In-situ monitoring of a groundwater heat pump for a low-temperature district heating network: energy performance, issues and challenges

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Outline

- Context
- Description of the case study
- Monitoring results
- Recommendations
- Conclusion

Context

2017 (Europe)

12% of heat supplied by district heating networks

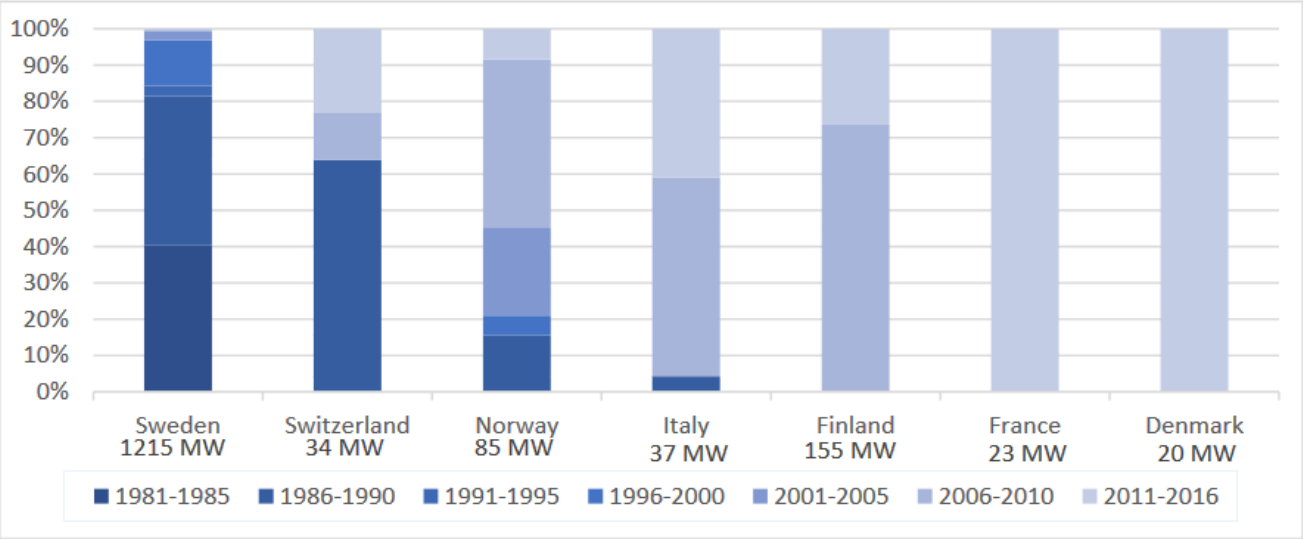


Figure 1. Establishment years and capacities of heat pumps in seven countries with the greatest capacities installed and currently operating.

Source: David et al., 2017 (doi 10.3390/en10040578)

Large-scale HPs ≈ 1.6 GW_{th}

x 25

Prospective scenario in 2050 (Europe)

50% of heat supplied by district heating networks

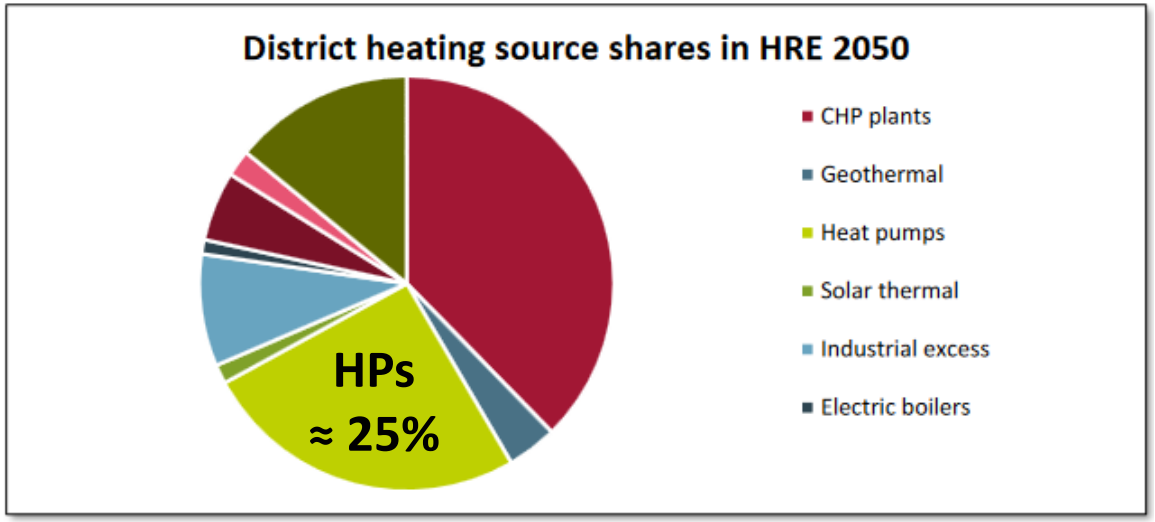


Figure 15. District heating source shares in HRE 2050 combined for all the 14 countries

Source: Paardekooper et al. 2018

Large-scale HPs ≈ 40 GW_{th}

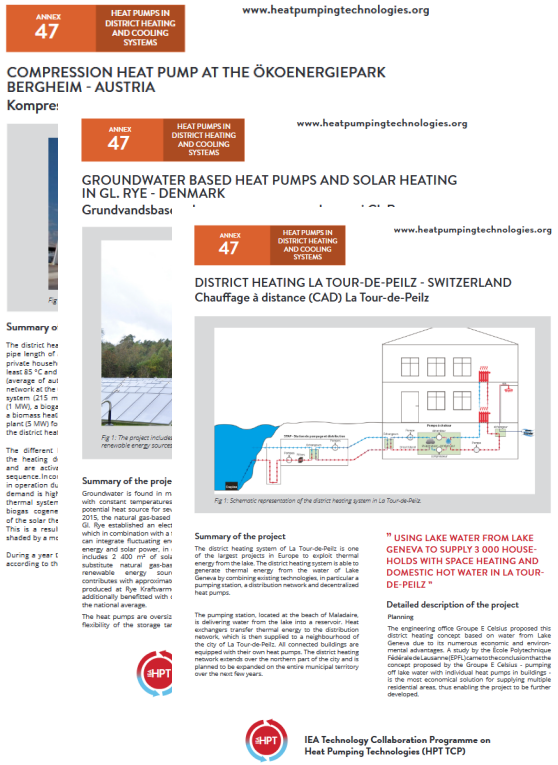
Context

- **Barriers** to the implementation of heat pumps (HPs) in district heating (DH) networks:
  - **Lack of knowledge** compared to other technologies
  - **Investment cost**

