Multiport Power Converter to enhance the resilience in a rural distribution network

Ministerio de Ciencia e Innovación of Spanish Government and Proyecto Equired (grant nº PID2021-124292OB-I00).

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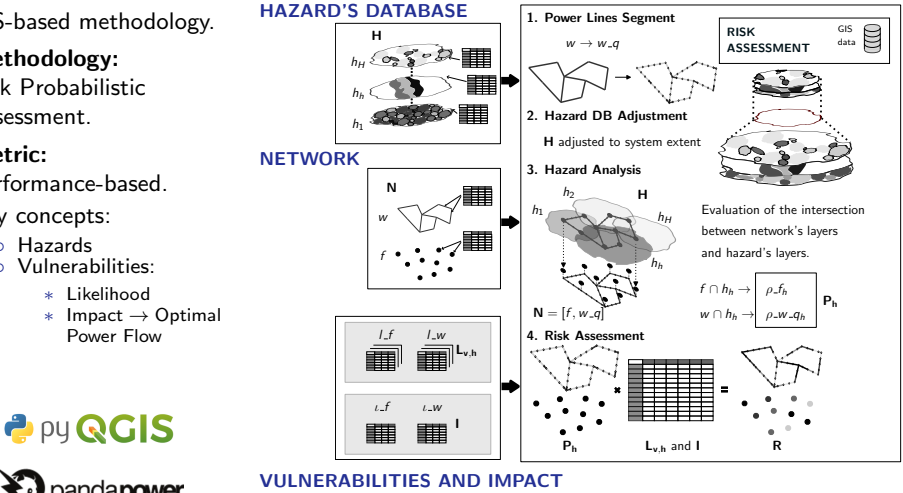
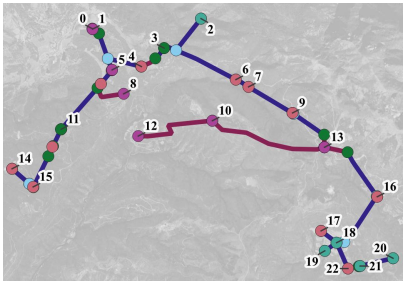
General Resilience Methodology

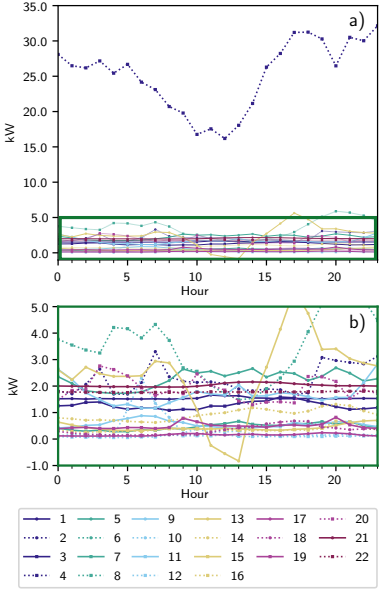
- GIS-based methodology.
- **Methodology:** Risk Probabilistic Assessment.
- **Metric:** Performance-based.
- Key concepts:
  - Hazards
  - Vulnerabilities:
    - Likelihood
    - Impact → Optimal Power Flow



Rural Distribution Network



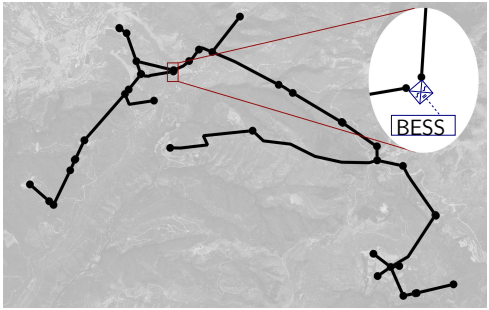
- 5 kV (MV) network
- Low demand
- Bus 0 is the only point connected to the main grid
- Bus 4 is the one with the highest demand
- Bus 13 includes a self-consumption PV system

