How do electricity tariffs shape renewable asset deployment and flexibility?

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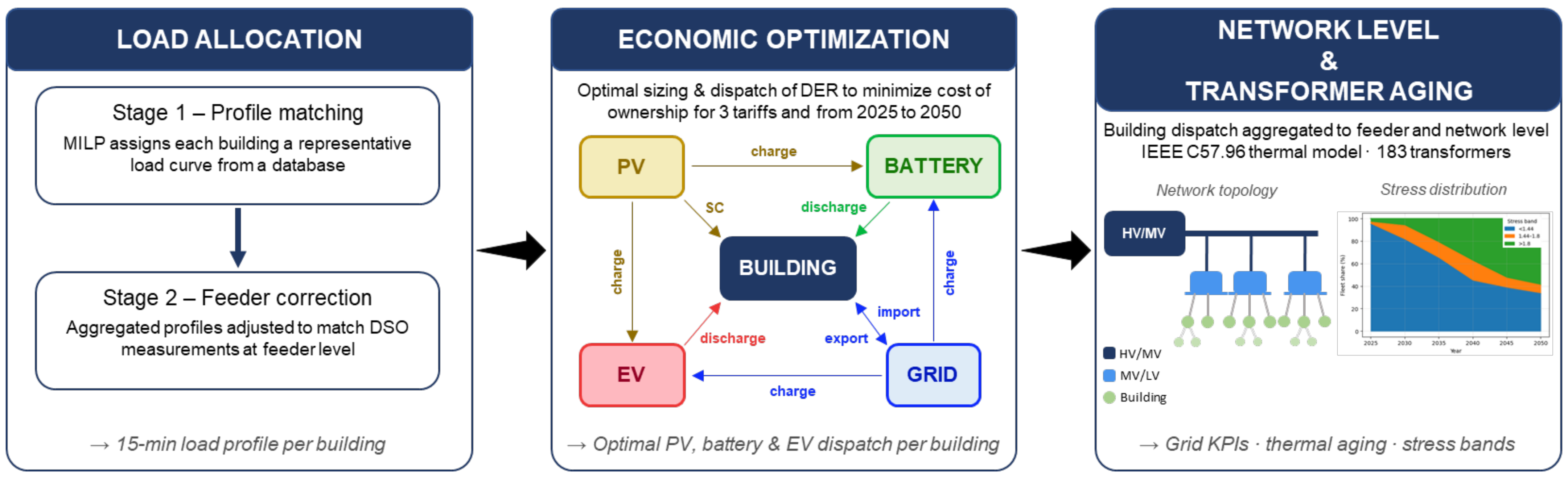
Introduction

- Cost reductions in PV and batteries enable a **cost-effective energy transition**
- At the same time, EVs and batteries provide **operational flexibility** (load shifting), potentially mitigating the need for costly grid reinforcement
- However, investments are ultimately **driven by prosumer-level economic decisions**

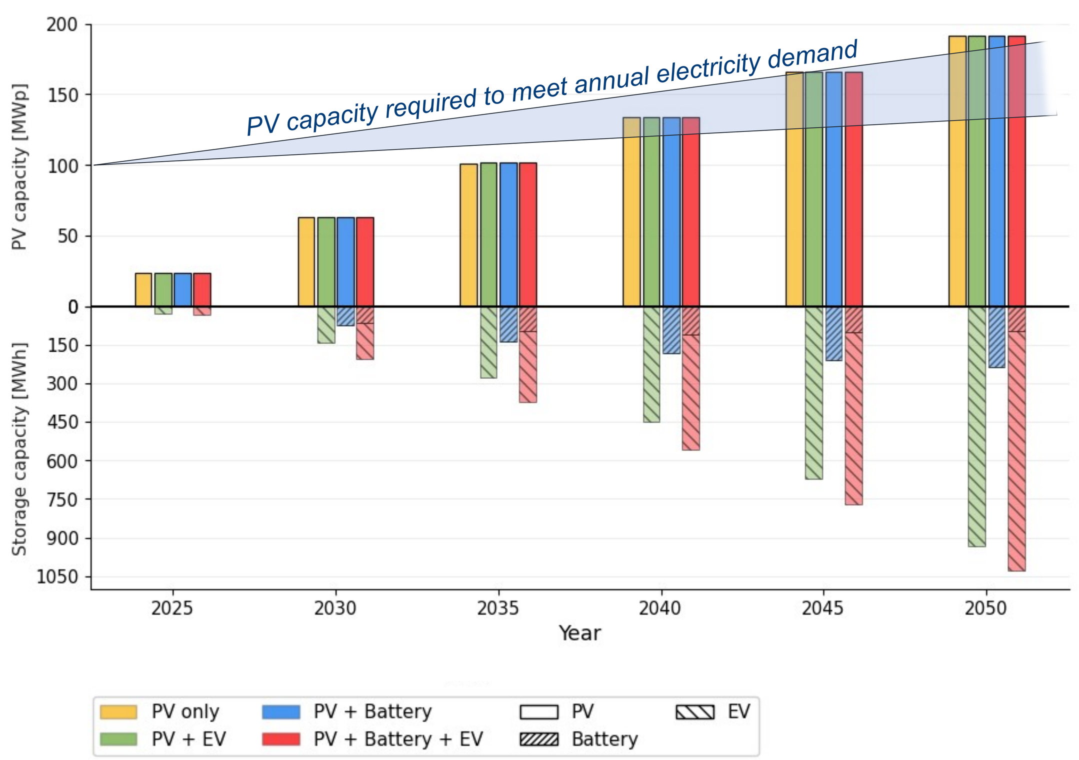
How do tariffs influence the deployment of distributed PV and stationary batteries as well as flexibility behavior?

