LATENT HEAT STORAGE FOR CENTRALIZED HEATING SYSTEM IN A ZEB LIVING LABORATORY: INTEGRATION AND DESIGN

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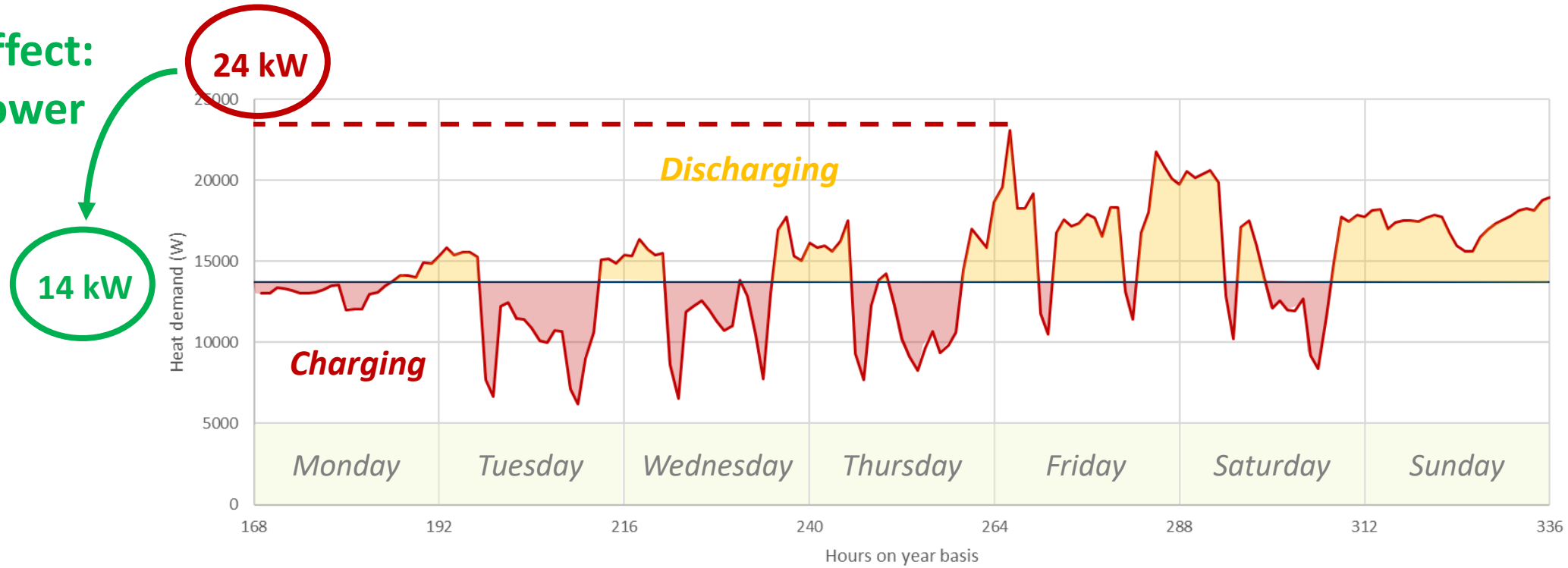
Facing a varying heat demand in buildings…

…and a correspondingly varying electricity price

Max effect:
42% lower



-> Heat storage enables peak shaving

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Alexis Sevault

ZEB Laboratory

1720 m^2 office/living lab

ZEB Laboratory - https://zeblab.no/

ZEB Lab:

Opportunities and constraints for heat storage


ZEB Laboratory - https://zeblab.no/

Heat demand	Energy system	Electricity sources	Heat sources	Environment
High daily variations	Centralised heating system (space heating, hot domestic water and	▪ Power grid ▪ Solar energy (roof)	▪ Heat pump ▪ District heating ▪ Low-temperature	▪ Low- or zero-emissions components ▪ Low impact
Quick thermal response	**Centralised active heat storage**	**Optimized self-consumption**	**Price-driven control strategy**	**Environment-friendly + Compact**

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Opportunities and constraints for heat storage


ZEB Laboratory - https://zeblab.no/

Heat storage using Phase Change Materials (PCM)

Advanced control strategies

- Quick thermal response
- Centralised active heat storage
- Optimized self-consumption
- Price-driven control strategy
- Environment-friendly + Compact

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Heat storage using PCM

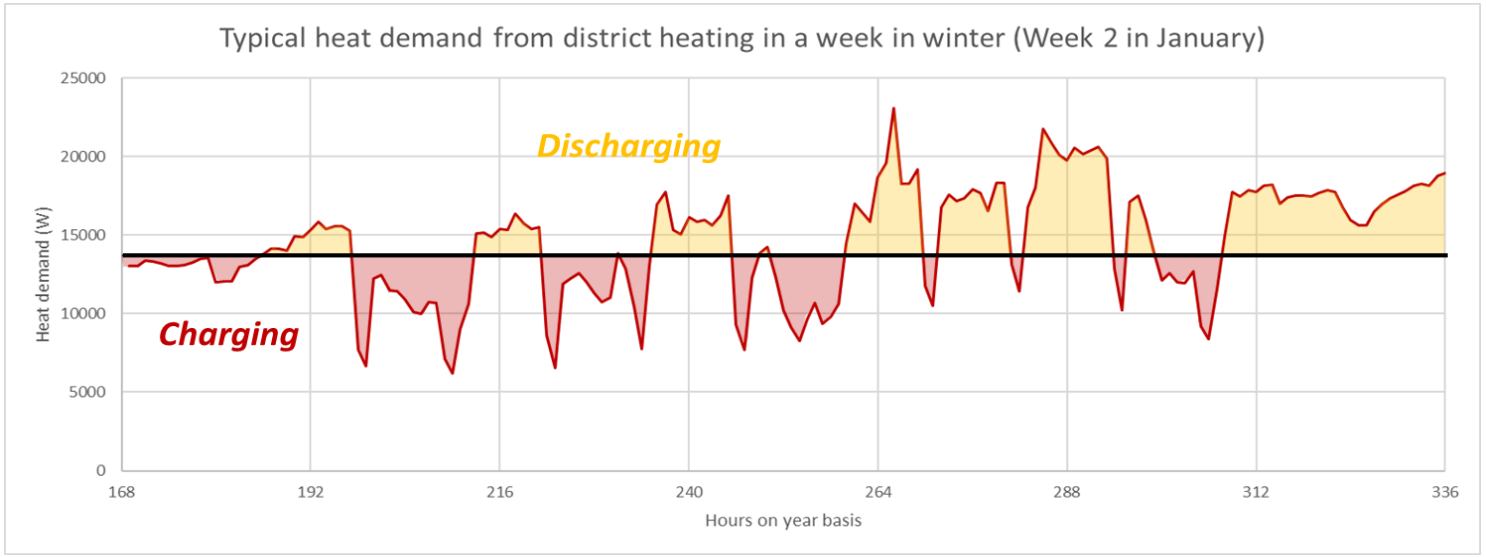
Tank volume: **5 m³**

Total weight: **6 tons**

Heat storage capacity: **200 kWh**

PCM: **Bio-based wax**

2-3 days of peak heat demands of 8-15 kW



Implementation with financial support granted by ENOVA: 1.3 MNOK

Max. required capacity for heating system when heat storage operates:

