SCORES

SELF CONSUMPTION OF RENEWABLE ENERGY BY HYBRID STORAGE SYSTEMS

Innovative renewable solutions for residential buildings

The SCORES project in a nutshell - *Erwin Giling, TNO, NL*

Heating with air heat pumps and PCM storage - *Luis Coelho, IPS, PT*

PVT water-to-water heat pumps - *Clement Dumont, Heliopac, FR*

Chemical looping heat storage - *Pavol Bodis, TNO, NL*

Building energy management system - *Hans Hennig, Siemens, NL*

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 766464.

The SCORES project in a nutshell

Erwin Giling, TNO, NL

TNO innovation for life

SCORES project

Self-Consumption Of Renewable Energy by hybrid Storage systems

SCORES combines and optimizes the **multi-energy generation**, **storage** and **consumption** of **local renewable energy** (electricity and heat) and **grid supply**.

Via the development of compact hybrid storage technologies, integrated through a smart **Building Energy Management System**, the project optimizes the self-consumption in residential buildings, brings new sources of flexibility to the grid, and enables **reliable operation** with a **positive business case** in Europe's building stock.

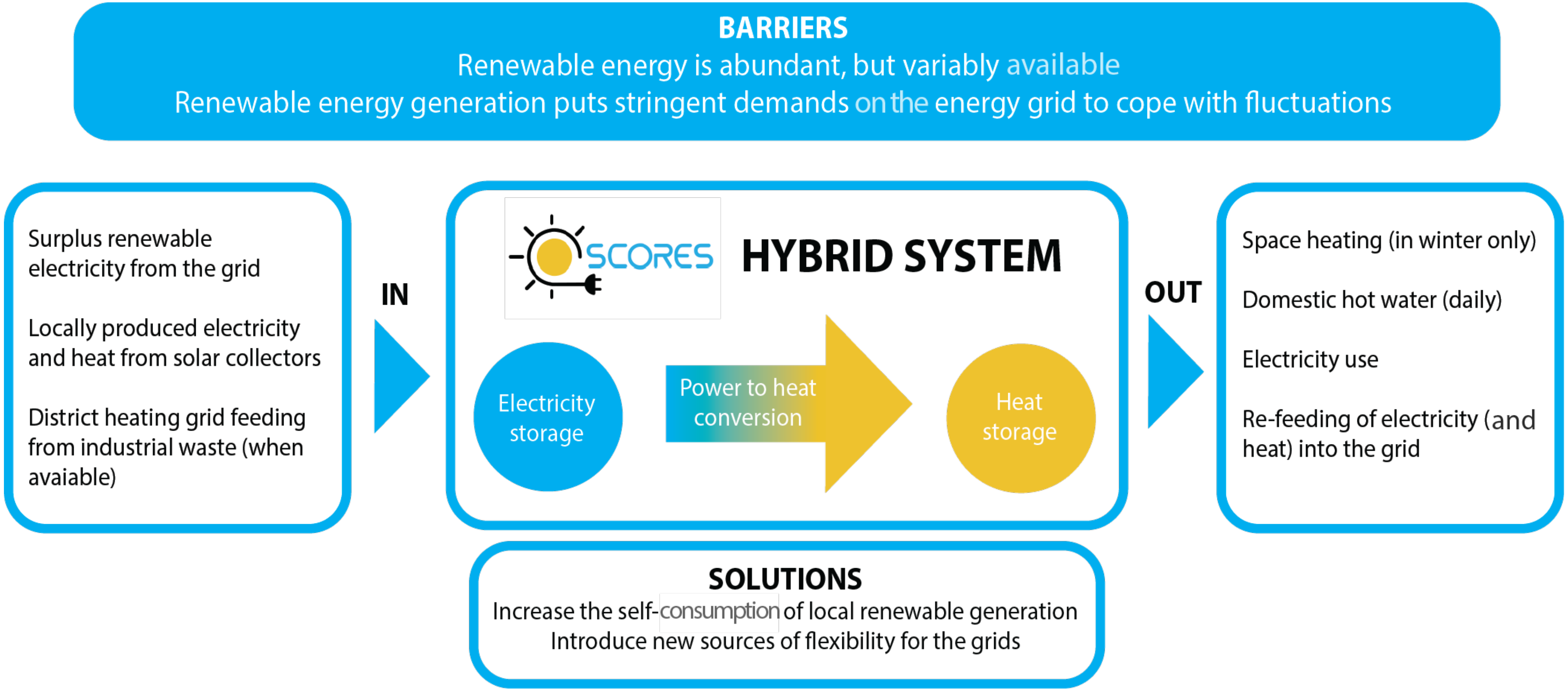
12 Partners

9 Work Packages

Budget **€6M**

48 (54) Months

SCORES – Overall concept

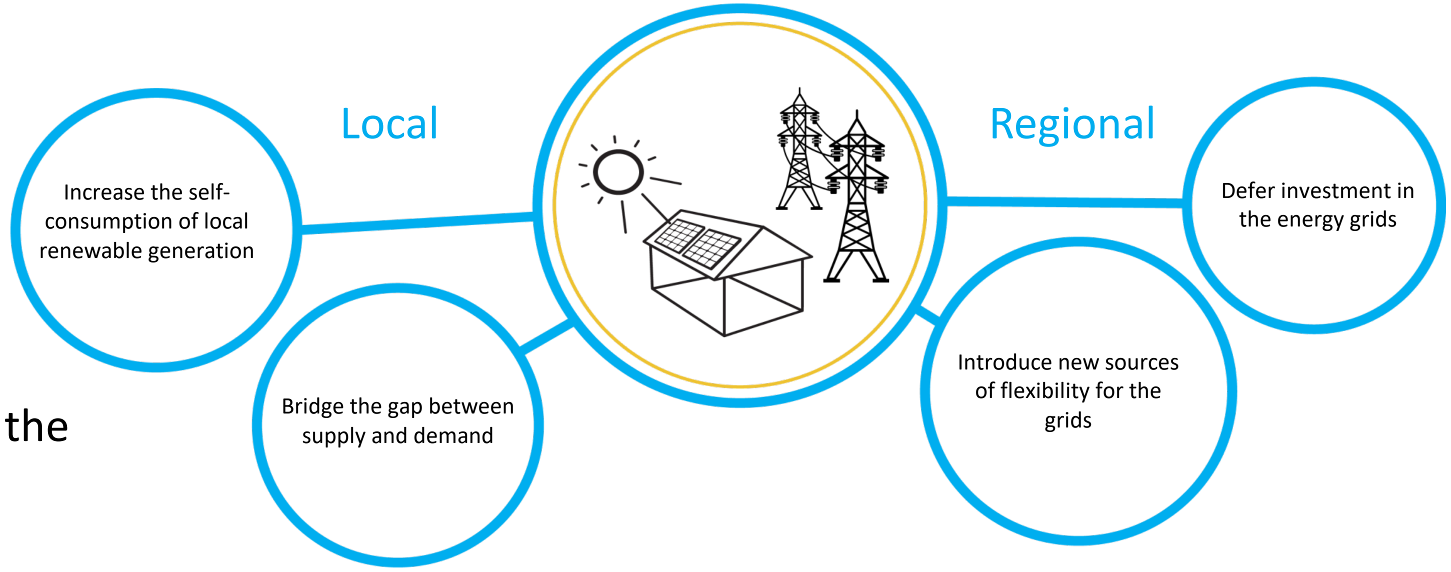


The SCORES concept is based on a hybrid system effectively and efficiently combining solutions that **harvest electricity** and heat from the sun, **store electricity**, **convert electricity into heat**, **store heat**, and **manage energy flows** in the building.

SCORES Consortium

Objectives

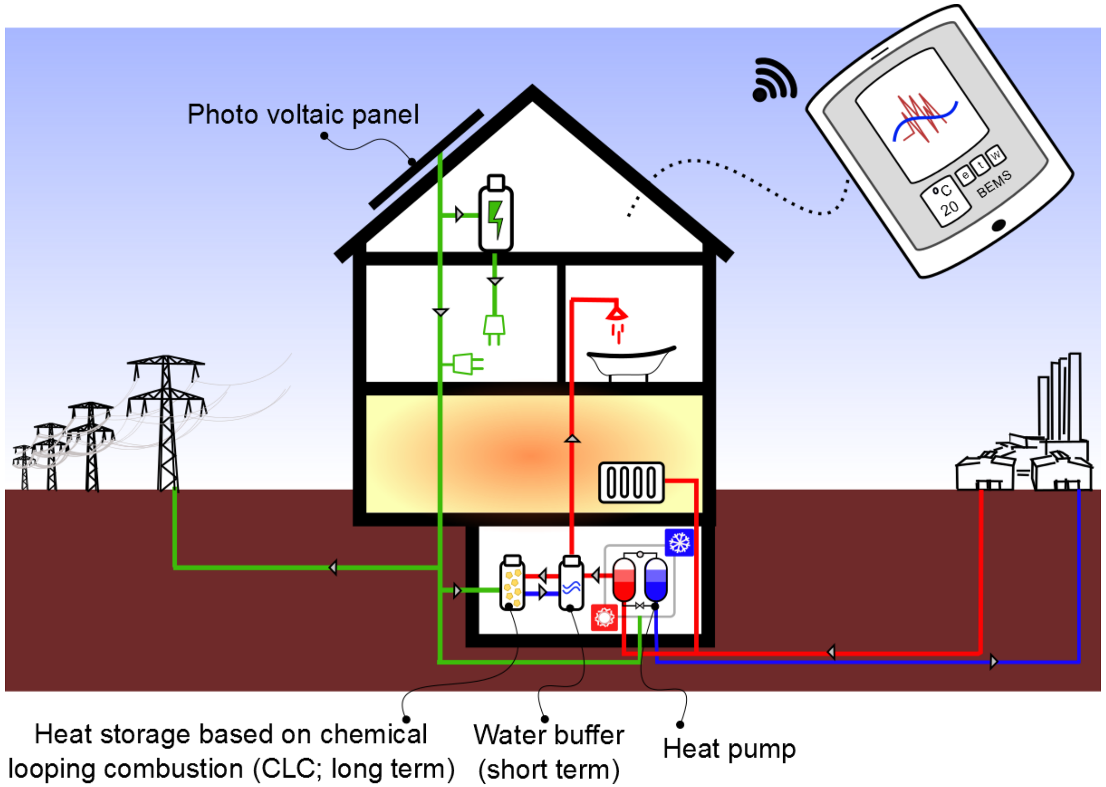
Demonstrate in the field the integration, optimization and operation of a building energy system including **new compact hybrid storage technologies**, that optimize supply, storage and demand of electricity and heat in residential buildings and that increases self-consumption of local renewable energy in residential buildings at the lowest cost.



- Re-use of Second Life Li-ion batteries for residential electrical storage
- Optimized electric driven heating with intraday PCM heat storage
- High-performance water to water heat pump supplied by hybrid PV and solar collectors.
- Efficient air to air heat pump for space heating with intraday PCM storage
- Improve and optimize compact, long term loss free heat storage technology
- An integrated building energy management system
- Asses the economical potential of the hybrid system

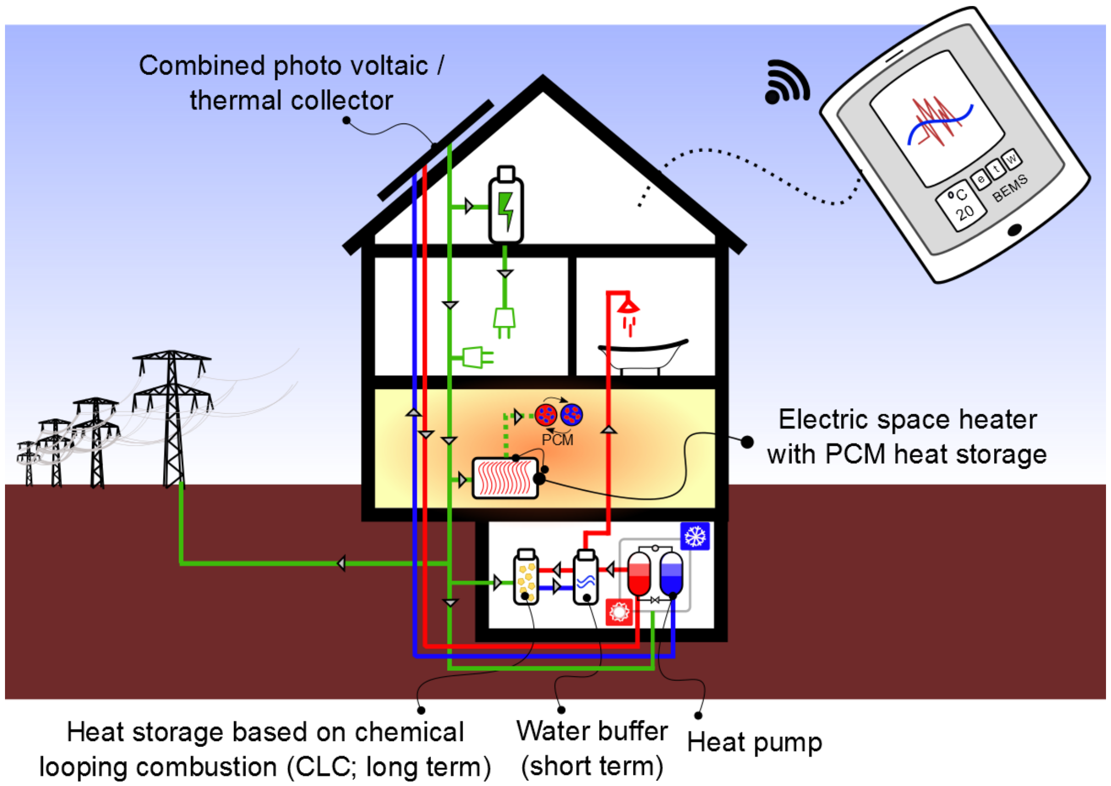
Demonstration cases

Connected to district heating grid:



Demo in Austria

Based on electric heating:



Demo in France

Demonstration

Demonstration of the integrated hybrid energy system takes place in **two real buildings** representative of different climate and energy system configurations for 3 cases:

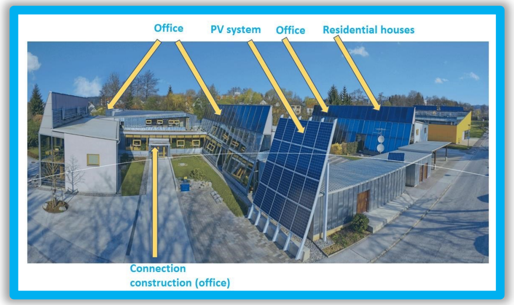
- in Northern Europe (**Austria**) with and without a heat grid
- In Middle/Southern Europe (**France**) without a heat grid.

Agen, France

New state of the art building has been constructed, comprising of 115 small apartments and collective areas for retired people.

Gleisdorf, Austria

In Gleisdorf, an already existing residential building block is connected to both the electricity network and the local heating network.