Methodology



Results - Estavayer-le-Lac case study

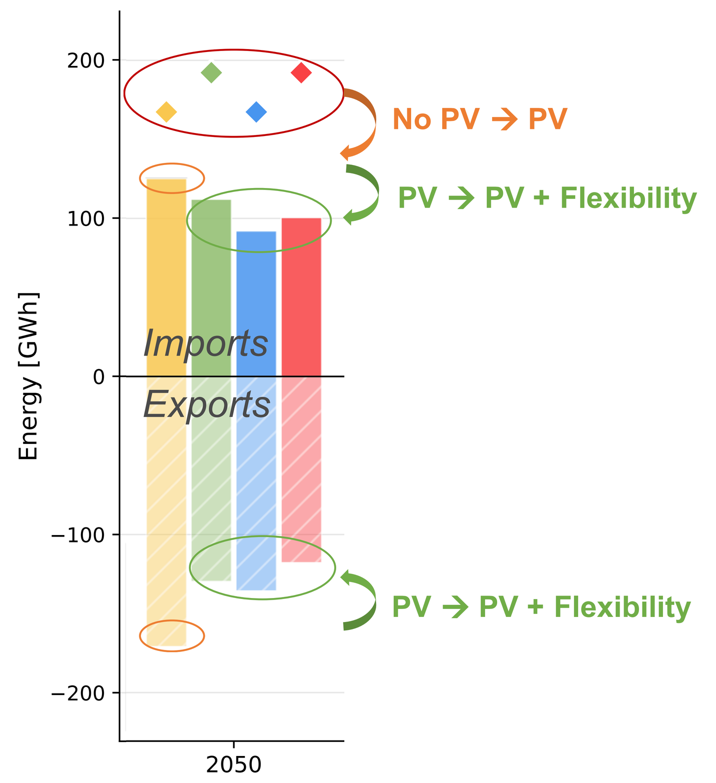
Prosumer economics drives massive PV and storage deployment effectively until 2050



- PV scales up to ~190 MWp, reaching **required capacity to balance annual demand** by 2040–2045
- **Stationary storage** reaches more than ~200 MWh (median ~17 kWh/prosumer)
  - *Cut by half when EVs are used for flexibility!*
- Little sensitivity to the tariff structure (additional analysis)

