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Impact of increased thermal length of heat exchangers for district heating substations by case example

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The methodology applied

Methodology:

Focus on the heat exchangers for heating (HE) and domestic hot water (DHW). Measurement are made for different thermal lengths of the heat exchanger for HE and DHW.

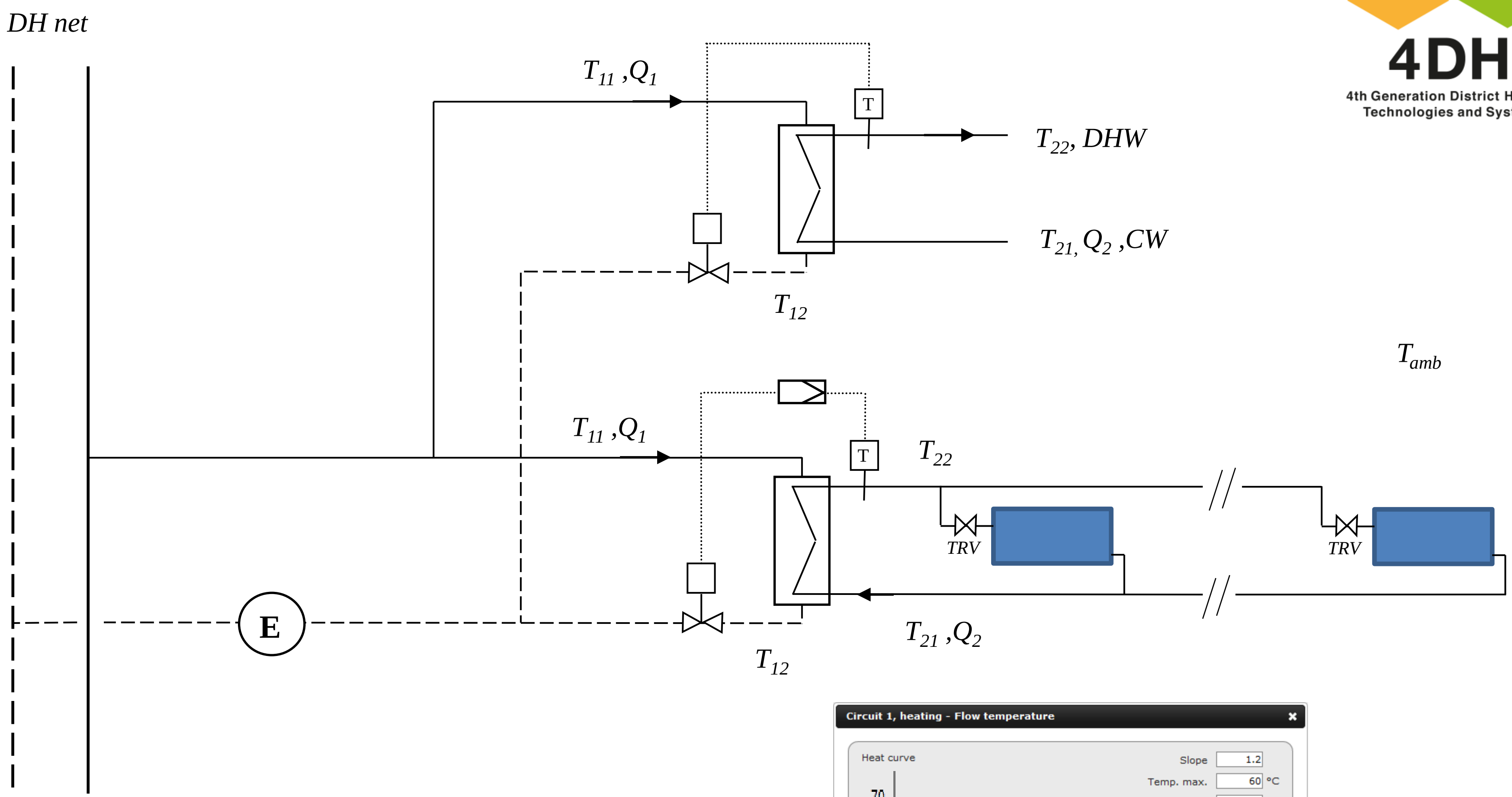
Aim: To verify the reduced DH return temperature as a result of the increased thermal length

Two measuring series:

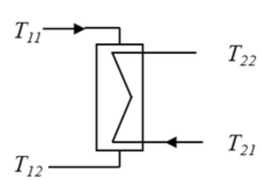
1. Measurements made directly at heat exchanger for heating, including temperature and flow.
- Independent on DHW
- Heating season, no changing on TRV settings during measuring periode !
2. Measurements made directly at heat exchanger for DHW, including temperature.
- Outside heating season, heating switched off !

