



# Stockage d'énergie dans les eaux de mine à Martelange

## *Retour sur les projets ArdNrgy et WeForming*

Vincent Lemort<sup>1</sup>, Frédéric Ransy<sup>1,3</sup>, Aitor Cendoya<sup>1</sup>, Pierre-Henri Gresse<sup>2</sup>, David Verscheure<sup>3</sup>, Jacques Windeshausen<sup>4</sup>

<sup>1</sup>*Thermodynamics Laboratory of the University of Liège*

<sup>2</sup>*Flexide Energy, Liège, Belgium*

<sup>3</sup>*Geotherm Engineering, Liège, Belgium*

<sup>4</sup>*Wingest, Bastogne, Belgium*

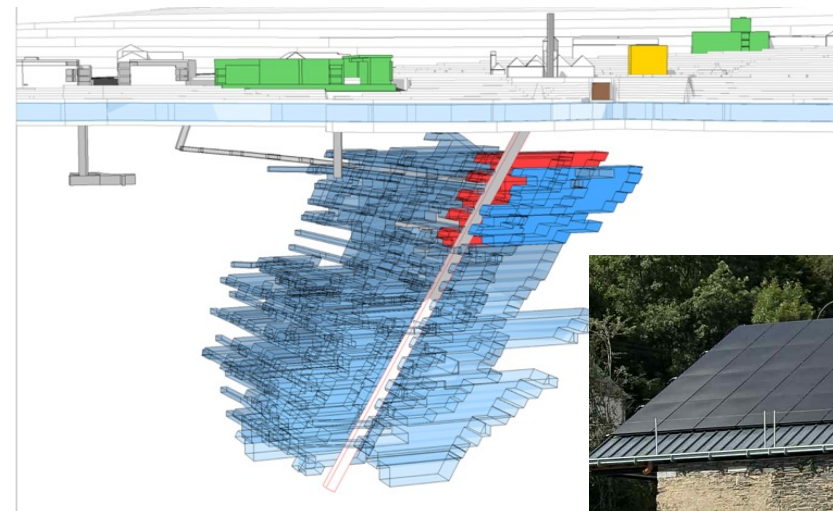
Workshop « Des matériaux aux systèmes : quelles solutions innovantes dans le stockage thermique pour répondre aux challenges des applications domestiques et industrielles ? »

Seraing, le 18 mai 2026

# Ardoisières de Martelange

## *Deux projets sur un même site*

- Slate mines in the South of Belgium
- Abandoned since the 90s
- Flooded with 500,000 m<sup>3</sup> of water = massive storage
- 12 chambers at depths between -40 and -160 m
- Residential buildings (60 apartments in 4 buildings) with heating/cooling demands (eco-neighborhood to be extended to 150 apartments, tertiary buildings, industry)
- Local electricity production: 70 kW<sub>e</sub> photovoltaic (PV) system and a 140 kW<sub>th</sub> photovoltaic-thermal (PT) collector installation

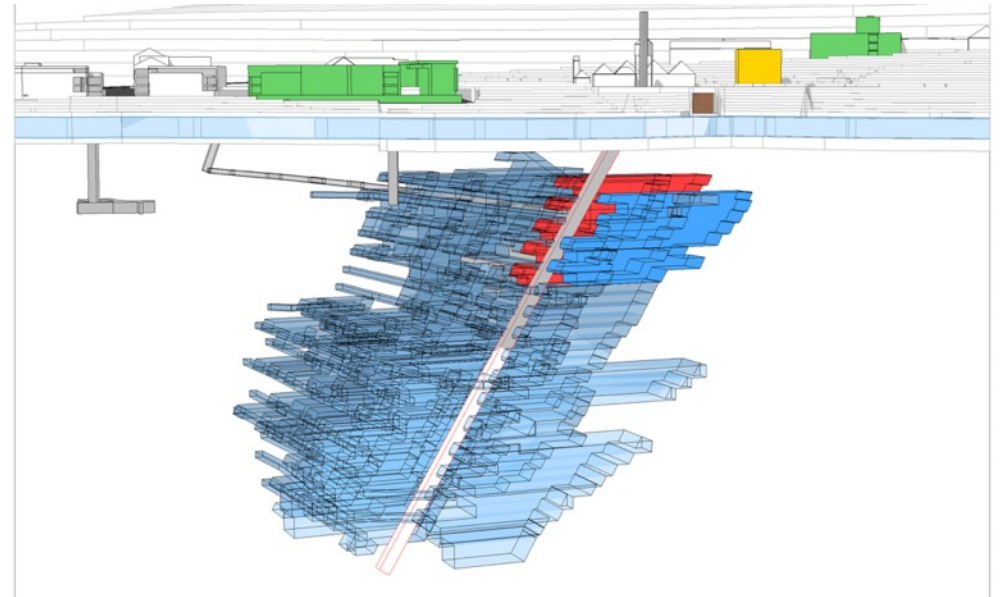


# Ardoisières de Martelange

## *Deux projets sur un même site*

### Heat and cold storage

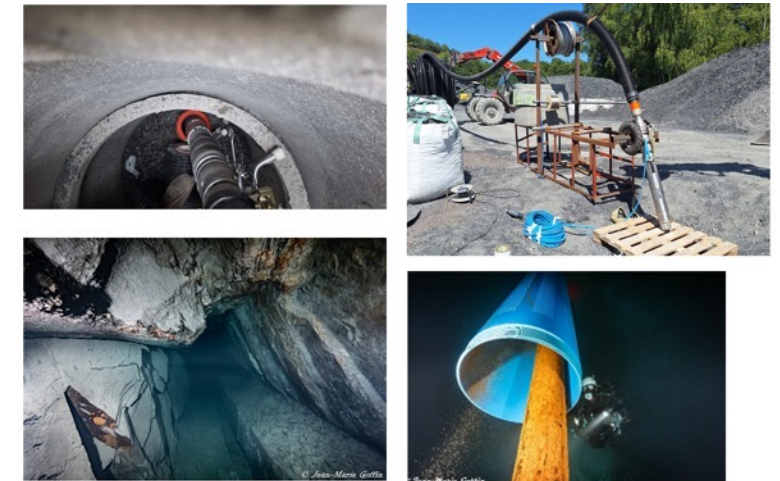
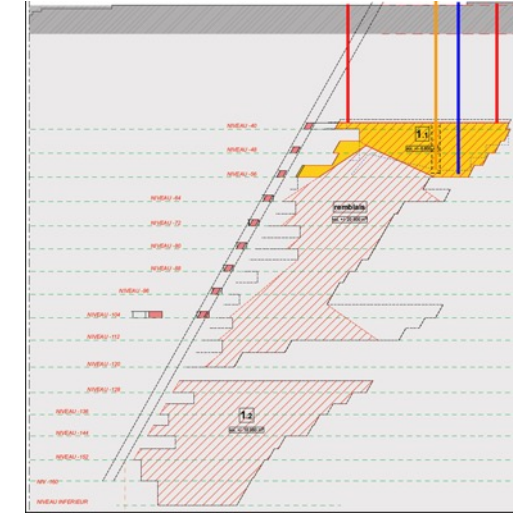
- ⇒ for covering heating/cooling demands in buildings: to increase **self-consumption** of local electricity production (water-to-water heat pump), increase energy resilience (self-sufficiency), offer services to the grid (day ahead and balancing markets) and decrease energy cost ([ArdNrgy](#))
- ⇒ for local and grid **electricity storage** (Carnot battery) ([WeForming](#))



