



# The role of energy storage in buildings: an introduction in the design challenge

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(EMIB: Energy & Materials in Infrastructure & Buildings)

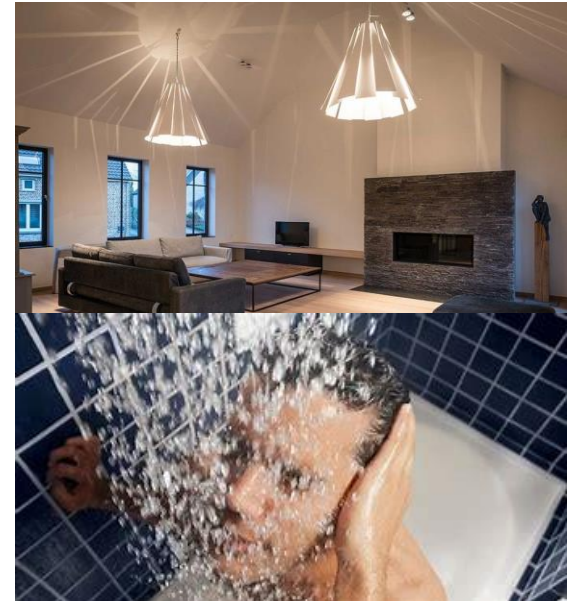
27th of May

# The role of energy storage systems

- *Matching production & demand (in buildings)*

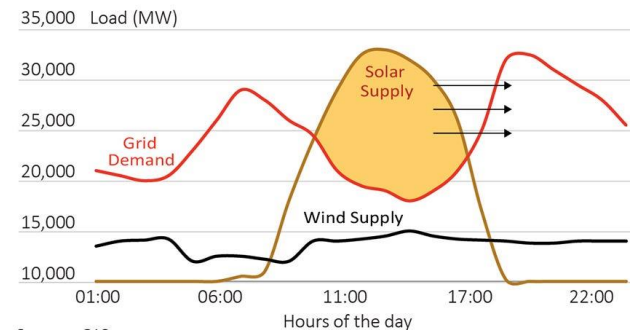


Energy  
Storage



- *Providing flexibility  
(by buildings)*

Figure 4: Energy storage could be a game-changer for renewable energy  
Time-shift benefits of energy storage

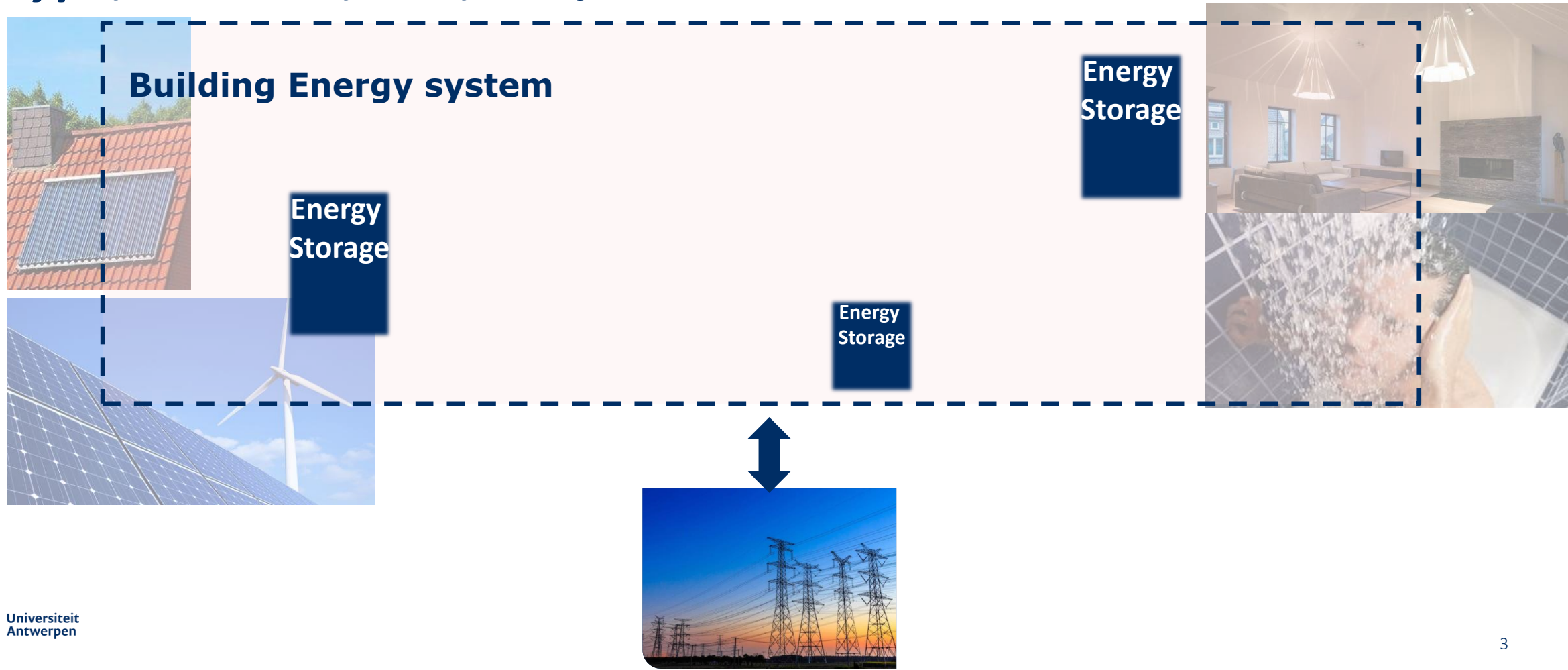


Source: QIC



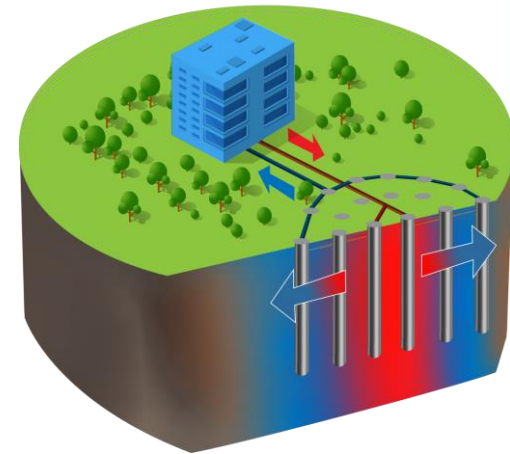
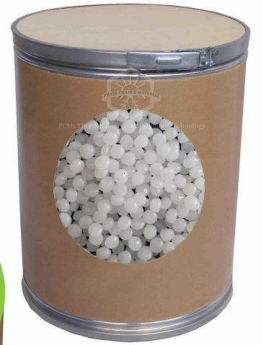
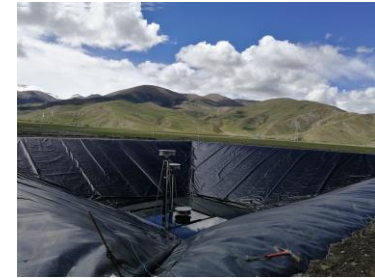
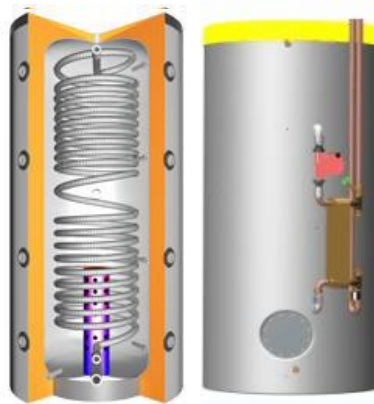
# Design of energy storage systems