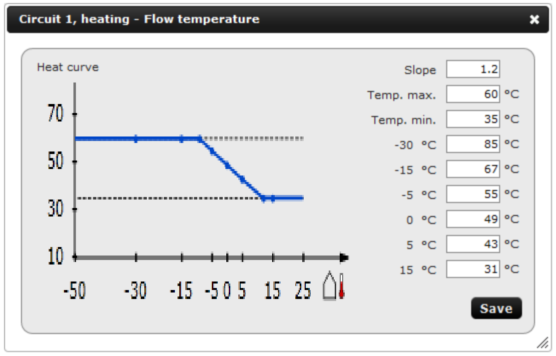
Heat meter data logged as well.

The field test installation



$$\Delta T_{hot} = T_{11} - T_{22}$$
$$\Delta T_{cold} = T_{12} - T_{21}$$





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The field test installation site

One family house:	224m^2, build 1979, 2 storey
Inhabitants:	2 adults and 3 teenagers
Heating consumption:	13,3 MWh/y
DHW consumption:	2,9 MWh/y
Total:	16,2 MWh/y (period 1. Sep. 2015 to 1. Sep. 2016)

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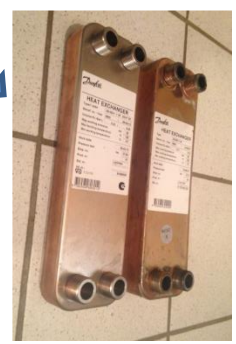
The field test installation site

Heating

DHW



Two types of HEX applied for Heating and DHW

Difference in Thermal length ! (*TL1* and *TL2*)

Heat exchangers *TL1* and *TL2*

Design Case

32 x 10 cm

Heating:

XB06H 26 plates

TL1 = 0,73

12kW

60/29,1-25/50°C

1,7/2,2 kPa

⬇

XB06H+ 26 plates

TL2 = 1,00 (+37%)

12kW

60/27,6-25/50°C

3,7/5,2 kPa

T return temp. red.: 1,5°C

DHW:

XB06H 26 plates

TL1 = 0,73

32kW

60/23,5-10/50°C

7,6/5,8 kPa

⬇

XB06H+ 40 plates

TL2 = 1,00 (+37%)