# Ardoisières de Martelange

## *Description du démonstrateur de stockage thermique souterrain*

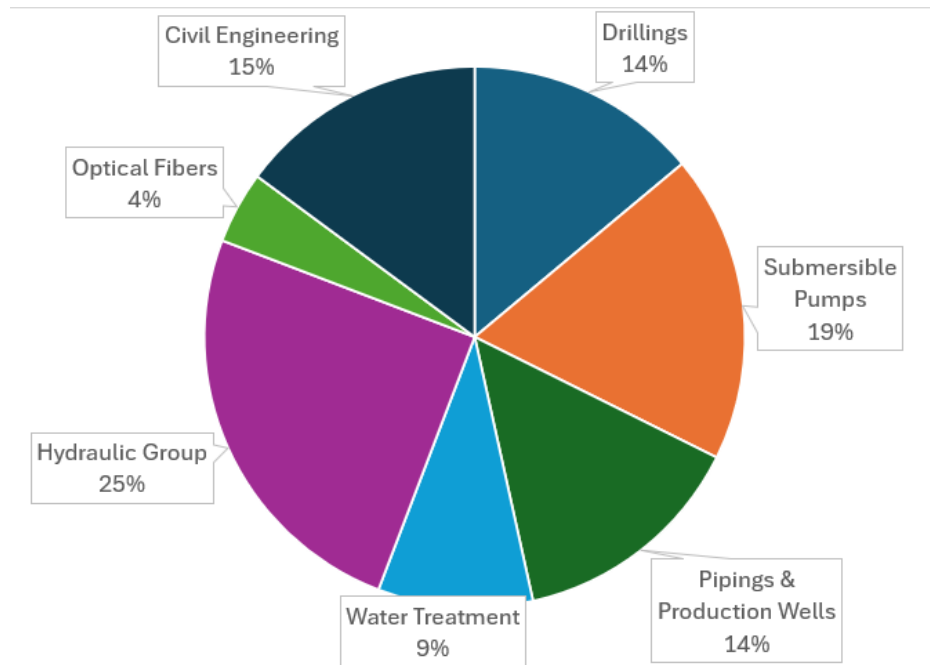
- Chamber considered for storage (closest to the surface):
  - 27200 m<sup>3</sup> according to historical plans
  - Because of waste dumped into the cavity: actual volume is 6500 m<sup>3</sup>
- 4 vertical boreholes:
  - 2 to extract hot water from the top of the cavity
  - 1 to extract water from the bottom
  - 1 in the middle to return hot or cold water (with a diffusion system for stratification)
- Submersible pumps to rout water to a technical building
- Plate heat exchanger to decouple mine water from overground water
- Optic fiber installed to measure water and rock temperature



# Ardoisières de Martelange

## *Coût du stockage thermique*

- Relative cost of 52 EUR/m<sup>3</sup> (could be decreased to 13 EUR/m<sup>3</sup> if 27200 m<sup>3</sup> were available)

