Assessing long-term sustainability of a regional district heating systems

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Background:
Swedish district heating (DH) systems

• In the past:
  — Oil
• Today:
  — Biomass (Heat-only boilers (HOBs) & Combined heat and power (CHP) plants)
  — Industrial waste heat (WH)
• Future DH supply challenges:
  — Competition for biomass
    • bio CHP, transport biofuels
  — Non-utilised industrial waste heat
    • base load only
  — Integration of heat and power sectors
    • intermittency issues
**District heat (DH) developments:**

Various infrastructural options:
- Connection of local systems
- Low-T district heat
- Large-scale heat storage
- Load levelling

➢ DH advertized as a sustainable option –
➢ But how to assess what is sustainably best?

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**Background**  |  **Purpose**  |  **Method**  |  **Results**  |  **Conclusions**
---|---|---|---|---

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**Sustainability dimensions:**

- Environmental
- Economic
- Social

**System aspects**
1) Complex system
2) Not obvious system boundaries:
- DH system
- Power system
- Transport biofuel system
3) Future developments

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---|---|---|---|---
Purpose

• Develop sustainability assessment framework well suited for the assessment of future DH developments
• Applied the sustainability assessment framework to issues of high relevance for decision makers

Integrated local energy systems assessment (ILESA)
based on life cycle sustainability assessment (LCSA)

ILESA toolbox

• Energy system model (computer-based) – MARKAL
• LCA
• Open-space (stakeholder) workshops
1st case

Construction of DH pipe (3 different DH pipe capacities assumed) from Stenungssund (industrial cluster with large amount of waste heat available) to Göteborg (large DH system)

• Main questions:
  — System cost?
  — Environmental impact?
  — Relevant social aspects?

Key assumptions

• C tax based on (shadow price from) European model with C cap
• Marginal assumptions
  — S – short term single technology (coal in winter, NG in summer)
  — M – complex mixed margin (defined by European model cap)
  — L – long-term margin
Energy system model (MARKAL_WS)
- Optimizing, dynamic
- 37 DH systems with different system characteristics:
  - Demand
  - Installed capacities
  - Technology options
- 2004-2029
- Assumed energy market developments
Total cost of DH production (net of taxes) and sum of CO₂ taxes in the region

CO₂ emission in model year 2019

Background  Purpose  Method  Results  Conclusions
LCA
Input data
from energy system model

Background  Purpose  Method  Results  Conclusions

LCA results  Global Warming Potential (GWP) and Resource Depletion –
highly dependent on marginal electricity assumptions

GWP 100 years - aggregated

Energy carriers 2029 (GWh)

ADP elements - aggregated

Background  Purpose  Method  Results  Conclusions
Open-space workshop

Stakeholders:
- District heat utilities
- Industries in the industrial cluster
- Municipalities
- + environmental NGO

<table>
<thead>
<tr>
<th>Environmental indicators</th>
<th>Economic indicators</th>
<th>Social indicators</th>
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<tbody>
<tr>
<td>Climate change</td>
<td>System cost of district heating</td>
<td>Local self-sufficiency with energy</td>
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<tr>
<td>Acidification</td>
<td>Distribution effects between stakeholders</td>
<td>Employment</td>
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<td>Eutrophication</td>
<td>Economic resilience to external impacts</td>
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<td>Primary energy use</td>
<td>Establishment of new industries</td>
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<td>Biomass/land use</td>
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Life cycle sustainability assessment*

1. Choose study object
2. Choose sustainability aspects
3. Identify important linkages
4. Choose methods/tools/models
5. (Create networks)
6. Carry out separate investigations
7. Do the synthesis

*Klöpffer 2008
Thank you!
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