Agent-GIS 5GDHC workshop

Technical performance analysis of 5GDHC

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Background

Work done in this part

- Development of a 5GDHC system model which enables dynamic simulations.
- Comprehensive evaluation of the techno-economic performances of the 5GDHC system in heating dominated climate using dynamic simulations.
- Uncertainty and sensitivity analysis of LCOH for the studied 5GDHC.
- Evaluation of impacts of PV or PVT collectors integration on LCOH.

Methodology

Simulation platforms

TRNSYS: HP and other system components

Fluidit: Network simulations

Python: Uncertainty and sensitivety analysis

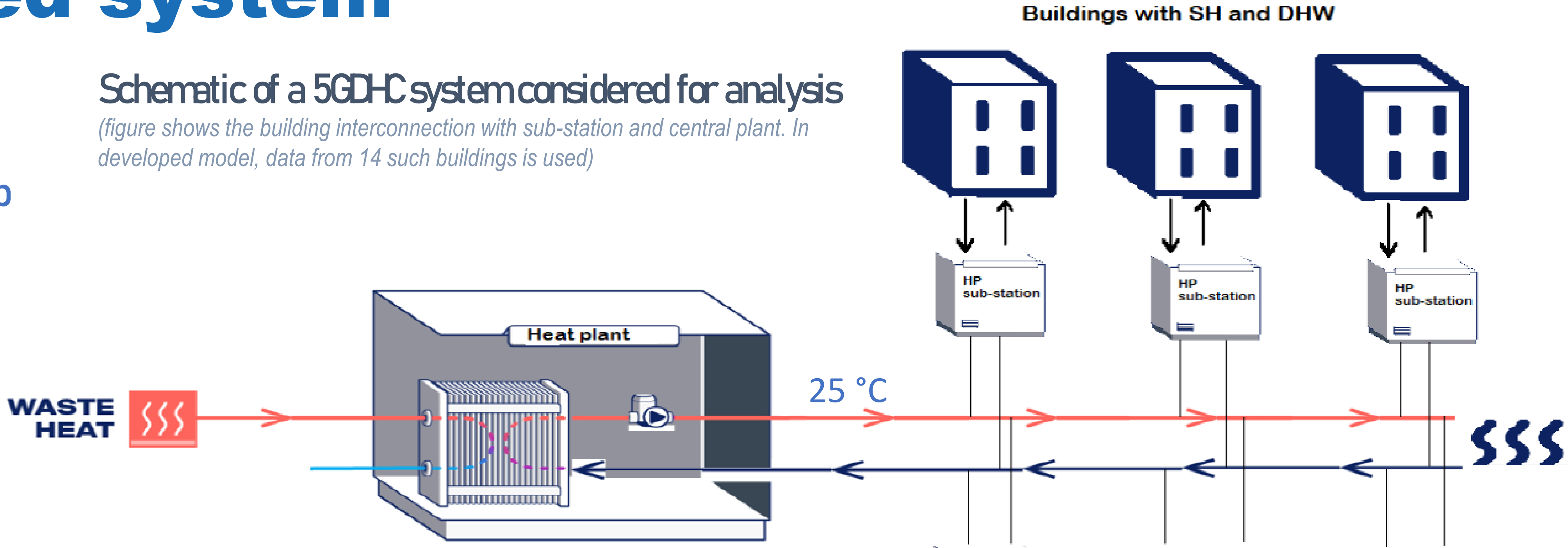
- District characterstics and heating load
- Sub-station model development in TRNSYS
- Thermo-hydraulic model for network in Fluidit heat
- Economic calculations using Microsoft excel
- Uncertainity and senstivity analysis using MCM in Python
- Effect of PV and PVT integration on system performance

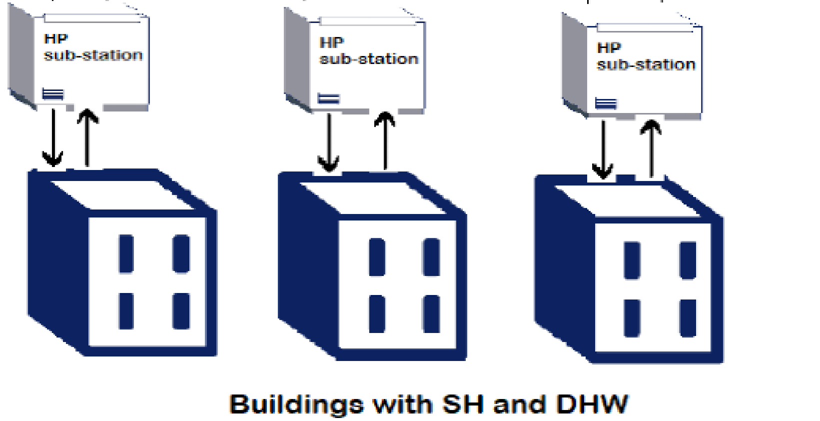
Studied system

A small district consists of a group of 14 multi-family houses (MFH) in Tallin, Estonia.

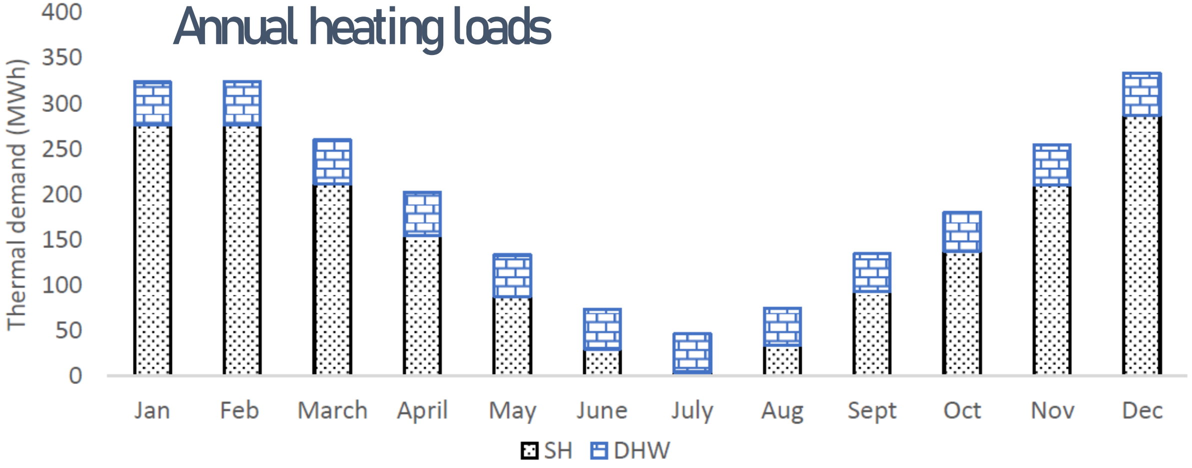
Schematic of a 5GDHC system considered for analysis

(figure shows the building interconnection with sub-station and central plant. In developed model, data from 14 such buildings is used)

