Pack or cabinet
- Protective devices
- Converter or inverter-charger
- Metering and communication



NORMATIVE ASPECTS

STATIONARY BATTERIES



BATTERY IMPLEMENTATION

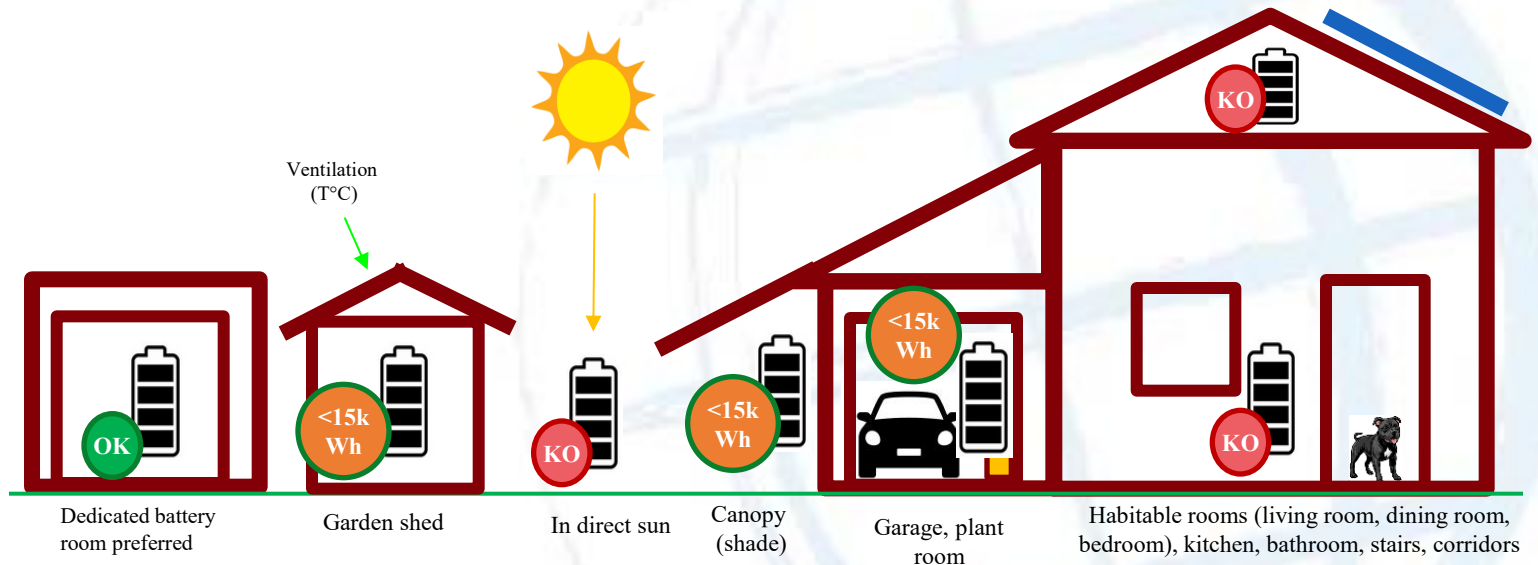
STATIONARY BATTERIES - SOME ESSENTIAL NORMATIVE RULES

- **Accessibility** → in general and regardless of the location: access reserved for informed and competent people = locking with a key or tool (room, envelope, etc.).
- **Connections and connections between battery cells** → Not accessible to unauthorized persons, protected against accidental contact and short circuits, in particular = mandatory protection of battery terminals.
- **Mandatory protection against overcurrent that would be powered by the battery** → the short-circuit current supplied by a battery can be very high (in relation to the storage capacity).
- **A battery is a source** → requirement for the implementation of an emergency shutdown device.
- **Risks related to fire or thermal runaway** → the installer must ensure compliance with all the normative provisions of implementation, depending on the location chosen for the battery.