- *Type, Location, Size, Use/Control !*



# Characterizing energy storage systems for design

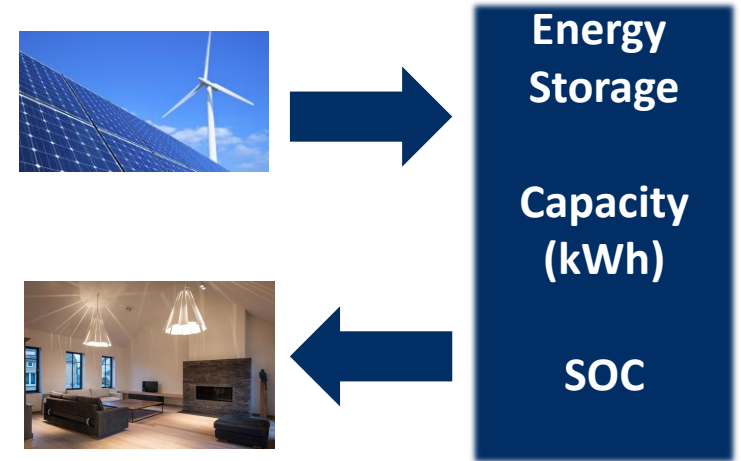
- *Large variety in energy storage (in buildings)*



# Characterizing energy storage systems for design

## ■ *Energy point of view*

- Capacity (**kWh**) – SOC (state of charge;%)
- Charging power (**kW**; limited ?)
- Decharging power (**kW**; limited ?)
- 'Efficiency' – Energy losses ...
  - ...due to conversion (%)
  - ...degradation and/or stand-by losses (**kWh / h**) (exergy loss)

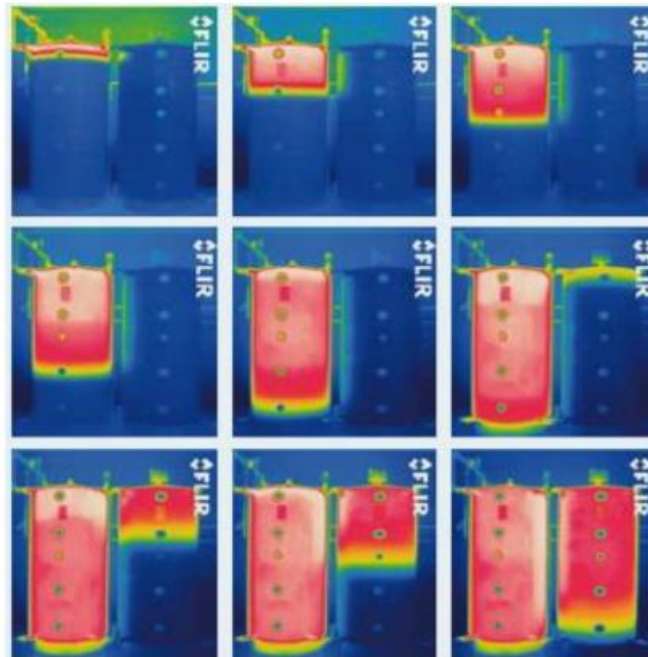


- **WARNING !** Energy storage IS NOT a renewable energy source
  - Some types do have free energy (low/zero exergy) gains !
  - $OUT \leq IN$

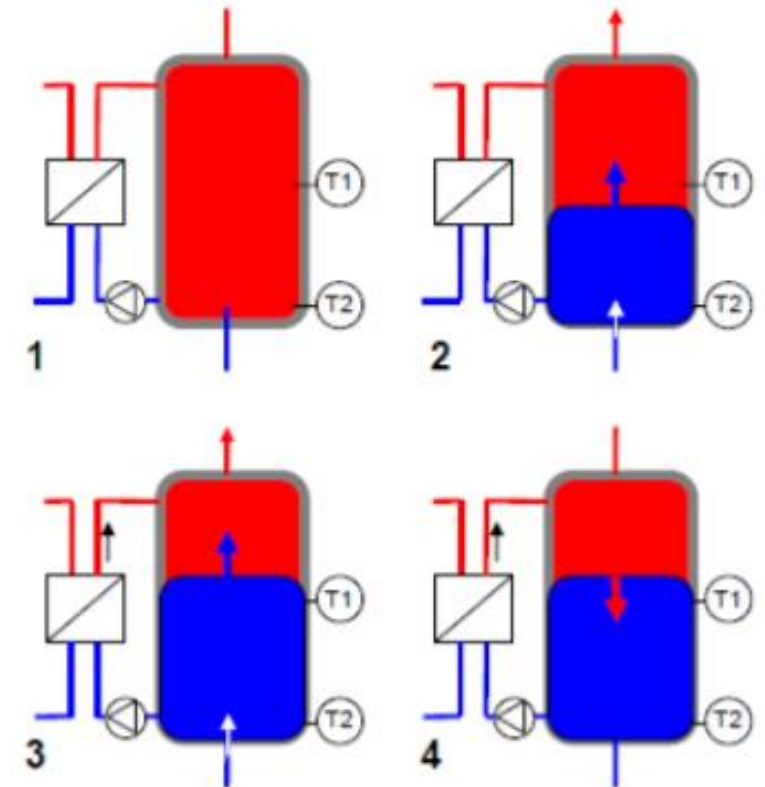


# Thermal storage

- *Remark time and use dependence of SOC (exergy)*
  - *Ex. stratification*



Figuur 41: Verloop opwarming bij in serie geschakelde boilers met externe warmtewisselaar.



# Characterizing energy storage systems for design

- *Other parameters*

- *CAPEX (€)*
- *Volume and/or weight*
- *Environmental impact (LCA – LCC)*
- ...



# Overview: main energy storage systems

	Electrical	Thermal applications	
Short term (day-week)	Flywheel Battery / EV ...	PCM  <i>Thermal inertia (buildings)</i>	Storage vessels  <i>Thermal inertia (systems)</i>
Long term (seasonal)	<i>Hydrogen cycle ?</i> Grid ...	PCM	ATES (incl.lake)  BTES (CTES)



