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Analysis of decentralized substation system with low temperature district heating and improvement for low return temperature

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Conflict between low temperature district heating and hygiene security

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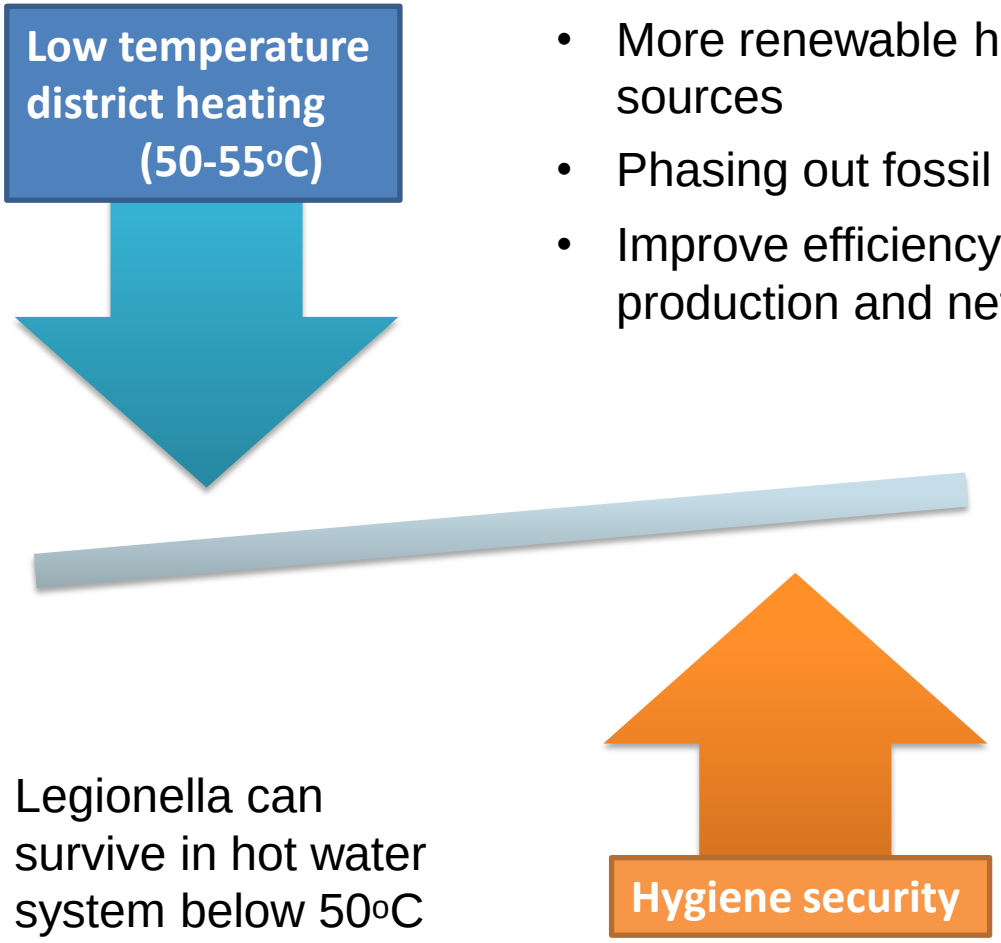
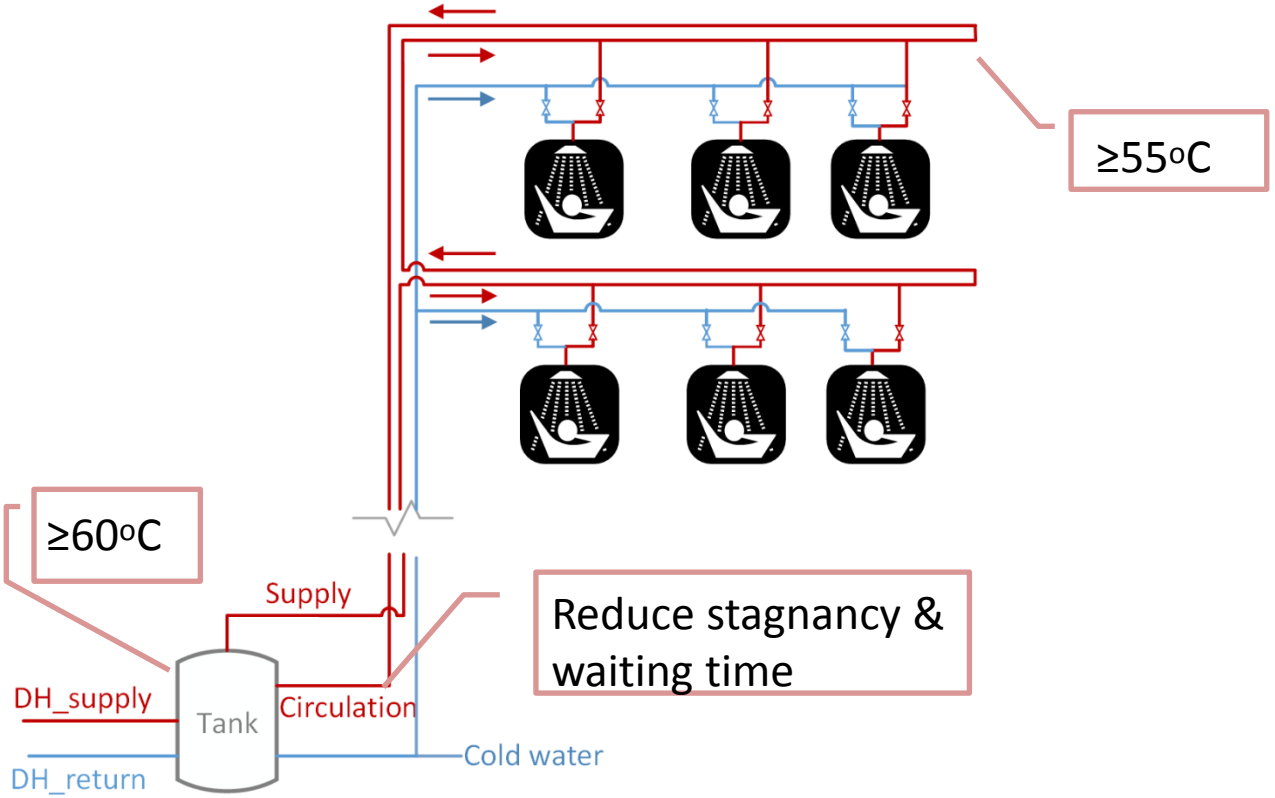