Storage Batteries Electrical Risks

Battery location in dwellings



To prevent any fire risk from the storage battery, the standard (for example the French XP C 15-712-3) restricts the rooms where the equipment may be installed

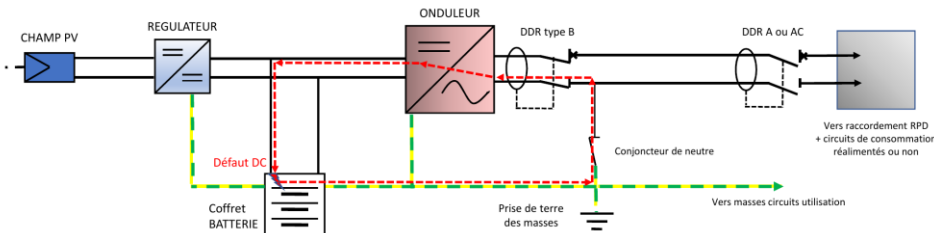
Protection against fault currents on the battery side

It all depends on whether there is galvanic isolation between the DC part and the AC grid



Without galvanic isolation

- A type B RCD on the AC side, between the inverter and the neutral earth: it detects the DC fault current flowing through the inverter.
- In backup mode (TN-S): external neutral-earthing contactor downstream of the type B RCD, plus a type A or AC RCD on the backed-up circuits.



With galvanic isolation

The isolated DC part is no longer seen by the RCD: it needs its own protective measure.

IT system: first fault is not dangerous, signalled by an insulation monitoring device.

SELV: ≤ 120 V ripple-free DC, safety source: the low voltage itself provides protection.

Only covers the part downstream of the isolation.



A French-specific rule: the standard does not recognise the RCM/RCMU built into inverters as protection against electric shock (XP C 15-712-3 § 7.3.2.3).

Short-circuit protection

Several thousand amps within milliseconds: only electromechanical protection is accepted in France



The risk

Short-circuit current (order of magnitude)

PV array



≈ rated current

Inverter



limited to a few $\times I_n$

Battery



several kA

- **Current rises within milliseconds:** the protection must trip before cables and terminals fail.
- **Consequences:** sustained DC arc, overheating, fire, thermal runaway.



Same logic as for the RCMU: an electronic function built into the equipment does not replace a standardised protective device.



The rule in France



Fuse or circuit breaker rated for direct current

The only recognised protective devices



Electronic disconnection (BMS MOSFET)

