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#SESAAU2021

Performance measurement and detailed modelling of an existing neutral-temperature DH network based on decentralized HPs

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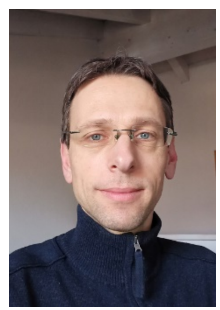

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Neutral-temperature DH

Neutral-temperature means close to ambient T (order of 15-25 °C)

These networks include decentralized heat pumps (HPs) at user substations

Main benefits:

- Easy access to low-T sources, e.g., urban waste heat (WH)
- In case of reversible HPs, users can become prosumers and the network can also provide cooling

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LIFE4HeatRecovery project

PROJECT LOCATION: Italy, Germany, Netherlands, Denmark

BUDGET: about 5.6 M€, EU funding rate 60 %

DURATION: June 2018 – June 2023

COORDINATING BENEFICIARY: Eurac Research (coordinator: Roberto Fedrizzi)

LIFE4HeatRecovery *demonstrates* the recovery of urban *WH available at low-T* (< 40 °C) in DH networks operated either at *conventional T or neutral T*. This is done by means of *HPs* used at heat recovery and/or heat utilization sides, with a focus on *prefabricated* solutions.

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The Ospitaletto demo case

Ospitaletto demo case, located in Italy

Neutral-T DH managed by the company **Cogeme**

Heat recovery from **steel mill** (cooling towers), including local reuse of heat (SH and SHW)

→ *Bidirectional* heat flow

In order to carry out a full analysis, the entire network is included in monitoring and modelling

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The network

LIFE 4 HEAT RECOVERY

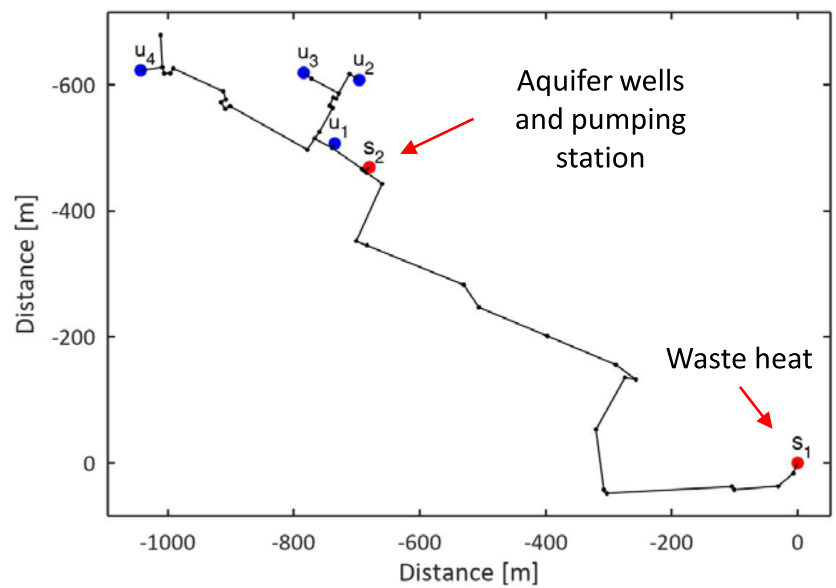
Two sources:

- Source s_1 , cooling towers @ 25 °C (priority)
- Source s_2 , aquifer wells @ 15 °C

Four users, u_1 , … , u_4 , mainly schools

Length of about 2 km

Mix of pre-insulated (steel+PUR) and non-insulated (HDPE) pipes



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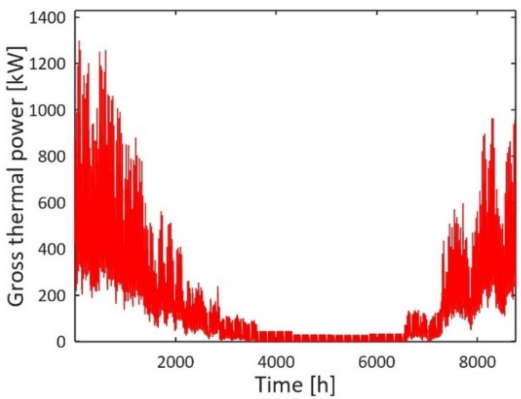
Monitoring

