CHPs and HPs to balance renewable power production: Lessons from the district heating network in Stockholm

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Fortum – a mid-sized European power generation player and a major producer in global heat

[Diagram showing power generation, heat production, and customers for major energy producers.]

1) Incl. Fortum's associated company Fortum Värme; power generation 1.3 TWh and heat production 8.2 TWh.
2) Veolia incl. Dalkia International and EDF incl. Dalkia's activities in France.
Source: Company information, Fortum analyses, 2013 figures pro forma; heat production of Beijing DH not available.
Research objective

In research much discussion on:

1. Utilizing CHP for balancing intermittent RES (Lund et al, 2014; Rinne and Syri, 2014; …).
2. Including large scale HPs into DH systems (Lauka et al, 2015; Lund et al, 2016…).

Fortum Värme has operated CHPs since 1970s and large scale HPs since 1990s → accumulated experience in these areas.
Stockholm district heating network

Heat: 4.8 GW, 12 TWh annually
Cooling: 220 MW, 450 GWh annually
Heating storage: 200 MW, 1800 MWh
Cooling storage: 55 MW, 400 MWh

4 larger utilities cooperate:
- Fortum Värme
- Söderenergi
- Norrenergi
- E.On.

Open District heating model
Methodology

Analyzed period:

Sources:
• Measured turbine production and electric power consumption.
• Production planning reports.
• Noordpool spot prices for SE3
• UMM

NPE used to describe the Net Power Export from the Fortum Värme.
## Fortum Värme CHPs and HPs

<table>
<thead>
<tr>
<th>Name</th>
<th>Fuel</th>
<th>Technology</th>
<th>MW heat</th>
<th>MW power</th>
<th>Condensing mode</th>
</tr>
</thead>
<tbody>
<tr>
<td>KVV8</td>
<td>Wood chips (2nd)</td>
<td>CFB</td>
<td>315</td>
<td>132</td>
<td>Yes</td>
</tr>
<tr>
<td>KVV6</td>
<td>Coal/Bio</td>
<td>2x PFBC</td>
<td>350</td>
<td>145</td>
<td>No</td>
</tr>
<tr>
<td>KVV1</td>
<td>Oil (bio/fossil)</td>
<td>Benson</td>
<td>330</td>
<td>220 (250)</td>
<td>Yes</td>
</tr>
<tr>
<td>Högdalen 1-4</td>
<td>Household waste</td>
<td>4x Roster</td>
<td>82</td>
<td>22,5</td>
<td>No</td>
</tr>
<tr>
<td>Högdalen 6</td>
<td>Industrial wood/waste</td>
<td>FBC</td>
<td>105</td>
<td>38</td>
<td>No</td>
</tr>
<tr>
<td>Hässelby 1-3</td>
<td>Wood pellets</td>
<td>3x water pipe</td>
<td>185</td>
<td>69</td>
<td>No</td>
</tr>
<tr>
<td>Brista 1</td>
<td>Industrial wood/waste</td>
<td>FBC</td>
<td>76</td>
<td>41</td>
<td>No</td>
</tr>
<tr>
<td>Brista 2</td>
<td>Household waste</td>
<td>BFB</td>
<td>50,5</td>
<td>20,5</td>
<td>No</td>
</tr>
<tr>
<td><strong>Sum</strong></td>
<td></td>
<td></td>
<td>1178,5</td>
<td>556 (586)</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Name</th>
<th>Heat source</th>
<th>COP</th>
<th>MW heat</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ropsten 1,2,3</td>
<td>Sea water / DC</td>
<td>3,4</td>
<td>251</td>
</tr>
<tr>
<td>Hammarby</td>
<td>Sewage treatment / DC</td>
<td>3,5</td>
<td>248</td>
</tr>
<tr>
<td>Nimrod</td>
<td>DC</td>
<td>3,3</td>
<td>36</td>
</tr>
<tr>
<td>Other</td>
<td>Sewage treatment / DC</td>
<td>3,3</td>
<td>125</td>
</tr>
<tr>
<td>Electric Boilers</td>
<td>n/a</td>
<td>0,98</td>
<td>(300)</td>
</tr>
<tr>
<td><strong>Sum</strong></td>
<td></td>
<td></td>
<td>660 (960)</td>
</tr>
</tbody>
</table>
2015-01-01 to 2016-07-30
Net Power Export Power and spot price SE3

NPE [MW]

SE3 Spot [SEK / MWh]

Time [h]
2015-01-01 to 2016-07-30
Net Power Export Power and spot price SE3

NPE [MW]

SE3 Spot [SEK / MWh]

Time [h]
Conclusions

• NPE from -200 to 200 MW.
  – Heat only (turbine bypass) to co-generation used more than CHP and HP ramping for daily/fast variations
  – For cold periods and high prices CHP shift NPE to export.
• HPs only marginally used for following power prices. But has been used for intraday regulation.
• Combination of CHP and HP good for seasonal variations.
• Factors to enable more flexibility:
  – More short term storage to decouple heat, cooling and electric power generation.
  – Risk taking. Having a CHP ready instead of HOB if risk for high electric power prices.
• Possible for process optimization.
  – Dedicated supply of HP to low temp areas of the network
  – Utilize low return temperatures to increase CHP power production (alpha).