Heat Insyde

BRINGING ADVANCED **HEAT** BATTERIES **IN** RESIDENTIAL HEAT
AND ELECTRIC **SY**STEMS CLOSER TO MARKET
THROUGH REAL LIFE **DE**MONSTRATION IN DIFFERENT CLIMATES

Etienne Wurtz
CEA SCIENTIFIC DIRECTOR

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 869810.

PARTNERS INVOLVED IN THE WP7

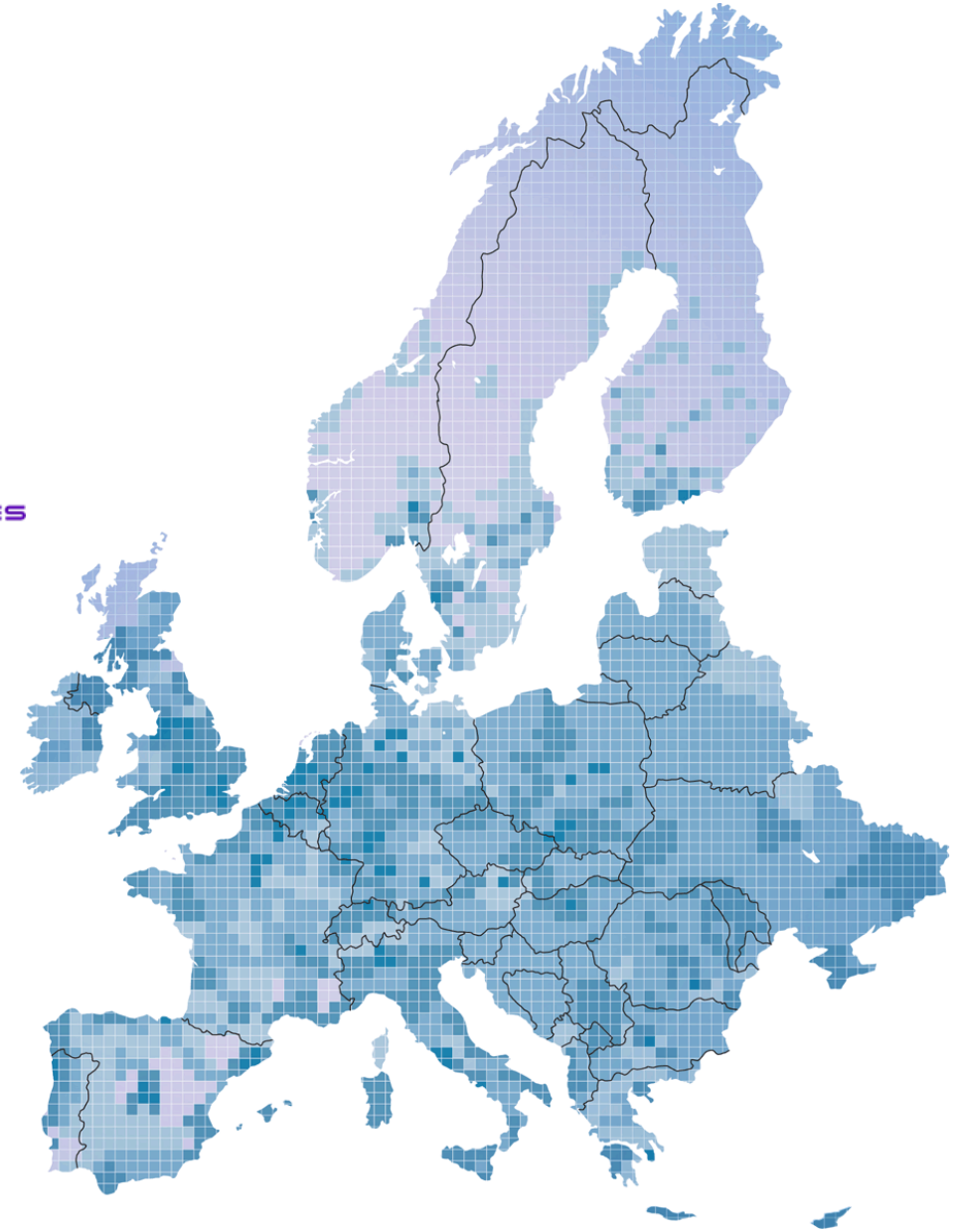
TNO

TU/e

VMI AIR PURIFICATION TECHNOLOGIES

CALDIC

cea



ENGIE Laborelec

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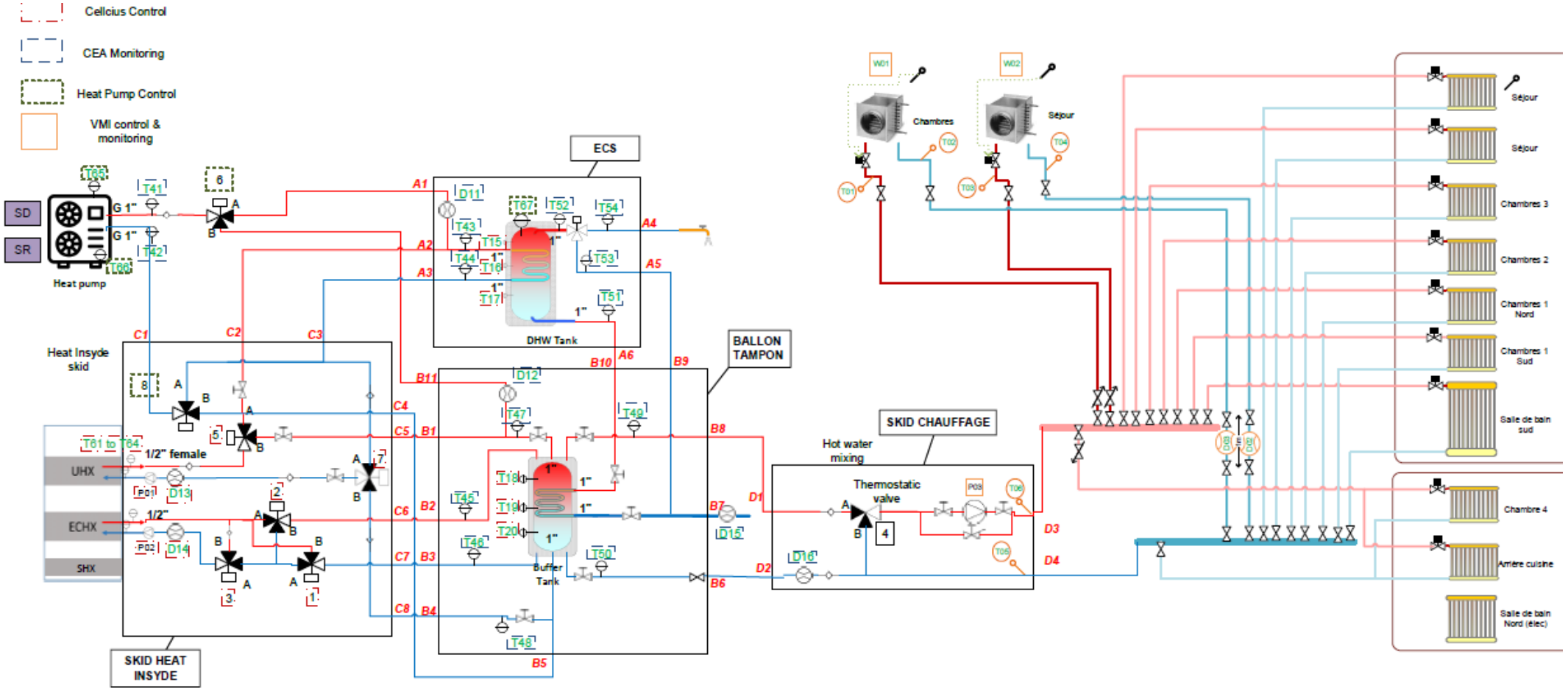
FASADA

TRUDO

HEAT BATTERY IMPLEMENTATION IN CADENET

Demonstration house in southern France (Cadenet)

HEAT BATTERY IMPLEMENTATION



Hydraulics scheme for installation in Cadenet - France

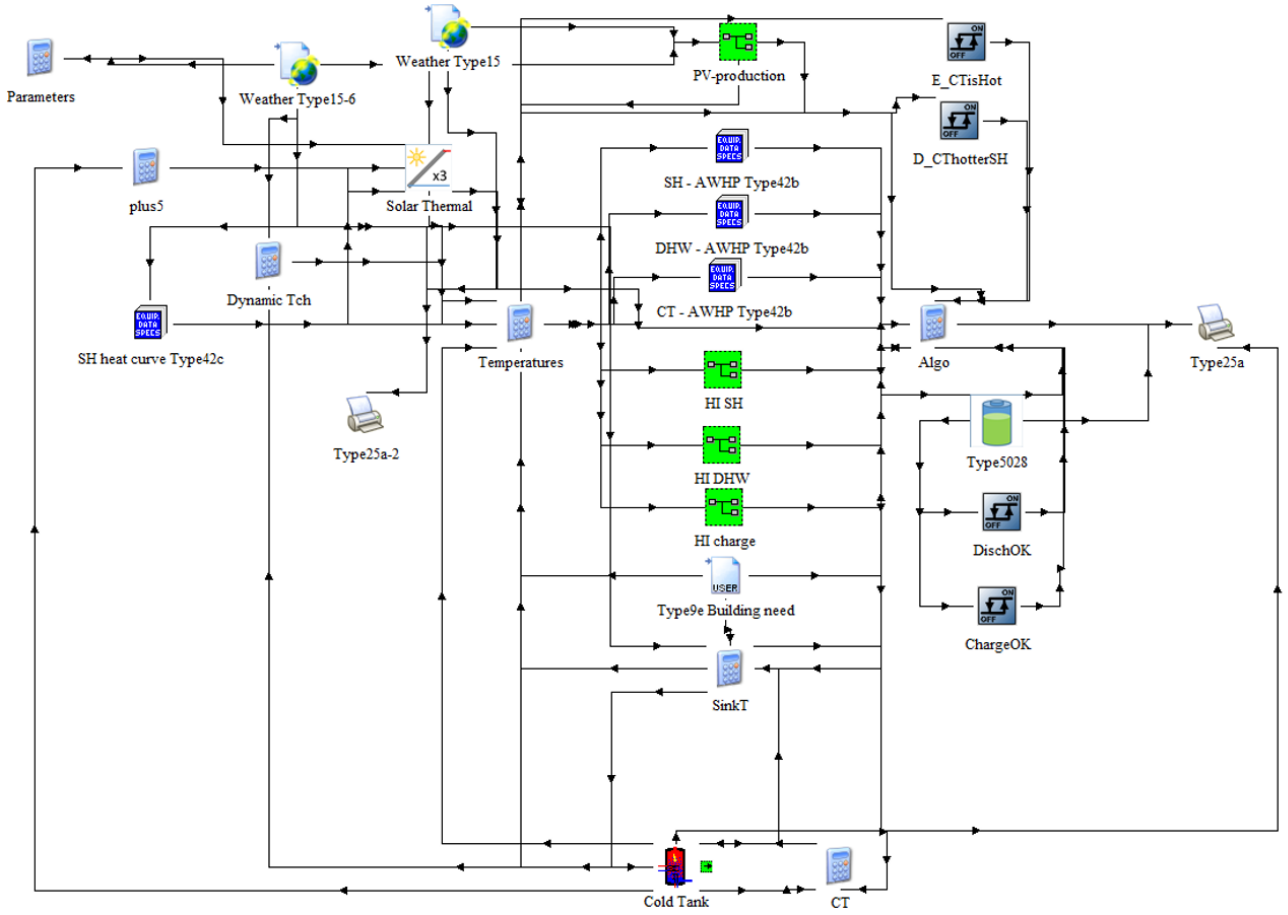
- Installation of the whole energy system in France

Heat Battery installed in the house basement

HEAT BATTERY IMPLEMENTATION IN FRANCE

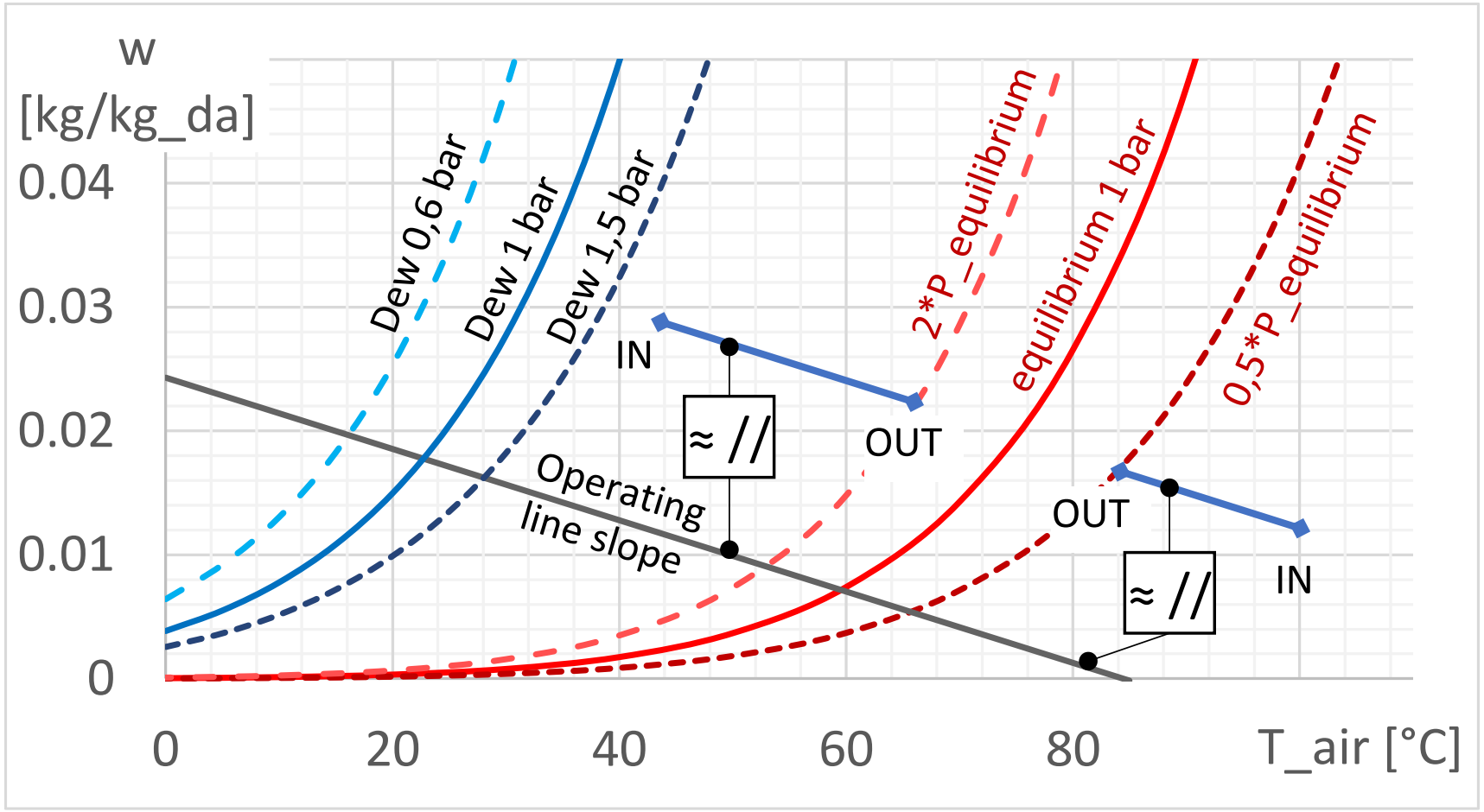
Water tanks used for heat distribution in the house

- Whole system simulated, from chemichal reaction to building heating



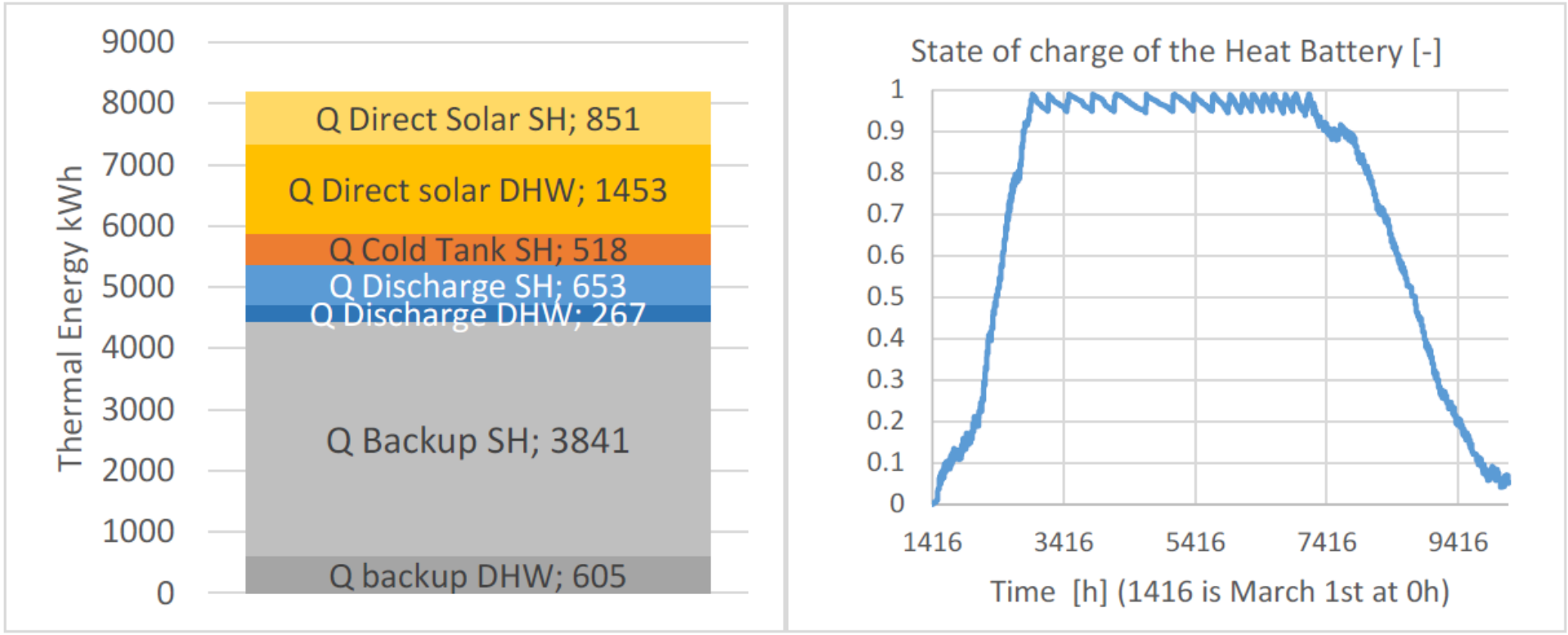
Full energy system model in the TRNsys software

Chemichal reaction



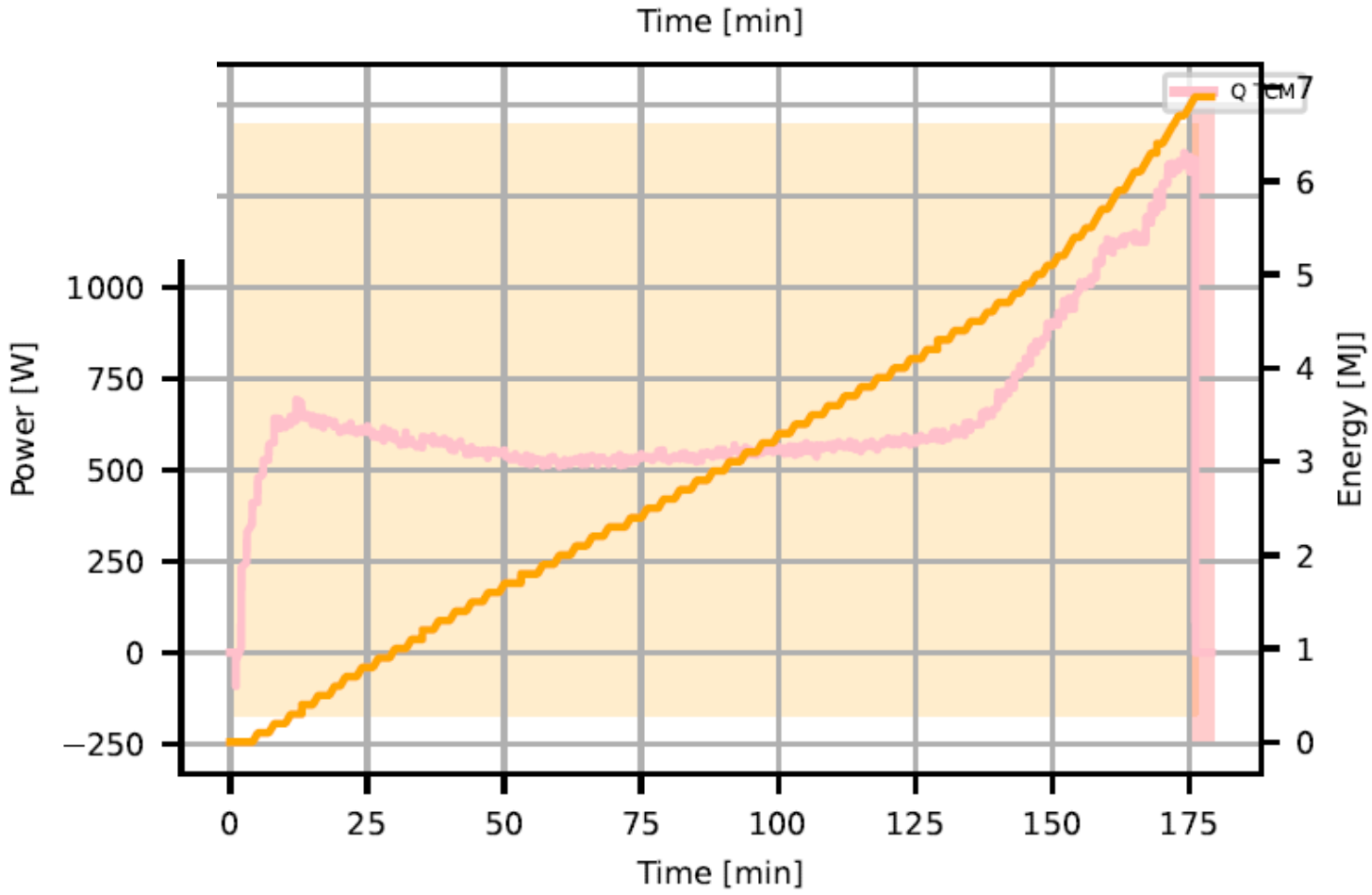
Air temperature/pressure plot, with half and twice K_2CO_3 equilibrium pressure, operating and dew point lines

Storage behaviour



Total energy balance and state of charge of the heat battery throughout one year (starting march 1st).
French demonstration site

FIRST RESULT OBTAINED IN CADENET



Discharging power and cumulated energy from the Heat Battery heat exchanger.
Test performed on the French demo site on 30th July 2024

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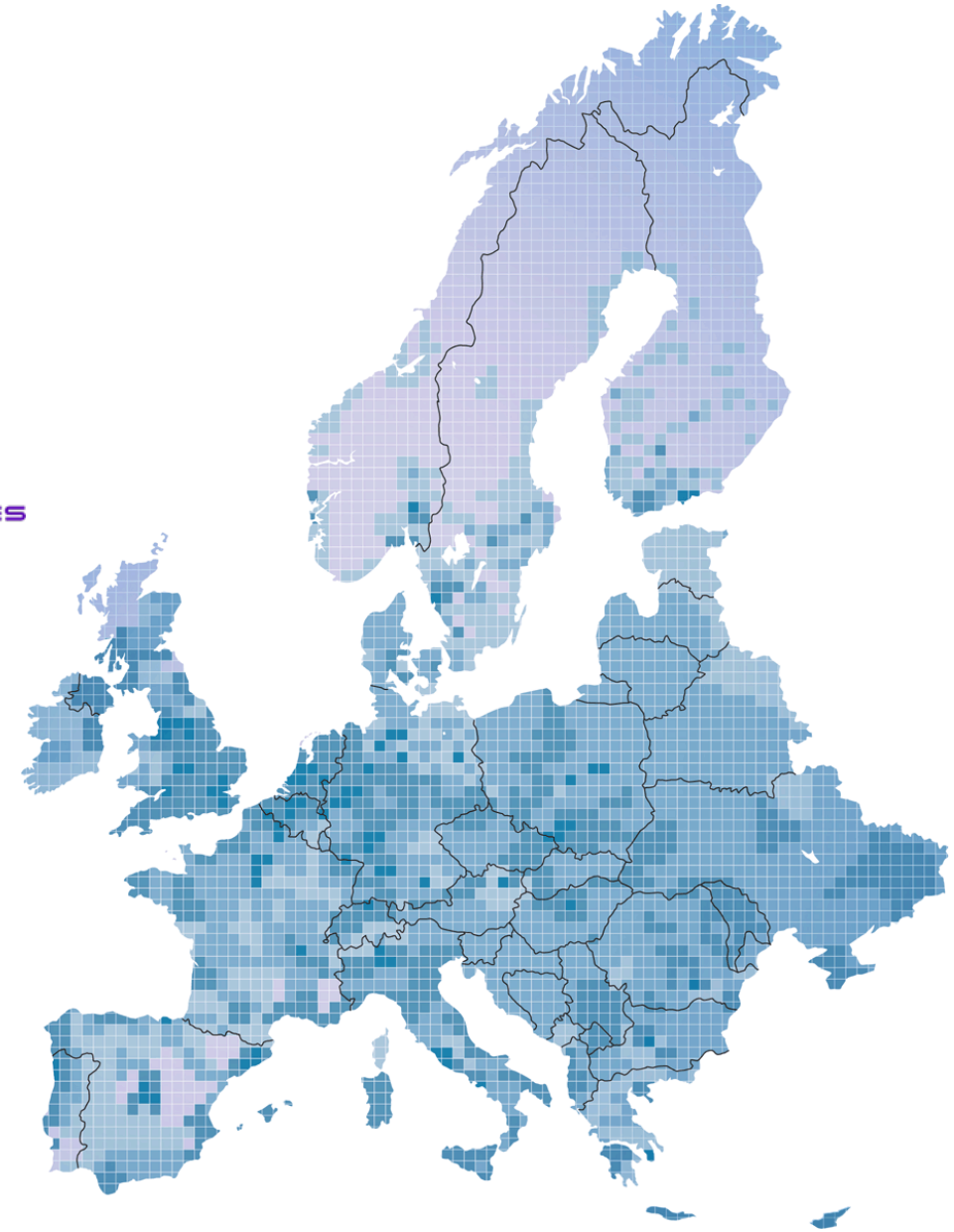