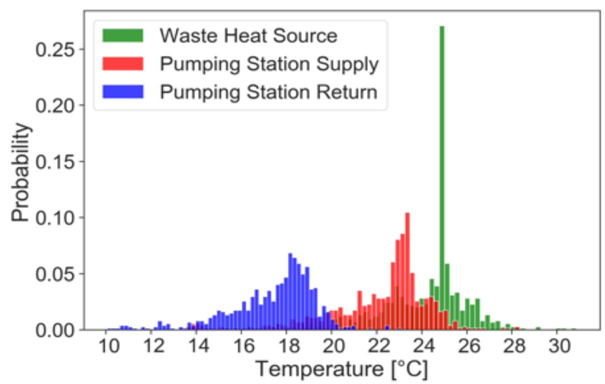
Load profile and supply temperatures

LIFE 4 HEAT RECOVERY

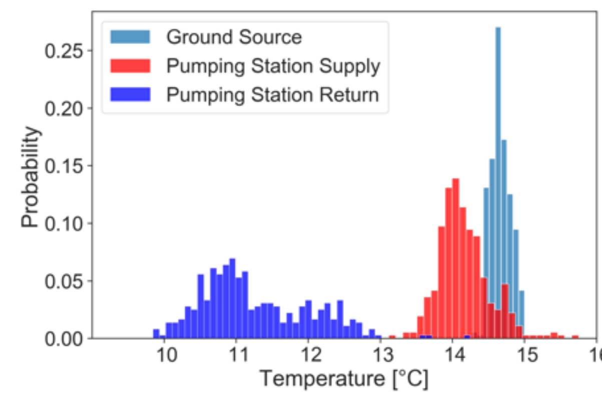
2019



WH source (s1)



Aquifer wells (s2)



Monitoring

2019 yearly data

Quantity	Unit	Measured value
Heat, HP condenser	MWh/y	1558
Heat, HP evaporator	MWh/y	1129
Electricity, HP	MWh/y	434
Electricity, pumping	MWh/y	65
SCOP	arb.u.	3.62
SPF	arb.u.	3.11

Thermal losses, mainly due to non-insulated pipes, are estimated to be about 30 % (partial monitoring available)

Model

Developed in Octave/Matlab

- Network geometry as a graph
- HPs included; variable time step

Hydraulic part:

- Boundary conditions: flow rates at users, pressure at reference vertex
- Kirchhoff laws at network nodes

Thermal part:

- Boundary conditions: source temperatures
- Heat transfer neglecting thermal diffusion, spatial distribution approach

$$(\partial_t + v\partial_x)\, T = -\frac{T - T_{ext}}{\tau} \quad \rightarrow \quad T(t,x) = T_{ext} + \left[T\left(t_0, x - \int_{t_0}^{t} v(t')\, dt'\right) - T_{ext}\right] e^{-(t-t_0)/\tau}$$

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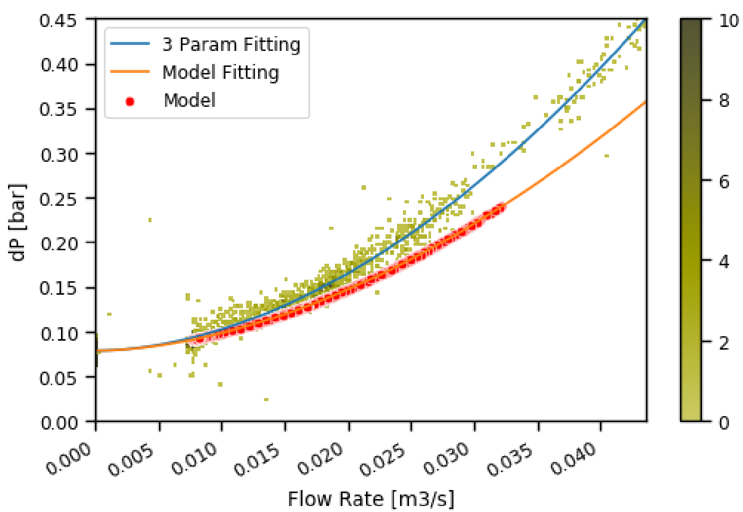
Model results 1