Not recognised as protection: it may fail stuck in the conducting state

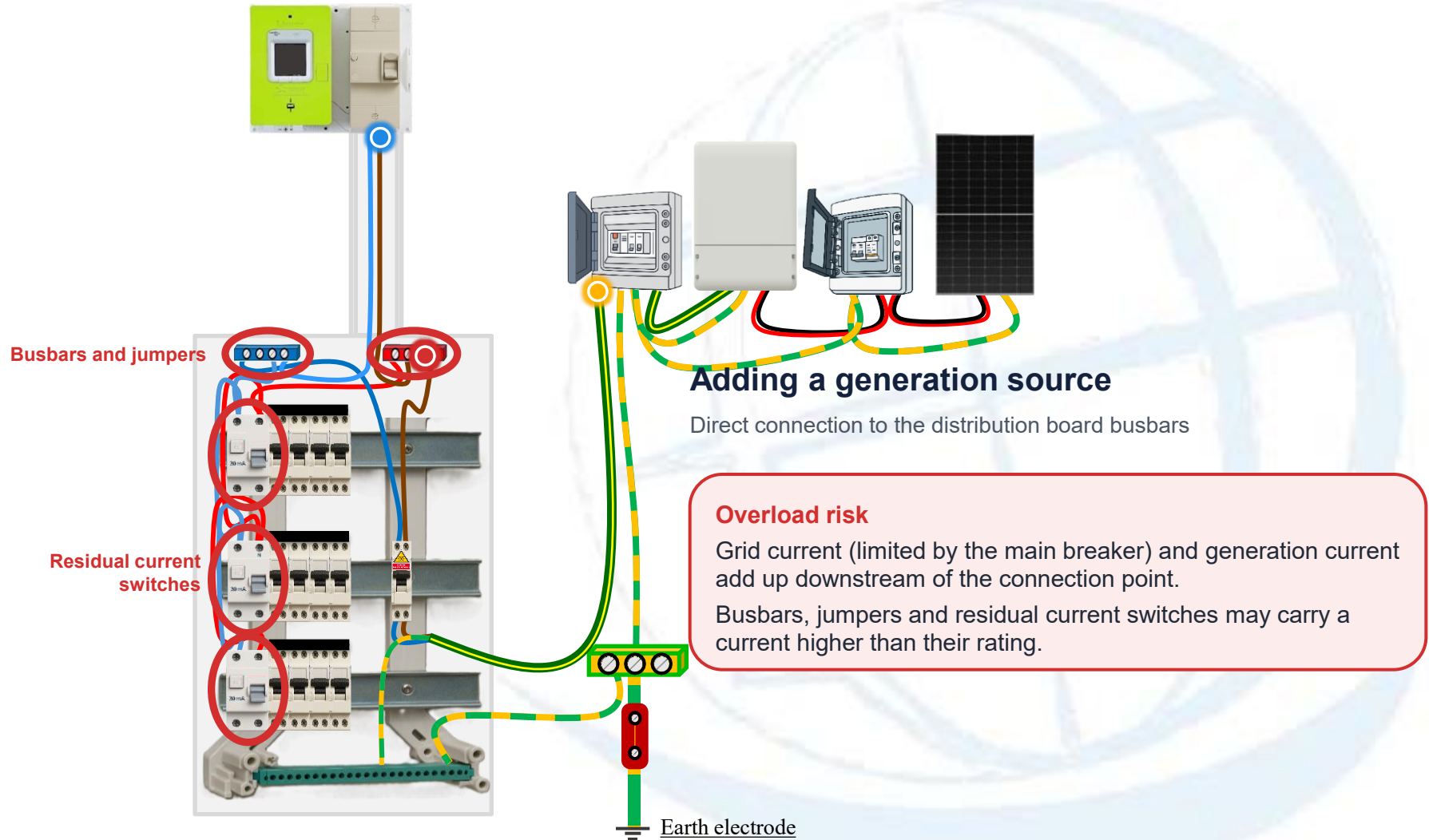
Implementation

