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Thermal length of heat exchangers for the next generation of DH substations

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4DH
4th Generation District Heating
Technologies and Systems

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The methodology applied

Methodology:

By applying a longer TL (thermal length), the area of the heat exchanger is increased, leading to increased investment costs.

At the same time a longer TL results in a lower DH return temperature, resulting in distribution heat loss savings for the DH network.

Based on a 12 year time duration (IR2%), the "affordable" TL is calculated

Tool:

Dynamic building model, supplied by DH, simulating a yearly heating consumption profile, with the focus on the DH return temperature as a function of the TL of the heat exchanger.

Application:

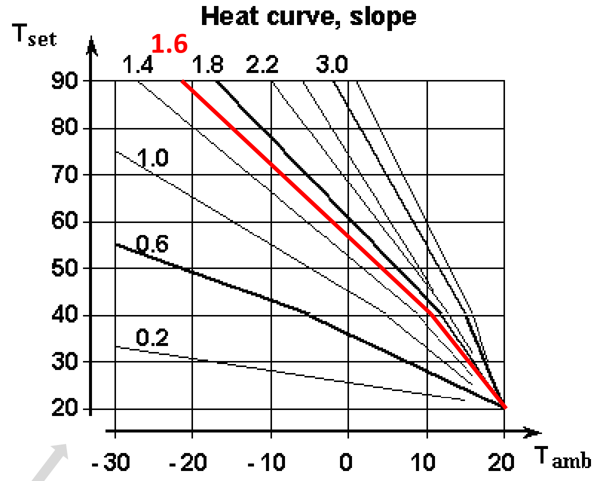
Indirect heating system for a building.

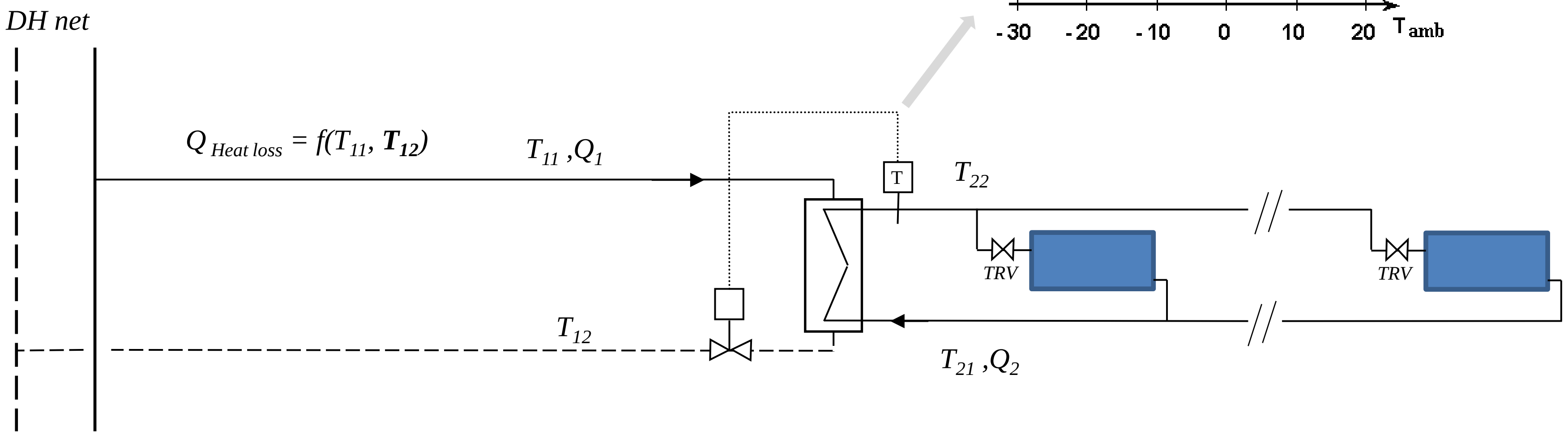
The heating system

The network return temp. (T_{12}) is a function of:

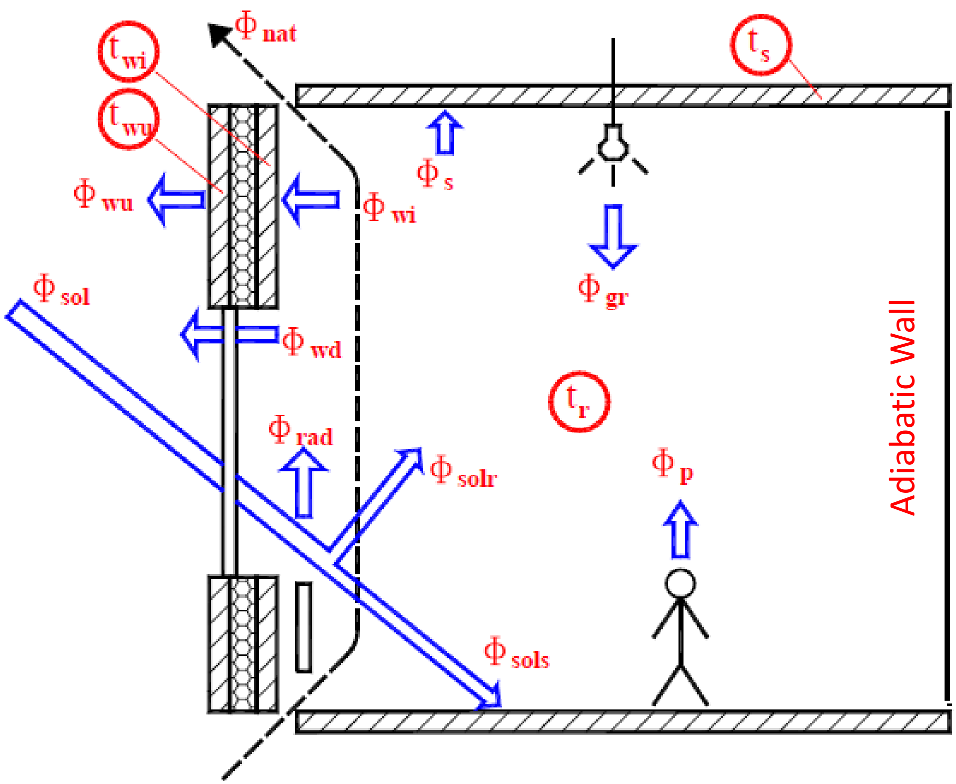
The secondary side heating system, (T_{21}, T_{22})
The heat demand, or load level, (T_{amb})
Solar radiation (W/m^2)
The primary temp. (T_{11}),

AND the heat exchanger TL!





The building model



Lumped Capacity Model
Based on SIMULINK dynamic model (MATLAB®)

6 rooms, 2x15m², 2x20m², 2x40m²
4 capacity model
(inner & outer walls, Furniture, air)
Total Area 150 m² (1 Family flat)
Yearly heat consumption 12 MWh

Concrete building envelope (heavy)

Outdoor climate: DRY weather data (DK)
(Ambient temperature and solar radiation (South) sampled in 5 minutes interval)

No free heat gain or persons heat emission taken into account.