- More renewable heat sources
- Phasing out fossil fuels
- Improve efficiency of production and network

- Legionella can survive in hot water system below 50°C

Conventional heating system



Standard for Legionella prevention

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CEN/TR 16355:2012(E)

Table 2 — Types of hot water installation

	Hot and cold water separately				Mixed hot and cold water					
	No storage		Storage		No storage upstream of mixing valves		Storage upstream of mixing valves		No storage upstream of mixing valves	
	No circulation of hot water	With circulation of hot water	No circulation of hot water	With circulation of hot water	No circulation of hot water	With circulation of hot water	No circulation of mixed water	With circulation of mixed water	No circulation of mixed water	With circulation of mixed water
Figure in Annex C	C.1	C.2	C.3	C.4	C.5	C.6	C.7	C.8	C.9	C.10
Temperature	-	≥ 50 °C [e]	In the storage Water heater [a]	≥ 50 °C [e]	Thermal disinfection [d]	Thermal disinfection [d]	In the storage water heater [a]	≥ 50 °C [e] Thermal disinfection [d]	Thermal disinfection [d]	Thermal disinfection [d]
Stagnation	-	≤ 3 l [b]	-	≤ 3 l [b]	-	≤ 3 l [b]	-	≤ 3 l [b]	-	≤ 3 l [b]
Sediment	-	-	remove [c]	remove [c]	-	-	remove [c]	remove [c]	-	-

[a] Temperature ≥ 55 °C the whole day or at least 1 h per day ≥ 60 °C.

[b] The volume of water contained in the pipework between the circulation system and the tap which has the greatest distance to the system.

[c] Remove the sediment from the storage water heater in accordance with the local conditions but at least once a year.

[d] Thermal disinfection for 20 min at a temperature of 60 °C, for 10 min at 65 °C or for 5 min at 70 °C at every draw-off point at least once a week.

[e] The water in the circulation loop shall be not less than 50 °C.

- No requirement.