Flexibility reduces both grid imports and exports

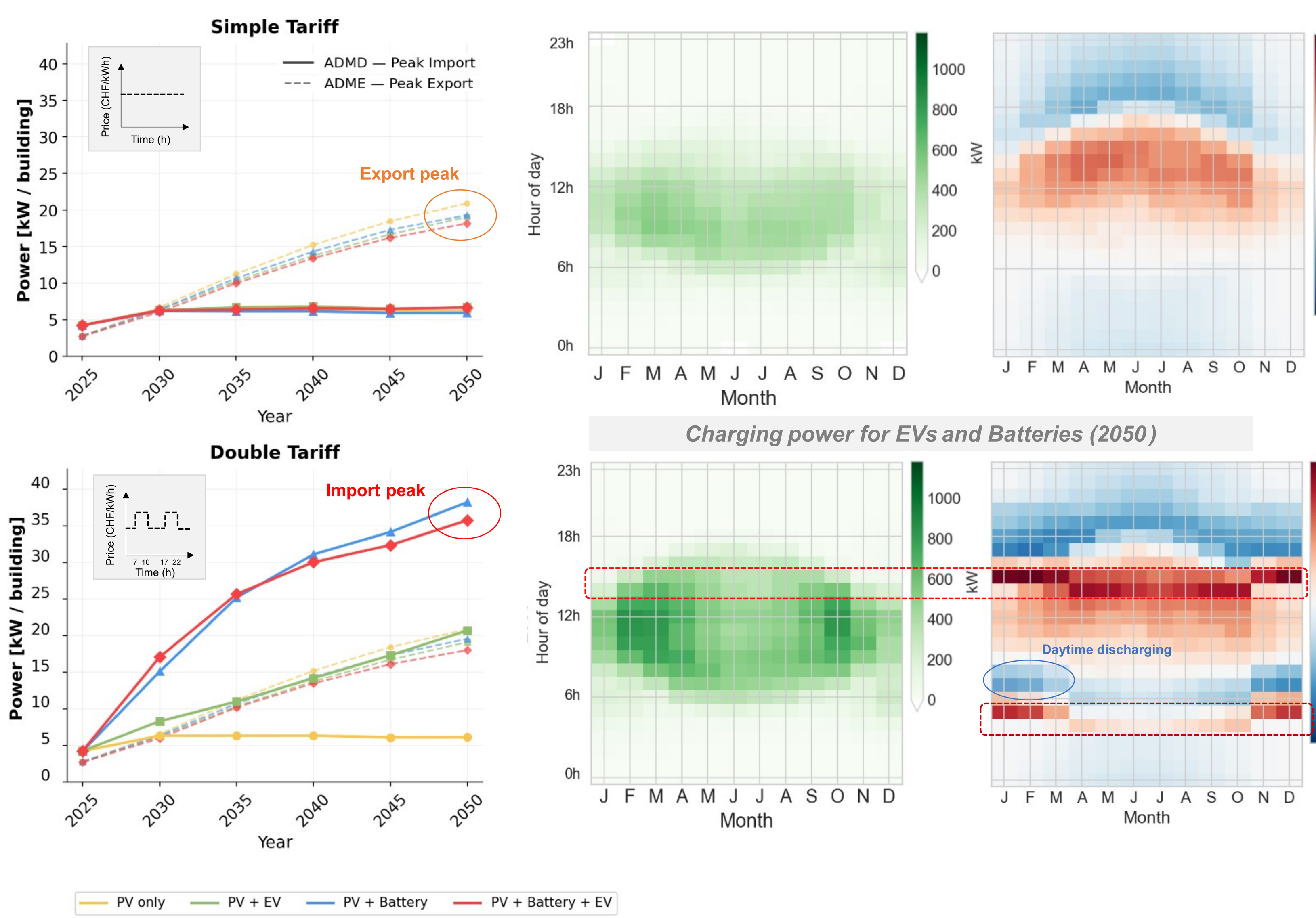
- **Grid imports** significantly reduced when combining PV and flexibility (cut by half when considering EVs!)
- While self-sufficiency reaches up to ~50% at the aggregated level thanks to flexibility, more than half of the PV generation is still exported to the grid.
  - ➡ Batteries are too small to *store all excess daytime PV production*
  - ➡ No *energy sharing*: flexibility is driven by individual, prosumer-based tariffs



