SCORES

SELF CONSUMPTION OF RENEWABLE ENERGY BY HYBRID STORAGE SYSTEMS

Training Course on Thermal Energy Storage for Heating, Cooling and DHW for Buildings

Air to air Heat Pump with Phase change Material (AHPP)

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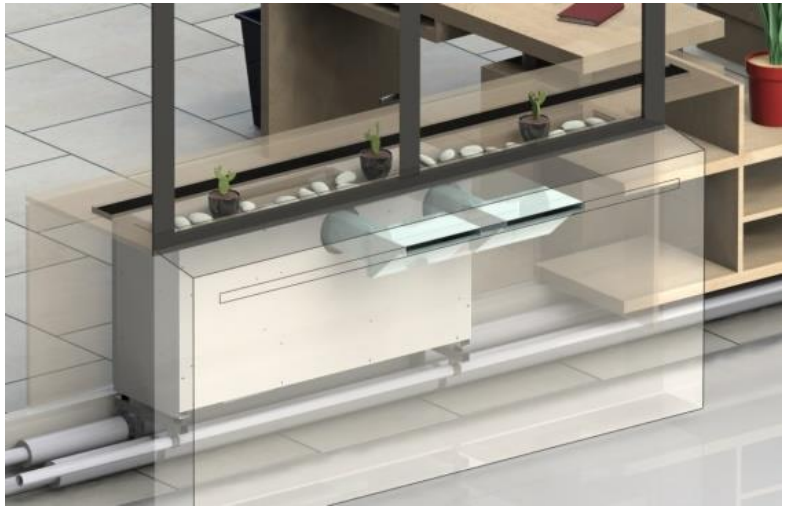
AHPP general design

The air-to-air heat pump with PCM energy storage (AAHP) will be an appliance installed inside a room of the building without external unit. It transfers heat from outside to inside the building via 2 ducts in the wall. The external air is sucked-in and it exchanges energy with the thermodynamic system in order to heat the room. The pictures below are drawings of similar machines in an office.

View from inside of the office

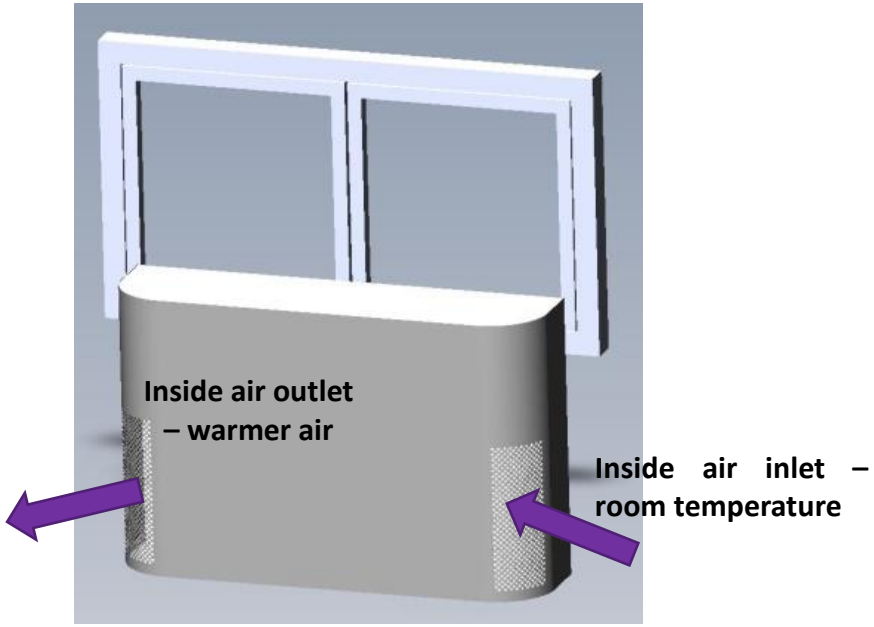


View from outside : 2 ducts integrated in the façade (equivalent diameter 200mm)

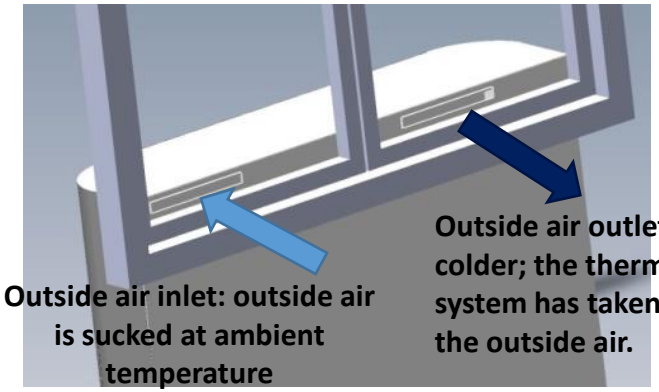
- **No external units outside**
- **Often integrated in office furniture**
- **Efficiency > 3**

AHPP general design – Application for the AGEN Building

Specific holes have been designed in order that the inlet and the outlet of the external air are integrated in the frame of the window.