Principle of decentralized substation

-Instantaneous HEX for local DHW production

flat

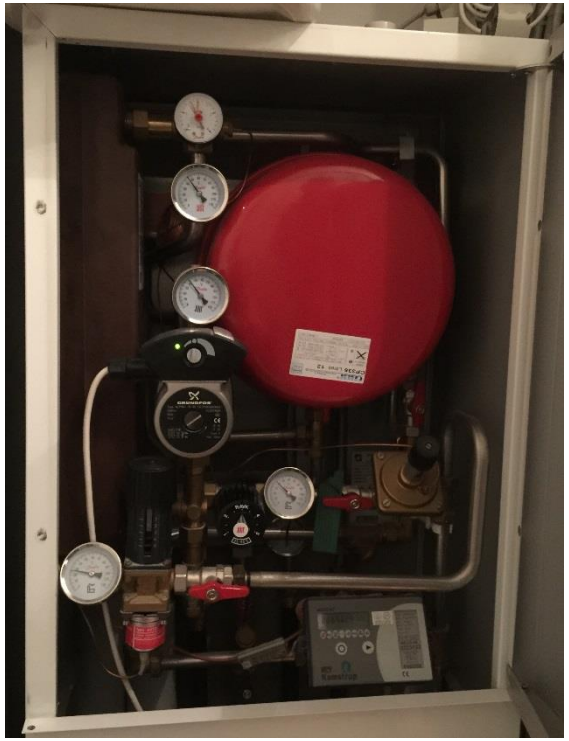
rict

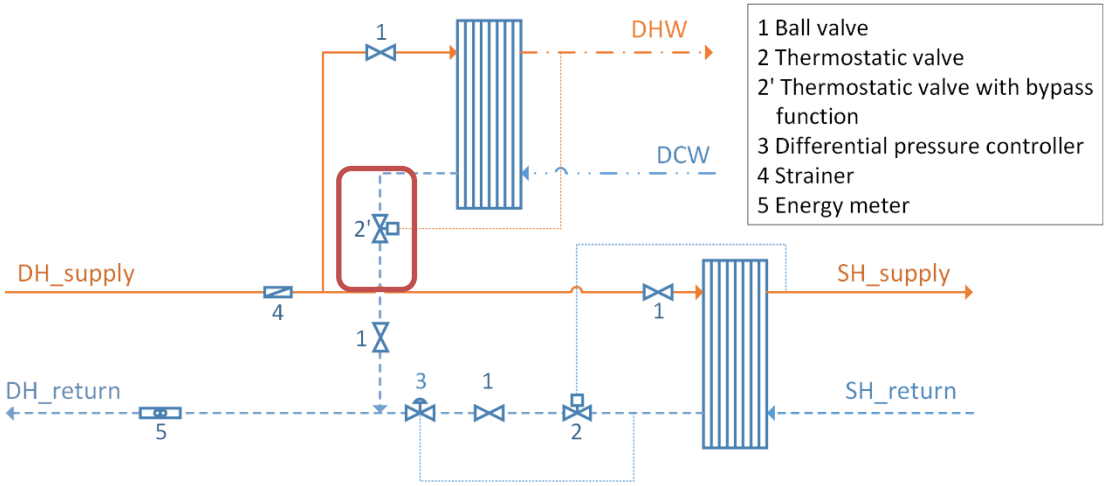
DH supply

Substation

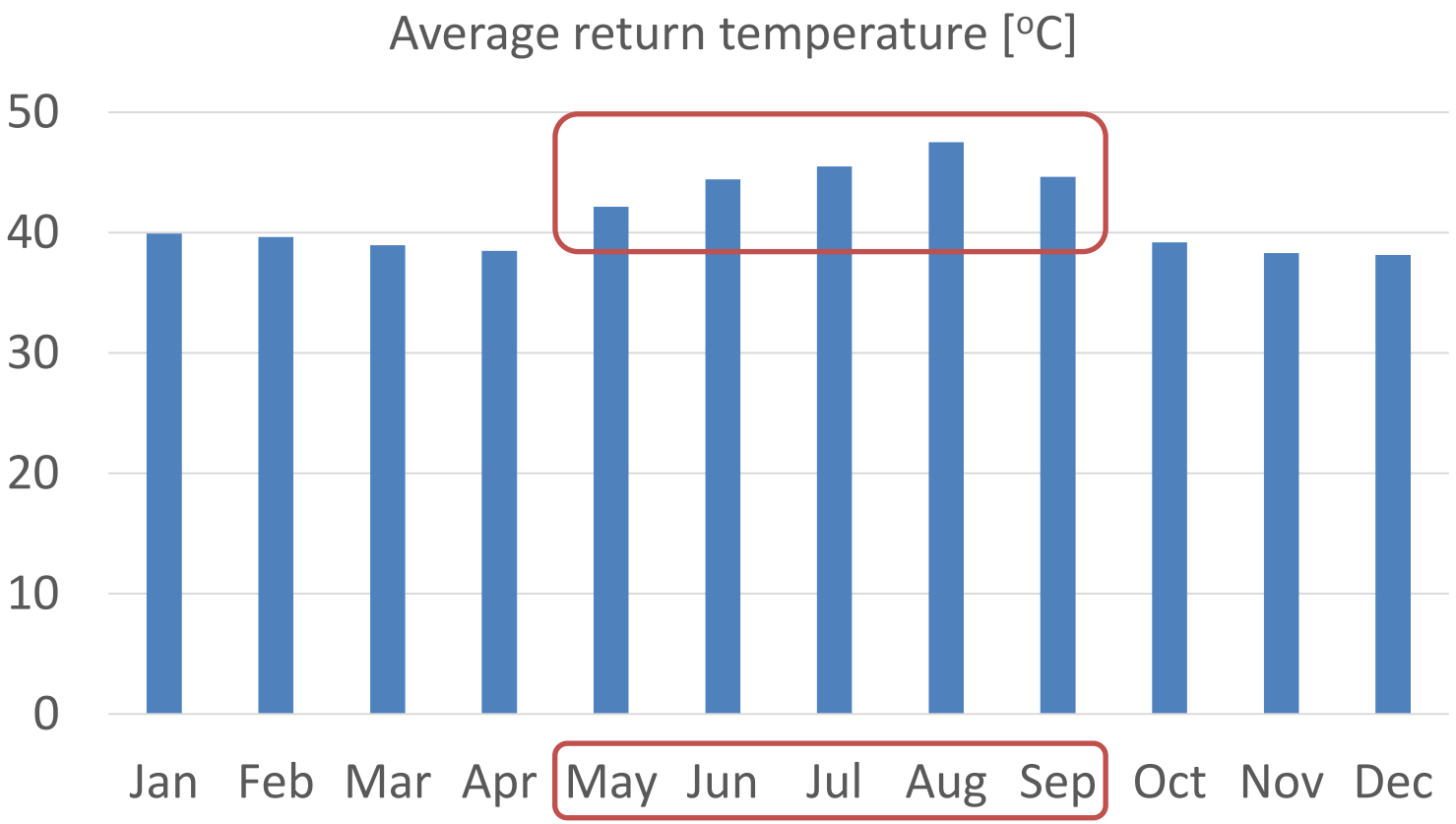
DH return