14 kW instead of 24 kW

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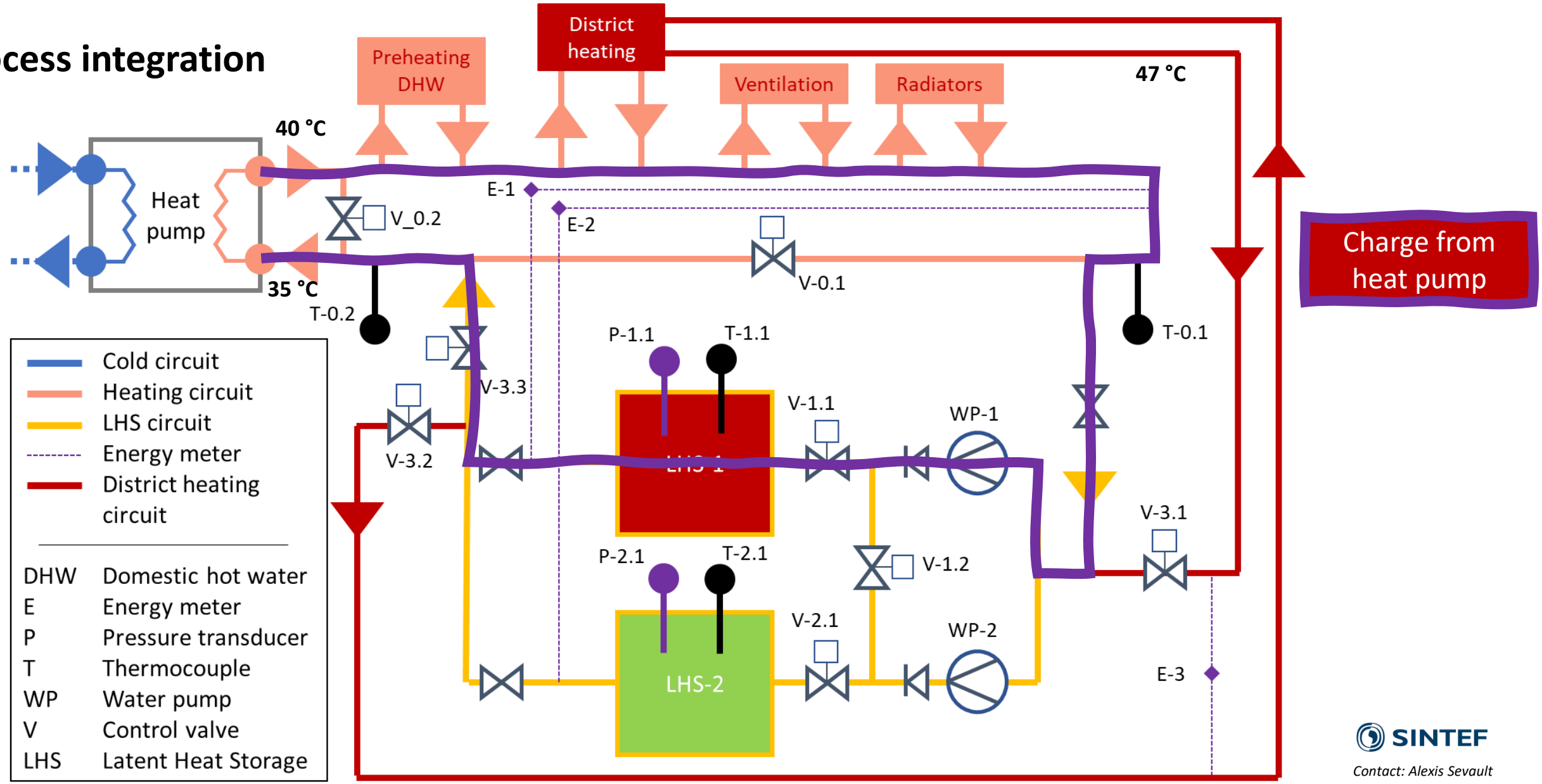
Process integration



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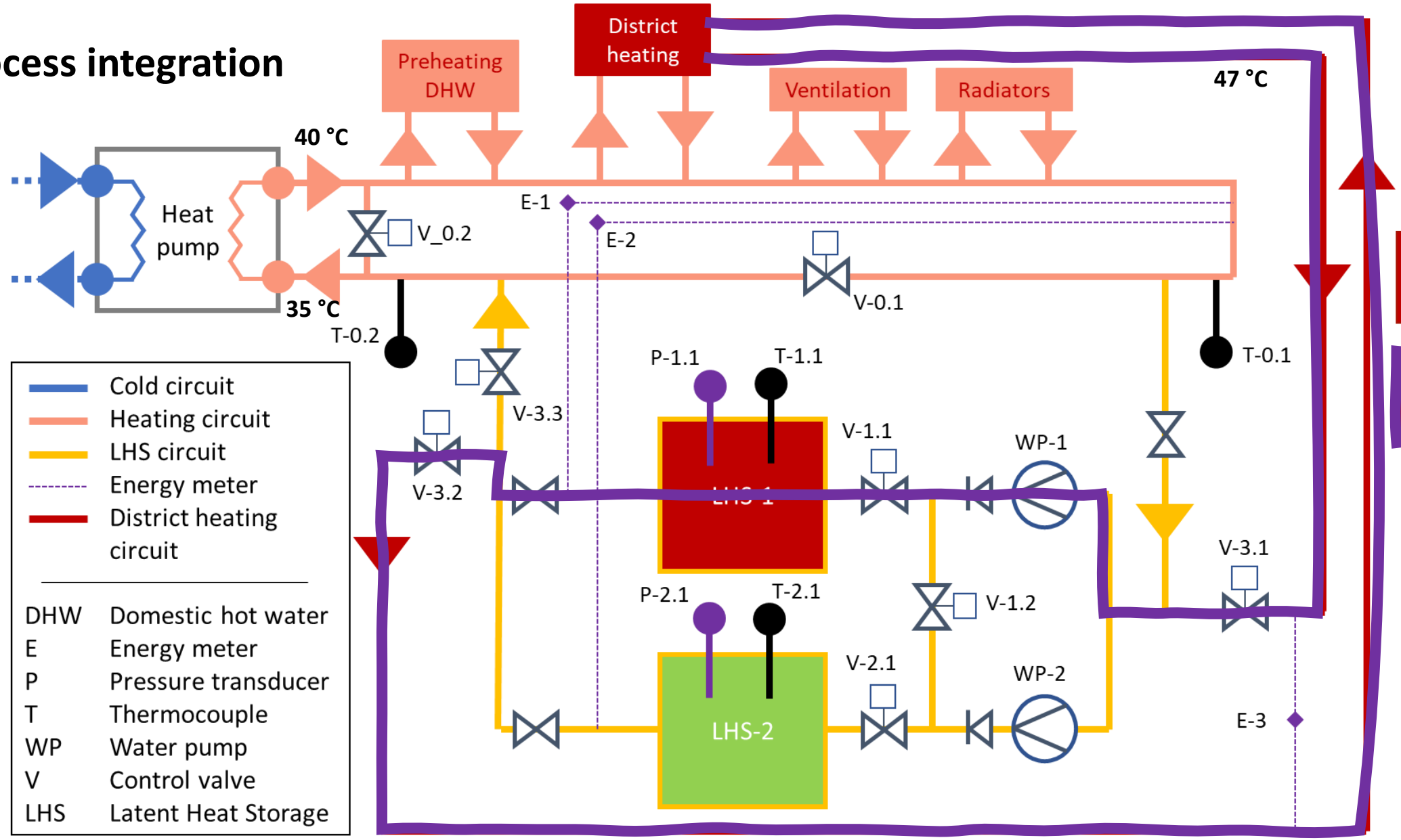
Process integration