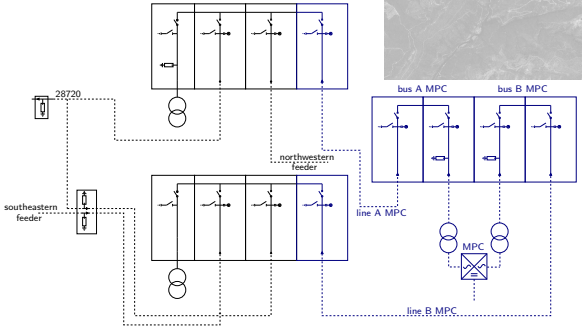


Multiport Power Converter

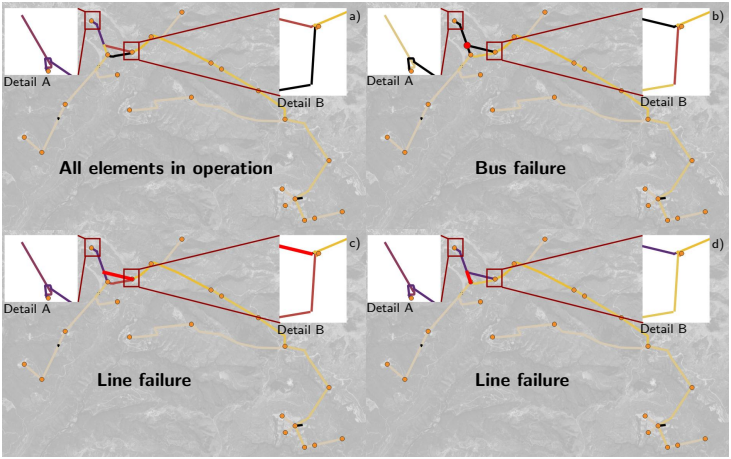
About MPC...

- Integrate three or more energy devices into a single.
- Facilitate power converter integration in the power system.





System operation during faults with MPC



- **ALL ELEMENTS CONNECTED:** The Main grid is the only supply point. MPC not used.
- **GRID FAULTS:** MPC provides the demand to each feader.

Systems's resilience with and without MPC

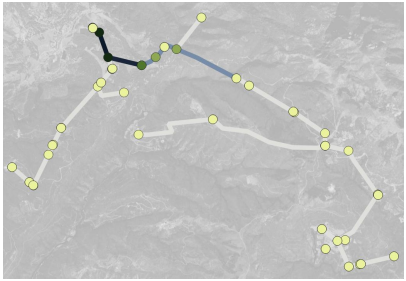
- **HAZARDS:**
  - 5 simple hazards (wildfire, wind, storms, high-access machinery and subsurface machinery)
  - 6 additional hazards obtained from combined events.
  - Hazard index based on a probabilistic and intensity scoring.
- **VULNERABILITIES:**
  - 8 vulnerabilities related to system's technical characteristics
  - Identified in collaboration with the local DSO
  - *LIKELIHOOD:*
    - 10 vulnerabilities' likelihood levels $\rightarrow$ Level of mitigation
  - *IMPACT:*
    - Optimal Power Flow:

$$\iota\_f_{v,h} = [max\_p\_load^{\mathcal{N}} - max\_p\_load^{\mathcal{N}-f}] \cdot rt_{v,h} \quad (1)$$

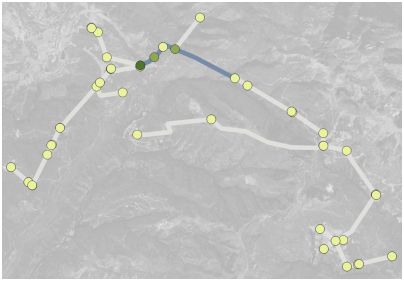
$$\iota\_w_{v,h} = [max\_p\_load^{\mathcal{N}} - max\_p\_load^{\mathcal{N}-w}] \cdot rt_{v,h} \quad (2)$$

Element's impact with and without MPC

without MPC



with MPC

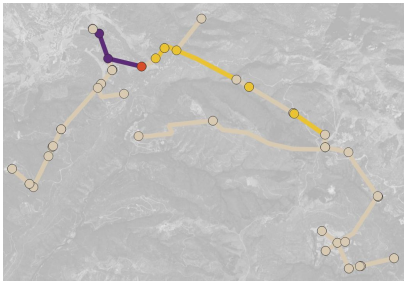


The MPC...

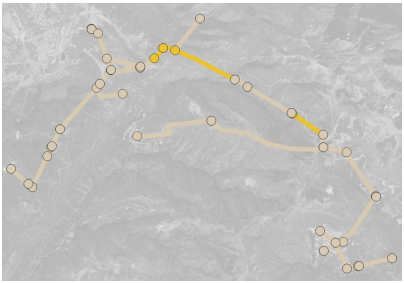
- provides redundancy to critical elements.
- includes a BESS that supplies the demand during faults.
- reduces the most critical element's impact

Systems's resilience with and without MPC

without MPC



with MPC



The MPC...

- reduces the power at risk in critical events.
- increases the overall system's resilience.

Conclusions

- Resilience analysis allows identifying critical elements, i.e., assets or regions that risk more energy or power.
- The MPC facilitates the integration of multiple elements, simultaneously improving various weaknesses.
- The MPC facilitates the interconnection of existing elements and the integration of new generation or storage elements.
- The MPC is identified as a potential technology from a resilience perspective.

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