32kW

60/17,1-10/50°C

5,8/6,3 kPa

T return temp. red.: 6,4°C

TL1 = 0,73

TL2 = 1,00

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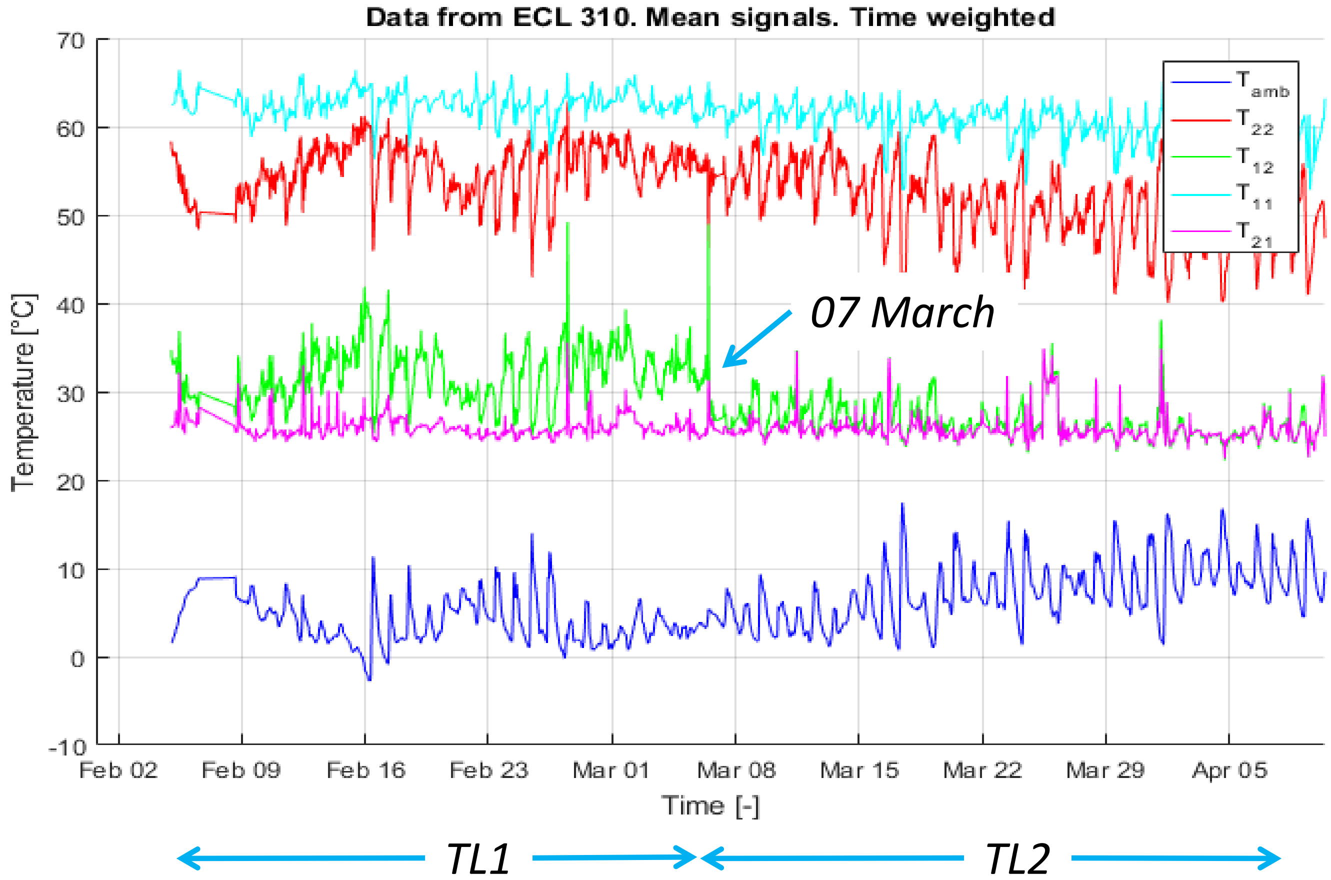
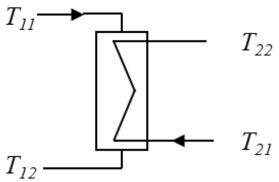
HE measurements

Direct temperature measurements at heat exchanger





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HE measurements

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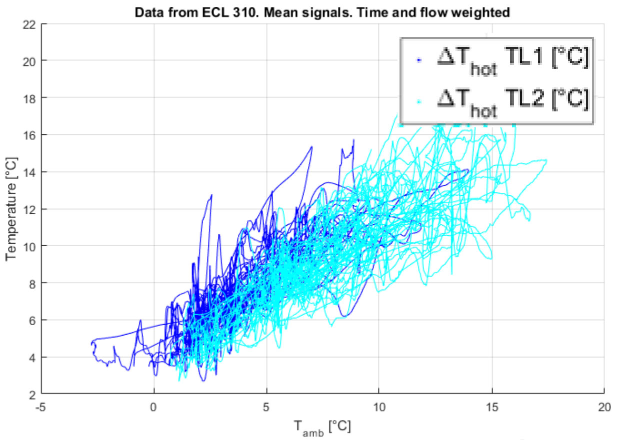