Front view of the AAHP: installation inside the room

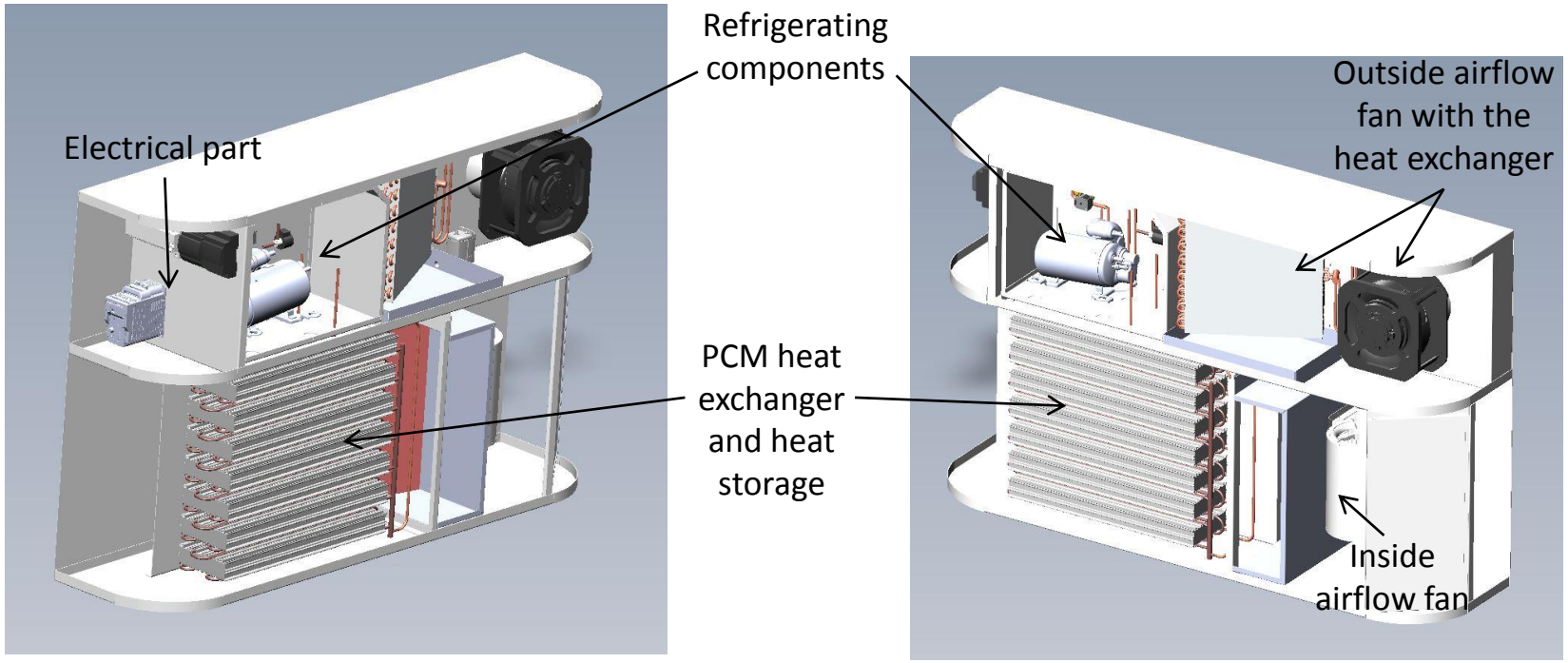


View of the AAHP from the outside of the room

Unfortunately, the building manager didn't agree to install the AHPP :

- **The need for the room was mainly cold and not additional hot**
- **The room was occupied : to avoid disturbances**

Design of the air-to-air heat pumps with the heat storage



Key points of the design:

- PCM heat Exchanger
- PCM selection
- New refrigerant with a lower GWP
- Tailor-made design for the building at Agen