# Identifying the design problem (part 1)

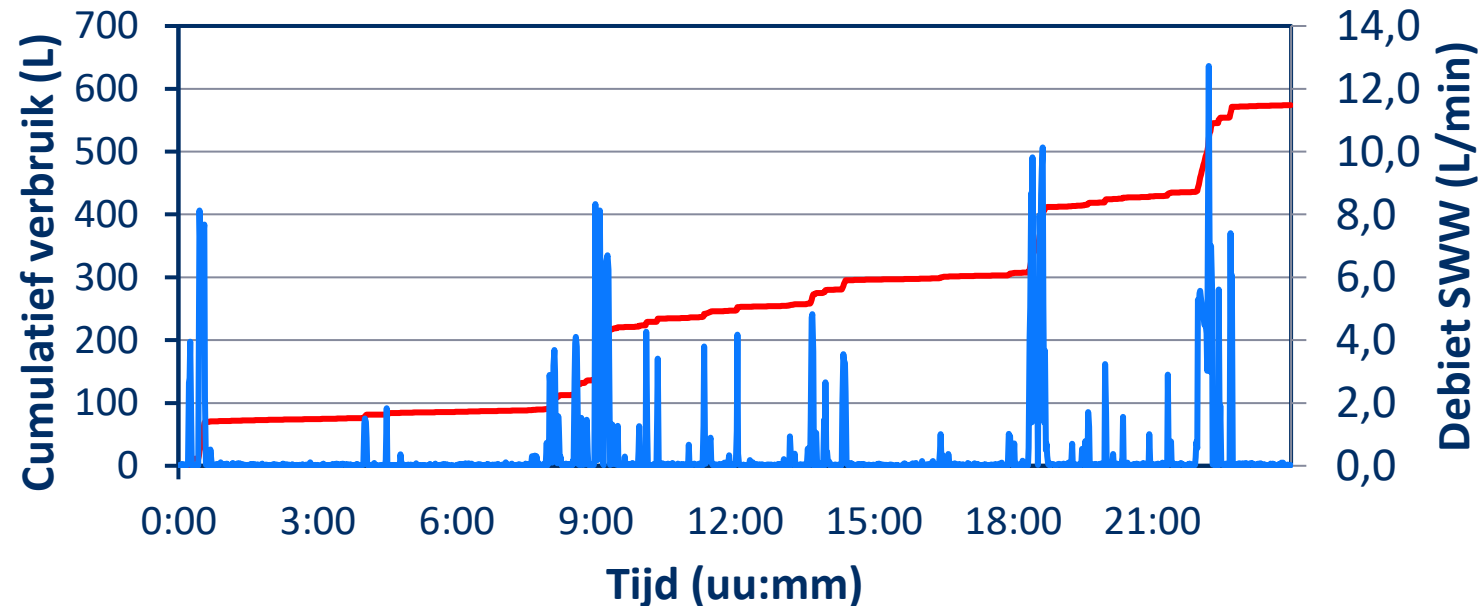
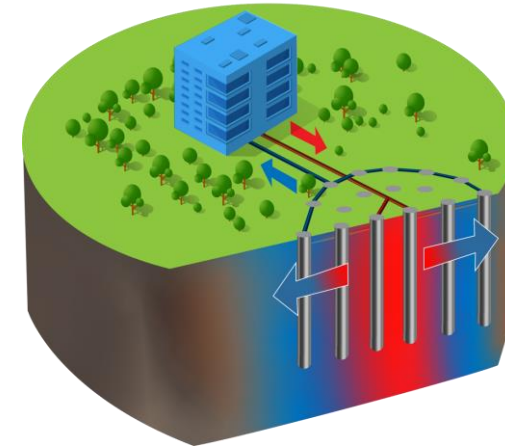
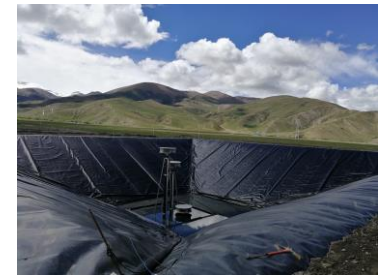
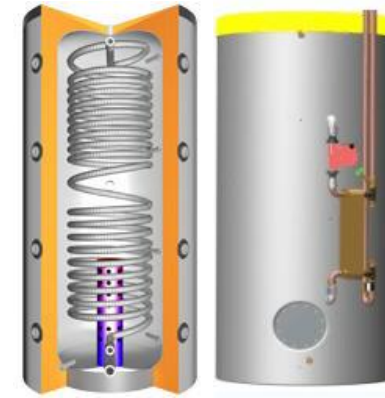
- *Production and demand profiles*
- *Defining the needs/KPI*
  - *Compact*
  - *Comfort*



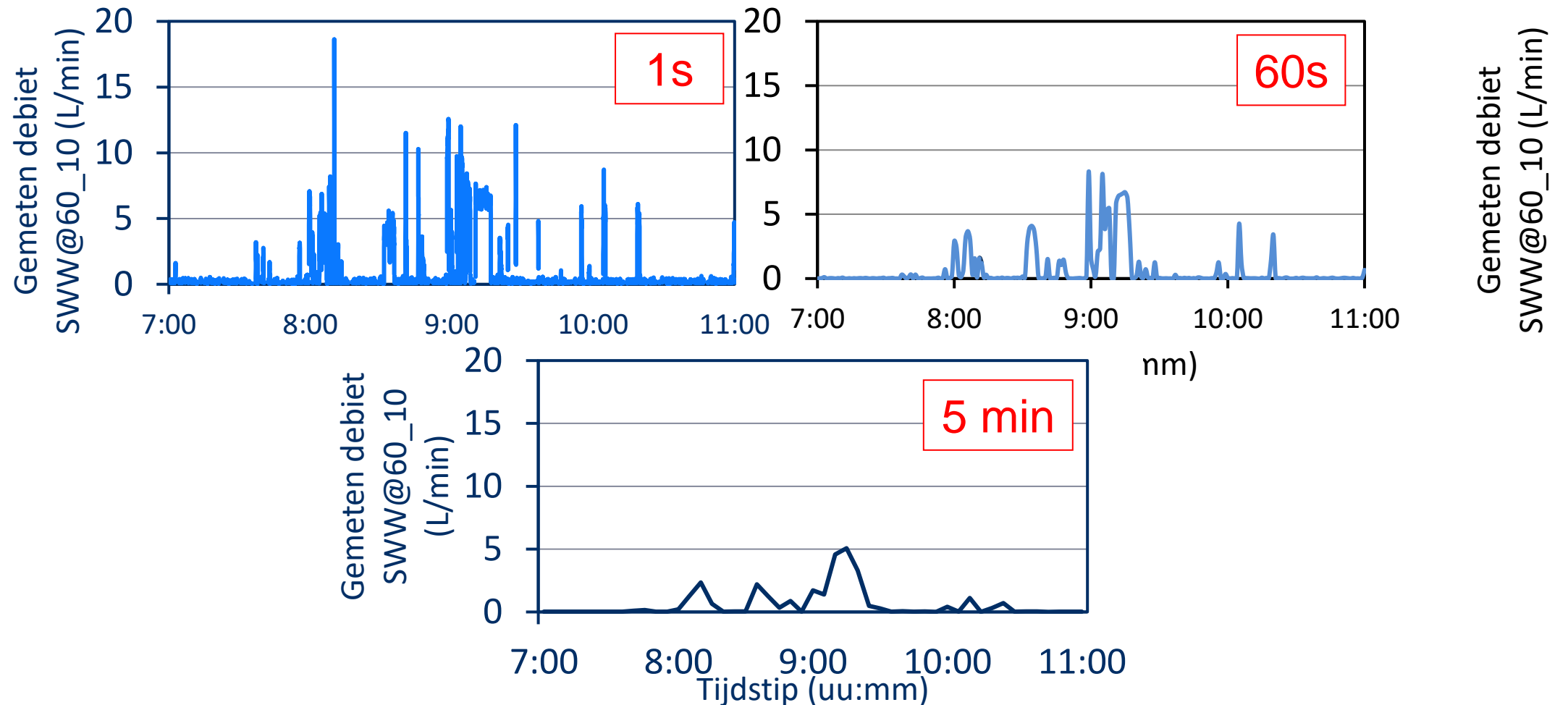
# Demand based design approach

## ■ Thermal storage

- Sensible heat – (water) reservoir
- Typical example (domestic hot water (DHW) )
  - Ref. TETRA project SWW – VIS instal2020 – COOCK SWW 2.0