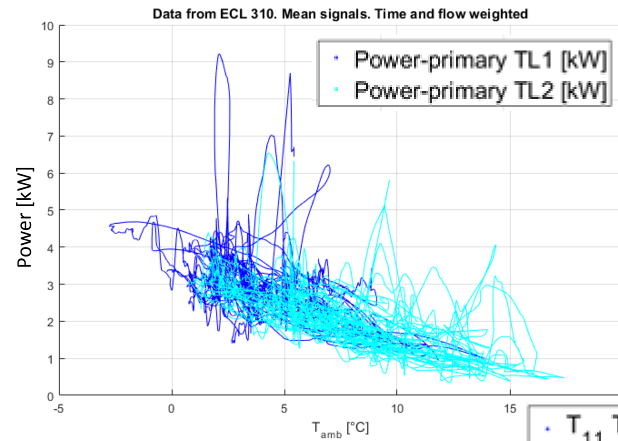

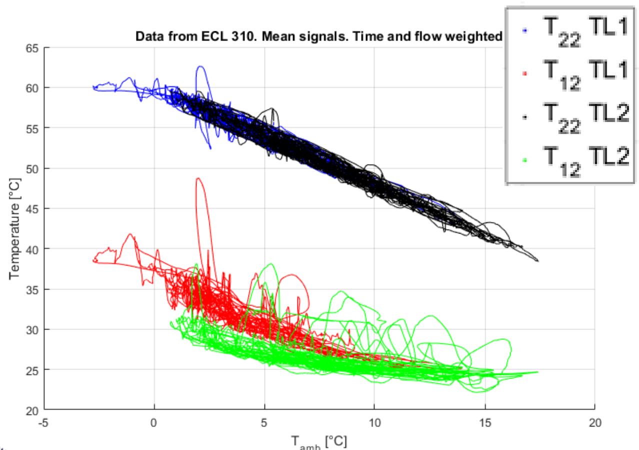

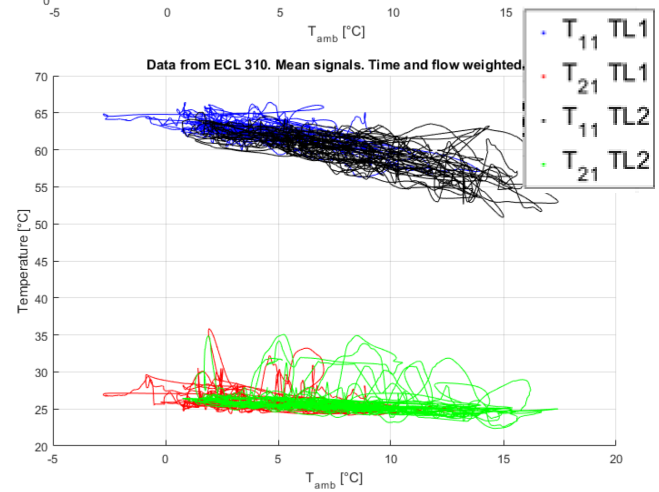

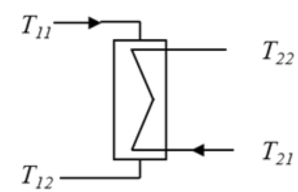

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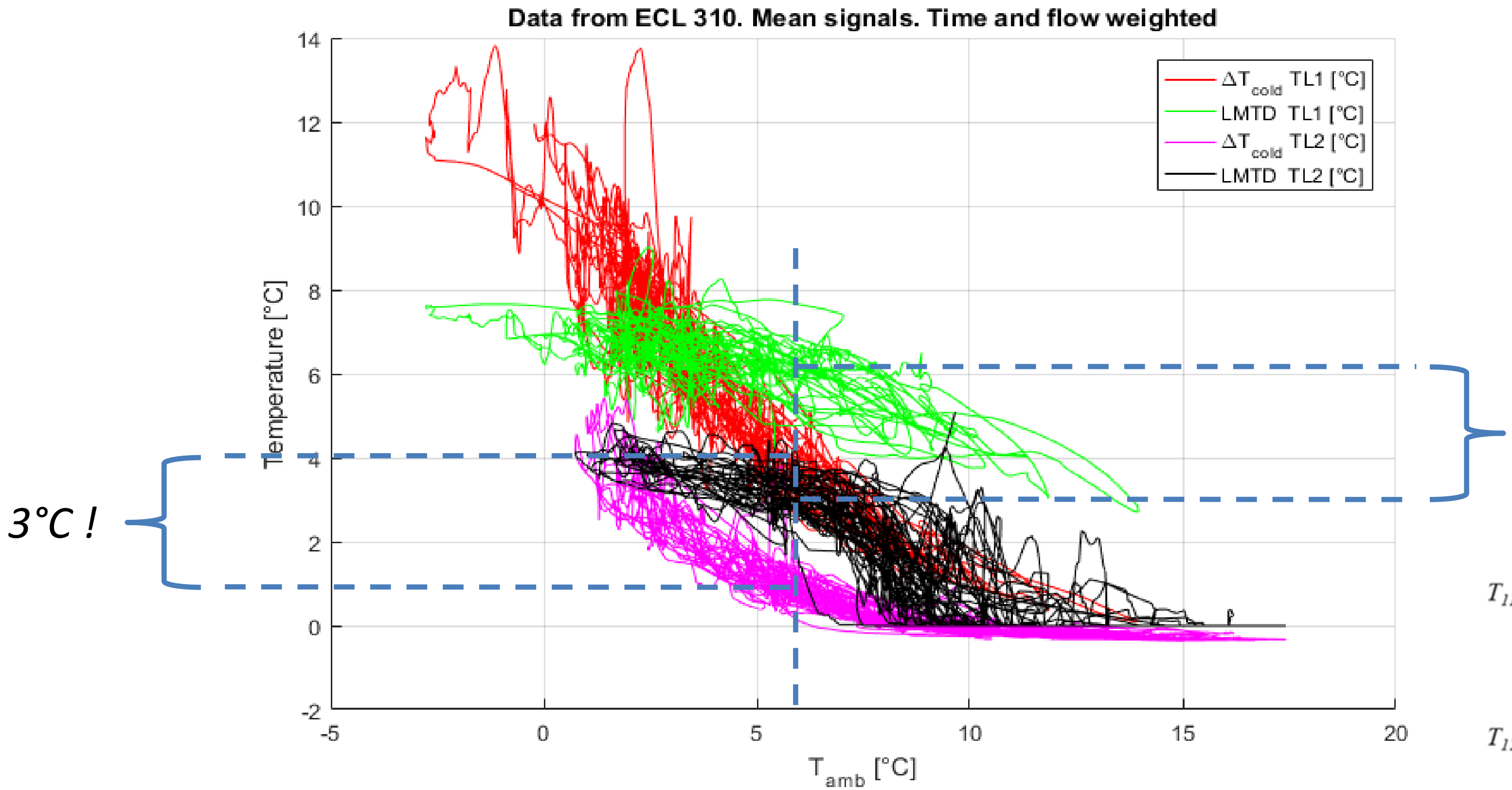
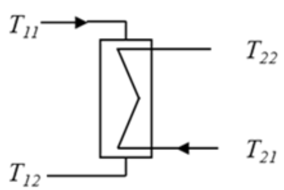
HE measurements