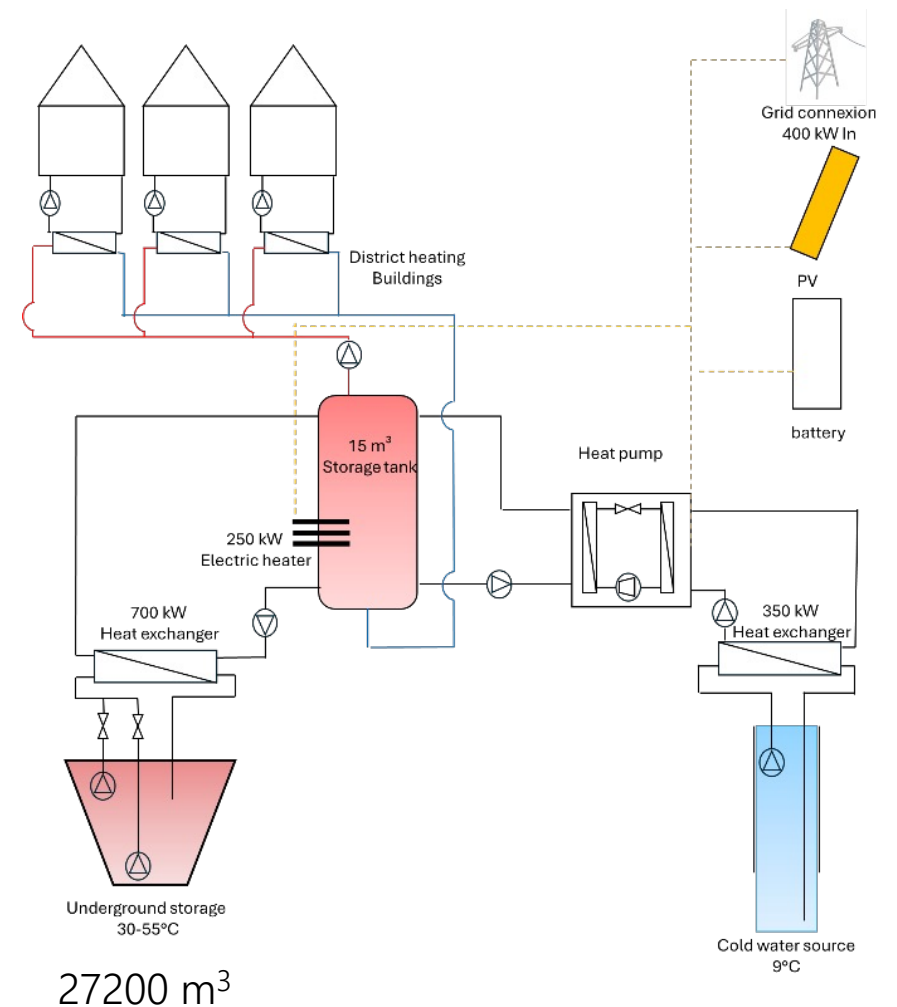


# Stockage thermique pour le chauffage (ArdNrgy)

## *Simulation du système énergétique*

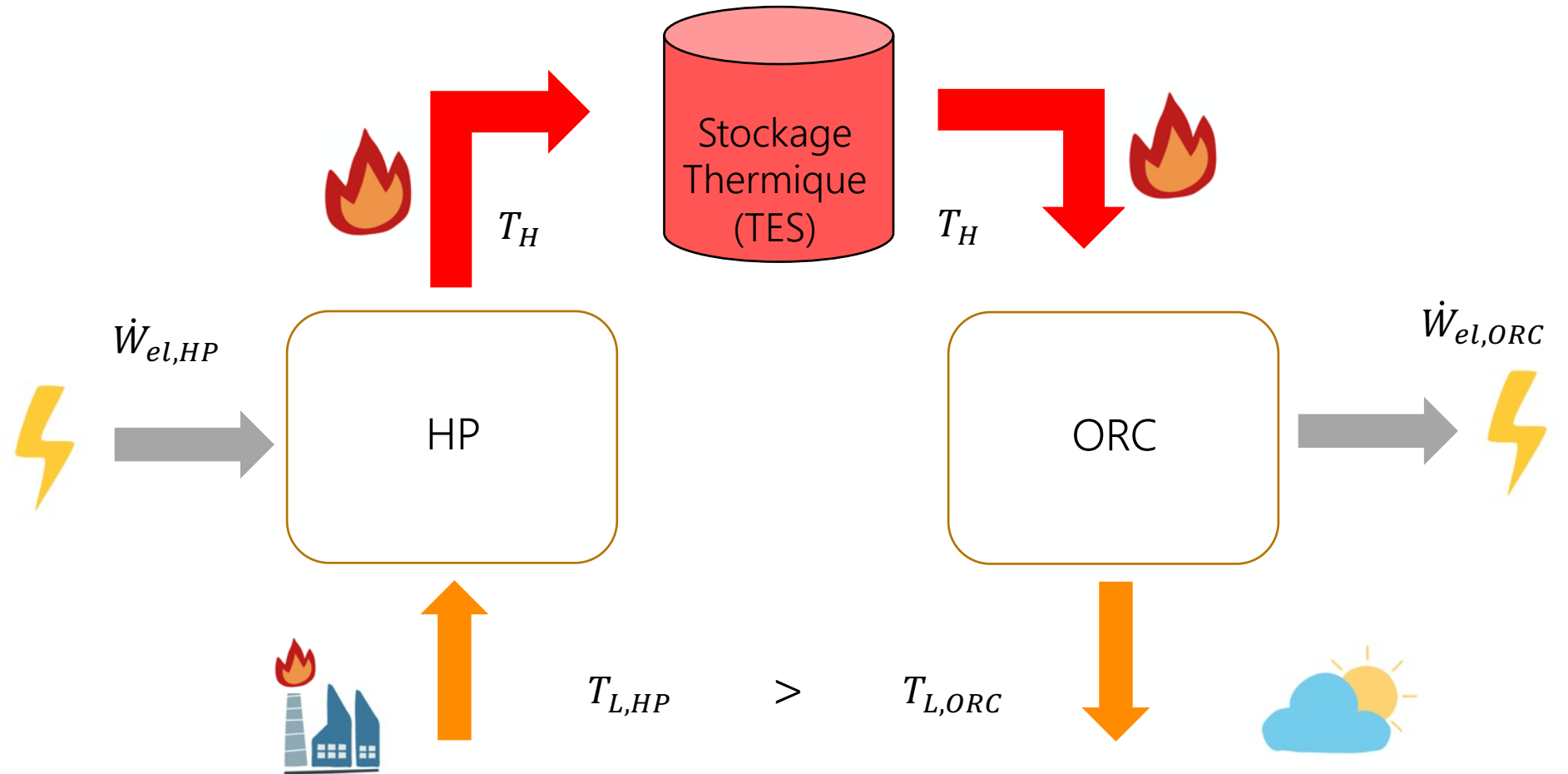
- 12 buildings of 13 apartments (underfloor heating: 35:25°C)
- HP capacity: 450 kW; PV panels: 200 kWp; battery: 120 kWh
- Underground storage: 27200 m<sup>3</sup>

$Q_{buildings}$ [MWh]	1140
$W_{load}$ [MWh]	439
$W_{pv}$ [MWh]	175
$W_{grid}$ [MWh]	265
SPF [-]	2.6
SCR [%]	100
SSR [%]	40
CAPEX [€/MWh]	98
OPEX [€/MWh]	85
COE [€/MWh]	183
$Q_{sto,in}$ [MWh]	948
$Q_{sto,out}$ [MWh]	647
$\varepsilon_{sto}$ [%]	68



# Stockage électrique par batterie de Carnot (WeForming)

*Principe de fonctionnement d'une BC*



*Valorization of waste heat  
or solar heat*

# Stockage électrique par batterie de Carnot (WeForming)

## Description du système énergétique

TI-Carnot battery

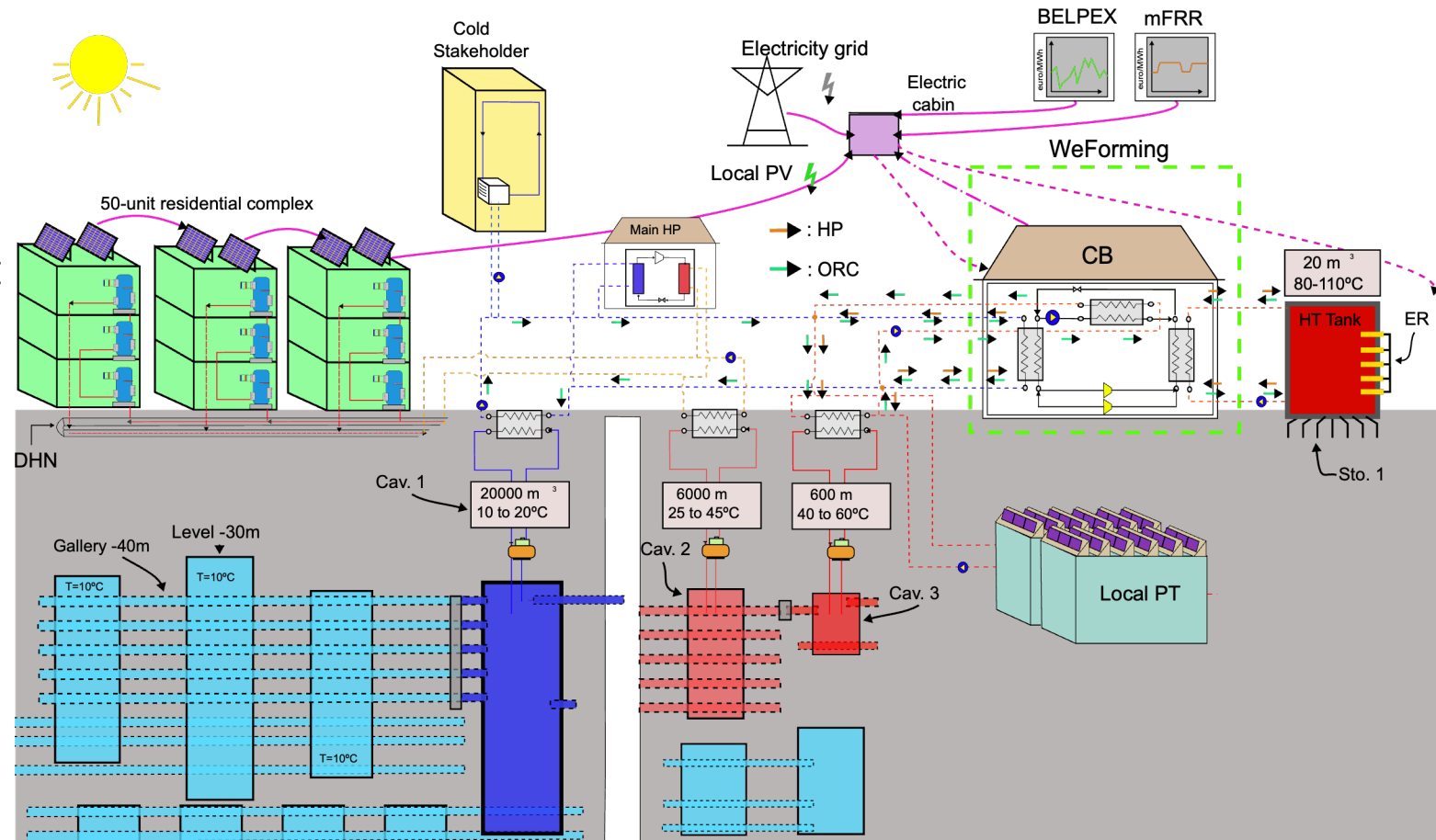
- 20 m<sup>3</sup> overground tank at 80-110°C (difficulty to find a submersible pump).