Heating with air heat pumps and PCM storage

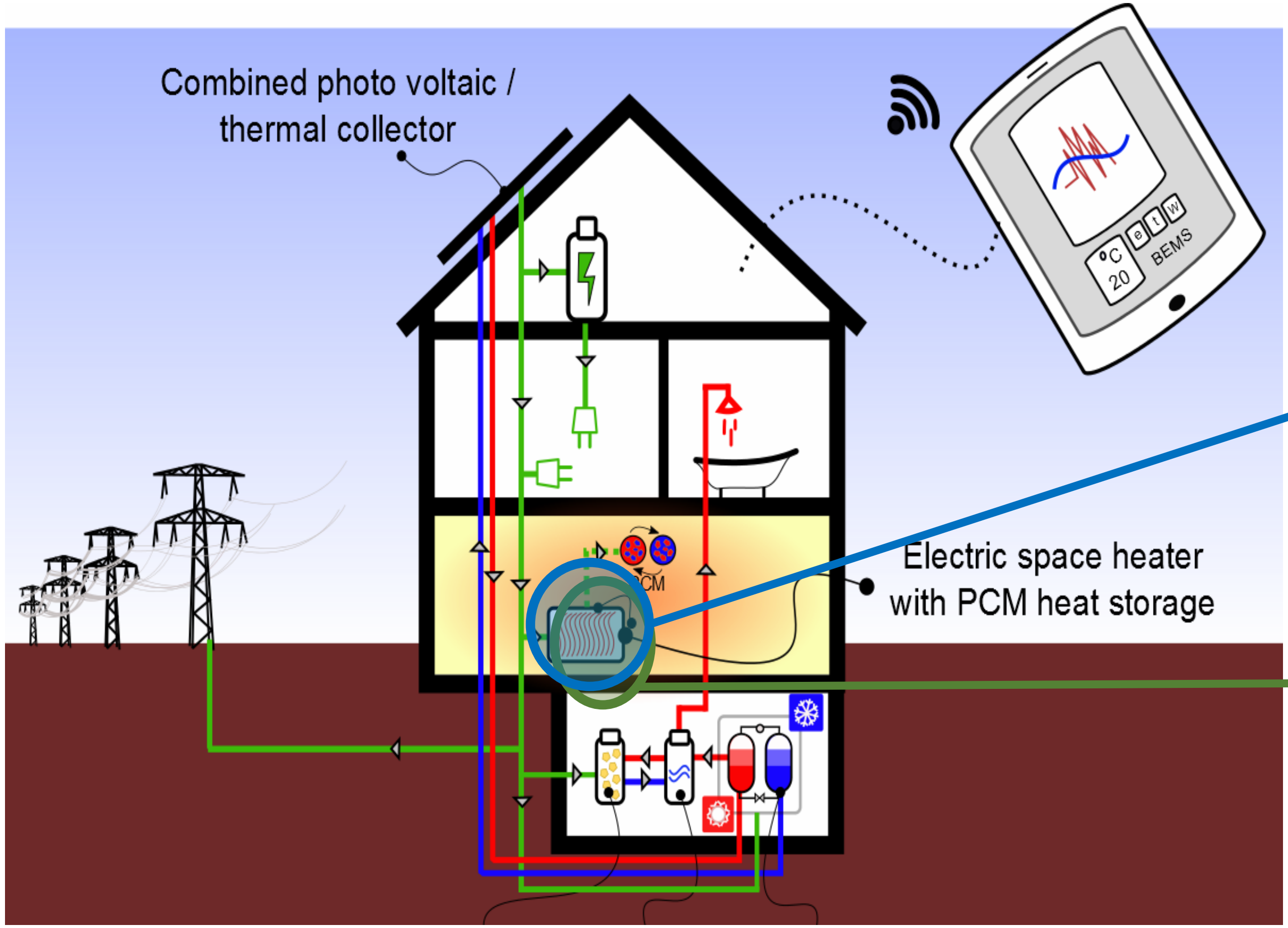
Luis Coelho,

Centre for Energy and Environment Research of Polytechnic Institute of Setúbal (CINEA-IPS), Portugal

IPS Instituto Politécnico de Setúbal

Heating with air heat pumps and PCM storage

Demo in France (Agen) (Based on electric heating)



Electric driven heating with intraday PCM heat storage

TASK 3.1
Electro Thermal storage units for ambient air comfort development (EHP)

(in alternative)

TASK 3.2
Air to air heat pumps with PCM storage energy system for space heating (AHPP)

Heating with air heat pumps and PCM storage

Objective:

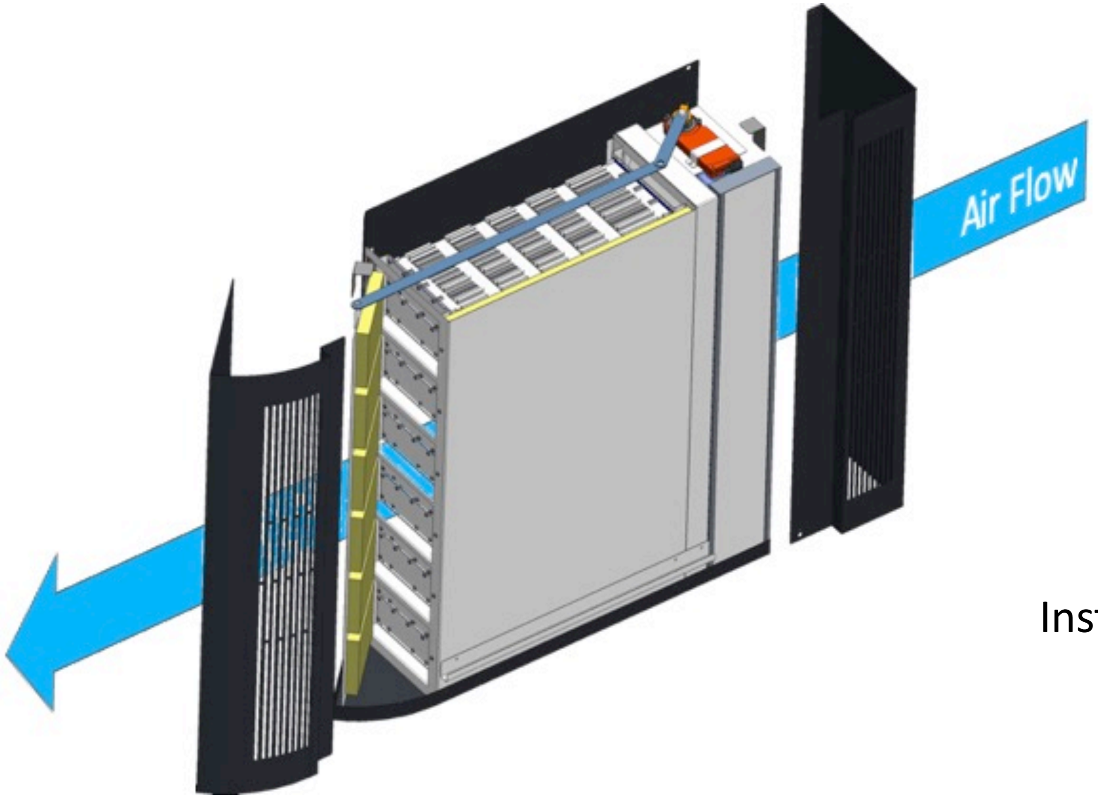
The use of PCM in a heat storage unit will contribute to **two important objectives** in **heating** systems of typical **residential houses**:

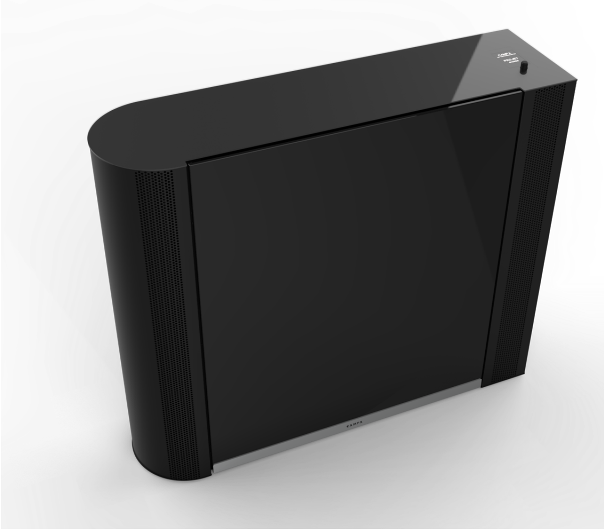
- It will **balance the electric demand** for typical residential houses, **decreasing the electricity consumption** during **peak hours**. The EHP/AHPP can operate **outside peak hours charging the PCM** heat storage. During **peak hours** the EHP/AHPP can be **switched off** or decrease its electrical consumption, the **PCM will provide** the missing **energy** during that period.

- It will **increase** the effective **use of solar energy from the PV or PVT collectors**. During the **sunny hours** the EHP/AHPP can **charge the PCM** heat storage and the **PCM can provide** this energy during periods with **low ambient temperature**.

Heating with air heat pumps and PCM storage

Electro Thermal storage units for ambient air comfort development (EHP)

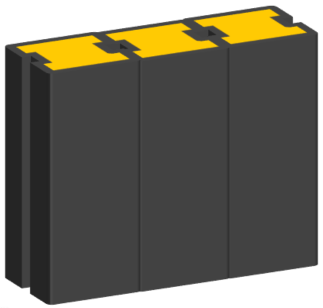


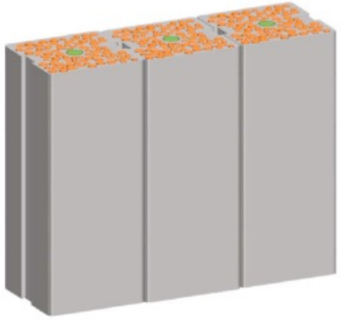


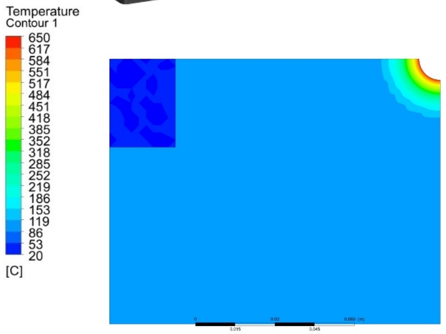
Installed in Demo B, Agen, France

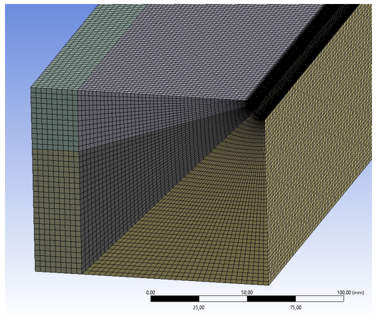
Heating with air heat pumps and PCM storage

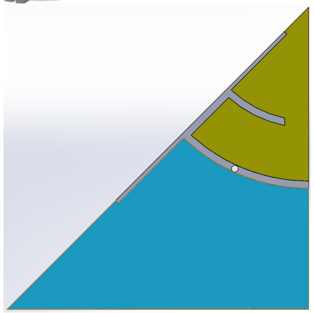
Optimisation of the core geometry and PCM using CFD simulations (EHP)

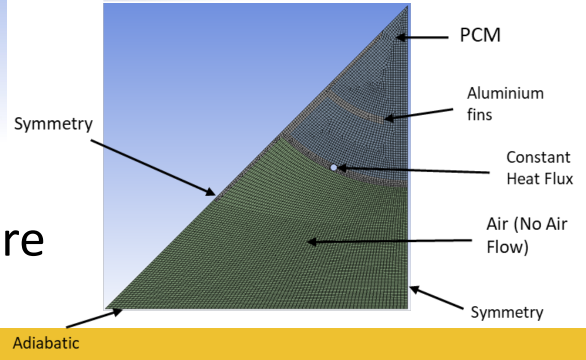


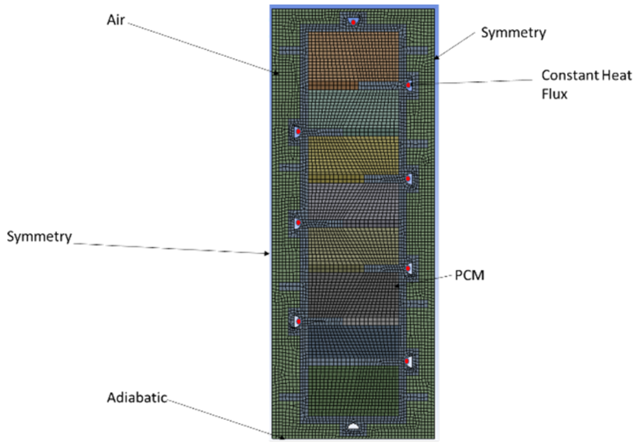


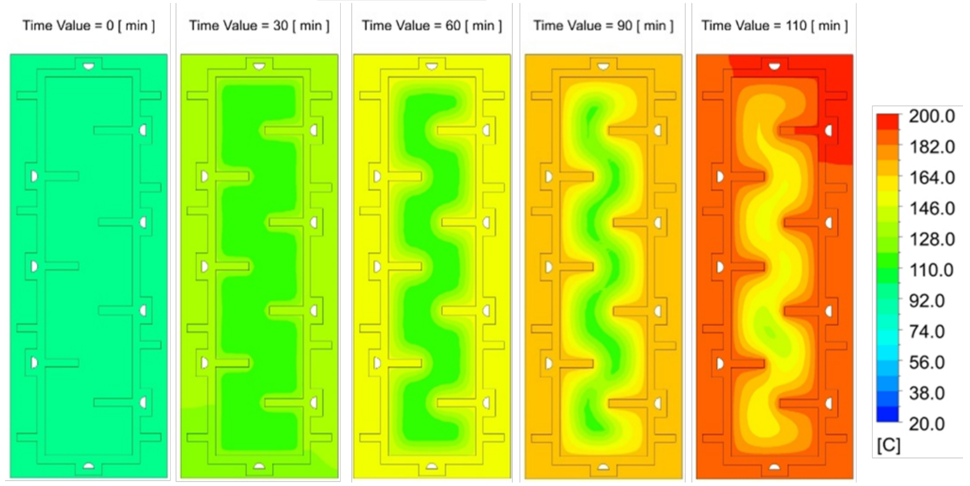












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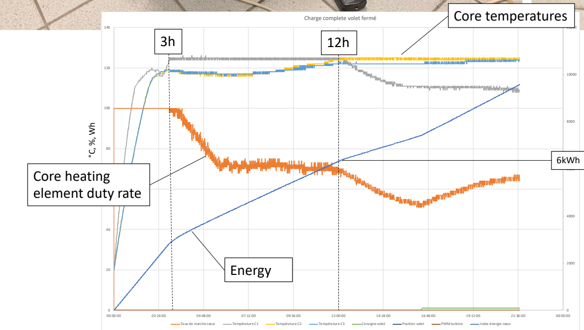
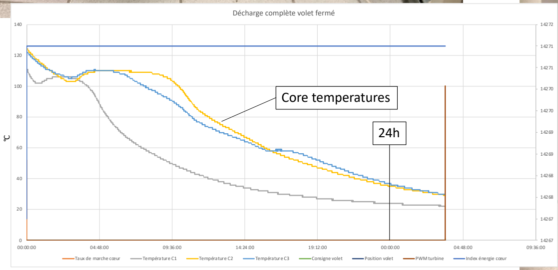
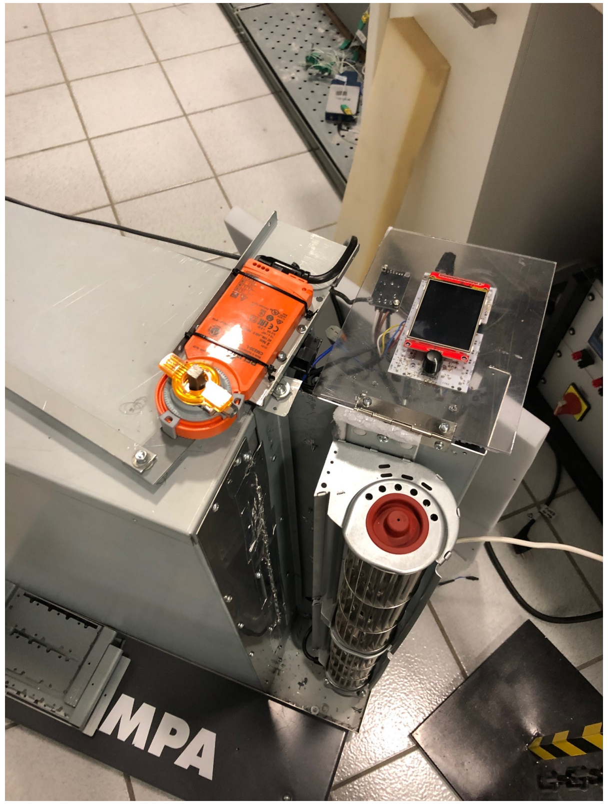
Heating with air heat pumps and PCM storage