Tariff design critically shapes flexibility behavior

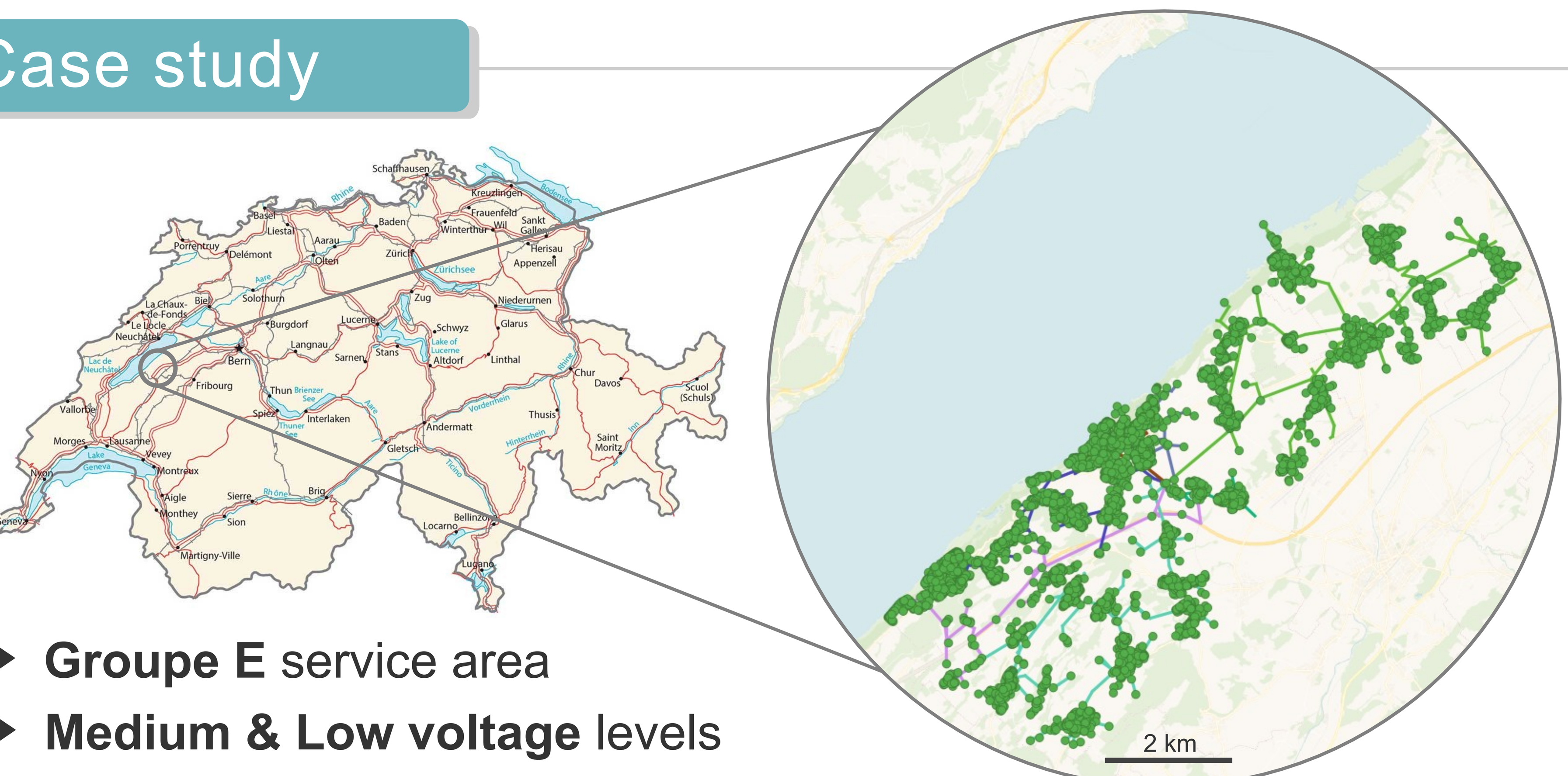
Impact of the tariff structure on peak power (import and export), comparing **simple and double tariffs**

- **Simple tariff**: limited by PV-driven **export peaks**, with minimal influence from EVs and batteries (limited storage capacities). Notably, daytime EV charging and nighttime battery discharge prevent any significant increase in import peaks for this simple tariff.
- **Double tariff:** creates high import peaks due to **synchronized charging**!
- Export peaks follow similar trends across tariff structures and scenarios, underscoring the need for more advanced tariffs or alternative mechanisms (e.g., dynamic or capacity-based tariffs, or PV curtailment).



Average annual peak power per building (solid lines for import, dashed lines for export) from 2025 to 2050, across the considered scenarios and two tariff structures. For 2050, the mean charging/discharging power of EVs (green) and stationary batteries (red/blue) are also reported as heatmaps.

Case study



- ➡ **Groupe E** service area
- ➡ **Medium & Low voltage** levels
- ➡ **8600+ prosumers** (residential + industrial)

Conclusion

Investments in **EVs and battery storage are cost-effective for prosumers** under current tariff structures, due to cost reductions in both PV and storage.

Smart management can effectively **mitigate EV and heat pump peak imports**, but only in combination with a **carefully designed tariff** to **prevent synchronyzed charging events.**

Export peaks (PV) are difficult to mitigate due to limited available storage and price incentives, even with nearly zero feed-in tariffs. Need for advanced solutions:

- *Dynamic or capacity-based tariffs*
- *PV curtailment*
- *Energy sharging through energy communities (CEL/ZEV)*

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