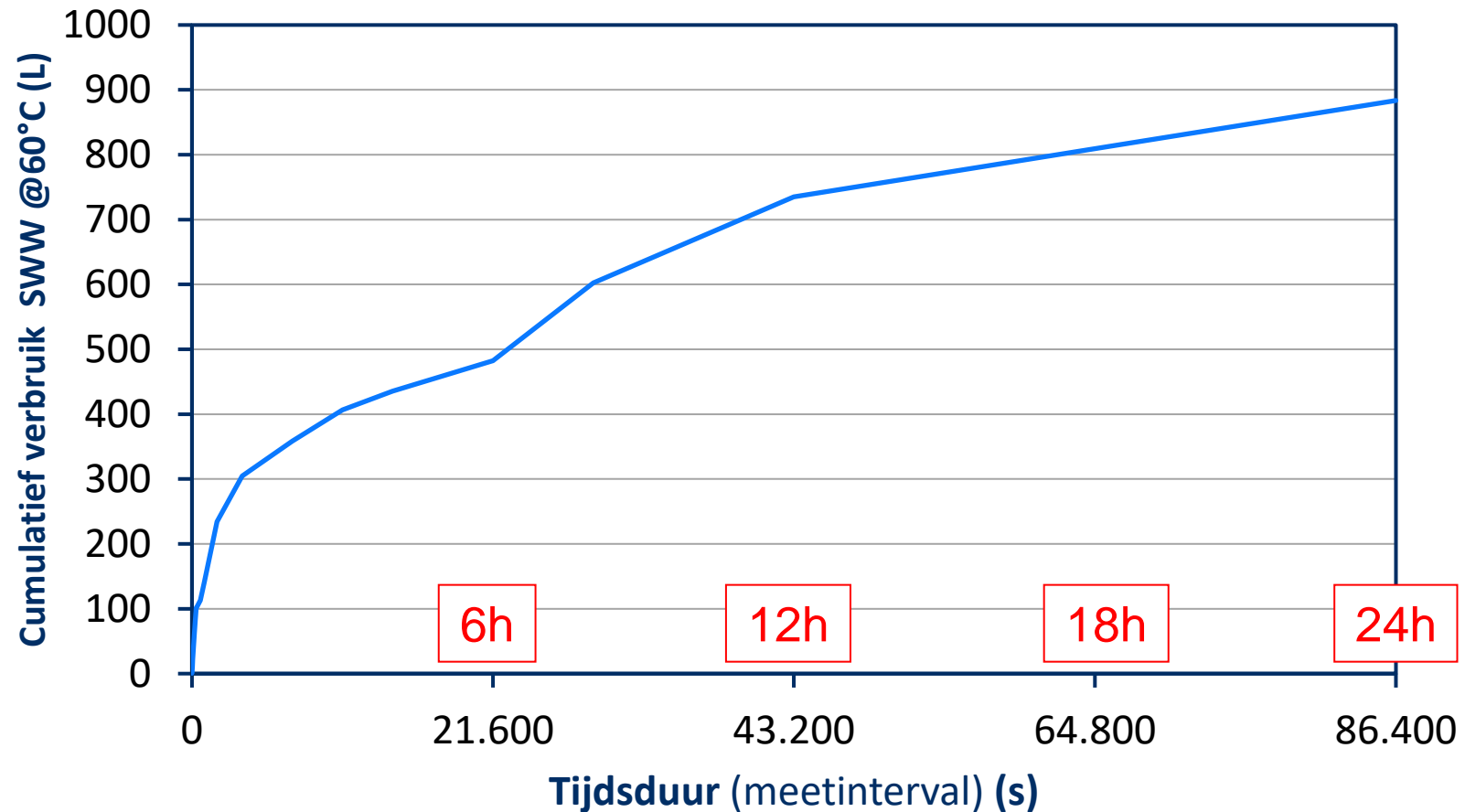


# Demand based design approach



# Demand based design approach

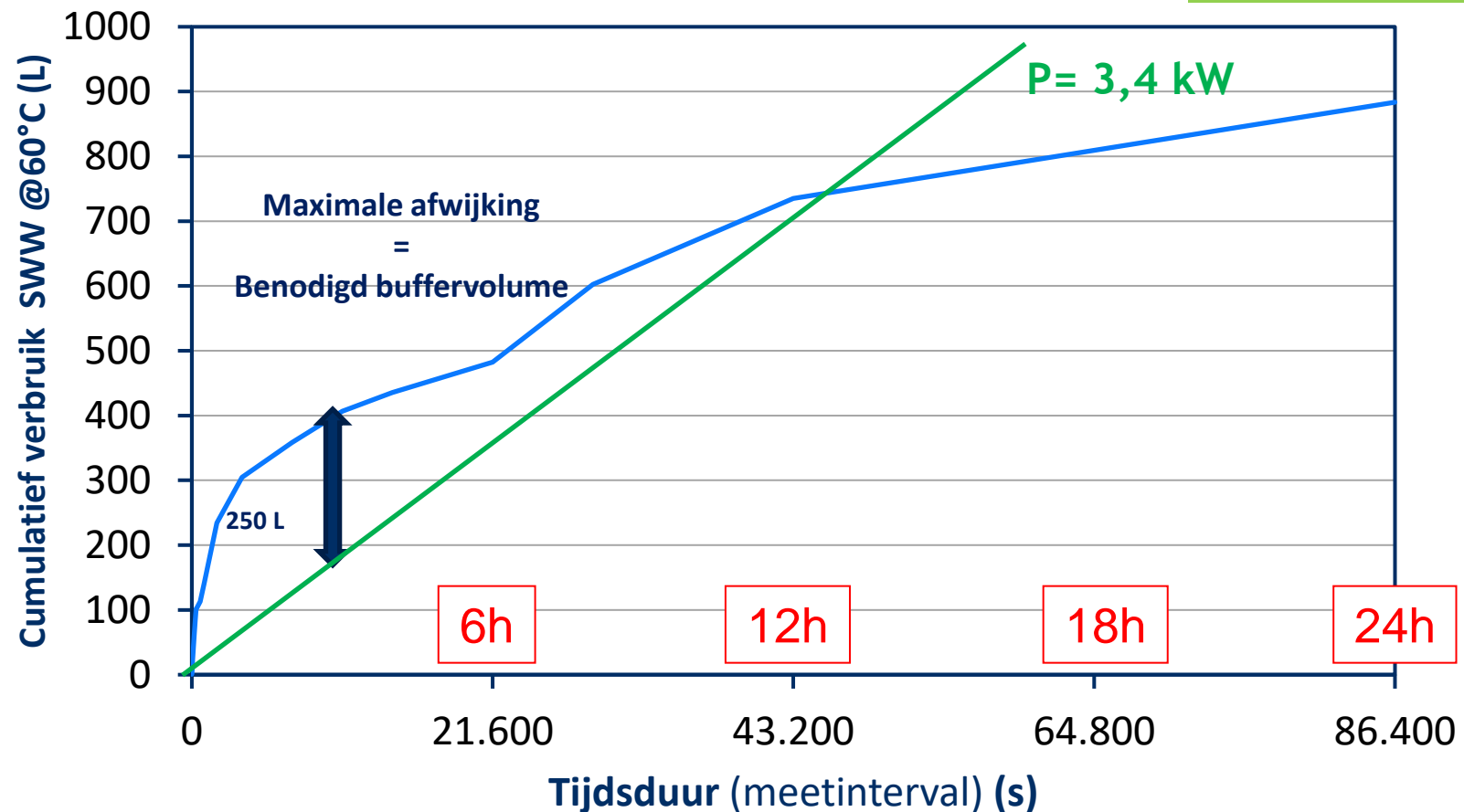
- *Maximal demand(kWh) per time interval*