→ Overcome the barriers by **sharing knowledge** on existing projects

- IEA HPT Annex 47:
  - 44 case studies
  - **challenges/issues not always provided**

→ Share results and lessons learned from **detailed monitoring of a large-scale HP**


ANNEX 47 HEAT PUMPS IN DISTRICT HEATING AND COOLING SYSTEMS

www.heatpumpingtechnologies.org

COMPRESSION HEAT PUMP AT THE ÖKOENERGIEPARK BERGHEIM - AUSTRIA

ANNEX 47 HEAT PUMPS IN DISTRICT HEATING AND COOLING SYSTEMS

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GROUNDWATER BASED HEAT PUMPS AND SOLAR HEATING IN GL. RYE - DENMARK

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DISTRICT HEATING LA TOUR-DE-PEILZ - SWITZERLAND
Chauffage à distance (CAD) La Tour-de-Peilz

Summary of the project

" USING LAKE WATER FROM LAKE GENEVA TO SUPPLY 3 000 HOUSEHOLDS WITH SPACE HEATING AND DOMESTIC HOT WATER IN LA TOUR-DE-PEILZ "

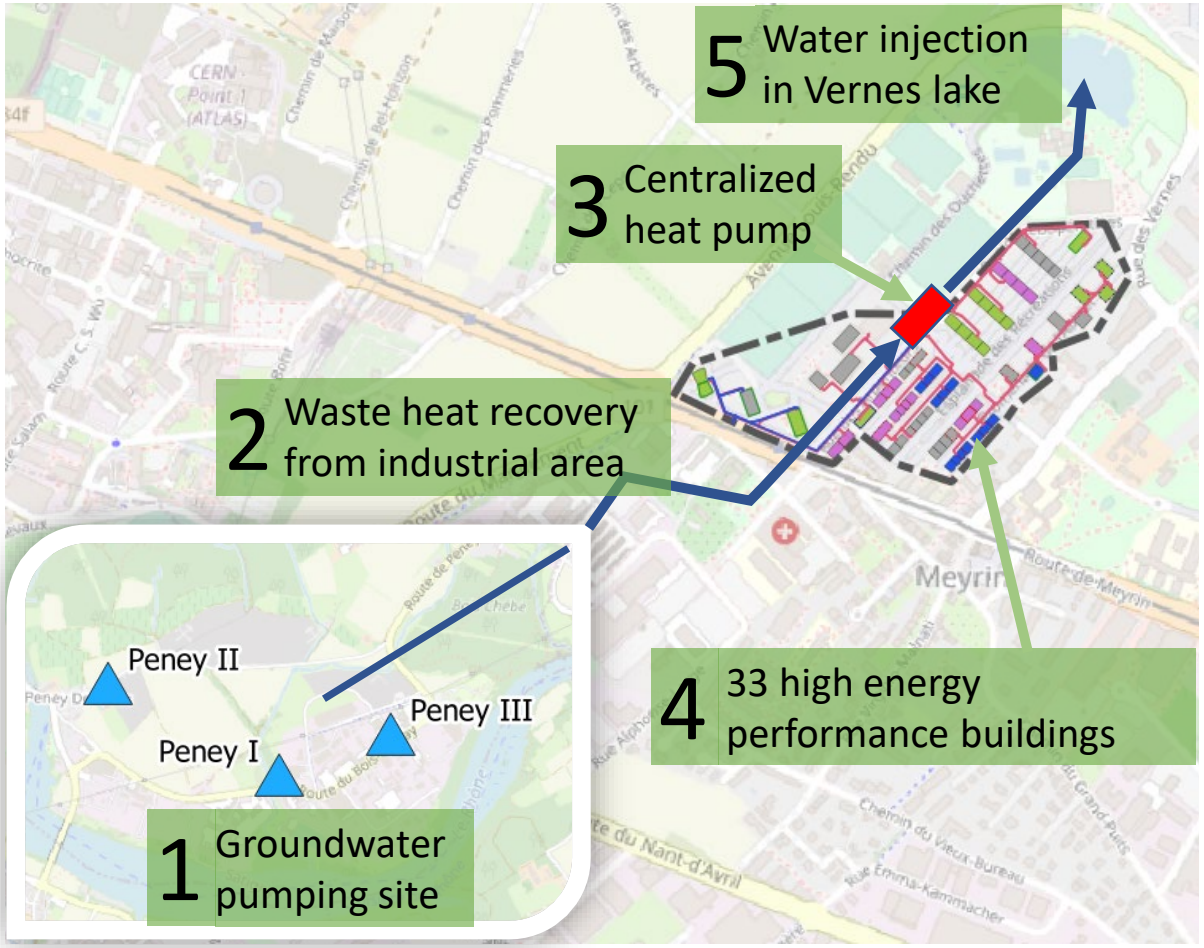
Detailed description of the project

IEA Technology Collaboration Programme on Heat Pumping Technologies (HPT TCP)

Source: Geyer et al. 2019. « IEA HPT Annex 47 Heat Pumps in District Heating and Cooling Systems.».