Final aesthetic design

Front view

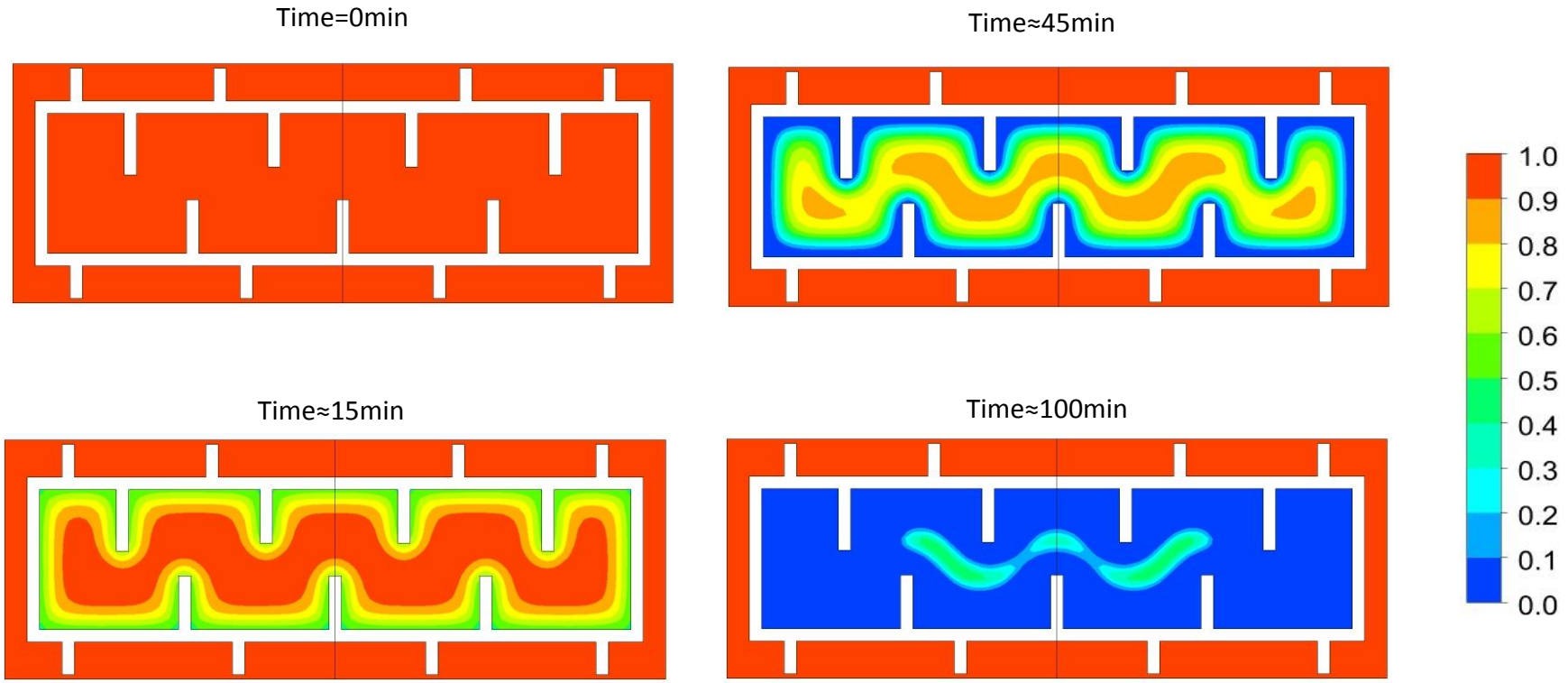
Rear view

Dimensions:
Length: 1580mm
Height: 700mm (without feet)
Depth: 385mm

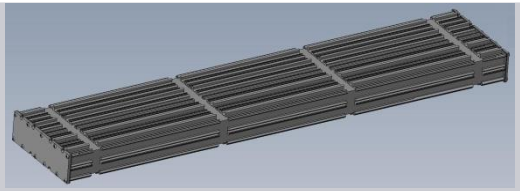
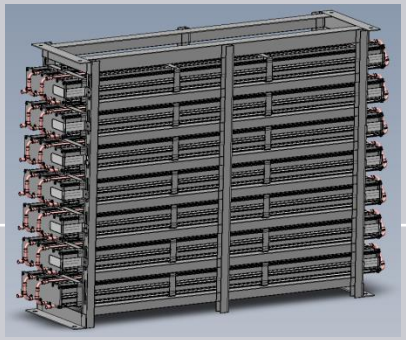
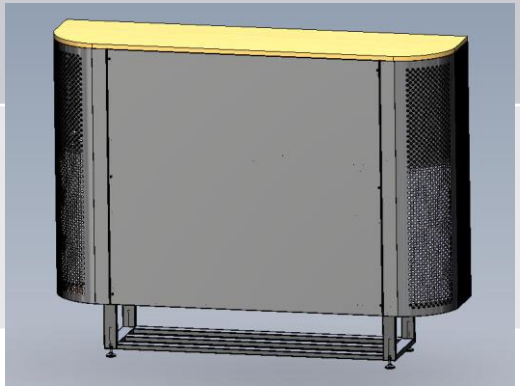
Weight 160kg

Aluminum profiles CFD study by IPS (example)

Mass fraction distribution – Discharging Process A53; inlet velocity 2.5m/s
IPS CFD study



Heating storage tank

Element	Size / Volume / Mass	Storage Capacity from 20 to 65°C	Details
Raw aluminum profile	159 x 800 x 50 mm - 4,40 kg 3,72 L available for filling	52 Wh	
PCM-filled Aluminum profile with caps	159 x 810 x 50 mm - 5,28 kg Filled at 90% with A36 – 3.34 L	289 Wh	
Rack of 7 PCM-filled aluminum profiles	200 x 900 x 590 mm – 49 kg 23,4 L	2025 Wh	
Complete AAHP	387 x 1582 x 700 mm (without feet) Estimated 160 kg	2025 Wh	

New refrigerant: R513A

The French demo site is classified as a “public access building”, so the main specification for the thermodynamic system was no flammable refrigerant.

Theoretical study to define the best compromise between:
thermodynamical properties / lowest GWP / no flammability

→ R513A

A first campaign of tests has been performed to validate the new refrigerant R513A. The tests have been done on 2 well-known France Energie heat pumps using R407C

Model	Refrigerant	Charge (g)	Mode	Electrical power (W)	Heating power (W)	COP	GWP
ARO 950	R407C	660	Heating	388	1985	5,12	1770
ARO 950	R513A	680	Heating	398	2020	5,08	573
		3,0%		**2,6%**	**1,8%**	**-0,8%**	
ARO 1150	R407C	660	Heating	531	2623	4,94	1770
ARO 1150	R513A	680	Heating	538	2632	4,89	573
		3,0%		1,3%	0,3%	-1,0%	

The heating power is almost the same and it seems the electrical consumption is lightly higher which means a decrease of the performance of about 1% **= negligeable.**

The main benefit is the lowest impact on the Global warming, divided by 3 using the R513A against the R407C.

France Energie test laboratory

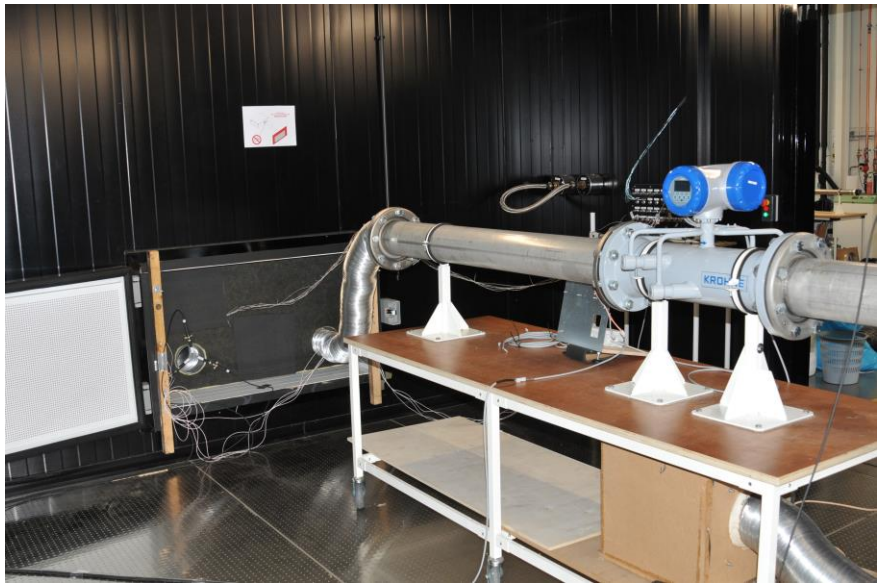
The France Energie laboratory is equipped with 2 test rooms to test the AHPP :