Decentralized substation unit

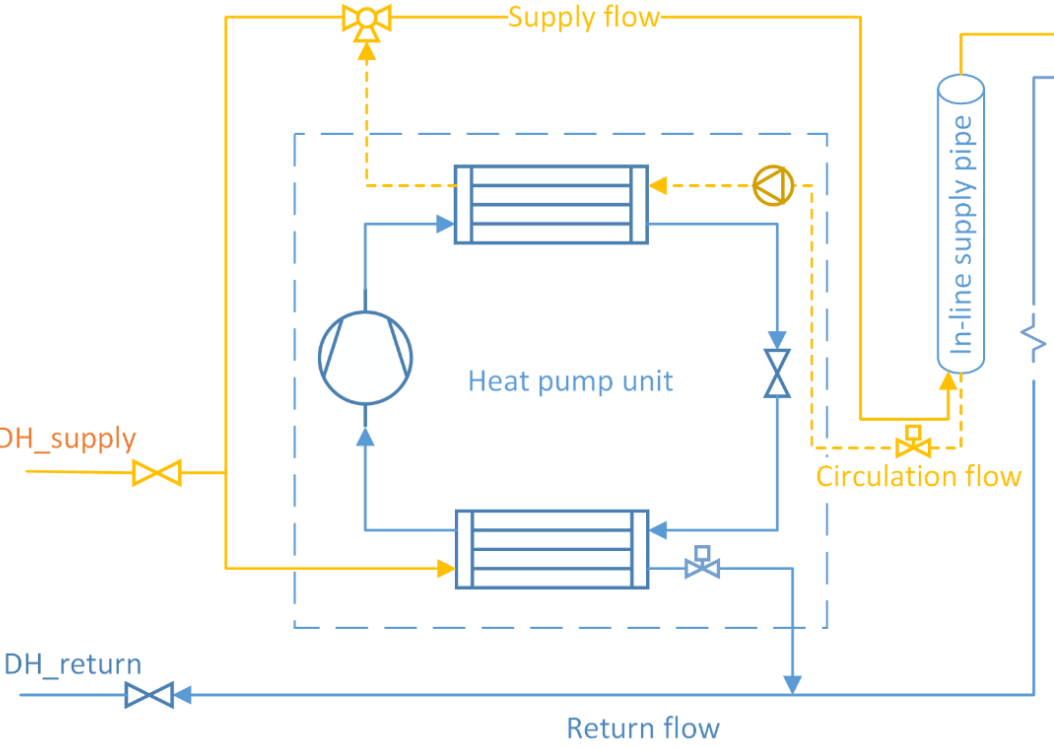




Seasonal fluctuation of the return temperature



New concept to reduce the return temperature



- Replacing the bypass by in-line supply pipe
- Heat pump cover the heat loss of supply line