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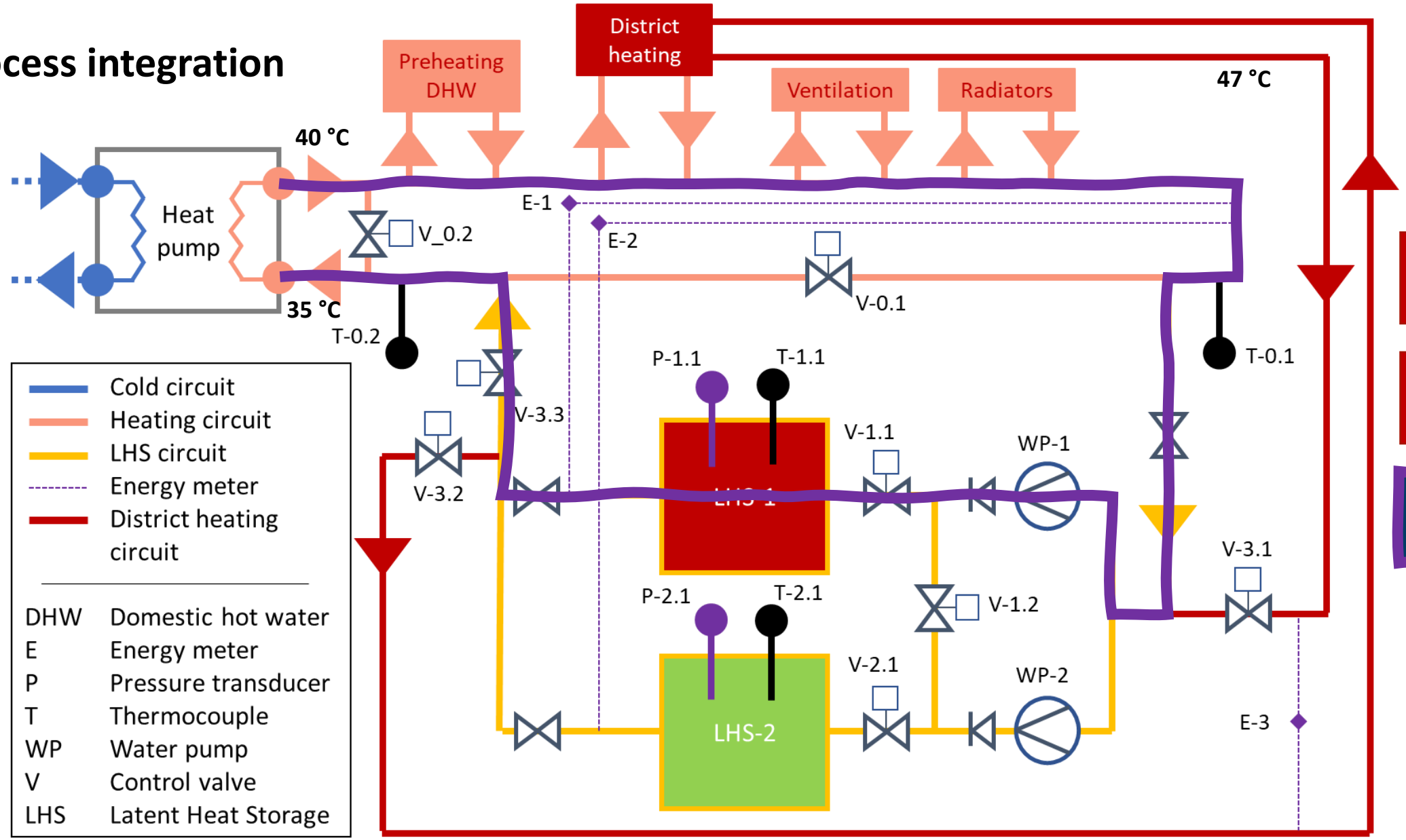
Process integration