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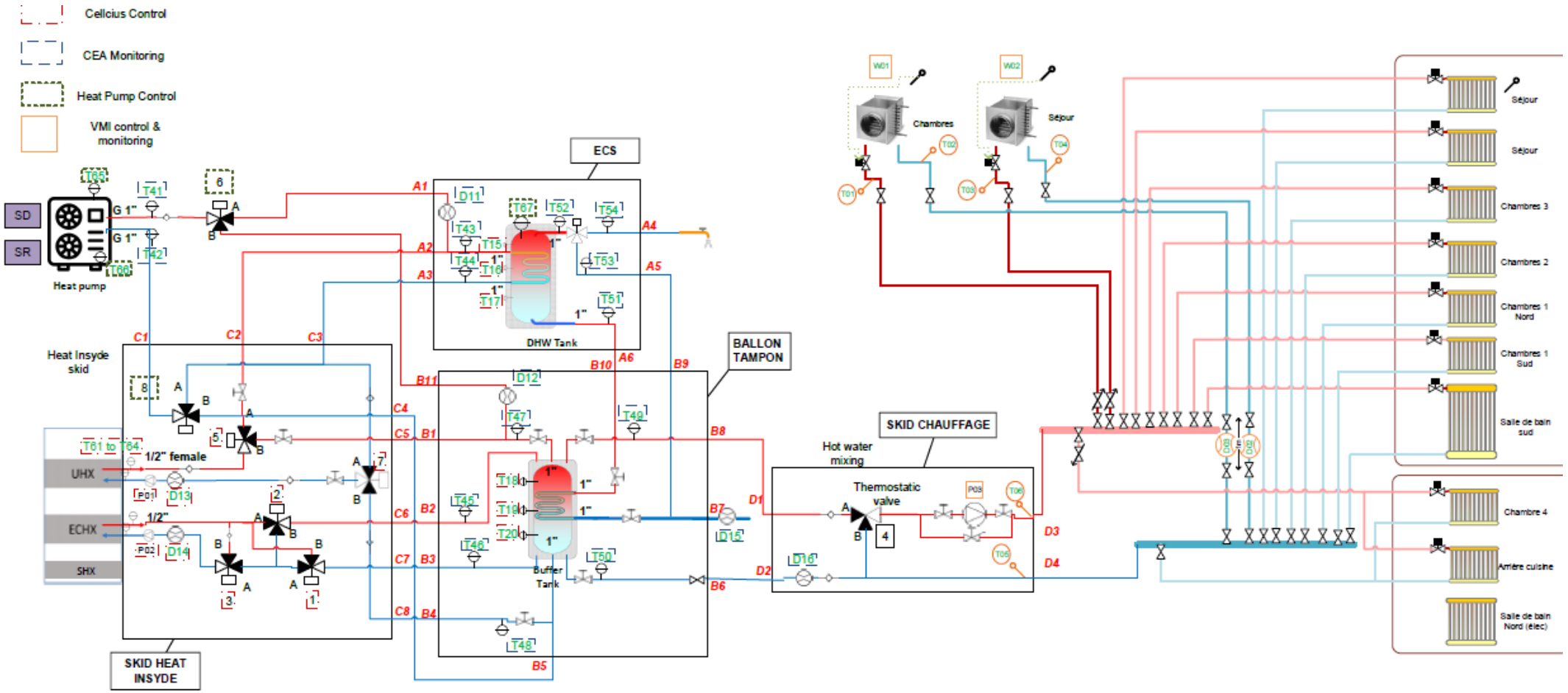

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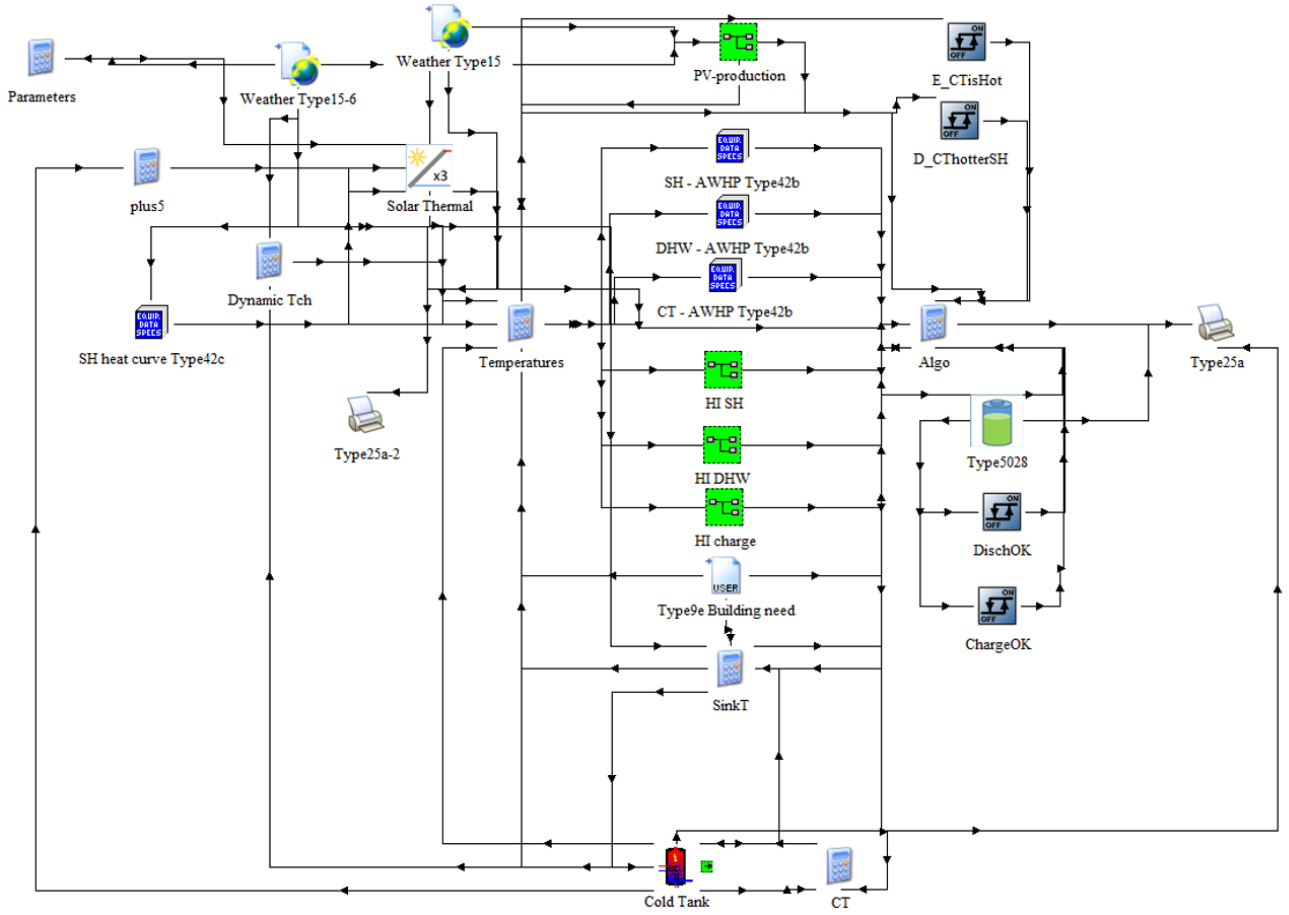

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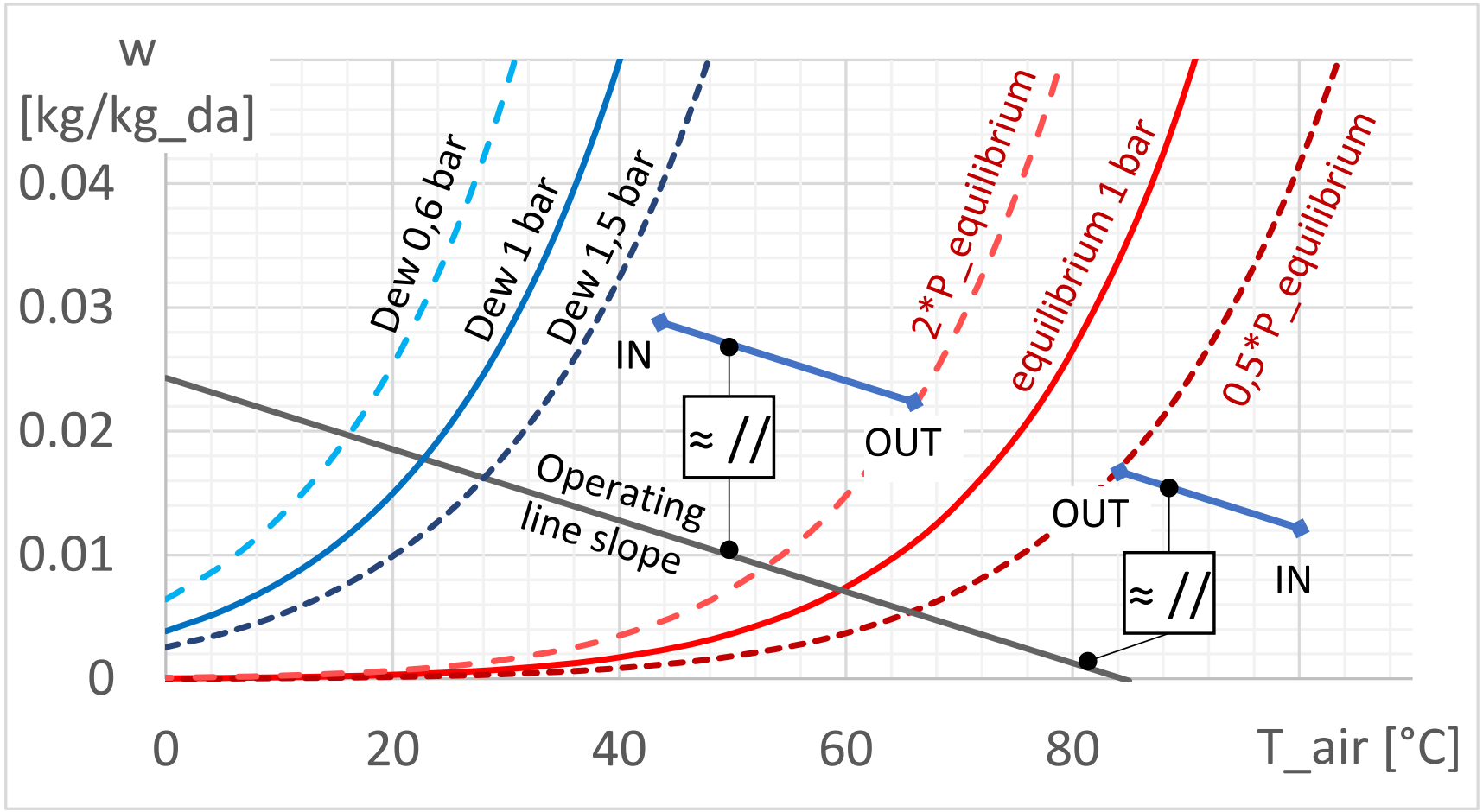

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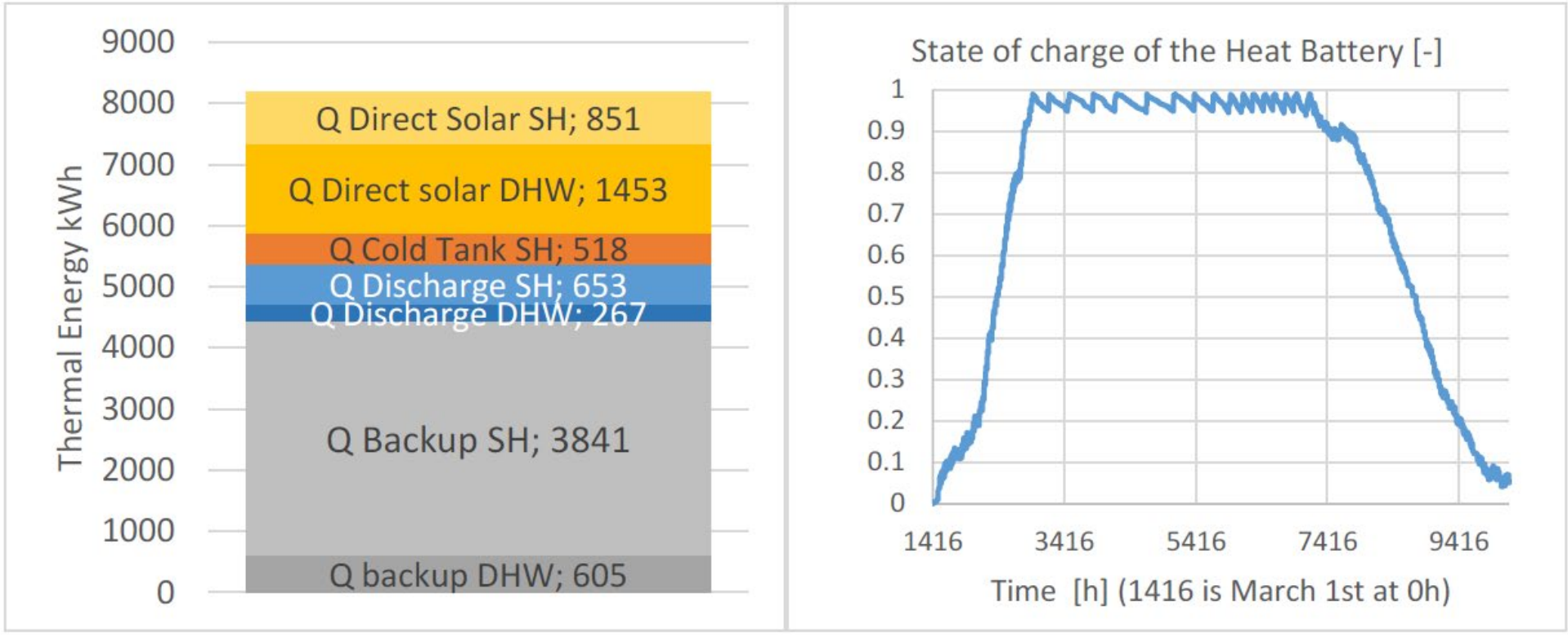

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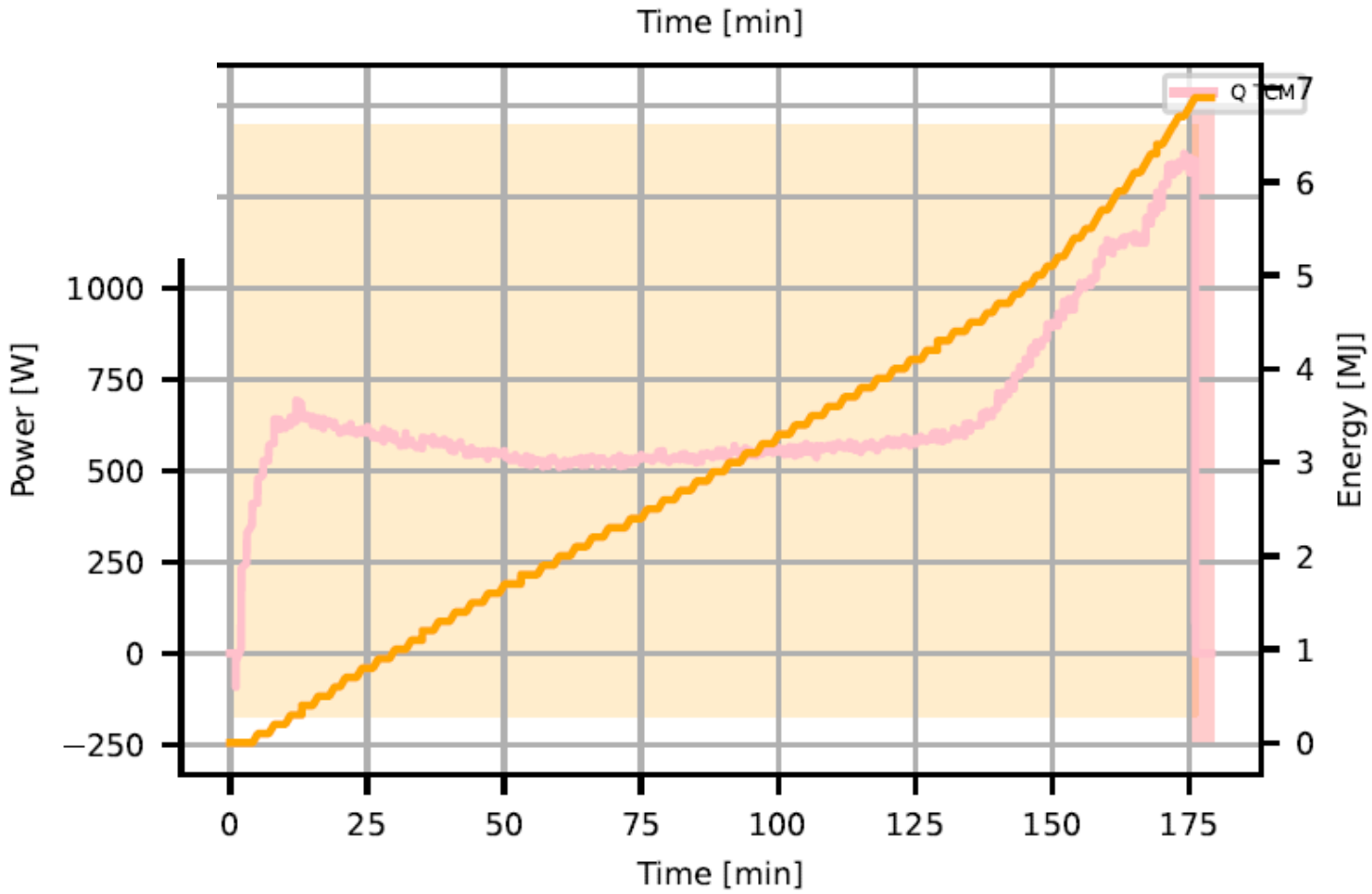

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WORKSHOP

HEAT-INSYDE

Storage materials – working principle and manufacturing

Heat Insyde

https://www.heat-insyde.eu

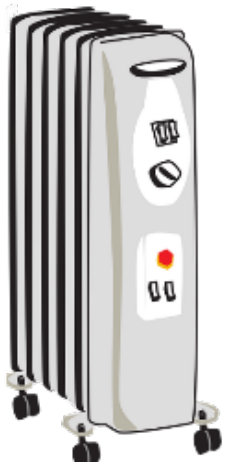
TU/e EINDHOVEN UNIVERSITY OF TECHNOLOGY

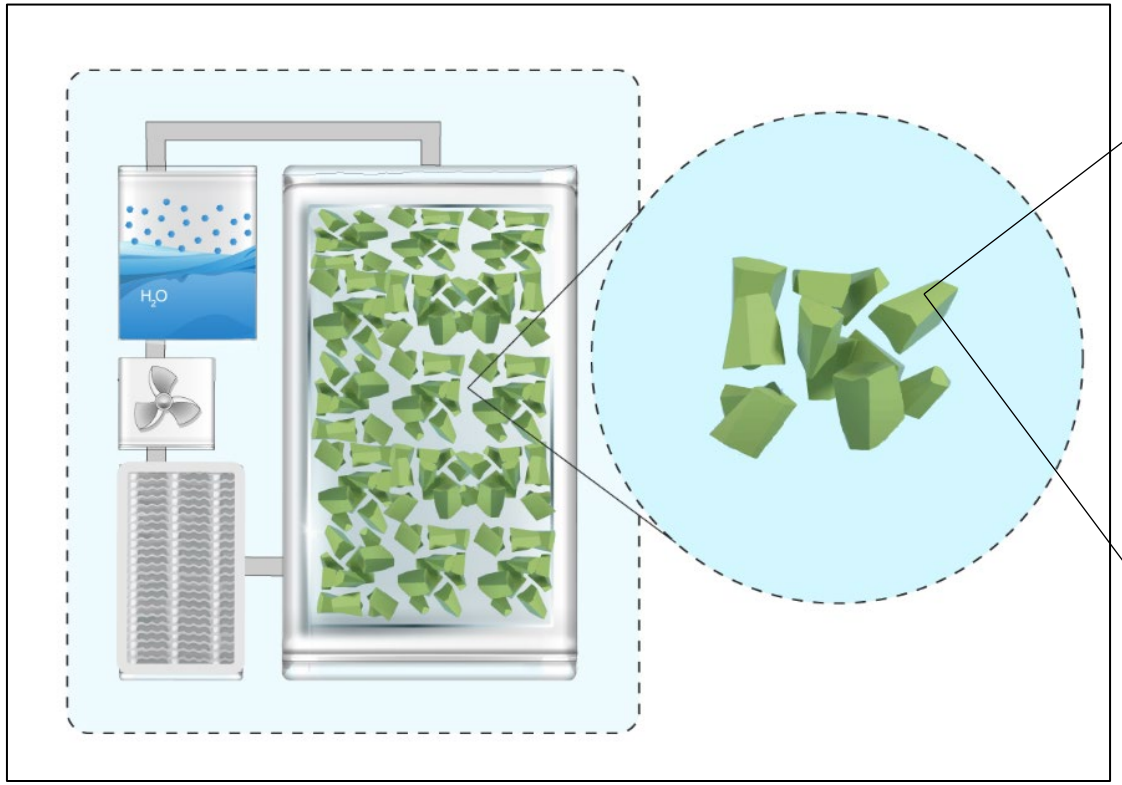
Henk Huinink

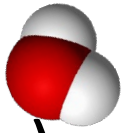
Contents

- Background of thermo-chemical materials
- Challenges
- Objectives and approach
- Size, power and stability
- Manufacturing

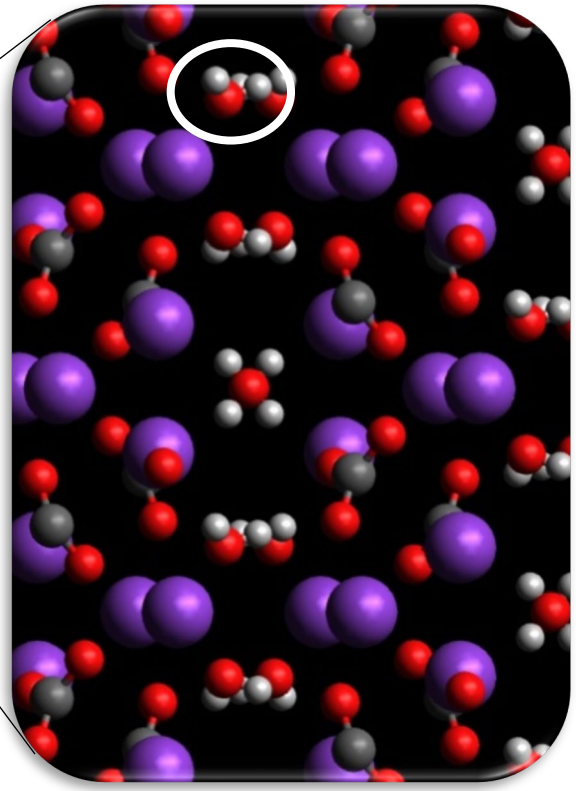
Background





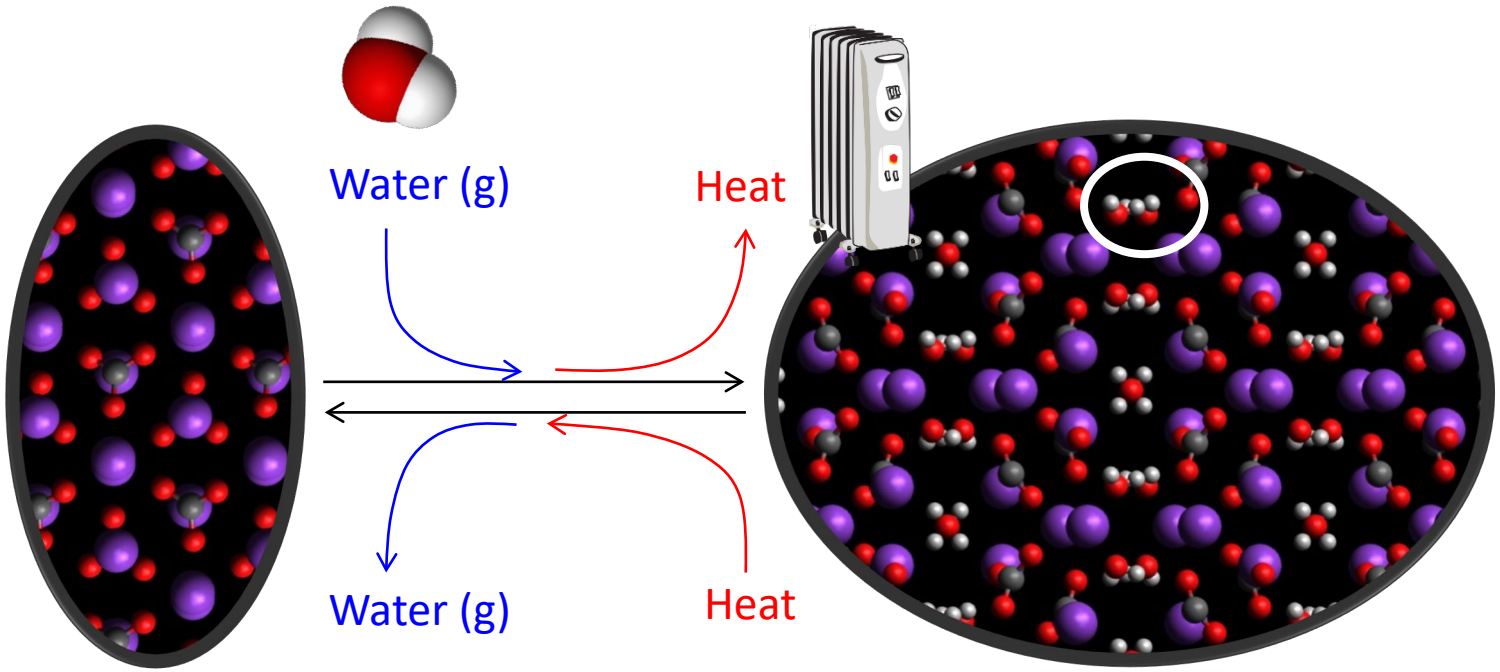


H_2O (g)



$K_2CO_3 \cdot 1.5H_2O$ (s)

Background



K_2CO_3 (s)

$K_2CO_3 \cdot 1.5H_2O$ (s)