- Avoid mixing bypass into the return flow

Models for calculating the distributio heat loss inside the building

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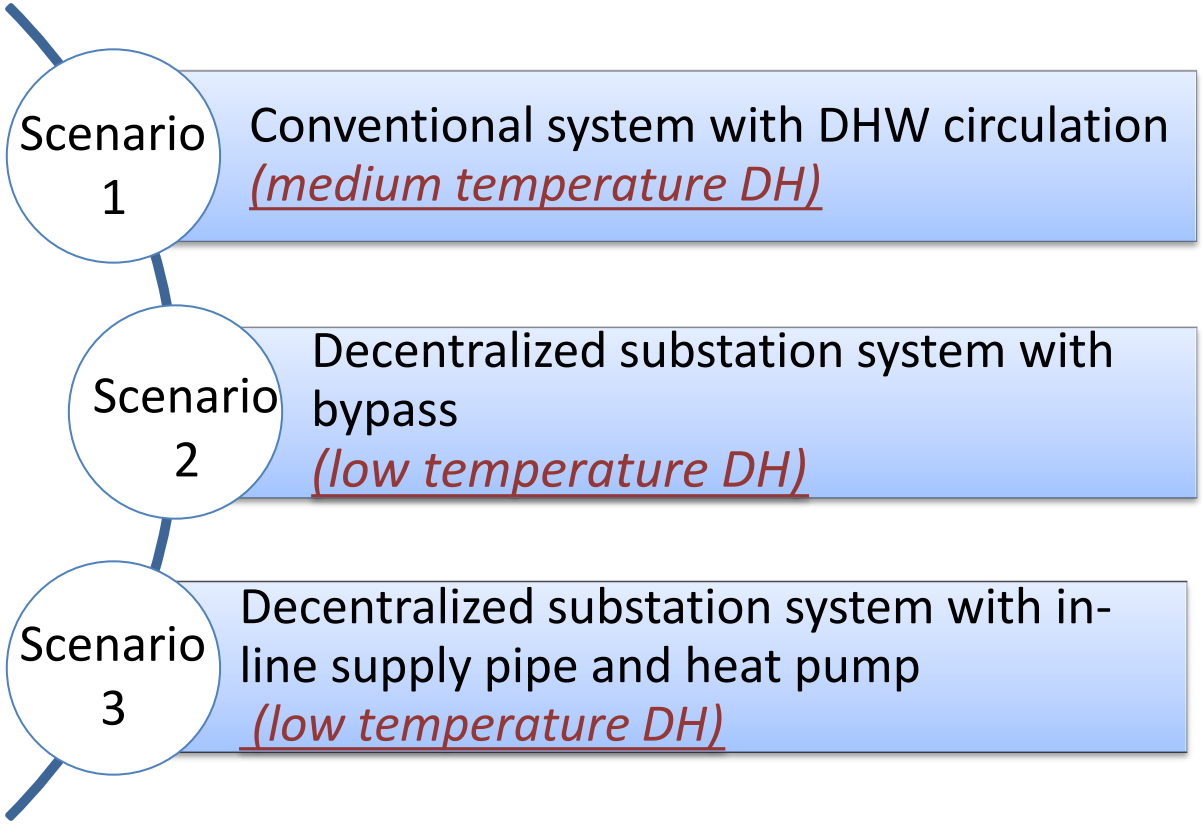
Same conditions on the consumer side