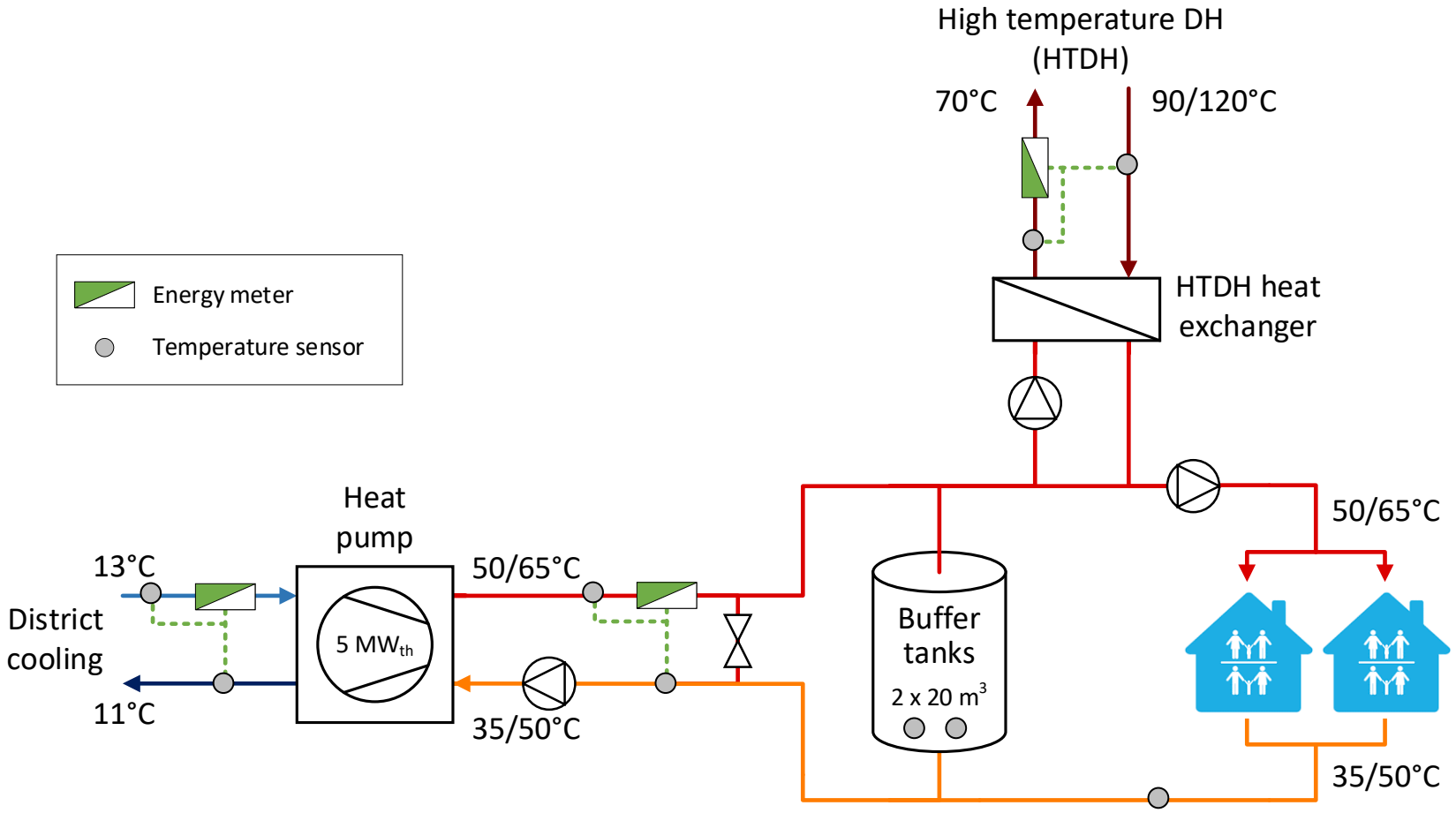
Case study

- Eco-district in the canton of **Geneva**, Switzerland
- 33 **high energy performance buildings** (≈170’000 m², 1’350 dwellings)
- Low temperature **district heating network** supplied by a **centralized groundwater HP** (5 MW_{th})