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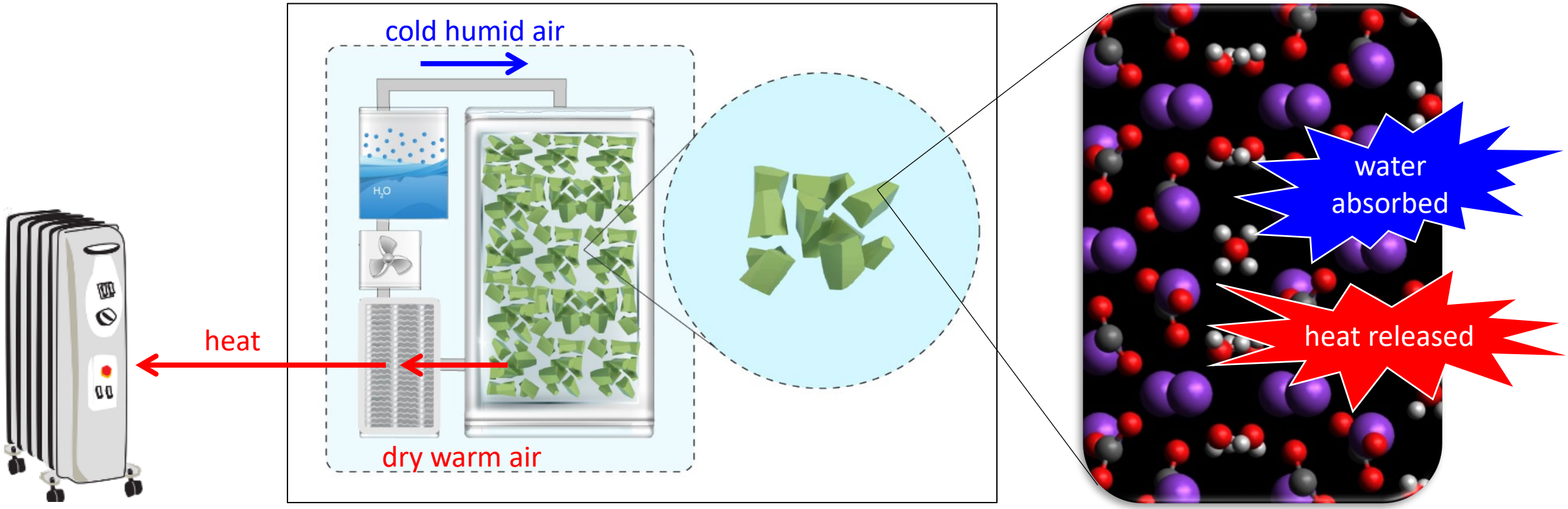
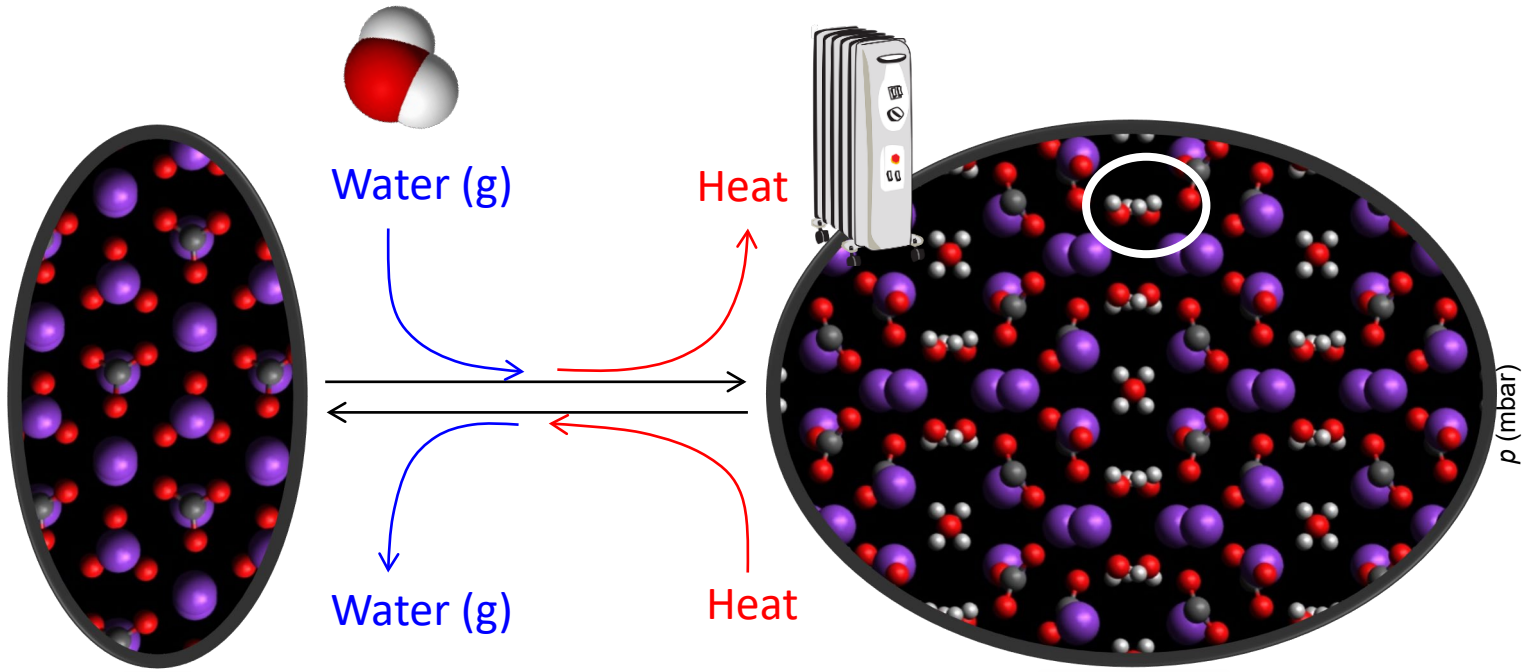
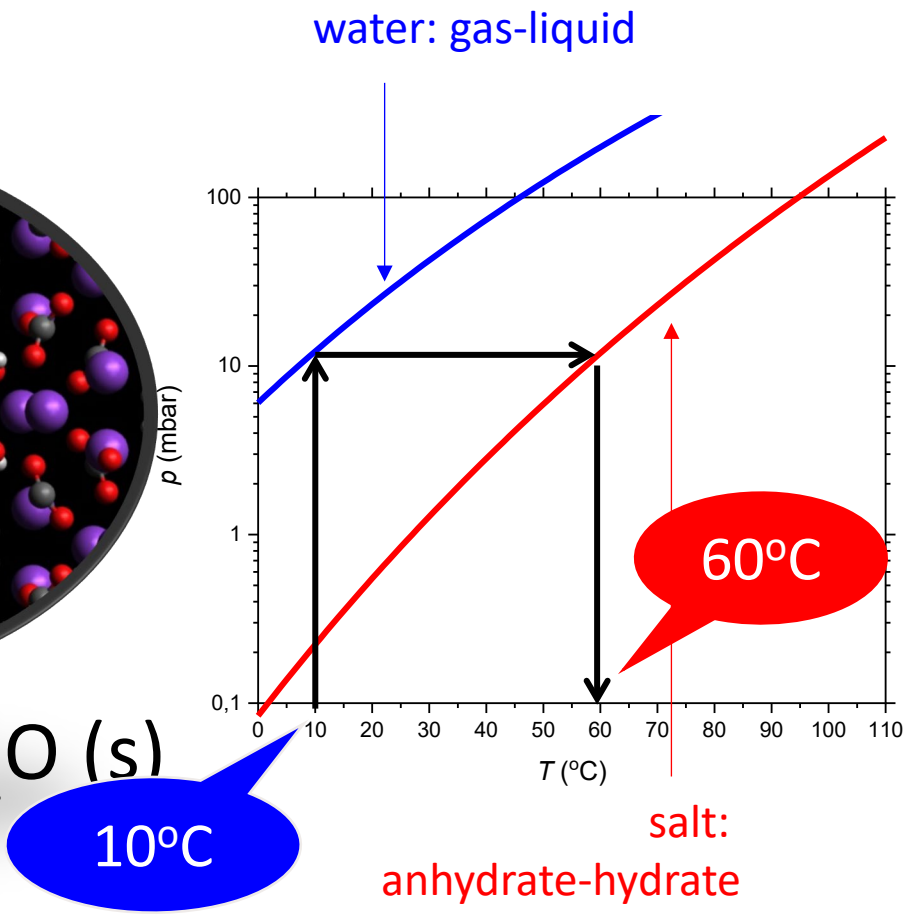

cold humid air
heat
dry warm air
water absorbed
heat released

Background

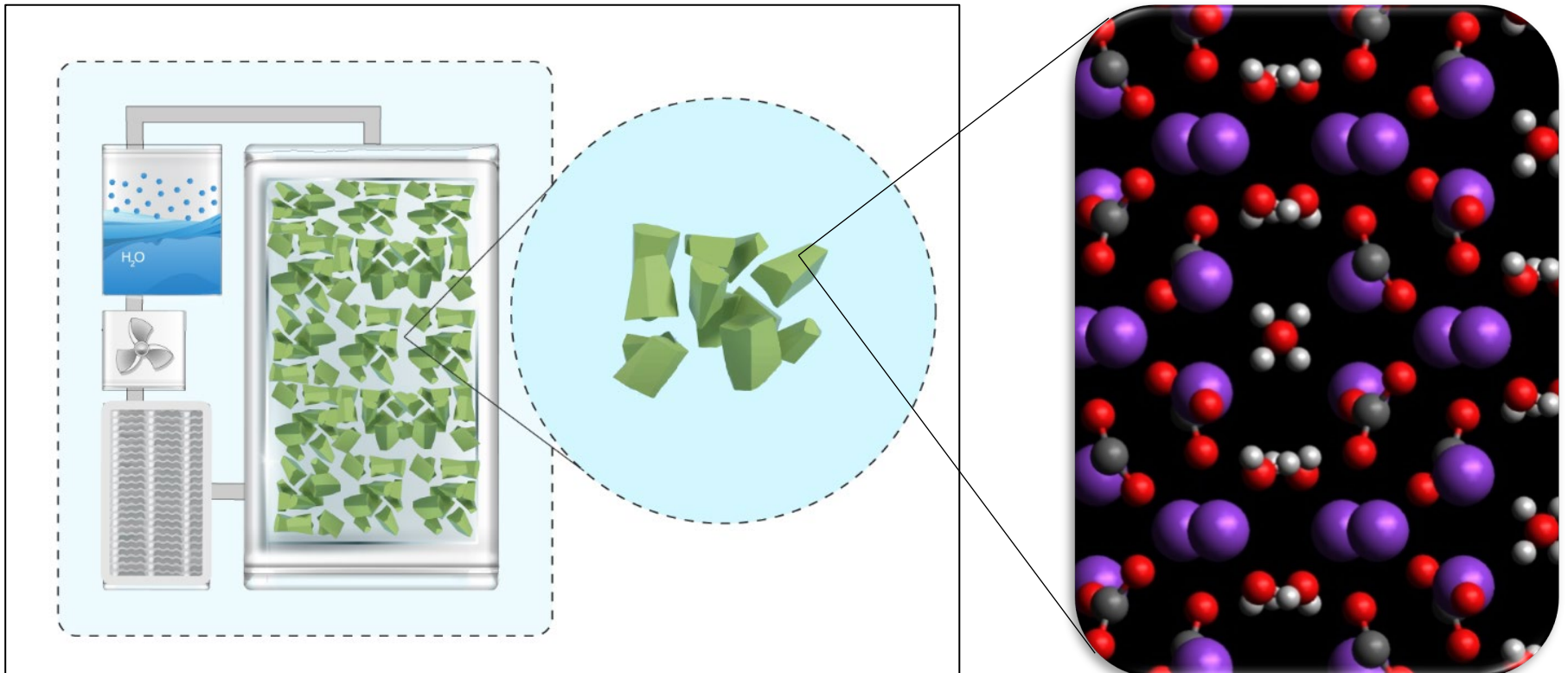
Donkers et al, Applied Energy (2017): https://doi.org/10.1016/j.apenergy.2017.04.080





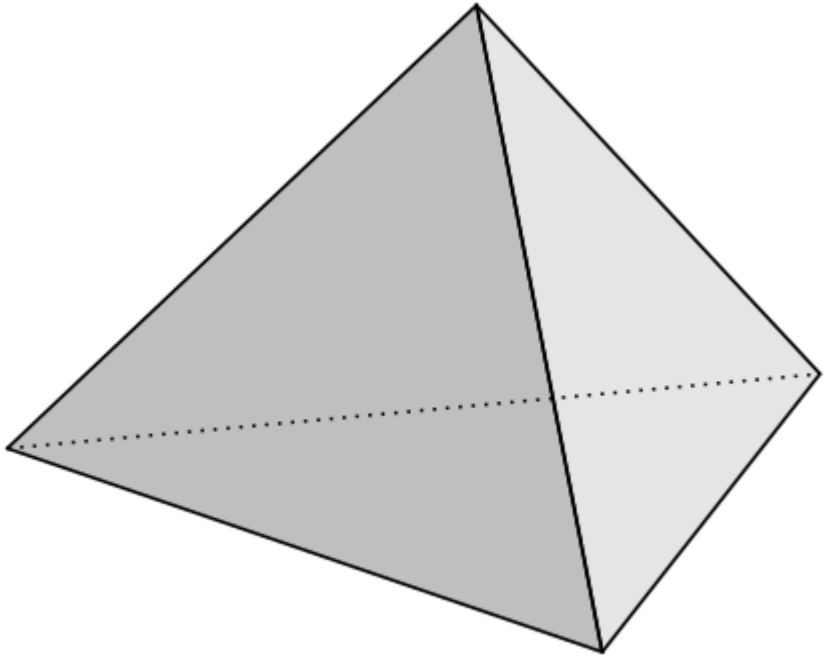
Challenges

- Good flow through particle bed
- Making the particles
- Power output particles
- Stability of particles
- Energy density



Challenges

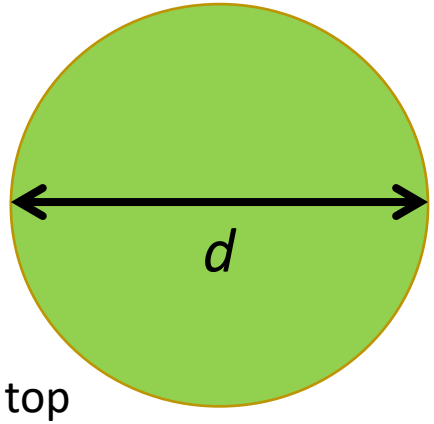
Particle power: $L \downarrow$



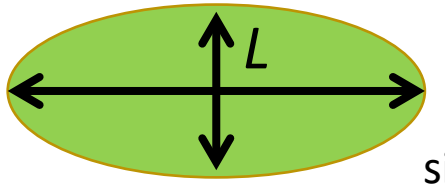
Energy density

Bed permeability (stability): $L, d \uparrow$

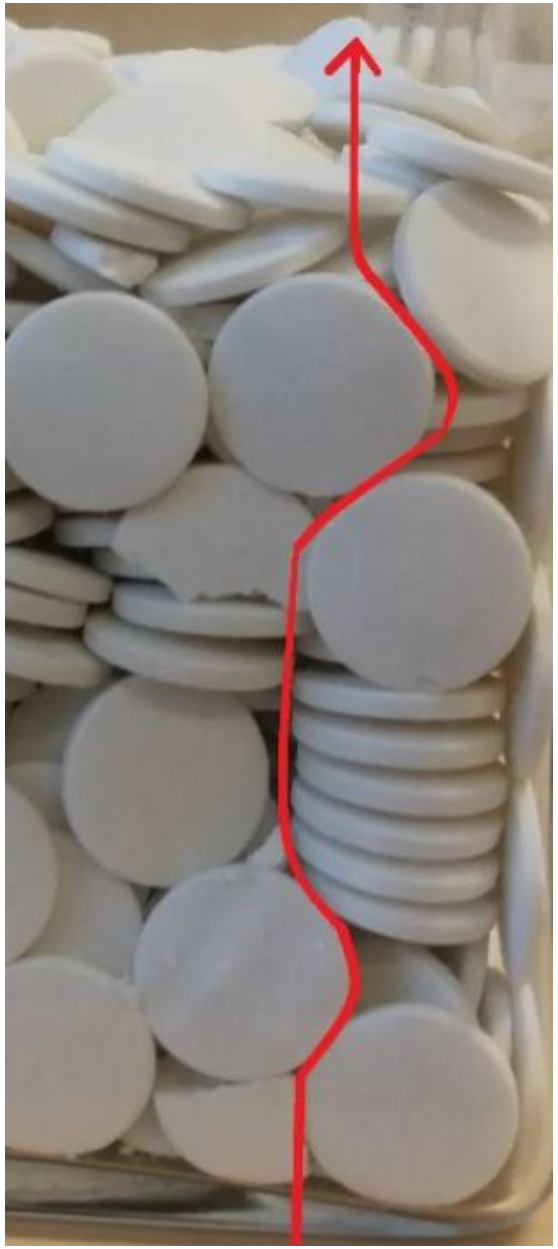
Manufacturability: $L, d \uparrow$



top

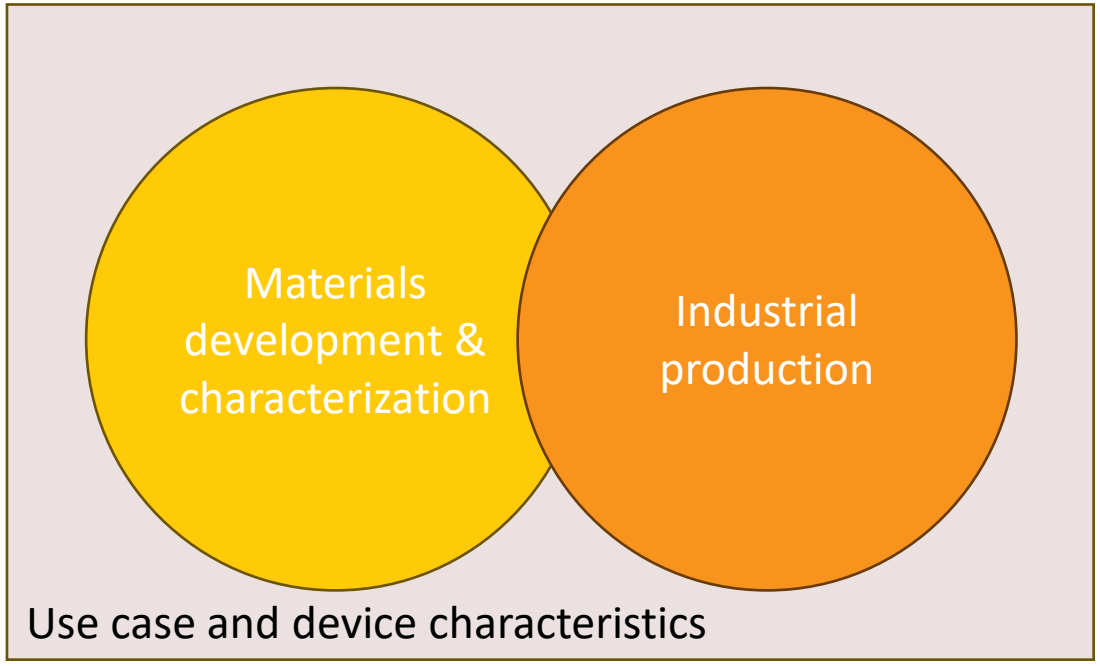


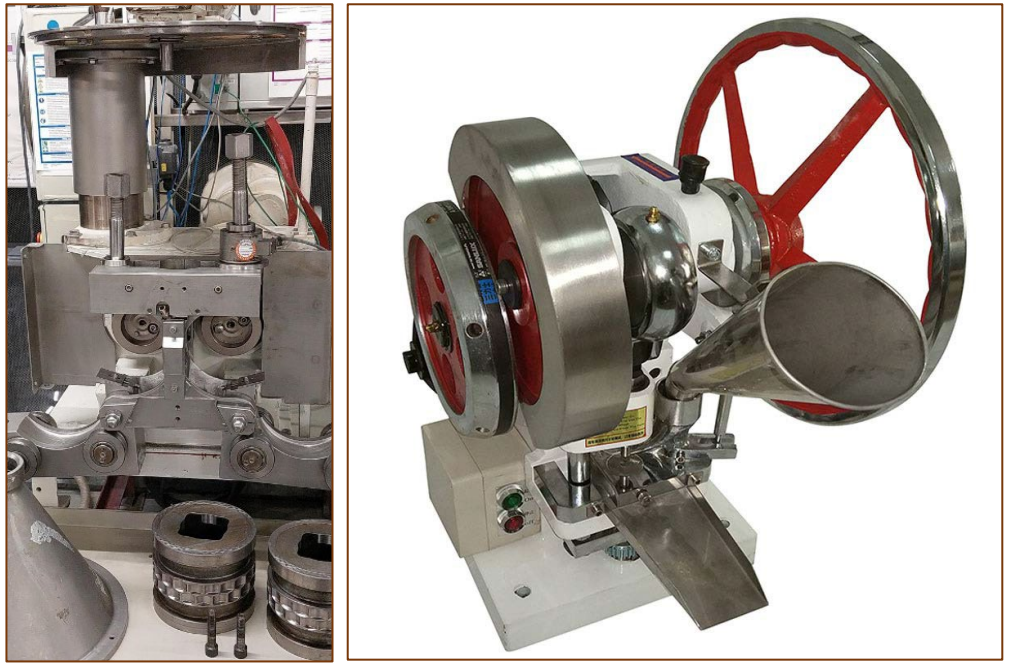
side



Objectives and approach

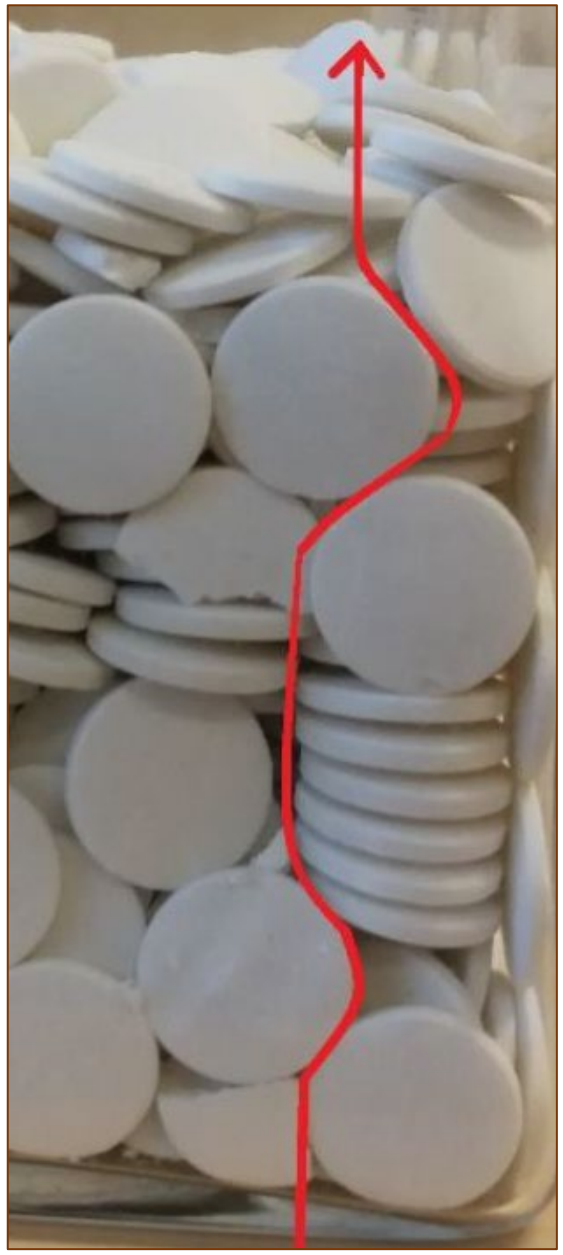
- Optimization of TCM particles with respect to power and energy density
- Stabilizing TCM particles with minimal loss of energy density and cyclic performance
- Develop an up-scaled, low-cost, and industrially feasible TCM production method

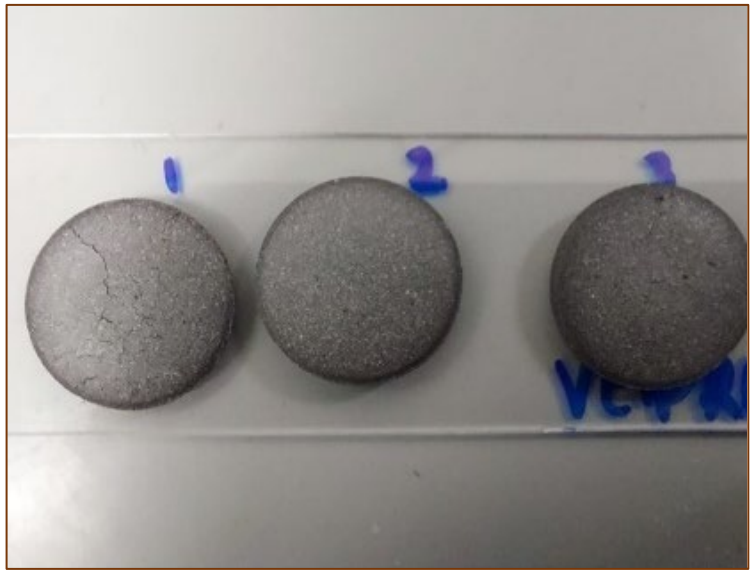




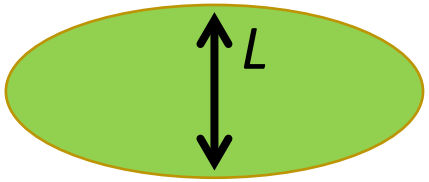
Existing particle production technologies

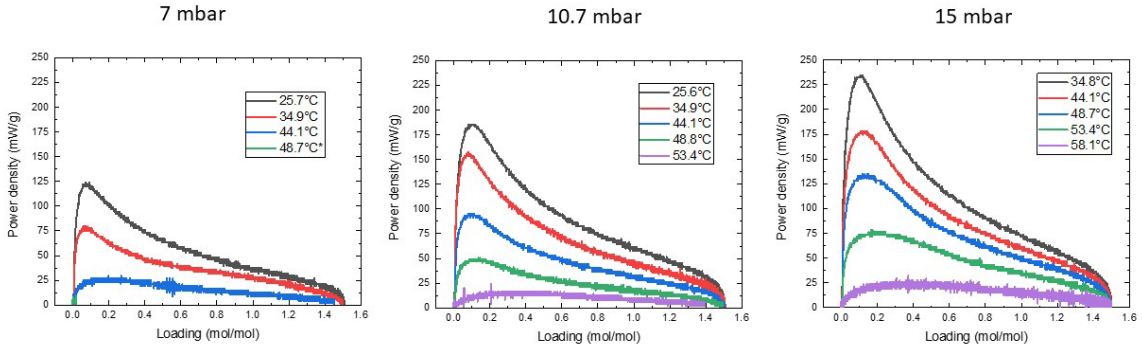
Size, power and stability



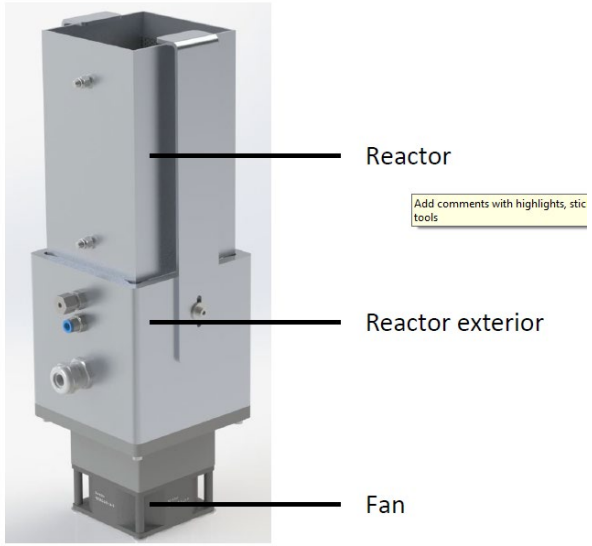


- Thickness critical
- Mm-sized for optimum power output and flow characteristics
- Diameter crucial for production