Direct temperature measurements at heat exchanger





T_{12} reduced 3,0°C based on T_{amb} weighted with degree days
Heating season October to April, 7 months
T_{amb} degree day weighted = 5,9°C

HE measurements

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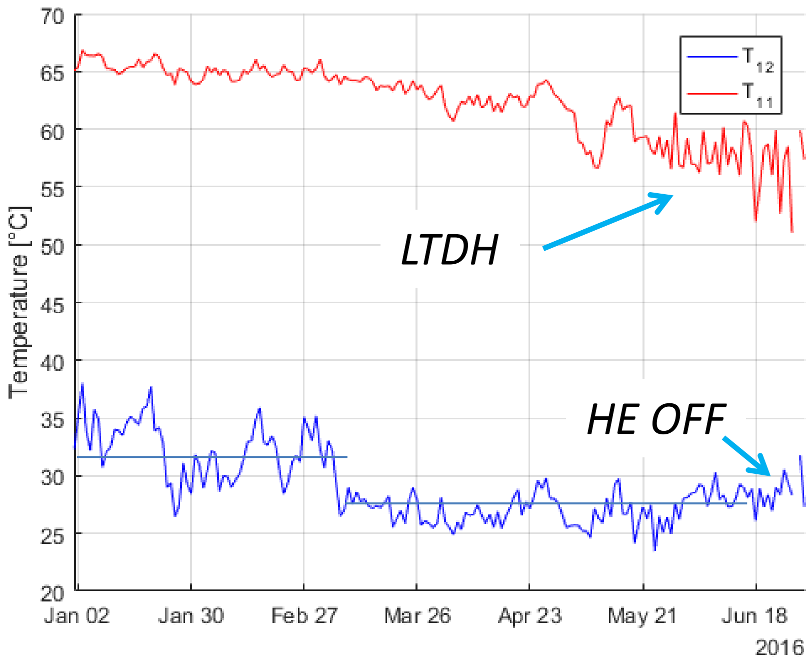
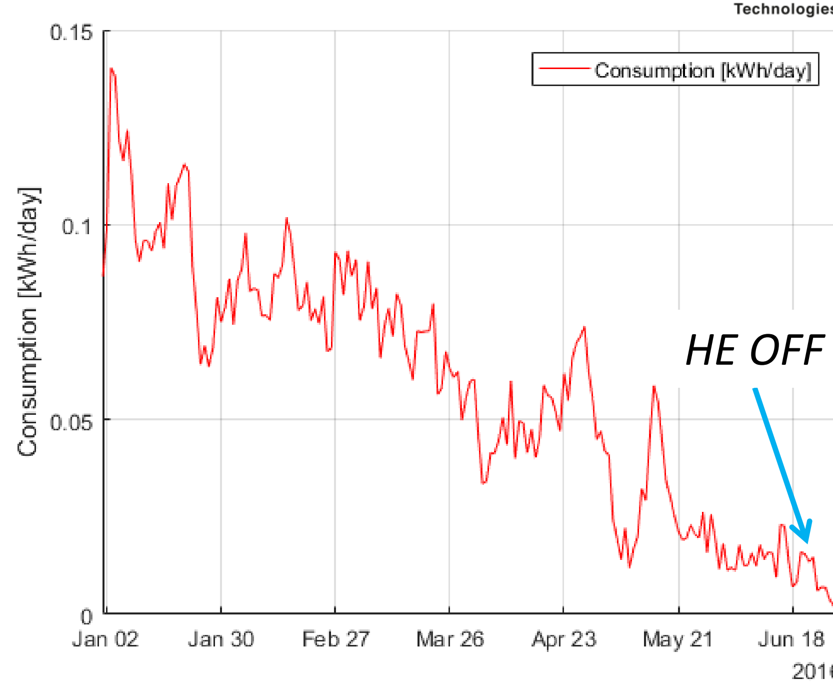
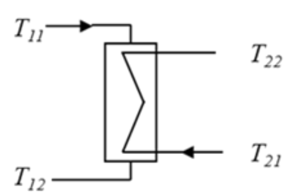
Data from heat meter, flow weighted !