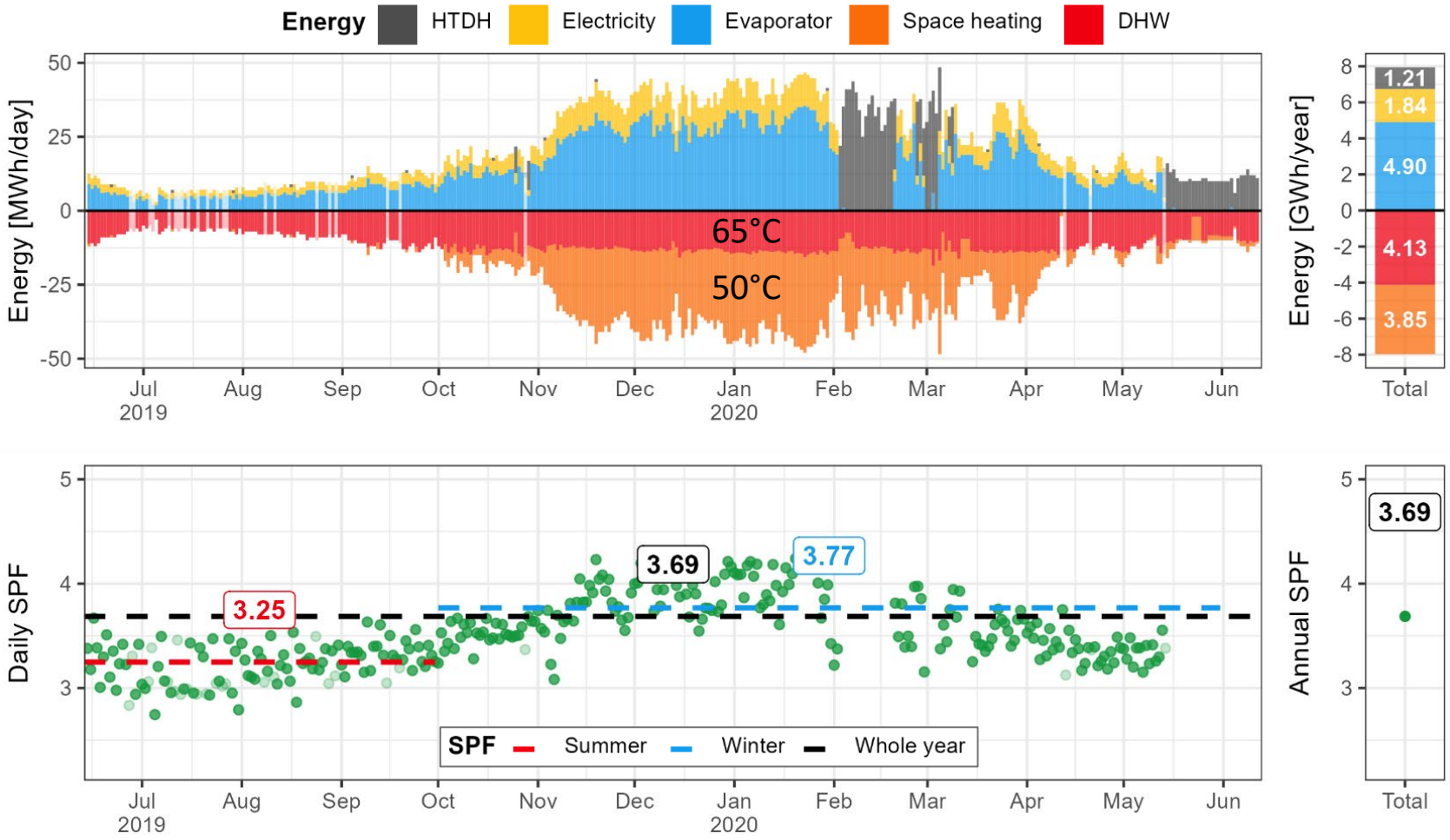


Case study

- **Centralized HP:** 5 MW_{th}
- **Buffer tanks:** 2 x 20 m^3
- **Supply temperature:**
  - SH mode: 50°C
  - DHW mode: 65°C (2 x 2h/day)
- **Back up** with high temperature DH (natural gas + waste heat)
  → objective: HP coverage > 80%