Model for calculating the distribution heat loss inside the building

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Scenario1	Scenario2	Scenario3

• Space heating: 35/25 °C
• Domestic hot water: ≥55°C
• Tank: 60 °C
	• Supply line: ≥50 °C
	• Return line:
	  • Heating season:25°C
	  • Non-heating season: mixed T (space heating 25°C+bypass50° C)
		• Supply line: ≥50 °C
		• Return line: 25°C

Calculation of the cost for covering the heat loss

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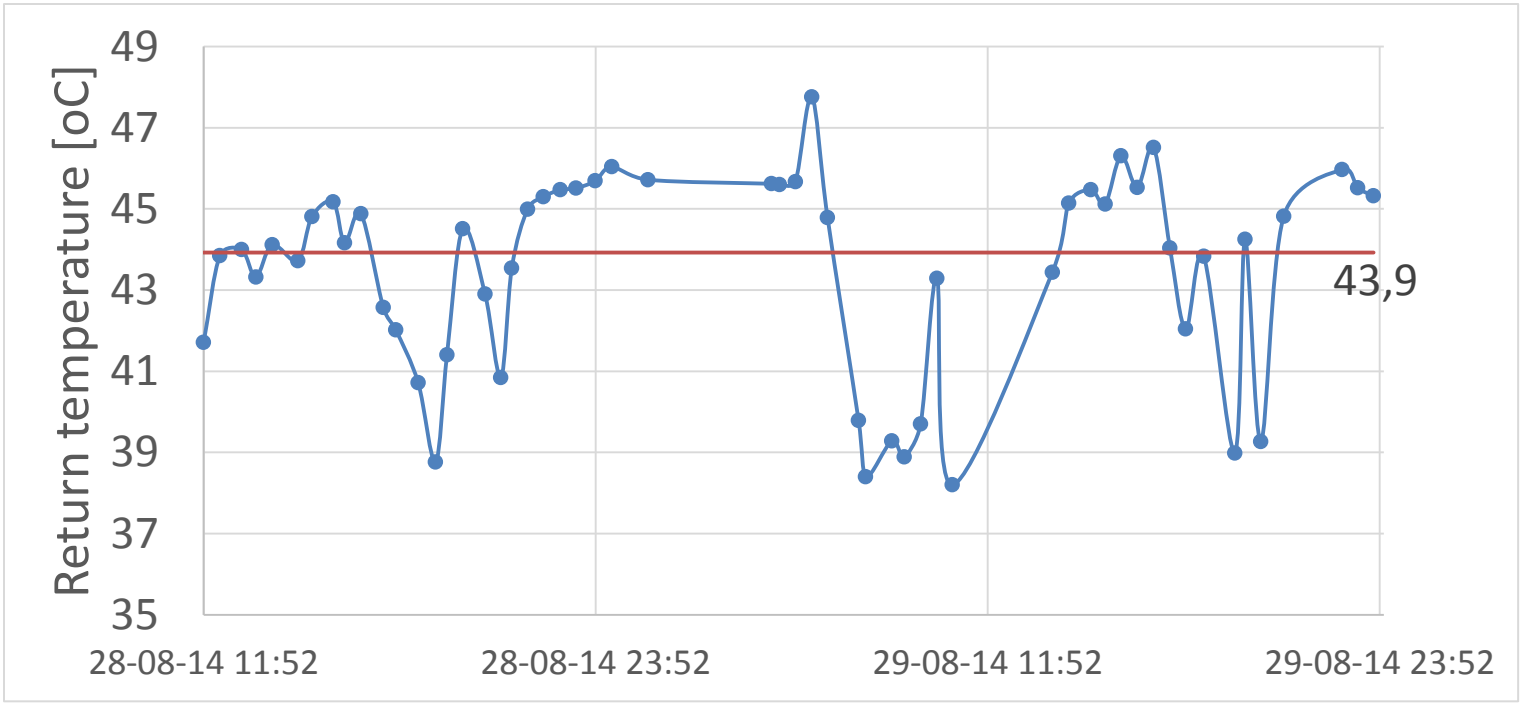
Input parameters for calculating the cost