- 1 for the internal climate +10°C < Tint < +40°C
- 1 for the external climate -15°C < Text < +50°C
- with a “technical opening” between the 2 test rooms

France Energie Laboratory tests on the AHPP

The AHPP have been installed inside the Internal Climate test room which simulates the ambient conditions of a room in a building

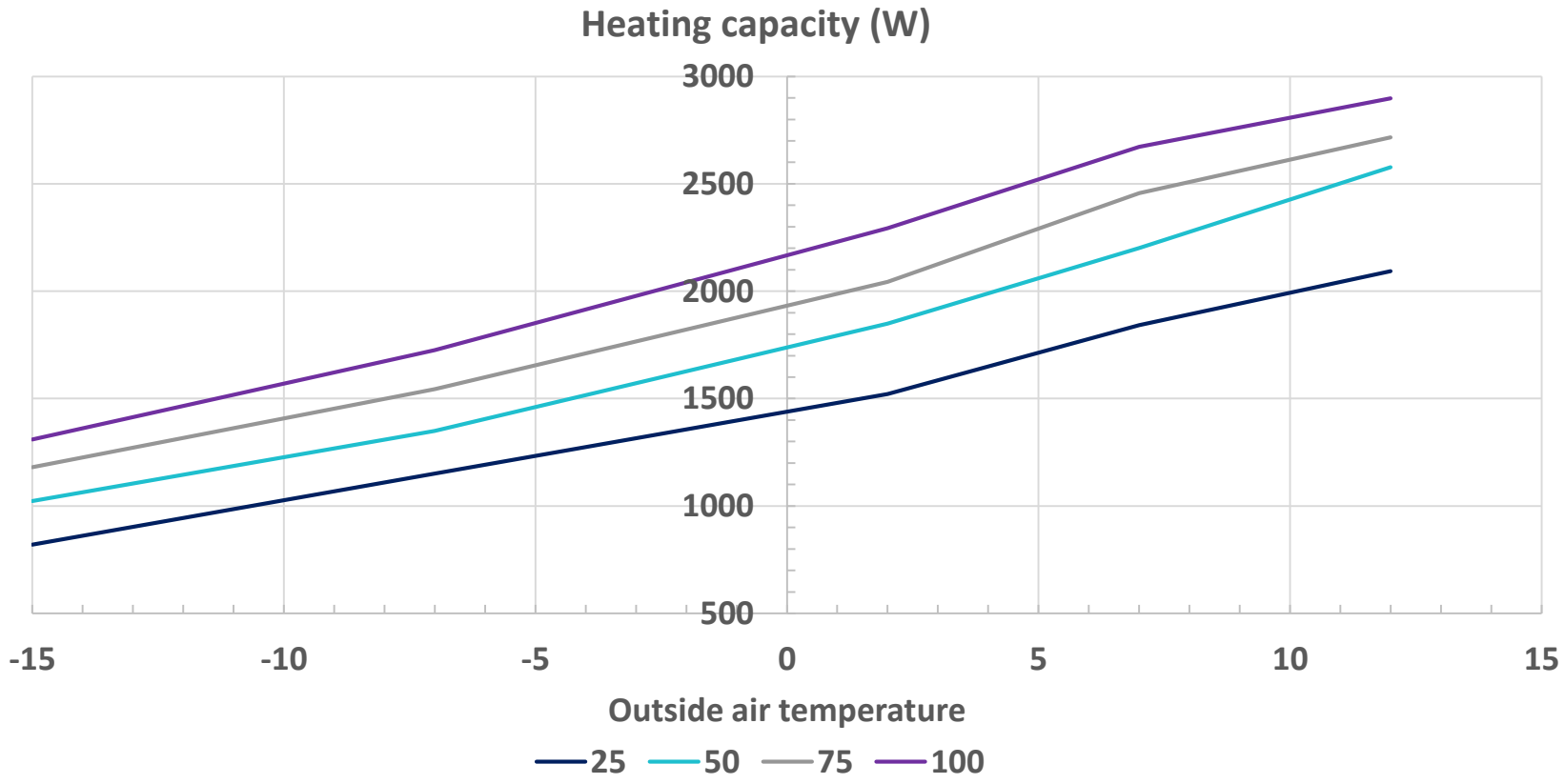
The External Climate test room simulates the outside air conditions



The instrumentation equipment is composed of 57 probes : temperature / humidity / airflow / pressure / Electrical Power