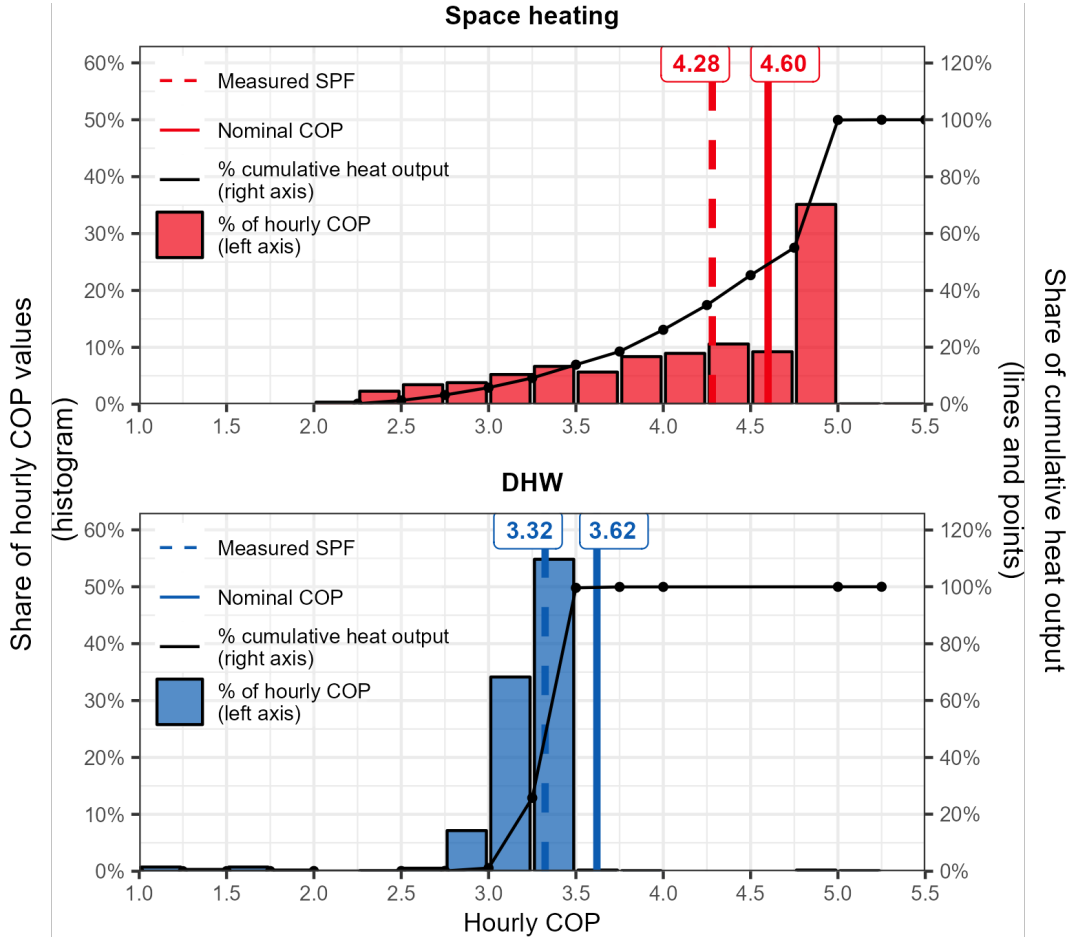


Energy balance and efficiency



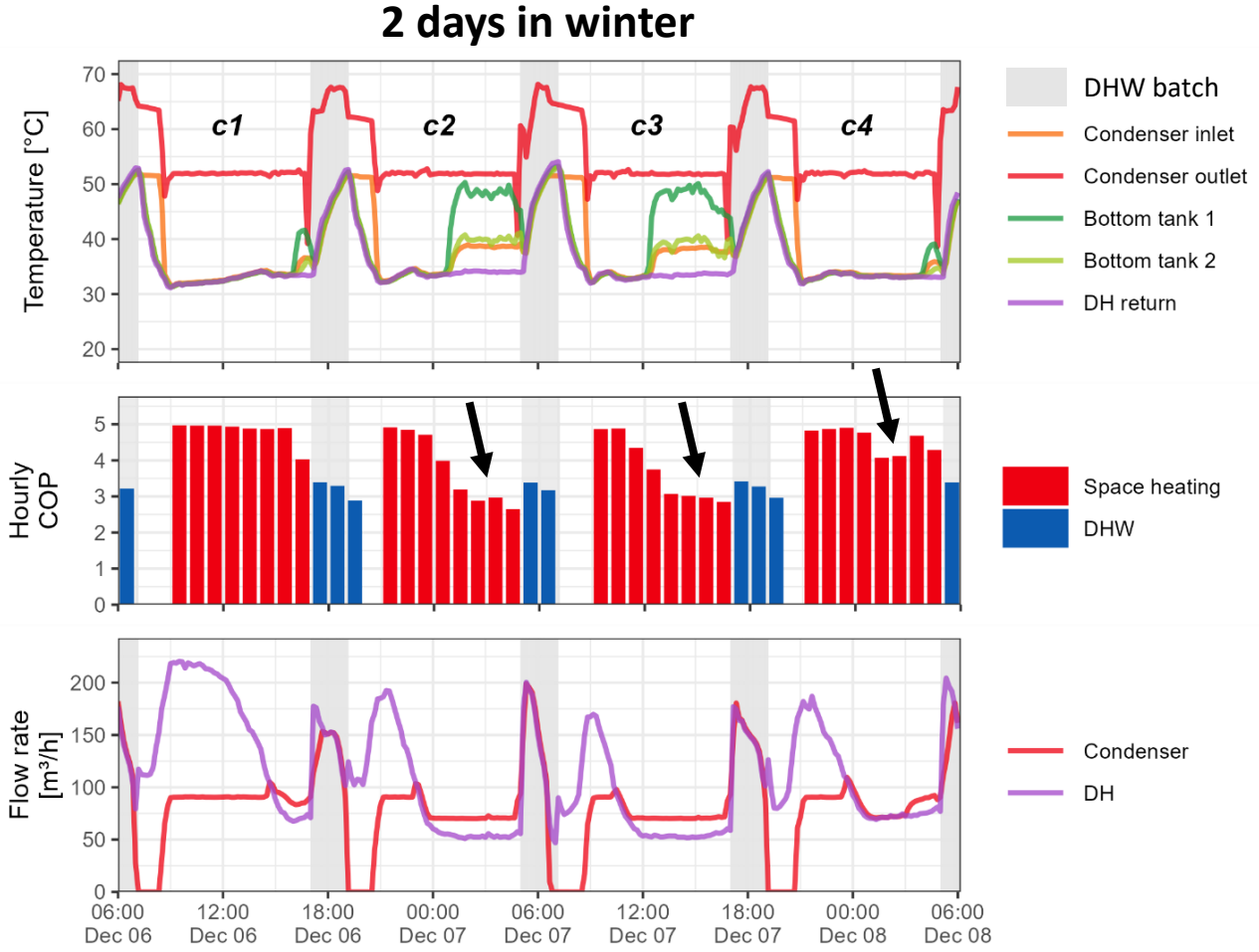
- **Total heat production:**
  - ≈ 8 GWh/year
  - 85% supplied by the HP
- **Space heating / DHW:**
  - 48% space heating (at 50°C)
  - 52% DHW (at 55-65°C)
- **Annual SPF:** 3.69

Efficiency comparison



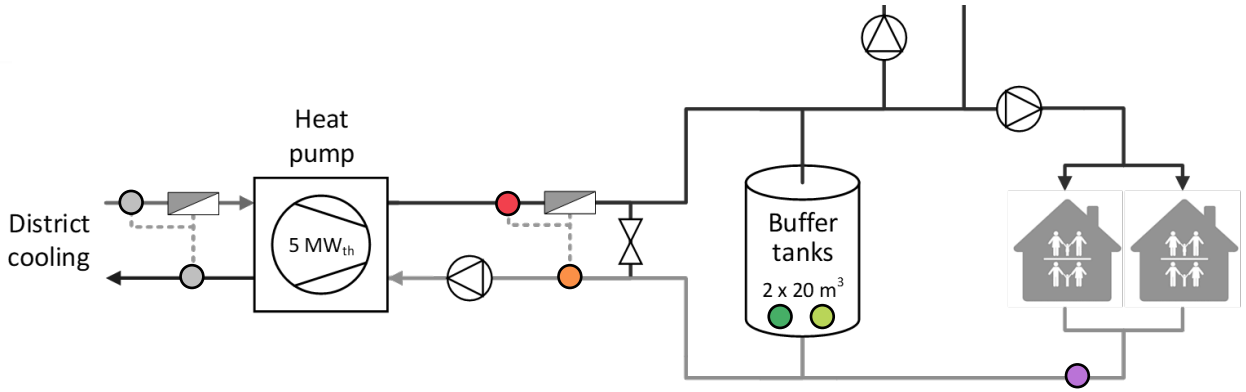
- **Space heating mode:**
  - Significant discrepancy
  - ≈ ½ of production with COP > nominal COP
  - ≈ ¼ of production with COP < 4.0
  - Overall: SPF = 4.28 (-7% compared to nominal COP)
- **DHW mode:**
  - Stable
  - Never reaches nominal COP
  - ≈ ¾ of production with COP between 3.25 and 3.5
  - Overall: SPF = 3.32 (-8% compared to nominal COP)