Laboratory tests using the selected geometry and PCM by CFD simulations (EHP)







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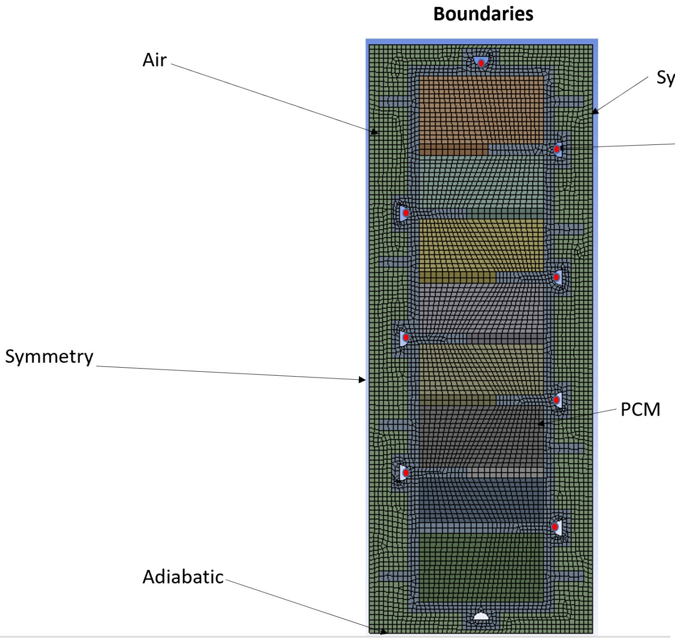
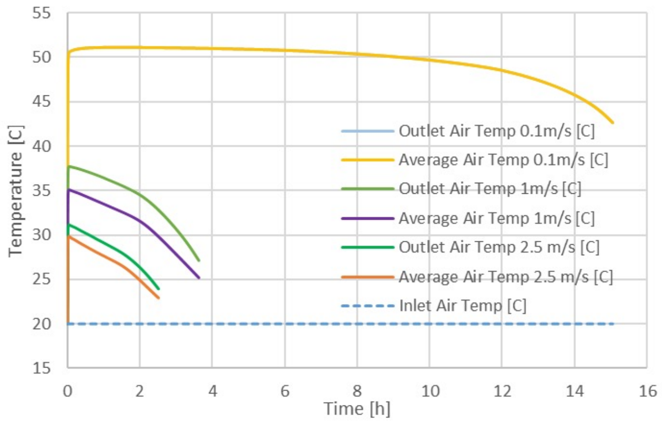
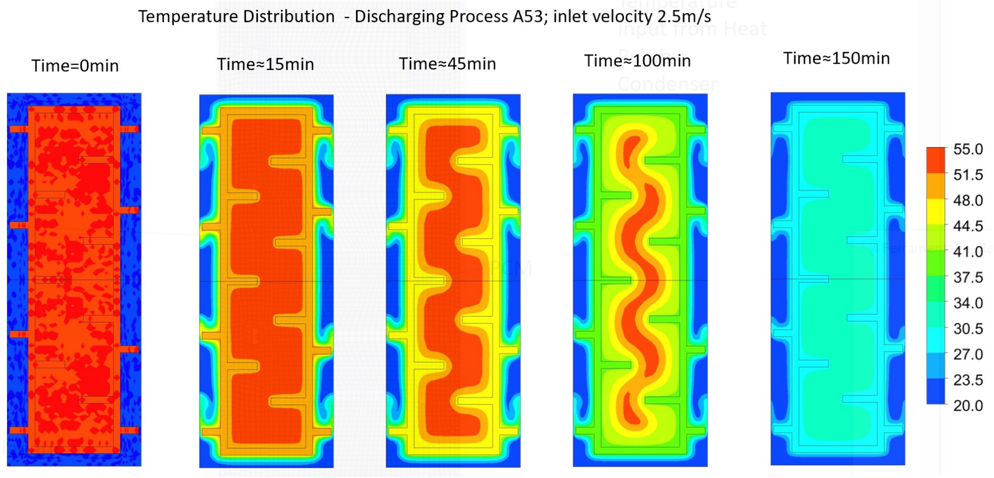
PCM: Erythritol, melting temperature, 118°C

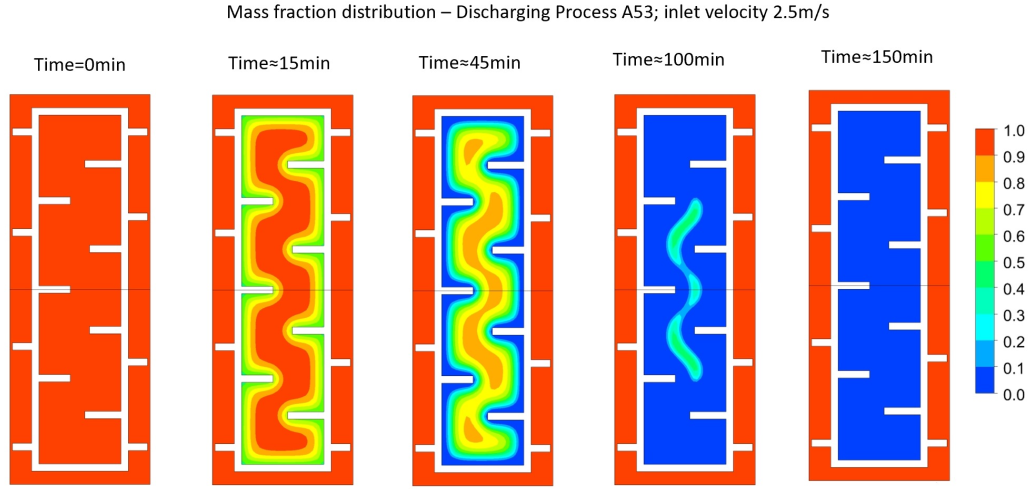
Heating with air heat pumps and PCM storage

Optimisation of the core geometry and PCM using CFD simulations (AHPP)









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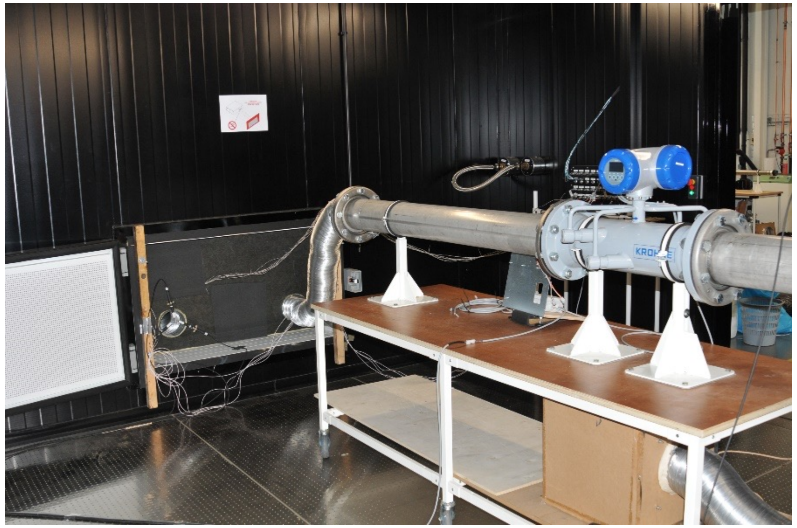
Heating with air heat pumps and PCM storage

Laboratory tests using the selected geometry and PCM by CFD simulations (AHPP)



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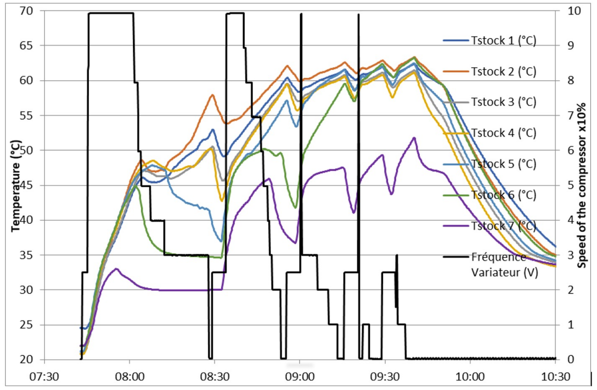
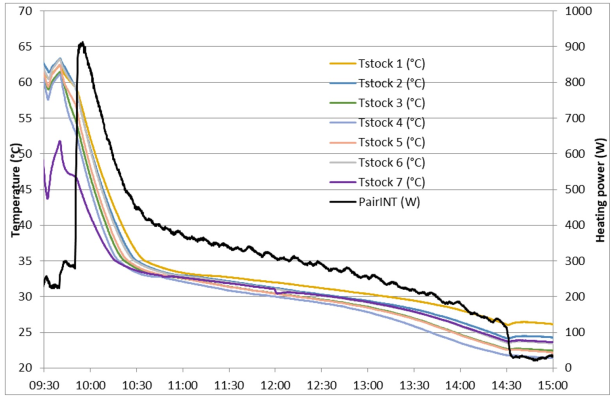
France Energie Laboratory Laboratories

PCM: Paraffin, melting temperature, 36ºC



Temperature behaviour of the PCM storage elements during the heat charge.



Heating discharge mode: graph of the heating capacity and the storage temperature of the AHPP.

Heating with air heat pumps and PCM storage

Main results from laboratory tests

Electro Thermal storage units (EHP)

KPI Name	KPI Unit	KPI Description
Heat storage capacity	3,88 kWh	Total energy stored in 1 appliance while it's fully charged. Evaluated through lab tests on the prototypes.
Thermal heat output	1 kW	Thermal energy that the appliance can provide constantly. Measured through lab tests
Heat retention capacity	7 hours	Time needed to reach 40% of storage capacity starting from a fully charged storage. Measured with lab tests.
Full Charge time	12 hours (3h for quick half charge)	Time required to fully charge an appliance starting from an empty state. Evaluated through lab tests on prototypes.
Full discharge time	10 hours	Time required to fully discharge an appliance starting from a full state at the maximum heat output. Evaluated through lab tests on prototypes.
Coefficient of performance	1	Coefficient of performance of the heating unit = heat provided to the room divided by the electricity used.
CO2 impact	1899 kgeCO_2	Equivalent CO_2 impact of one appliance.

Air to air heat pumps with PCM (AHPP)

KPI Name	KPI Unit	KPI Description
Heat storage capacity	2 kWh	Total energy stored in 1 appliance while it's fully charged. Evaluated through lab tests on the prototypes.
Thermal heat output	1,3kW – 3kW (respectively at -15°C and +12°C outside temperature)	Thermal energy that the appliance can provide constantly. Measured through lab tests
Heat retention capacity	70 minutes	Time needed to reach 80% of storage capacity starting from a fully charged storage. Measured with lab tests.
Full Charge time	120 minutes	Time required to fully charge an appliance starting from an empty state. Evaluated through lab tests on prototypes.
Full discharge time	24h	Time required to fully discharge an appliance starting from a full state at the maximum heat output. Evaluated through lab tests on prototypes.
Coefficient of performance	COP = 1,65 – 3.03 (respectively at -15°C and +12°C outside temperature)	Coefficient of performance of the heating unit = heat provided to the room divided by the electricity used. Evaluated through test lab and yearly operation simulation in Agen.
CO2 impact	4713 kgeqCO_2 for the appliance. Or 1764 kgeqCO_2 For 1 kW heating power	Equivalent CO_2 impact of one appliance.

PVT water-to-water heat pumps

Clement Dumont, Heliopac, FR

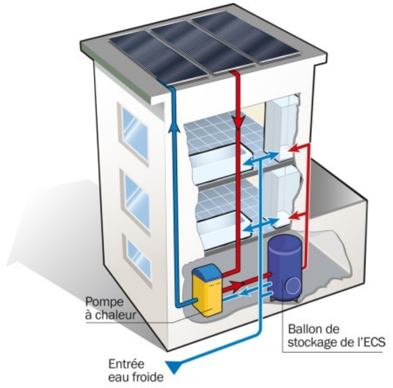
THE COMPANY

→French design and manufacture of collective DHW production systems based on heat pumps
→Solar heat source
→Support for our systems and commitments

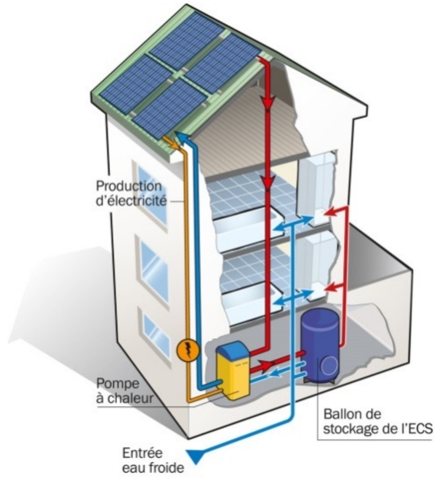
HELIOPAC benefits from more than 30 years of experience in the field of renewable energy and the production of of domestic hot water (DHW).

Some figures:
800 installations in France/ 55 000m² of collectors in Europe

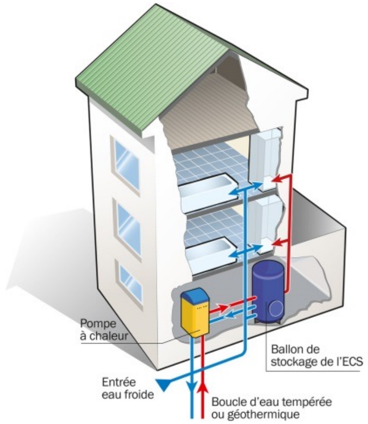
Our DHW production solutions



heliopacsystem®



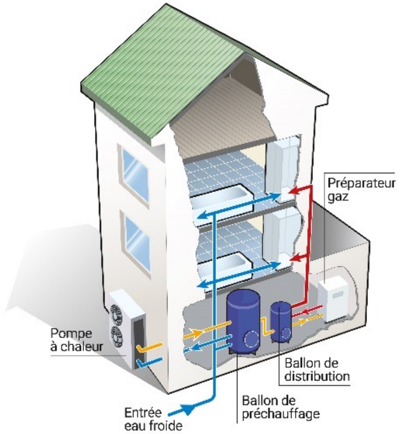
heliopacsystem+®

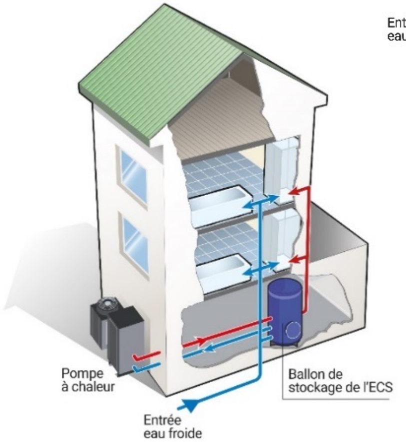


geopacsystem®

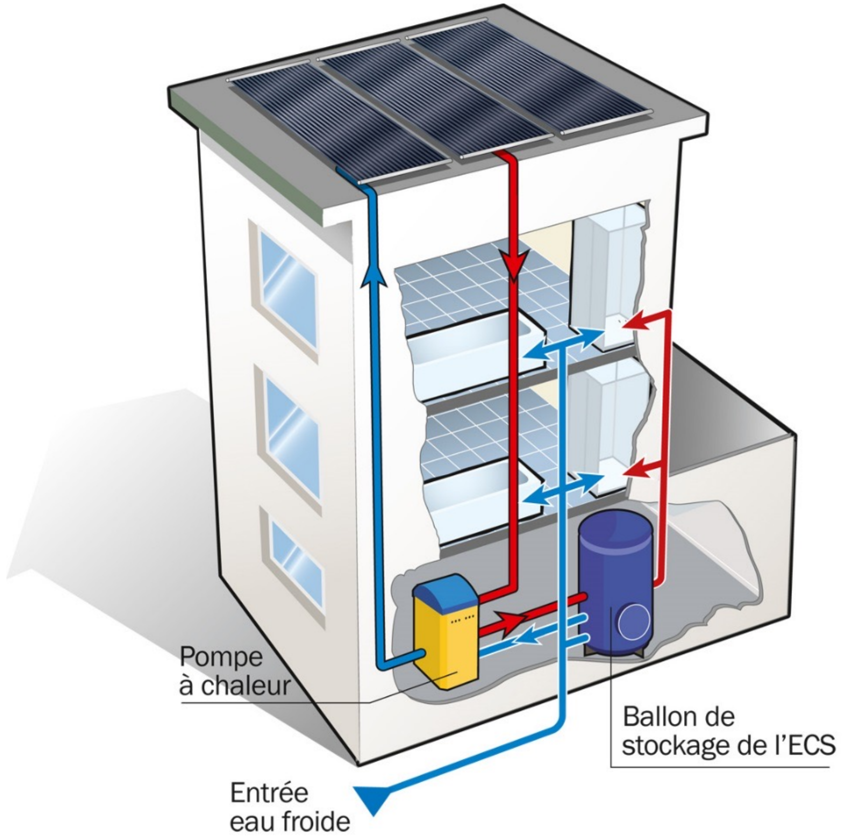
Water/water Heat Pumps

+ air/water





heliopacsystem®



heliopacsystem® is a solution for the production of domestic hot water by means of a heat pump on a low-temperature flexible solar collector, which can be used in almost all climatic conditions.