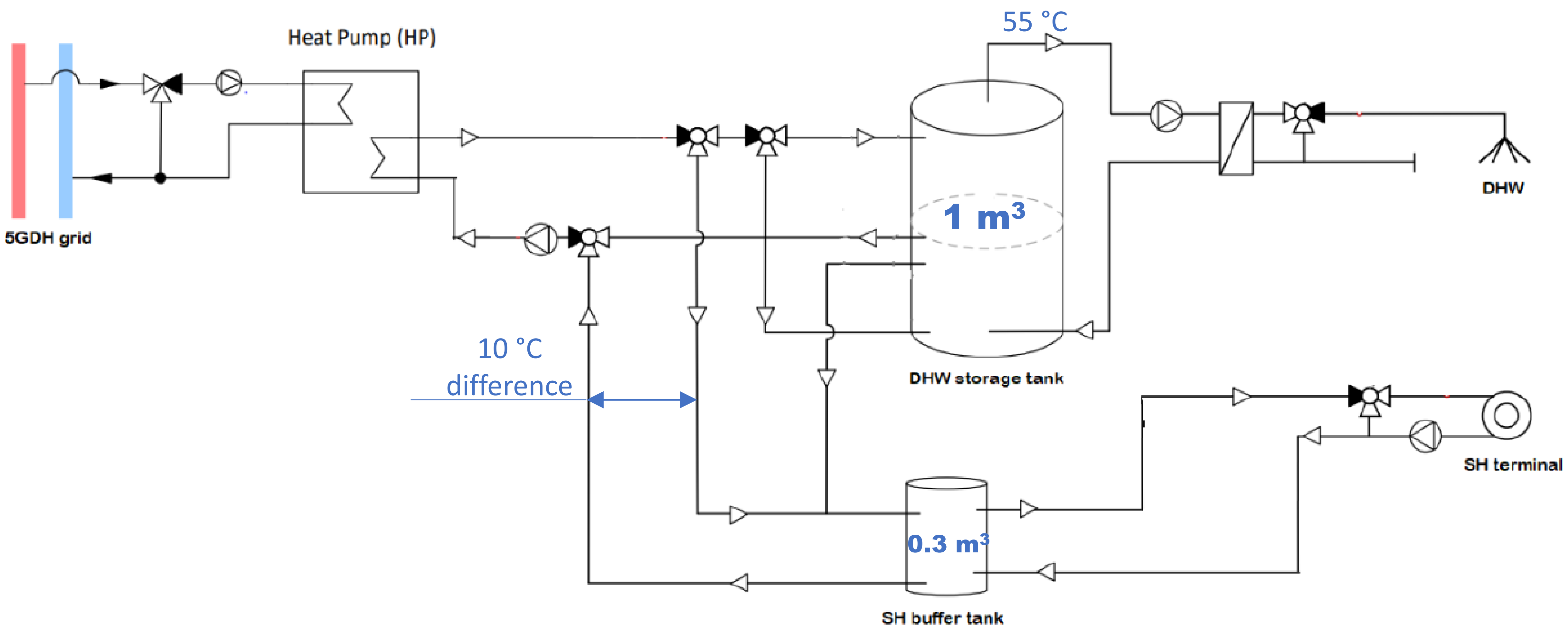




Annual heating loads



Configuration of substations

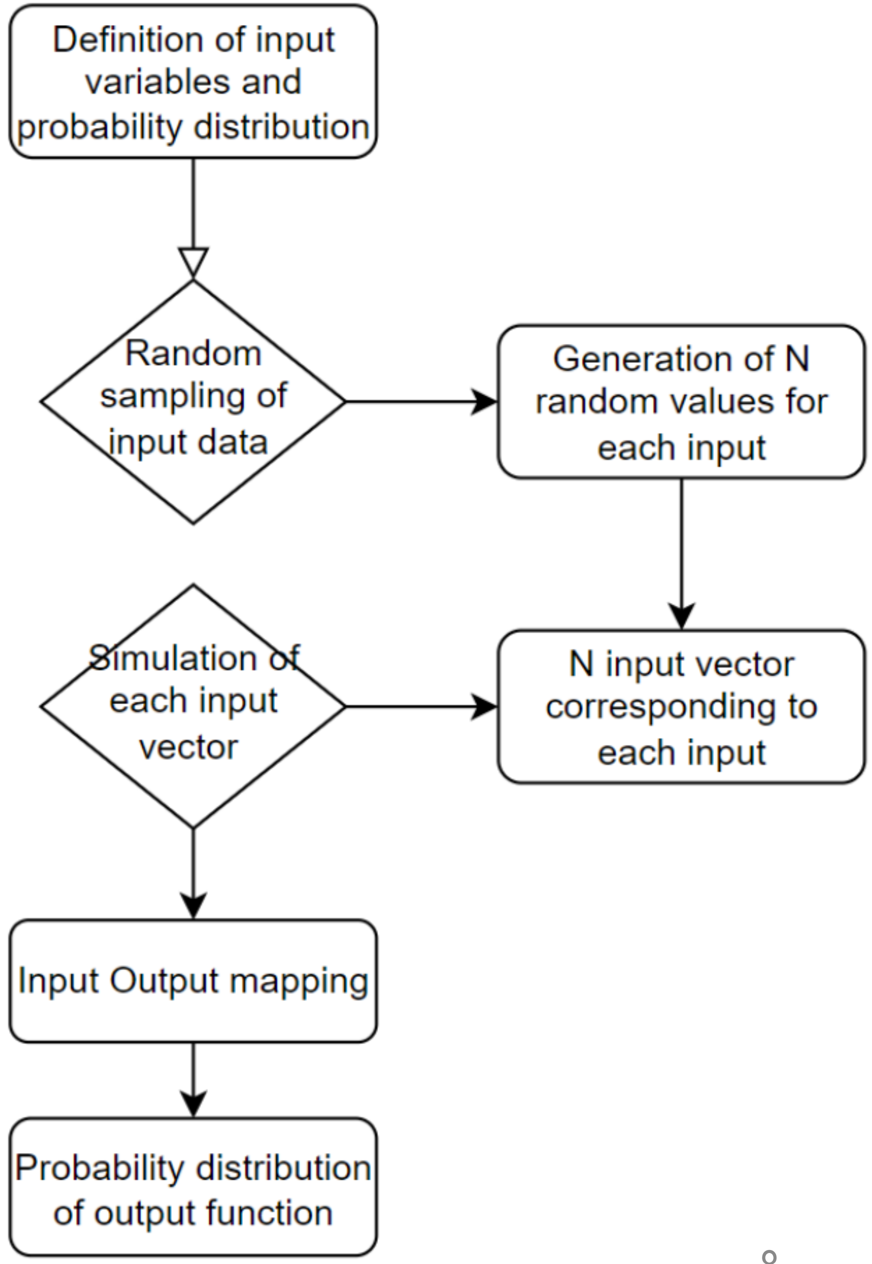


Uncertainty analysis

Settings

- 7 input variables are chosen
- 20 000 repeations

	Mean	Min.	Max.	Distribution type	Unit
Capital cost of sub-station	700	500	1000	PERT	€/kWth
Piping cost (average)	350	250	450	PERT	€/m
Electricity price	100	70	150	PERT	€/MWh
Cost of waste heat	10	5	30	PERT	€/MWh
Discount rate	3%	1%	10%	Triangle	%
Heat losses	5%	3%	15%	Triangle	% of heat delivered
System lifetime	30	25	35	Triangle	years