Natural ventilation of 0,5 1/hr

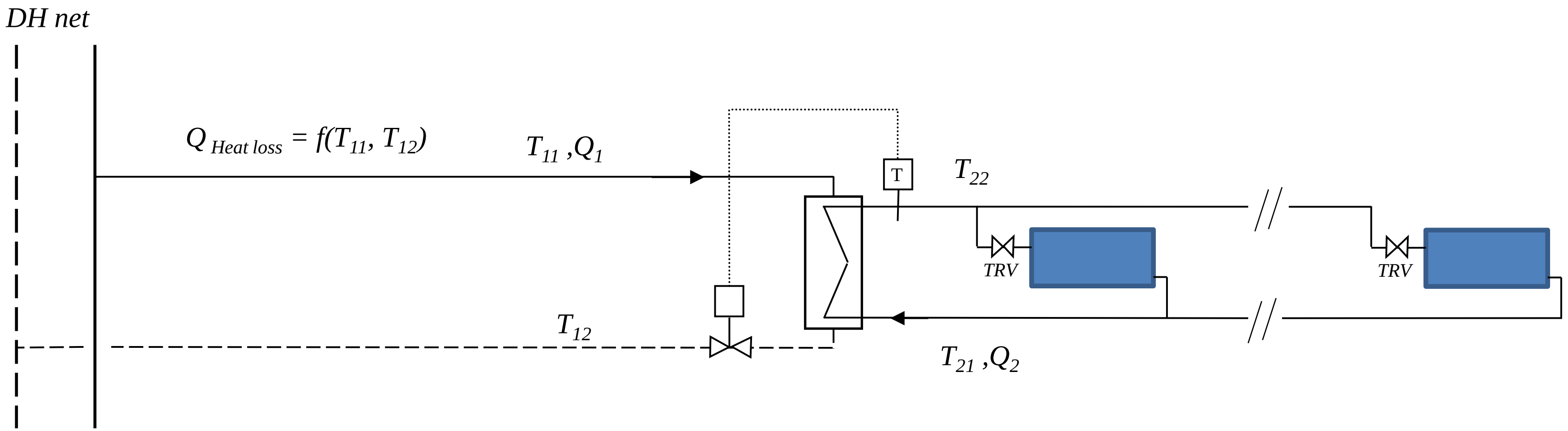
The Scenarios simulated

Scenario 1:

$T_{11} = T_{22} + 10°C$, but minimum $60°C$ (Normal applied)

Scenario 2:

$T_{11} = T_{22} + 5°C$, but minimum 55$°C$ (LTDH applied)



The heat exchangers

Capacity 10 kW
dP max = 20 kPa

TL = 1,0 Ar = 1,0
70/42,8 – 60/30
(100/33 – 60/30)