Sun, rain, wind and fog are elements that favourize the recovery of renewable energy by the system.

heliopacsystem®

Flexible collectors on a roof

heliopacsystem®

Key physical points

- Convective temperature collector
  - Ambient (80%)
  - Radiations (20%)

Key technical points

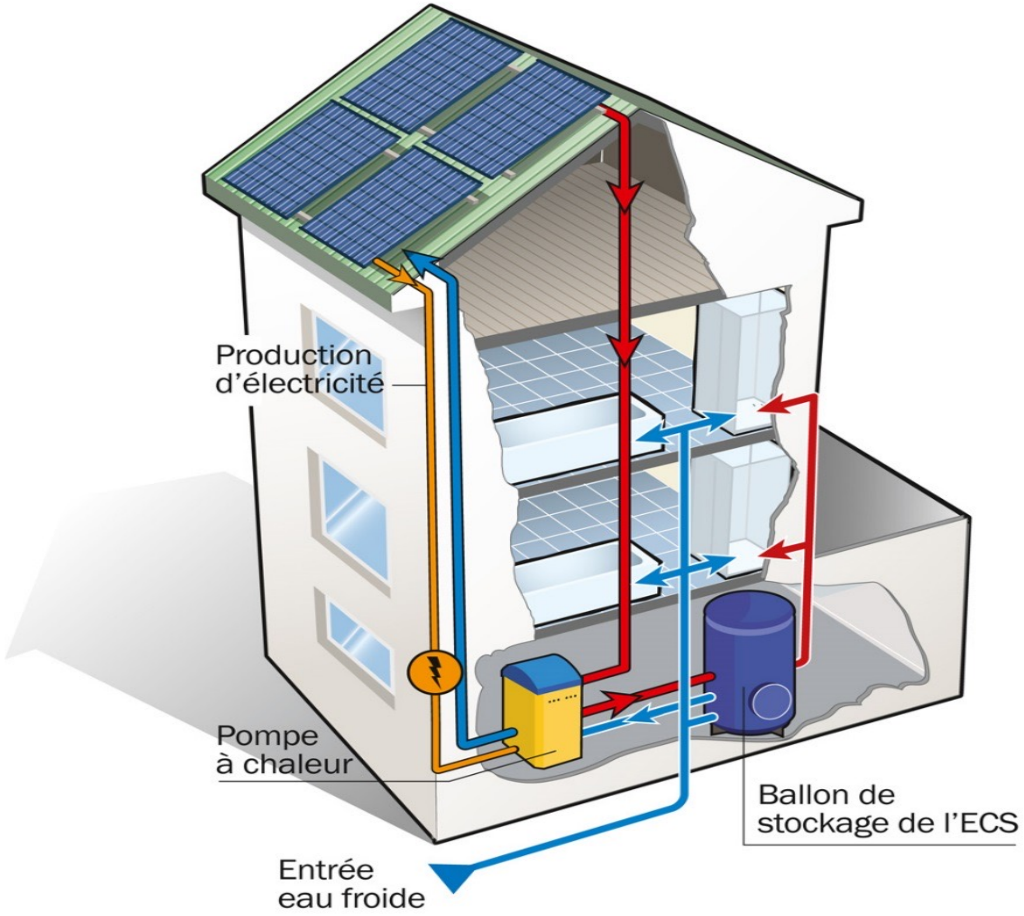
- Flexible
- Low wind resistance
- Light (11 Kg/m^2)
- EPDM 30 year lifespan or more
- Save space on the roof

heliopacsystem®

Key points:

- Day and night operation all year round
- Low maintenance on the roof
- No risk of overheating the solar circuit
- The collector expands, so there is no need to install an expansion vessel to counteract overpressure
- Saves space on the roof

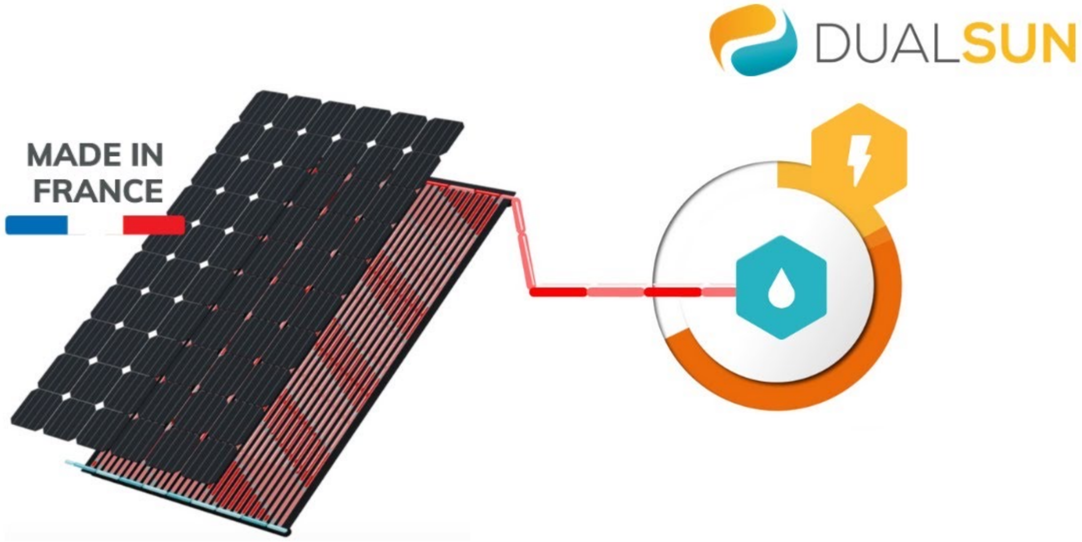
heliopacsystem+®



heliopacsystem+® provides heat and electricity for collective DHW production.

This hybrid system improves the efficiency of the photovoltaic panels through heat transfer.

- The heat exchanger is completely integrated into the underside of the photovoltaic panel



heliopacsystem+®

heliopacsystem+®

Key points:

- A very large part (up to 90%) of the energy needed to produce domestic hot water is provided by the system (renewable heat and electricity).
- Very low C02 emissions
- The cooling of the photovoltaic cells by the heat pump improves their efficiency (+10 % to +15%)
- Continuous operation (convective collector)
- Low maintenance
- Factory-assembled, easy to install
- Saves space on the roof

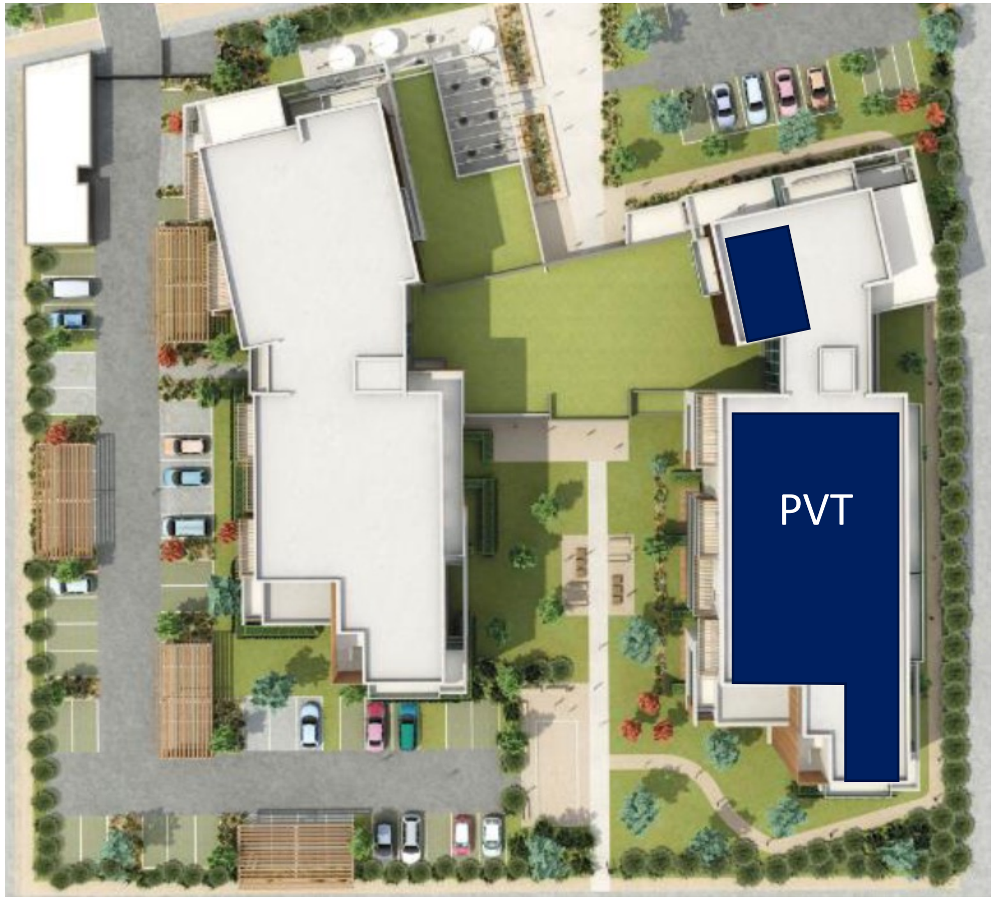
SCORES – DEMO SITE in AGEN (France)

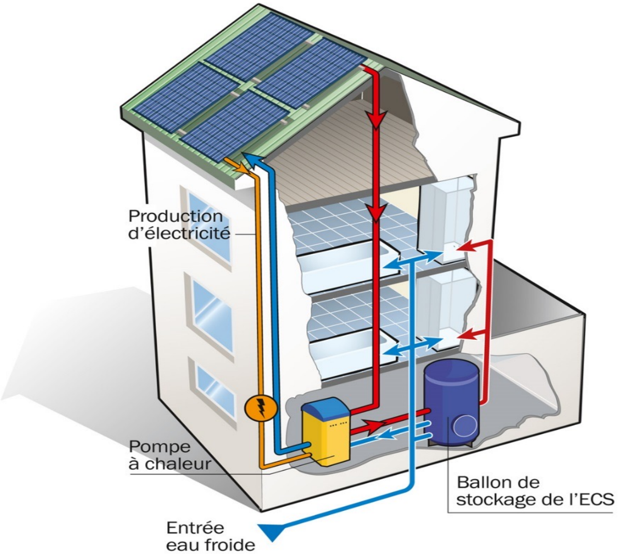
heliopacsystem+®

- Retirement residence
- 115 residential apartments

SCORES – DEMO SITE in AGEN (France)