Economic parameters

Capital costs of various system components

	Description	Value	units
Heat plant	Capex of heat exchanger	90	€/kW
Network	Pipe + insulation cost including installation		
	DN200	534	€/m
	DN125	364	€/m
	DN100	307	€/m
	DN80	191	€/m
	Capex of fluid pumps	35	€/(m^3.h)
Sub-station	Total installed cost of HP substation	700	€/kW_{th}
User side	Total installed cost of piping (fixed)	200000	€

O&M costs of various system components

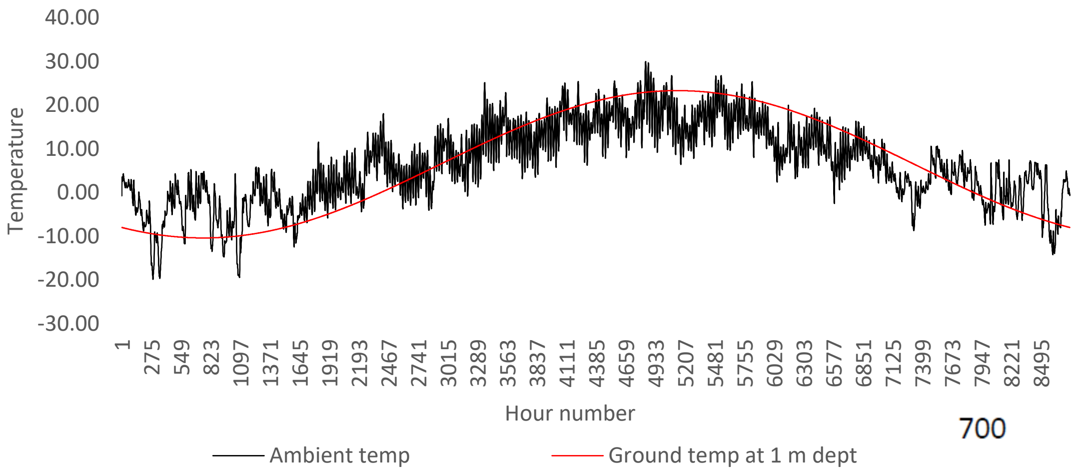
	Fixed OPEX (€/MW/year)	Variable OPEX (€/MWh)
Heat plant	150	0.2
Network	50	0.05
Sub-station	3500	1.9
user side	100	0.2

Other costs

	Cost (€/MWh)
Electricity	100
Waste heat	10

Results

Aggregated evaporator load for district

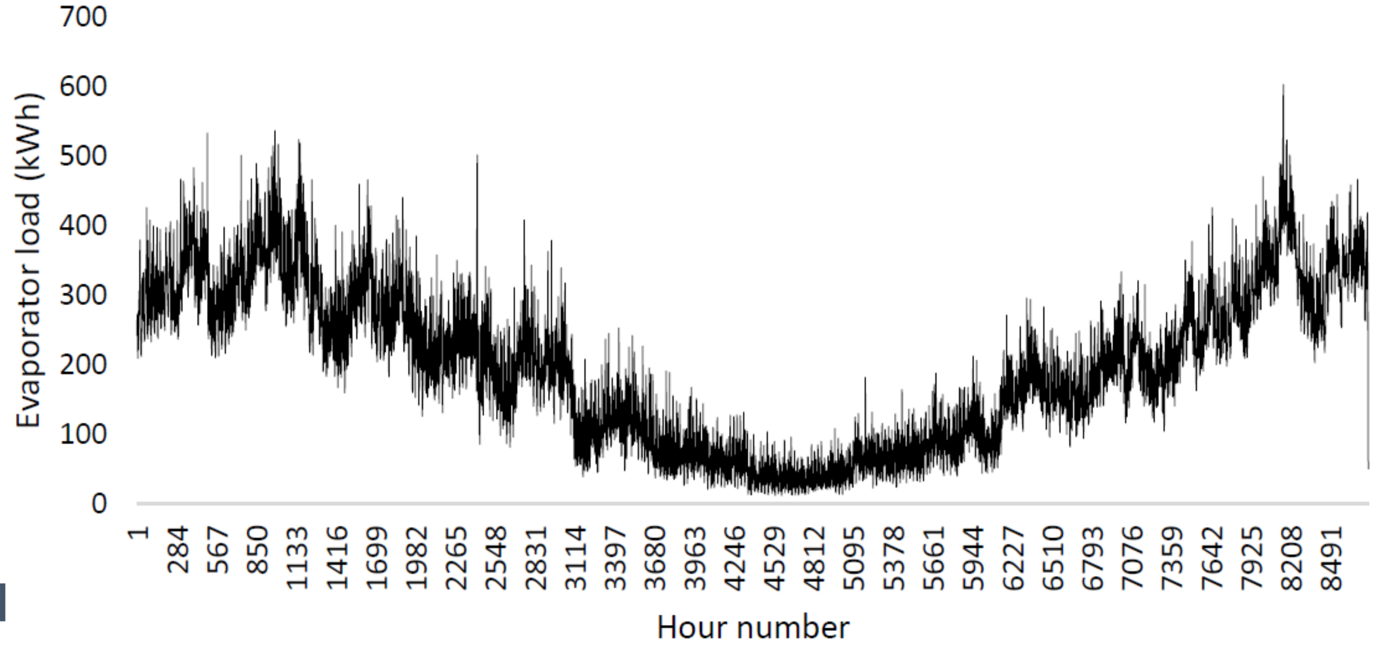


Variation of ambient and ground temperature

Used as inputs for evaluating the heat loss and the SH and DHW loads.