Typical days

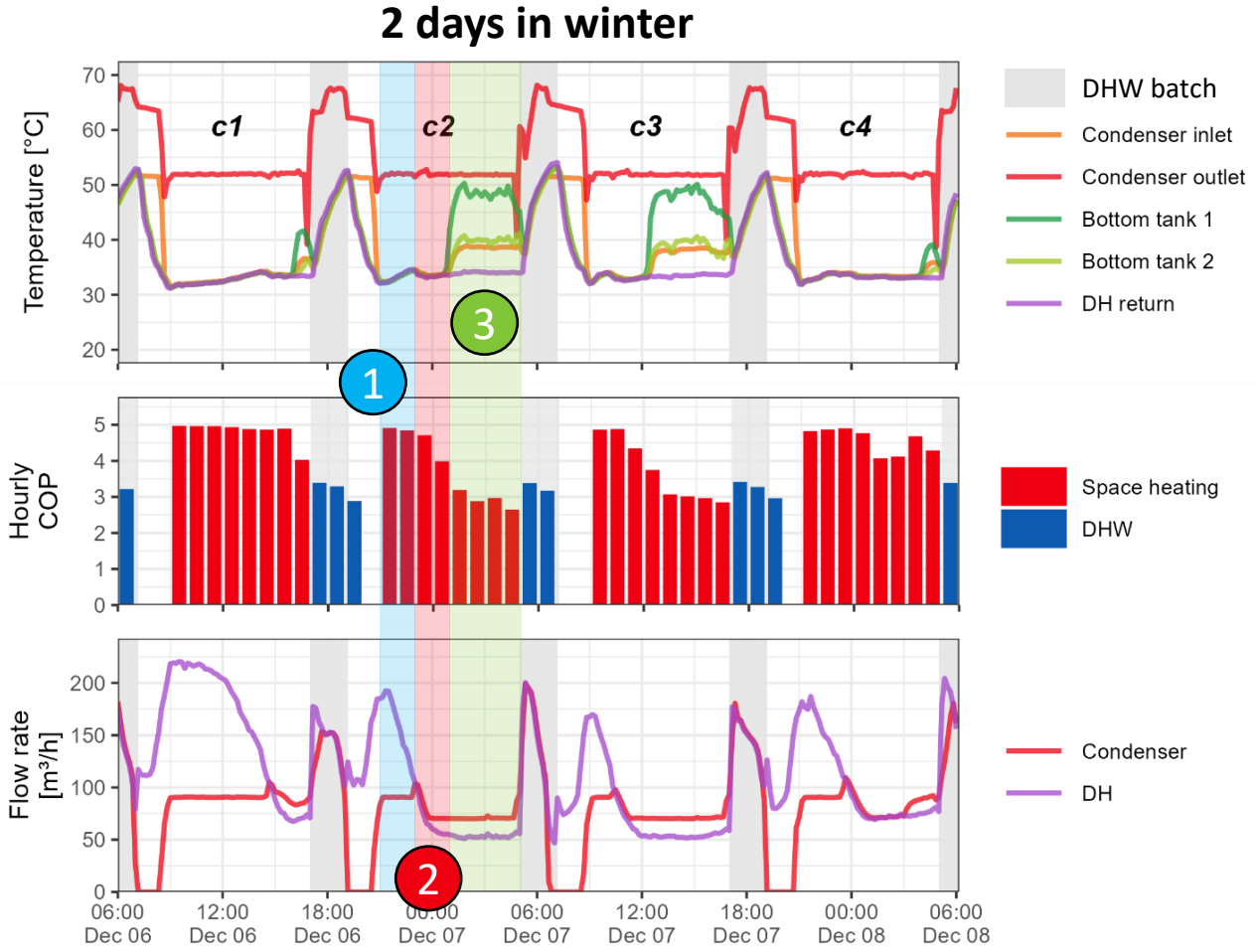


- Low COP in space heating before DHW batches
- **Causes:**
  - Decrease in **condenser flow rate**
  - Increase of temperature at **bottom of storage** (35°C → 50°C)

- **HP capacity is too high** compared to district load and storage volume!



Typical days



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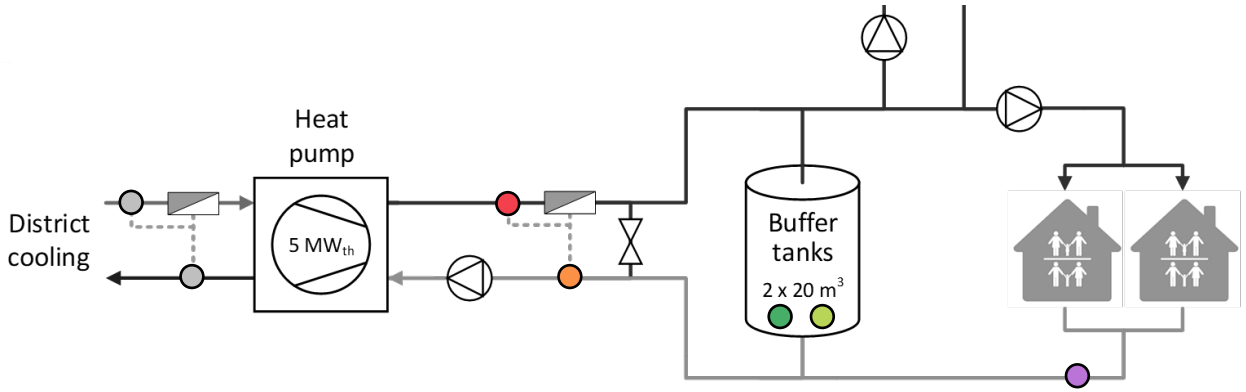
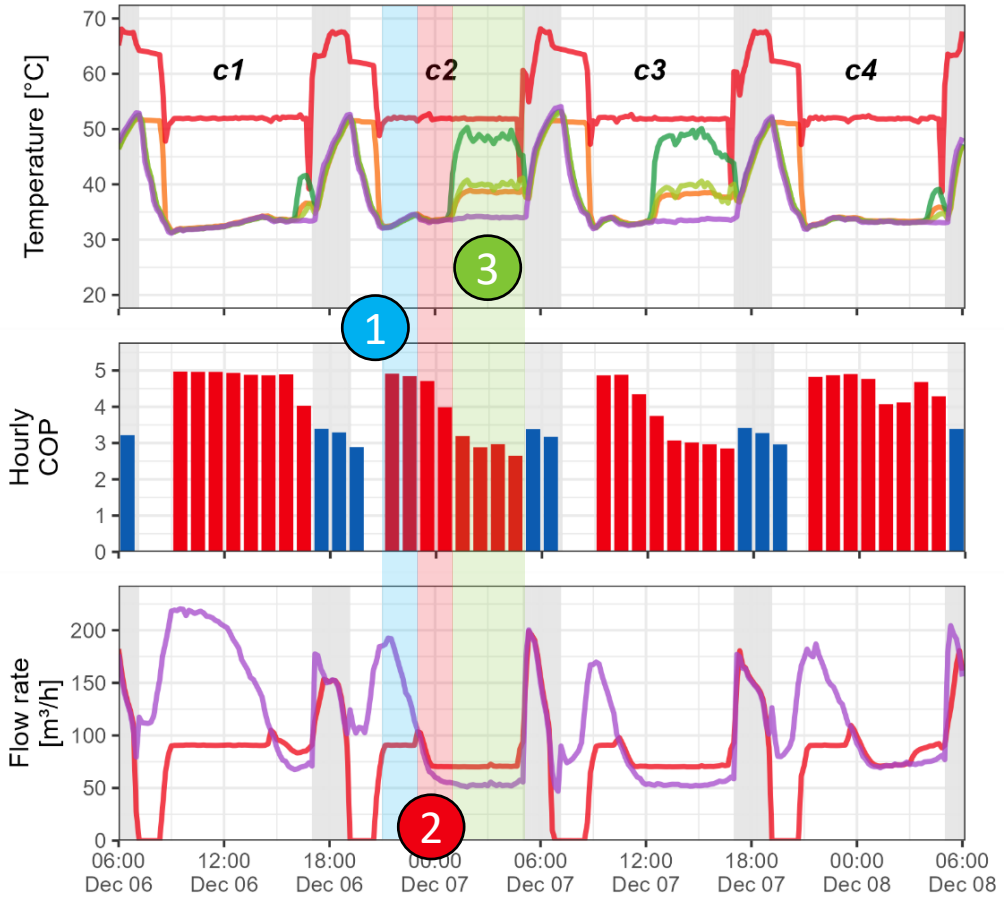
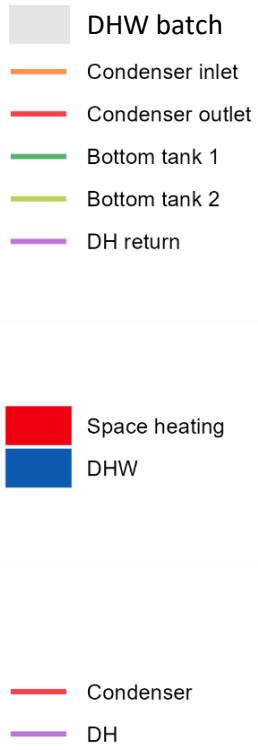


