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

\[ \Delta T_{\text{hot}} = T_{11} - T_{22} \]
\[ \Delta T_{\text{cold}} = T_{12} - T_{21} \]
The field test installation site

<table>
<thead>
<tr>
<th>Description</th>
<th>Details</th>
</tr>
</thead>
<tbody>
<tr>
<td>One family house:</td>
<td>224m², build 1979, 2 storey</td>
</tr>
<tr>
<td>Inhabitants:</td>
<td>2 adults and 3 teenagers</td>
</tr>
<tr>
<td>Heating consumption:</td>
<td>13.3 MWh/y</td>
</tr>
<tr>
<td>DHW consumption:</td>
<td>2.9 MWh/y</td>
</tr>
</tbody>
</table>
The field test installation site

Two types of HEX applied for Heating and DHW

Difference in Thermal length! (TL1 and TL2)
## Heat exchangers TL1 and TL2

### Design Case

#### 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

#### 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.: 1.5°C_  
_T return temp. red.: 6.4°C_
HE measurements

Direct temperature measurements at heat exchanger

Data from ECL 310. Mean signals. Time weighted

07 March

TL1 → TL2

HE measurements

Direct temperature measurements at heat exchanger
HE measurements

Direct temperature measurements at heat exchanger

Data from ECL 310. Mean signals. Time and flow weighted

$T_{12}$ 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

Data from heat meter, flow weighted!

07 March
DHW measurements

Direct temperature measurements at heat exchanger

$T_{12\,av} = 27.4^\circ C$ (DH return)

$T_{21\,av}$ the same ? $> 23.9^\circ C$ and $24.0^\circ C$ (CW)

$T_{12\,av} = 26.2^\circ C$ (DH return)
DHW measurements

Data from heat meter, flow weighted!

**Primary temperatures**

- **TL1**
- **TL2**

11 August

Reduced DH return temp. $T_{12} = 4^\circ C$

**DHW Consumption**

- **TL1**
- **TL2**

8 kWh/day average
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: \(0,03 \times 62,90 \times 13,3 = 25,1\) EURO/y
Bonus DHW: \(0,04 \times 62,90 \times 2,9 = 7,3\) 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
   - $\Delta T_{hot}$ is lower than in design case > increasing $\Delta T_{cold}$
   - 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

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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:

$$\frac{3}{100} \times \frac{7}{12} \times 5,4 \text{ MWh/y} = 0,126 \text{ MWh/y} > \text{value 6,3 EURO/y}$$

Energy saving related to HE:

$$\frac{4}{100} \times \frac{5}{12} \times 5,4 \text{ MWh/y} = 0,068 \text{ MWh/y} > \text{value 3,4 EURO/y} \quad \text{Total 9,7 EURO/y}$$

*) Included in bonus