# Demand based design approach

- *Maximal demand(kWh) per time interval*

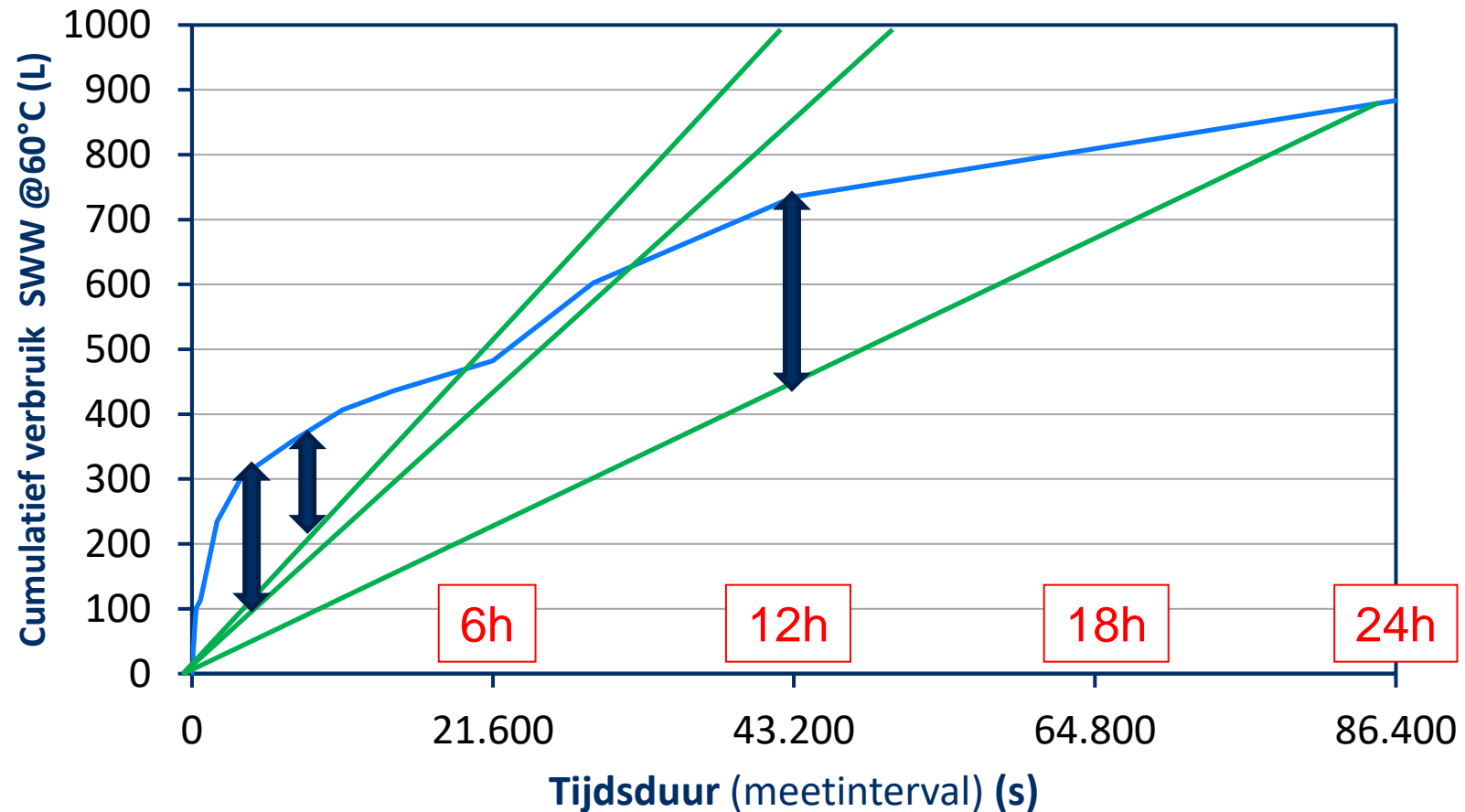
$$P_Q = \dot{V} \cdot \rho \cdot c_{\text{water}} \cdot (T_{\text{SWW}} - T_{\text{KW}})$$