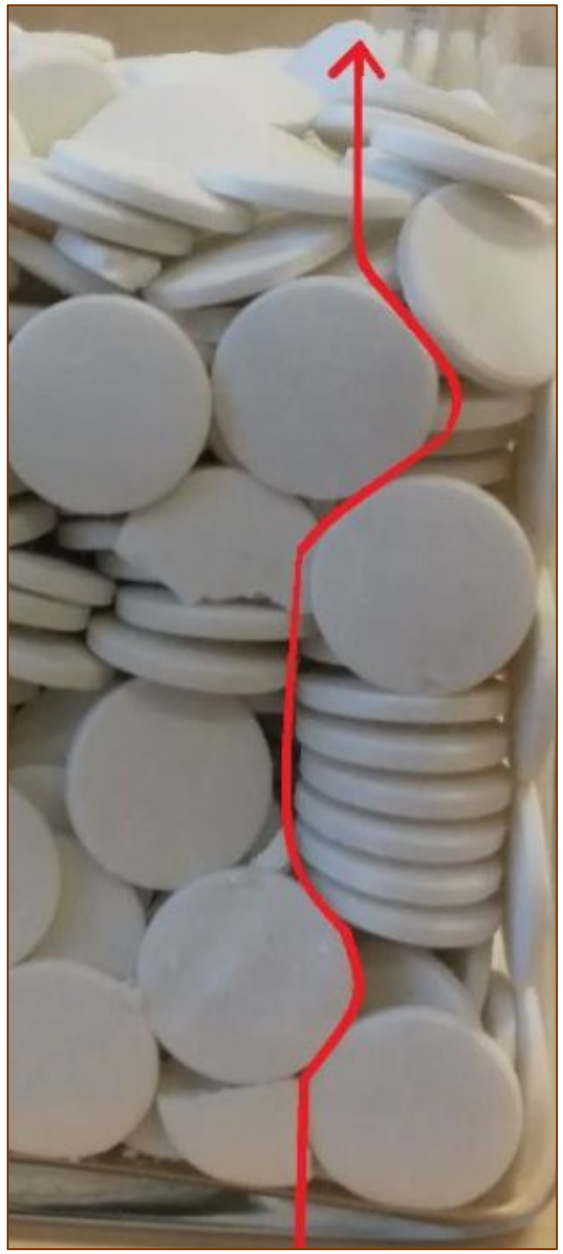


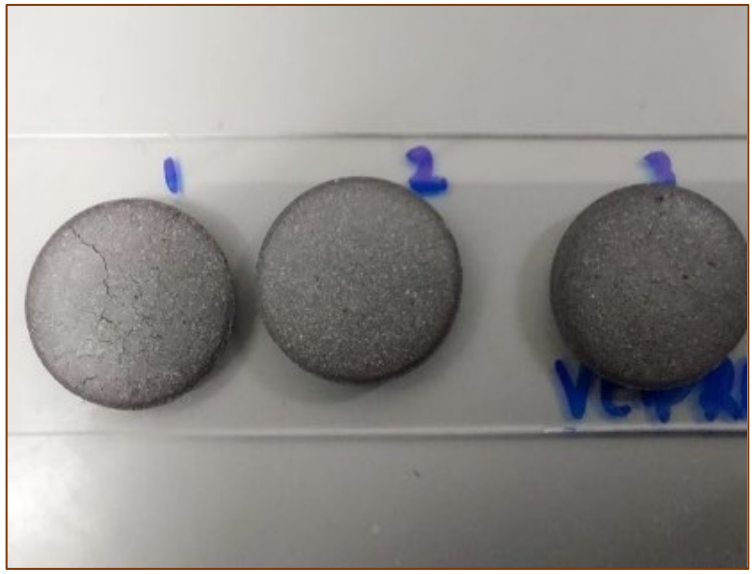
Particle power output



Particle bed tests

Size, power and stability

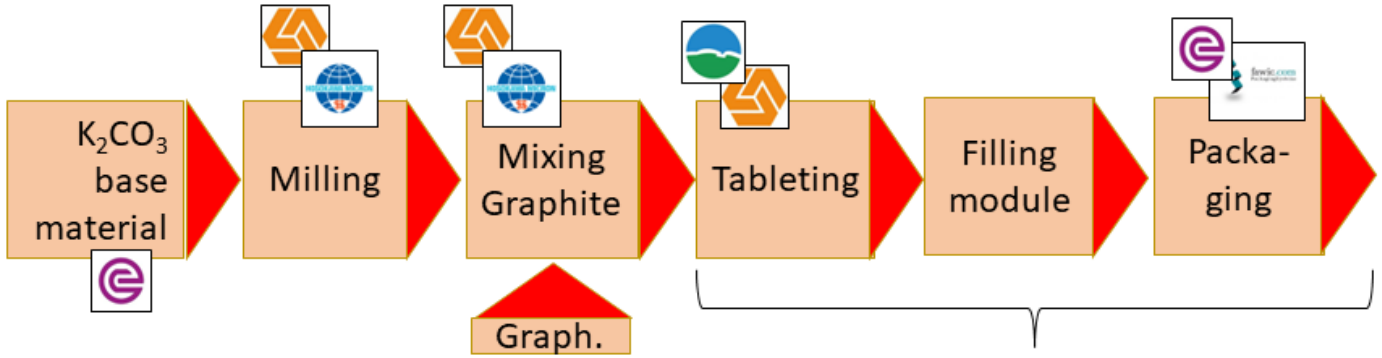




Property	Value
Energy density (bed level)	0.61 GJ/m^3 = 169 kWh/m^3
Power density	44 W/kg 71 kW/m^3
Stability over 10 cycles	5 – 10-fold increase of pressure drop
Costs	3 – 6 €/kg

Doubled due Ukraine crisis (raw materials)

Manufacturing



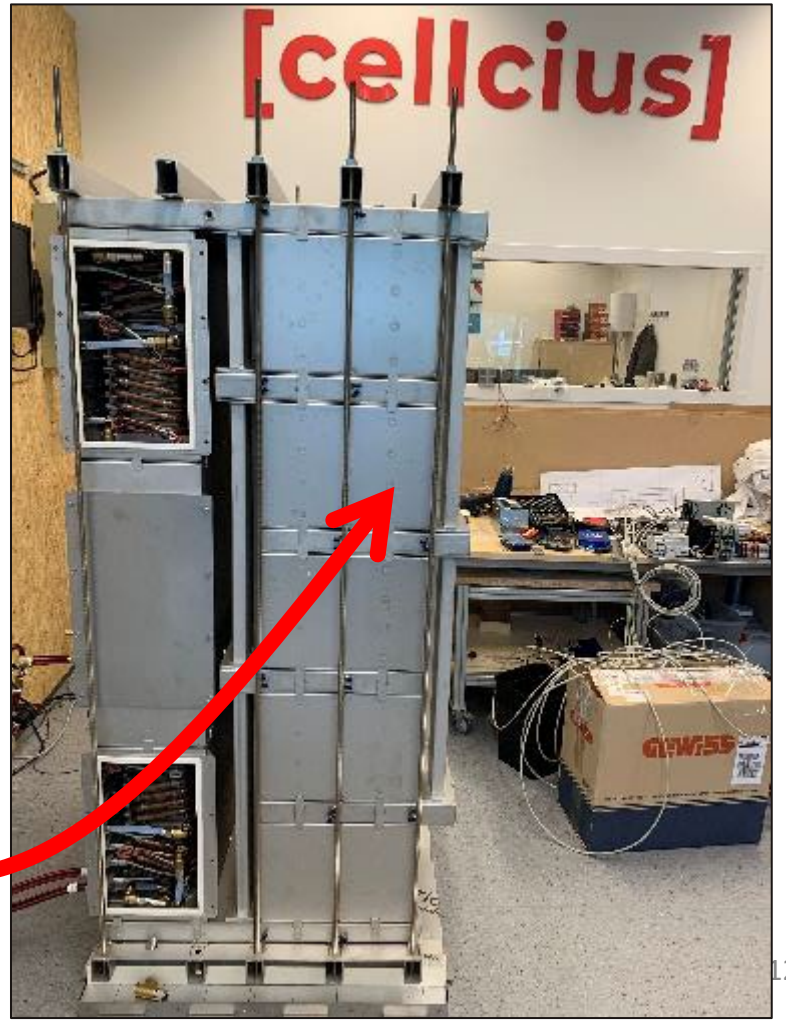
Hosokawa

VEIP

Fawic

Tableting

Filled module



PANEL DISCUSSION

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WORKSHOP

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A compact and sustainable heat storage solution for clean energy

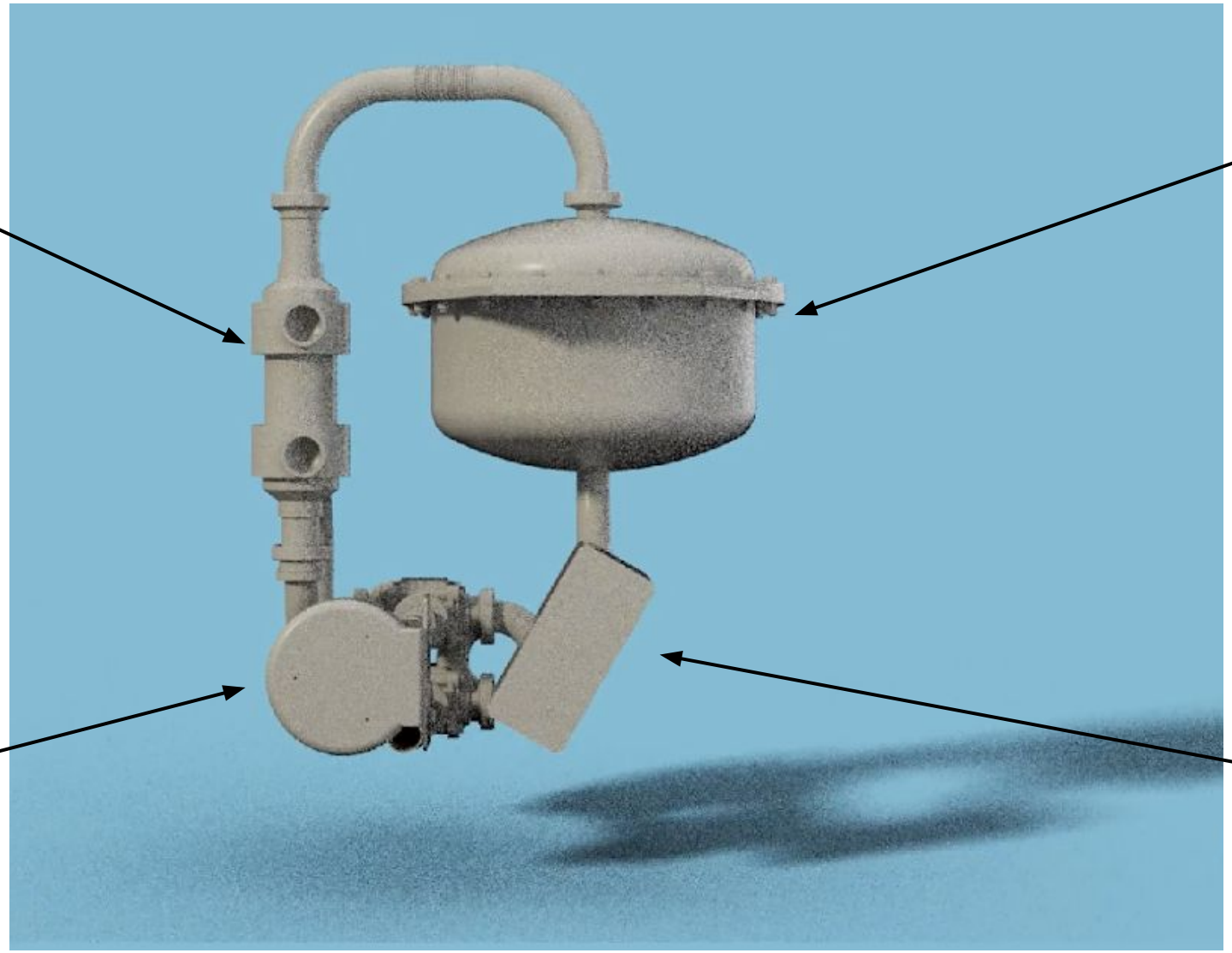
Heat Insyde

[cellcius]

Tom Chermin

https://www.heat-insyde.eu

Development of a compact domestic heat storage prototype



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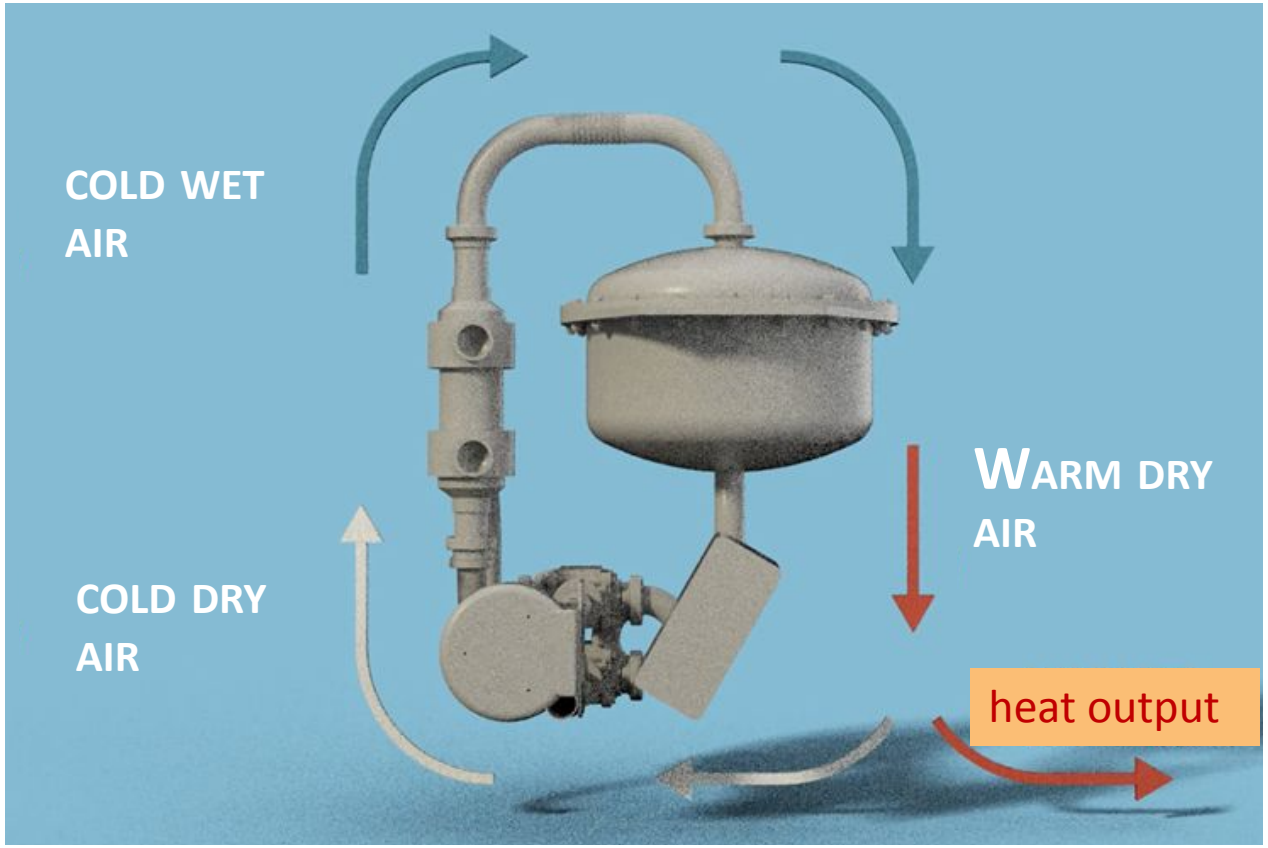
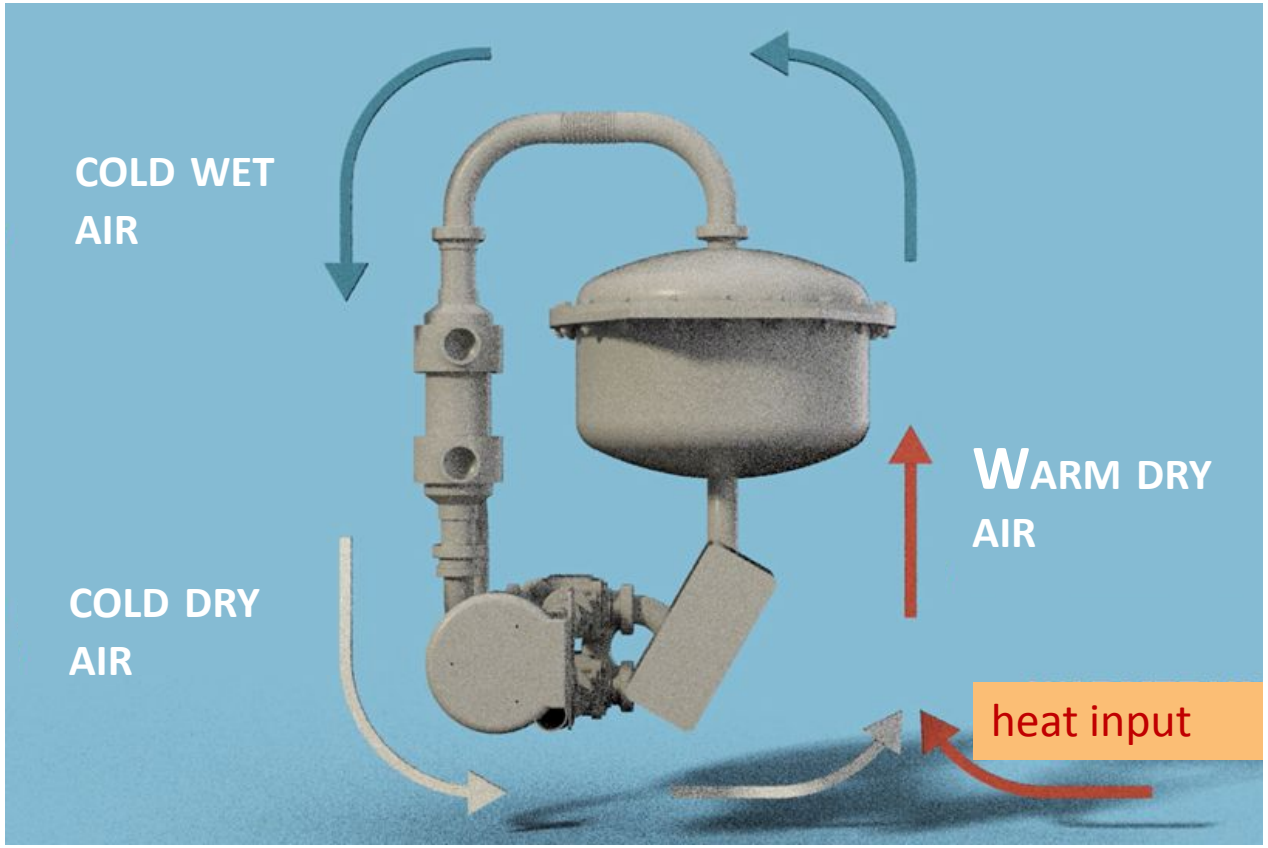


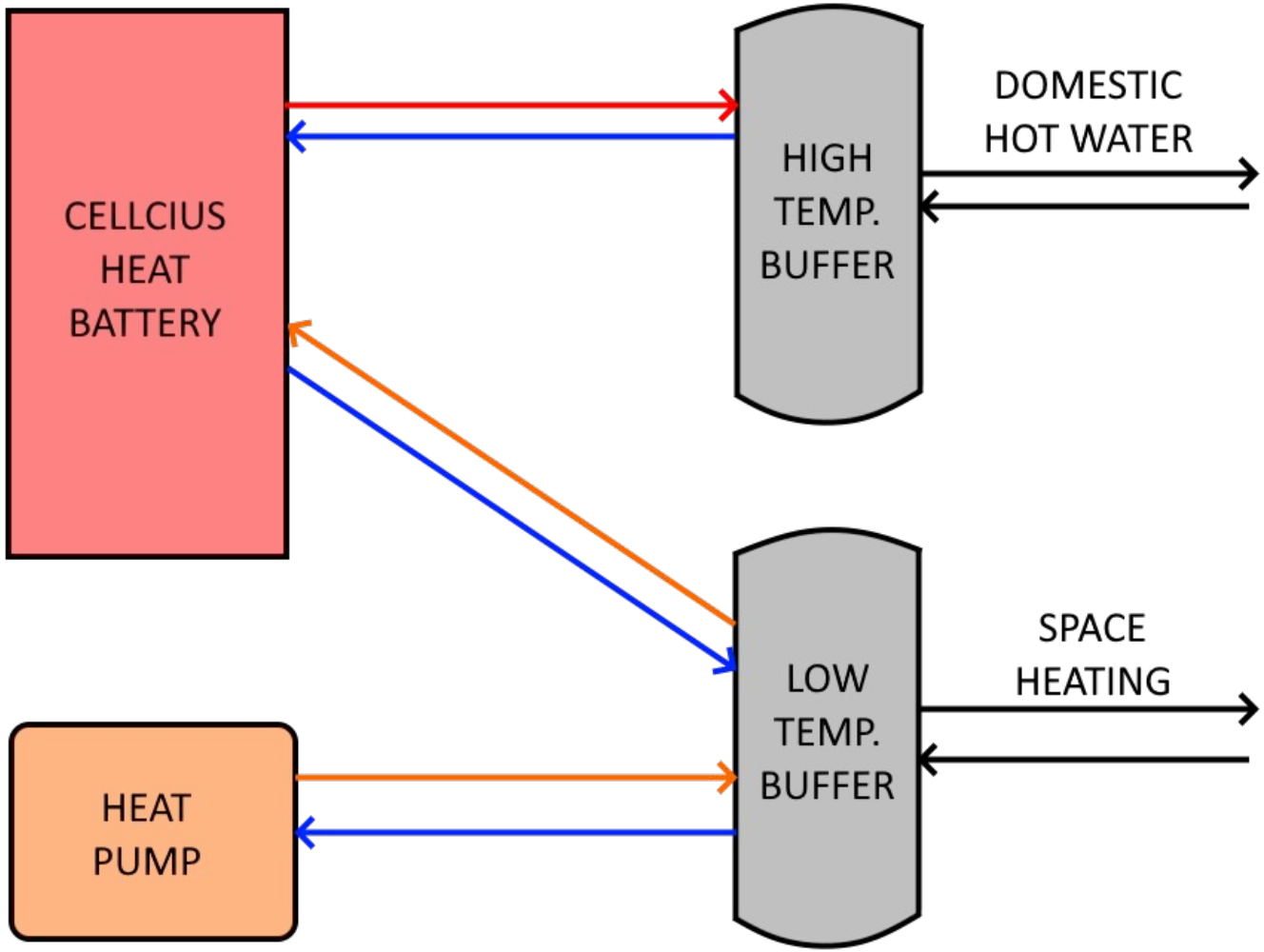
Discharging the TCM to generate heat



Charging the TCM to store heat

Development of a compact domestic heat storage prototype

- The battery works in tandem with a heat pump
  - Taking advantage of the high COP of a heat pump for low temperatures
  - Using the battery to generate high temperatures where heat pumps start to lose their efficiency



- **KPI targets based on the presented use case:**

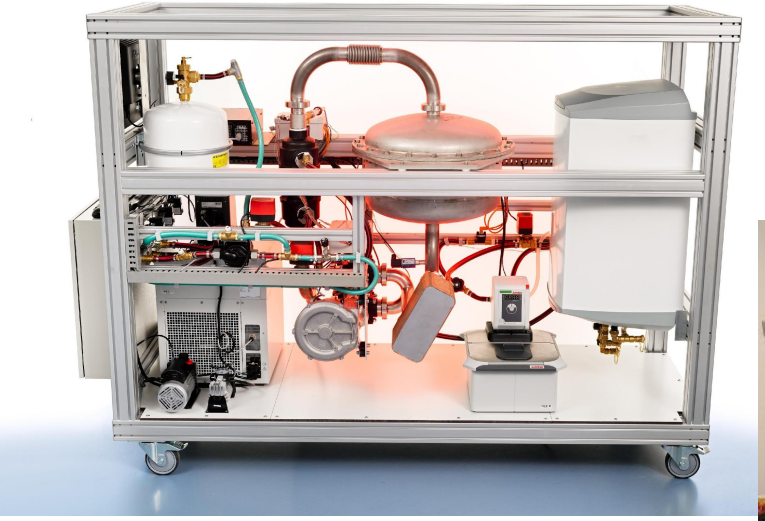
- Storage capacity of 200 MJ (55 kWh)
  - This allows the battery to bridge about a week of hot water

- Discharging power of 500-1500 W
  - Based on simulations and calculations done by CEA

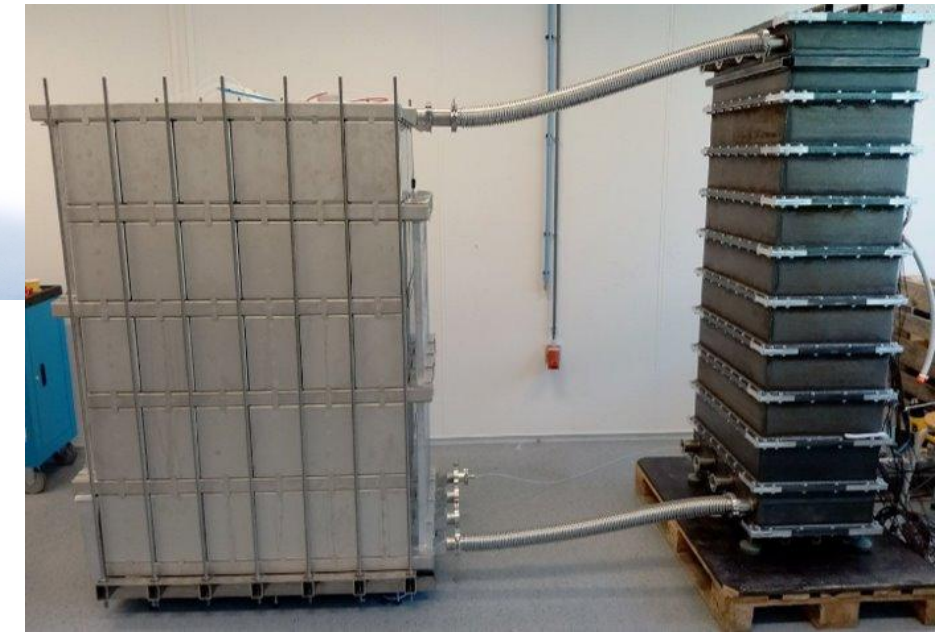
- Charging power of 500-2000 W
  - Based on simulations and calculations done by CEA