← *TL1* → ← *TL2* →   ← *TL1* → ← *TL2* →

07 March



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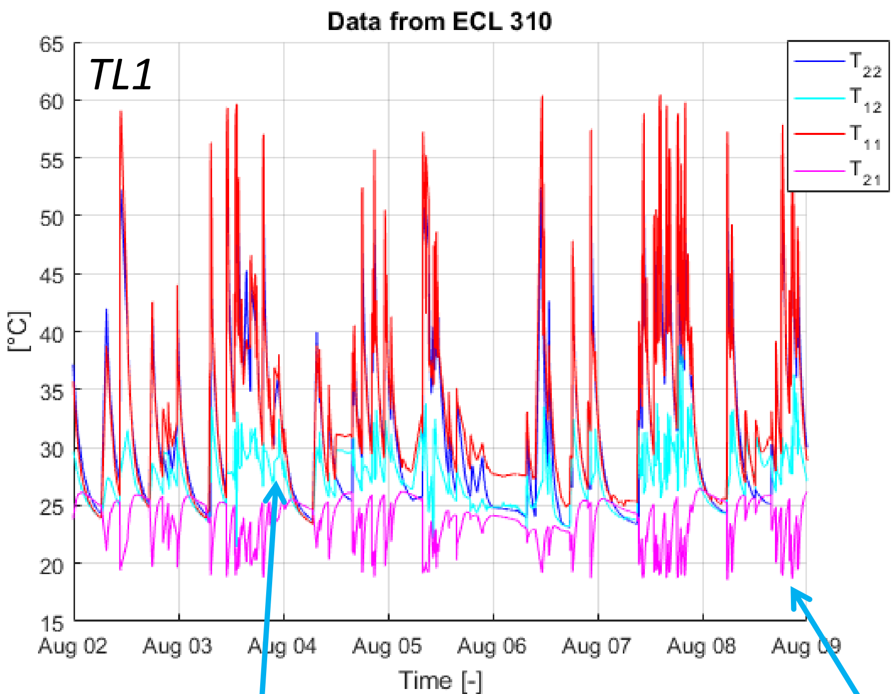
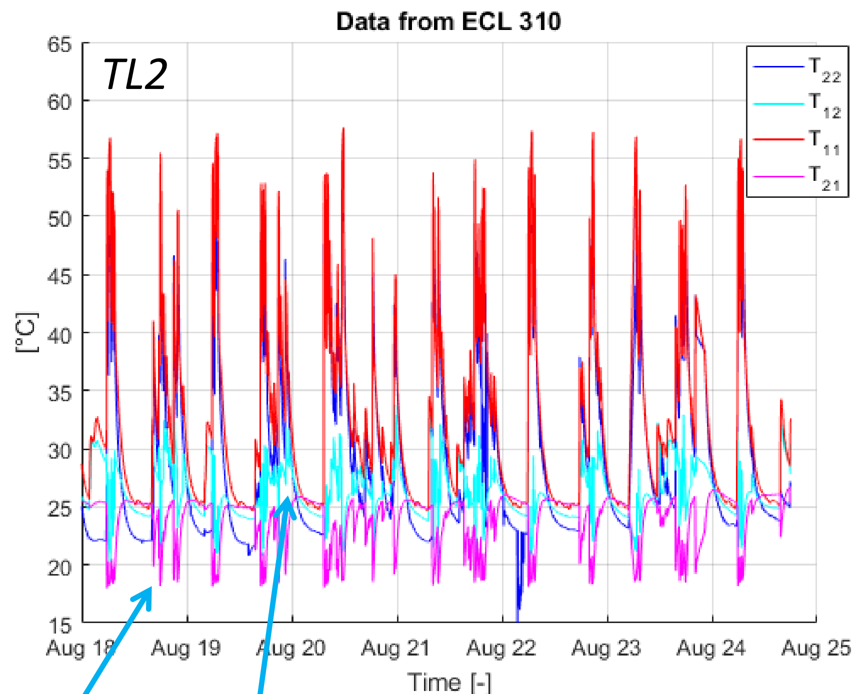
DHW measurements