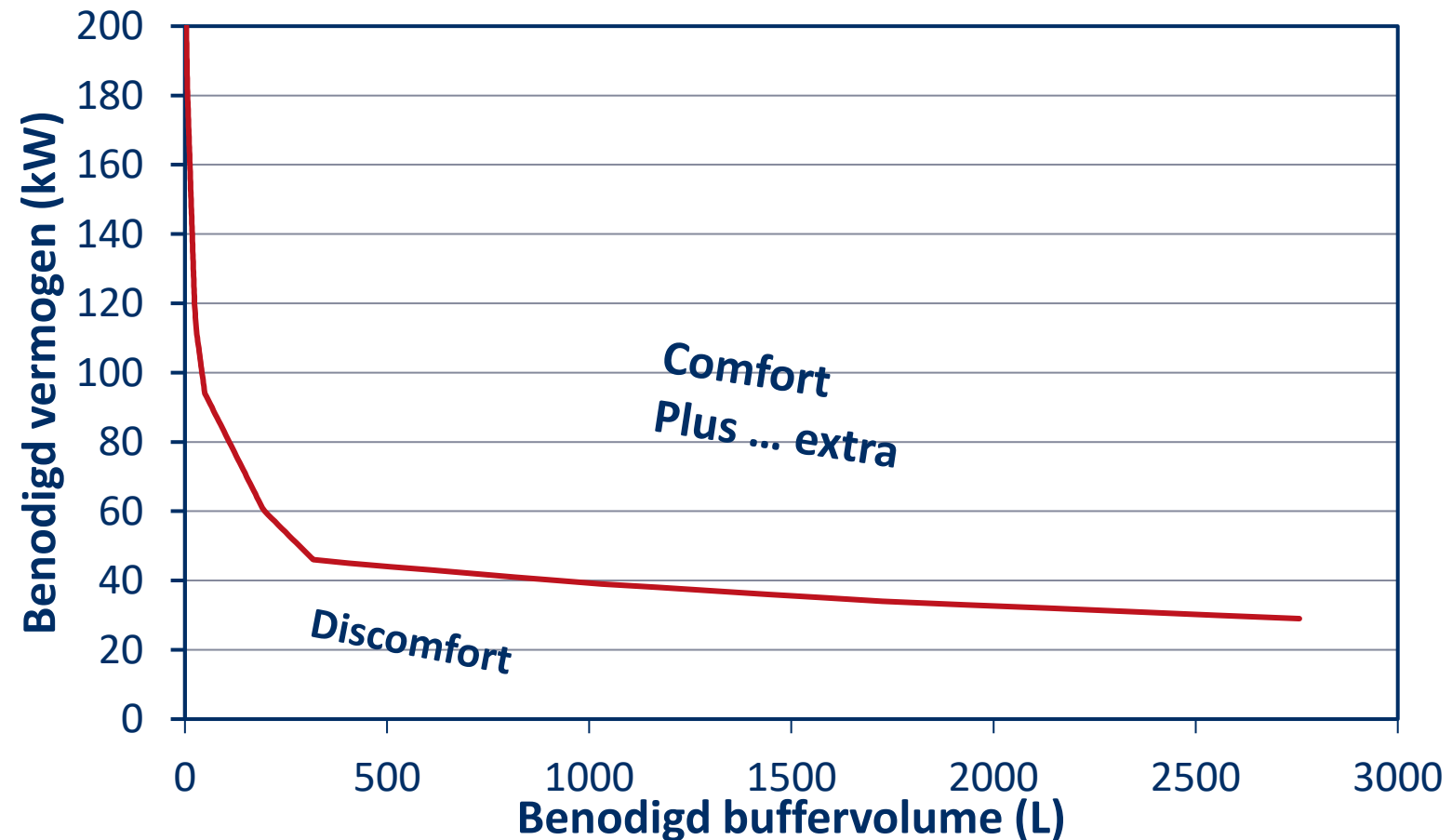
# Demand based design approach

- *Maximal demand(kWh) per time interval*



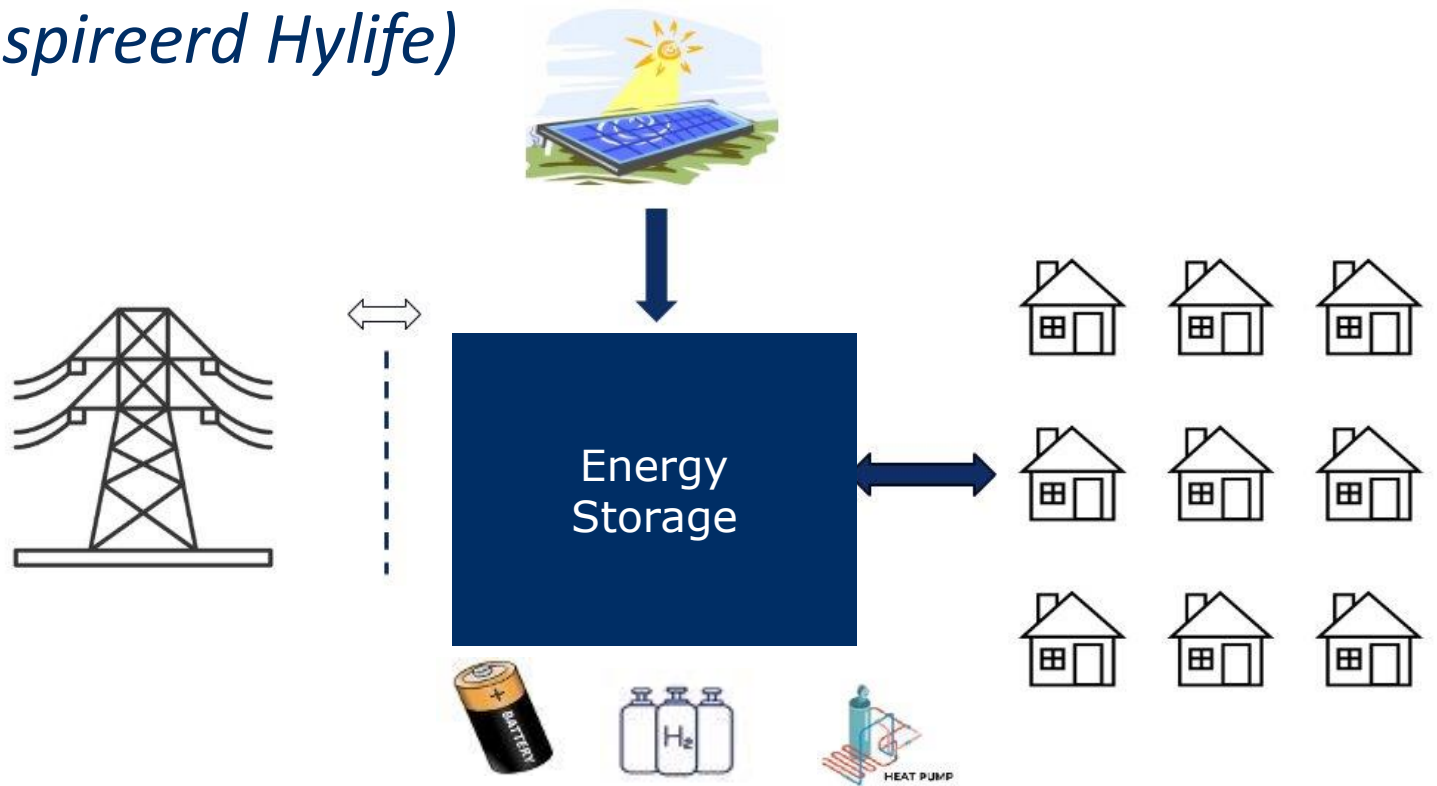
# Demand based design approach

- *Charging power vs storage (design)*



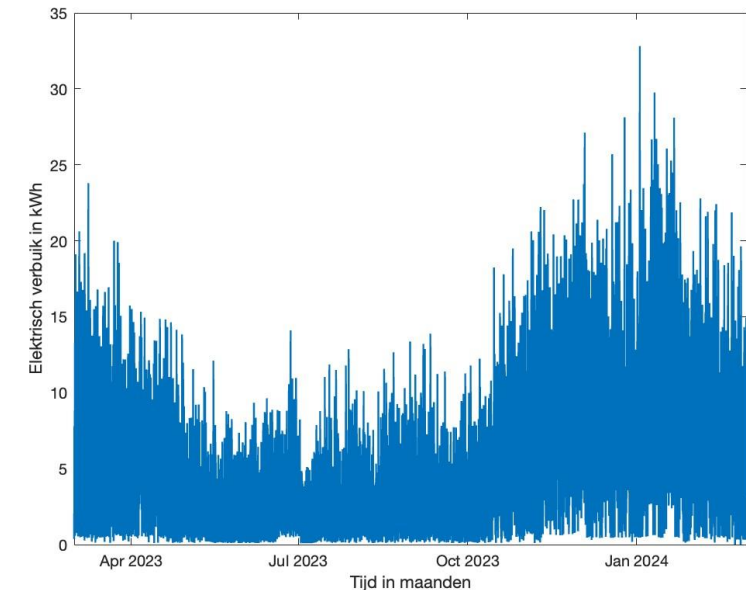
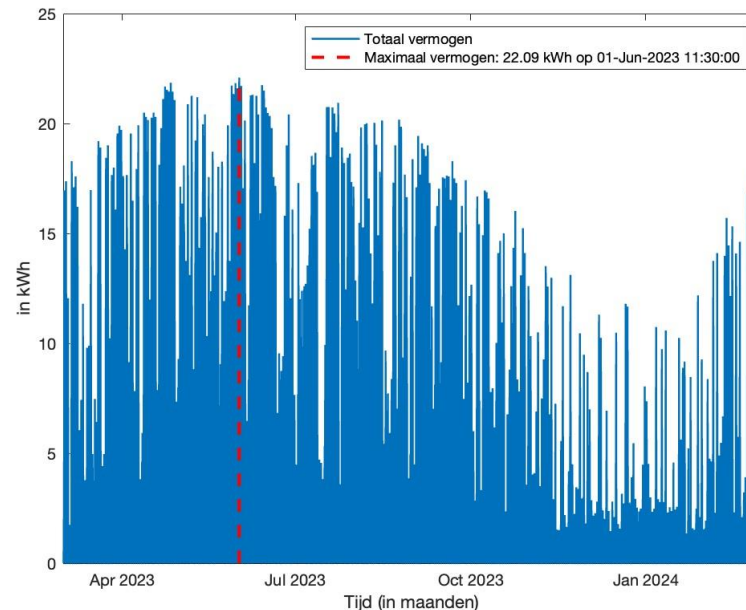
# Demand-supply based design approach