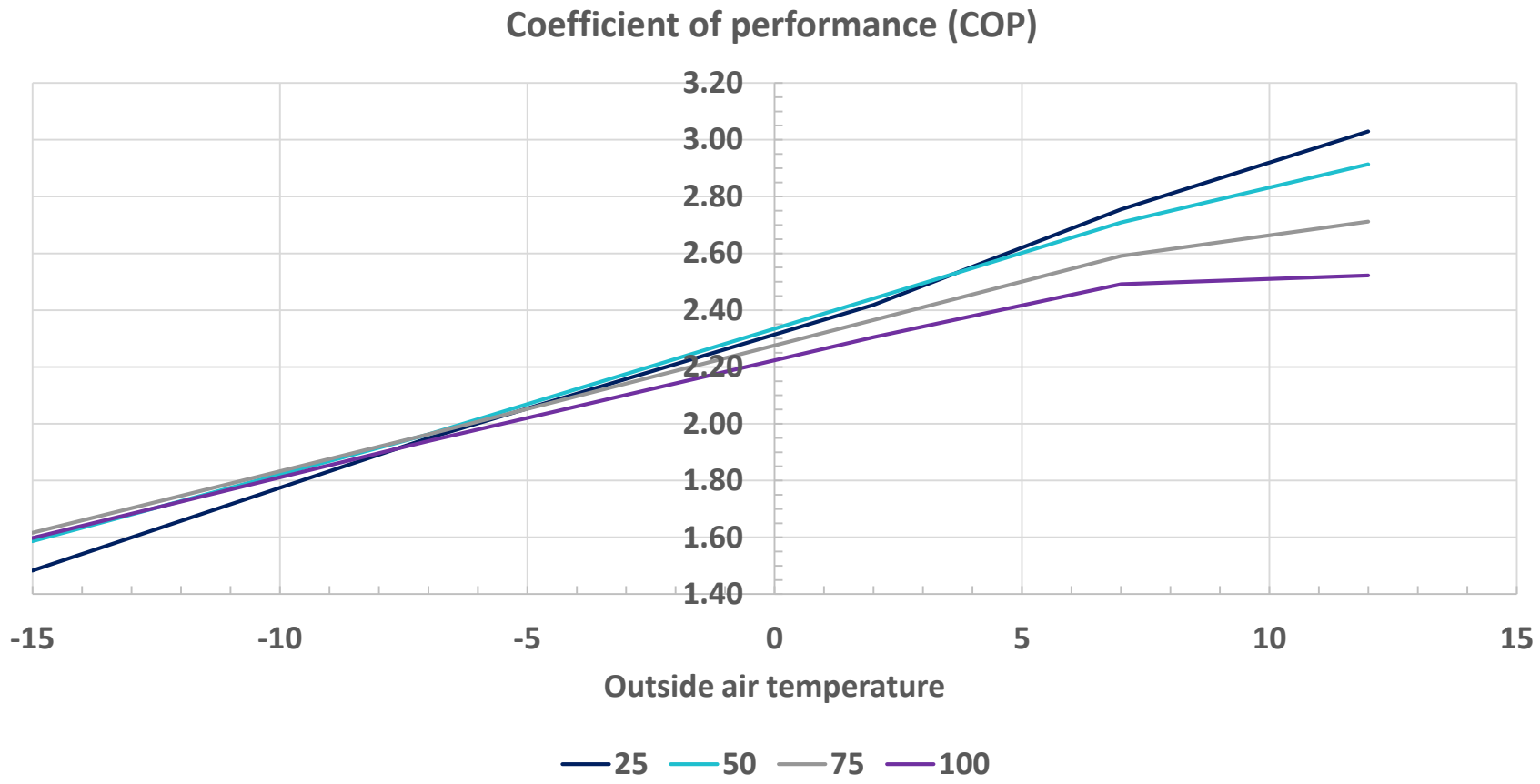
Air to air heat pump heating power – Outdoor air

Graph of the heating capacity according to the air outside temperature and according to the speed of the compressor (Freq = 25% – 50% – 75% – 100%)



Air to air heat pump performances COP – Outdoor air

Graph of the COP according to the air outside temperature and according to the speed of the compressor (Freq = 25% – 50% – 75% – 100%)