- Modular system
  - To allow easy installation in confined areas

Development of a compact domestic heat storage prototype



2019



2021

2022

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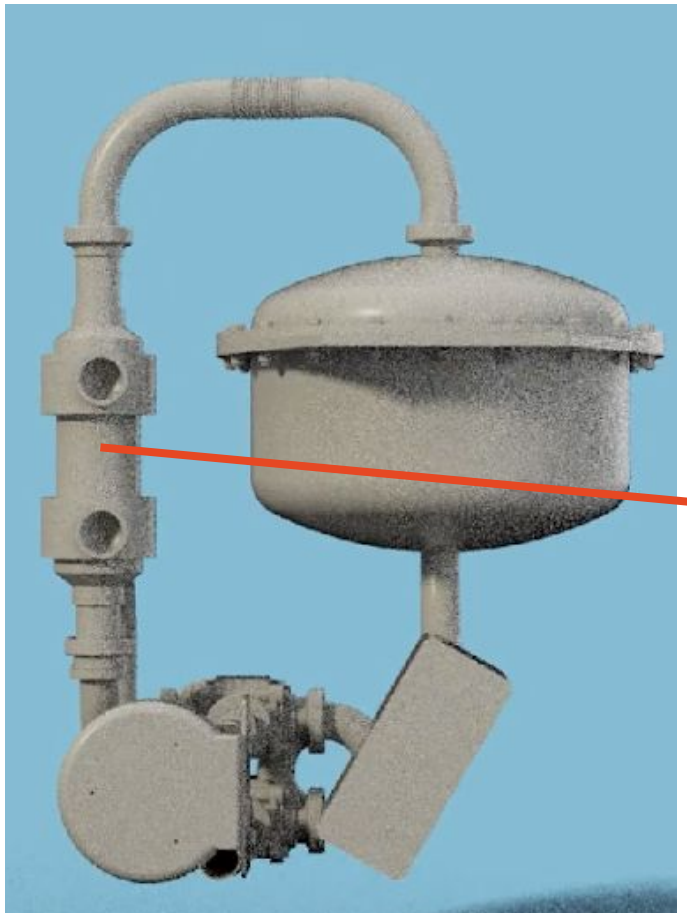
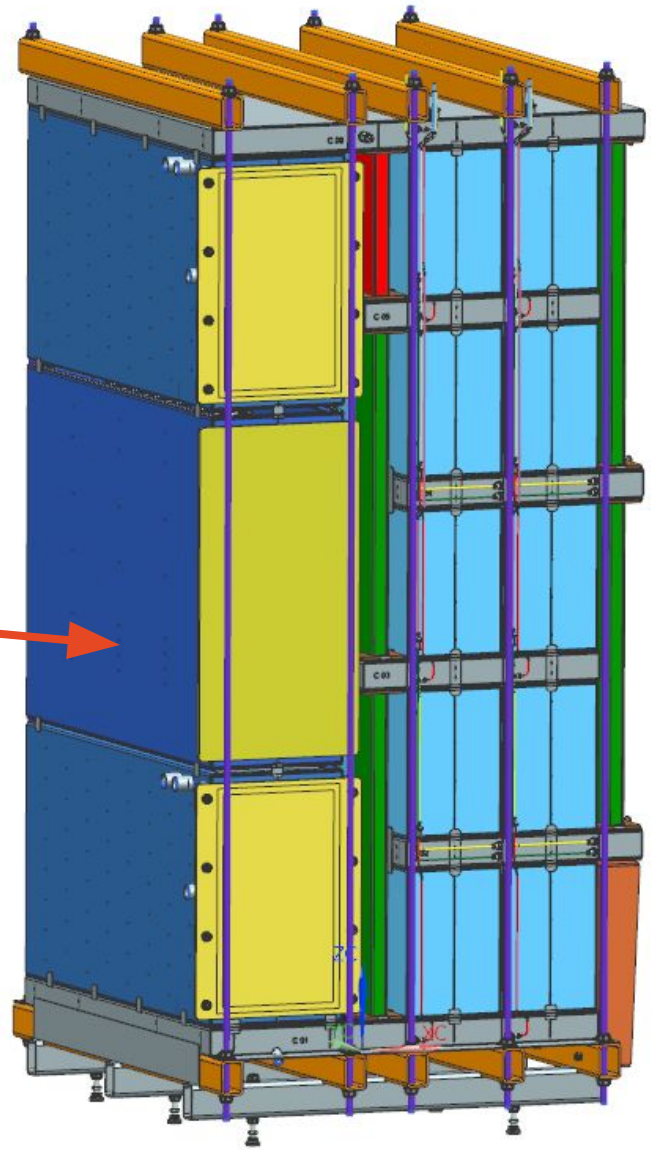


Evaporator/
Condensor



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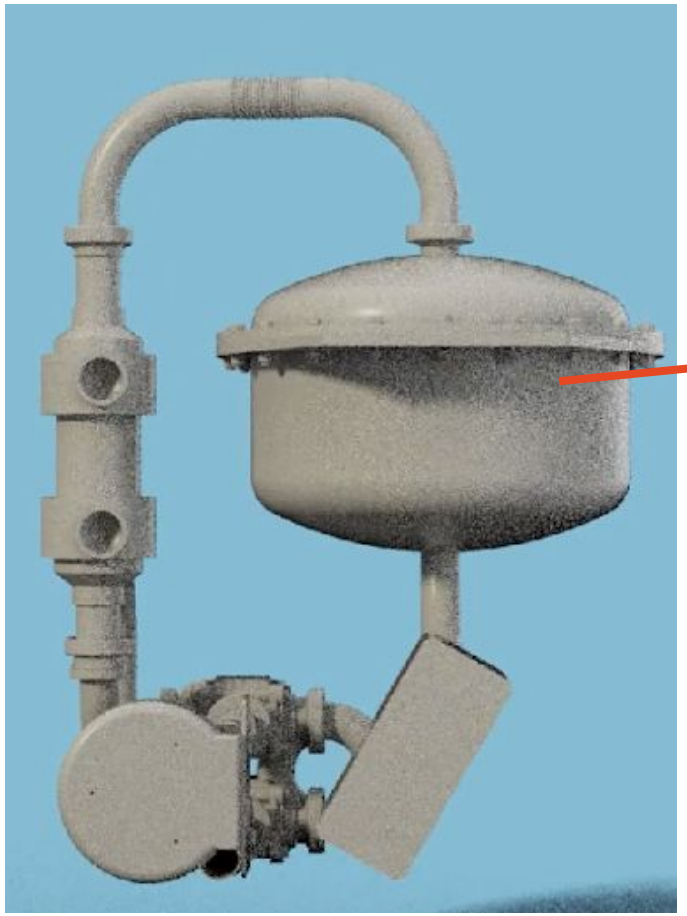
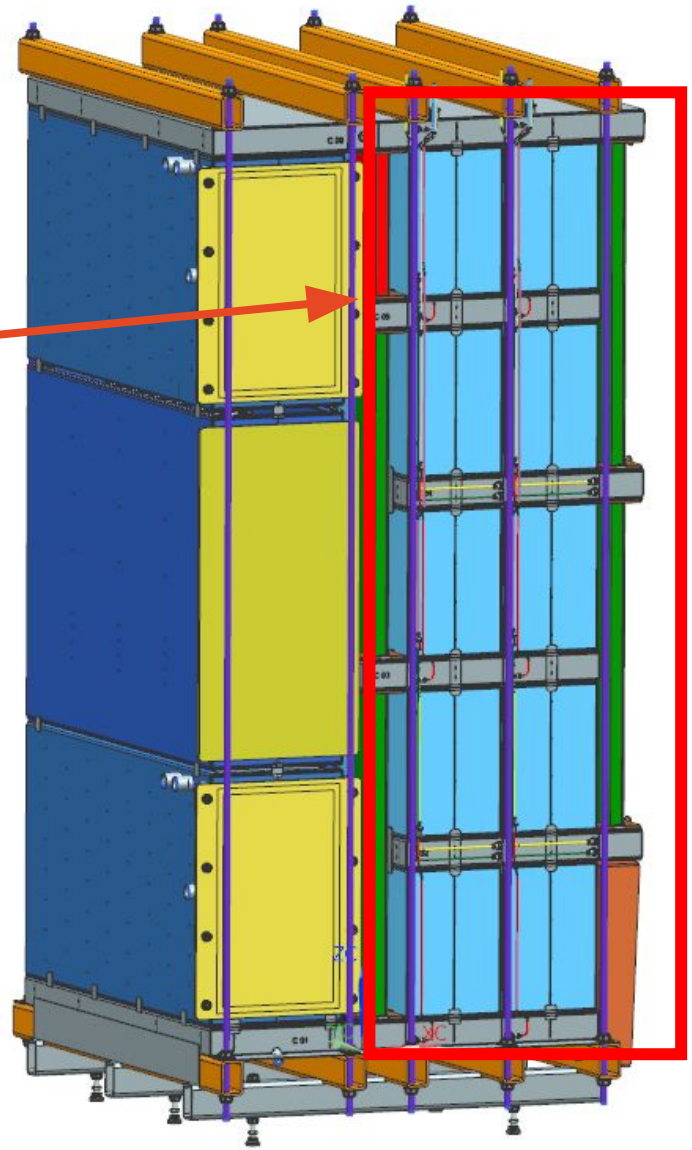


TCM-reactor



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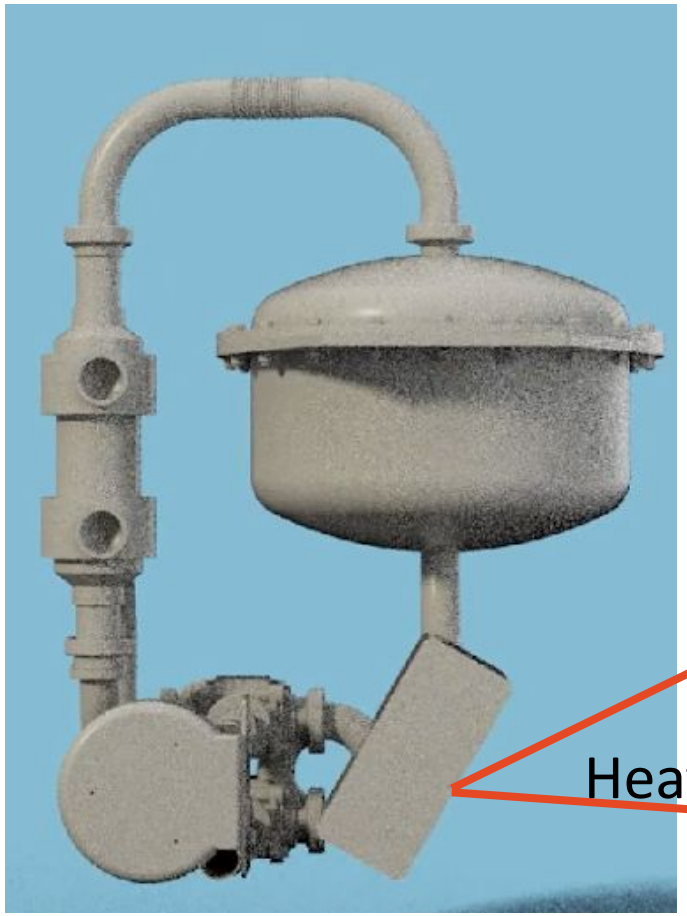
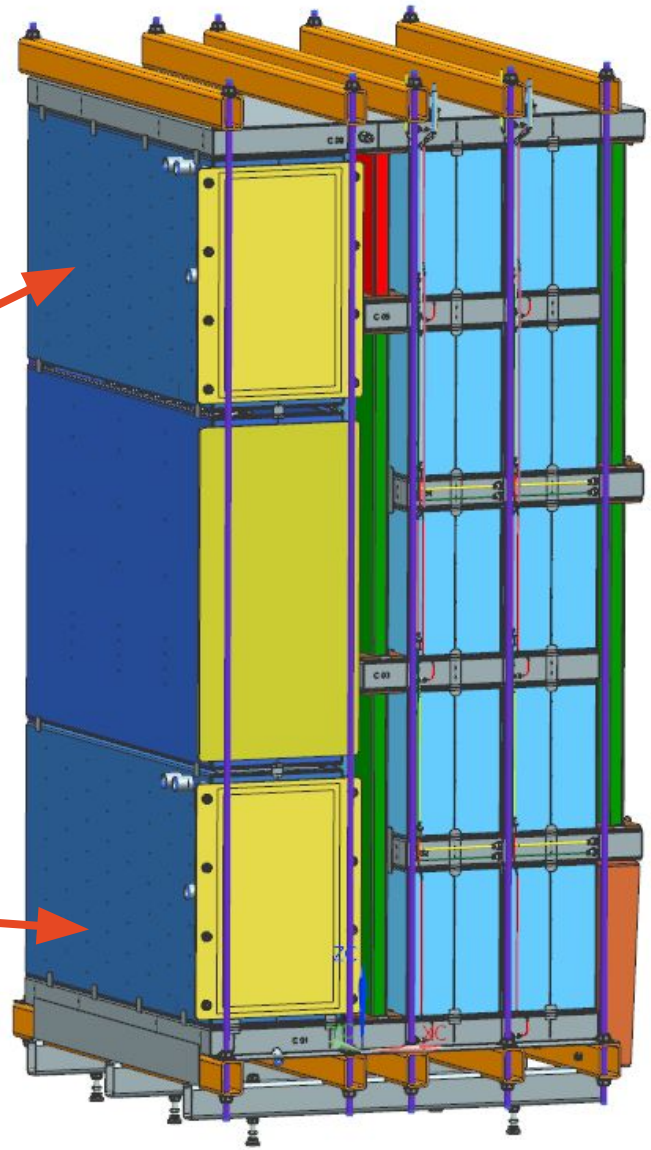
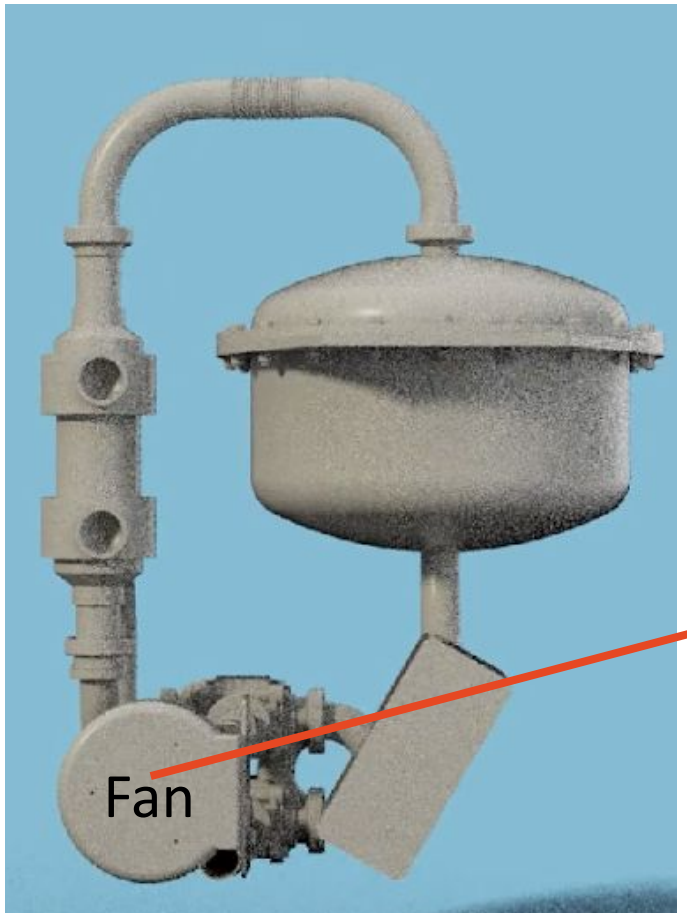
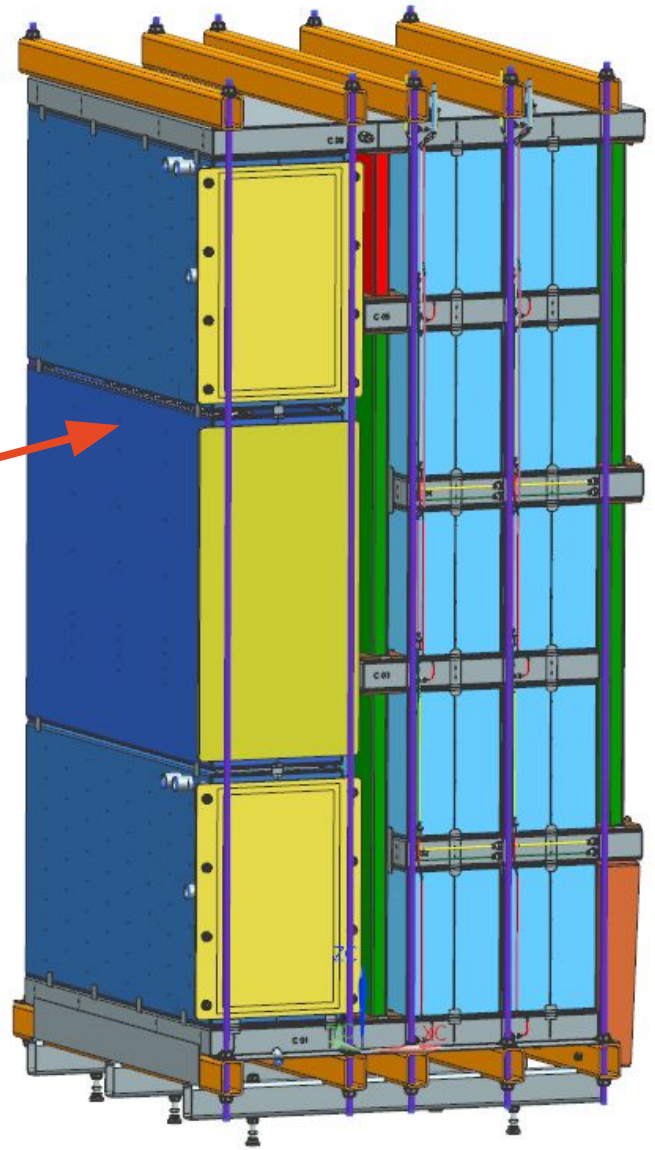


Heat exchanger



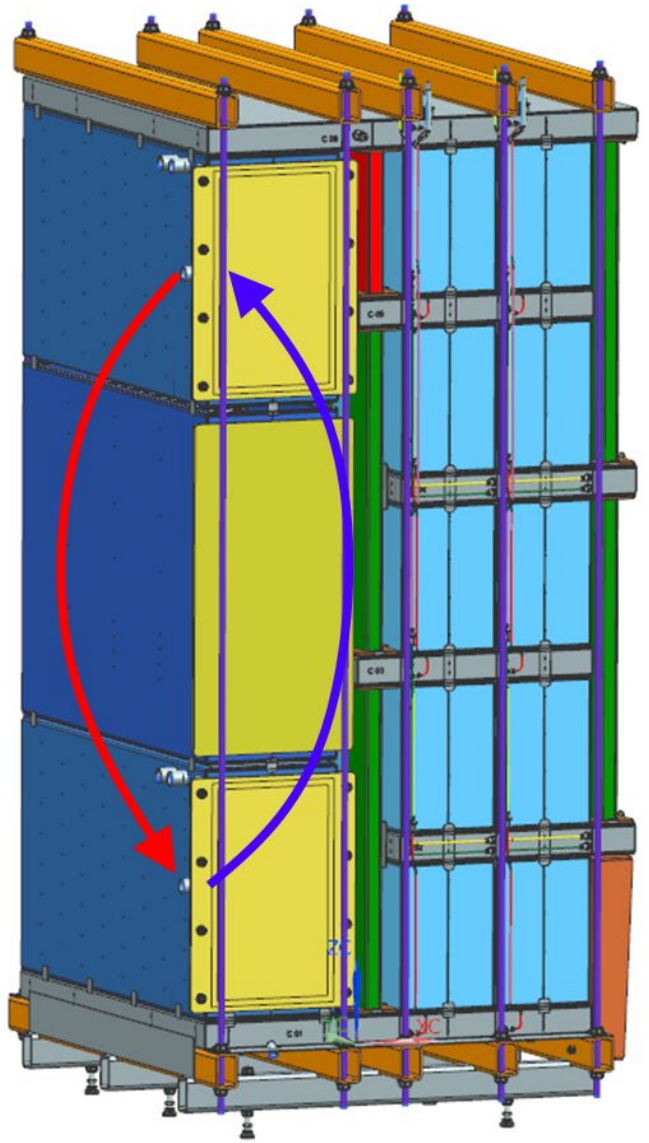
Development of a compact domestic heat storage prototype





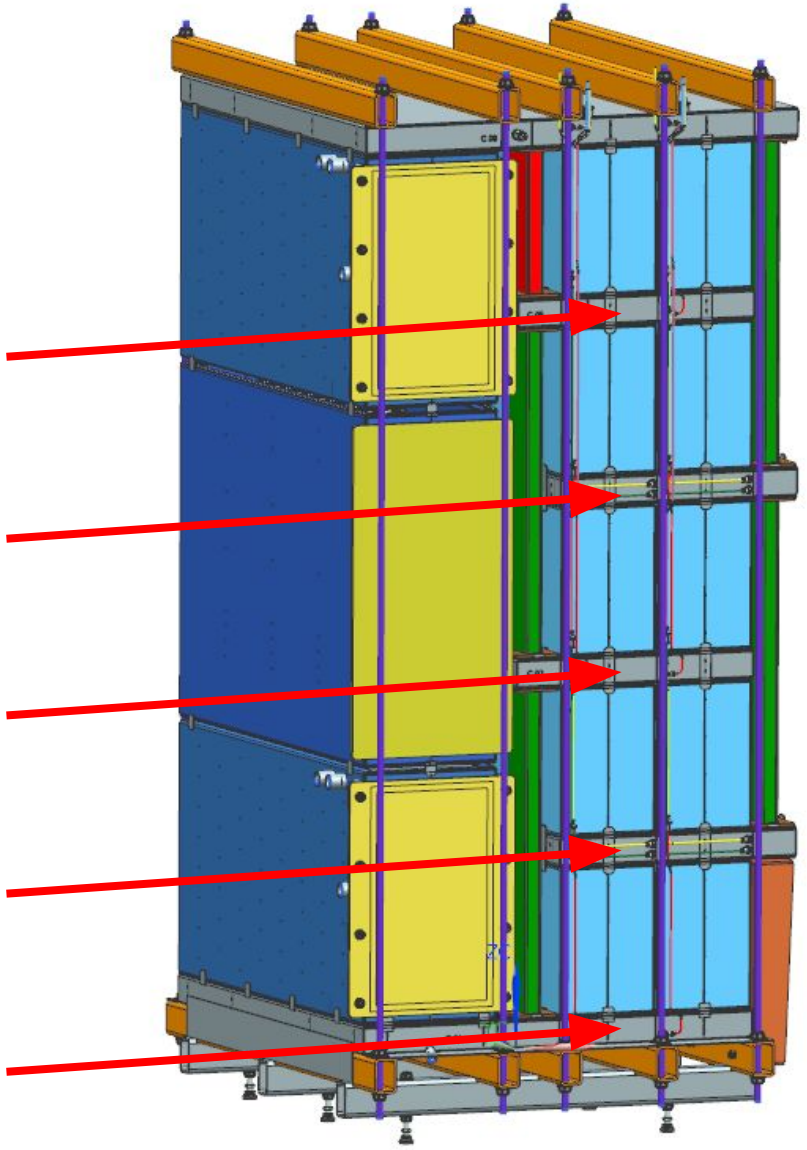
Development of a compact domestic heat storage prototype

- New function: Heat recovery loop
- Prevents excess heat from being lost in the evaporator/condenser
- Upwards of 80% of heat is saved



Development of a compact domestic heat storage prototype

- New function: Valve separation
- Allows for sectioned charging and discharging
- Acts as 10 small batteries in one

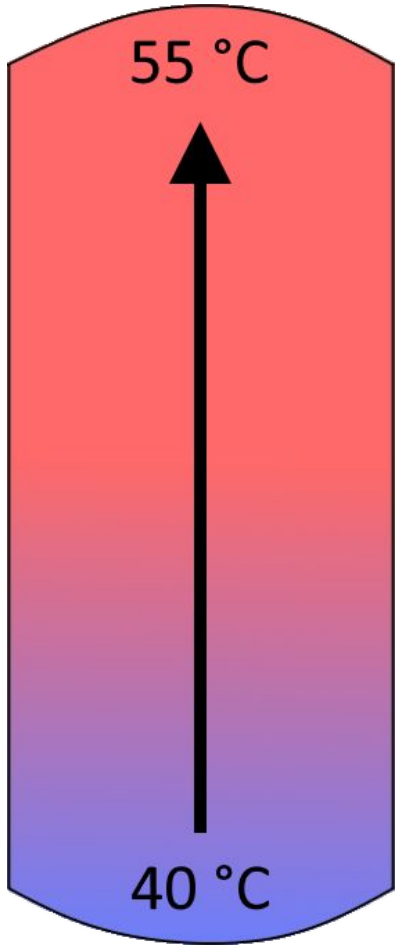


Development of a compact domestic heat storage prototype

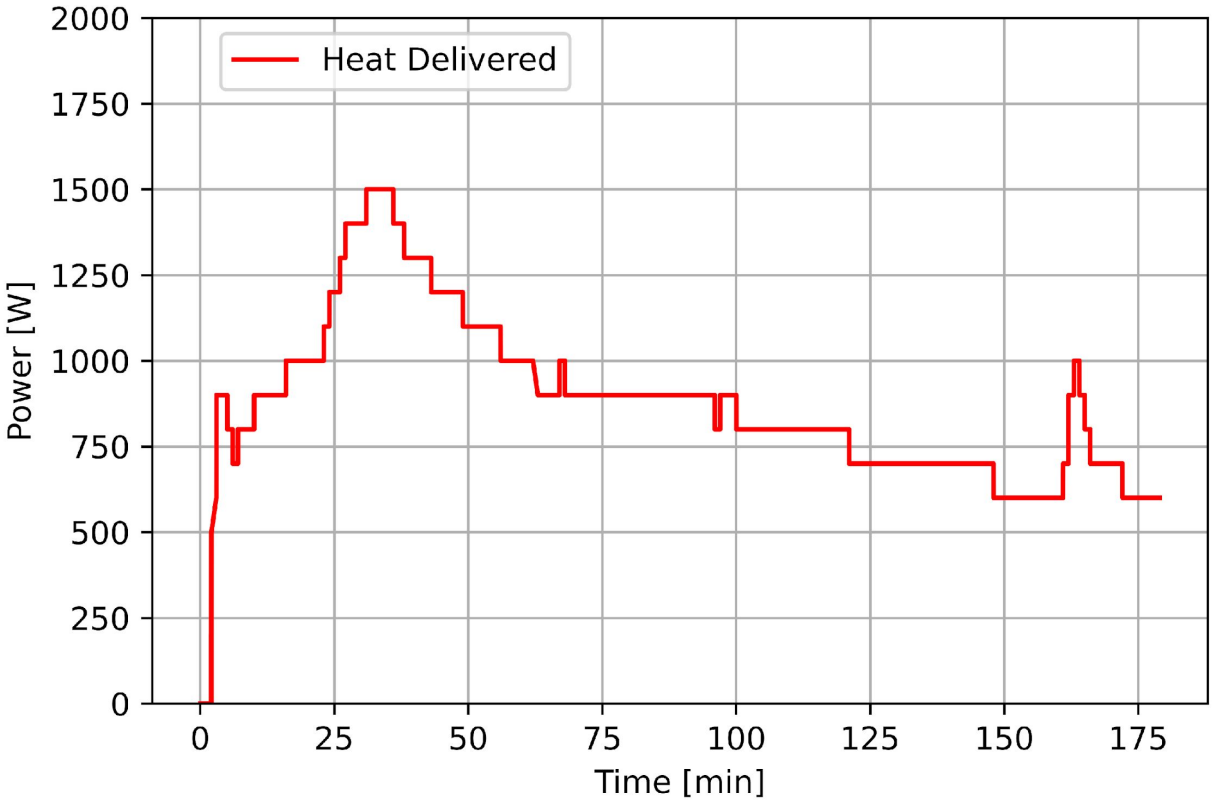
- First battery installed in Eindhoven
- Complete domestic heating system with integrated battery
- Direct installation in a house is also possible

Development of a compact domestic heat storage prototype

- KPI: Discharging power of 500-1500 W

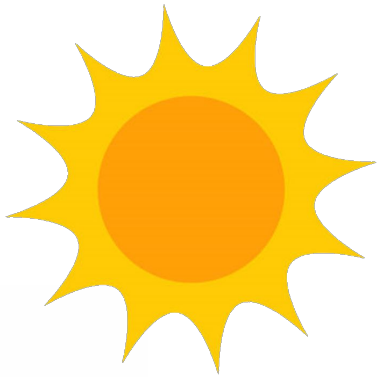


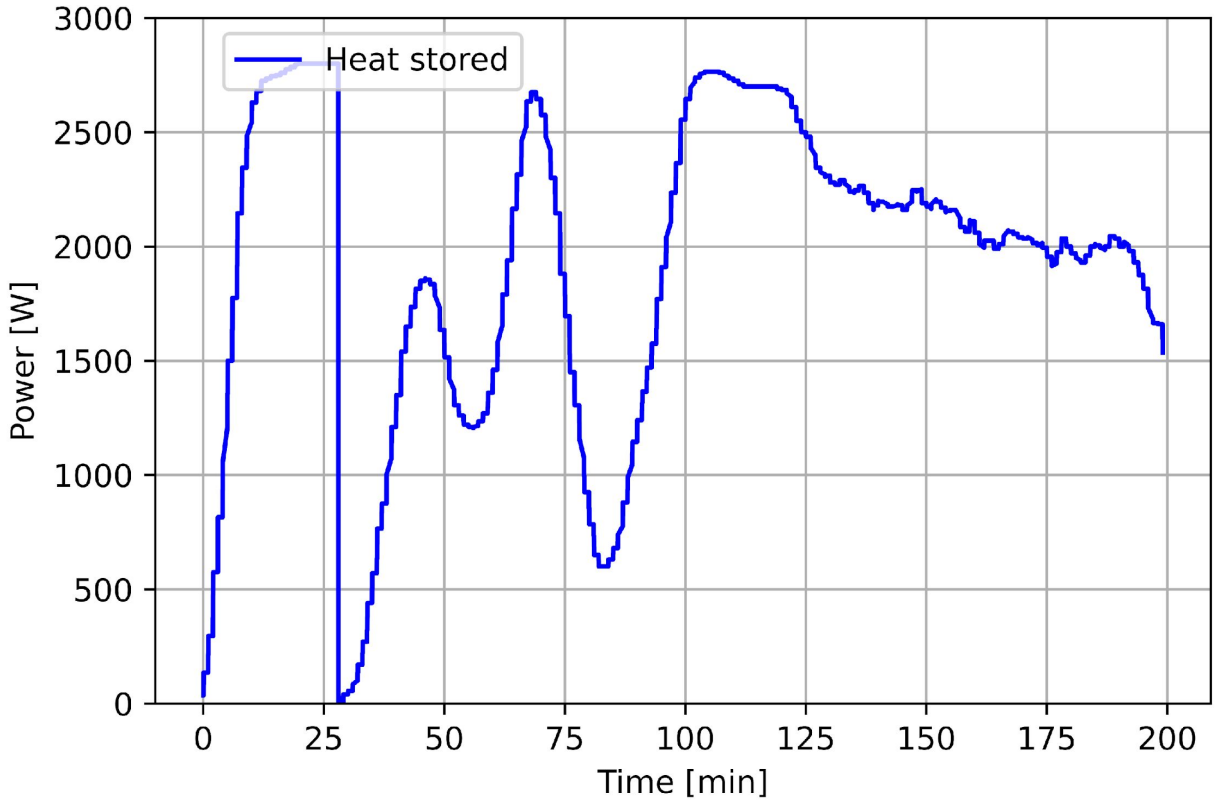
High Temperature Buffer



Development of a compact domestic heat storage prototype

- KPI: Discharging power of 500-1500 W
- KPI: Charging power of 2000 W





Development of a compact domestic heat storage prototype

- KPI: Discharging power of 500-1500 W
- KPI: Charging power of 2000 W
- KPI: Storage capacity of 55 kWh

10 TCM modules of ~6 kWh

Heat Insyde

BRINGING ADVANCED **HEAT** BATTERIES **IN** RESIDENTIAL HEAT AND ELECTRIC **SY**STEMS CLOSER TO MARKET THROUGH REAL LIFE **DE**MONSTRATION IN DIFFERENT CLIMATES

SUSTAINABLE PLACES 2024

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 869810.