- **Electrical storage sizing**
  - *Thesis 2023-2024 (geïnspireerd Hylife)*



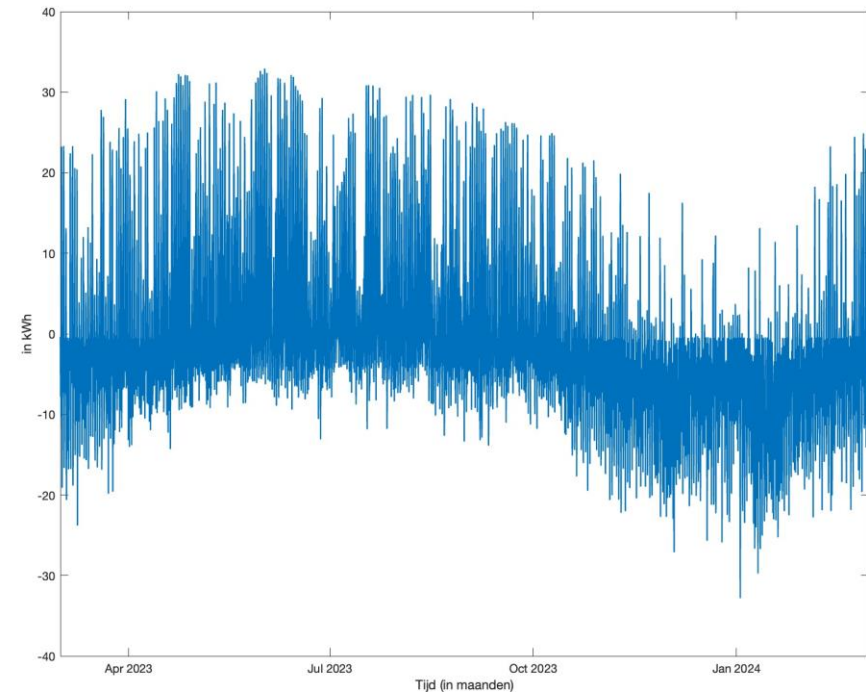
# Demand-supply based design approach

- **Electrical storage sizing**
  - *Thesis 2023-2024 (geïnspireerd Hylife)*
  - *Hourly demand & generation*



# Demand-supply based design approach

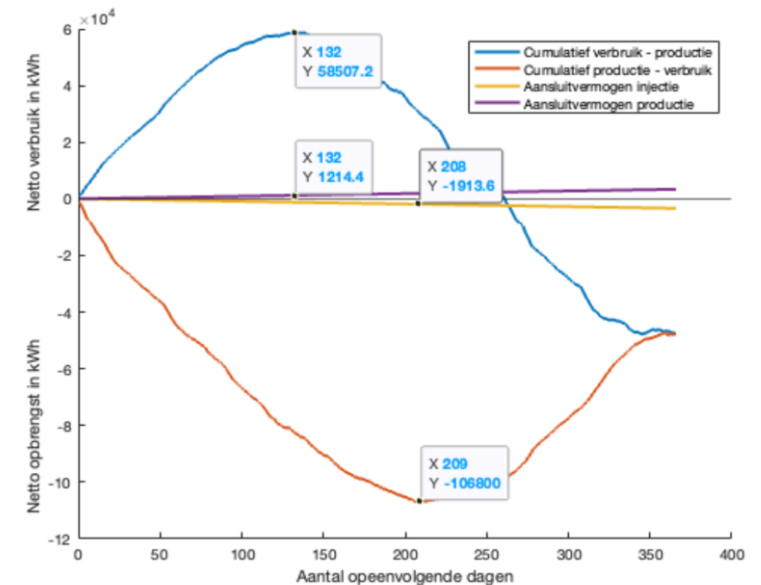
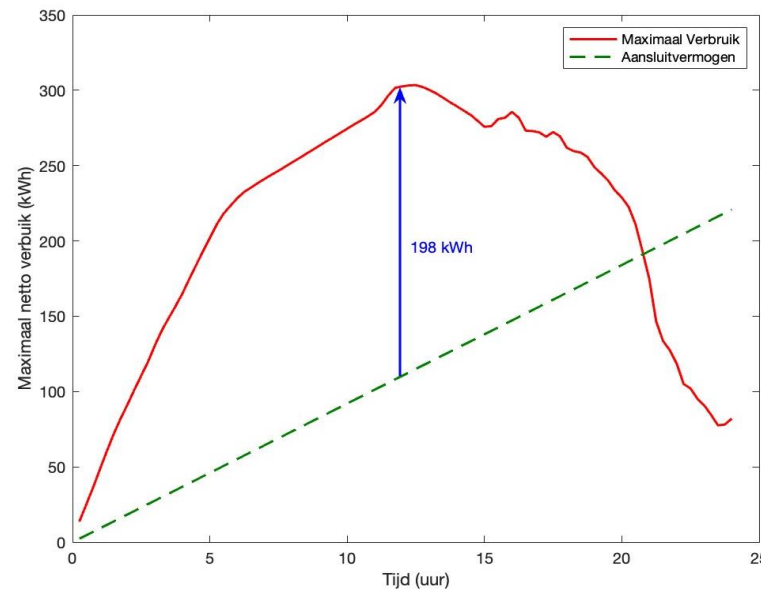
- **Electrical storage sizing**
  - *Thesis 2023-2024 (geïnspireerd Hylife)*
  - *Hourly demand & generation*





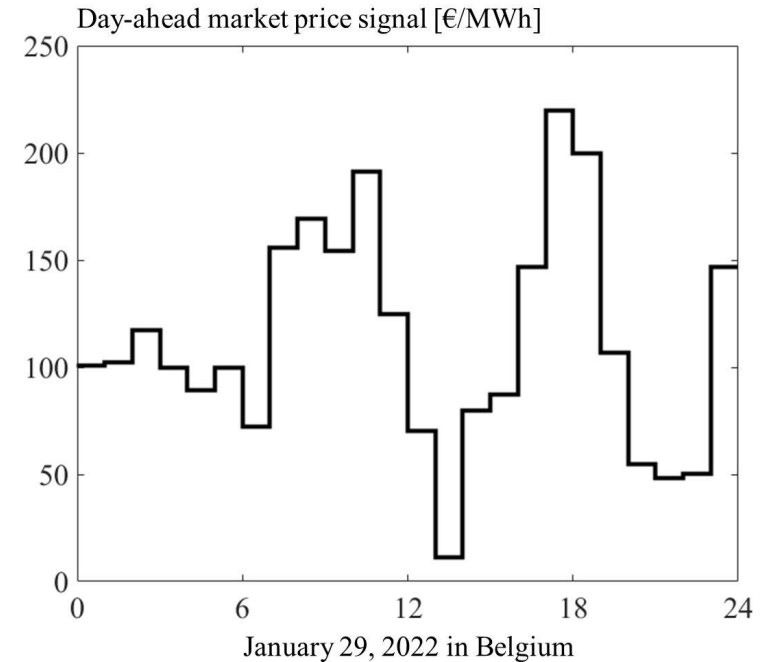
# Demand-supply based design approach

- **Electrical storage sizing**
  - *Thesis 2023-2024 (geïnspireerd Hylife)*
  - *Hourly demand & generation (scope peak shaving)*