Charge from heat pump

Charge from district heating

Discharge to heat pump

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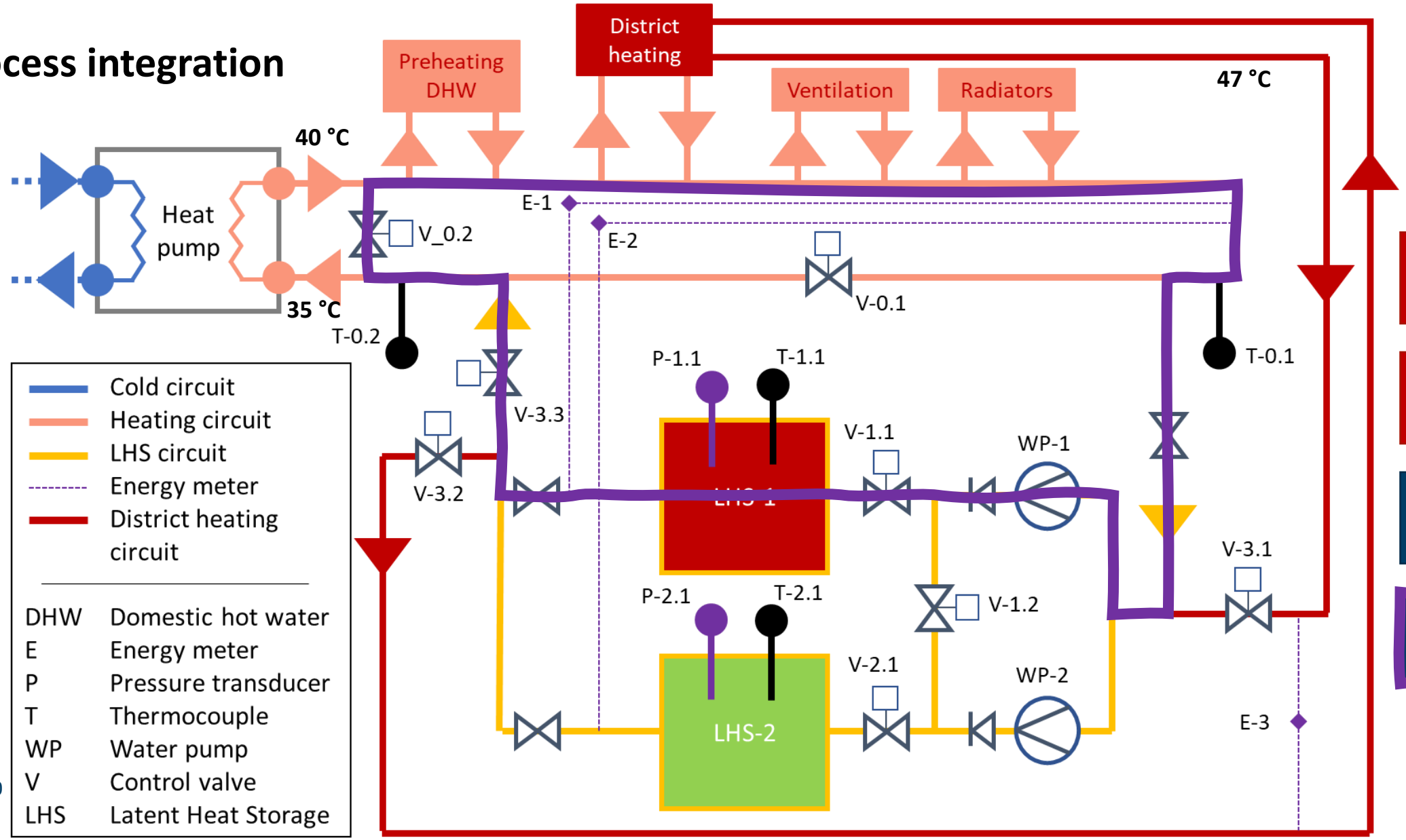
Process integration



Charge from heat pump

Charge from district heating

Discharge to heat pump

Discharge to heating circuit

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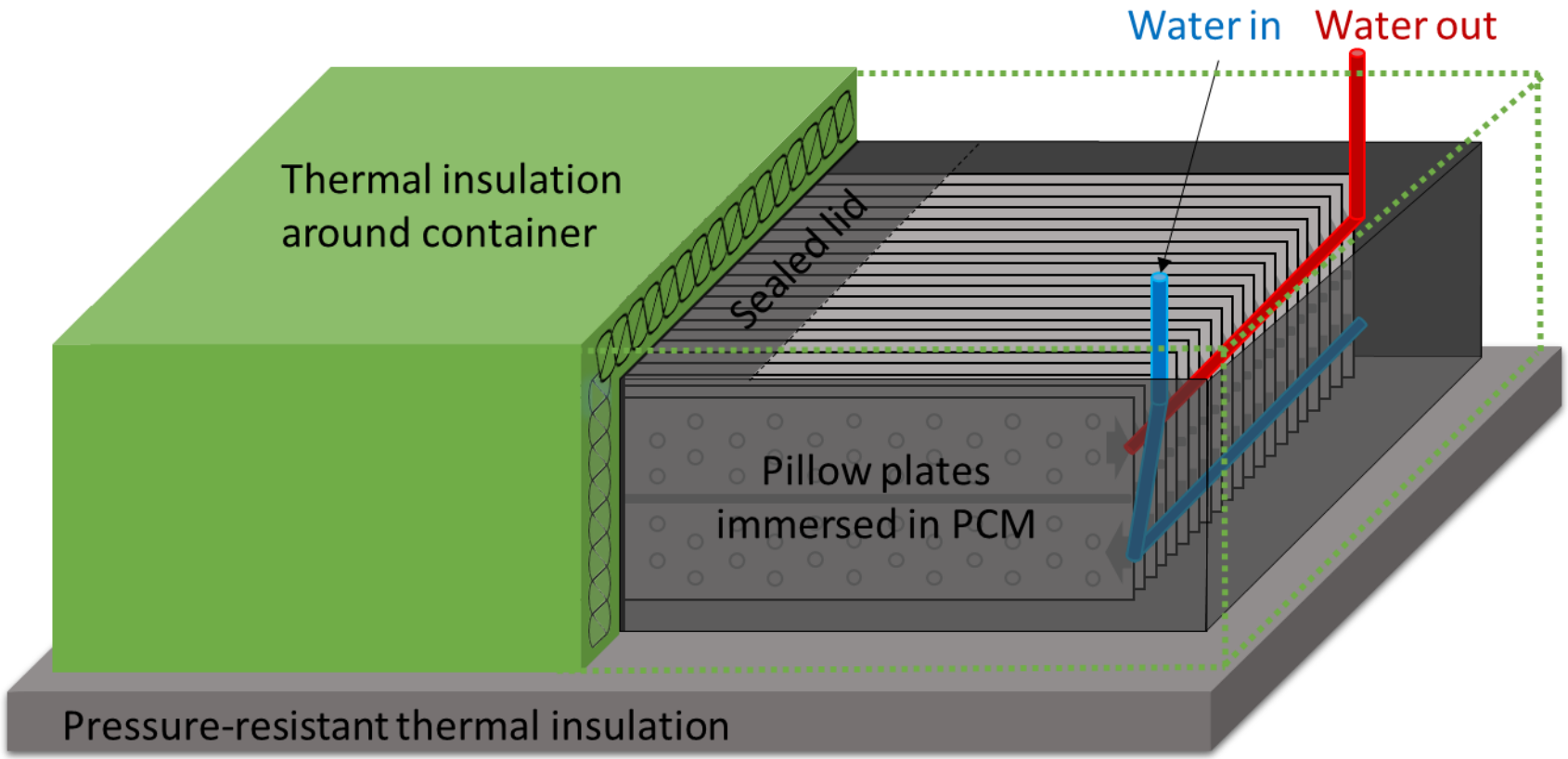
Measured PCM melting temperature range and peak [°C]	**35 – 39 (36.5)**
Measured PCM solidification temperature range and peak [°C]	33 – 35.5 (34.5)
Measured PCM latent heat of fusion and crystallisation [kJ/kg]	198.6 // 196.4
PCM density [kg/m^3]	957 (@32 °C) // 819 (@75 °C)
PCM thermal conductivity [W/(m.K)]	0.24
PCM specific heat capacity (solid // liquid) [kJ/(kg.K)]	2.3 // 1.4
PCM degradation temperature [°C]	> 50
Total theoretical heat storage capacity [from 30 to 40 °C] [kWh]	Ca. 200
Ratio of latent heat to total heat storage capacity	90 %