Location, date

SUSTAINABLE PLACES 2024

23-25 September 2024

Luxembourg

Energy storage

WORKSHOP

HEAT-INSYDE

A compact and sustainable heat storage solution for clean energy

Heat Insyde

https://www.heat-insyde.eu

TNO

Yulia Galagan

Heat Insyde

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SUSTAINABLE PLACES 2024

Yulia Galagan (TNO)

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24 September 2024, Luxembourg

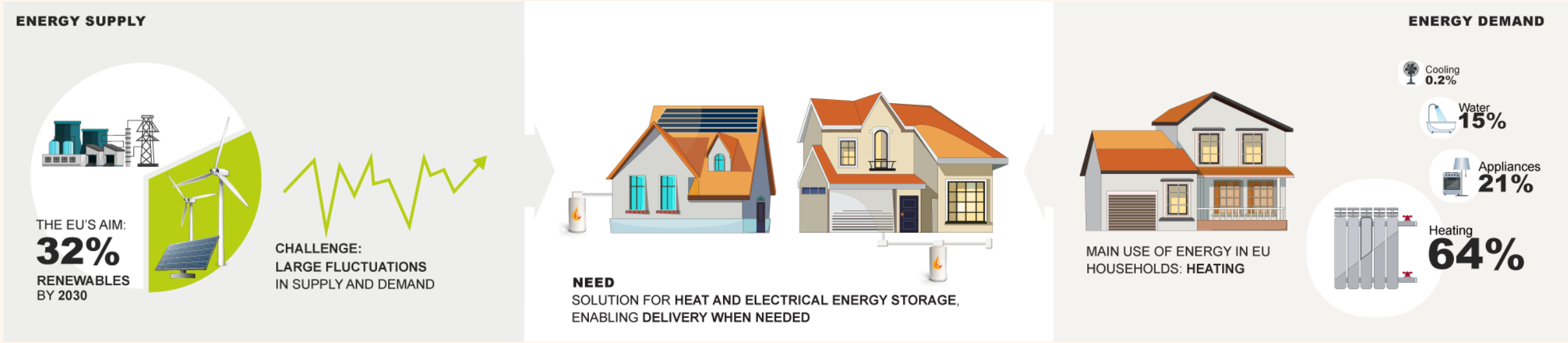
Programme

- ***"HEAT-INSYDE Project and Introduction to Heat Storage Technology"*** Yulia Galagan (**TNO**) 10'
- ***"Storage materials – working principle and manufacturing"*** Henk Huinink (**TU/e**) 15'
- ***"Development of a compact domestic heat storage prototype"*** Tom Chermin (**Cellcius**) 15'
- ***"Heat Battery implementation in French context, moving bed reactor testing and numerical simulation for battery sizing"*** Etienne Wurtz (**CEA**) 15'
- ***"Implementation of Heat Battery in a residential building in Poland"*** Agnieszka Łukaszewska (**FASADA**) 15'
- **Panel discussion** (moderated by TNO with inputs of all partners) 20'

WHY?

- The EU aims to increase the energy **share** of renewable energy systems **to 32% by 2030.** This transition comes with **large fluctuations** in supply and demand so it is essential to store energy that can be delivered when needed.

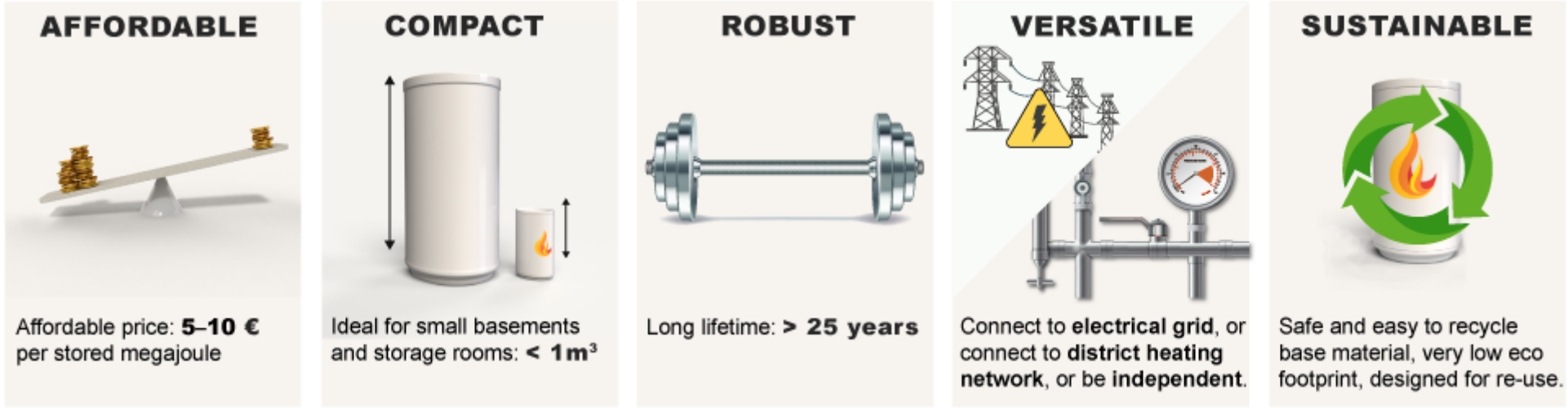
Energy supply, demand and use in European households:



- The **main use** of energy by European households is **for heating**, but no compact and affordable solution is available to efficiently store and supply heat energy based on user demand.

Main objectives of HEAT-INSYDE, a H2020 Innovation Action (IA):

- **Advance a ground-breaking closed-loop heat storage concept** to Technology Readiness Level 7.
- Deliver an **affordable**, highly **compact** and **sustainable** solution with **robust** performance.
- **Real-life validation** in 3 different European climate zones.
- Combine compact storage with a highly efficient heat pump effect delivering **hybrid functionality.**
- Create new opportunities for **grid flexibility**, with configuration in both **heat and electricity systems.**

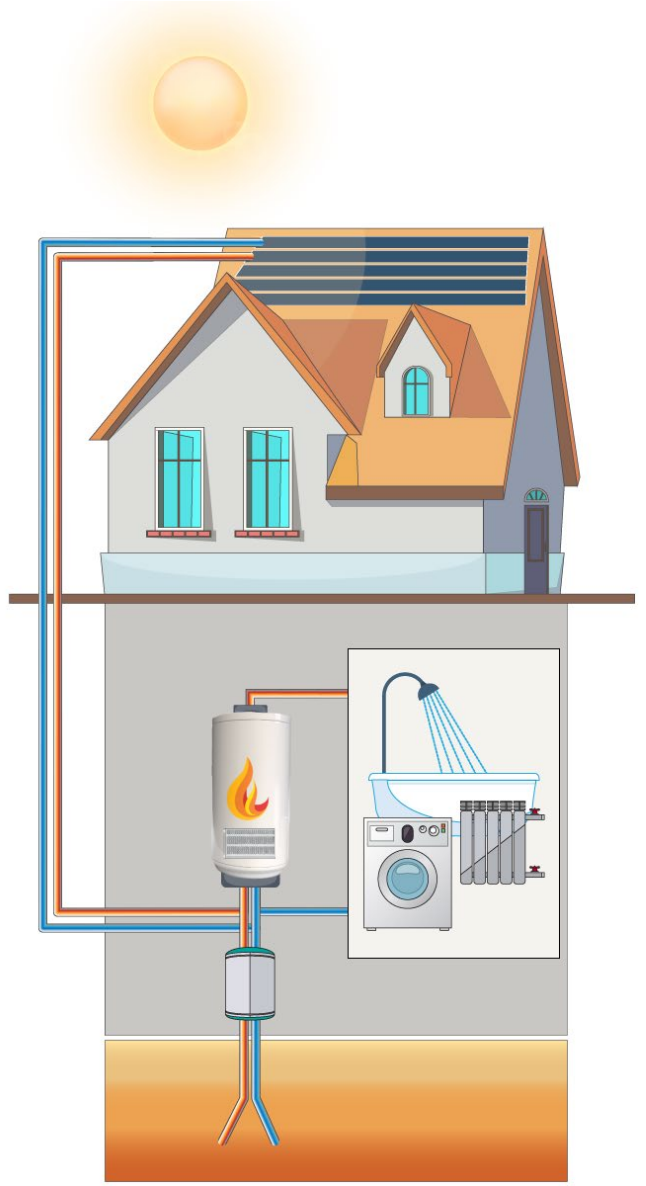


INTEGRATED IN A DECENTRAL RENEWABLE ENERGY SYSTEM

- ✓ Solar panels as pre-heater
- ✓ Air side of heat pump combined in solar panels
- ✓ Smart integration of condenser side in heating system
- ✓ Direct electrical charging

DEVELOPMENT:

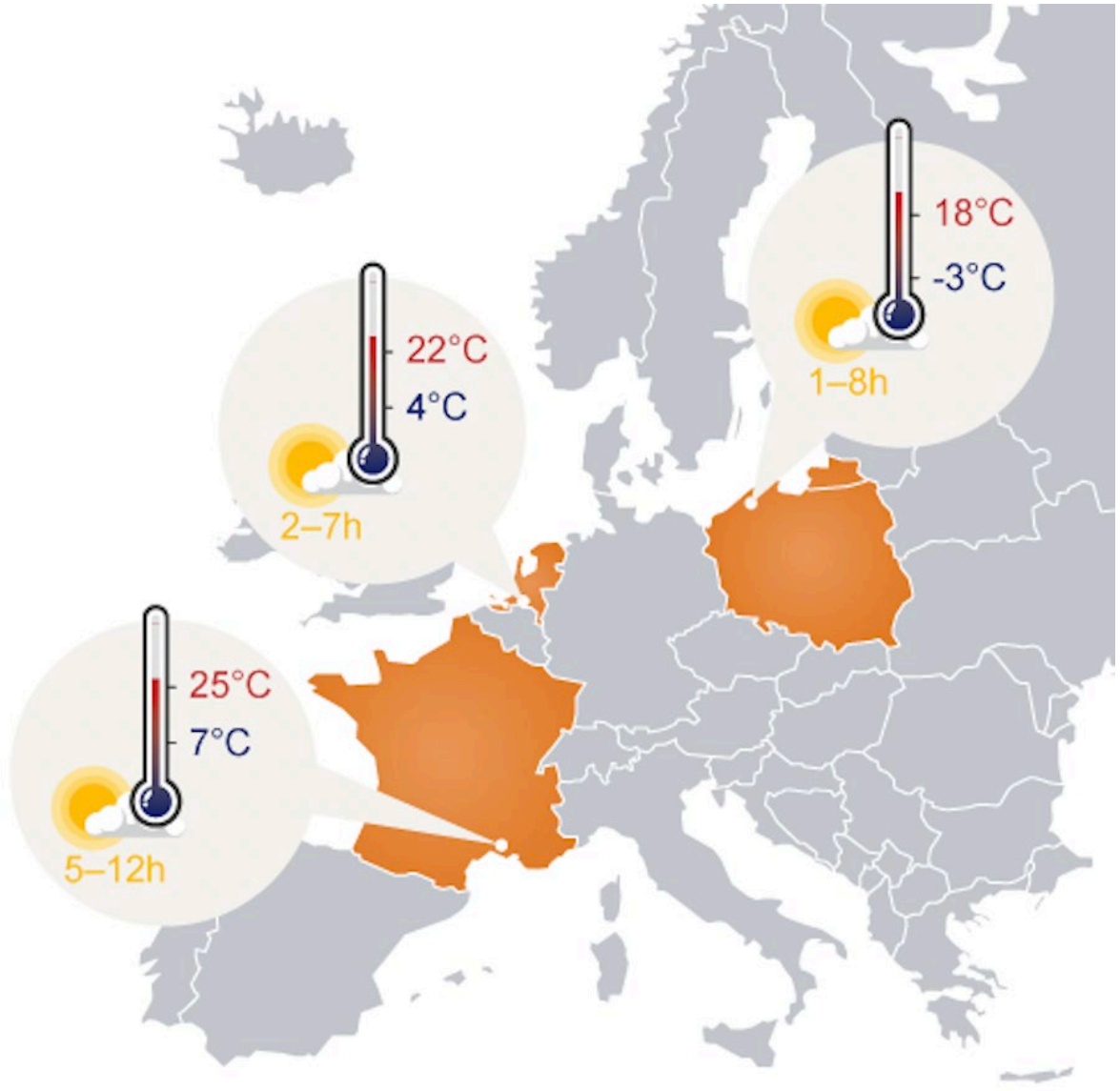
- Selection of concept adapted on demo-location
- Integration of battery with existing system
- Testing under end-user conditions
- ROI, safety, business case



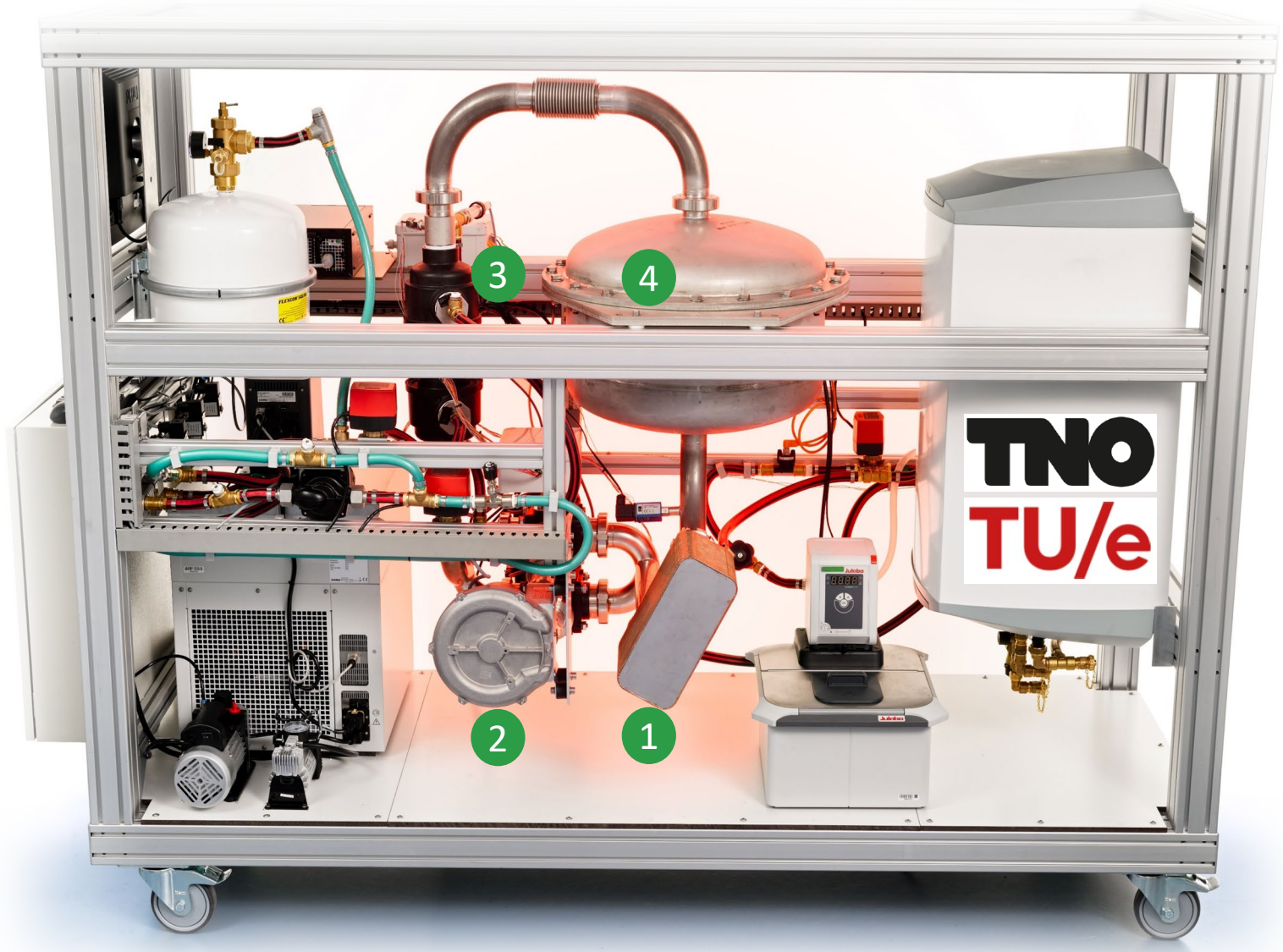
VALIDATION

The HEAT INSYDE heat battery is validated in real-life demonstrations in **3 European climate zones**

Netherlands Eindhoven
France Saint-Paul-lès-Durance
Poland Gdansk



THE STARTING POINT



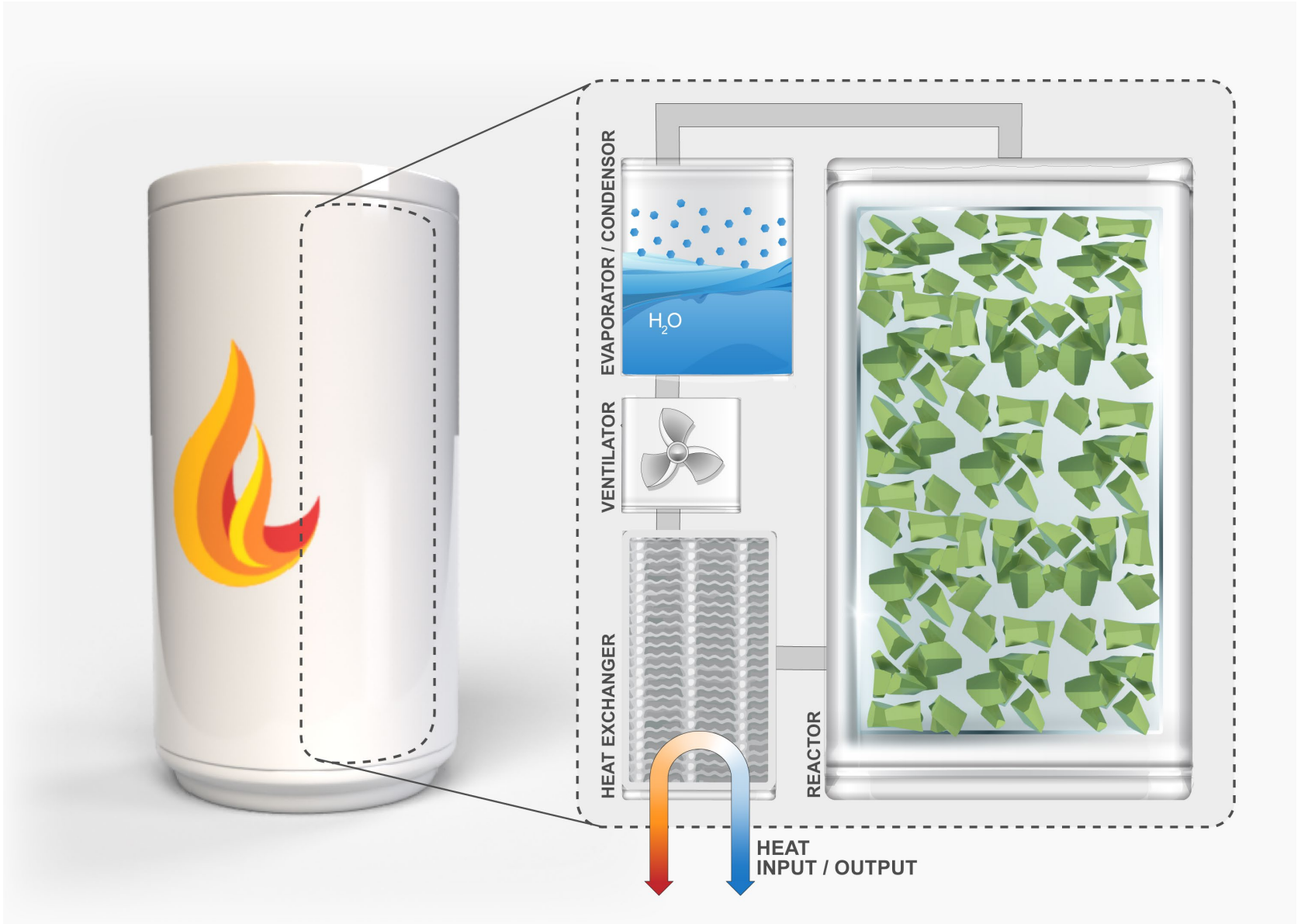
(2019) 7kWh demonstrator

Breakthroughs

- ✓ Stable thermochemical composite
- ✓ ‘Closed-loop’ system concept

1. Heat exchanger
2. Ventilator
3. Evaporator/Condensor
4. Reactor

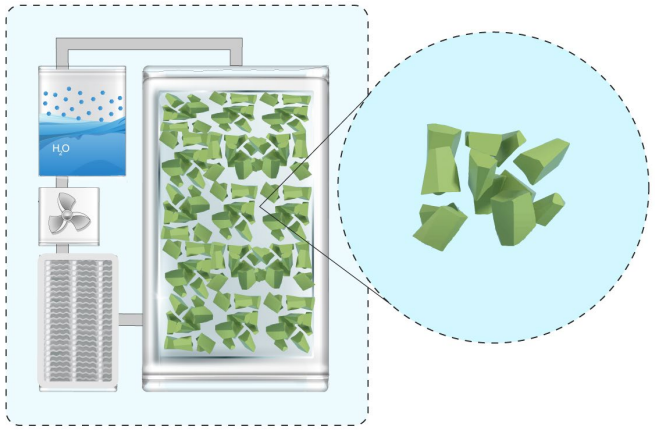
BREAKTHROUGH: the closed-loop reactor concept