Features	Abbrevation	Value
Price of electricity [DKK/kWh]	P_{el}	2
Price of district heating [DKK/kWh]	P_{DH}	0.8
Heat pump COP	COP	4

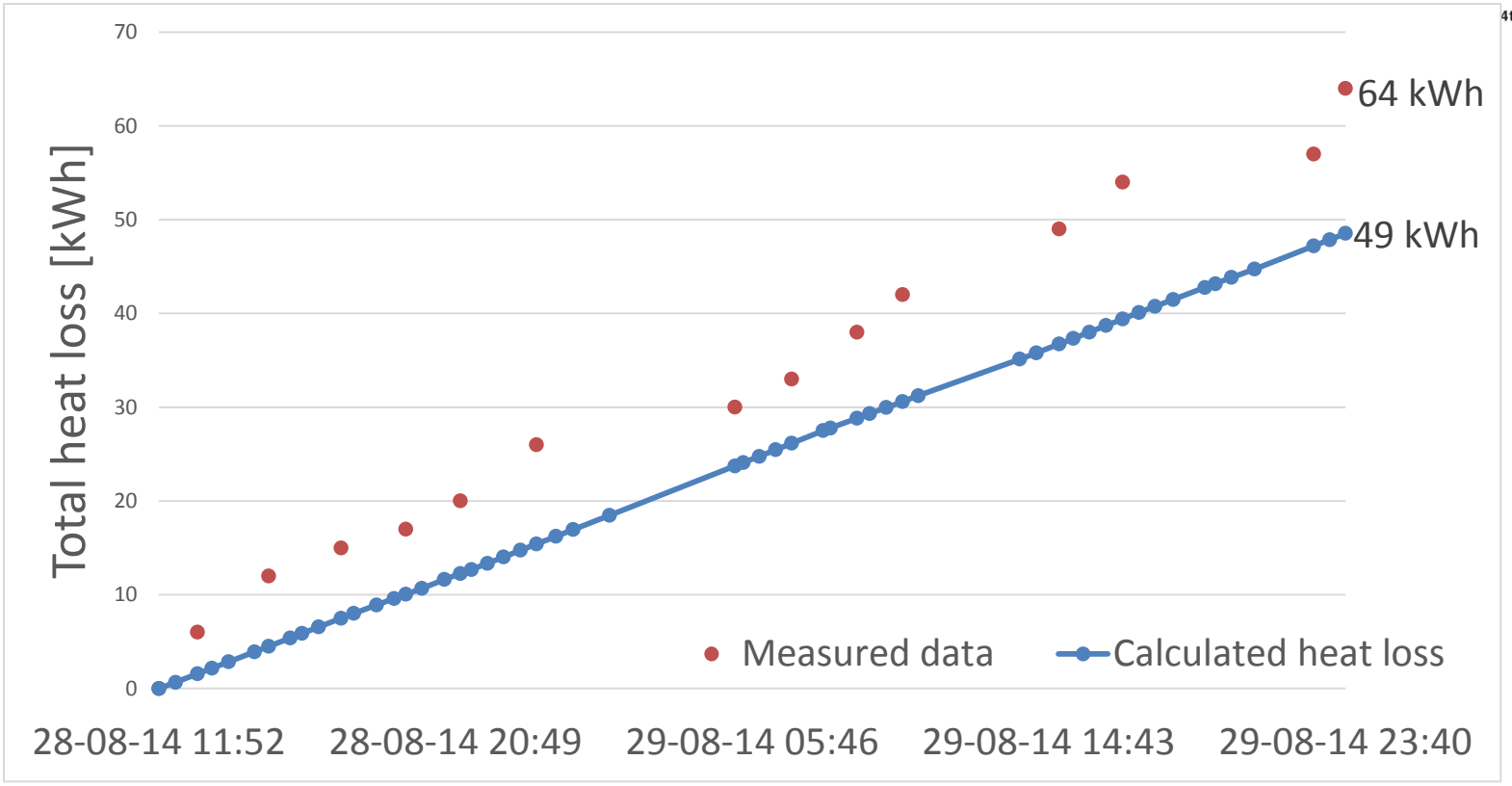
For full comparison of the economy analysis, investment, costs in the production and network should be included in the future work