TL = 1,5 Ar = 1,53
70/36,1 - 60/30

TL = 2,0 Ar = 2,4
70/32,9 – 60/30

TL = 2,5 Ar = 3,33
70/31,5 – 60/30

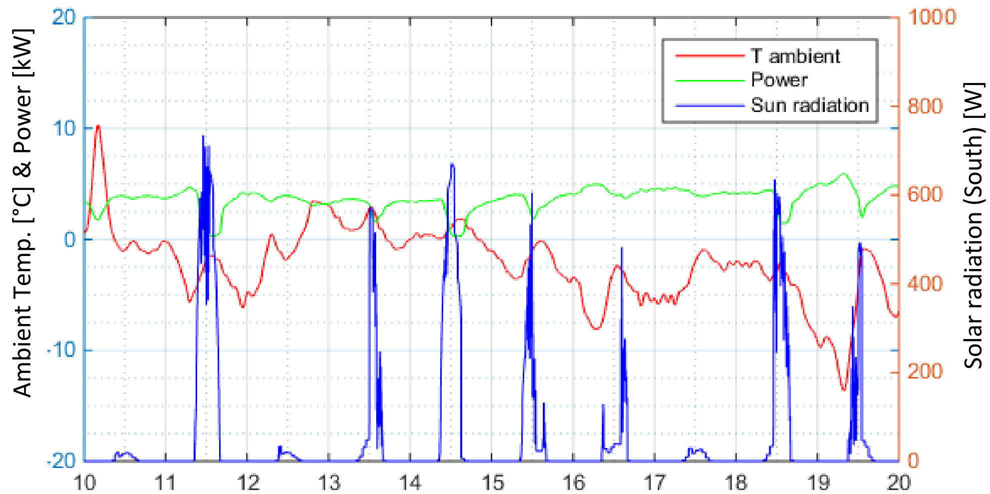
TL = 3,0 Ar = 4,53
70/30,8 – 60/30

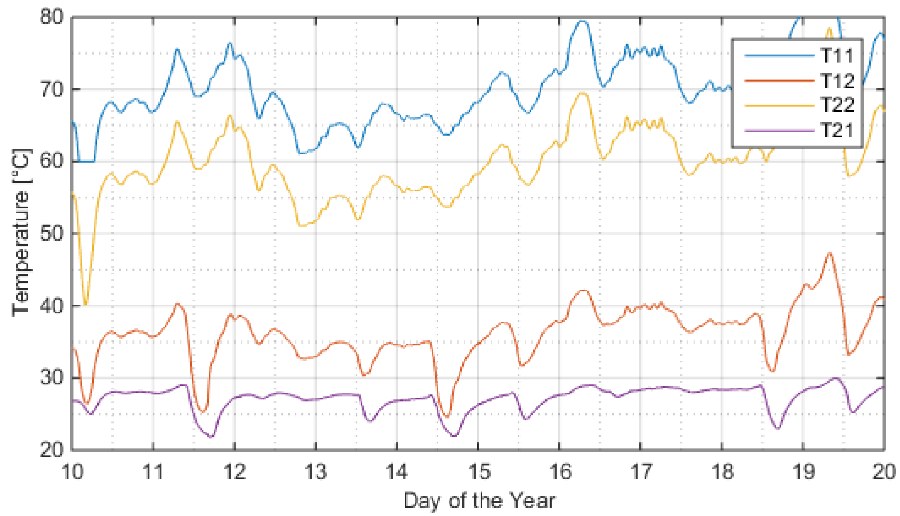
The Economy

DH net loss	Energy costs	Area increase HE pr. °C reduced return temp. (12 years, 2% IR)
[%]	[EUR/MWh]	[%]
10	**40**	**19**
10	**60**	**29**
20	40	44
20	60	66

Assumptions:
1°C lower return temperature results in 1% saved thermal distribution loss.
Heating is applied 8 months/year.
12 years of saved thermal energy loss is spend on additional heat exchanger area.
dP media = 20 kPa, utilised where possible, analysis based on symmetric heat exchanger
Costs of heat exchanger is based on end-consumer prize.

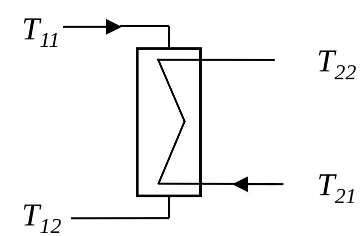
Example of simulation results





Scenario 1

TL = 1



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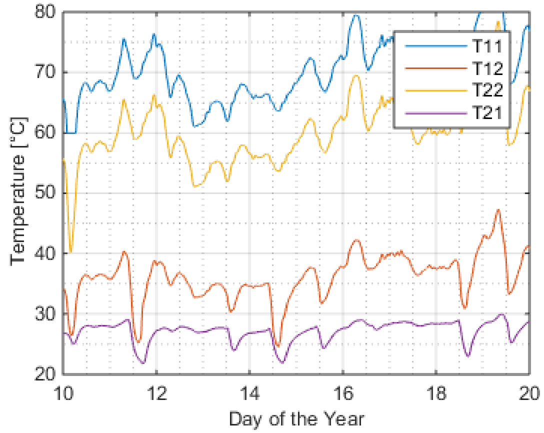
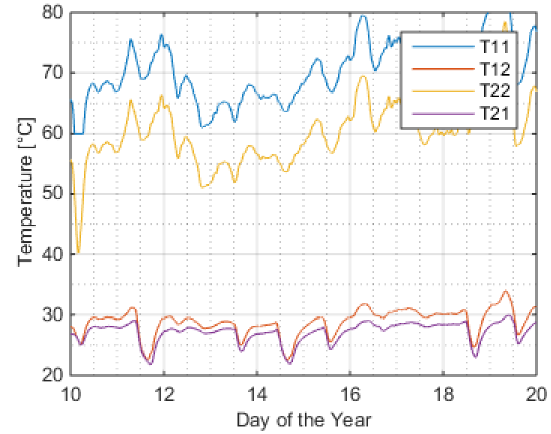
Example of simulation results