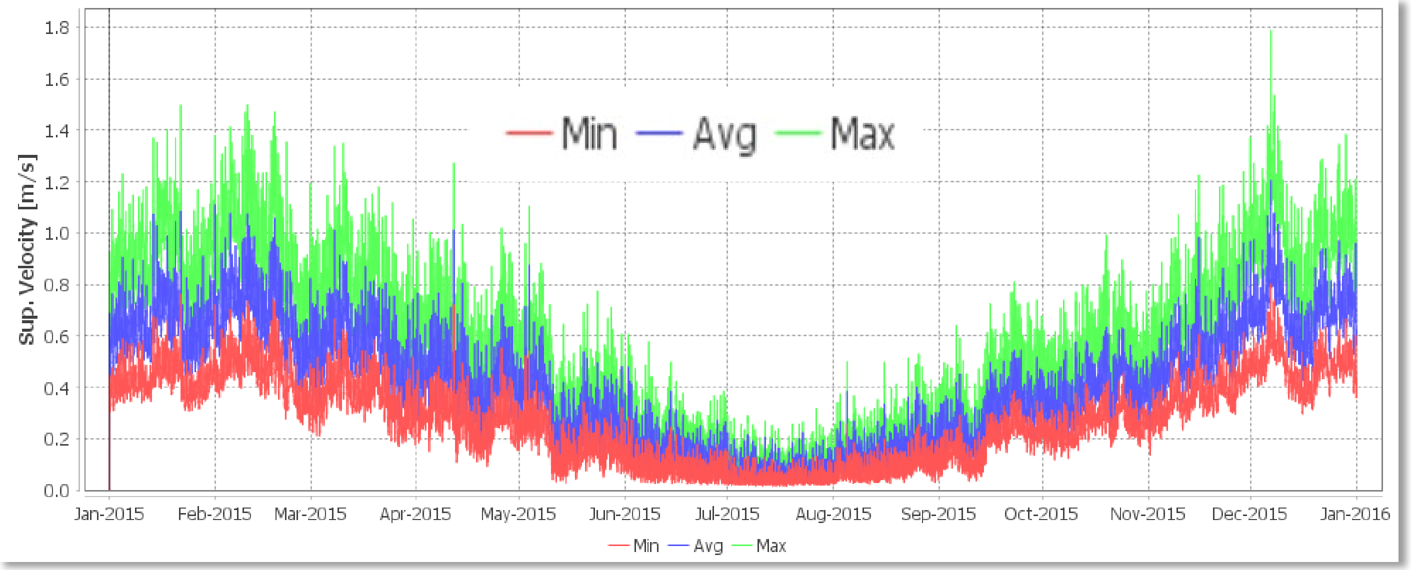
Annual electricity uage

- *HP substation: 723 MWh*
- *User side pump: 37 MWh*
- *Network side pump: 32 MWh*