Validation of the decentralized substat model



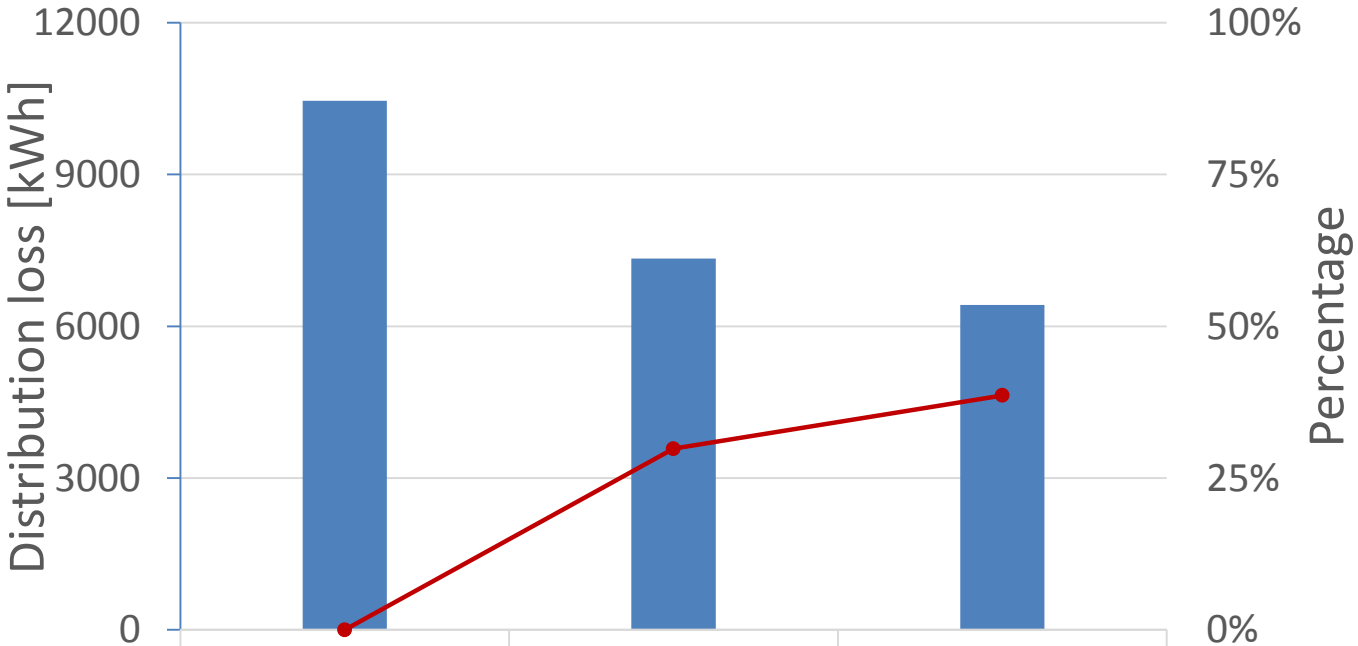
- Deviation 2.44 °C ($\chi = -0.39$)

Validation of the decentralized substat model



- Deviation might be caused by heat bridge

Annual distribution heat loss of 3 scenarios



	Scenario 1	Scenario 2	Scenario 3
loss	10457	7337	6421
Savings	0%	30%	39%

Cost for covering the distribution heat loss

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Cost [DKK/yr]	Scenario1	Scenario 2	Scenario3	
Supply	7810	4100	Heat	Electricity
			3990	700
Return	560	1770	680	
Total	8370	5870	5370	

Conclusion

- **Decentralized substation system can realized low temperature district heating without risk of Legionella**
- **Compared to conventional system, decentralized substation system can save 30% distribution heat loss, and 30% cost**
- **Decentralized substation sytem with in-line circulation pipe and heat pump can save 39% heat loss and 36% cost compared to conventional system**