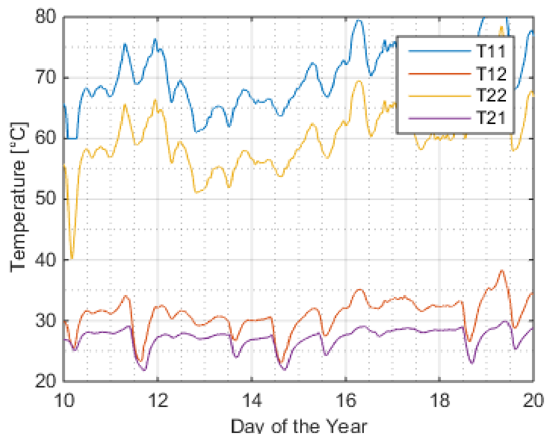
TL = 1



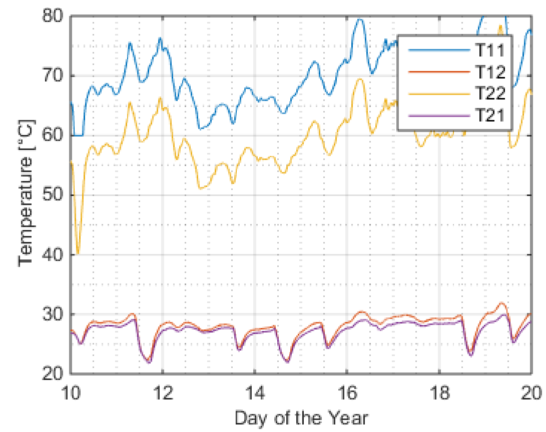
TL = 2,0



TL = 1,5



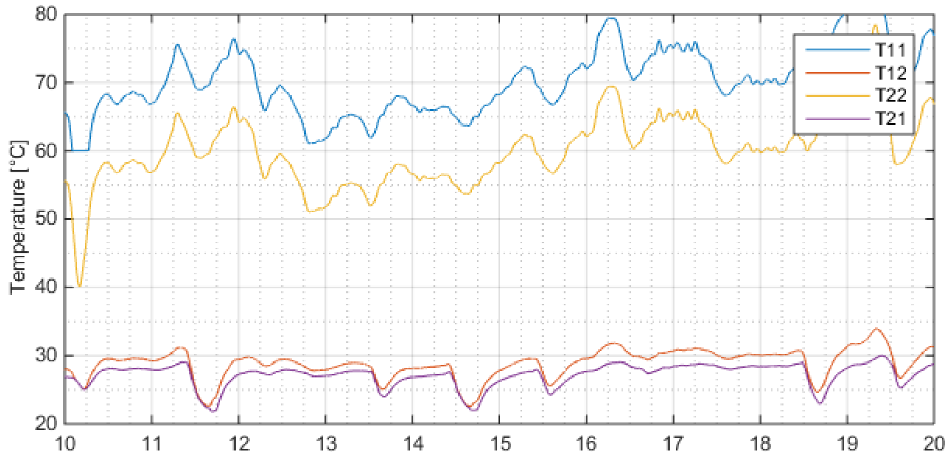
TL = 2,5



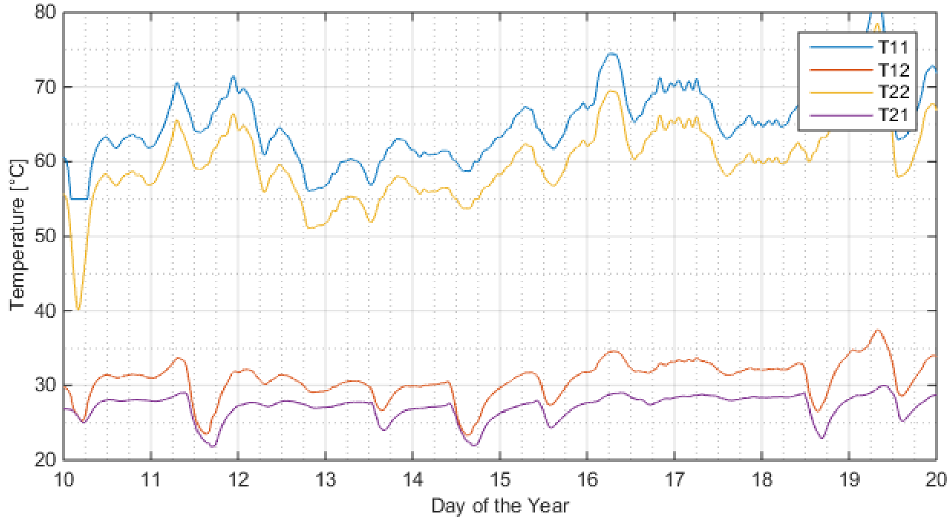
Scenario 1

Example of simulation results

Scenario 1
TL = 2



Scenario 2
TL = 2



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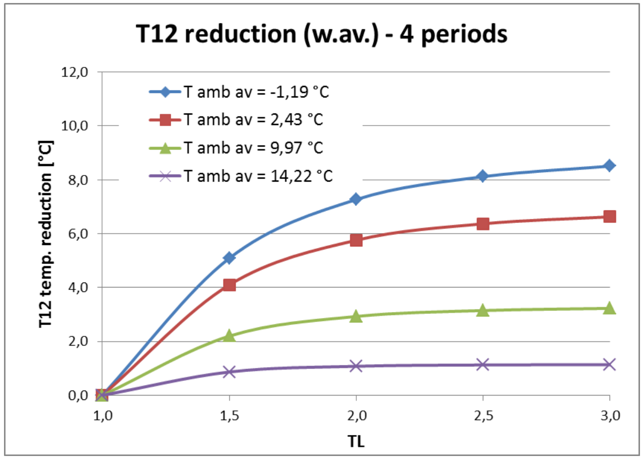
