Microgrids

ELEN0445

Optimization module overview

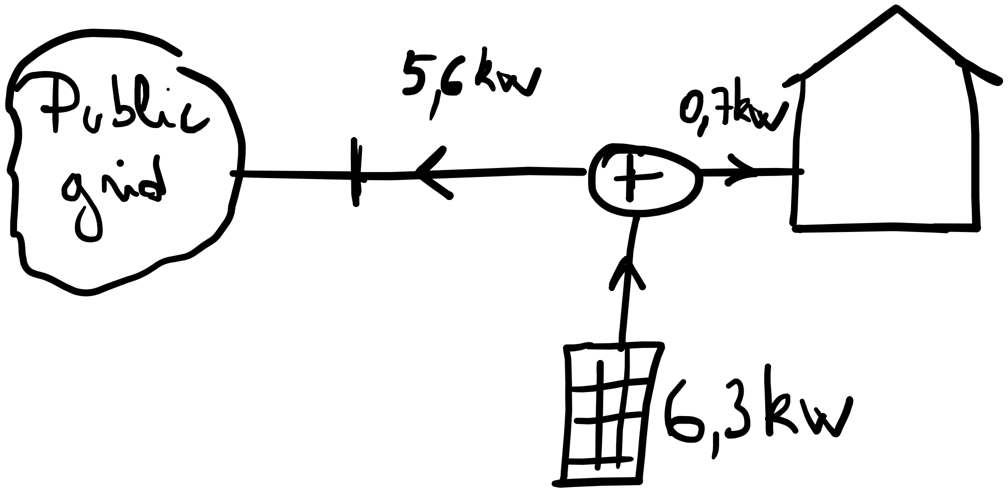
You have learned

- What is a microgrid (structure)
- What are its main components
- Power electronics interfaces (MPPT, etc.)
- The levels of control
- How to make some forecasts
- How to design an installation using SMA’s software

Now, I want to teach you how we can optimally <u>control</u> and <u>size</u> a microgrid

- We will still focus on a one-node microgrid for illustration
- But the more complex the microgrid, the funniest: this could be extended to
  - a network of microgrids -> insert the power flow equations in the problem, adds "spatial" complexity
  - Other energy vectors (e.g., house heating, district heating, H2, etc.) -> multi-energy systems
  - Community microgrids -> fairness questions

Real-time control

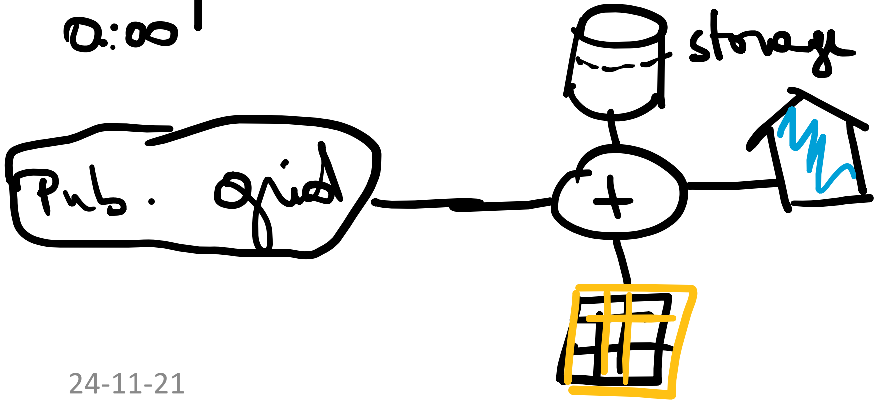


- Sequence of events.

- Should you stop charging?

(You can import max 11kW from the grid.)

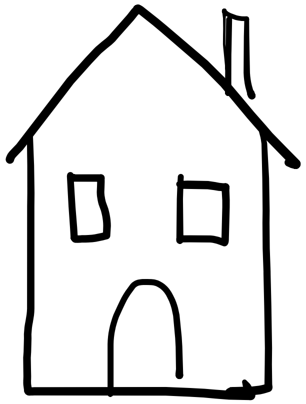
Operational planning



- forecasted demand
- forecasted PV

- Shell you
  - store
  - send back to grid
  - Move load?
- Function of prices, physical limits, efficiencies.

Sizing



- Should you connect to the grid?
- Should you buy a genset (or a CHP)
- Should you invest in PV or wind generation?