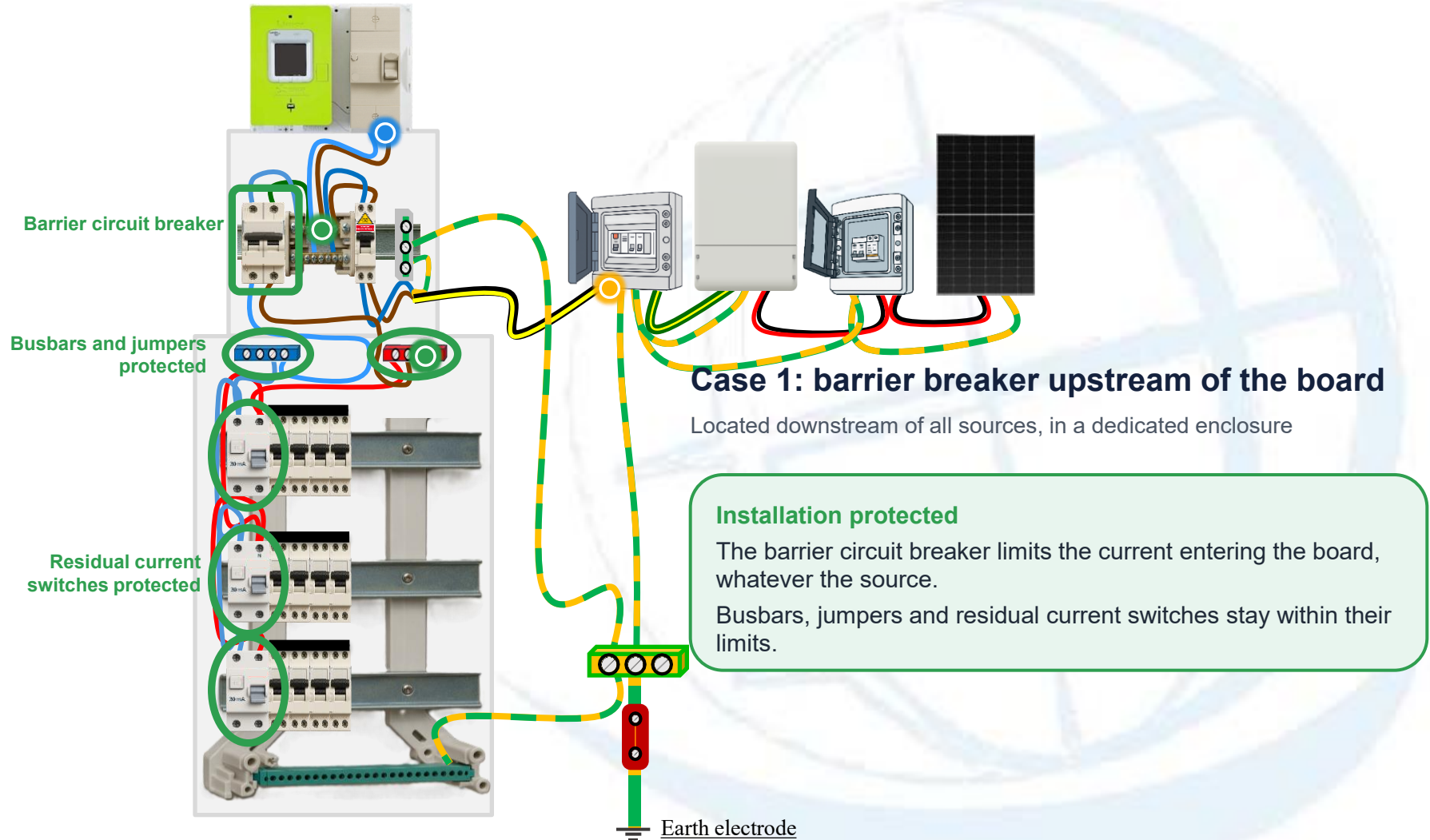
- As close as possible to the battery terminals
- DC breaking capacity $\geq$ battery short-circuit current