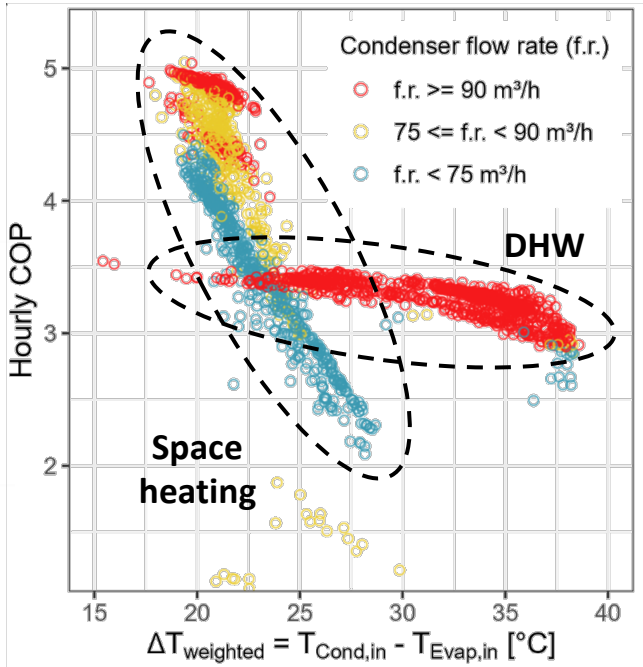
Typical days

2 days in winter

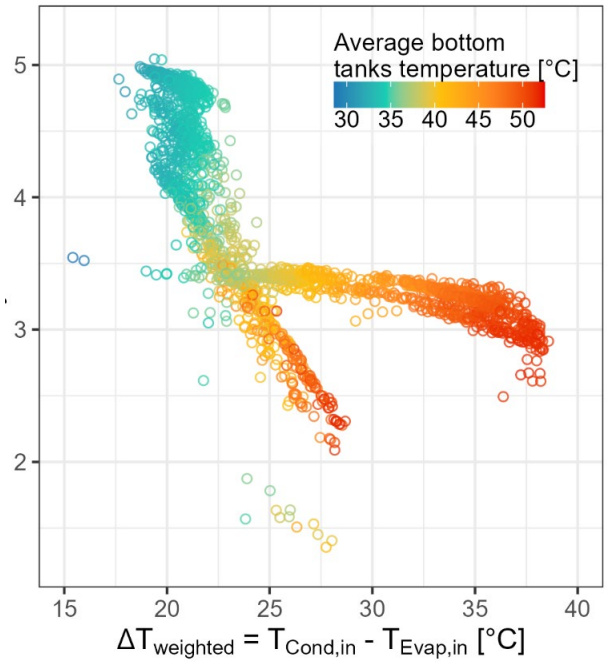




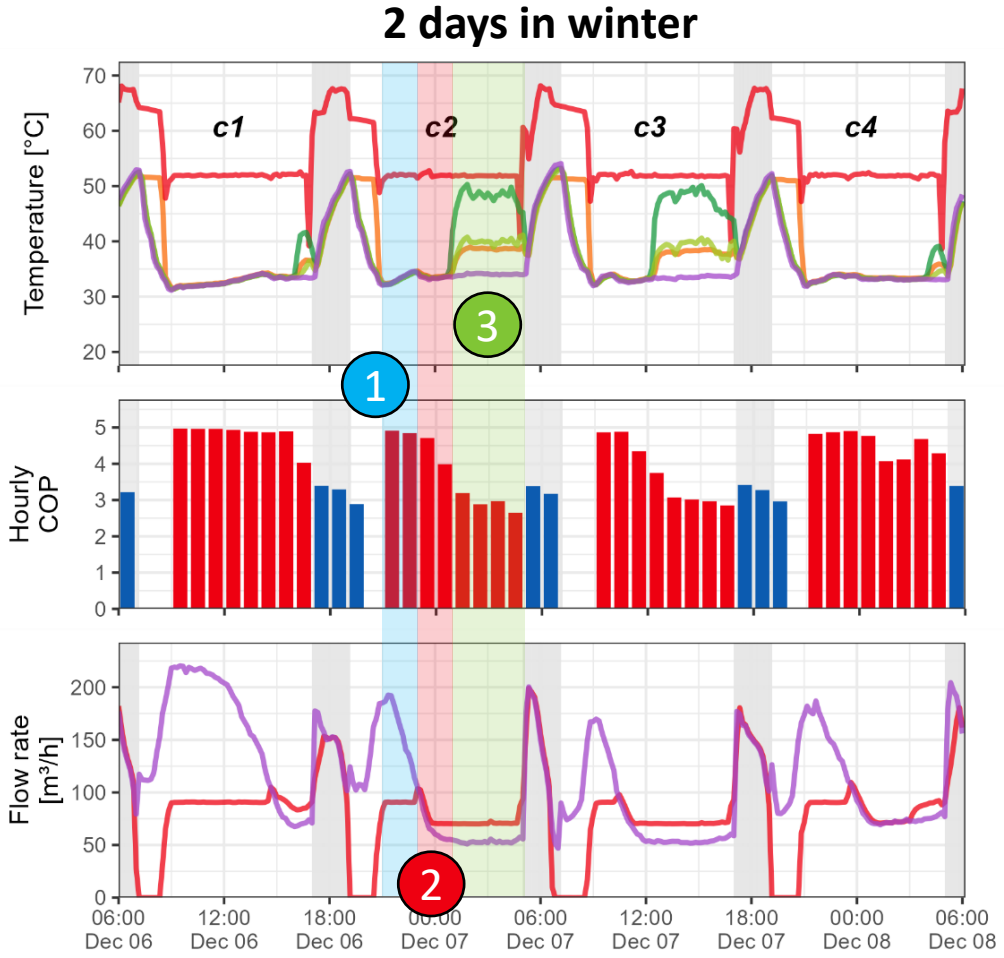
Influence of condenser flow rate

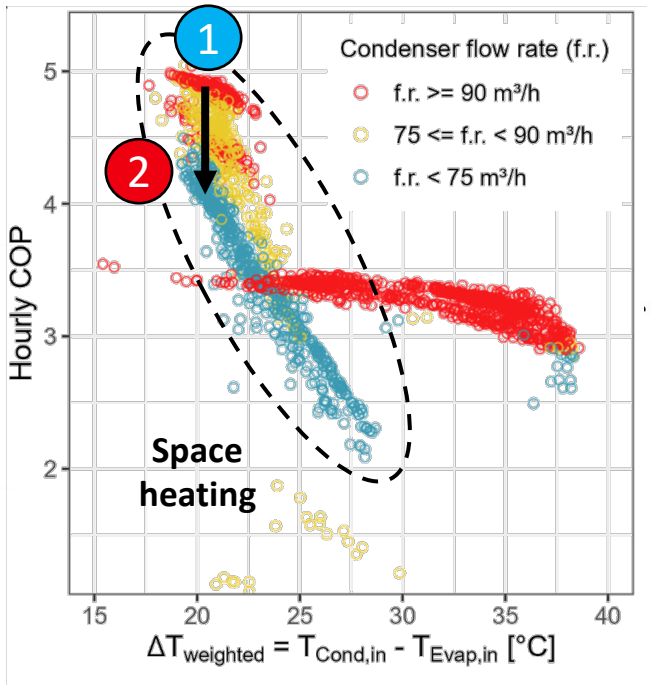


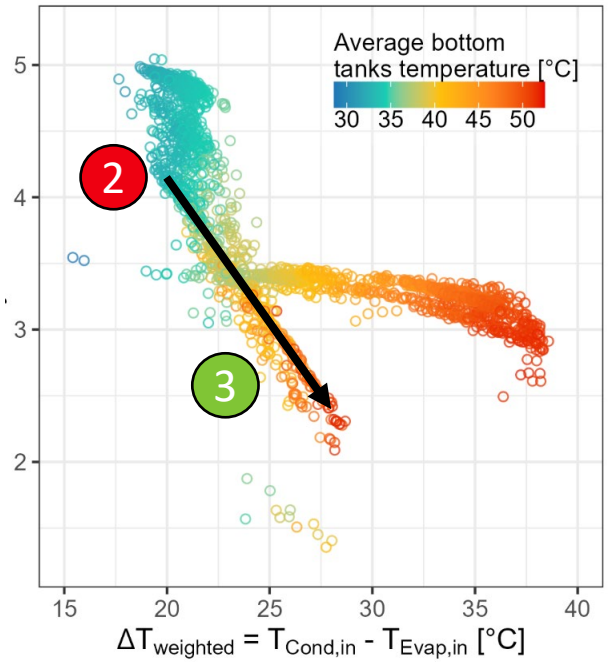
Influence of tank temperature



Typical days







Recommendations

- **Control logic:**

Adapt the DH supply temperature to the outdoor air temperature	**Stop the HP sooner** and operate on the DH inertia to avoid overheating the buffer tanks	**Optimize DH substations** to prevent high return temperatures

- **Sizing and system concept:**

Use several smaller HP instead of one high-capacity HP for more flexibility	**Install bigger volumes of thermal storage** compared to the minimum HP capacity	**Explore other strategies for DHW preparation** than DHW batches + storage

Conclusion

- **Detailed analysis of a large-scale heat pump** supplying a low temperature district heating network (LTDH)

- **Annual SPF = 3.69** (pumping excluded), close to expected **but could be optimized**

- Low energy performance due to:
  - **High capacity** of heat pump
  - **High return temperature** from district heating substations, **mainly in DHW mode**

Massive development of heat pumps for district heating networks
➔ **Important to optimize heat pumps, to explore and share results of alternative solutions to this concept**

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Ville de Meyrin

Bibliography

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