All these problems are linked

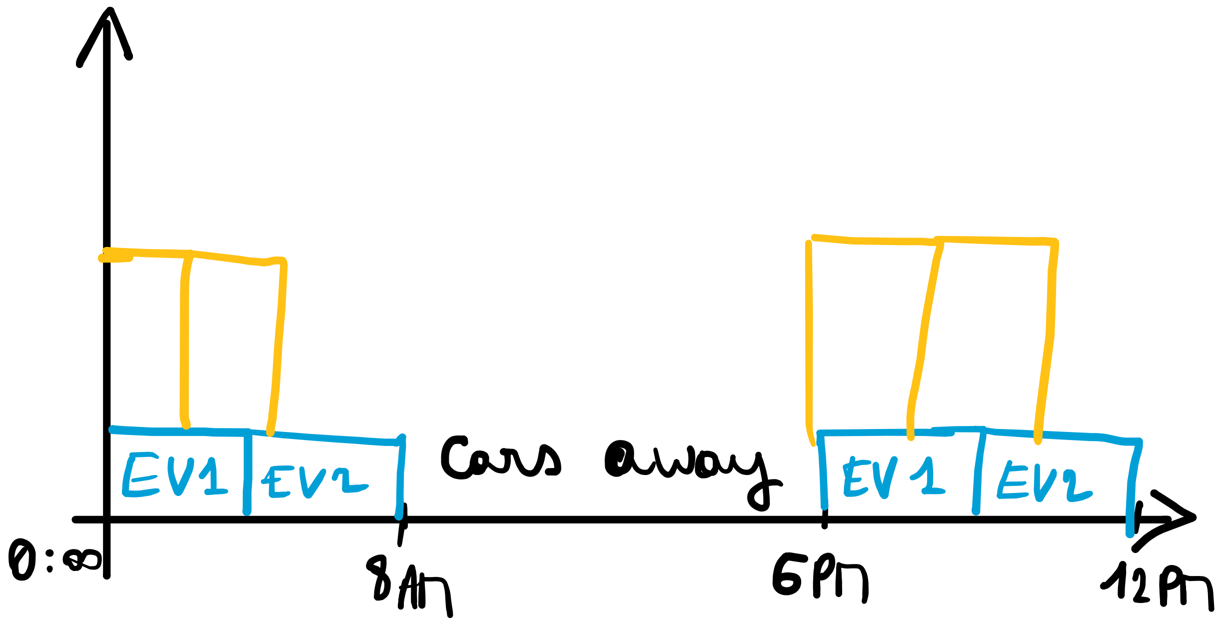
- Sizing depends on the operational planning policy:

E.g. ∘ you have 2 E.V.s and you need to choose how many A to take from the grid.

∘ Your cars can charge at 2.5, 6 or 11 kW.

i.e. ~ 11, 26 or 48 A at 230V.

Sizing and operational planning

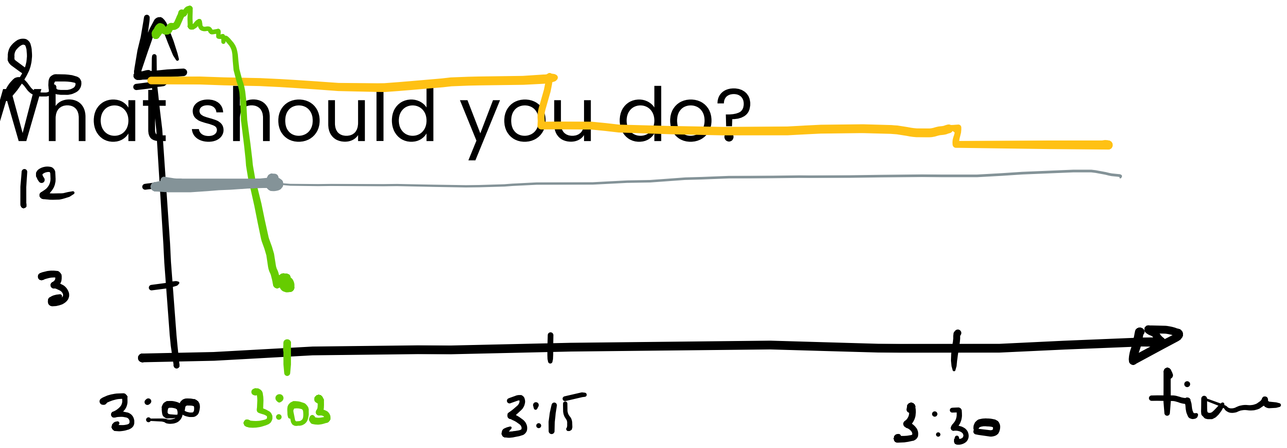


Your ability to optimize charges will impact a lot the grid connection

Requires good forecasts (prices, generation, consumption)