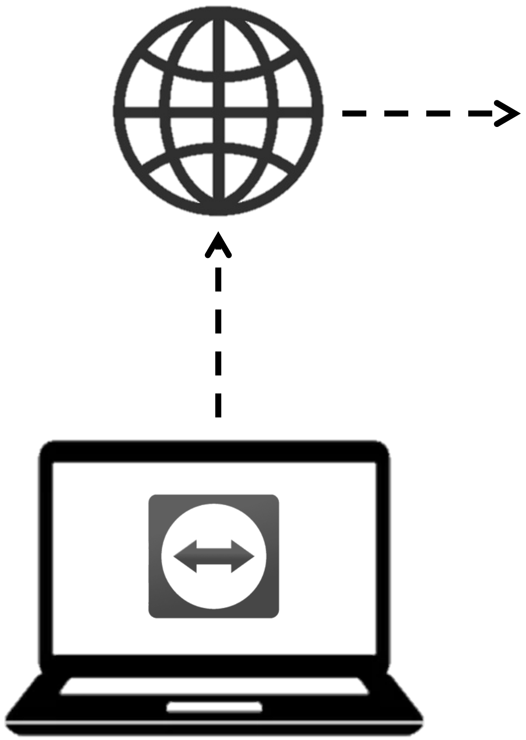
heliopacsystem+®

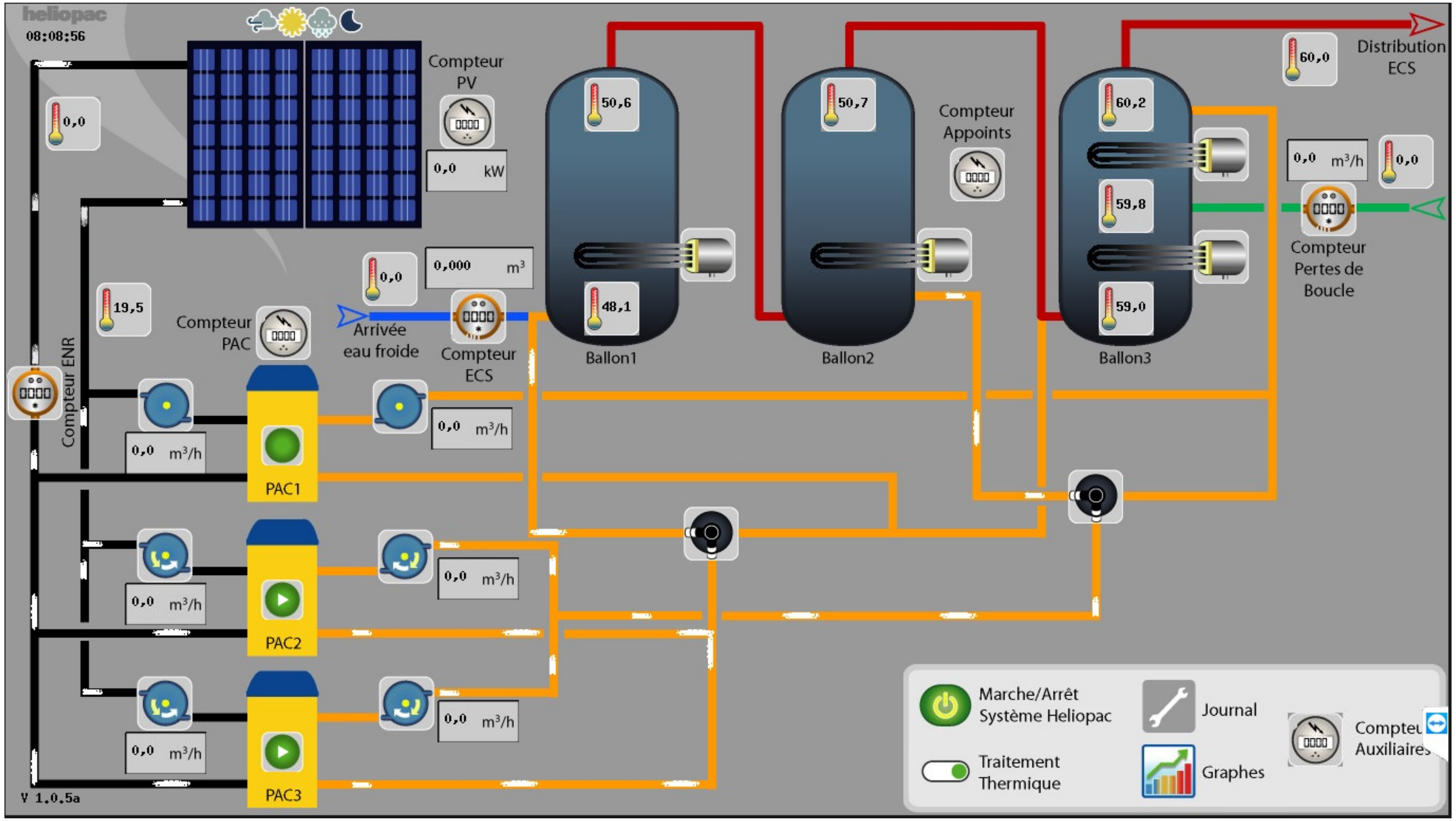




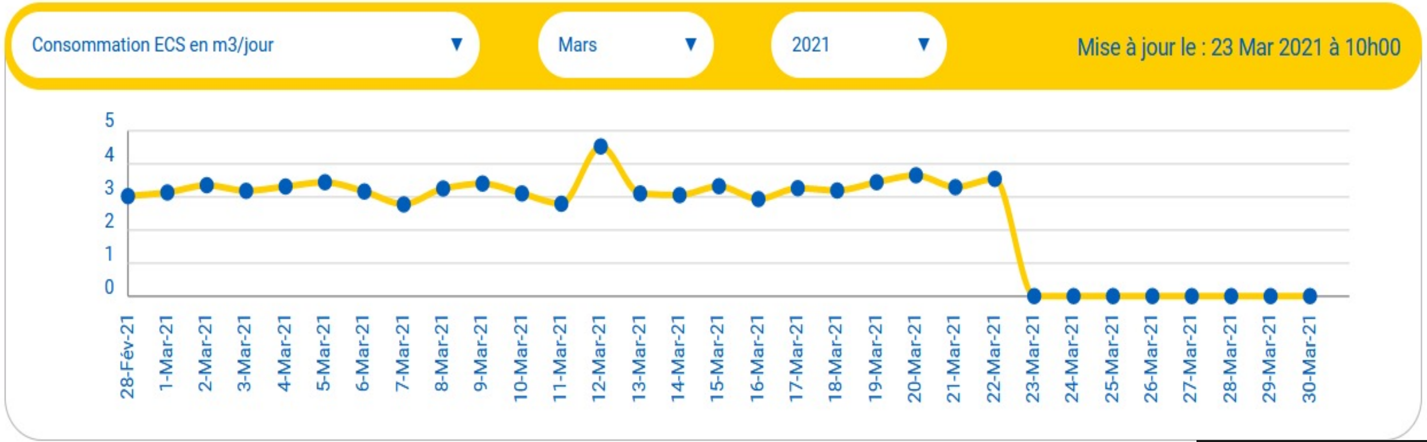
- 129 PVT Pannels
- 7 m^3 water buffers
- 3 heat pumps (12 kW each)

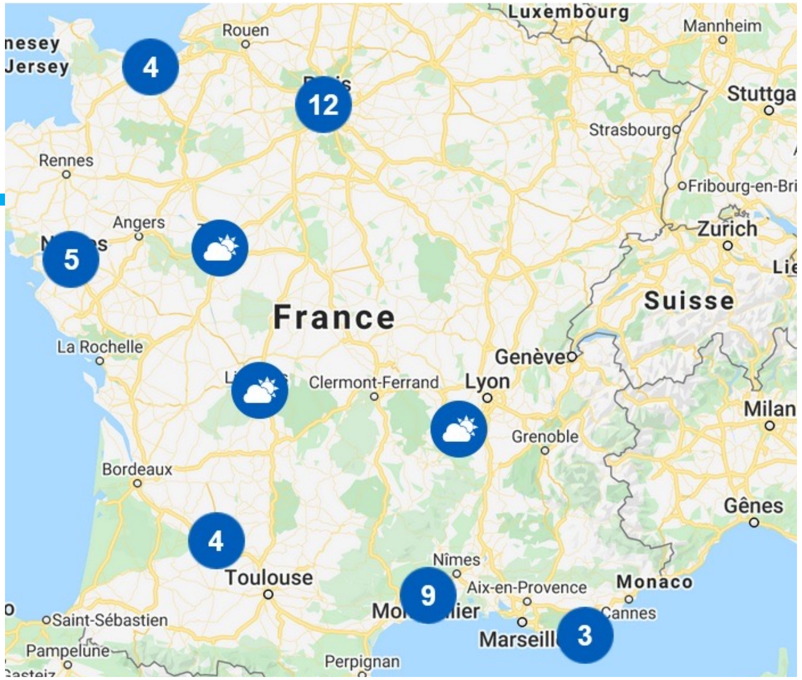
HELIOPAD – Remote Control

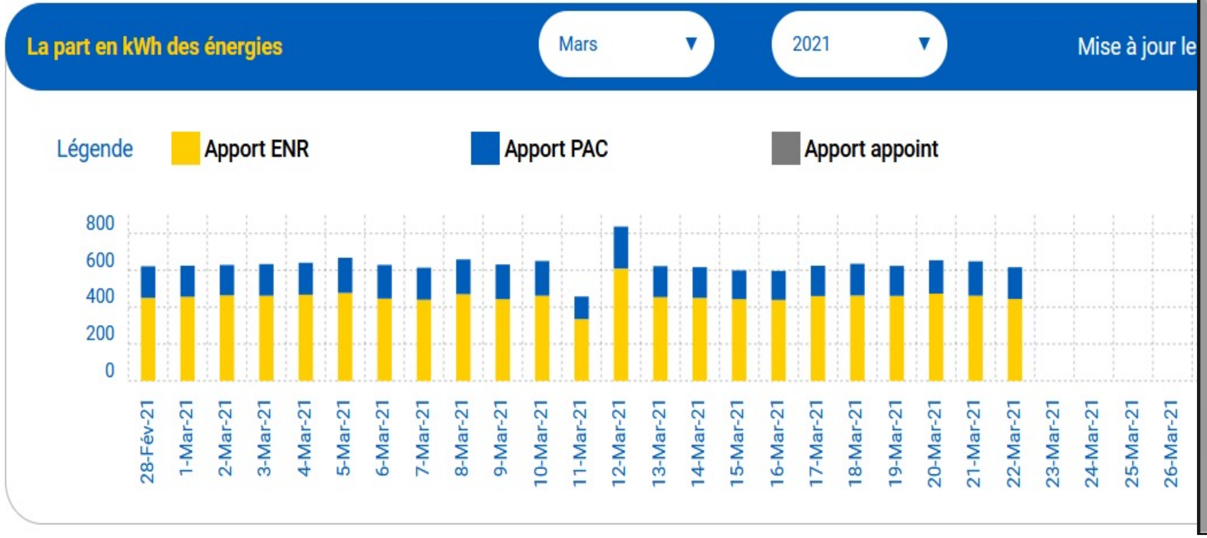


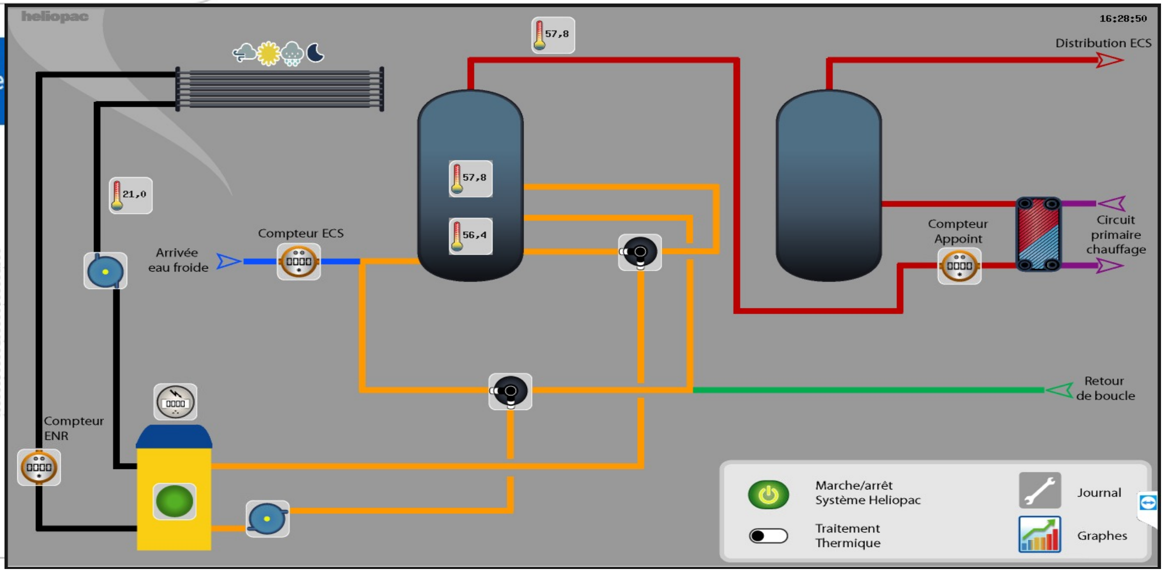


Tracking site



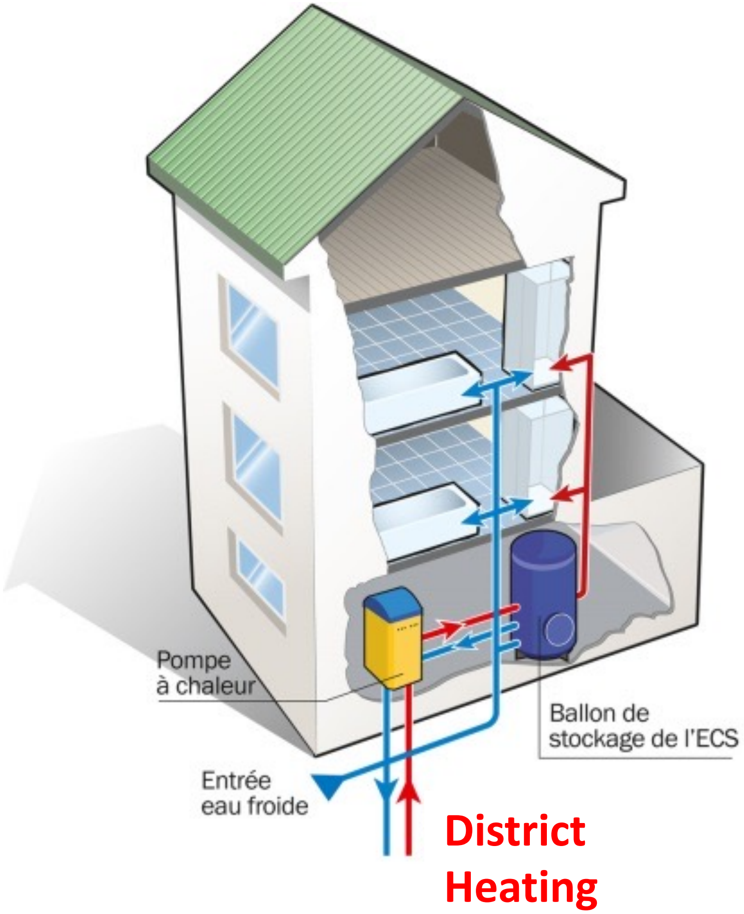


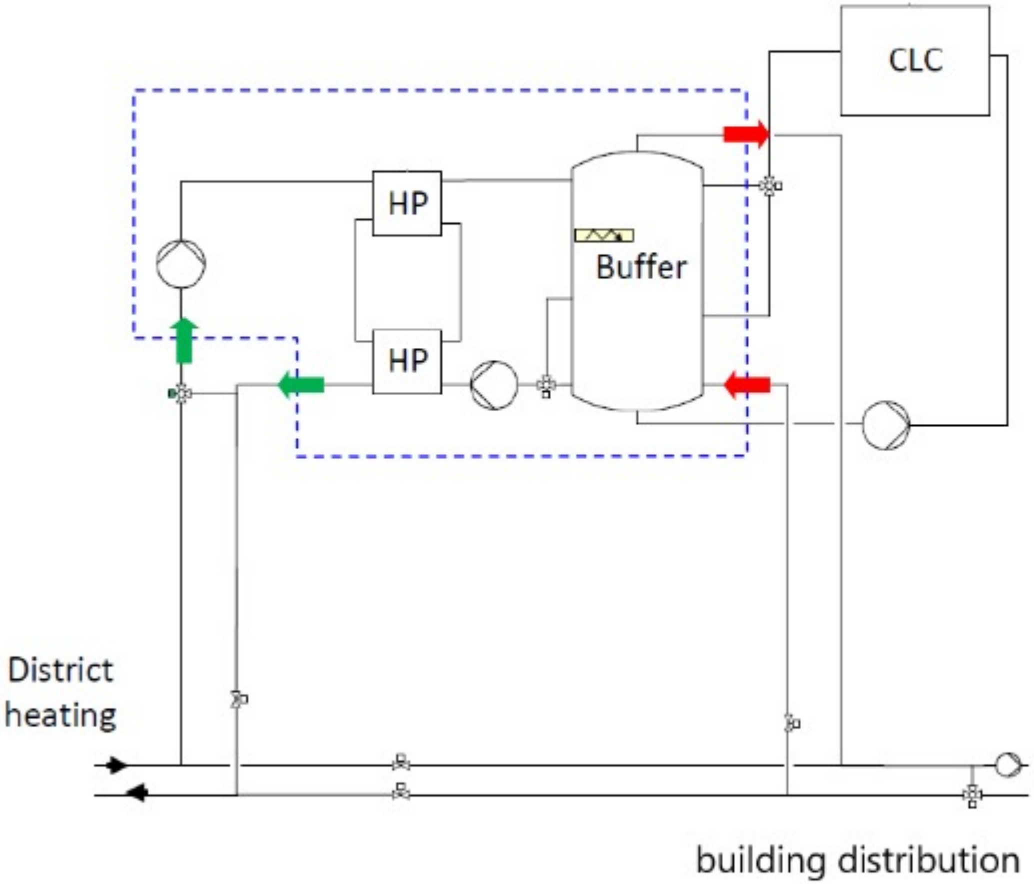




SCORES – DEMO SITE in GLEISDORF (Austria)

geopacsystem®





International acknowledgement

HELIOPAC equips 2 buildings elected at the Green Building & Citys Solutions Awards* during the COP22 in Marrakech.