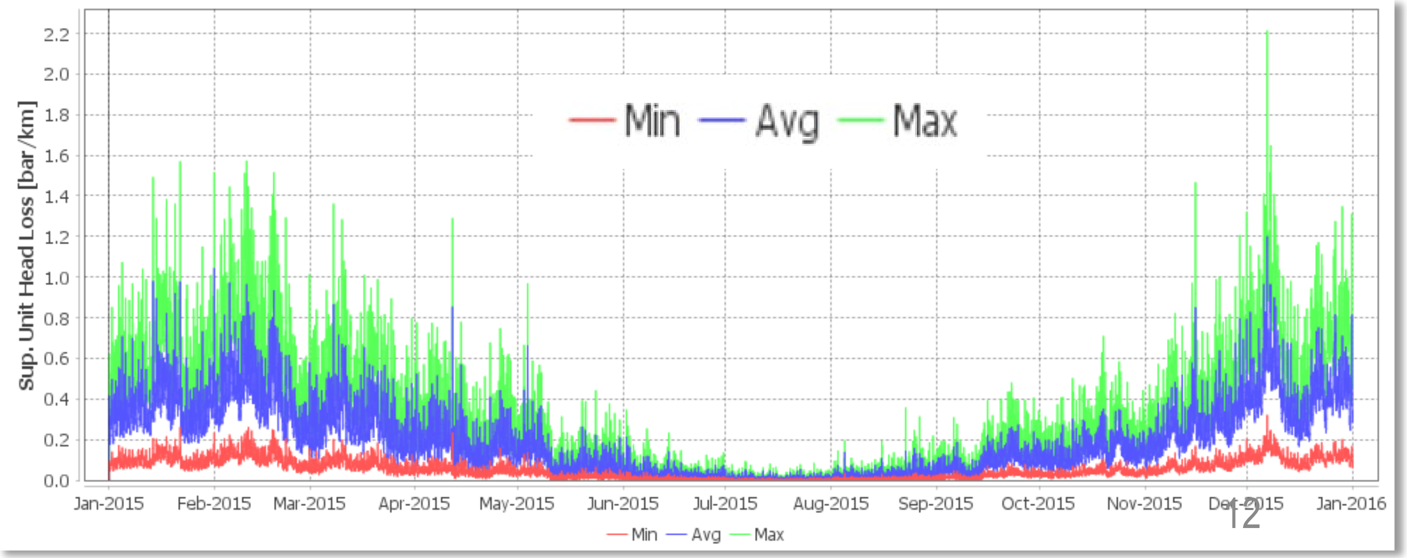


Variation of aggregated evaporator load

Network performance

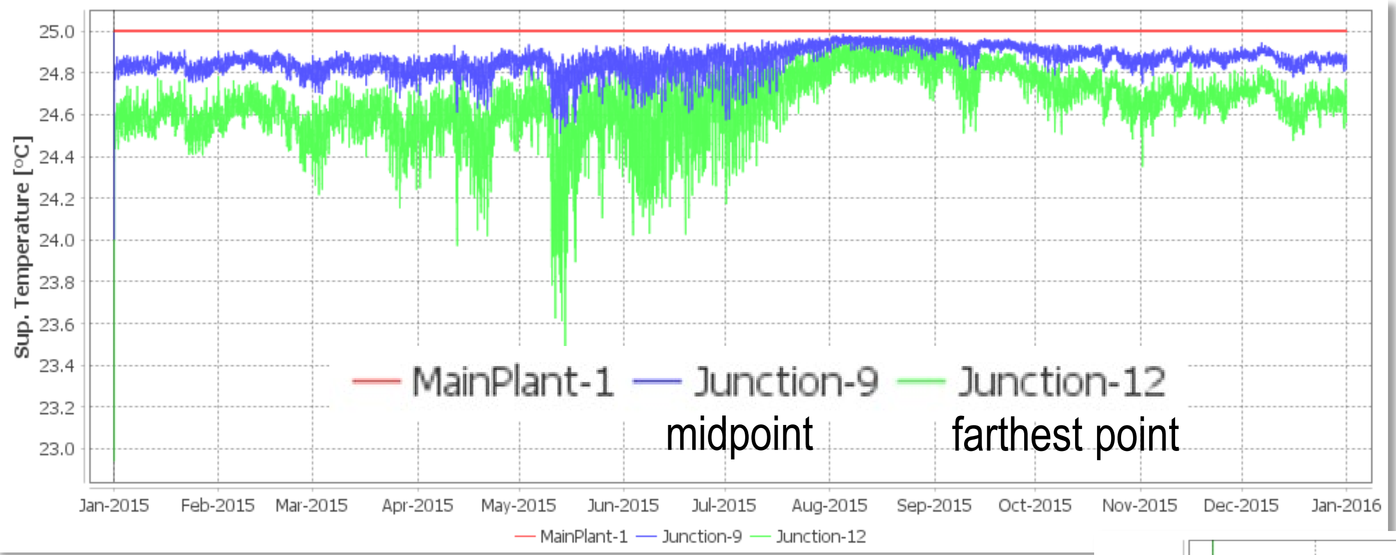


Flow velocities variation in supply pipe



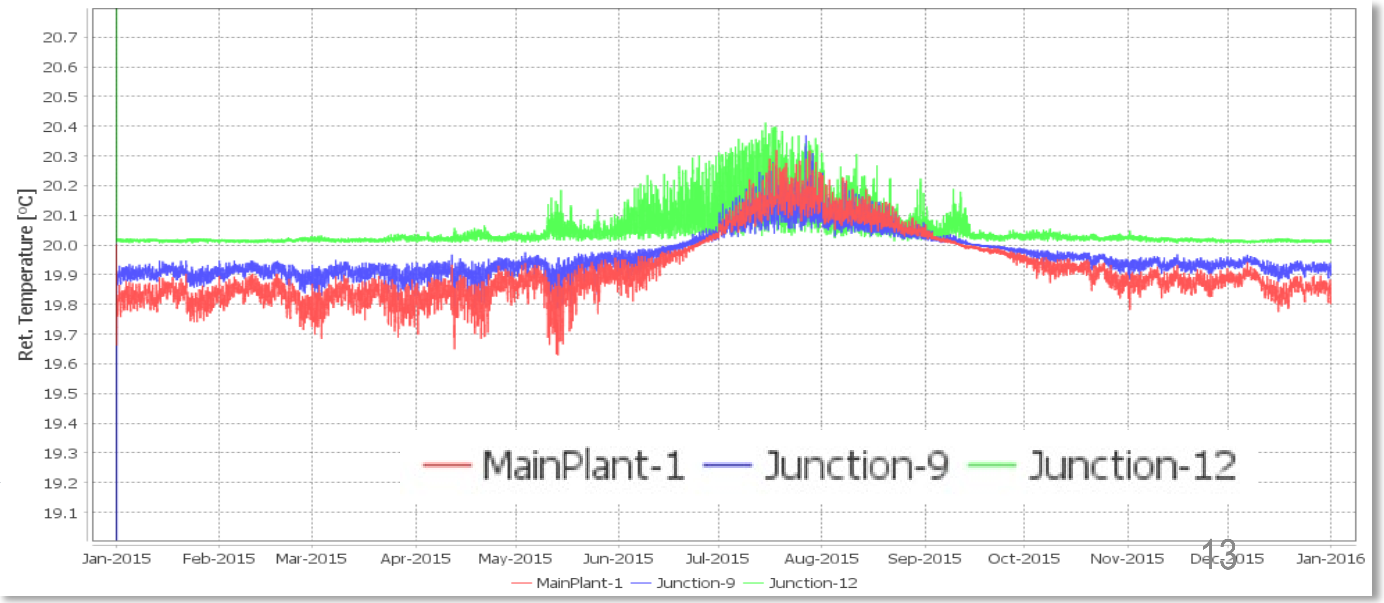
Pressure drop variation in the supply pipe

Network performance



Variation in <u>supply</u> temperature at 3 nodes in the network

The average temperature decreases to junction 9 is 0.15 °C



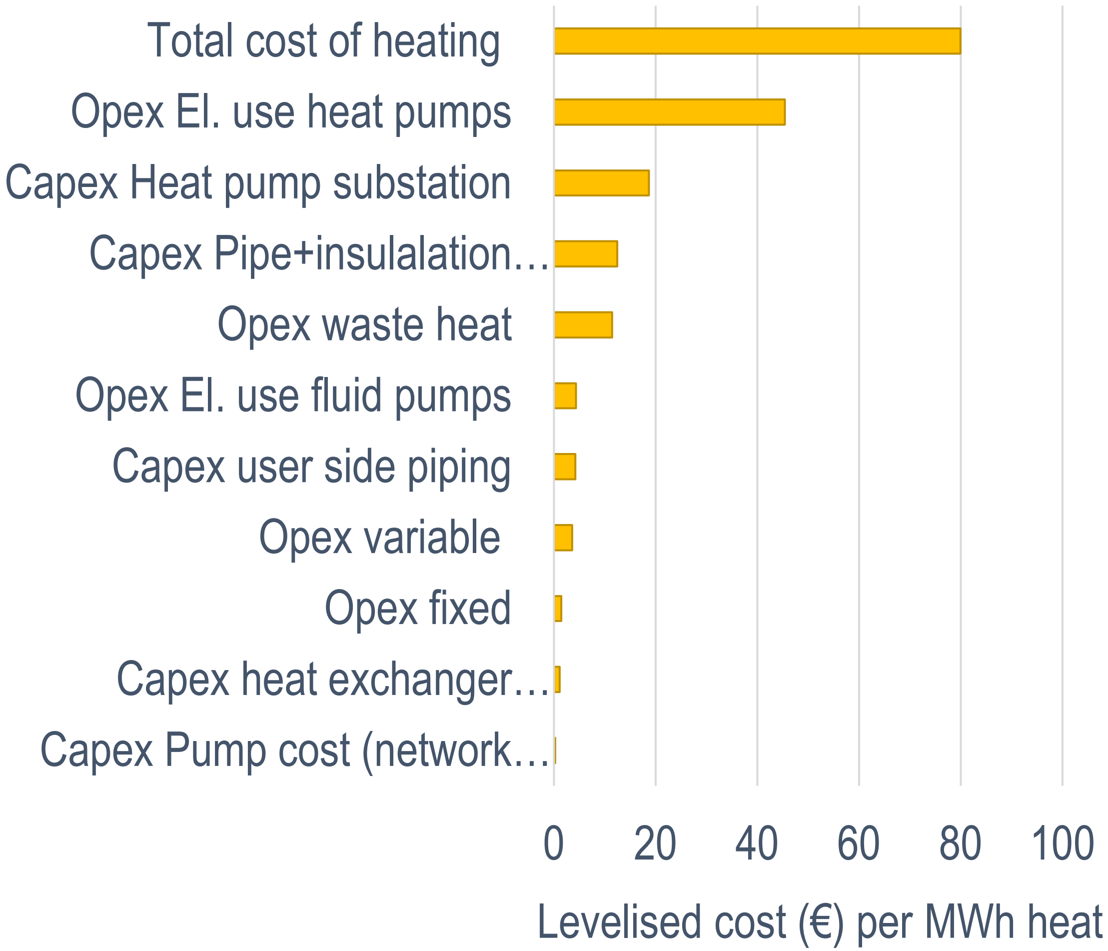
The average temperature decreases to junction 9 is 0.13 °C