Uncalibrated model:

- Uncertainty in flow rate *F* due to fluctuations in substation control
- Minor pressure losses are neglected



3 parameter Fit;

$$Dp = Dp_0 + kF^{\alpha}$$

Dp_0	k	α
0.079	130.00	1.87

Model Fit;

$$Dp = Dp_0 + kF^{\alpha}$$

Dp_0	k	α
0.079	78.64	1.80

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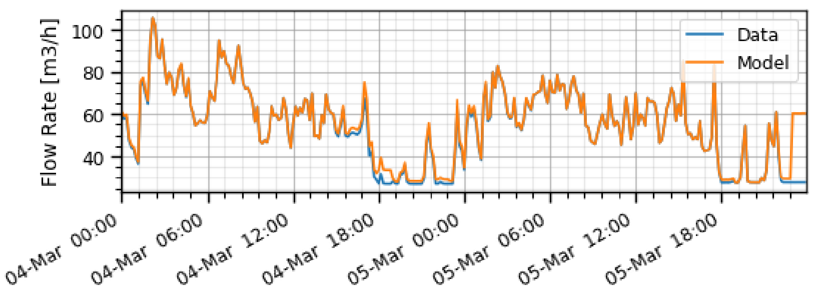
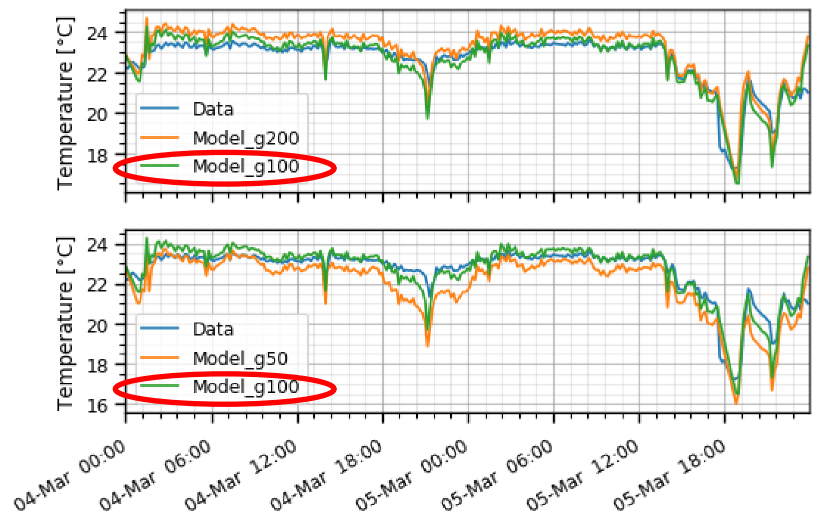
Model results 2

Uncalibrated model: possibly significant error in temperature due to lack of detailed ground modelling

Validation of temperature calculation using measured flow as an input and including an effective ground insulation (crucial for non-insulated pipes):



Undisturbed ground temperature at an effective diameter of 1 m (pipe depth 1.3 m)



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Conclusions

Measured performance:

- Supply temperature between 15 and 25 °C
- Seasonal performance factor (SPF) about 3.1 (including pumping consumptions)
- Thermal losses (mainly due to non-insulated pipes) about 30 % of supplied heat
- Pumping consumptions order of 4 % of final heat

Model validation:

- Good agreement after calibration
- Importance of including effective ground insulation for non-insulated pipes

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Thank you for the attention!

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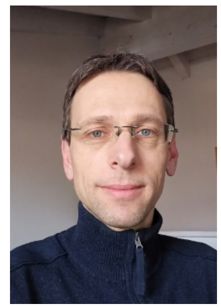

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