Eco-quartier du Fort d'Issy (92) : 1600 dwellings, 2300 m² of shops and offices

Lycée Public des Mauges à Beaupreau (49) : 80-bed boarding school and 8 staff houses

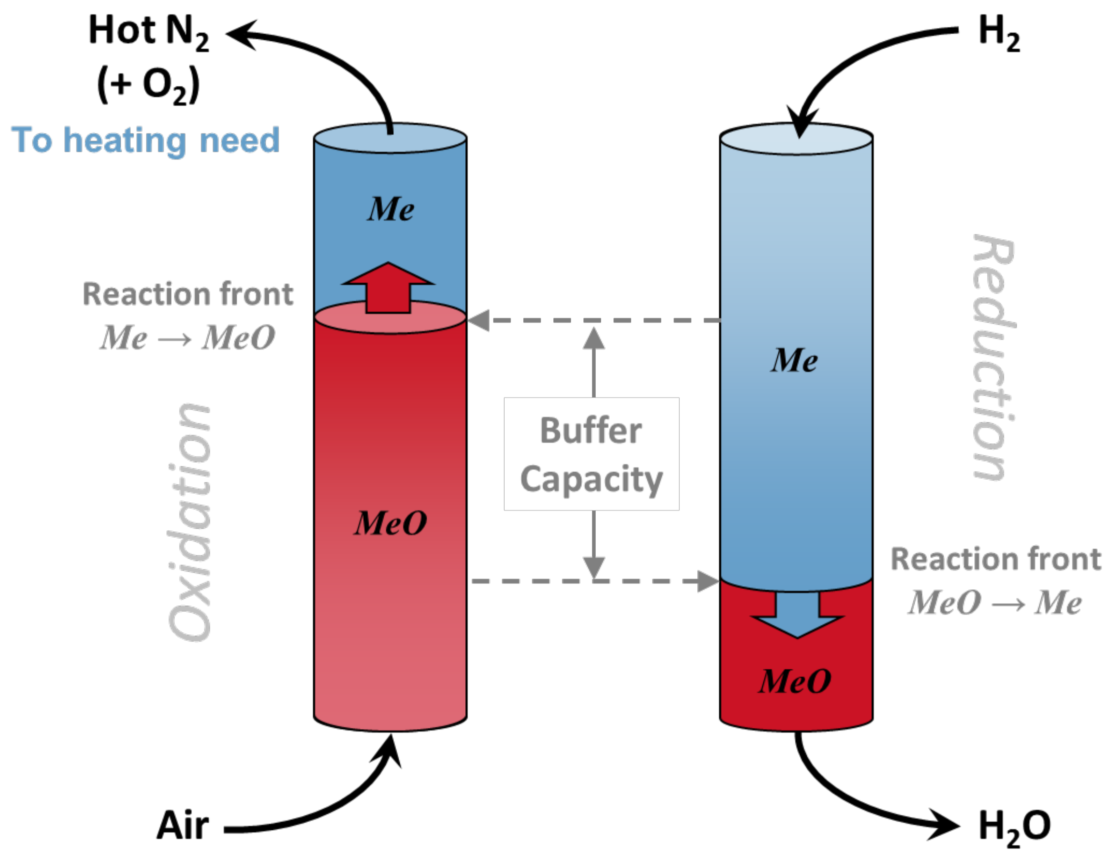
*International competition organised by the Construction 21 network. This competition highlights exemplary buildings and solutions that contribute to the fight against global warming.

Chemical looping heat storage

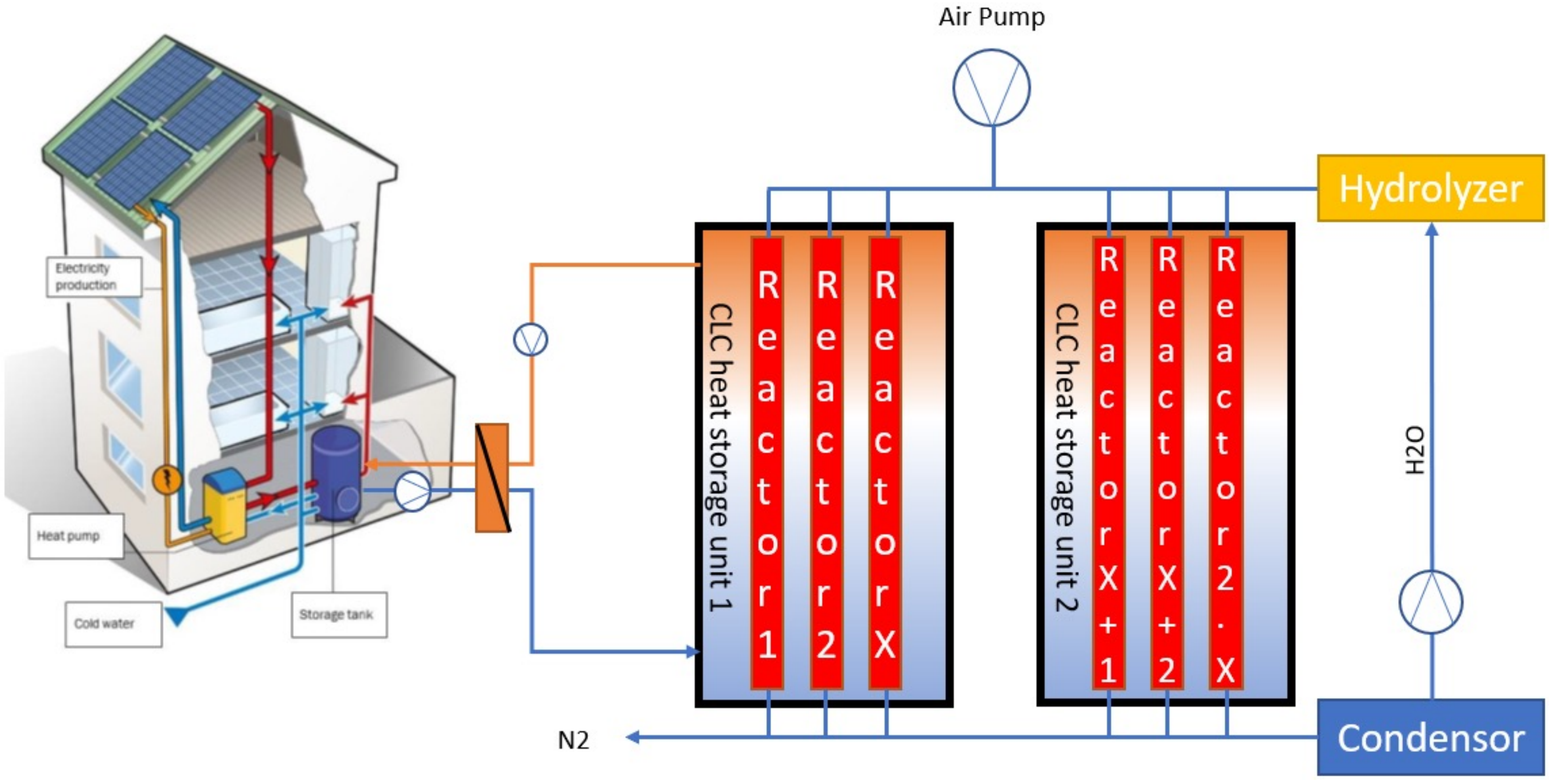
Pavol Bodis, TNO, NL

Chemical Looping (Redox-Heat) Storage– How does it work?

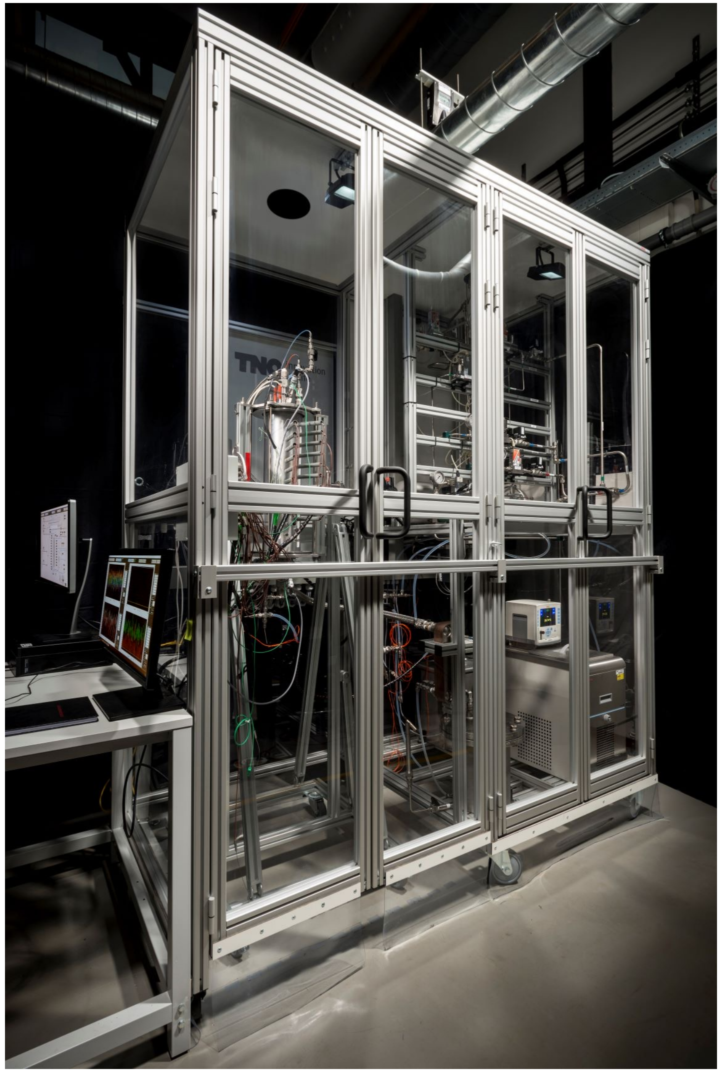
- CLC has been developed recently for power generation with inherent CO_2 separation
- A metal with specific characteristics is “looped” through oxidized and reduced states to release or store energy, respectively
- CLC technology has been adapted into Technology based on Redox reaction and thus we call it Redox Heat
- **Targeted energy storage density on system level of >1GJ/m³**

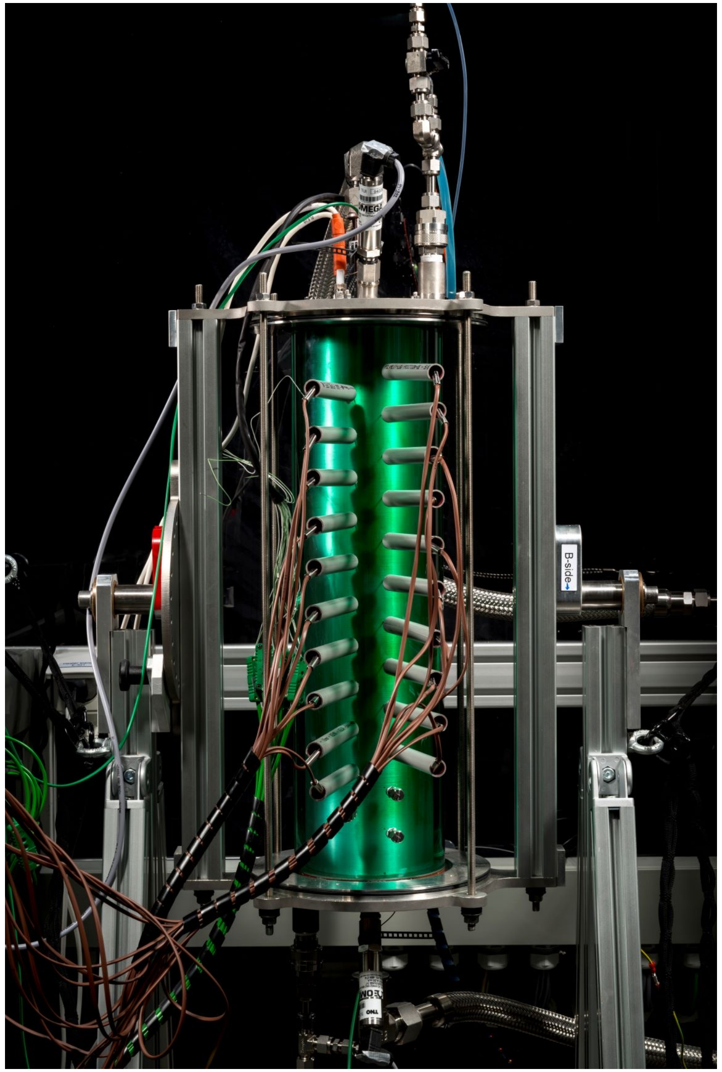


Redox Heat subsystem – Interface with a building

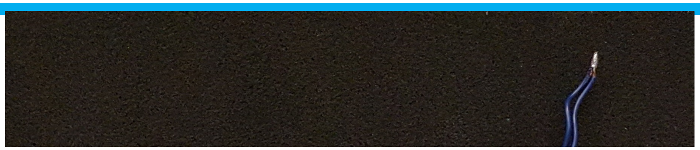


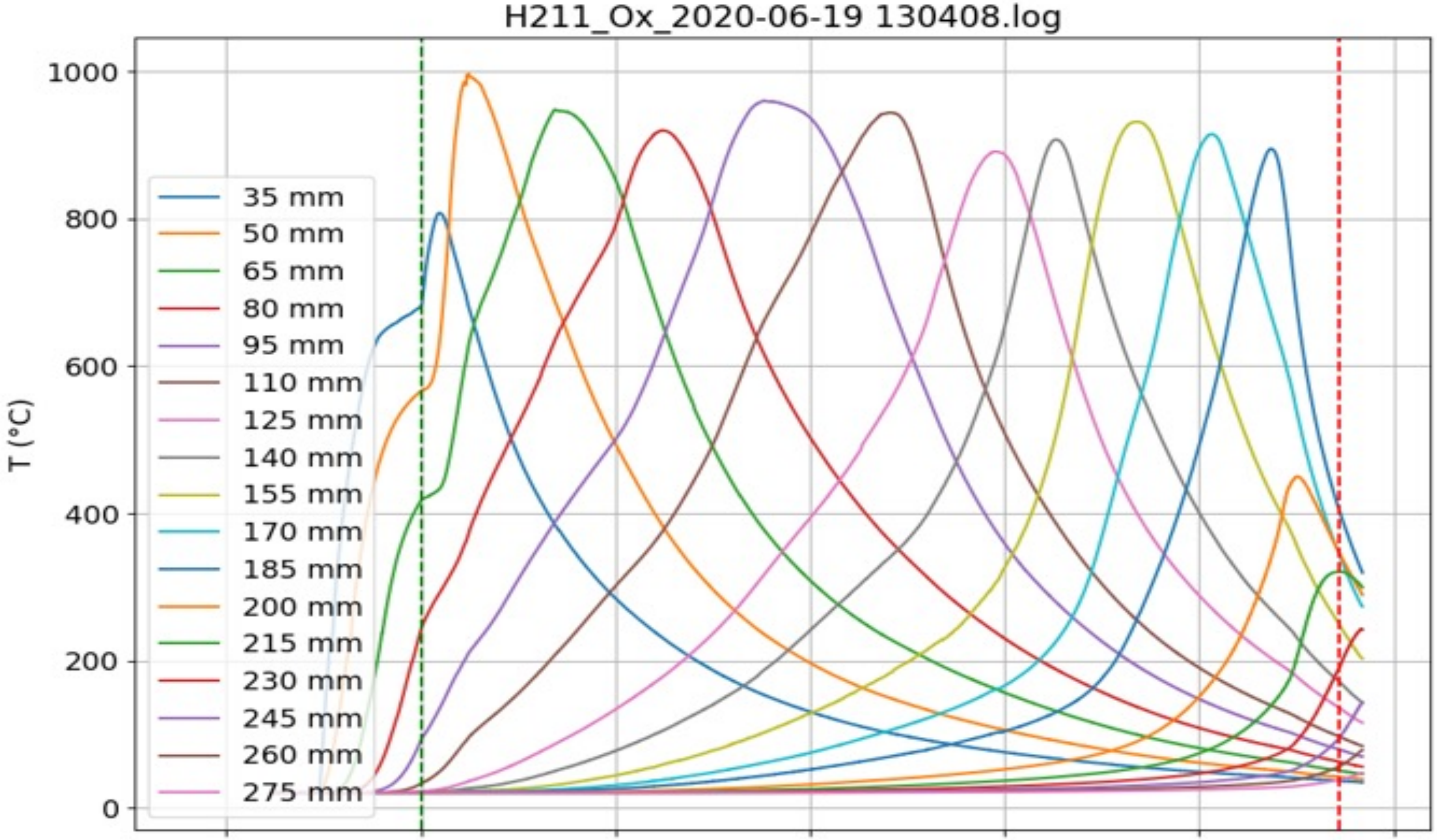
Redox Heat – How does it look like?