Variation in <u>return</u> temperature at 3 nodes in the network

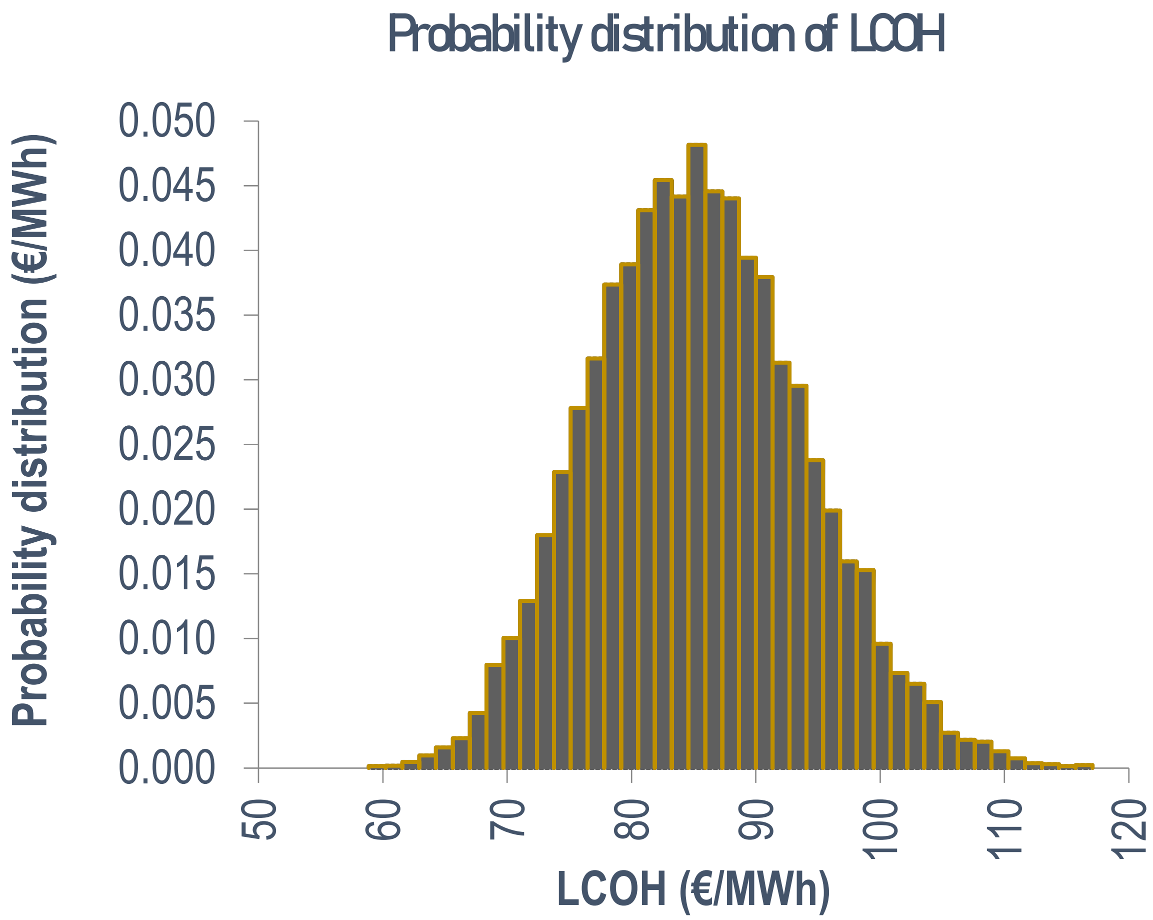
Economic performances

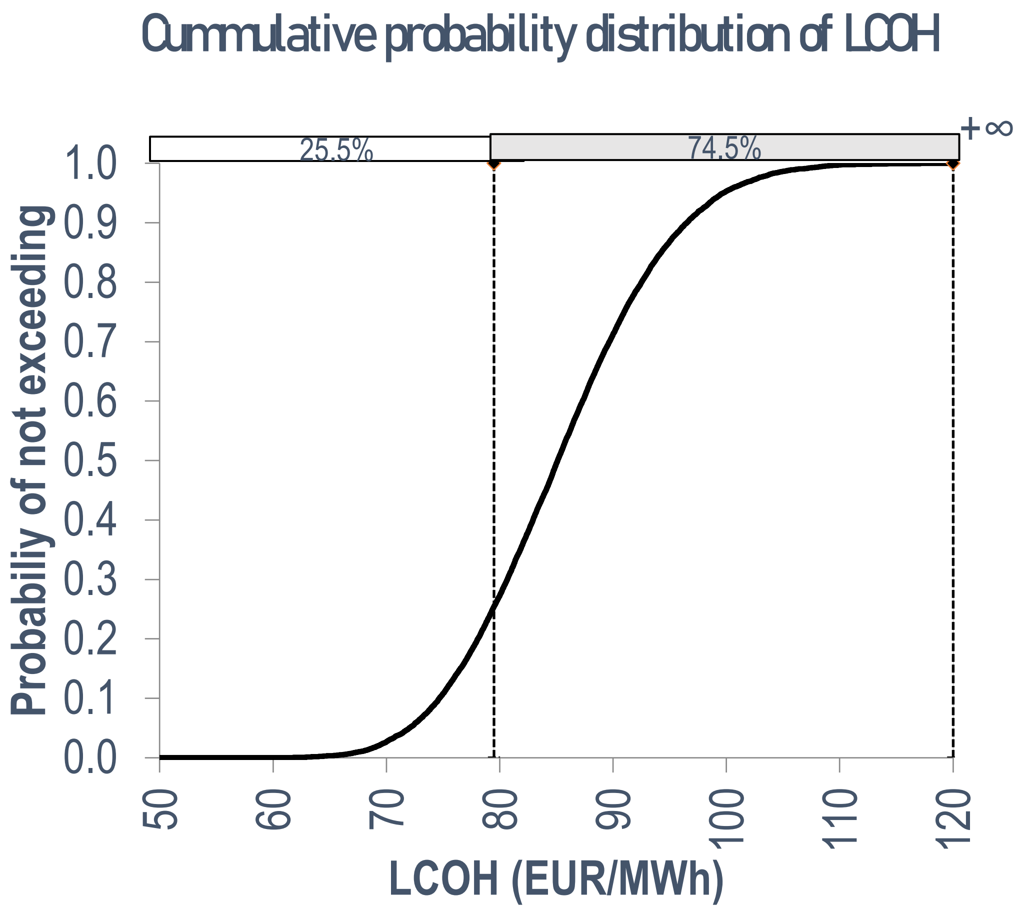
CAPEX component	Total cost
Heat pump substation	890034 €
heat exchanger central plant	54255 €
Pipe + insulation cost including installation	593000 €
User side piping	200000 €
Pump cost (network + user)	10966 €
Total capex	1748255 €

CAPEX component	Total cost
O&M cost for the system	105 000 €/year
Parametrized Capex (peak 1.4 MW)	1250 €/kW
Cost of heat parametrised to heating delivered by network	113 €/MWh
Cost of the heat "seen" by the customer	80 €/MWh