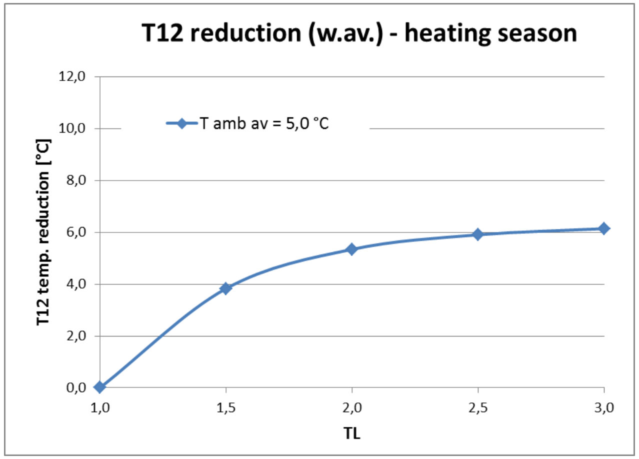
Reduction of T_{12}

Scenario 1

$T_{11\,min} = 60°C$

$T_{11} = T_{22} + 10°C$

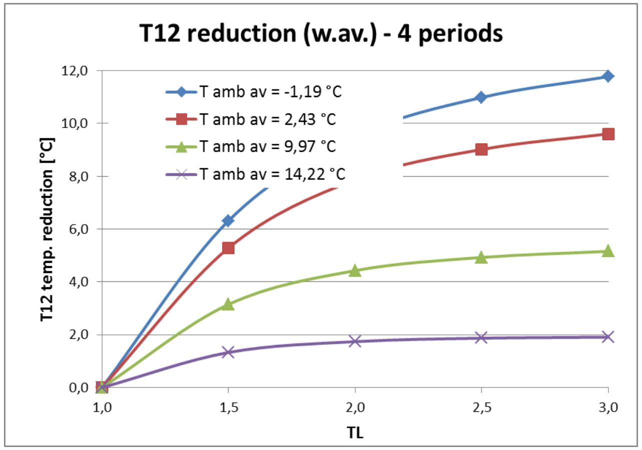


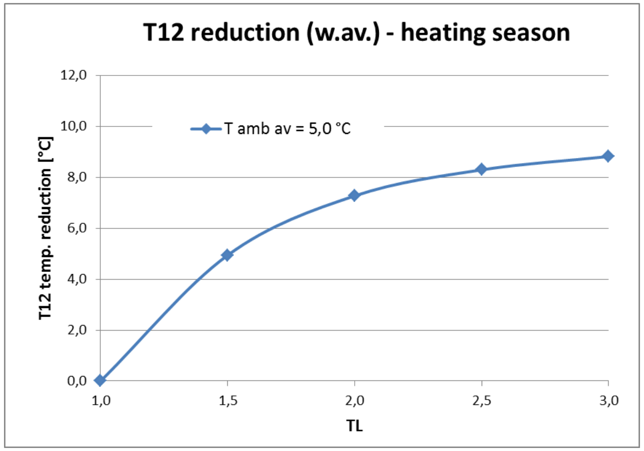


Scenario 2

$T_{11\,min} = 55°C$

$T_{11} = T_{22} + 5°C$





Affordable thermal length (TL)