- 600 m<sup>3</sup> underground chamber at 40-60°C : PVT or industrial waste heat (40-60°C).

C/H demands

- 20000 m<sup>3</sup> underground chamber at 10-20°C : produced by main heat pump; natural generation.

- 6000 m<sup>3</sup> underground chamber at 25-45°C : produced by main heat pump.

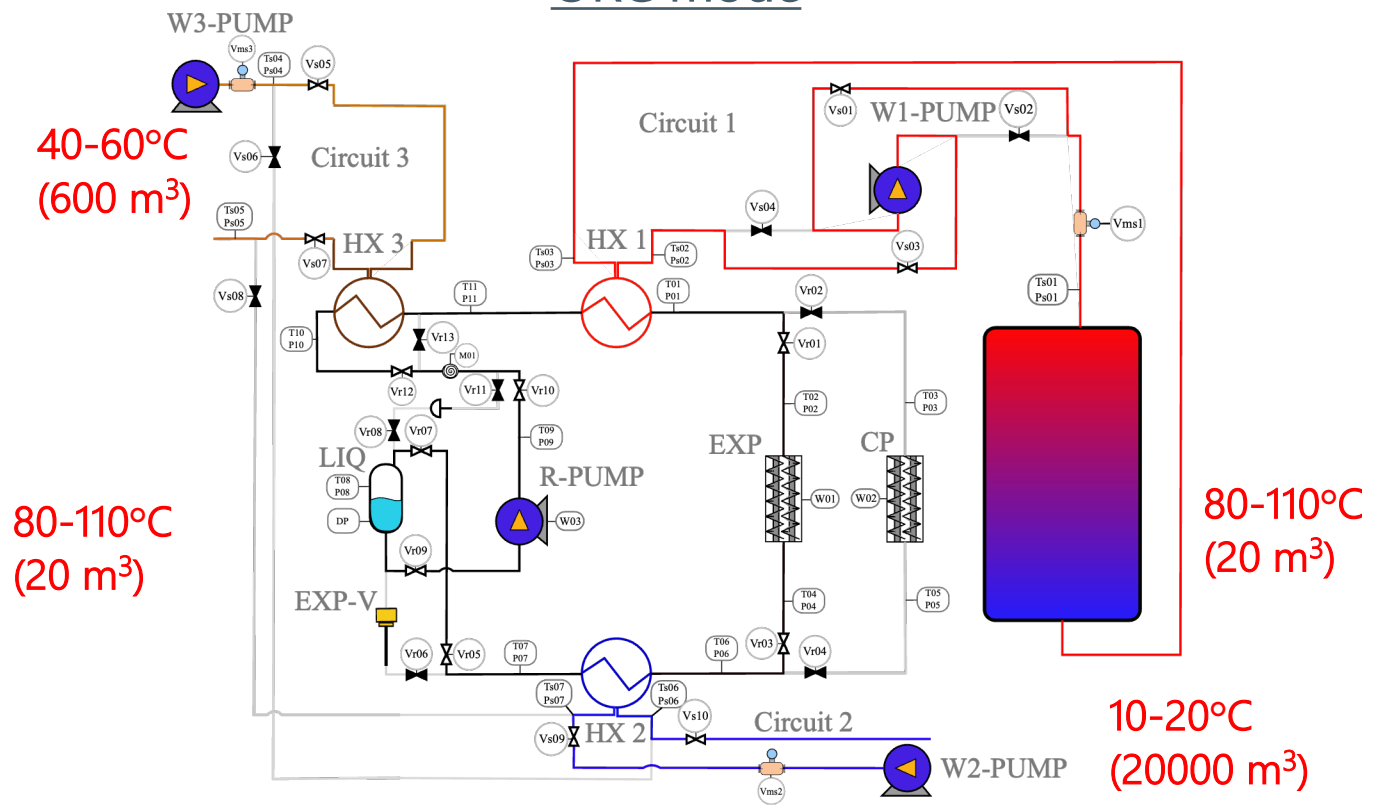
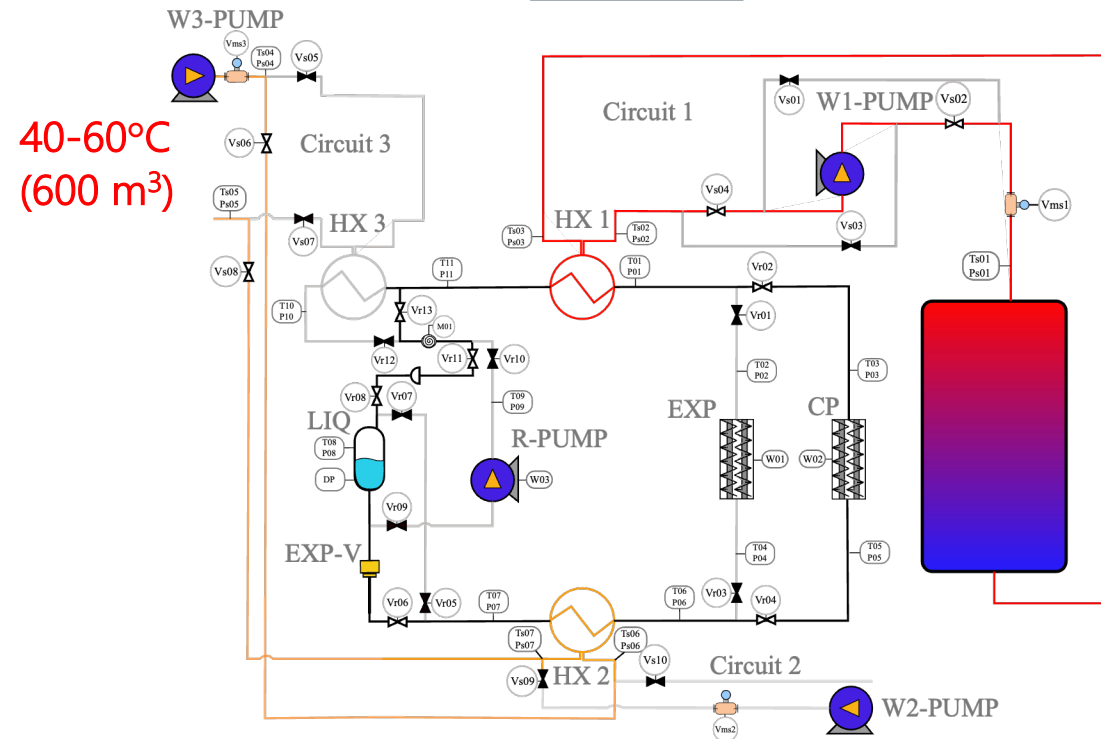


# Stockage électrique par batterie de Carnot (WeForming)

Prototype de machine semi-réversible de 500 kWth (HP) et 50 kW<sub>e</sub> (ORC)