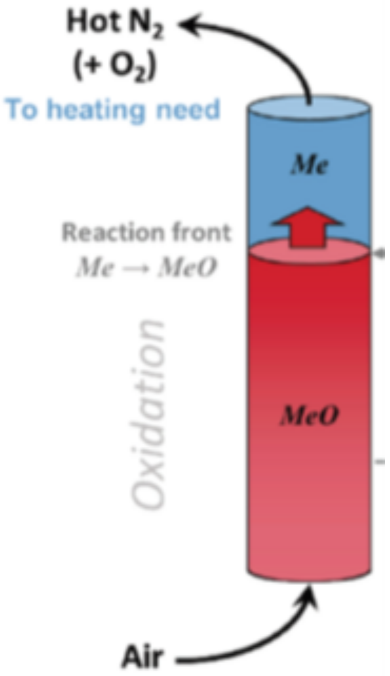




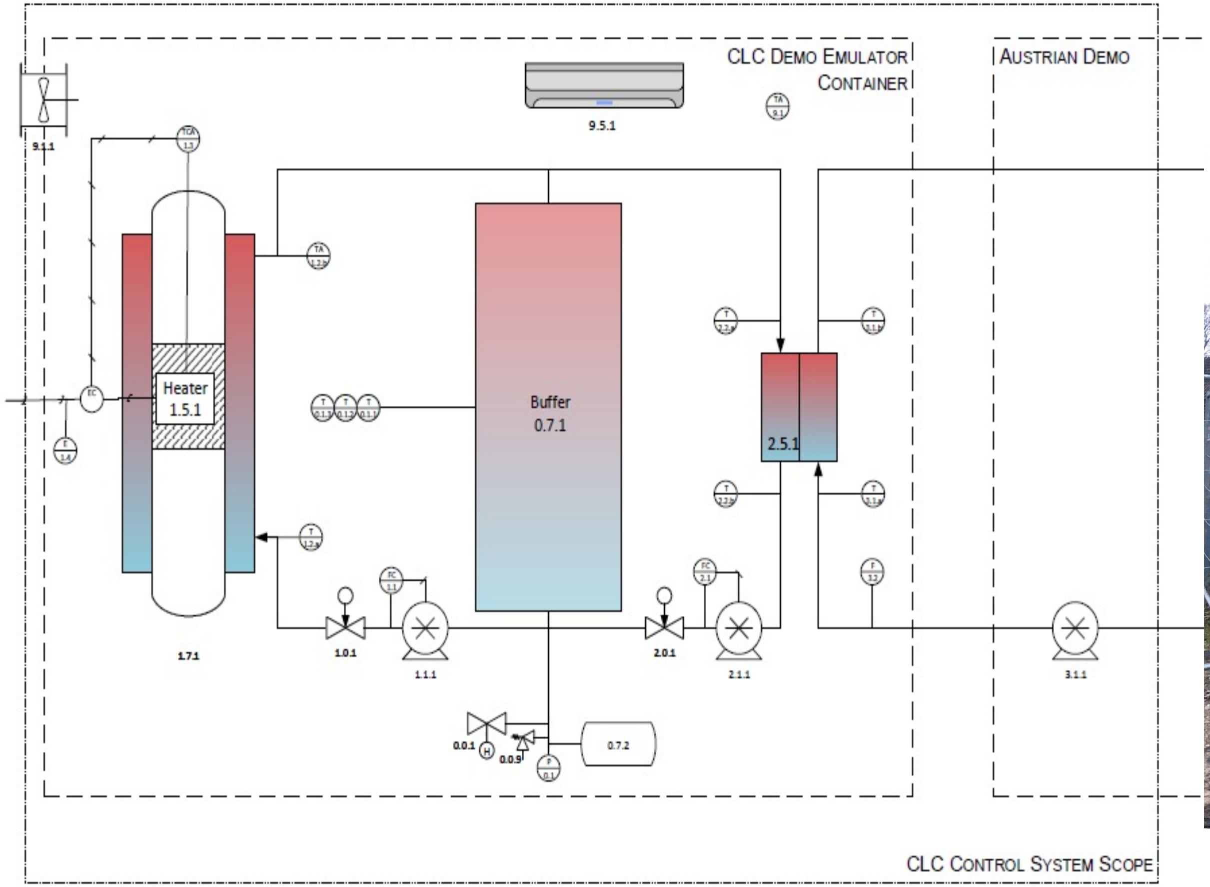
Redox Heat - Results







Redox Heat – Demonstration (Redox-Heat emulator)



Conclusion and the way forward

- Prototype of the Redox-Heat reactor was built
- Redox-Heat technology was successfully demonstrated in the lab
- Emulator system has been installed in Austria

- Further development is needed to increase number of cycles
- Further scale-up and Cost reduction are required

Building energy management system

Hans Hennig, Siemens, NL
Graphs/Simulations by Keith O'Donovan (AEE INTEC)

Why use a BEMS

BEMS = Building Energy Management Systems

- Standard building management systems rely on current measurement only (outside temperature / radiation)
- Few systems look ahead (solar load estimations mostly)
- Equipment is thus started when it can/must, not when it is optimal to start it
- A BEMS system starts the equipment at an optimal point based on available energy or energy cost

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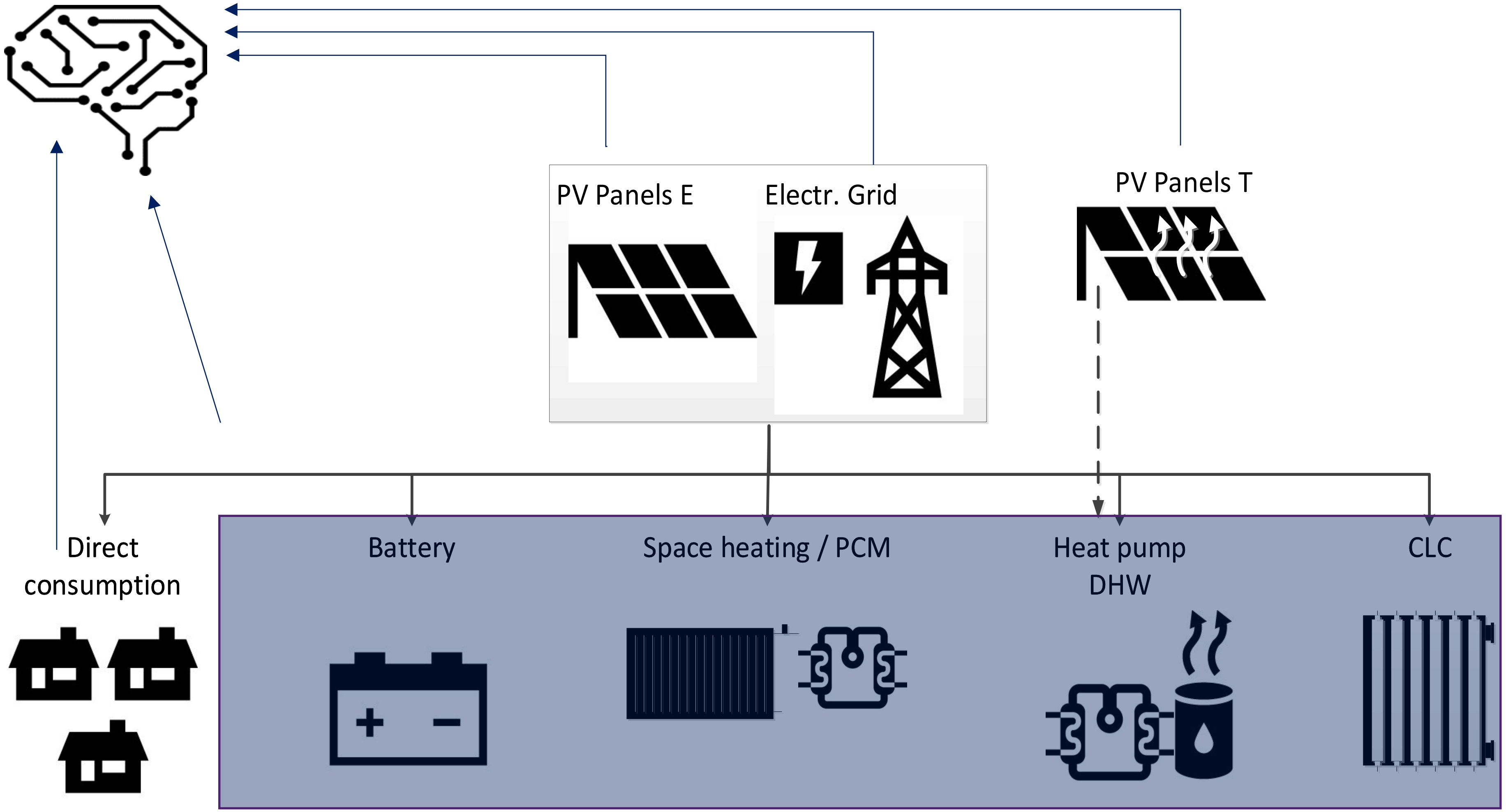
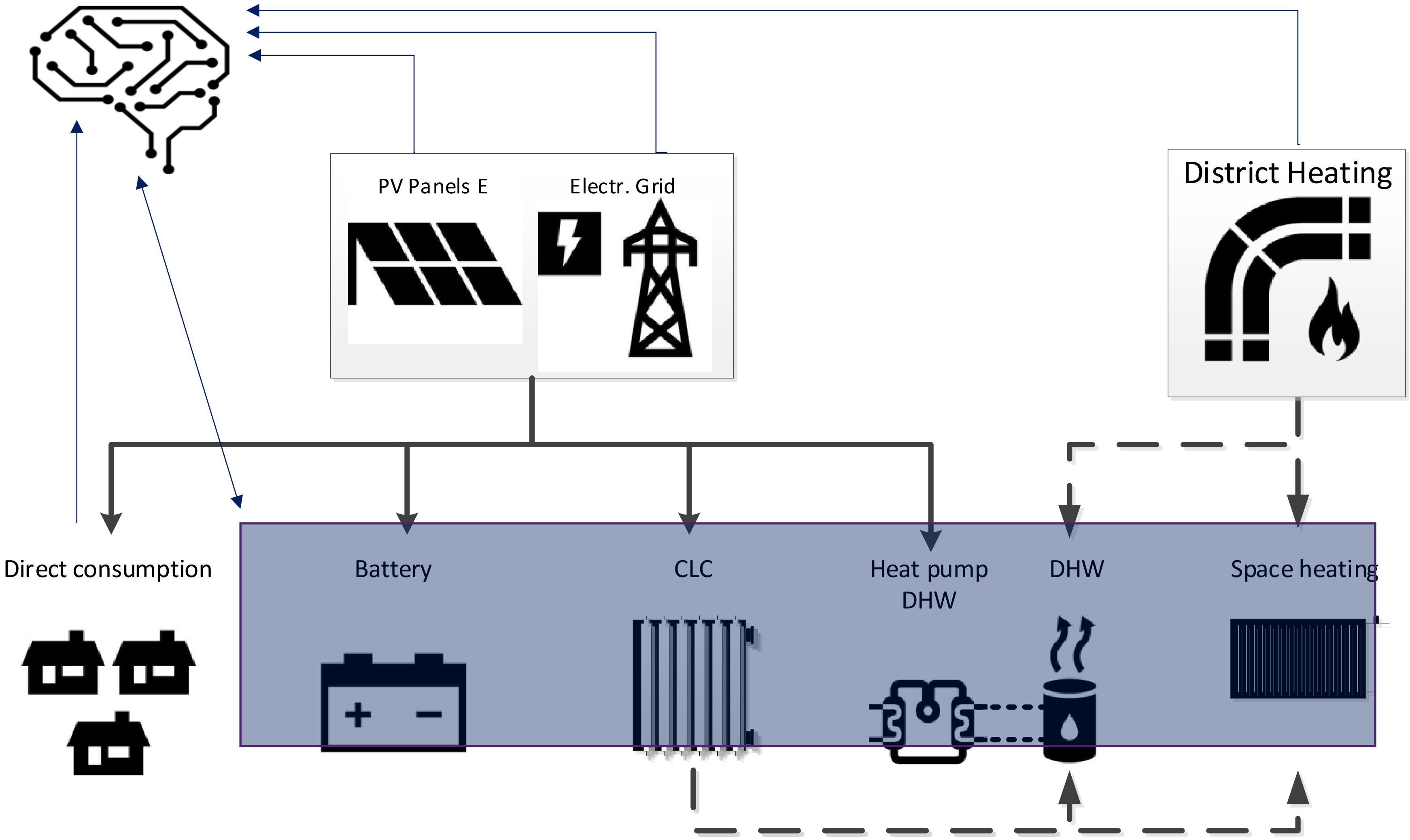
System setup Demo B (AGEN - France)

BEMS (Building energy management system)



System setup Demo A – (Gleisdorf – Austria)

BEMS (Building energy management system)



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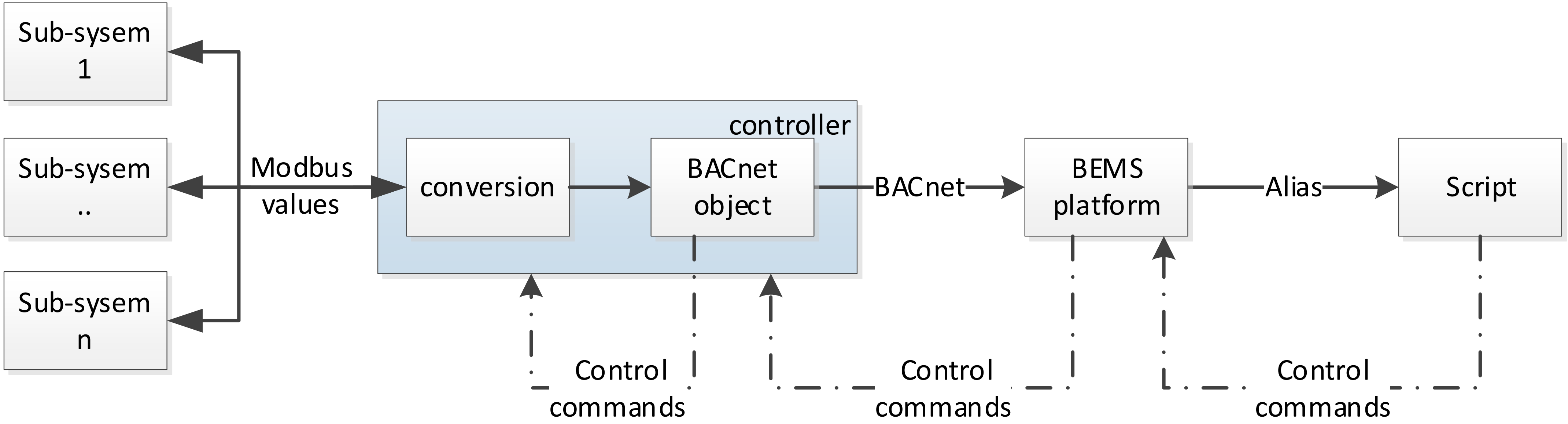
Control process

- BEMS is script based (java) and running on on-site server
- Results will be transferred back via controller to sub-systems