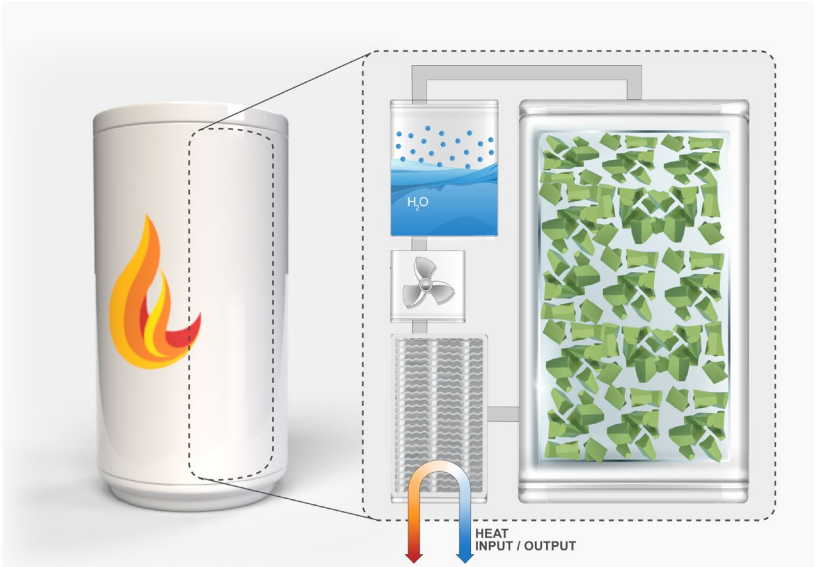
Simplicity
4 key components

3 MAIN TECHNOLOGIES

Multicyclic stable thermochemical material

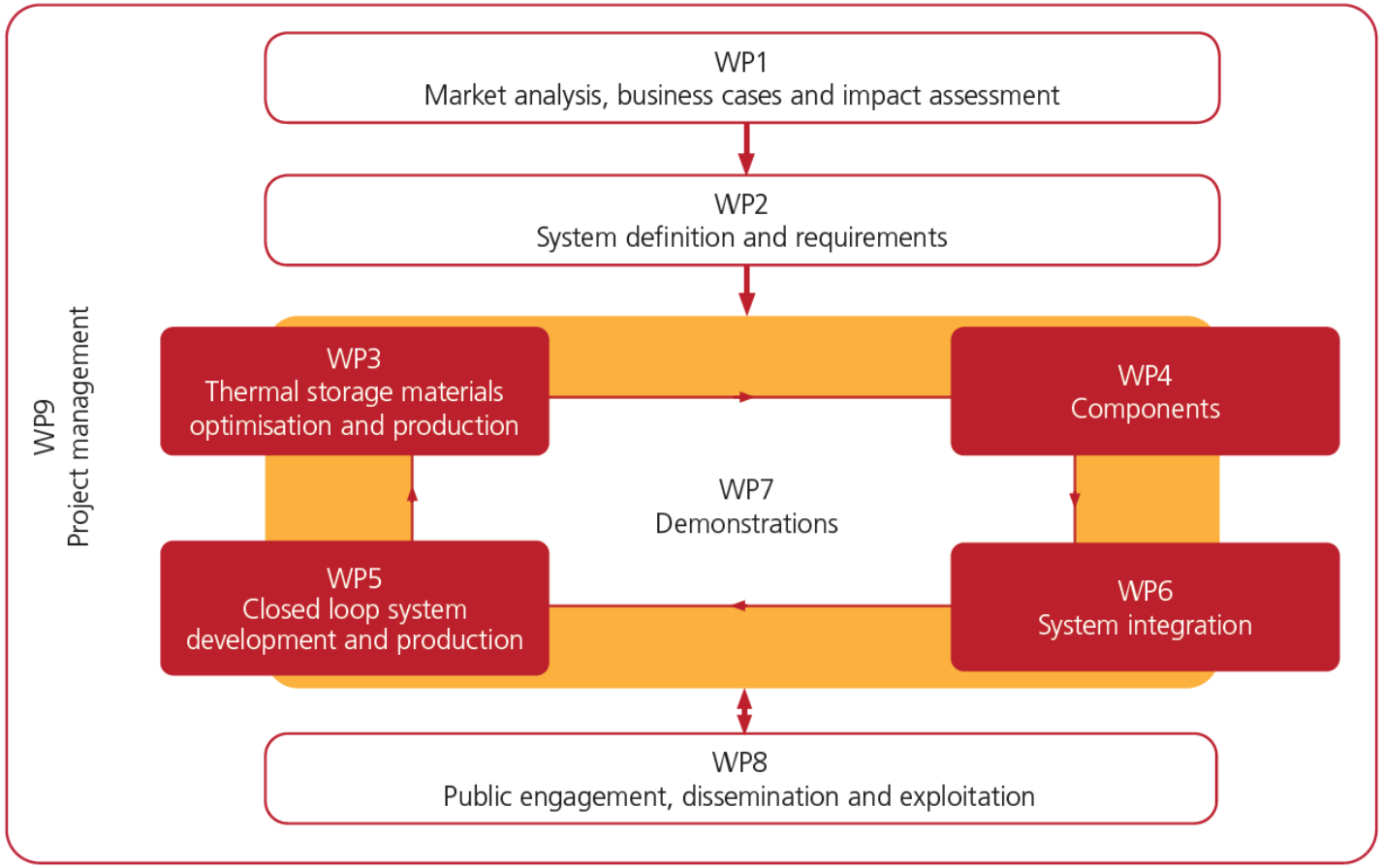


Compact thermochemical heat storage systems



Energy management and interfacing

HOW: THE WORK PLAN



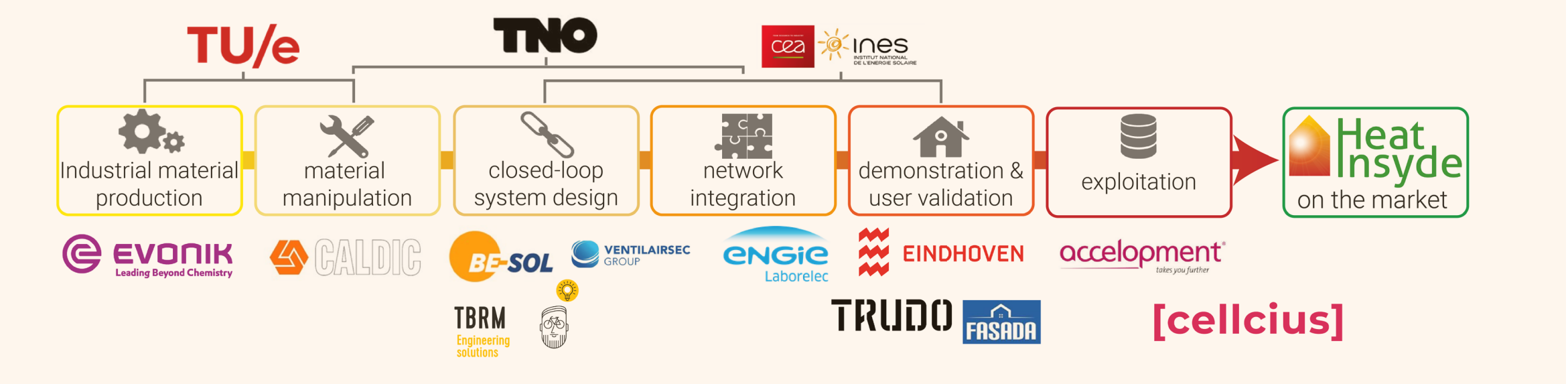
14 partners
6 countries

3 user-centred demo sites

7,8M euro

October 2019 - March 2025

WHO?



HEAT-INSYDE mobilizes all key players relevant to the manufacturing and distribution chain of our solution


THANK
YOU!

PANEL DISCUSSION

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WORKSHOP

HEAT-INSYDE

Storage materials – working principle and manufacturing

Heat Insyde

https://www.heat-insyde.eu

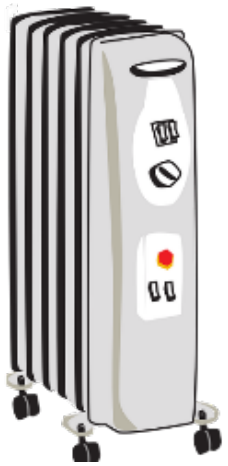
TU/e EINDHOVEN UNIVERSITY OF TECHNOLOGY

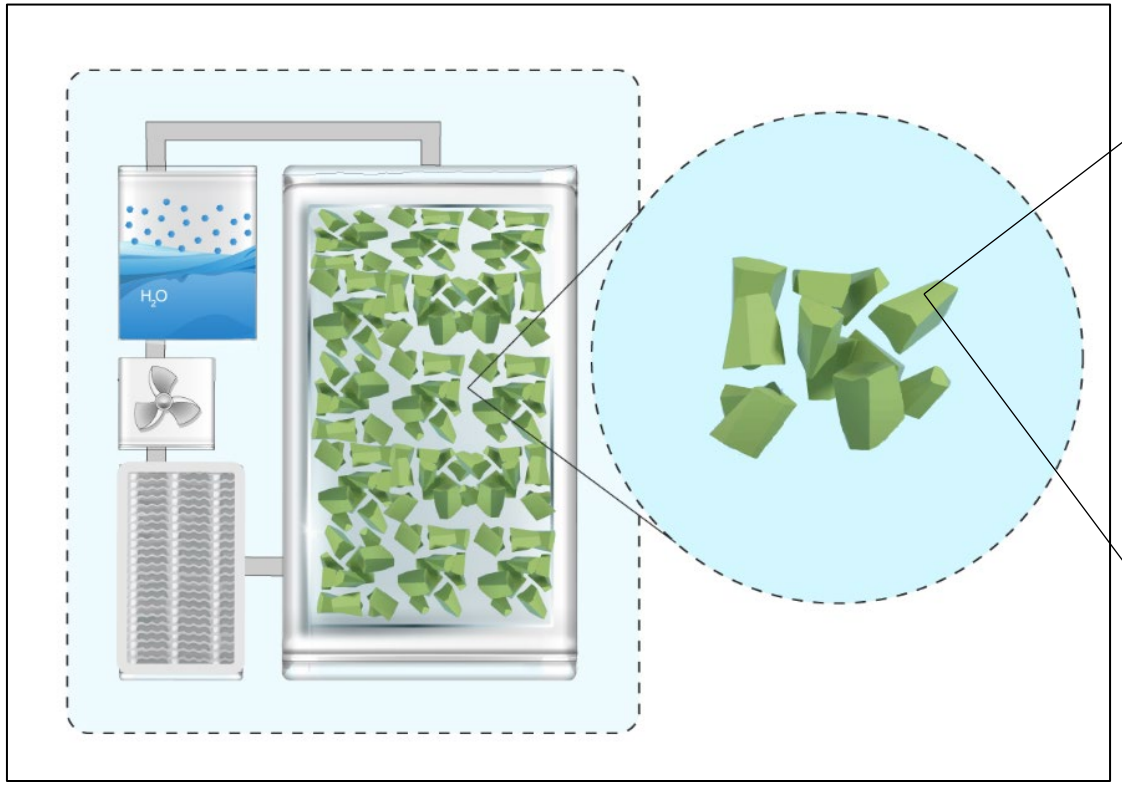
Henk Huinink

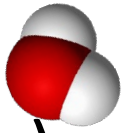
Contents

- Background of thermo-chemical materials
- Challenges
- Objectives and approach
- Size, power and stability
- Manufacturing

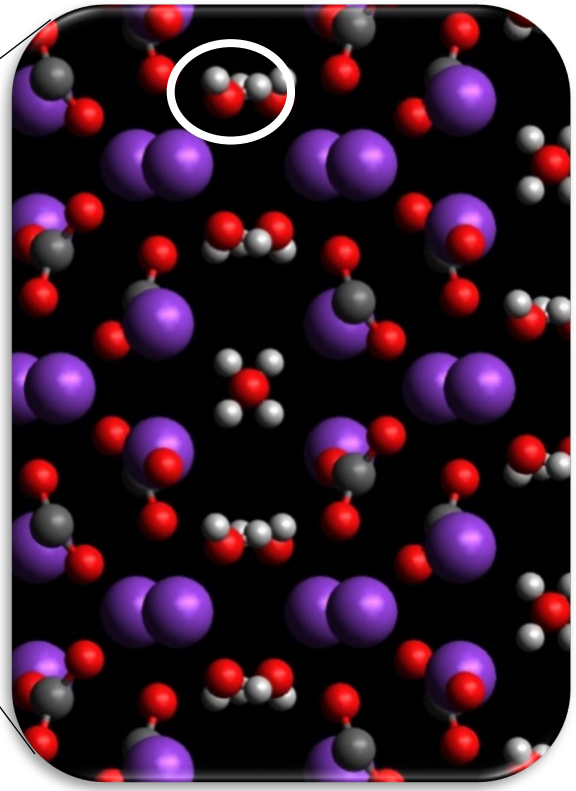
Background





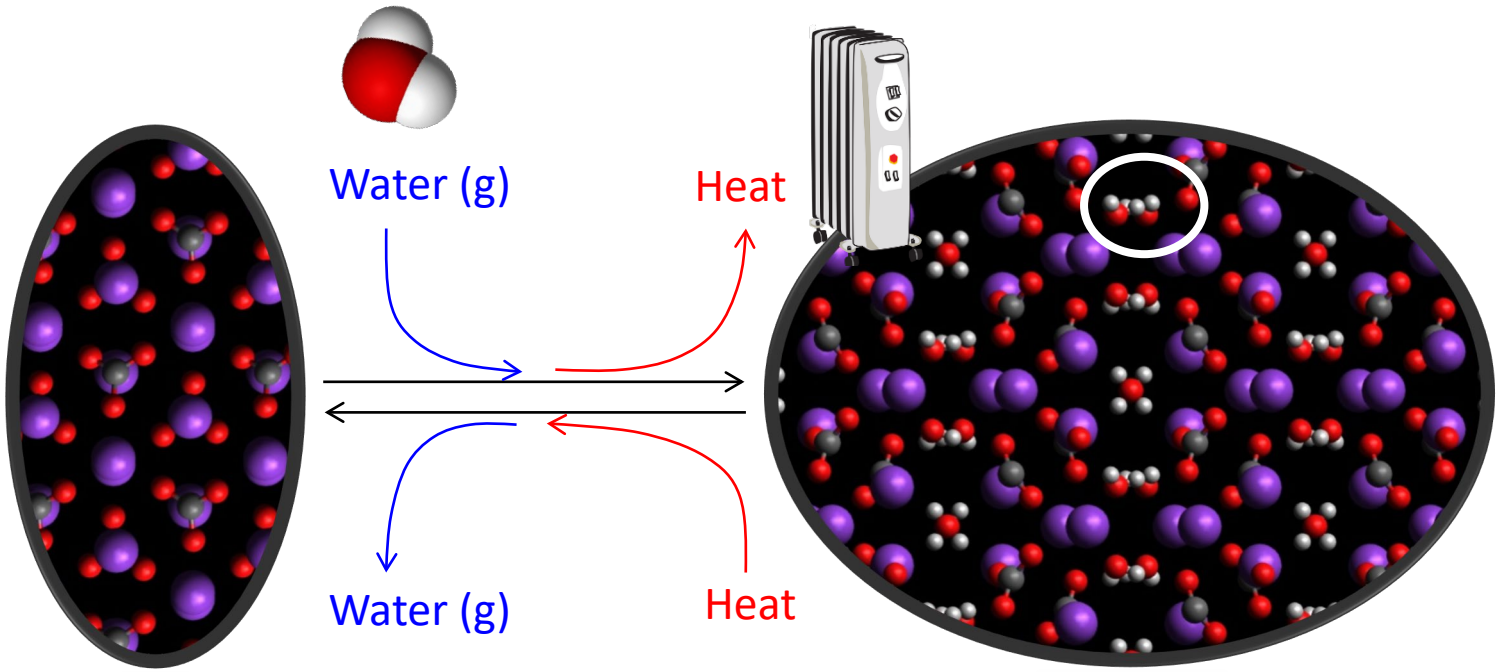


H_2O (g)



$K_2CO_3 \cdot 1.5H_2O$ (s)

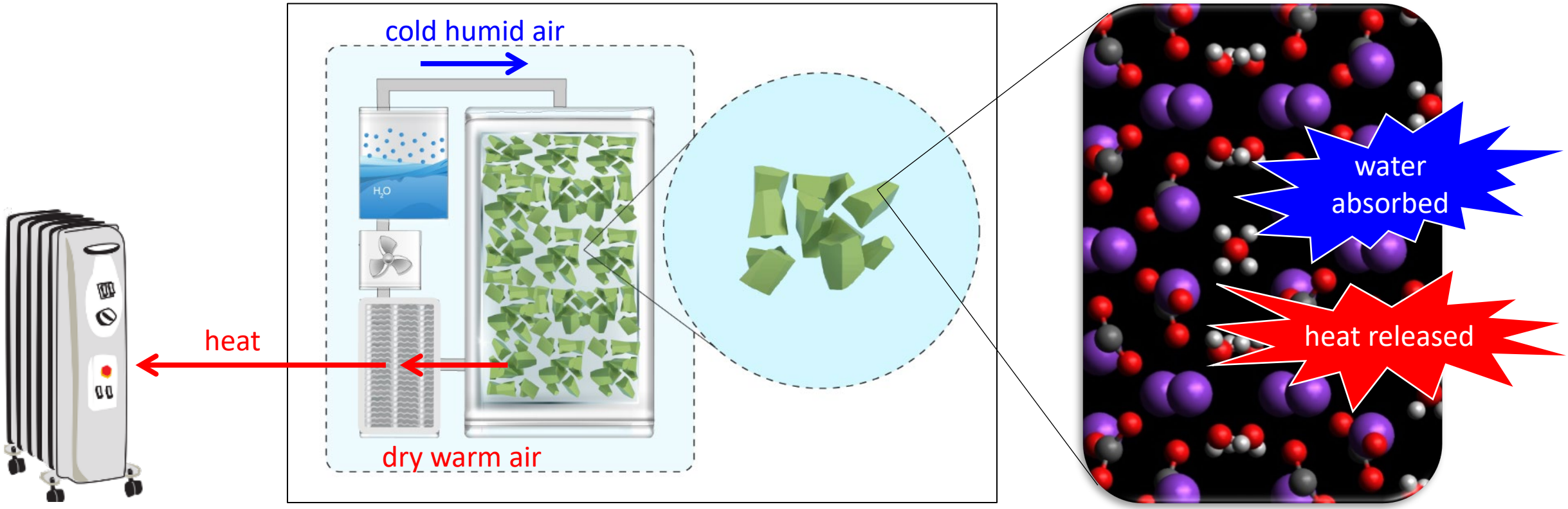
Background



K_2CO_3 (s)

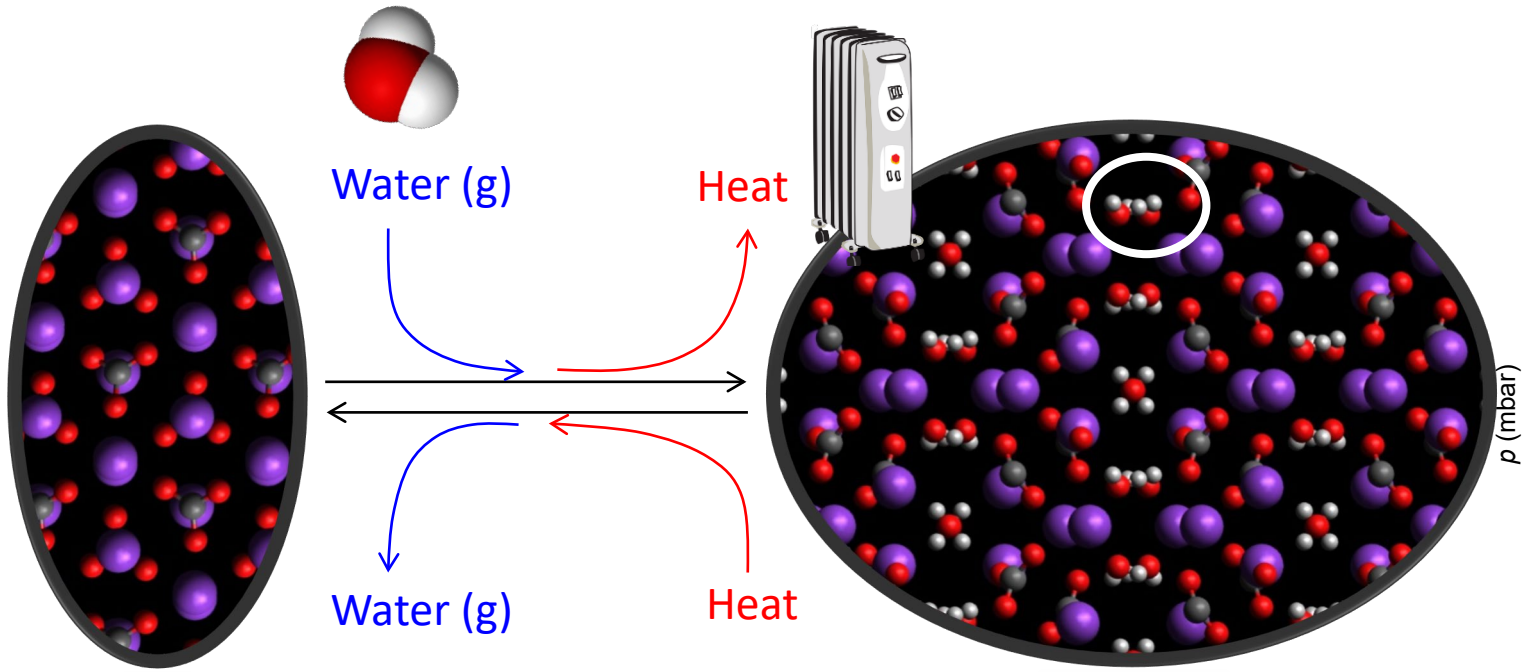
$K_2CO_3 \cdot 1.5H_2O$ (s)

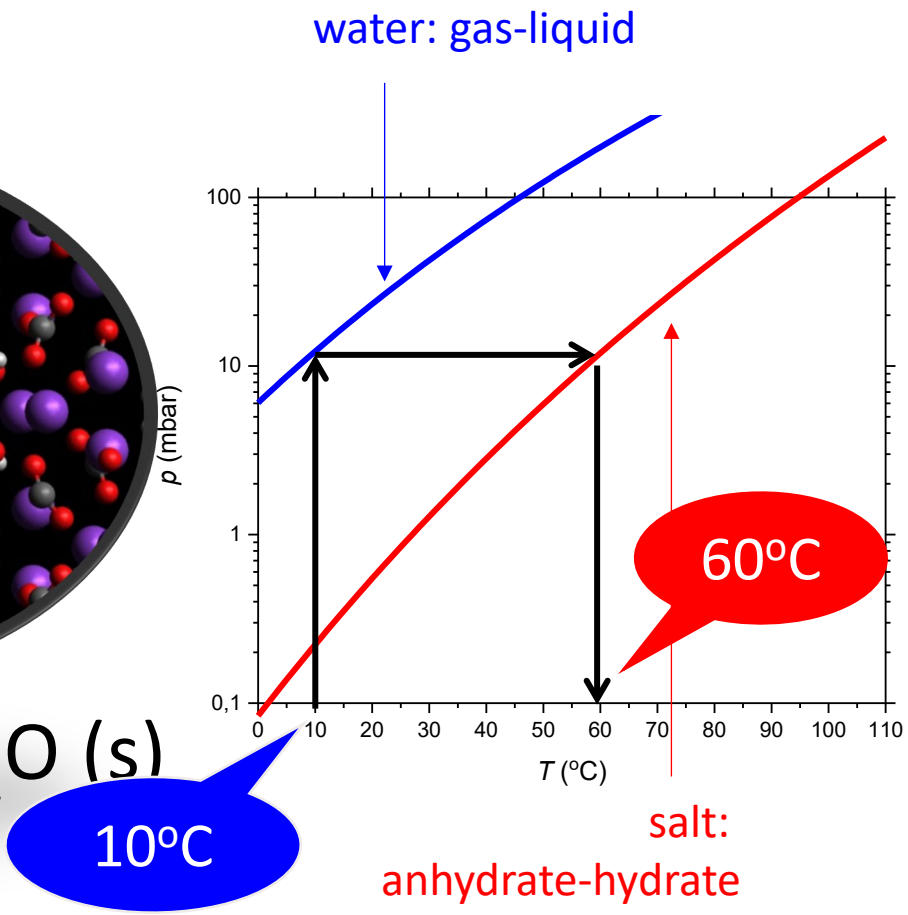
Background


cold humid air
heat
dry warm air
water absorbed
heat released

Background

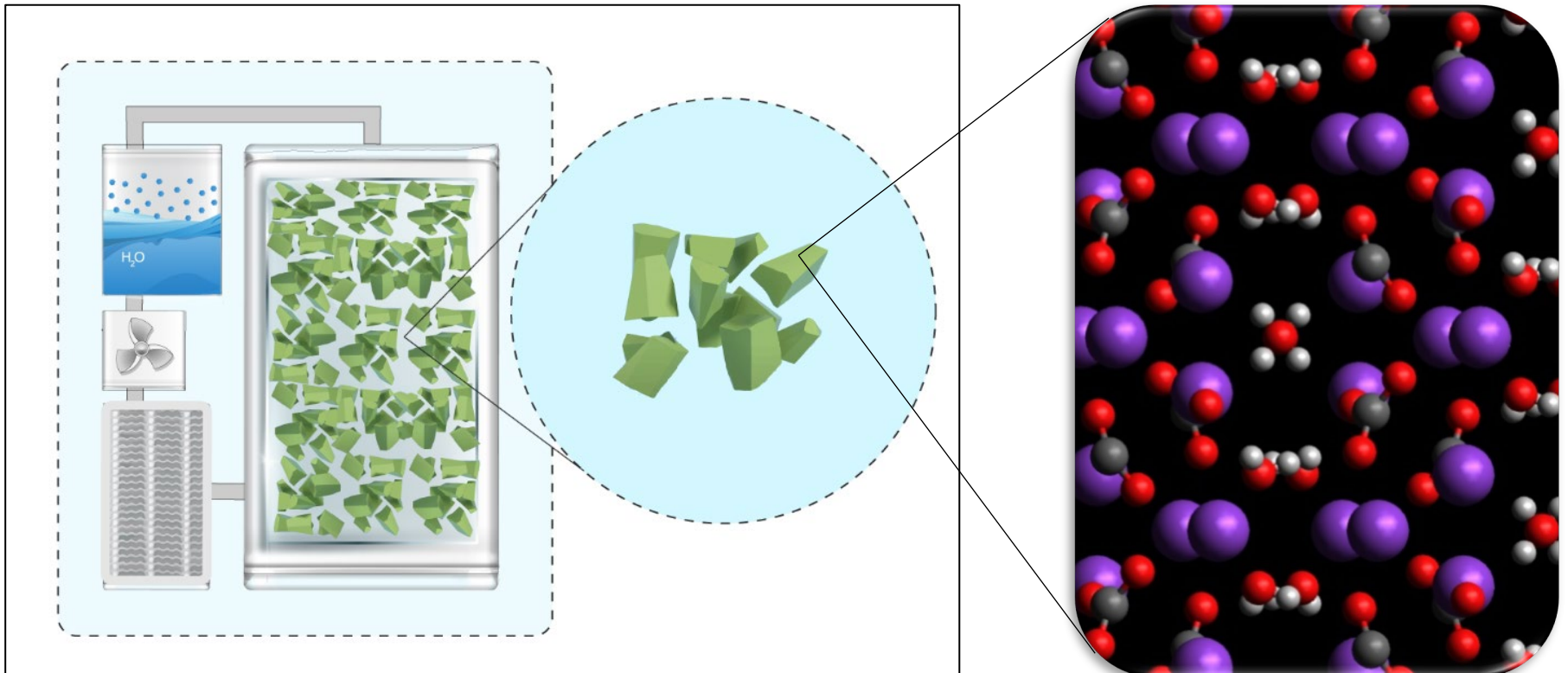
Donkers et al, Applied Energy (2017): https://doi.org/10.1016/j.apenergy.2017.04.080





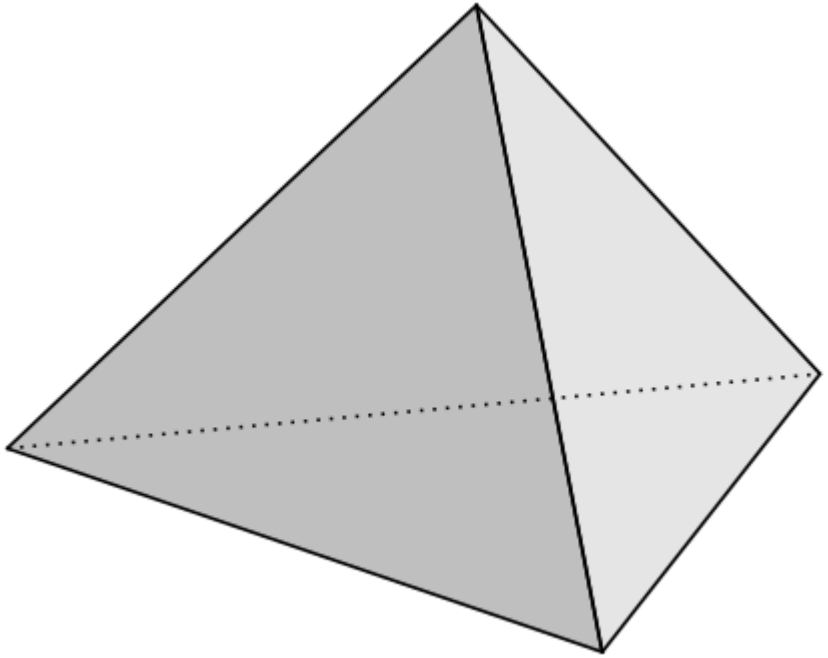
Challenges

- Good flow through particle bed
- Making the particles
- Power output particles
- Stability of particles
- Energy density