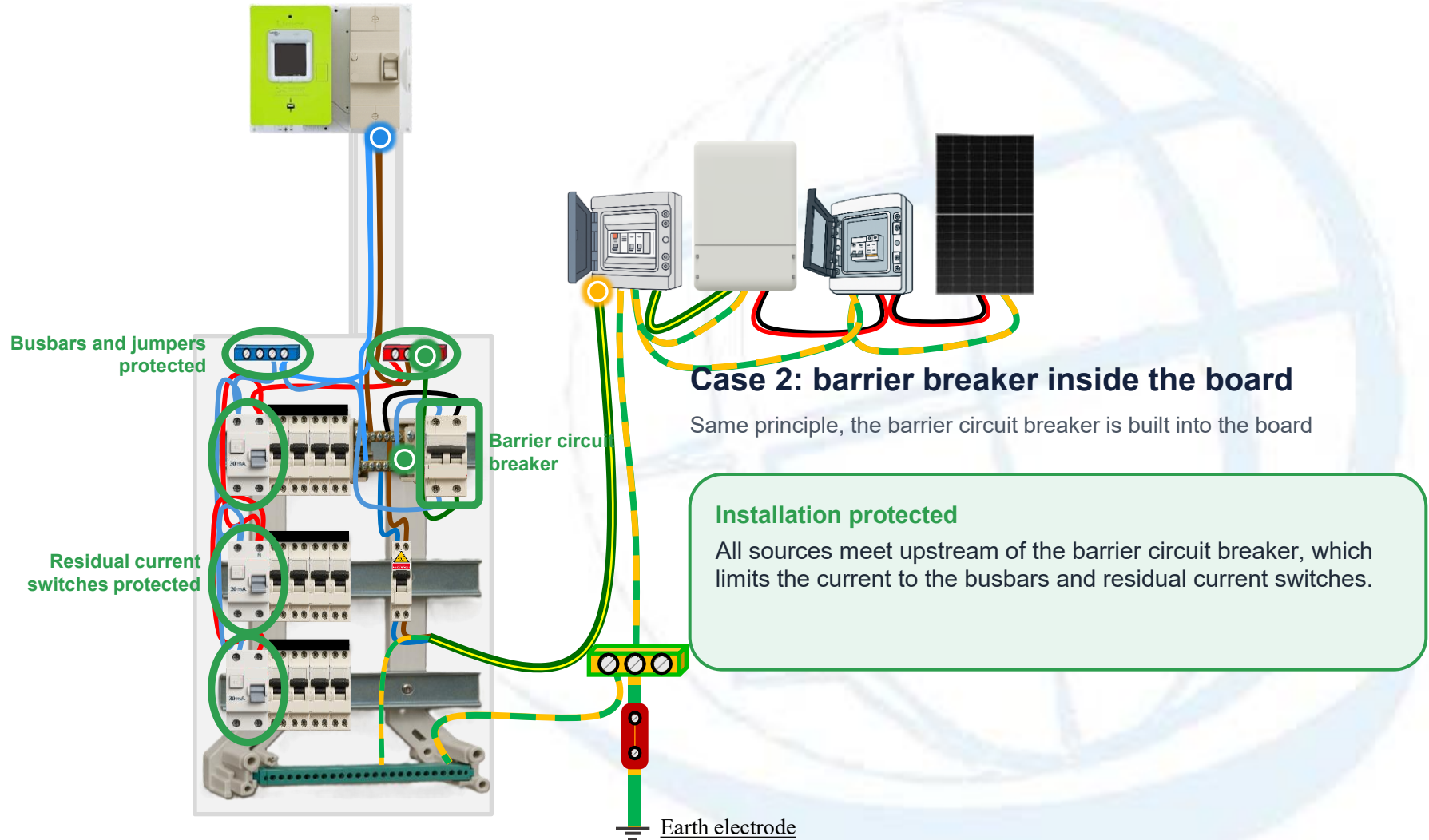


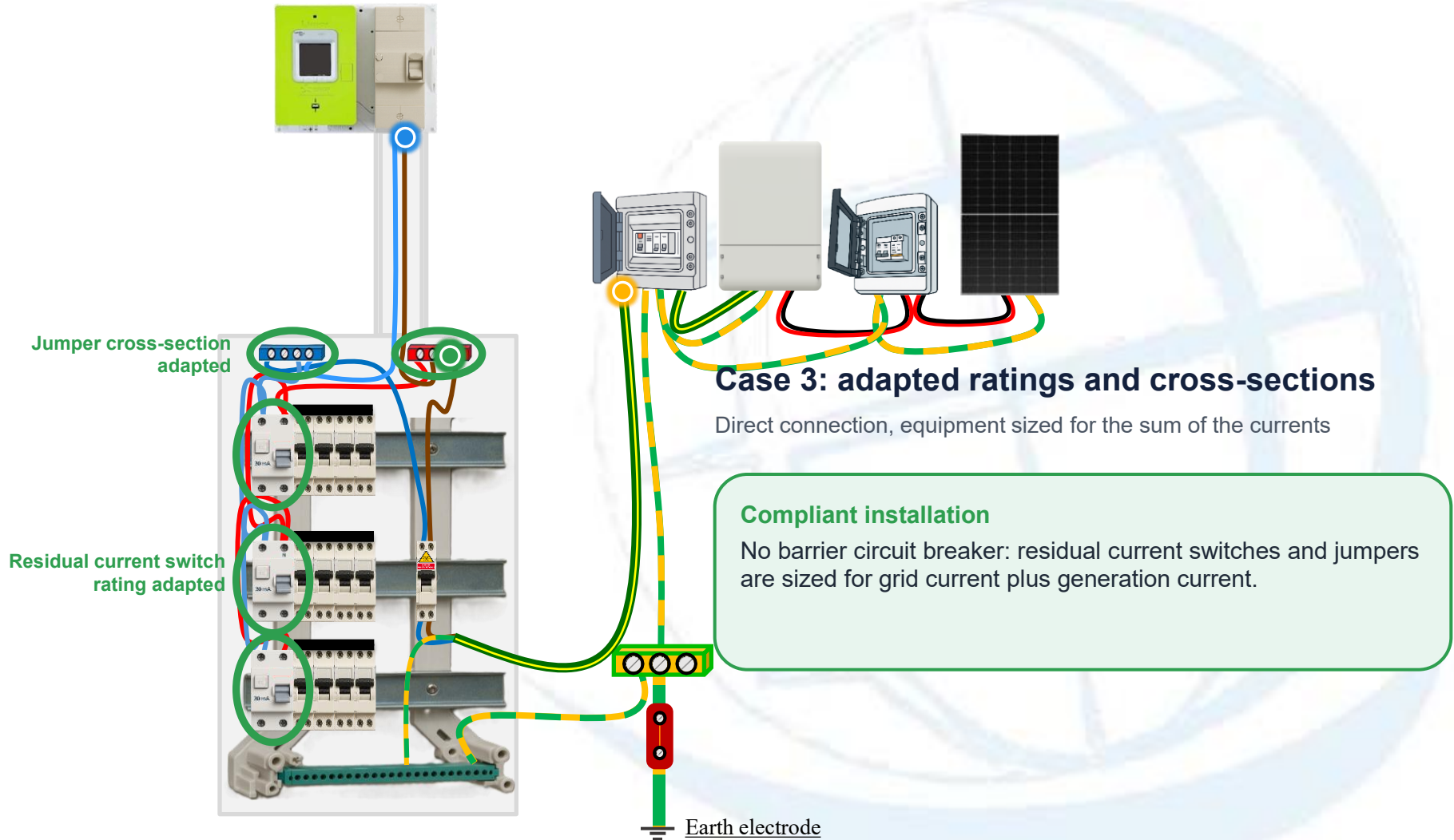
Self consumption

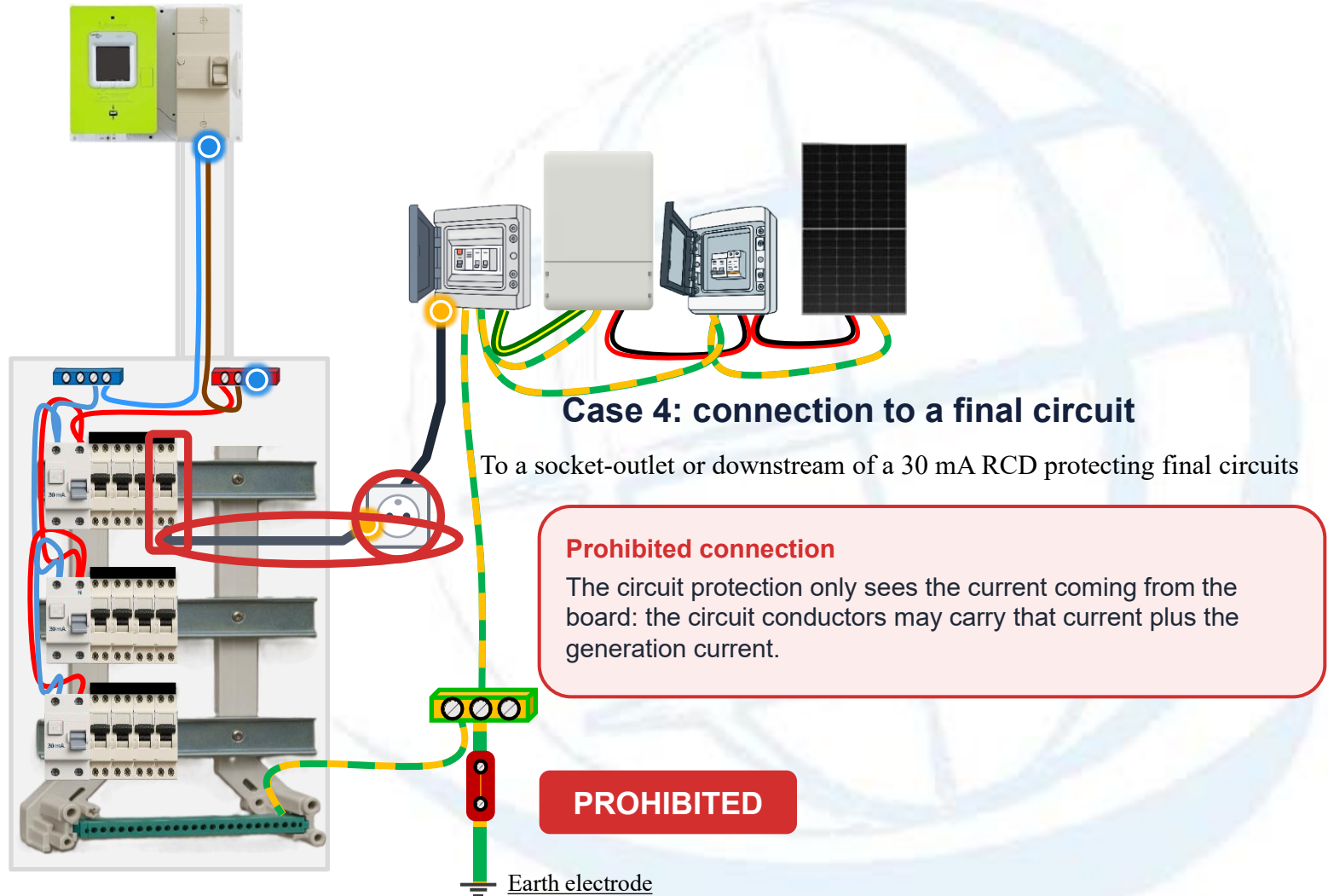
Different possible configurations











INNOVATION – DEVELOPMENT OF STORAGE BATTERIES INSTALLATIONS

Permanent technical watch

- **Regular exchanges with manufacturers and designers of equipment and configurations**
- **New Equipements of configuration:** Technical intelligence
- **Development of battery storage:** Necessary training of technical staff specifically on new configurations, in order to increase the number of qualified people in relation to the increase in applications submitted for such installations.

Examples of permanent adaptation...