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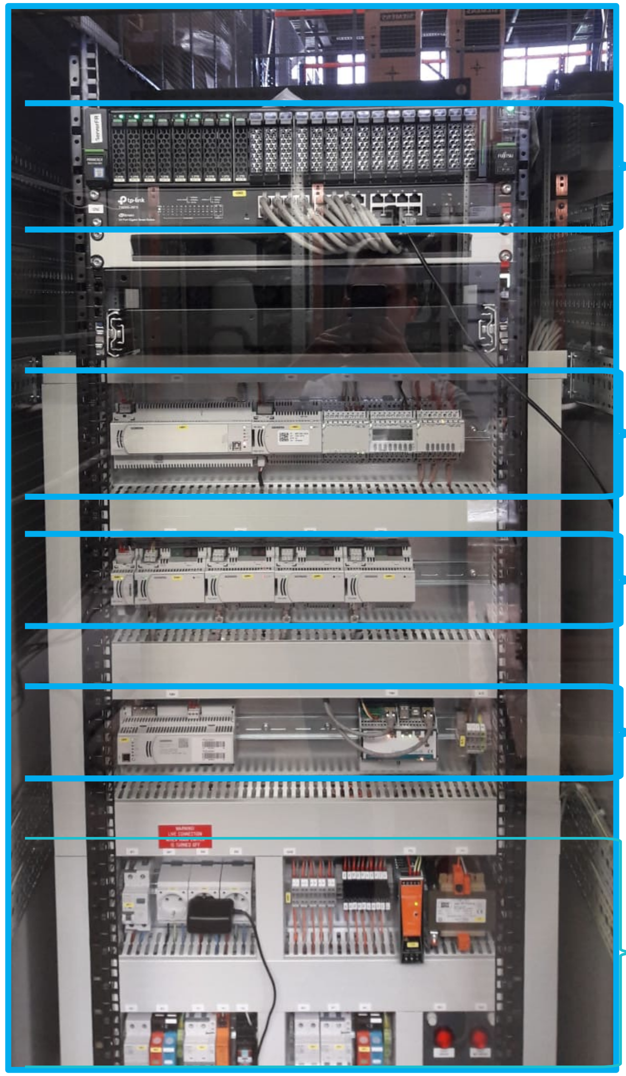
Controlling hardware



Server & switch

Controller & power source

Interfacing to sub-systems

Interfacing & connection box

Control lights & power connections

Algorithm setup

- Two algorithm parts are running at different speeds
  - Prediction algorithm:
    - Makes predictions of non-controllable variables
    - Uses physical formulae and regression for the predictions
    - Determines energy surplus based on calculated energy flows
  - Decision algorithm:
    - determines how best use energy surplus dependent on boundary conditions and algorithm settings
    - Uses a set of rules to determine optimization

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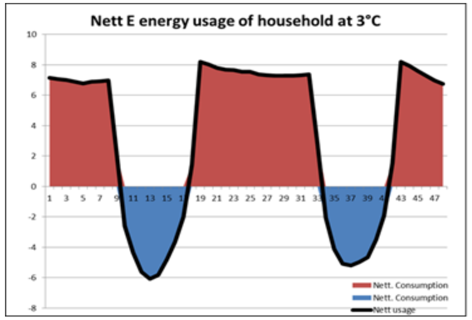
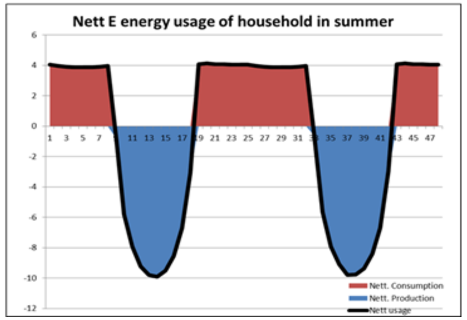
BEMS Algorithm – Simulation Interfacing

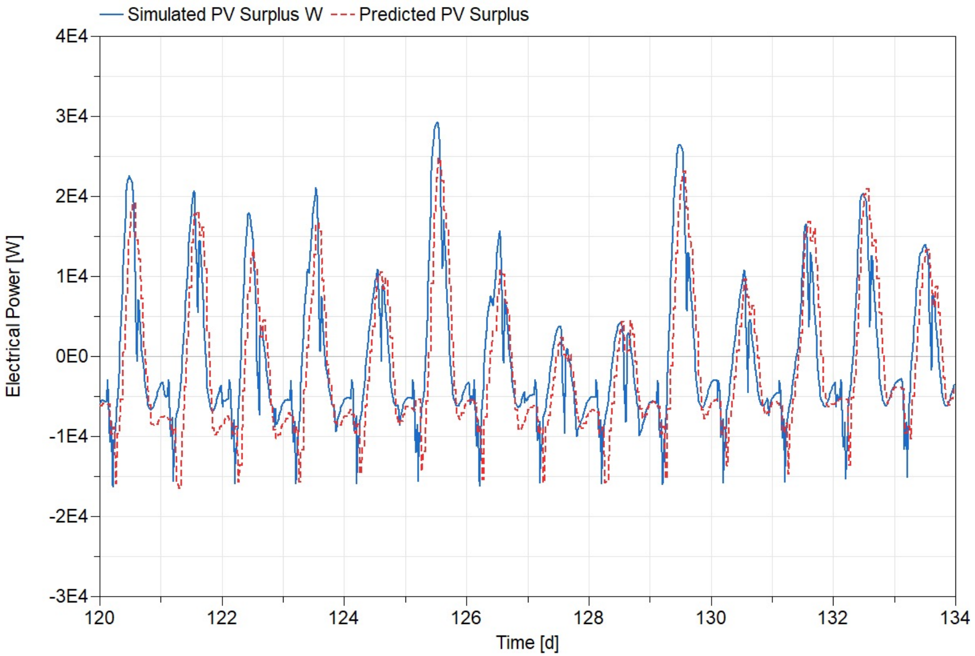
- BEMS reads datapoints from simulation to predict generation and consumption profiles over a 24 hour prediction horizon:
- PV surplus = $P_{PV} - P_{sh\_elec} - P_{dhw\_elec} - P_{gen\_elec}$

Theory



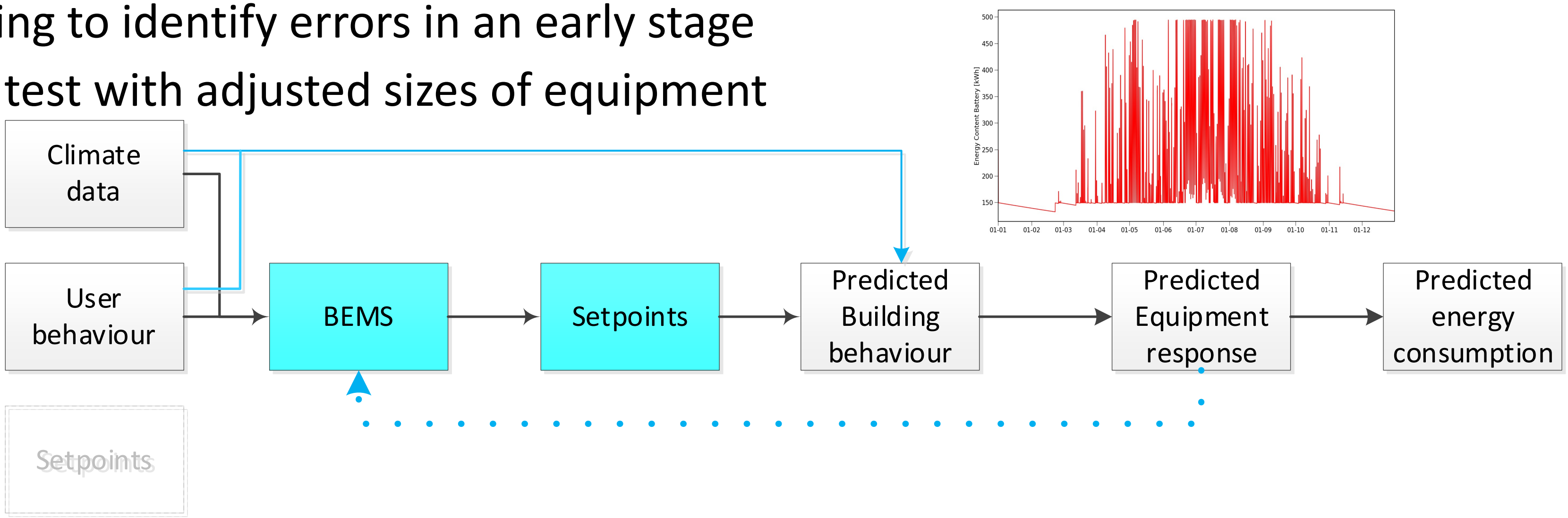


Simulation



Interactive simulation

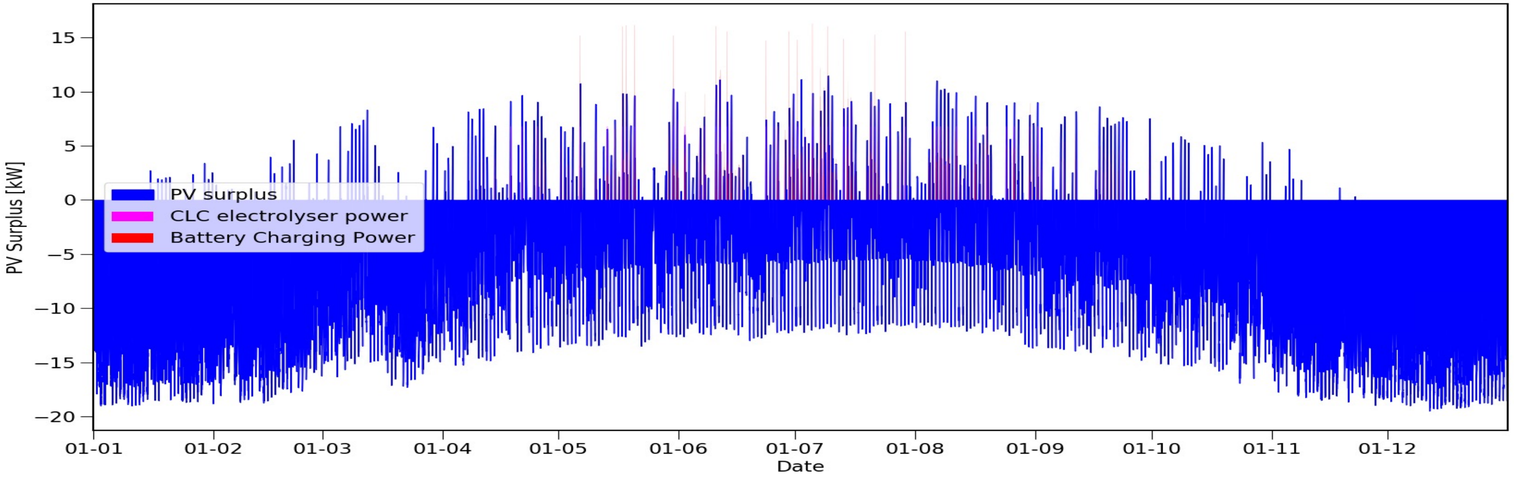
- Why:
  - Testing to identify errors in an early stage
  - Run test with adjusted sizes of equipment

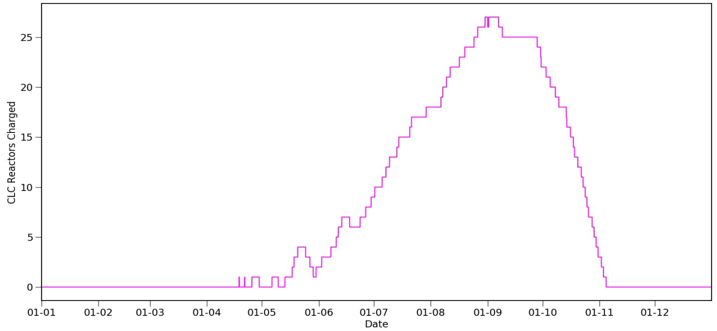


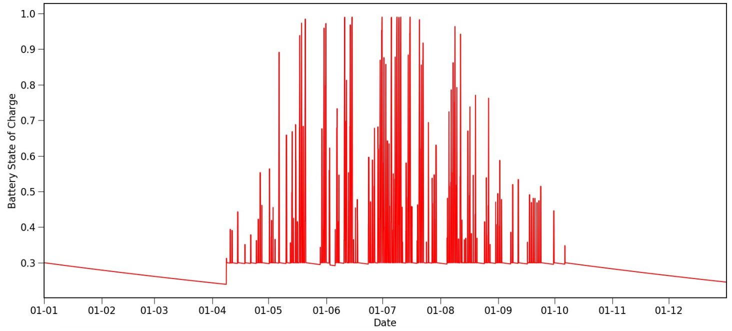
- Steps:
  - Algorithm and simulator (Dymola) will use weather data as input including “forecasted” weather
  - The BEMS will receive the status of the simulated system from Dymola and will determine subsequent actions
  - Dymola will receive subsystem commands from the BEMS and will determine the effect on the simulated system

Artificial scaling of components

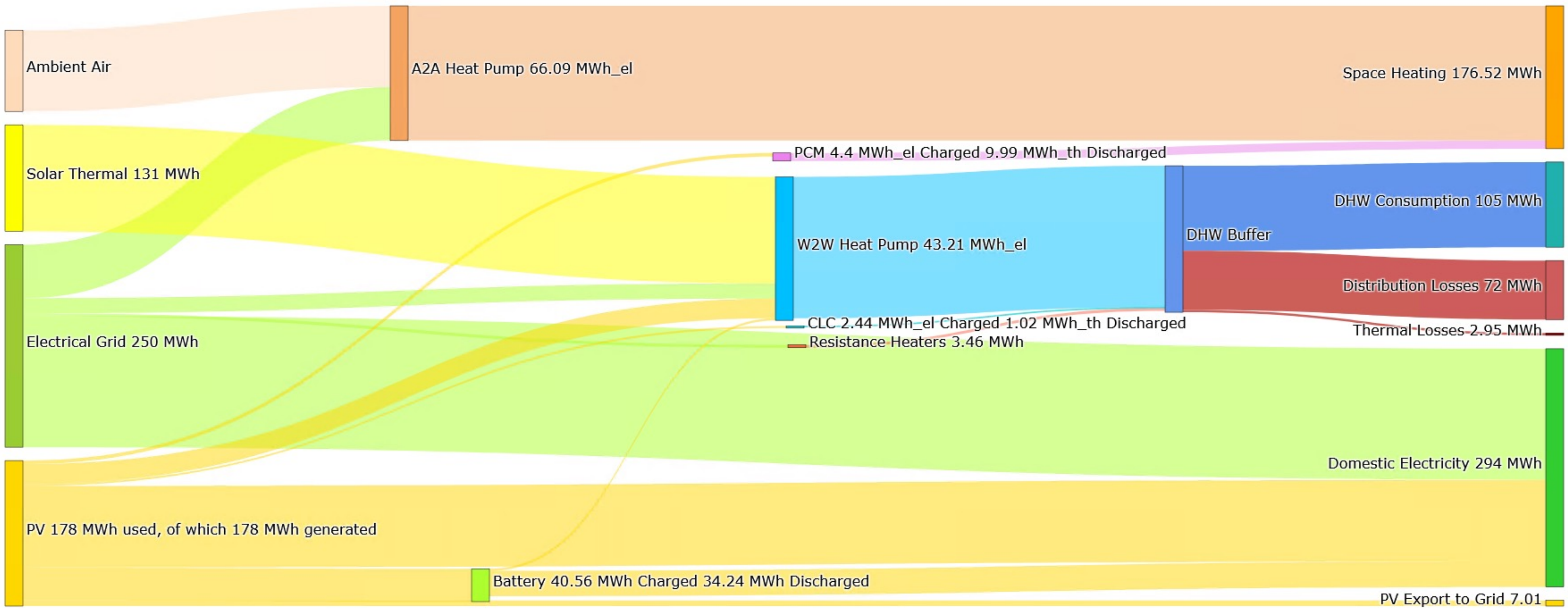
- PV area available in Austrian demo (25m^2) is predicted to be too small for BEMS to see any surplus
- Increase PV area artificially to 120m^2 in order for BEMS to see need for storages during monitoring (SCORES future system)







SFSB-4 Results: Yearly Energy Flows



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Learnings

- An all-round and fixed team is required for such projects
- Work from the desired outcome backwards to the design and the existing products (not vice versa!)
- Start with interfacing signals in a very early stage
- Remote-connection to systems and adequate support on-site is a must (travel time & Covid)
- The modeling of the system in the algorithms proved much more labor intensive then estimated in the beginning
- Interactive simulation for testing systems works quite well but takes effort to set op properly
- In research projects not all technologies will perform as expected

Thank you!

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