Latent Heat Storage unit



Height: **1.5 m**

Width: **1.4 m**

Length: **2.25 m**

4 times more compact
than hot water storage

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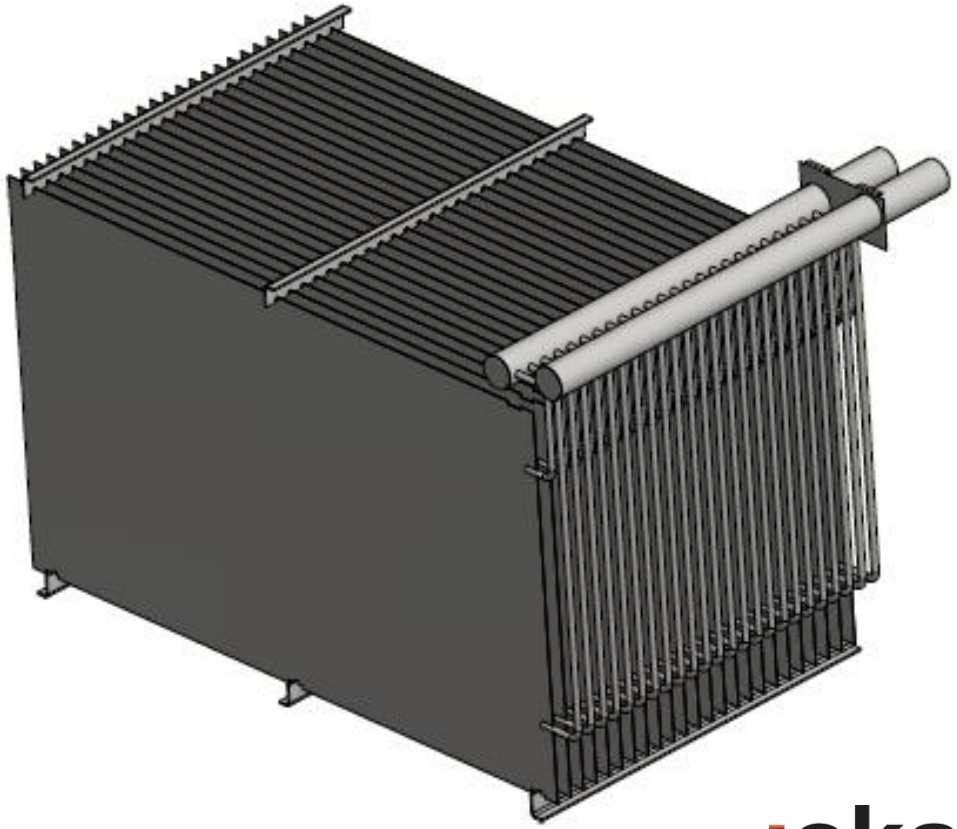
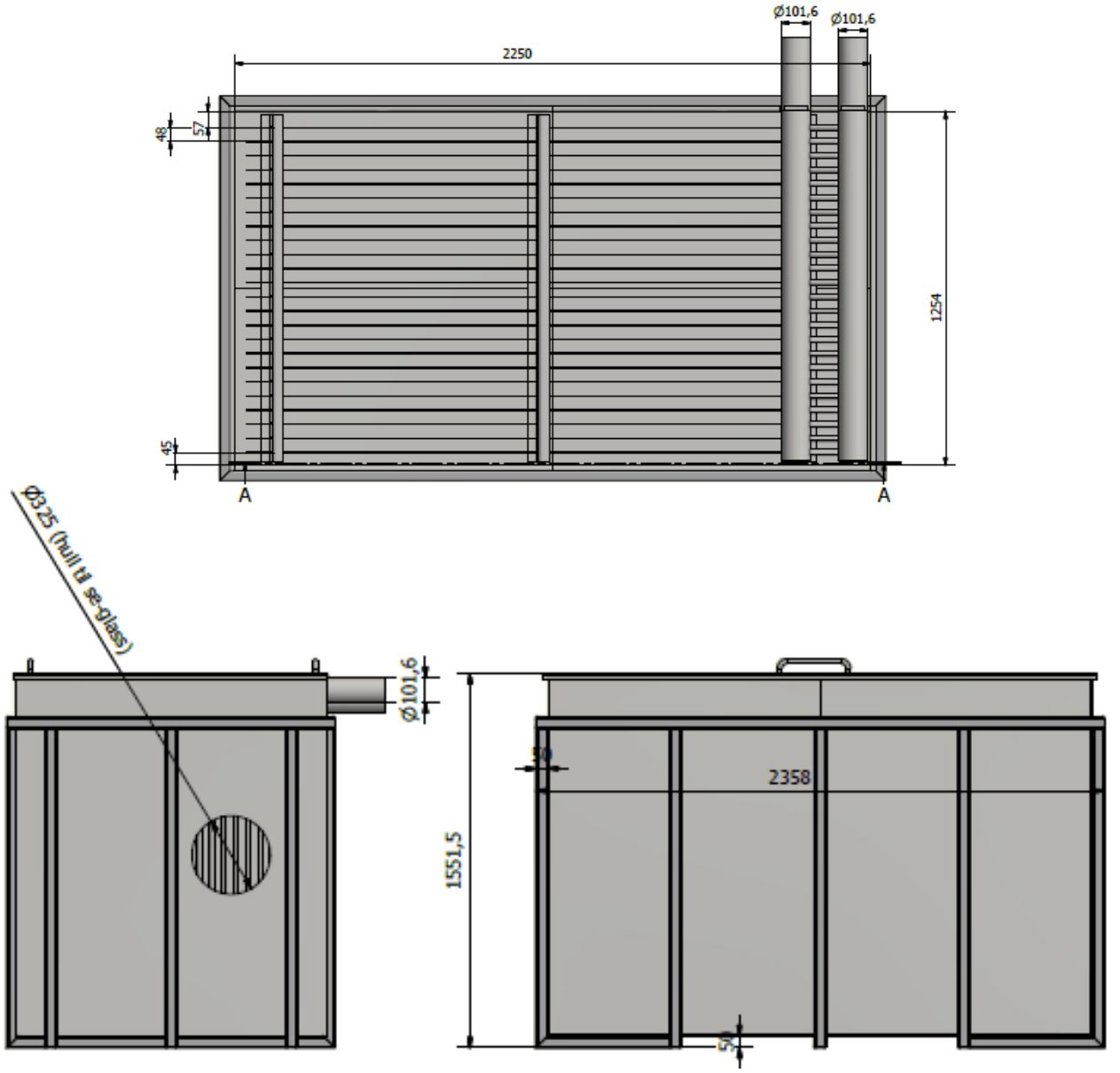
Latent Heat Storage unit
LHS1