Real-time vs operational planning

- It is 3:03 PM, you planned to charge your EV at full power because you forecasted 20 kW of PV generation
- A cloud is passing and the real-time production is 3 kW
- What should you do?



- Real time gen =

- EV. charge .

Possible solutions

- Take power from the grid -> self-sufficiency decreases
  - Depends also on your sizing decision
- If you can withdraw from the grid, you may create a *peak* (what if PV stays low until 3:15?)
- What is the value of having the car charge +x%?
- This is also where forecasts and uncertainty come into play

Ideally we would solve all these problems together, but

- Investment decisions are made on a yearly basis or so
- Forecasts are usually available for a few hours or days ahead
- Real-Time variations are difficult to predict
- Some decoupling have to be done in practice

Coordination between real-time control and operational planning

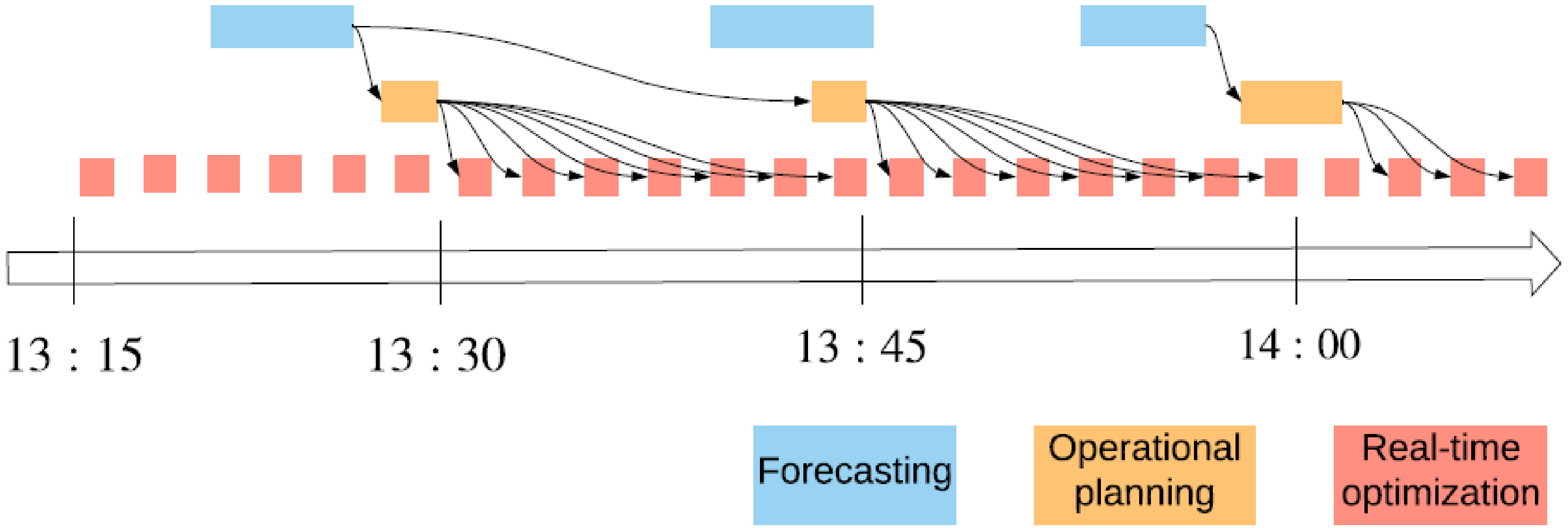


Fig. 1: Hierarchical control procedure illustration.

Goals of this module

- Learn about *mathematical programming*
- Learn to *model* problems as LPs or MIPs
- Understand how *solvers* work
- Solve the *real-time control* problem
- Solve the *operational planning* problem
- Solve the *sizing* problem