REHABILITATION STRATEGY OF DISTRICT HEATING

Arto Nuorkivi, D. Sc. (Tech)
Aalto University
Espoo, Finland
email: energy@nuorkivi.fi

The sole responsibility for the content of this presentation lies with the authors. It does not necessarily reflect the opinion of the European Union. The European Commission is not responsible for any use that may be made of the information contained therein.

DH Rehabilitation as Part of UP-RES Project

1. UP-RES: Urban Planners with Renewable Skills;
2. Objective: Improve access of RES in urbans and regions through education of urban planners;
3. Partners: universities, associations and consultants from Finland, Hungary, Spain, U.K. and Germany;
5. Communication of the training models and materials to other EU countries in 10 languages by Dec. 2012;
6. Financially supported by Intelligent Energy Europe.

Would you like to have the World Best DH system?
• Low heat tariffs
• High profits
• No subsidies
• High usage of RES in heat production
• Low emissions
• High share of CHP
• Three quarters of heat is produced by CHP
• High generation efficiency

Efficient network
Efficient production
Environmental sustainability
Financial sustainability

Rehabilitation Process

Resource Losses to be Minimized

Resource Losses
District heating customer
Heat
Process losses of Thermal Chain
Heat needed by Customers

Immaterial measures
Material measures

Fuel
- Purchased heat
- Purchased electricity
- Purchased water
- Maintenance tools and materials
- Energy production capacity

Work losses
Thermal losses
Electricity losses
Water losses
Material replacement
Excess capacity

District heating customer
Net heat sales
Electricity from CHP

Outcome
Flow grid
**Benefits Related to Measures**

- **Thermal chain**
  - Economic relations
  - Material measure
  - Immaterial measure

- **Cost allocators in rooms**
  - Thermo-static valves in rooms
  - Elimination of local boilers

- **Training, IT, Exchange of experiences (twinning), Bench-marking, Campaigns, Preventive maintenance,**

- **Bio and renewable fuel introduction**

- **Heat exchanger in substation**

**Materialized Outcome of Rehabilitation**

1. DH network losses reduced by half if 10-20% of worst pipelines replaced with preinsulated pipes;
2. DH water losses reduced by 30-70% depending on the substation rehabilitation rate;
3. Remaining lifetime of all DH network assets extended by 3-6 years at minimum;
4. Maintenance cost reduced even 90% due to both reduced amount of damages and smaller unit costs of their repair;
5. Need of man power reduced by 10-20%;
6. Electricity consumption in DH pumping reduced by 40-70% due to variable speed drives, new pipes and temperature control systems;
7. And finally: The costs of DH reduced by 30-60 % in the real terms (see the last slide).

**Non-linear Relations between Measures and Benefits**

Examples:
- Substation investments provide exponential EE but linear water consumption benefits
- Network rehab provides logarithmic EE benefits
- All investments provide trigonometric benefits in man power (human resources)

Formulas:
- Trigonometric: \( \Theta(c,t) = 1 - \cos(\frac{\pi}{2} R(c,t)) \)
- Logarithmic: \( \Theta(c,t) = \log(10 R(c,t) + 1) \)
- Exponential: \( \Theta(c,t) = 0.1/(0.1 + 10 e^{-10 R(c,t)}) \)

**Structure of Dynamic Rehabilitation Model**

<table>
<thead>
<tr>
<th>Input</th>
<th>Season</th>
<th>Year</th>
<th>Period</th>
<th>Output</th>
</tr>
</thead>
<tbody>
<tr>
<td>Thermal chain</td>
<td>Heat demand</td>
<td>Adjustment of heat load</td>
<td>Rehabilitation strategy</td>
<td>Rehabilitation measures</td>
</tr>
<tr>
<td>New replacement value</td>
<td>Heating demand</td>
<td>Rehabilitation measures</td>
<td>Effectiveness of rehabilitation measures</td>
<td>Rehabilitation measures</td>
</tr>
<tr>
<td>Unit costs in base year</td>
<td>Water temperatures</td>
<td>Thermal losses</td>
<td>Total costs</td>
<td>Savings</td>
</tr>
<tr>
<td>Financing available</td>
<td>Electricity sales</td>
<td>Water consumption</td>
<td>Maintenance needs</td>
<td>Temperature balances</td>
</tr>
<tr>
<td>Economic/financial analysis</td>
<td>Fuel consumption</td>
<td>Electricity sales</td>
<td>Human resources</td>
<td>Savings</td>
</tr>
<tr>
<td>Target values (RAT)</td>
<td>Bulk heat purchases</td>
<td>Electricity generation</td>
<td>Electricity consumption</td>
<td>Emissions</td>
</tr>
<tr>
<td>Required IRR</td>
<td>Energy balance</td>
<td>Undelivered heat energy</td>
<td>Variable heat energy</td>
<td>Heat production capacity</td>
</tr>
<tr>
<td>Operation and in base year</td>
<td>Other parameters</td>
<td>Electricity consumption</td>
<td>Additional heat energy</td>
<td>Temperature balances</td>
</tr>
<tr>
<td>(See Appendix 4)</td>
<td>Resources used in base year</td>
<td>Energy balance</td>
<td>Undelivered heat energy</td>
<td>Sales</td>
</tr>
<tr>
<td>(See Appendix 4)</td>
<td>Other parameters</td>
<td>Energy balance</td>
<td>Undelivered heat energy</td>
<td>Sales</td>
</tr>
<tr>
<td>(See Appendix 4)</td>
<td>Other parameters</td>
<td>Energy balance</td>
<td>Undelivered heat energy</td>
<td>Sales</td>
</tr>
</tbody>
</table>

**Pioneering Example: Poland 1992-1999**

Heat price: PLN/m² in 1999 level