HP mode

ORC mode

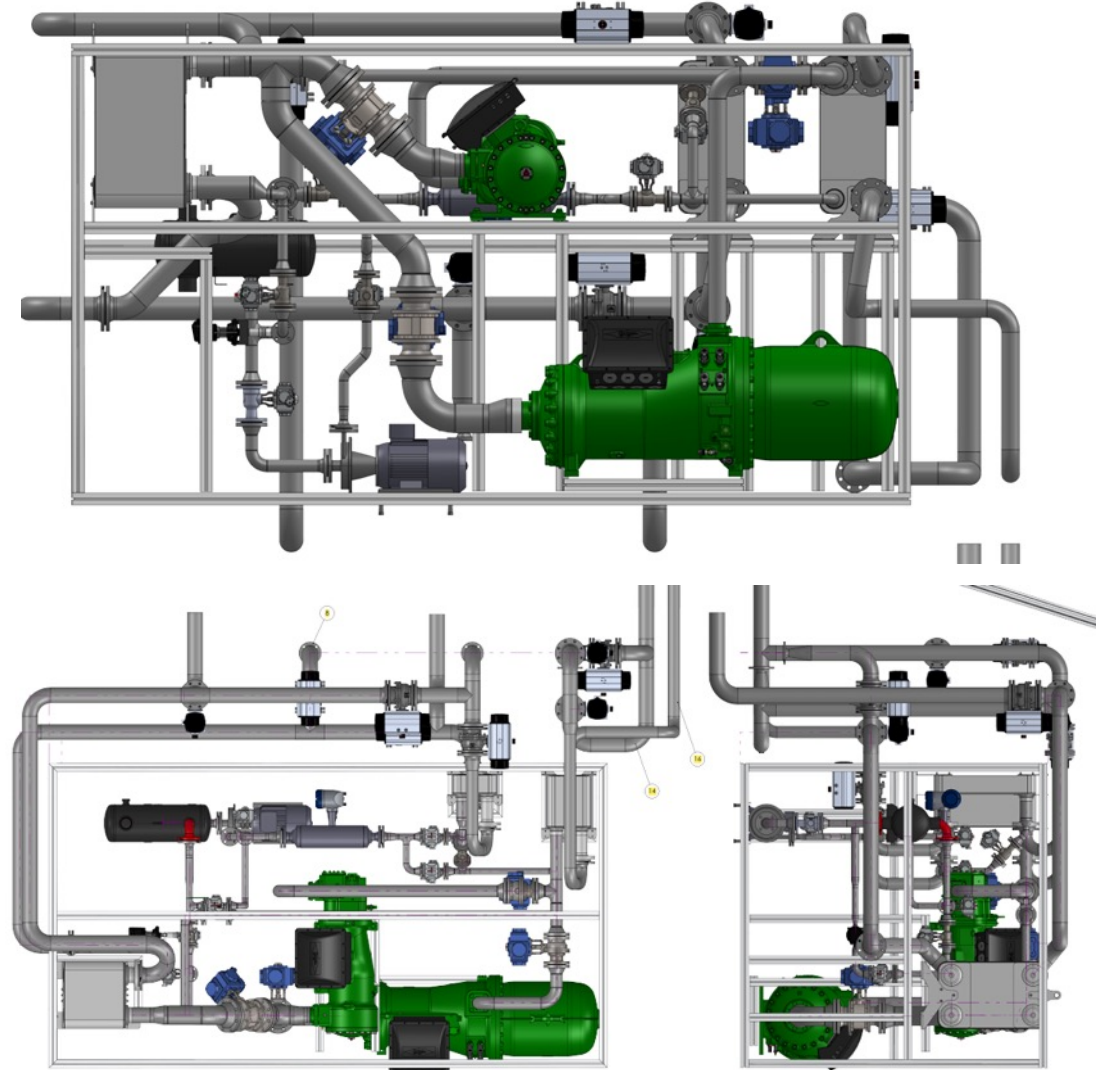
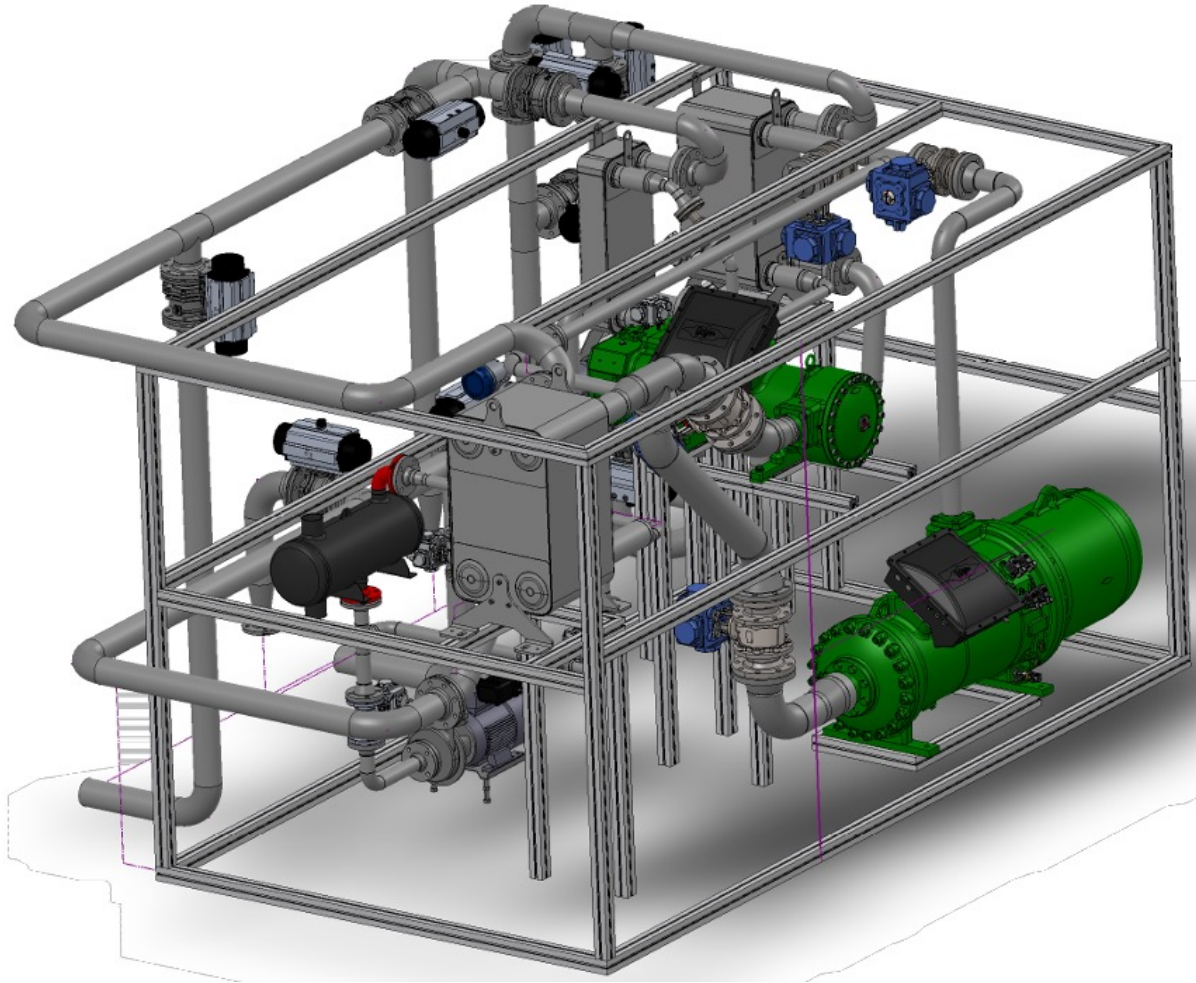