10% Loss
40 EUR/MWh

10% Loss
60 EUR/MWh

Scenario 1

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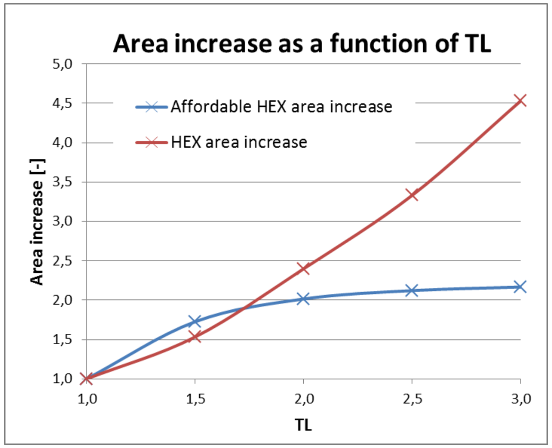
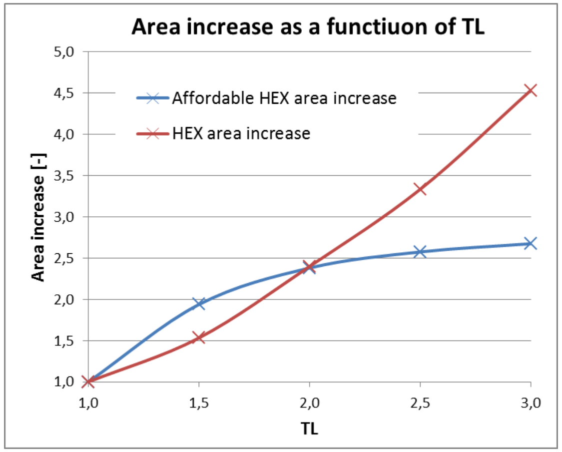
$T_{11} = T_{22} + 10°C$



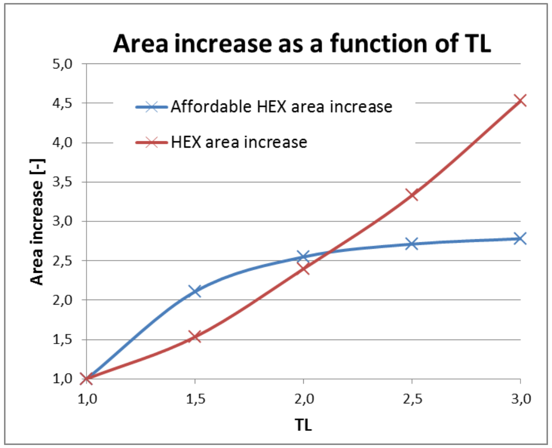


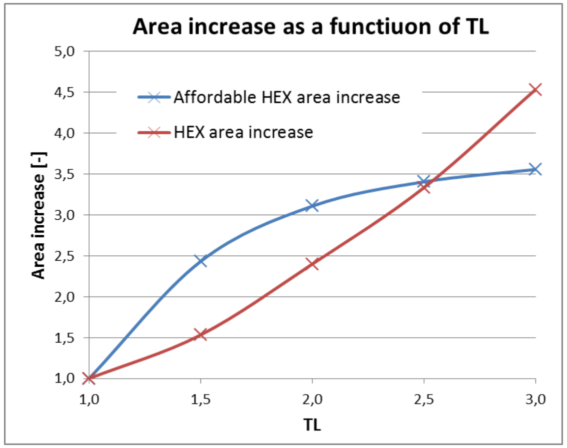
Thermal Length:
1,7 to 2,0
Area increase:
1,8 to 2,4

Scenario 2

$T_{11\,min} = 55°C$

$T_{11} = T_{22} + 5°C$





Thermal Length:
TL 2,1 to 2,5
Area Increase:
2,6 to 3,4

Discussion

Plant efficiency and increased available surplus heat sources for reduced DH temperatures not included.

Impact from change of pumping costs not included. Basically flows are reduced due to increased primary *dT*.

Higher *dT* leads to lower flow, resulting in additional network capacity

Products are ready today in terms of 2 path heat exchangers. Still some design needed (or market pull) for physically short 1 path heat exchanger in combination with long thermal length.

Field test would be relevant to confirm simulated results.

Conclusions

Economically beneficial to specify heat exchanger with longer thermal length

- DH has to develop for positioning itself in the future energy system > 4G
- Also beneficial for current system situation (lower return temp, future proof)
- Heat exchanger retrofit is not so obvious from a economic point of view.

The analysis showed feasible to

- Increase thermal length by a factor of 1,7 to 2,5 >
  in general TL=2 would be a fair recommendation
- Increase area by a factor of 1,8 to 3,4 >
  in general a factor 2,5 would be a fair recommendation
- Reduced primary flow by 14% (Scenario 1) to 22% (Scenario 2) @ TL=2

Other arguments

- heat exchanger technology develops !
- fits to historical trend
- Supports the technical demands of 4G DH / LTDH
- We must push the technology for realizing 4G DH going forward

Thank You for the Attention

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