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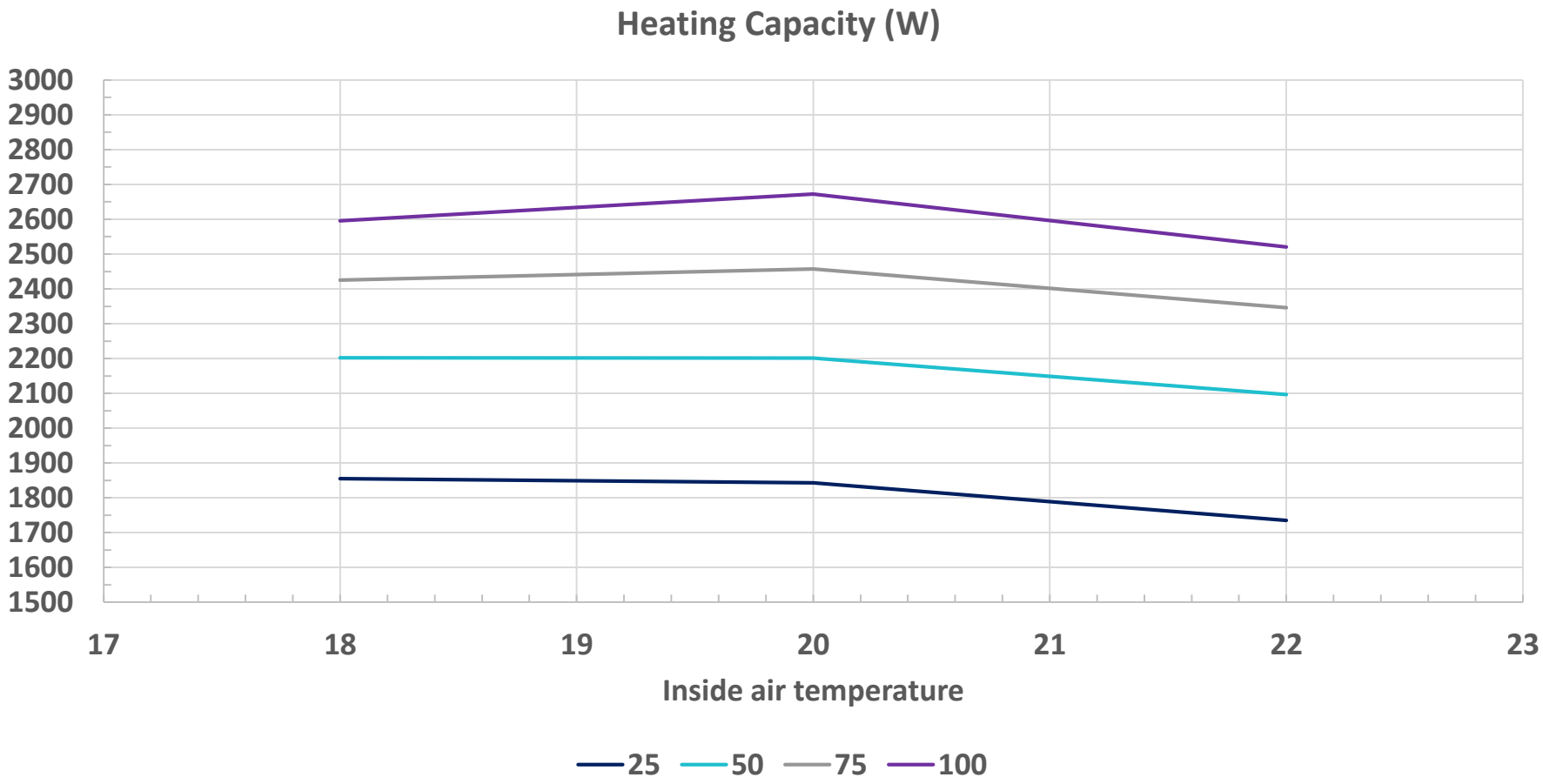