:skala

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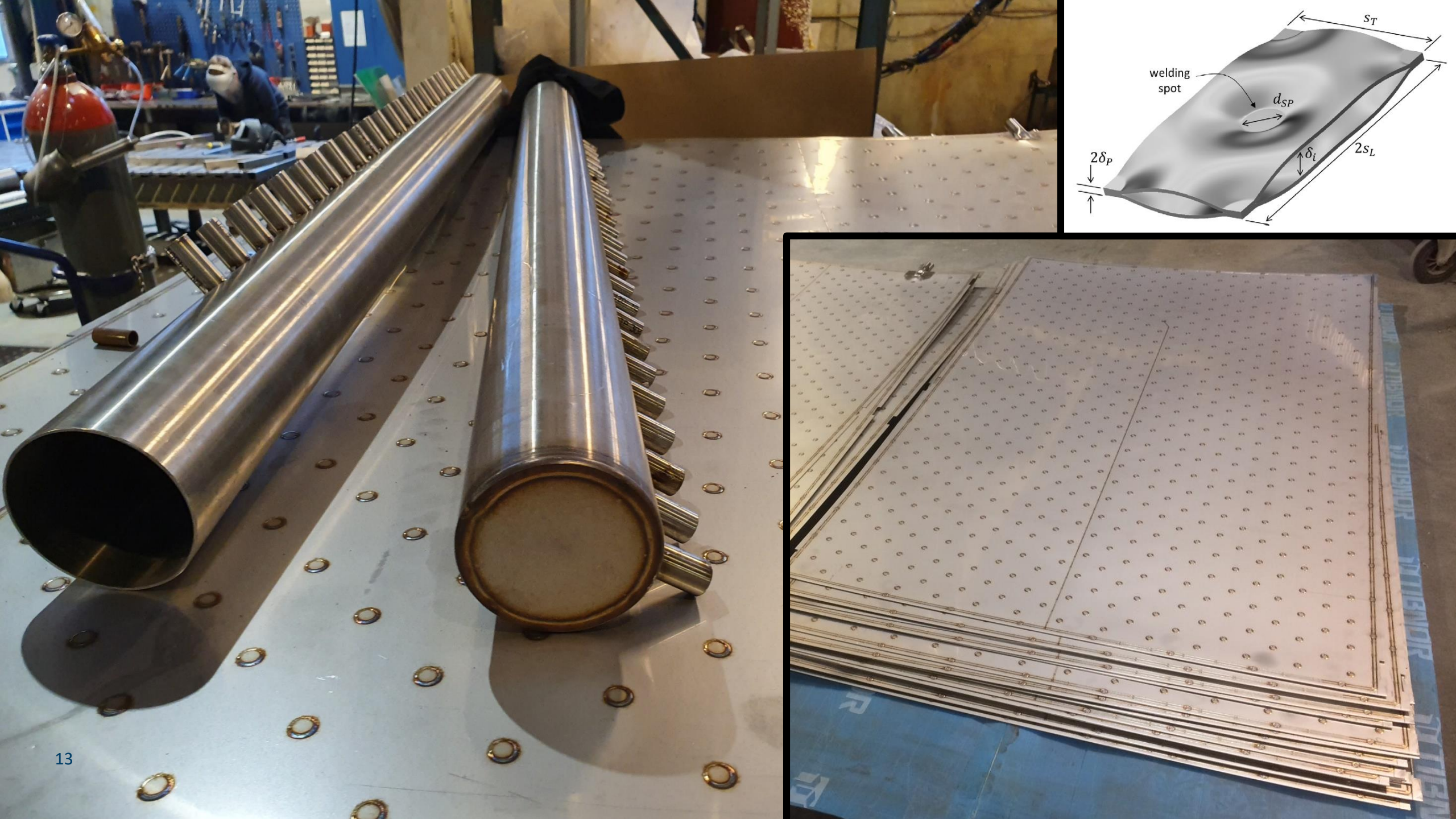
s_T
welding
spot
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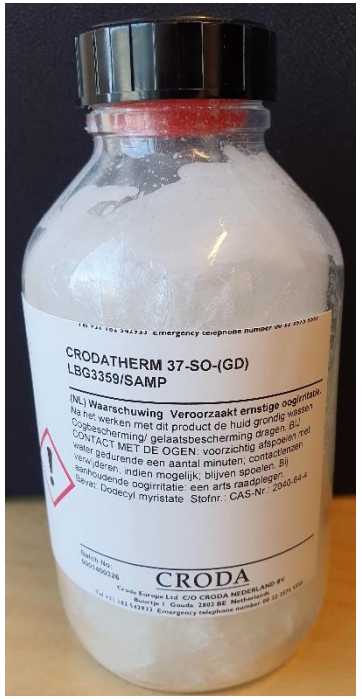
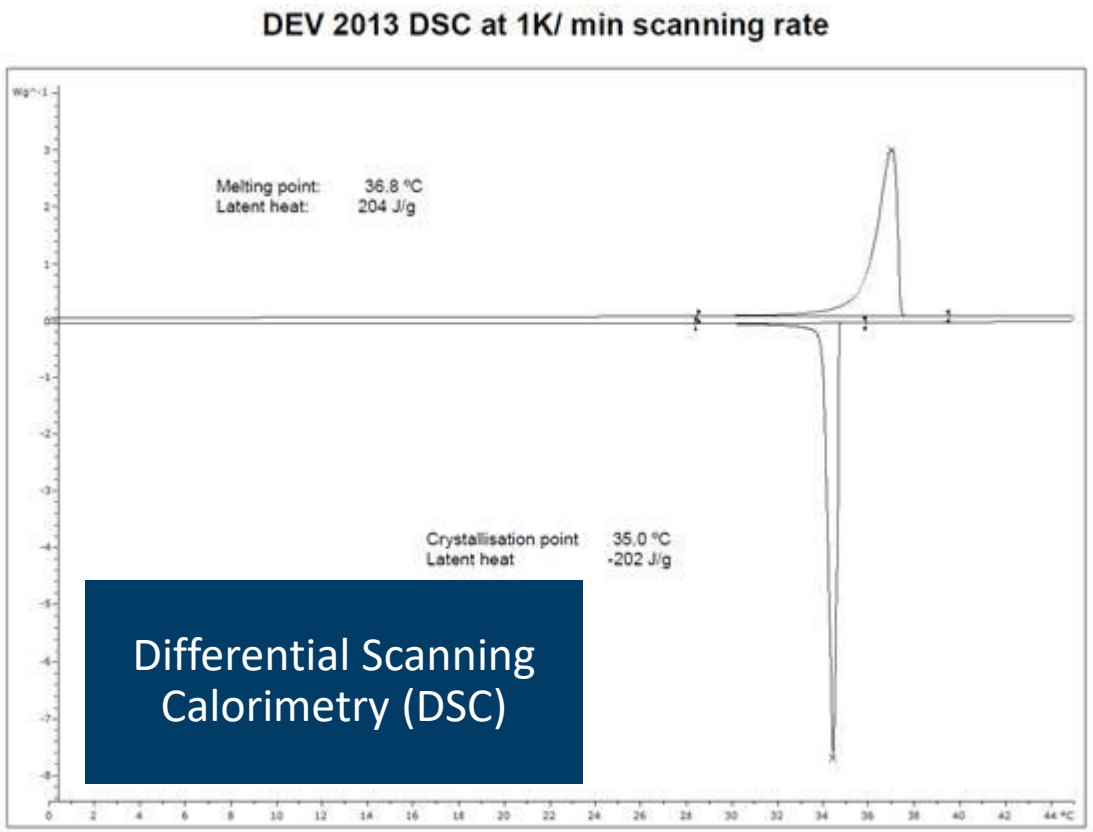
Selected PCM:

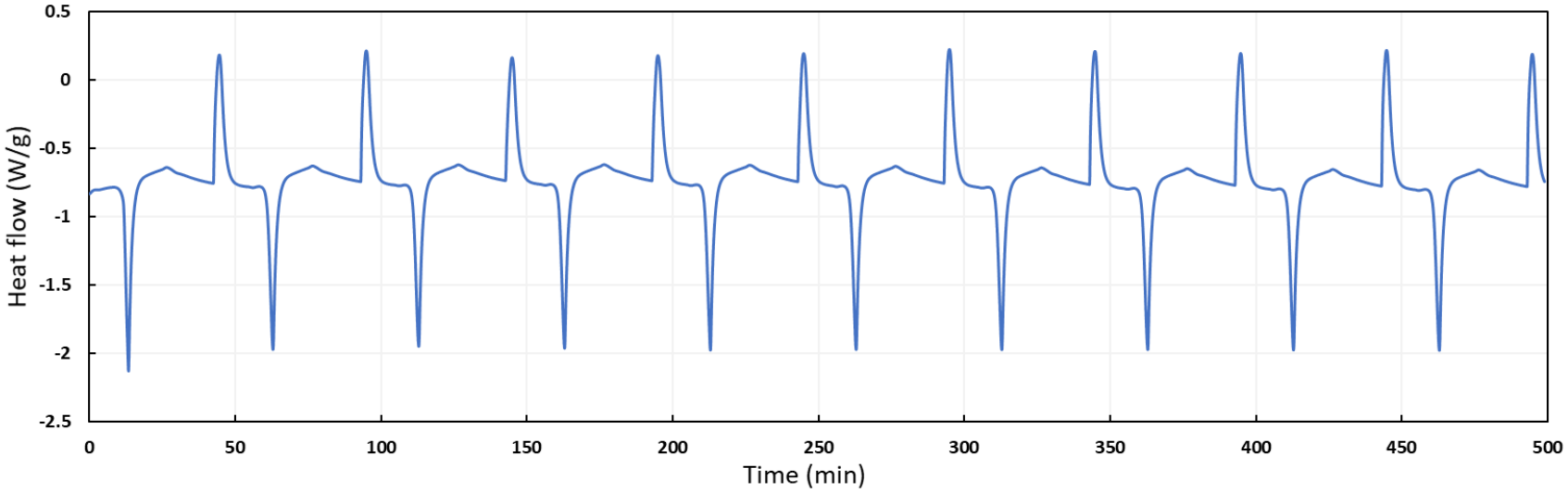
Bio-based wax - Crodatherm 37

CRODA





Differential Scanning Calorimetry (DSC)



Thermogravimetric Analysis – DSC

10 melting/solid. cycles

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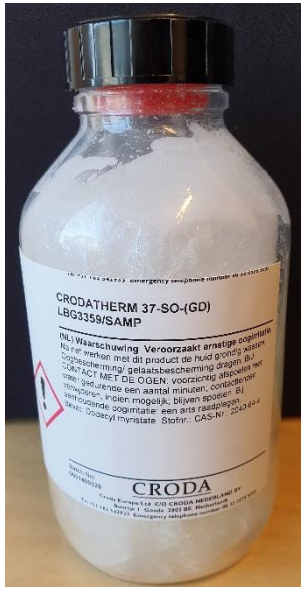
CRODA

Practical test with larger mass



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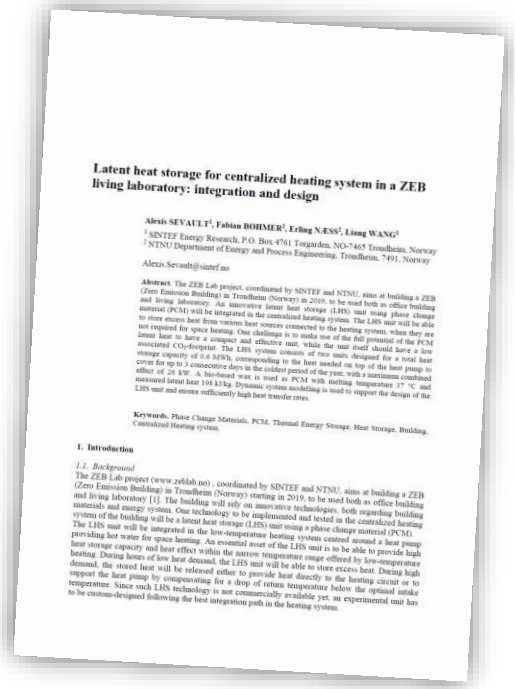
Based on plate-and-tube HX with 300 kWh heat storage capacity



Latent heat storage for centralized heating system in a ZEB living laboratory: integration and design

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Abstract. The ZEB Lab project, coordinated by SINTEF and NTNU, aims at building a ZEB (Zero Emission Building) in Trondheim (Norway) in 2019, to be used both as office building and living laboratory. An innovative latent heat storage (LHS) unit using phase change material (PCM) will be integrated in the centralized heating system. The LHS unit will be able to store excess heat from various heat sources connected to the heating system, when they are not required for space heating. One challenge is to make use of the full potential of the PCM latent heat to have a compact and effective unit, while the unit itself should have a low associated CO_2-footprint. The LHS system consists of two units designed for a total heat storage capacity of 0.6 MWh, corresponding to the heat needed on top of the heat pump to cover for up to 3 consecutive days in the coldest period of the year, with a maximum combined effect of 20 kW. A bio-based wax is used as PCM with melting temperature 25 °C and measured latent heat 198 kJ/kg. Dynamic system modelling is used to support the design of the LHS unit and ensure sufficiently high heat transfer rates.

Keywords. Phase Change Materials, PCM, Thermal Energy Storage, Heat Storage, Building, Centralized Heating system.