# Identifying the design problem (part 2)

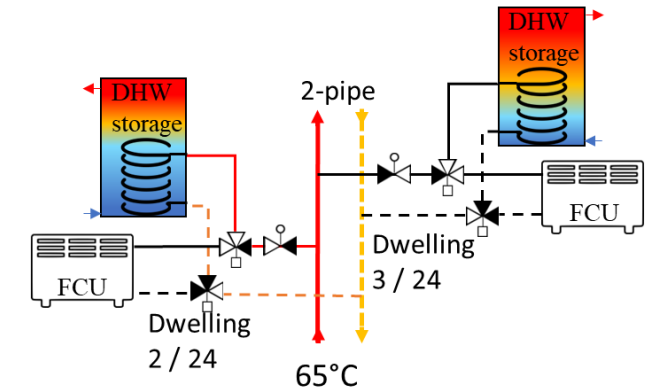
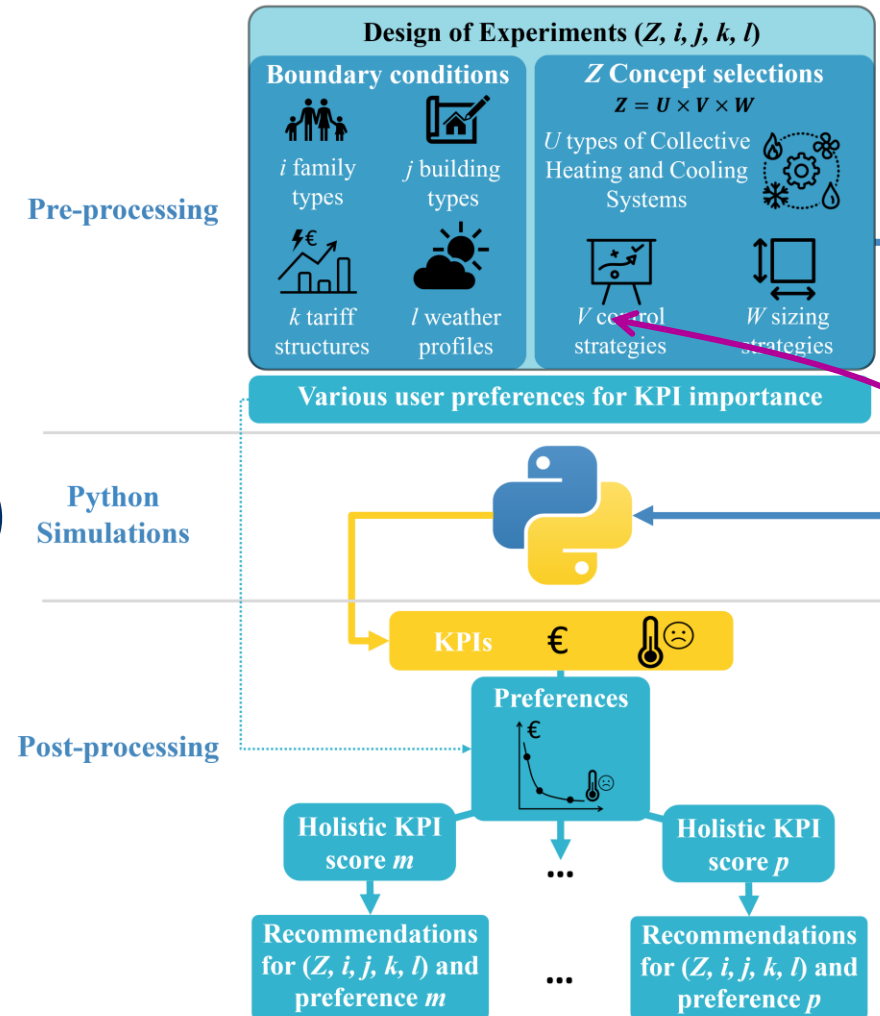
- *Production and demand profiles*
- *Defining the needs/KPI*
  - *Compact*
  - *Comfort*
  - *Opex minimization*
    - *Optimization of production*
      - *No cycling – maintenance*
      - *Low electricity tariff*
    - *Peak shaving*
  - *LCC*
  - *...*



**business model:**  
**ESCO (energy service company)**  
**VPP (virtual power plant)**

# Simulation based design & control

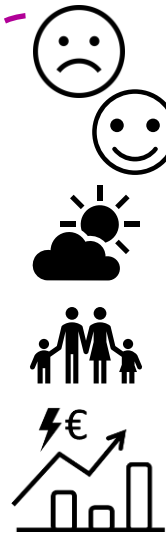
- **Storage planning**
  - Flexibility
  - Sizing
  - Layouting
- (central vs decentral)
- Impact on system



## Rule-based



## Reinforcement learning



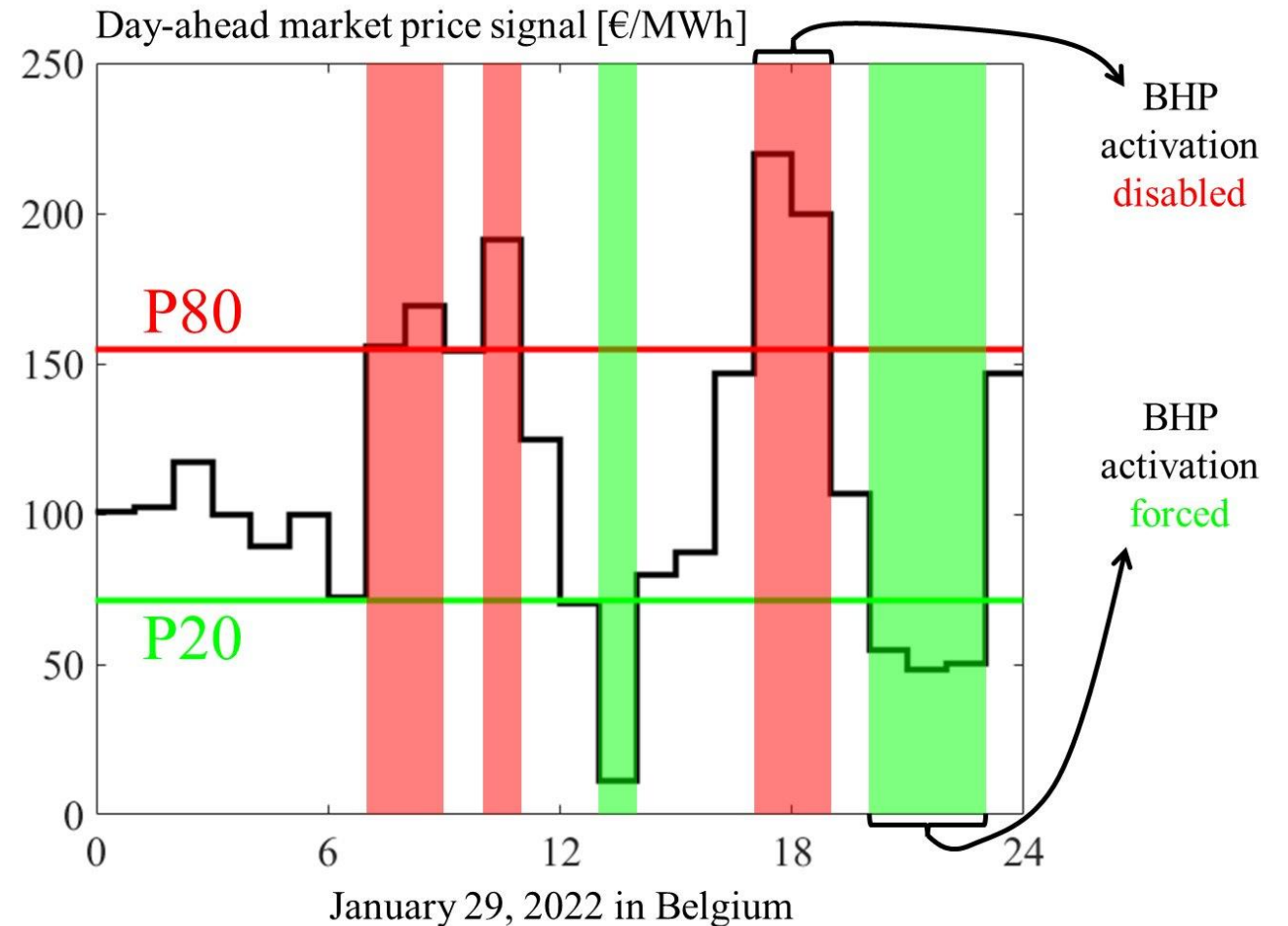
# Simulation based design & control !

- **Storage planning**

- *Results:*  
*avoiding peak hours !!*  
*~~higher use at low hours !!~~*

- **Future**

- *Impact sizing !*



# Conclusion & future plans

- *Energy exist in many forms*
- *Energy storage is no source, but comes with a cost !*
- *Different design strategies exist*

*=> Depending on application*

- *Ongoing research:*
  - *optimizing location and sizing of thermal storage in networks*



# Contact information

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