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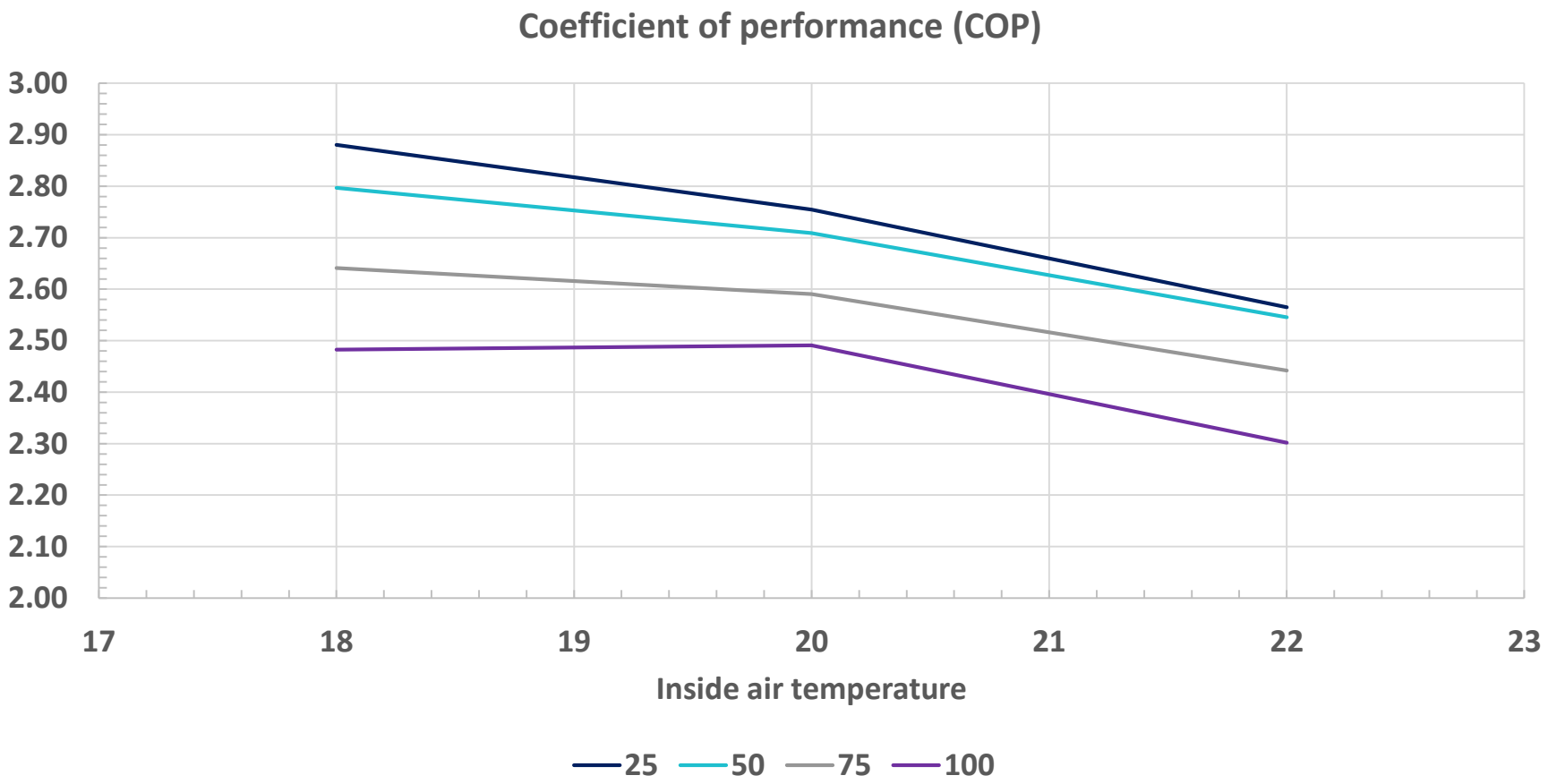
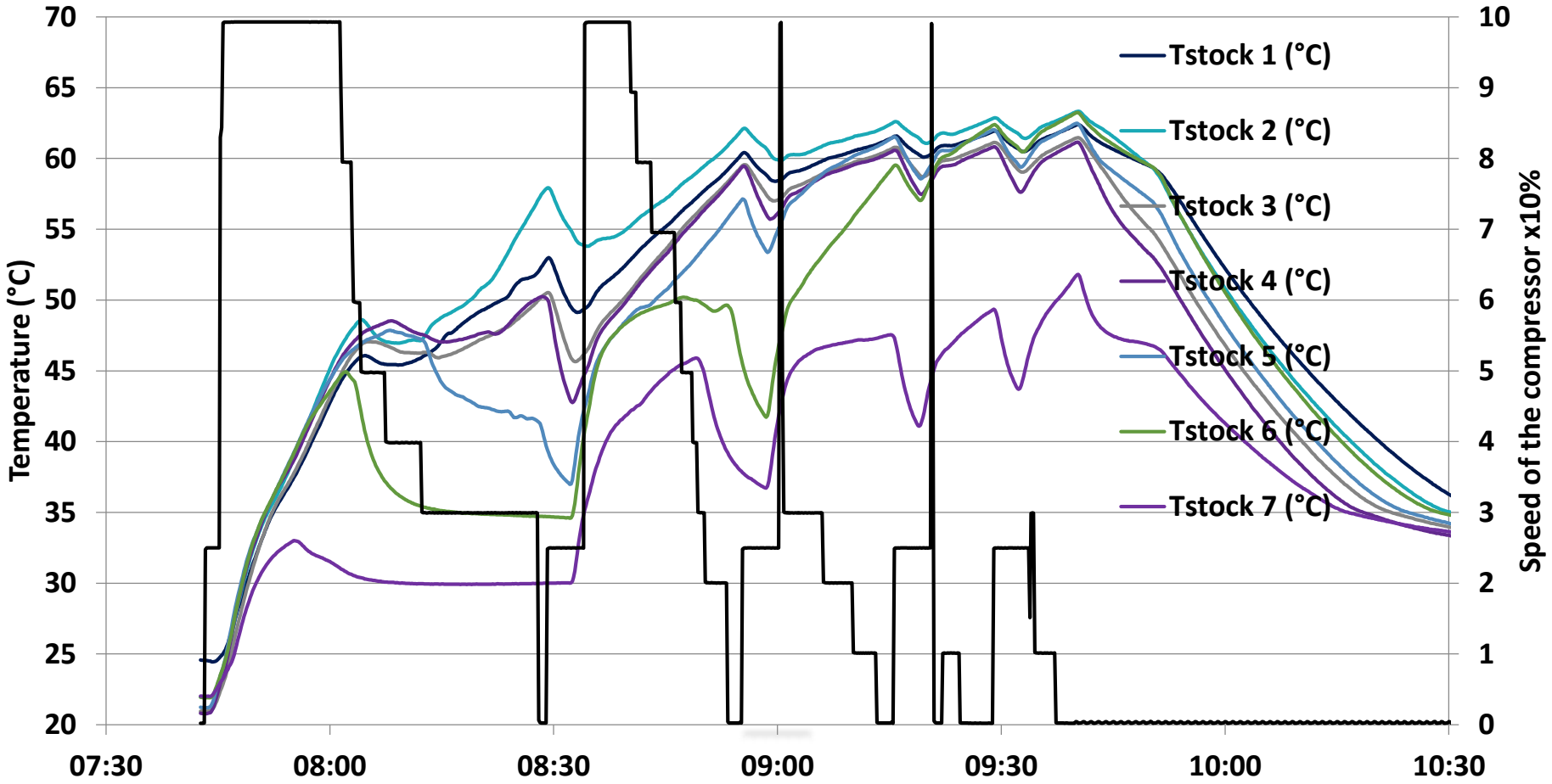