Direct temperature measurements at heat exchanger

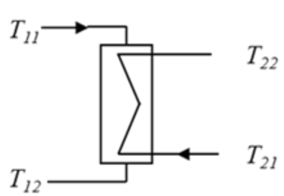




$T_{12\ av}$ = 27,4°C (DH return)

$T_{12\ av}$ = 26,2°C (DH return)

$T_{21\ av}$ the same ? > 23,9°C and 24,0°C (CW)



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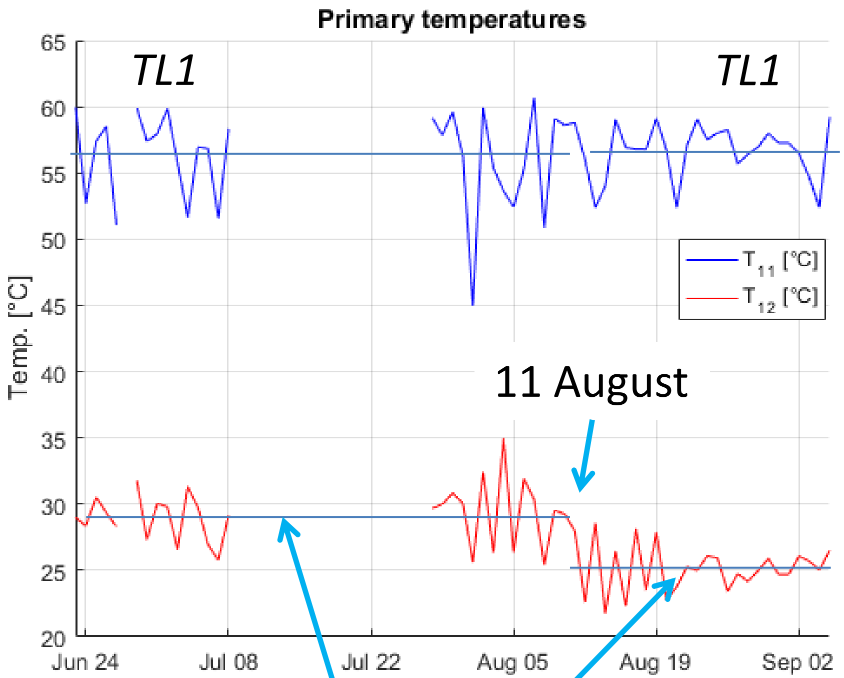
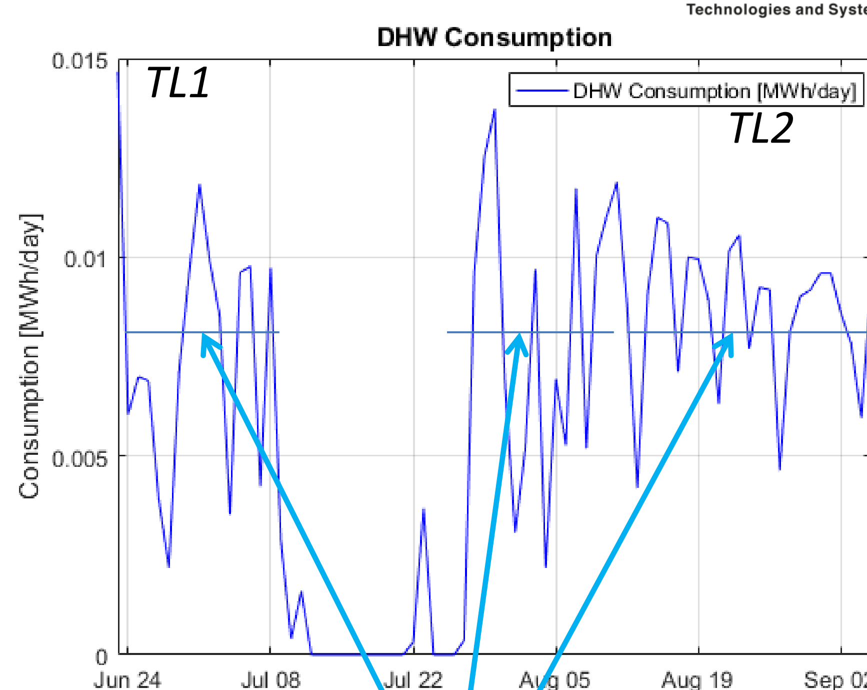
DHW measurements