- Semi-reversible: dedicated compressor and expander. All other components are shared
- R1233zd(e)

	: On/Off Valve		: Screw compressor/expander		: Sight glass		: Water T&P sensors
	: Centrifugal pump		: Liquid receiver		: Refrigerant T&P sensors		: Water fluid valve
	: Expansion valve		: Coriolis mass flow meter		: Refrigerant mass flow meter		: Water flow meter
	: Heat Exchanger		: Electromagnetic flow meter		: Refrigerant valve		: Watt meter

# Stockage électrique par batterie de Carnot (WeForming)

*Prototype de machine semi-réversible*



# Stockage électrique par batterie de Carnot (WeForming)

*Prototype de machine semi-réversible*



# Stockage électrique par batterie de Carnot (WeForming)

*Prototype de machine semi-réversible*



*Installation à Martelange (mars-mai 2026)*

# Stockage électrique par batterie de Carnot (WeForming)

## Simulation

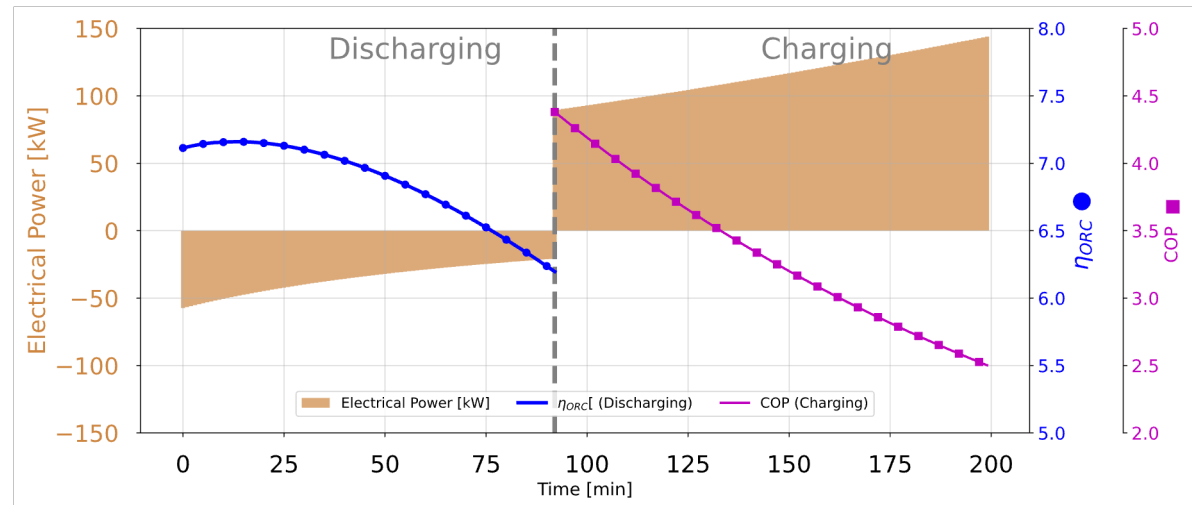
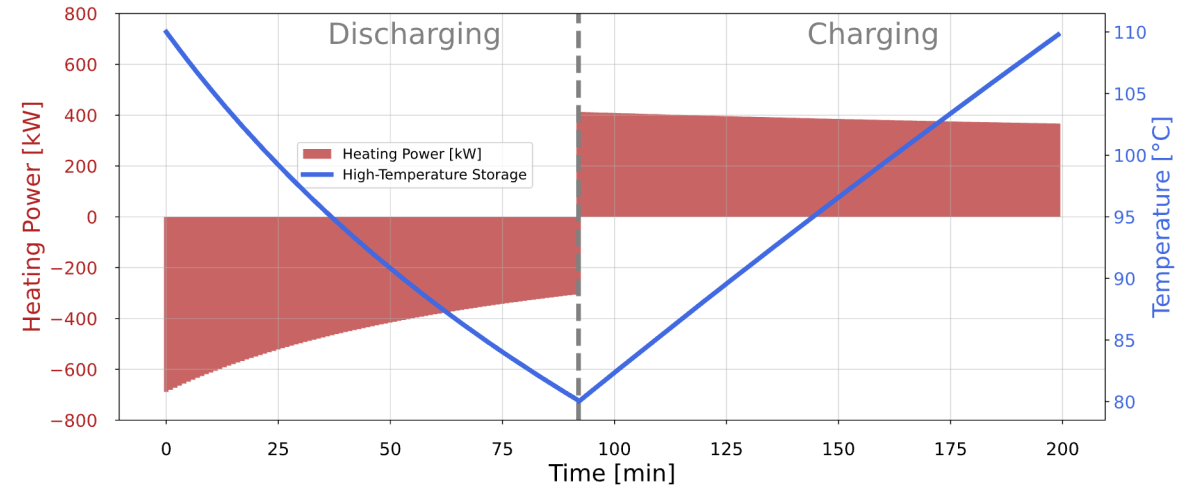
- overground 20 m<sup>3</sup> hot storage:
  - SOC=100% at 110°C
  - SOC=0% at 80°C
- No modeling of the stratification (fully mixed)
- ORC efficiency: 7.12% to 6.20%
- Heat pump COP: 4.38 to 2.50

$$\eta_{P2P} = \frac{\int_{\tau_{ini}}^{\tau_{dis}} E_{net,ORC} d\tau}{\int_{\tau_{dis}}^{\tau_{char}} E_{net,HP} d\tau} = 22.64\%$$

- Includes the consumption of **auxiliaries**
- Could be increased by integrating larger-grade waste heat or decreasing the storage temperature (CB "degenerates", large volumes for storing the same electricity, consider LCOS)