Challenges

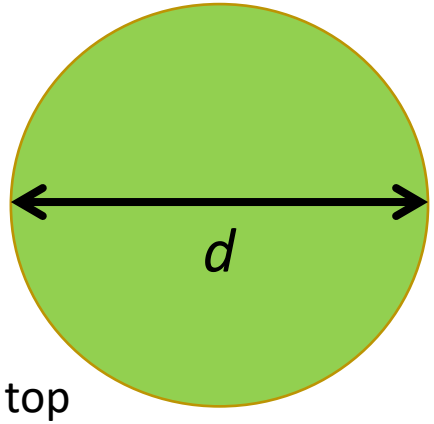
Particle power: $L \downarrow$



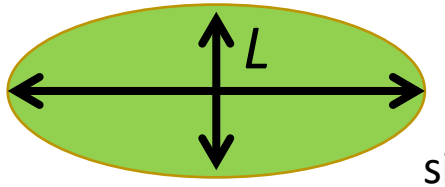
Energy density

Bed permeability (stability): $L, d \uparrow$

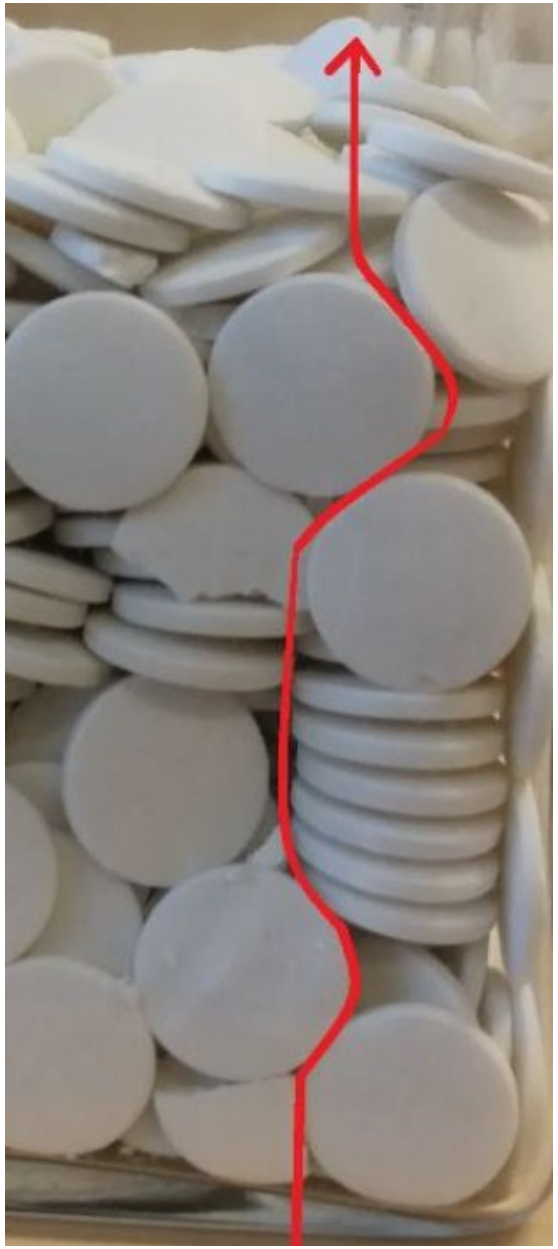
Manufacturability: $L, d \uparrow$



top

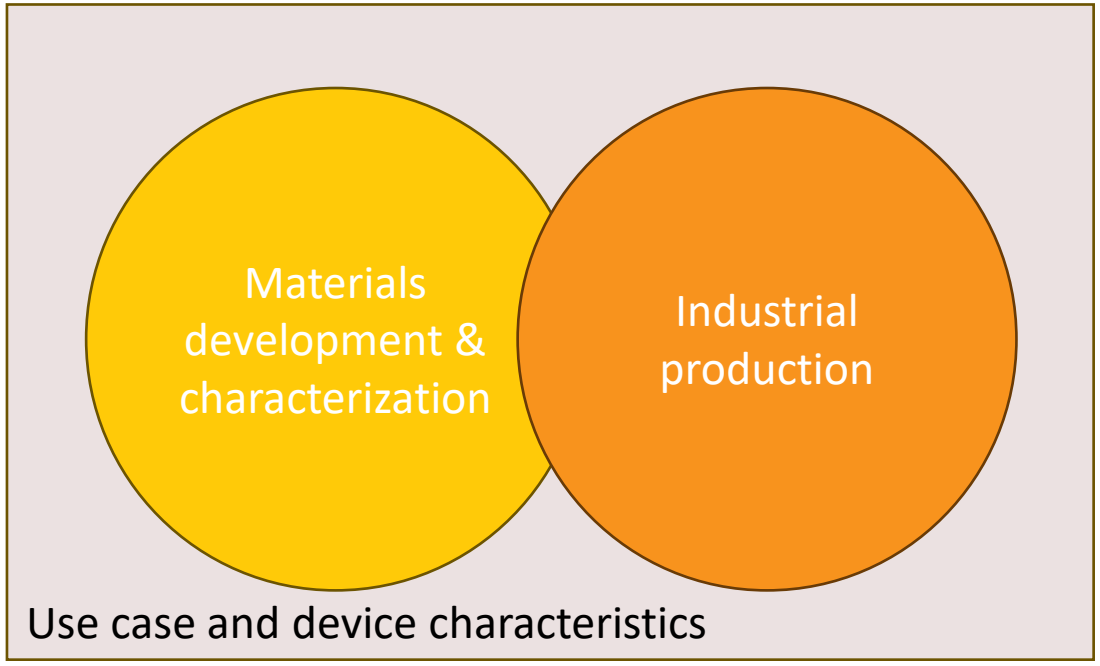


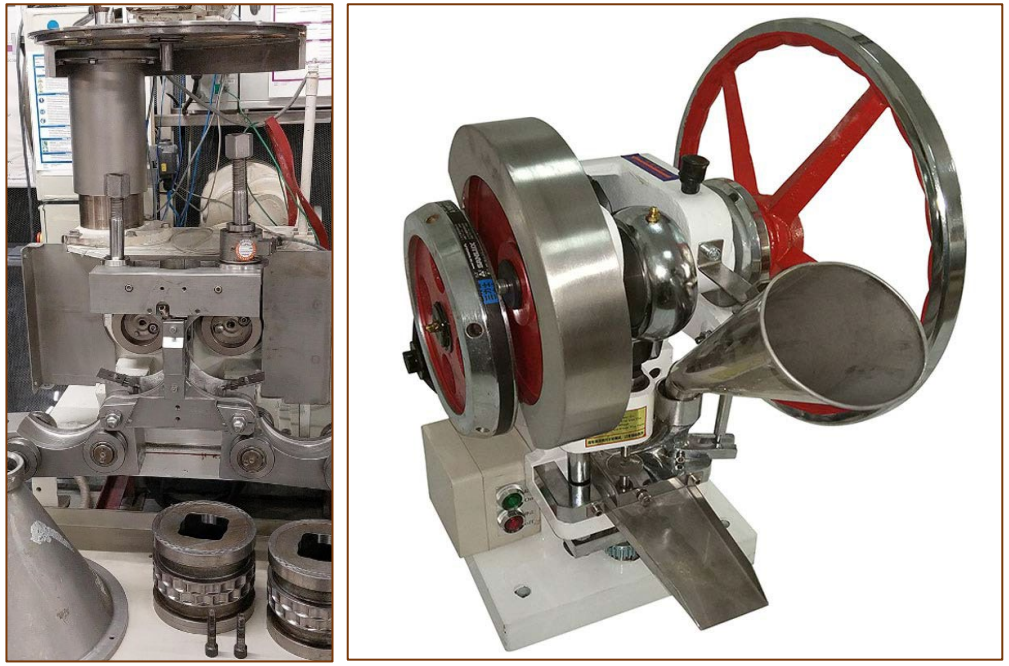
side



Objectives and approach

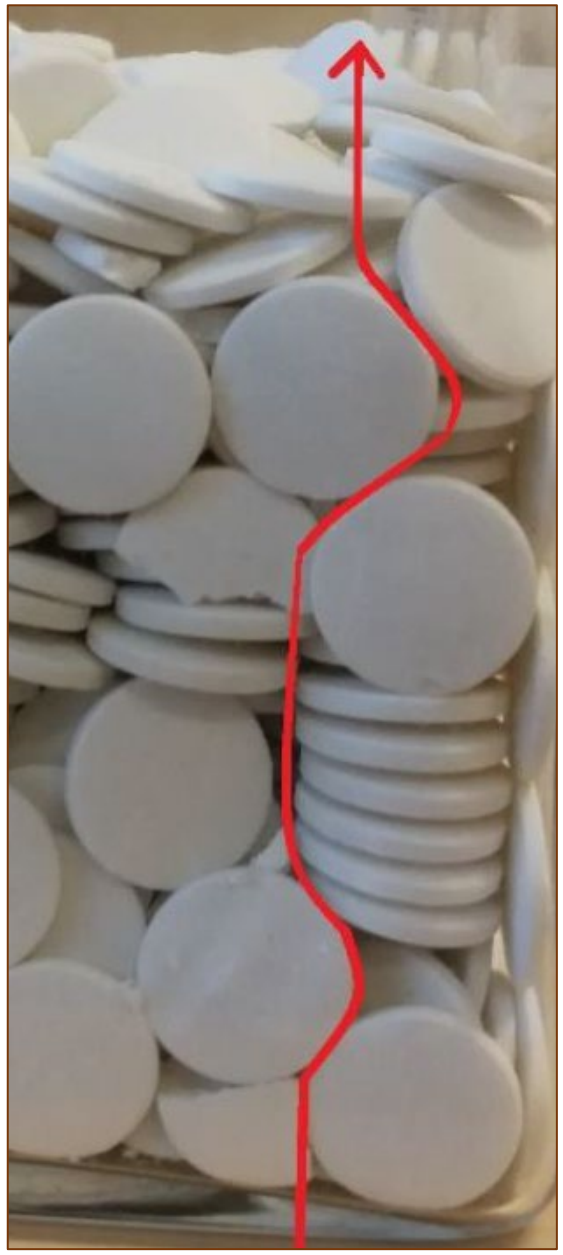
- Optimization of TCM particles with respect to power and energy density
- Stabilizing TCM particles with minimal loss of energy density and cyclic performance
- Develop an up-scaled, low-cost, and industrially feasible TCM production method

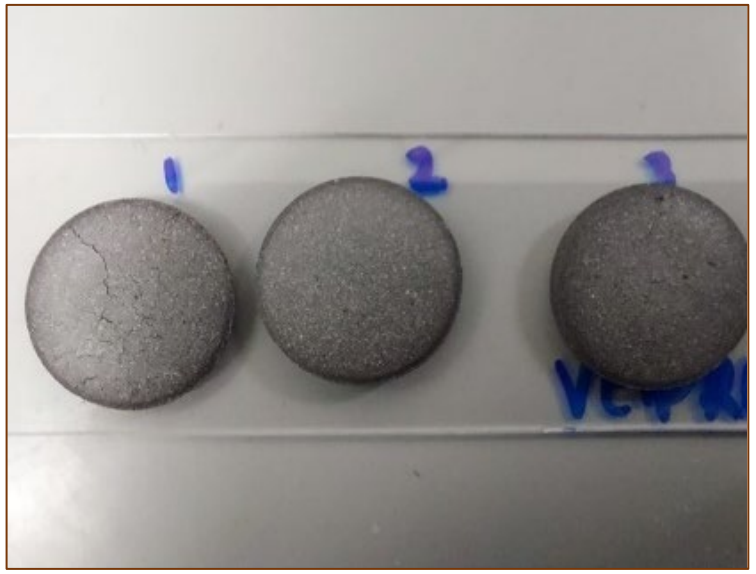




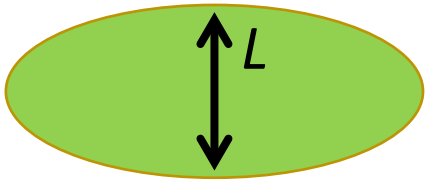
Existing particle production technologies

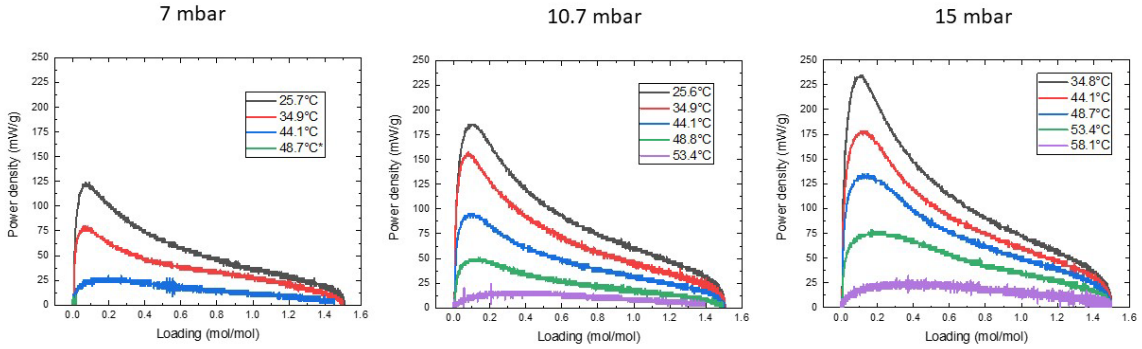
Size, power and stability



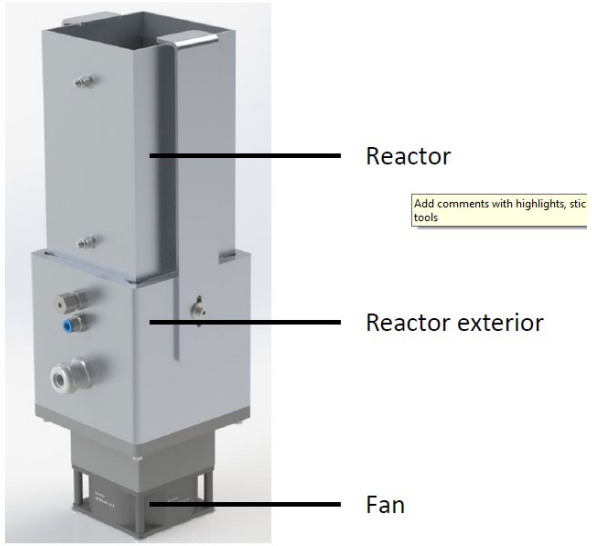


- Thickness critical
- Mm-sized for optimum power output and flow characteristics
- Diameter crucial for production



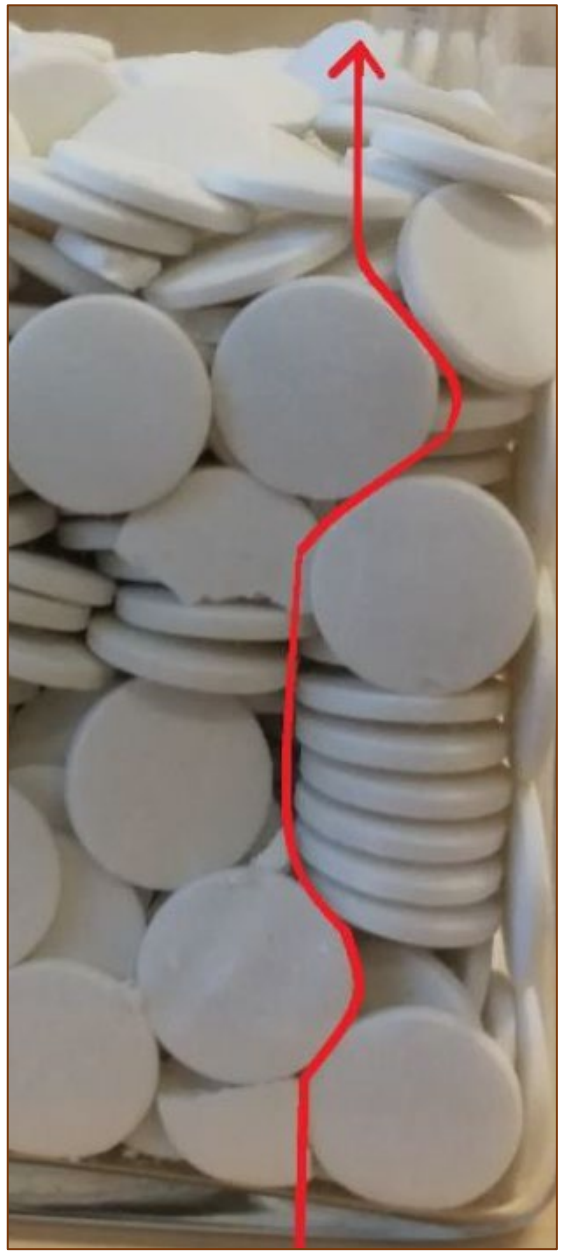


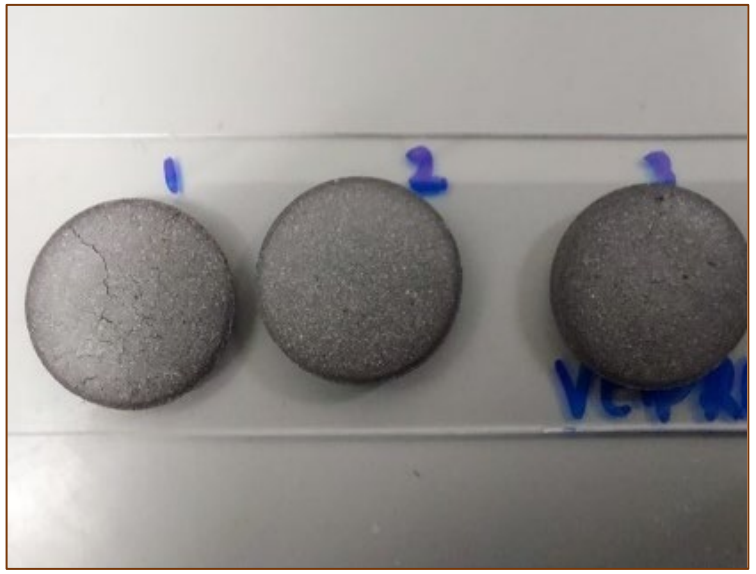
Particle power output



Particle bed tests

Size, power and stability

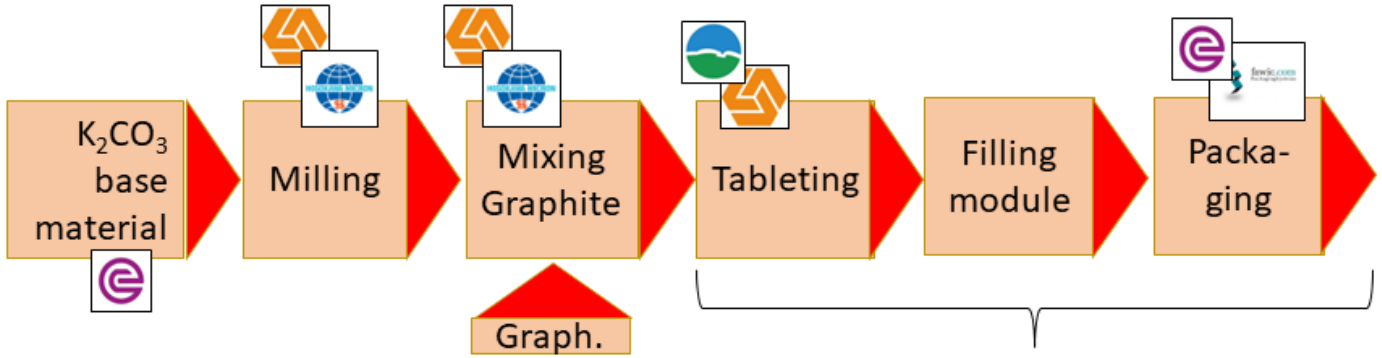




Property	Value
Energy density (bed level)	0.61 GJ/m^3 = 169 kWh/m^3
Power density	44 W/kg 71 kW/m^3
Stability over 10 cycles	5 – 10-fold increase of pressure drop
Costs	3 – 6 €/kg

Doubled due Ukraine crisis (raw materials)

Manufacturing



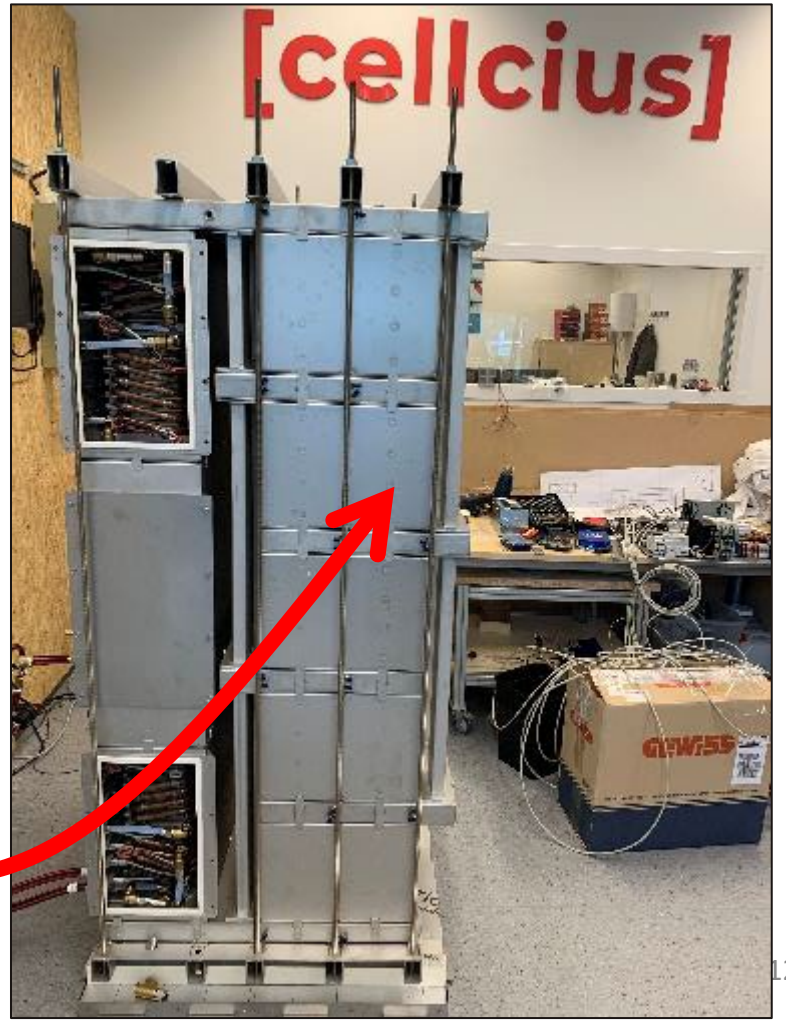
Hosokawa

VEIP

Fawic

Tableting

Filled module



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Heat Insyde

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Implementation of Heat Battery in a residential building in Poland

Heat Insyde

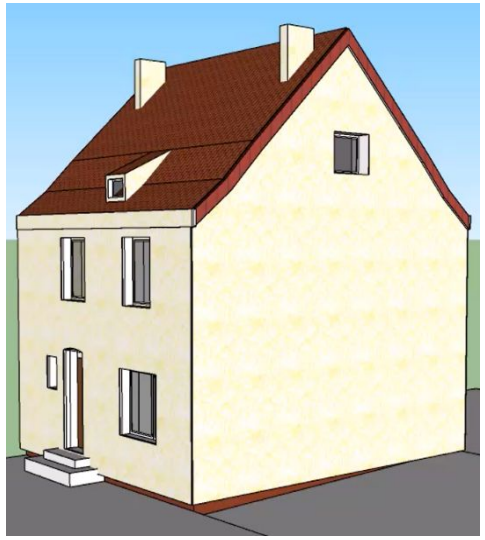
https://www.heat-insyde.eu

FASADA

Agnieszka Łukaszewska

Demonstration building in Poland

- Two storey social residential building in Gdynia, Poland
- Owner Municipality of Gdynia
- Constructed in 1943, renovated in 2016
- Heating and Domestic Hot Water provided -> gas boiler
- Focus on 1 flat (60m2)



GOAL

- Testing and validating of the heat storage in real house with living inside occupants in various climatic conditions

CHALLENGES & REQUIREMENTS

- Dedicated room/space for storage systems, tanks, or heat pump installation
- Three-phase electrical power supply required
- Building connection power should exceed 12 kW
- Connection to both fresh water and domestic hot water, as well as heaters at the installation site
- Ideally, the existing boiler room should be repurposed into a heat storage area, replacing the current heat source
- The building's envelope must be properly insulated
- In older buildings, additional internal piping or electrical works may be necessary

Step 1 Installation of the PVs and heat pump

- Installation of the 12 PV modules (JA SOLAR JAM72S20-460/MR SF) with Hoymiles inverters (5,52kWp)
- Plumbing works and installation of water-air heat pump (Monoblock panasonic WH-MDC07J3E5 7kW)
- Elimination of gas as a source of heating and hot domestic water




Step 2 Installation of the heat battery

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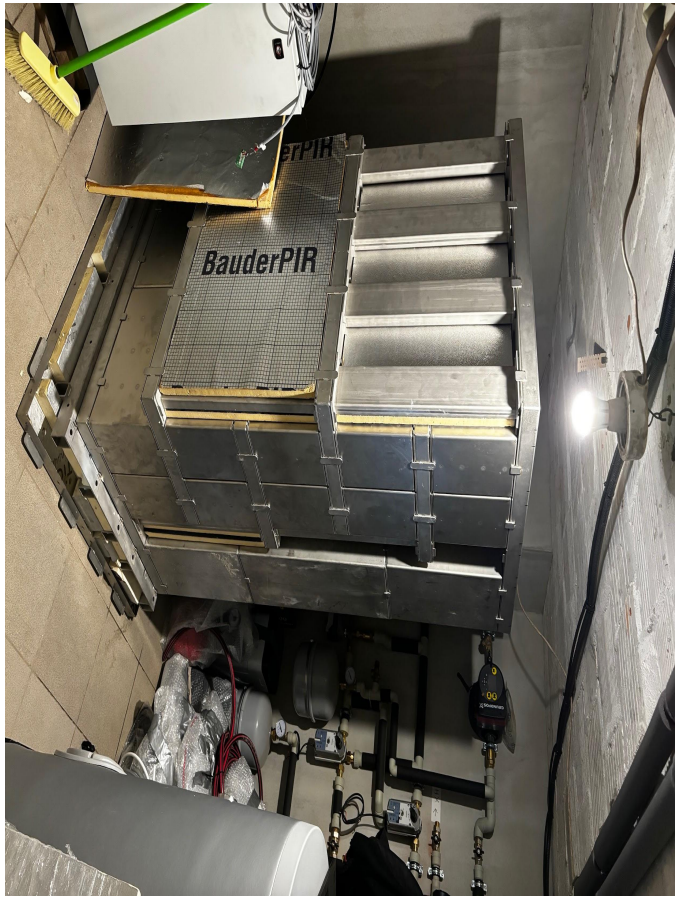

CONCLUSIONS

- Public building owners are interested in alternatives to eliminate fossil fuel dependency.
- The battery installation process is smooth and efficient, more effort needs to be dedicated to the connection to the existing building installation system.
- Installing renewable energy systems (RES) and heat battery in existing buildings present more challenges.
- Further effort is needed to ensure silent operation of the battery, auxiliary equipment, and maintenance-free performance.


THANK
YOU!