Combining solar and district heating in IDA ICE

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Introduction

- The project aims to find future district heating solutions for residential districts.
- How much solar energy can be utilized in connection with district heating in a small house?
- District heating substation model, including solar heating, was implemented into building energy simulation (IDA-ICE).
District heating substation

- Domestic hot water out: 58 °C
- District heat in winter/summer: 85/75 °C
- DHW circulation: 58/55 °C, 250 W
- Domestic hot water in: 8 °C
- Floor heating, max.: 38 °C

10/10/2014
District heating substation, with solar collectors

- Domestic hot water out 58 °C
- District heat in winter/summer 85/75 °C
- Floor heating, max. 38 °C
- Solar collectors, 3 to 12 m²
  Zero loss efficiency 75%
- Storage tank, 200 to 1200 liters

DHW circulation 58/55 °C 250 W
Standard heating plant (boiler) in IDA ICE

Standard Plant

Plant model with (by default) very large capacity. Supply hot water setpoint is a function of outside air temp. Chilled water temperatures to zones and AHU are constant. Open boiler and chiller to set parameters.
Some useful system components in IDA ICE
New district/solar heating substation model

Sunny day 23.6 at 10:00
Building heating power
Located in Helsinki, Finland

Heating power, W

<table>
<thead>
<tr>
<th>Date</th>
<th>House 1</th>
<th>House 2</th>
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Space heating, kWh | 6 401 | 17 982 |
DHW use, litres per day | 133 | 220 |
DHW heating, kWh | 2 820 | 4 675 |
DHW circulation, kWh | 2 190 | 2 190 |
Total heating, kWh | 11 410 | 24 845 |

Hot water use profile

Probabilty of consumption

Hour of day
Solar collector efficiency

![Graph showing the relationship between collector efficiency and mean temperature-outdoor temperature.]
Example of solar collector heating power (W)
House 2, collector area 6 m², tank volume 400 l

- Less solar heat at the end of the week
Example of tank temperatures
House 2, collector area 6 m², tank volume 400 l

- The tank is cooling down towards the end of the week
Example of DHW heat exchanger operation

House 2, collector area 6 m², tank volume 400 l

- The storage tank can sometimes cover also DHW circulation need (250 W)
Example of heating heat exchanger operation
House 2, collector area 6 m², tank volume 400 l

- The storage tank can cover heating need few hours in the evening
Energy cumulation during the year
House 2, collector area 6 m², tank volume 400 l

- Solar energy from March to September
- Used mainly for domestic hot water
Savings in district heating energy due to solar heat

House 2

- Energy saving max. 54% of DHW heating need (4675 kWh, 220 l/day)
- Savings per collector area decrease with increasing collector area
- Storage tank volume has only a small influence
- Solar energy to DHW circulation small

<table>
<thead>
<tr>
<th>Solar collector area</th>
<th>Storage tank volume</th>
<th>From tank to heating</th>
<th>From tank to DHW</th>
<th>From tank to DHW circulation</th>
<th>District heat to DHW heat exchanger</th>
<th>District heat to heating exchanger</th>
<th>District heat saving</th>
<th>Saving per collector area</th>
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</thead>
<tbody>
<tr>
<td>3  m²</td>
<td>200 litres</td>
<td>68 kWh</td>
<td>1166 kWh</td>
<td>18 kWh</td>
<td>5681 kWh</td>
<td>17914 kWh</td>
<td>1259 kWh</td>
<td>420 kWh/m²</td>
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<td>6  m²</td>
<td>400 litres</td>
<td>193 kWh</td>
<td>1616 kWh</td>
<td>58 kWh</td>
<td>5220 kWh</td>
<td>17790 kWh</td>
<td>1843 kWh</td>
<td>307 kWh/m²</td>
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<td>6  m²</td>
<td>800 litres</td>
<td>241 kWh</td>
<td>1610 kWh</td>
<td>19 kWh</td>
<td>5267 kWh</td>
<td>17741 kWh</td>
<td>1845 kWh</td>
<td>307 kWh/m²</td>
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<tr>
<td>12 m²</td>
<td>800 litres</td>
<td>389 kWh</td>
<td>2010 kWh</td>
<td>149 kWh</td>
<td>4764 kWh</td>
<td>17593 kWh</td>
<td>2496 kWh</td>
<td>208 kWh/m²</td>
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<tr>
<td>12 m²</td>
<td>1200 litres</td>
<td>425 kWh</td>
<td>2027 kWh</td>
<td>109 kWh</td>
<td>4791 kWh</td>
<td>17558 kWh</td>
<td>2504 kWh</td>
<td>209 kWh/m²</td>
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<td>0 liters</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>6871 kWh</td>
<td>17982 kWh</td>
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### Savings in district heating energy due to solar heat

**House 1**

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<tr>
<td>m²</td>
<td>litres</td>
<td>kWh</td>
<td>kWh</td>
<td>kWh</td>
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<td>6335</td>
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<td>64</td>
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<td>108</td>
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<td>6</td>
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<td>80</td>
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<td>3240</td>
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</table>

- Energy saving max. 73% of DHW heating need (2820kWh, 133 l/day)
**Effect on district heating return temperature**  
House 2, collector area 6 m², tank volume 400 l

- About 3 degrees higher with solar energy
- Decreases CHP (Combined Heat and Power) power production
Conclusions

- Complicated heat production systems can be built into IDA ICE
- Simulation less robust than using the standard heating plant
- Sollar collectors save max 50% - 70% of domestic hot water heating need
- Relative savings 200 - 400 kWh/m² per collector area, decreasing with area
- Tank size does not have a big influence
- It is challenging to combine economically solar heating with district heating
- Better susbtation concepts needed
- Energy for hot water circulation from the tank is small in the present arrangement
- One possibility is to heat the bathroom with the heating system water, instead of domestic hot water circulation
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