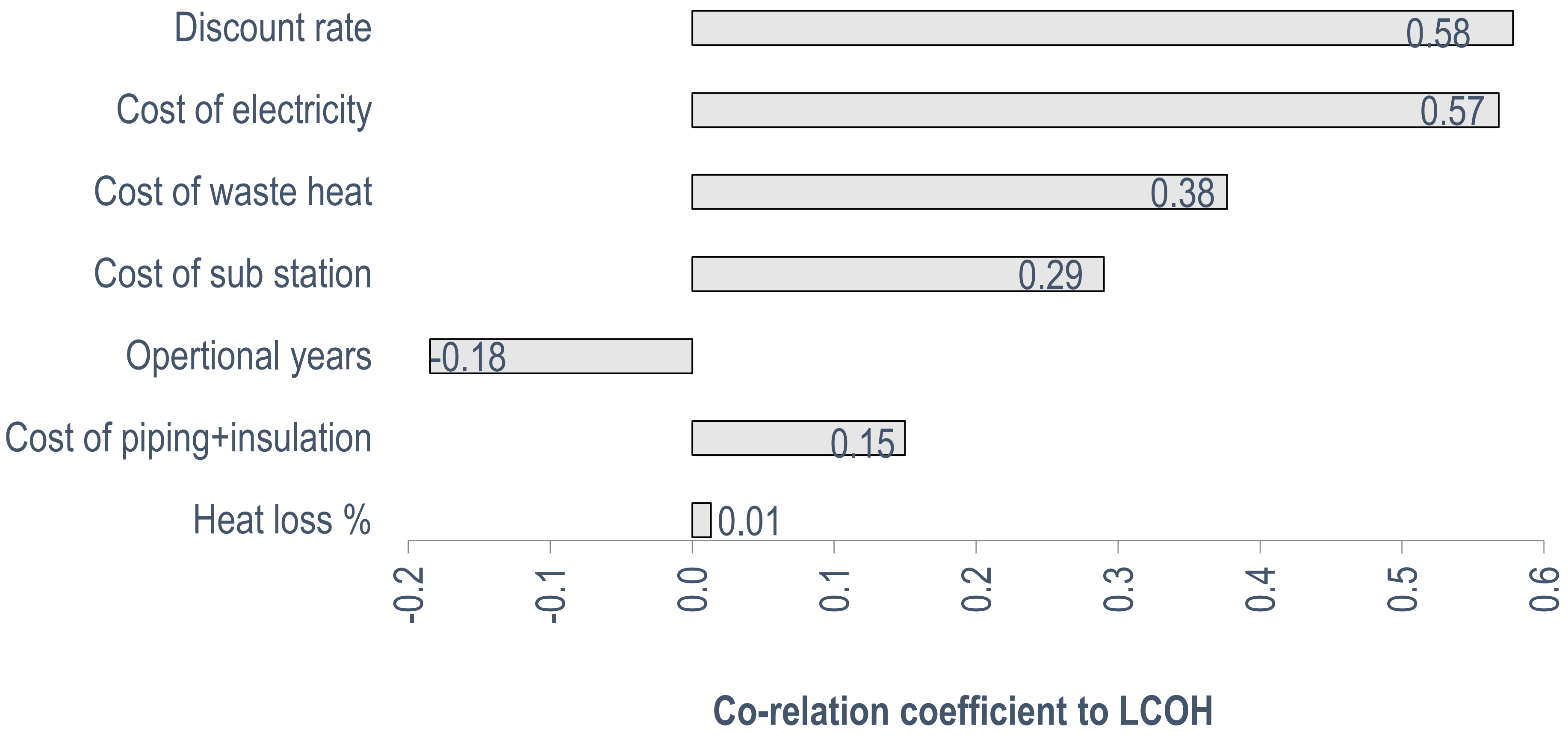


Uncertainty analysis results



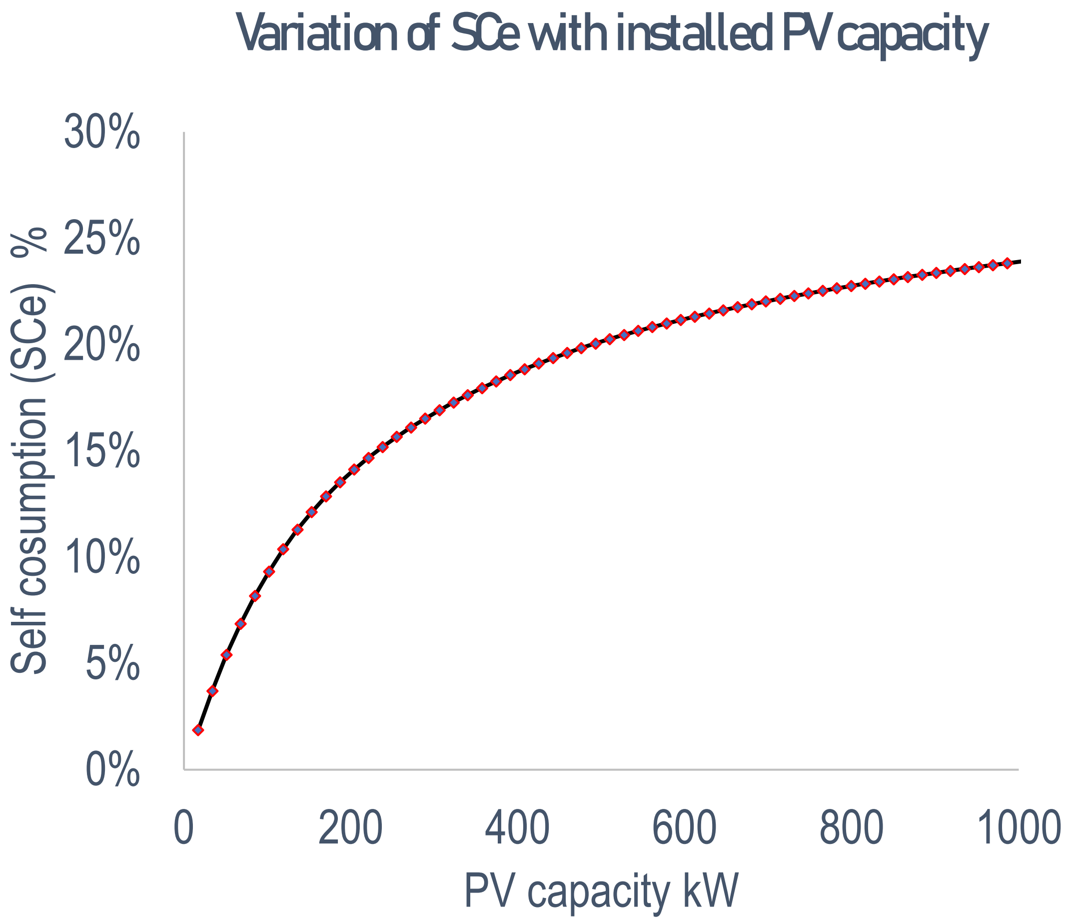


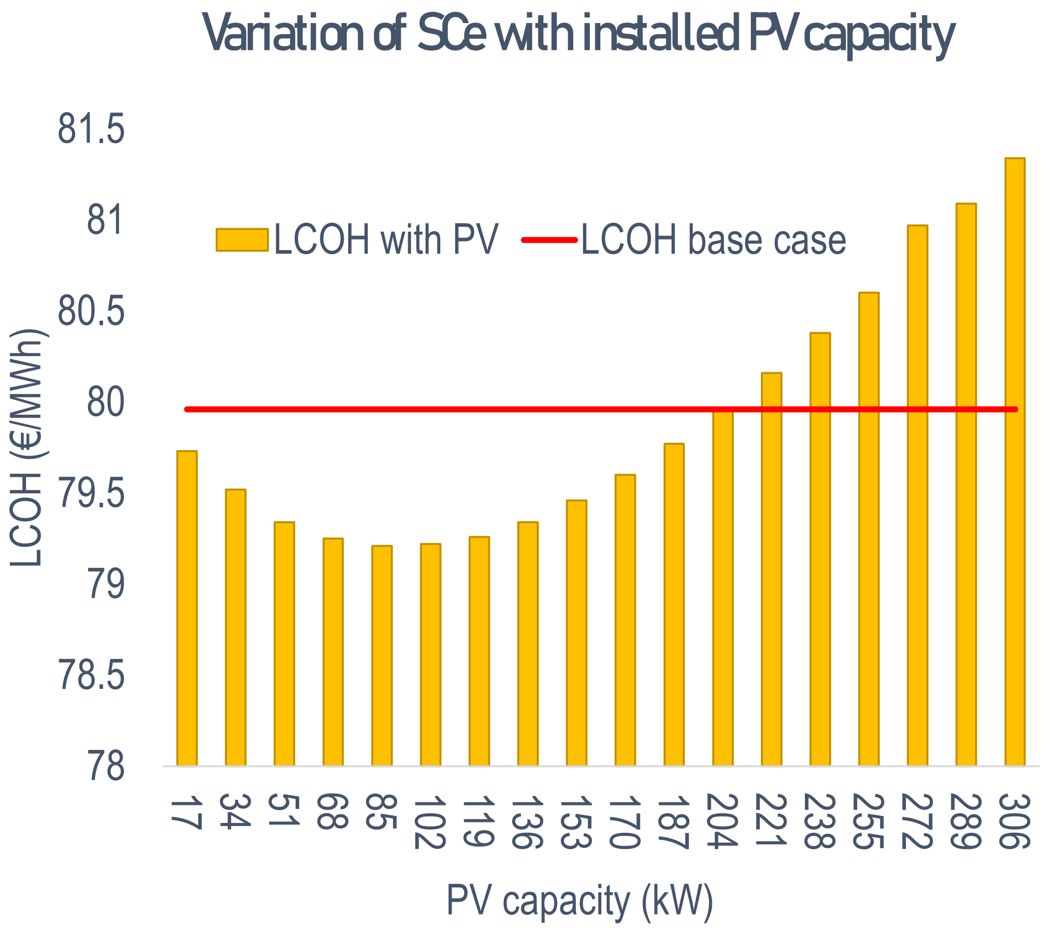
Sensitivity analysis results



Discussions

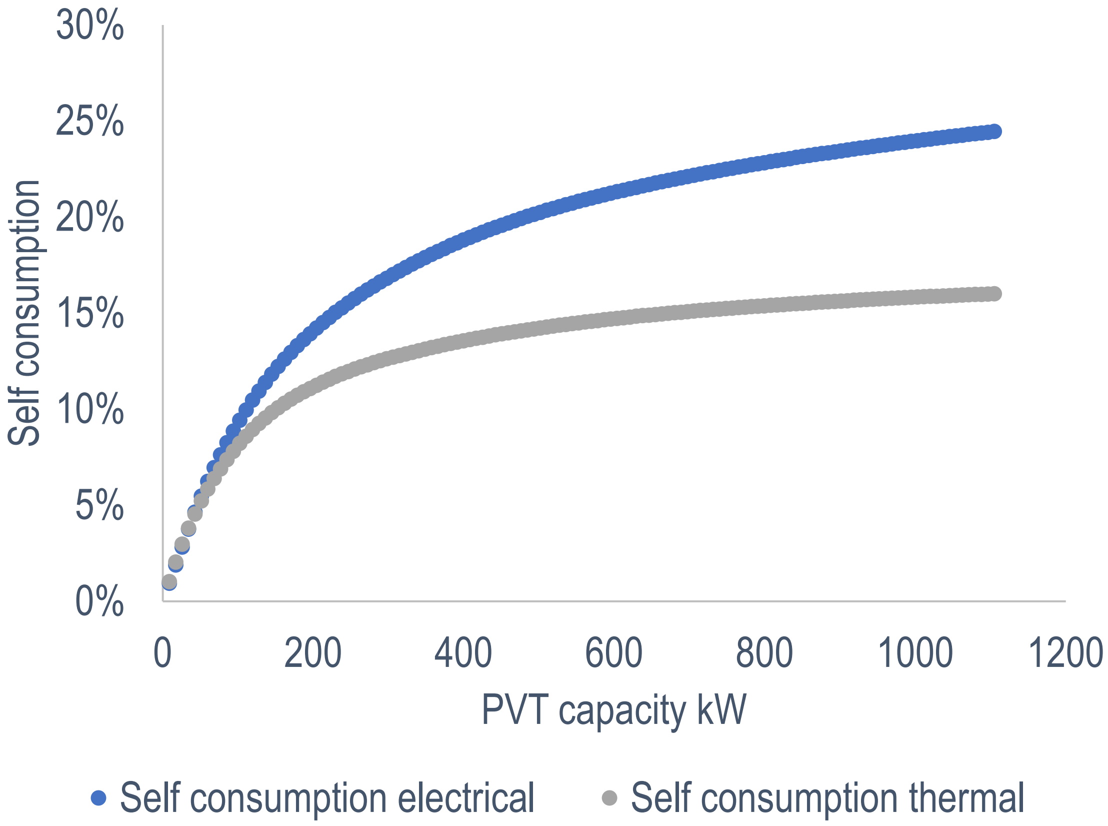
Impacts of PV system integration





Impacts of PVT system integration

Variation of SC_e and SC_t with PVT capacities



Variation of LCOH with heat cost

		Price of waste heat source (€/MWh)			
		10	25	50	75
LCOH (€/MWh)	Base case	79.96	91.16	109.8	128.5
	PVT 25 kW	80.06	90.98	109.14	127.29
	PVT 50 kW	80.34	91	108.76	126.6
	PVT 100 kW	81.36	91.7	108.93	126.6
	PVT 150 kW	82.85	93	109	126.6

Conclusions

Key takeaways

- For the designed boundary conditions, the system can deliver heat with a LCOH of 80 €/MWh, which is competitive with natural gas-based heating at current prices.
- Electricity costs for driving heat pumps accounts for the largest energy usage in a 5GDHC system.
- Discount rates, the cost of electricity, and the cost of waste heat are the three most important parameters affecting the LCOH.
- Integration of PV up to a limited capacity results in 1 % reduction when compared to the base case LCOH.
- The economic benefit with PVT is lower compared to PV, due to the limited economic returns on heating utilisation. However, if the waste heat price is higher, then PVT can result in lowering the LCOH with a limited effect.

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Thank you!

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