1. Introduction

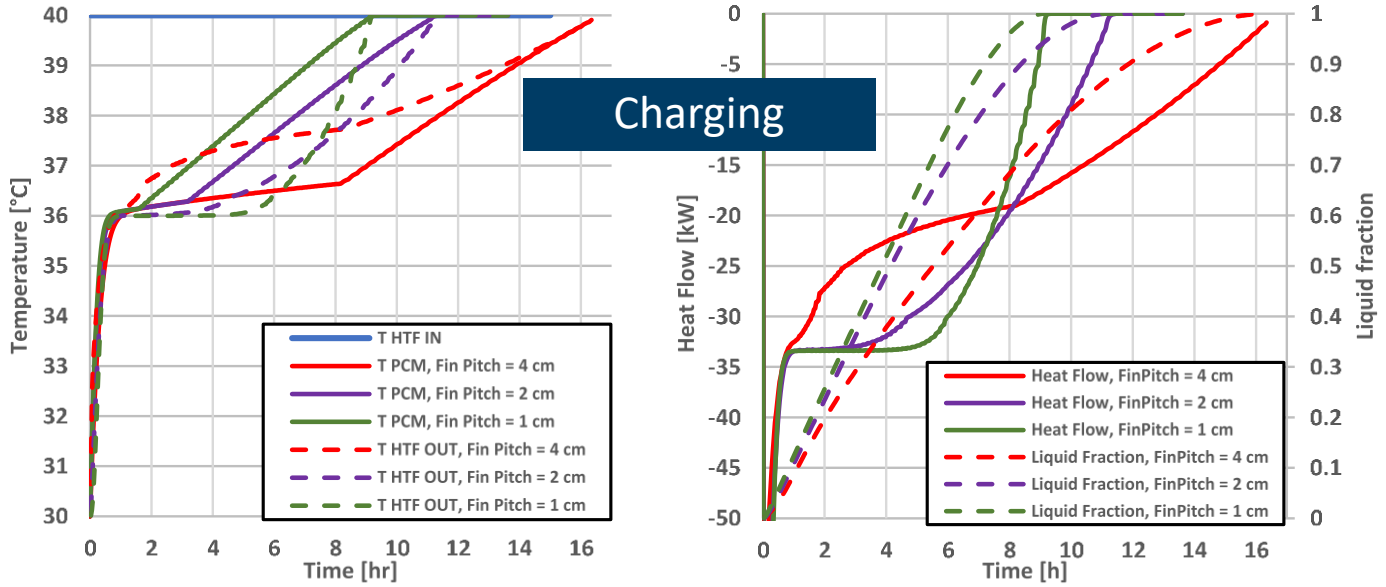
1.1. Background

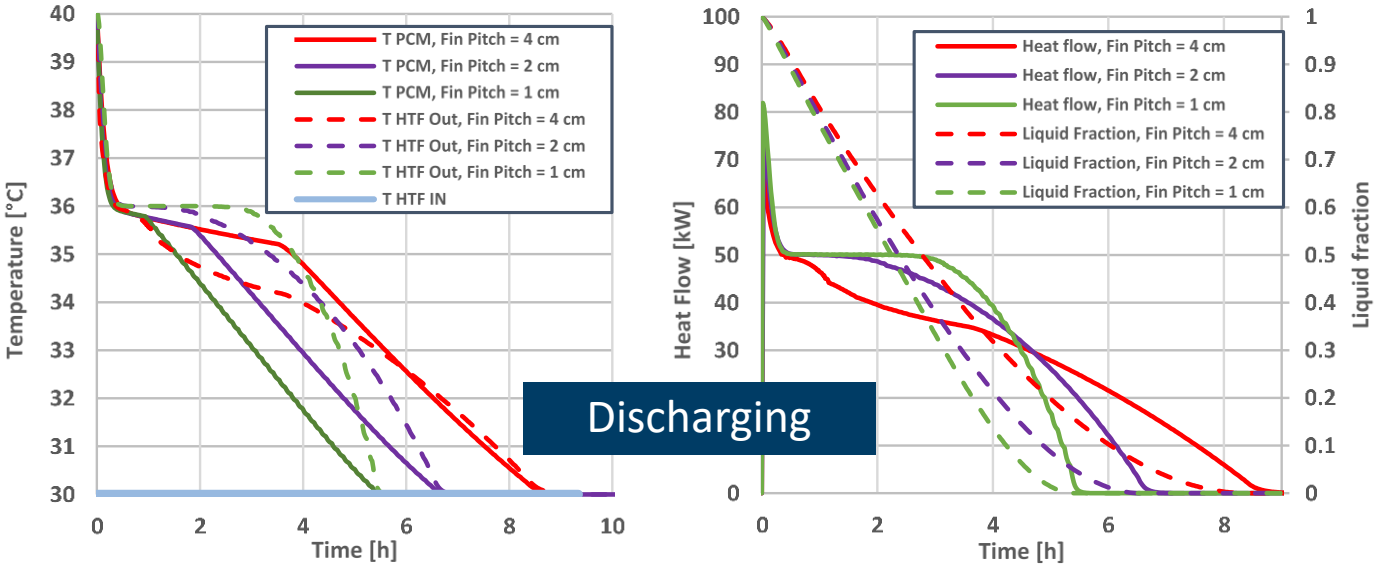
The ZEB Lab project (www.zeblab.no) , coordinated by SINTEF and NTNU, aims at building a ZEB (Zero Emission Building) in Trondheim (Norway) starting in 2019, to be used both as office building and living laboratory [1]. The building will rely on innovative technologies, both regarding building materials and energy systems. One technology to be implemented and tested in the centralized heating system of the building will be a latent heat storage (LHS) unit using a phase change material (PCM). The LHS unit will be integrated in the low-temperature heating system centred around a heat pump providing hot water for space heating. An essential asset of the LHS unit is to be able to provide high heat storage capacity and heat effect within the narrow temperature range offered by low-temperature heating. During hours of low heat demand, the LHS unit will be able to store excess heat. During high demand, the stored heat will be released either to provide heat directly to the heating circuit or to support the heat pump by compensating for a drop of return temperature below the optimal intake temperature. Since such LHS technology is not commercially available yet, an experimental unit has to be custom-designed following the best integration path in the heating system.

Ref: *Sevault A., et al.; Latent heat storage for centralized heating system in a ZEB living laboratory: integration and design, in press, Proc. of Nordic ZEB+ Conference, Norway, 2019*

Influence of fin pitch with constant mass flow rate of water of 2 kg/s

- Left: Temperature of HTF at inlet and outlet and average PCM temperature
- Right: PCM liquid fraction and heat flow from PCM to HTF





HTF = Heat transfer fluid

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Conclusions

- Ideal case for heat storage using PCM
- Peak shaving using 4 operation modus
- LHS unit is in construction and PCM is delivered
- Modelling of heat transfer rates matches heat demand profiles
- Installation of LHS unit and first tests planned in Spring 2020

PCM = Phase Change Materials *LHS = Latent Heat Storage*

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Thank you for your attention!

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