93 minutes

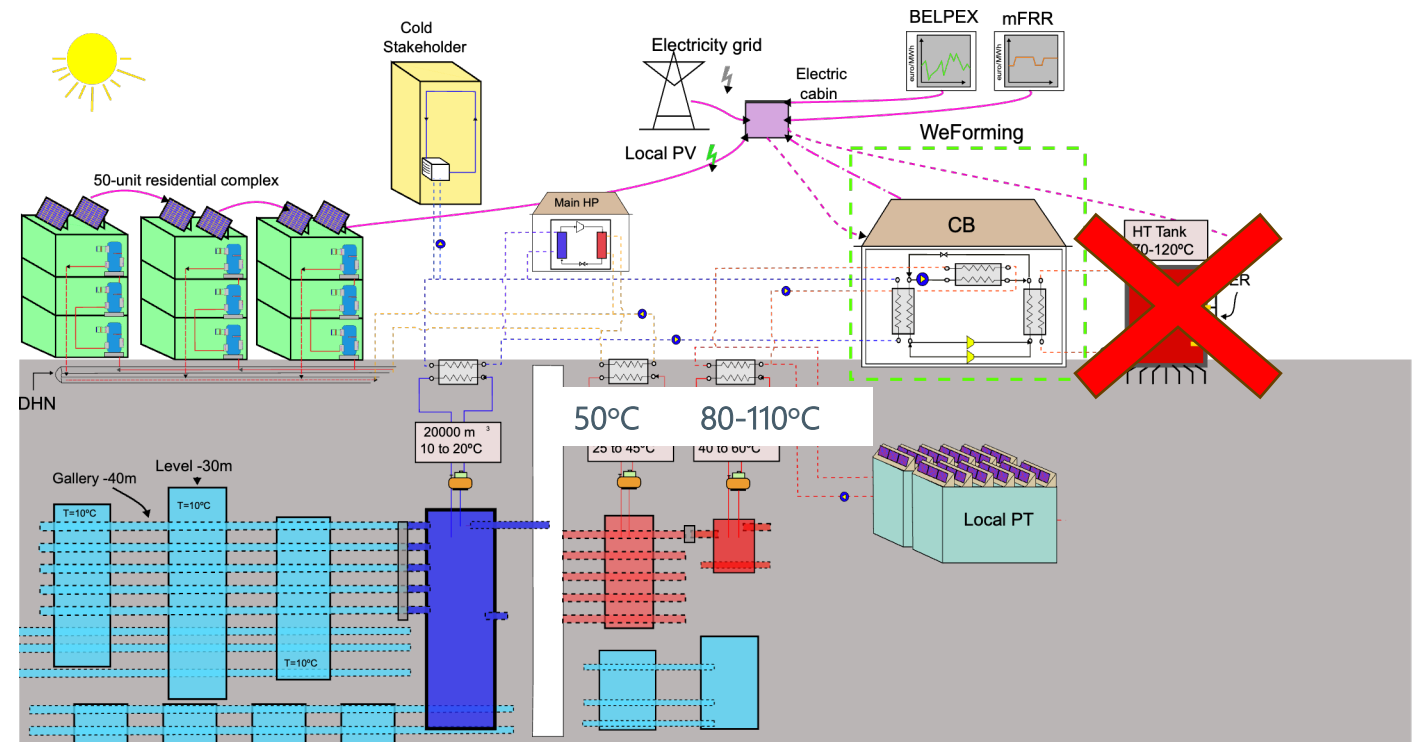
108 minutes



# Stockage électrique par batterie de Carnot (WeForming)

## Simulation

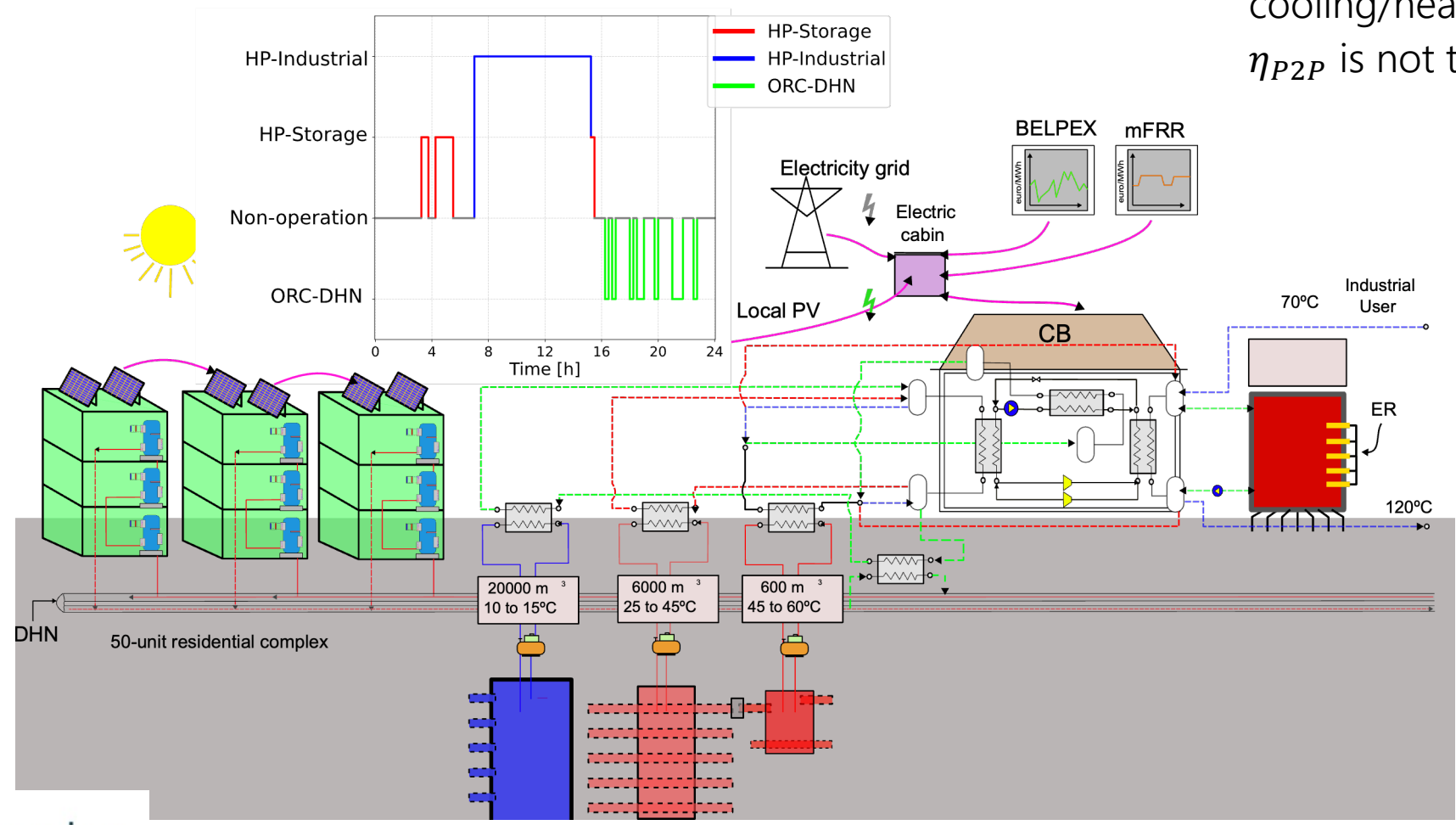
- Storing higher temp heat in the 600 m<sup>3</sup> chamber
- discharging and charging times of 46.5 and 54.2 hours, respectively, with a RTE of 24.34%.
- need specific pump.