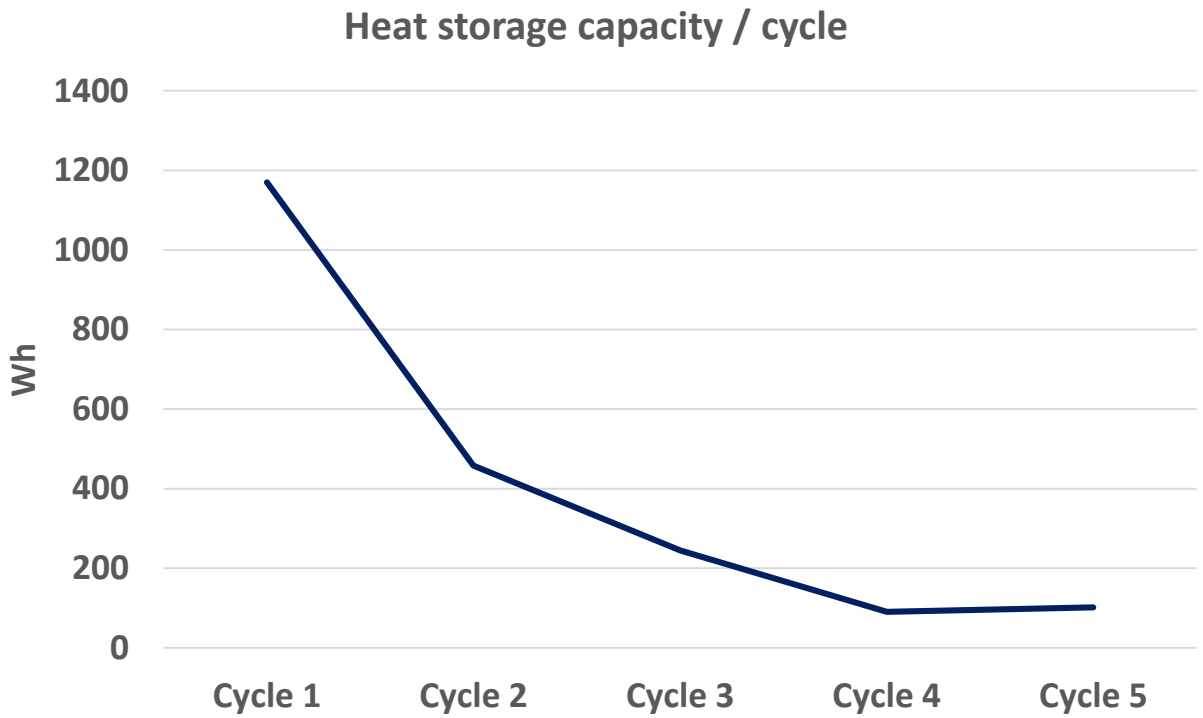
Heating charge of the PCM

Temperature of the PCM storage elements during the heat charge



Charging process of the PCM

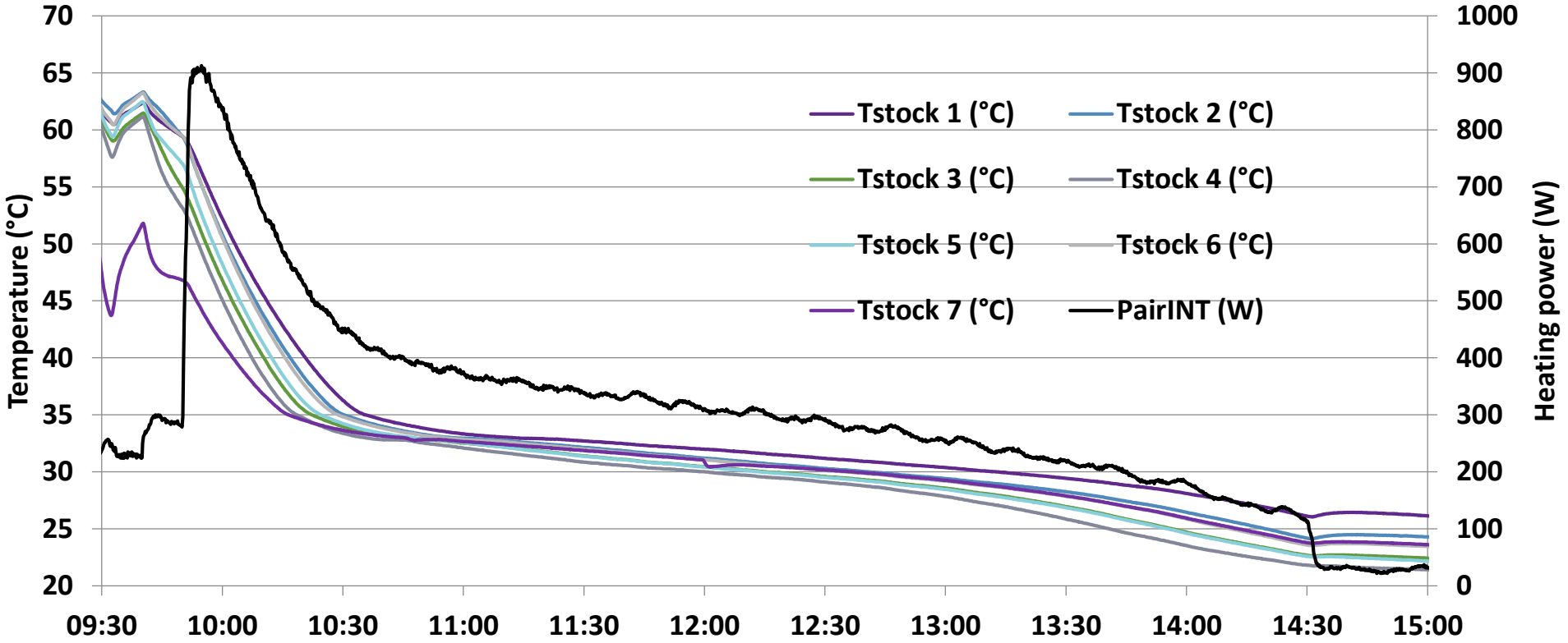
Temperature of the PCM storage elements during the heat charge



The AHPP can store about 2000 Wh within a maximum time of 2 hours and with external temperature above +2°C.

Heat discharge of the PCM

Temperature of the PCM storage elements during the heat discharge with <u>fixed speed of the airflow</u>

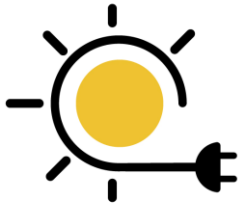


In real life, the heat release is driven by the temperature differences between the room temperature and the setpoint temperature.

Air to air heat pumps: Key Indicator Performance

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 air 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	1764 kgeqCO2 For 1 kW heating power	Equivalent CO2 impact of one appliance.

Business opportunity



Advantages

- A great interest for a self consumption building purpose
- To avoid electricity peaks
- No noise during the discharge period = additional comfort during the night

Disadvantages

- Require significantly greater space
- More expansive

Thank you

Thank you!

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