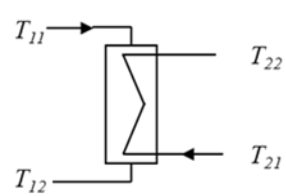
Data from heat meter, flow weighted !





Reduced DH return temp. T_{12} = 4°C

8 kWh/day average



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The Economy

The value of 1°C reduced return temperature:

For each degree return temperature below 35°C a saving of 1% of the variable cost is given as a bonus. *(Ref.: Augustenborg Fjernvarme AMBA)*

HE return temp. reduced by 3,0°C

DHW return temp. reduced by 4,0°C

Variable cost of energy: 62,90 EURO/MWh

Bonus HE:	0,03 x 62,90 x 13,3 =	25,1 EURO/y
Bonus DHW:	0,04 x 62,90 x 2,9 =	7,3 EURO/y
Total saving:		32,4 EURO/y

Additional costs HEX (+14 plates) 90 EURO > Simple pay back time 2,8 years

Remaining life time bonus (12,2 years) = 396 EURO

Discussion

Data are based on a part of the year, then analysed and calculated as yearly values

- Anyhow this is assumed to have a minor impact on the yearly result

Compared to the design values from the dimensioning case:

HE: Design gave 1,6°C reduced return temp.
Field measurements gave 3°C
- ΔT_{hot} is lower than in design case > increasing ΔT_{cold}
- Low dP at part load > influence on flow distribution in HEX

DHW: Design gave 6,4°C reduced return temp.
Field measurements gave 4°C
- Impact of idle temp. at no tapping is reducing the benefit !
- T_{cw} is in reality higher than design , > easier for HEX !

The bonus system represents the value of reduced DH return temperature

- The bonus is assumed to cover all related parameters, plant efficiency, pumping costs and thermal distribution loss
- It might not be totally fair bonus system! > Dependency of DH flow temperature is relevant (applied e.g. at Thisted DH utility)

Conclusions

The measurements revealed:

- A reduced return temperature of 3°C for HE going from *TL1* to *TL2*
- A reduced LMTD of 3°C for HE going from *TL1* to *TL2*
  (TL increased by 37%, Area same, Costs same)
- A reduced return temperature of 4°C for DHW when going from *TL1* to *TL2*
  (TL increased by 37%, Area increased 54% > increased costs)

Additional initial investment:

- 90 EURO, compared to yearly bonus of 34,2 EURO gives simple pay back time of 2,8 years
- Bonus for remaining lifetime of heat exchangers/substation 396 Euro
- Economical beneficial to specify heat exchangers with longer thermal length
- Heat exchanger retrofit is not so obvious from a economic point of view.

General remarks:

- DH has to develop for positioning itself in the future energy system > 4G
- We must push the technology for realizing 4G DH going forward
- Highly relevant to adapt tech. specification related to HEX performance for Utilities
- In general thermal lengths should be increased compared to specifications of today

Thank You for the Attention

Contact information:

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Back Up- The Economy

1°C lower return temperature results in 1% saved thermal distribution loss.
Heating is assumed to dominate the return temp. during 7 months/year.

Assume 25% thermal distribution loss for the DH network
For this case the thermal distribution loss would be 5,4 MWh/y belonging to the investigated site

Energy saving related to HE:

3/100 x 7/12 x 5,4 MWh/y = 0,126 MWh/y > value 6,3 EURO/y

Energy saving related to HE:

4/100 x 5/12 x 5,4 MWh/y = 0,068 MWh/y > value 3,4 EURO/y Total 9,7 EURO/y*

*) Included in bonus