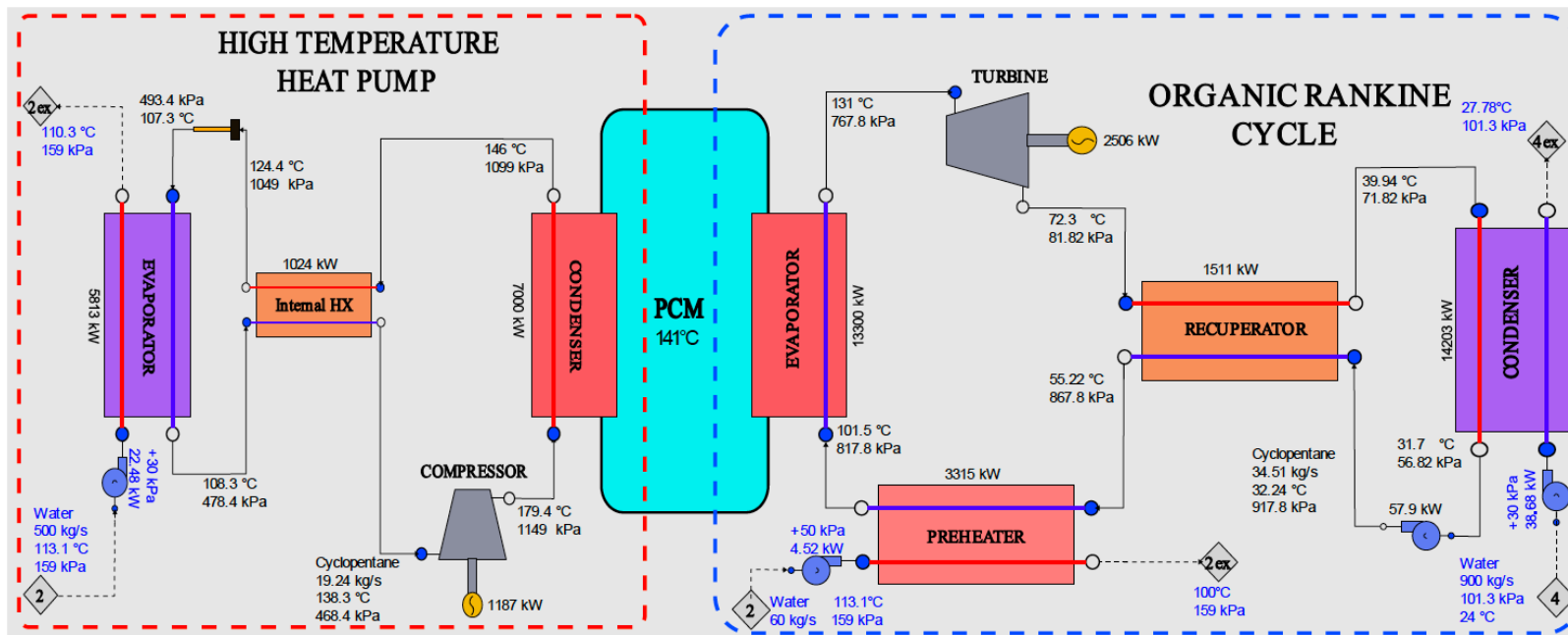
# Stockage électrique par batterie de Carnot (WeForming)

## Simulation

- If the system provides heating to an industrial process or cooling/heating to buildings, the  $\eta_{P2P}$  is not the good KPI.



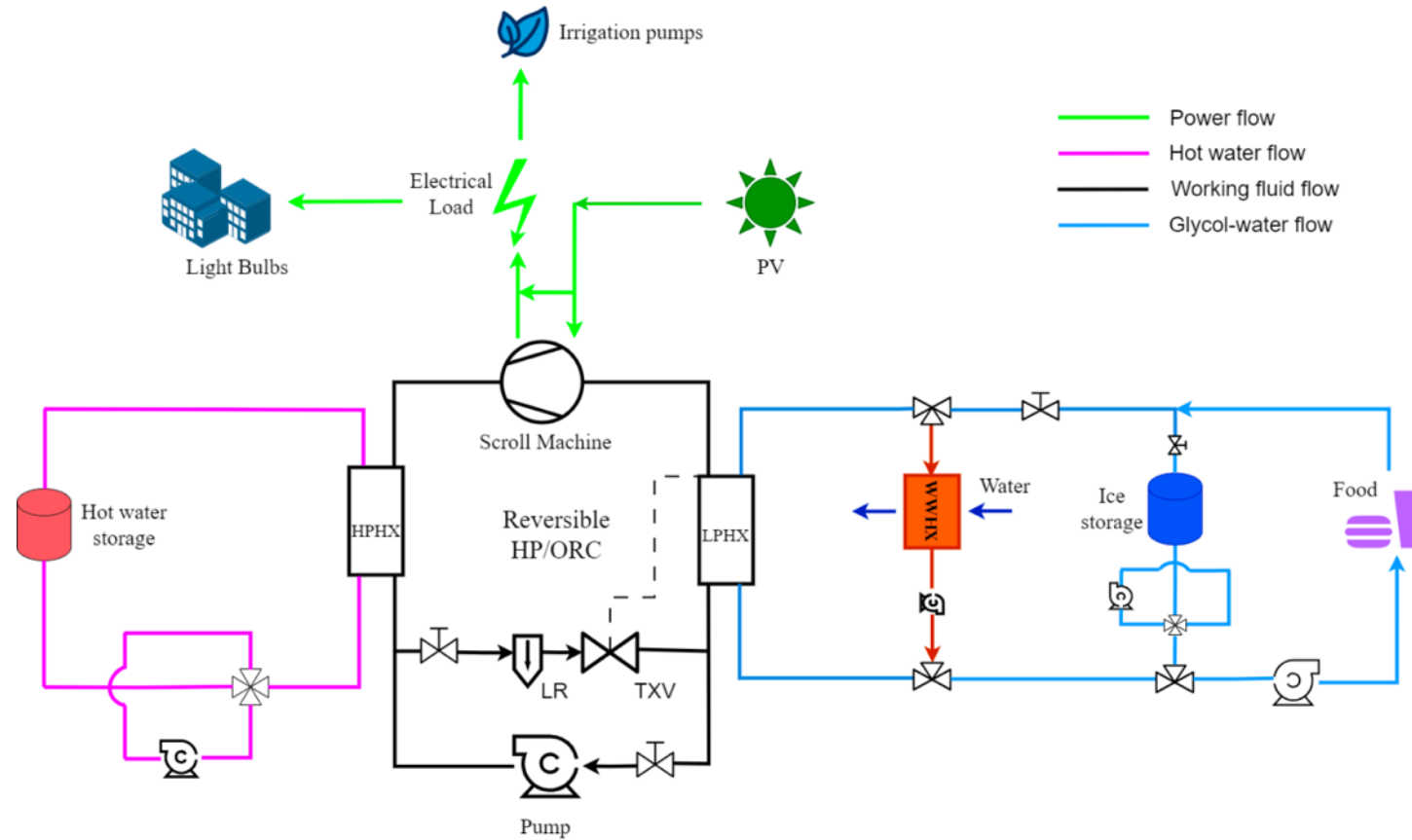
# Utilisation du stockage latent dans les batteries de Carnot



- PCM: erythritol (sugar alcohols)
- $T_{melt} = 117-119$
- PCM tank: Kelvin-cell lattice structure + 300 kg PCM
- High temperature heat pump prototype of 10-20 kWth

# Utilisation du stockage latent dans les batteries de Carnot

- o Ice thermal storage can be used for covering **cooling** demand: case study of an off-grid Nigerian farm



Source: B. Guo and V. Lemort. « Designing of an off-grid reversible heat pump/organic rankine cycle system for electricity and cooling demands of a nigerian family farm. » In *37th International Conference on Efficiency, Cost, Optimization, Simulation and Environmental Impact of Energy Systems*. ECOS2024, 2024.

# Many thanks for your attention!

[vincent.lemort@uliege.be](mailto:vincent.lemort@uliege.be)

The contributors to this presentation would like to acknowledge the funding provided by the European Union's Horizon Research and Innovation program under grant agreement No. 10112355, in the framework of the WeForming project. They also would like to acknowledge the funding provided by the Walloon Region of Belgium in the framework of the ARDNrgy project.



The WeForming project has received funding from the European Union's Horizon Europe Programme under the Grant Agreement No. 101123556.



The UK participant is co-funded by UKRI.