- **Battery charge controllers with galvanic DC/DC separation: analysis and consideration of the galvanic separation provision, (anecdotal existence at the time of drafting the normative documents). Impact in particular on the protection measures against indirect DC contacts on the PV field side and DC/battery distribution (SLT in DC, consequently = type of DDR on the AC side, etc.).**
- **Sub-assemblies comprising the battery and its charge controller under the same Class I envelope: provision subsequent to the drafting of the normative documents, Impact in particular on the protective measures against indirect DC contacts on the PV field side and DC/battery distribution (SLT in DC, consequently = type of DDR on the AC side, etc.). In this case, the galvanic isolation of the regulator is not considered with regard to the protection measure.**
- **Case of the battery connected to the AC bus by a dedicated converter: this case is not considered by the reference system. After analysis, the DC distribution part is limited to the DC side of the DC/AC converter of the battery. The applicable indirect contact protection measures are related to the presence or absence of a DC/AC galvanic isolation arrangement. The presence of the battery on the AC bus has no impact on the need for overcurrent protection of the PV field.**
- **So-called "all-in-one" configurations, inverter, regulator and battery under a common envelope: this type of product is developing, the analysis has an impact in particular on the protection against indirect DC contacts, and on the emergency battery shutdown device, which is required by the standard.**

MERCI - THANKS

