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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

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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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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)

Background Purpose Method Results Conclusions

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ILESA toolbox

- Energy system model (computer-based) – MARKAL
- LCA
- Open-space (stakeholder) workshops

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1st case

<u>Construction of DH pipe</u> (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

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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

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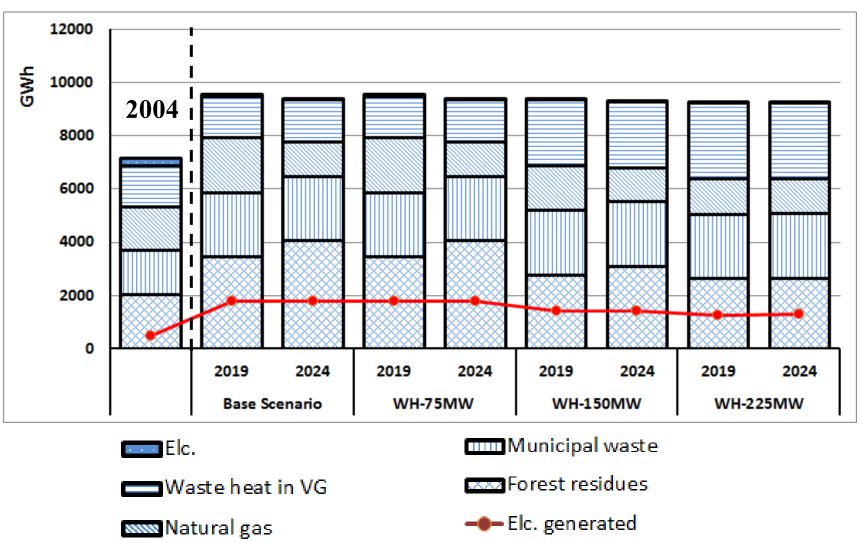
Regional DH fuel and electricity use and electricity generation



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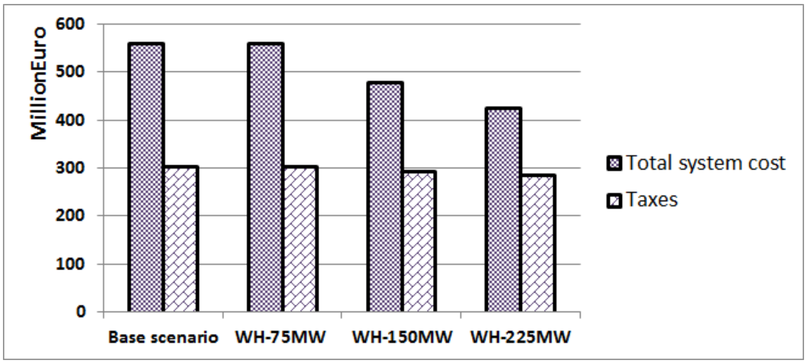
Total cost of DH production (net of taxes) and sum of CO_2 taxes in the region



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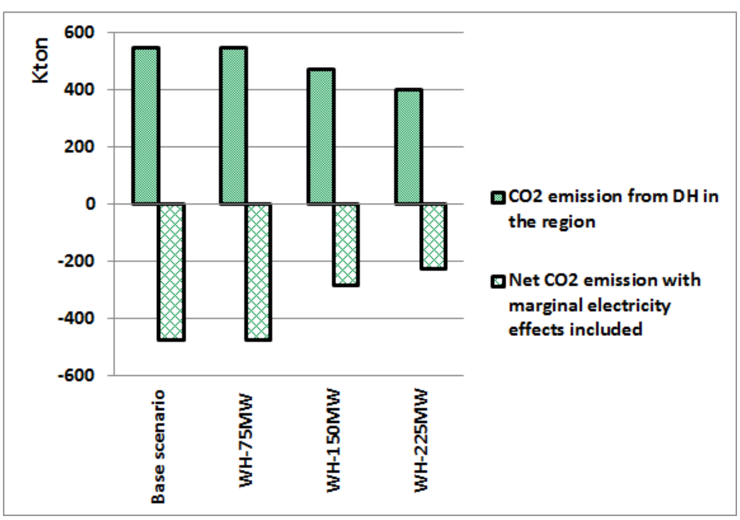
CO_2 emission in model year 2019



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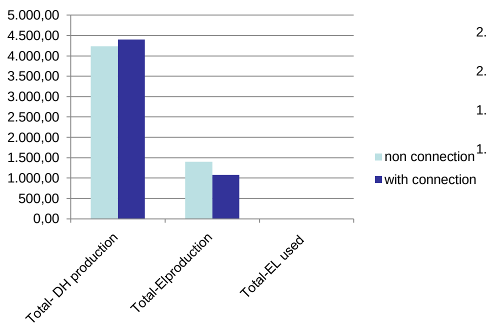
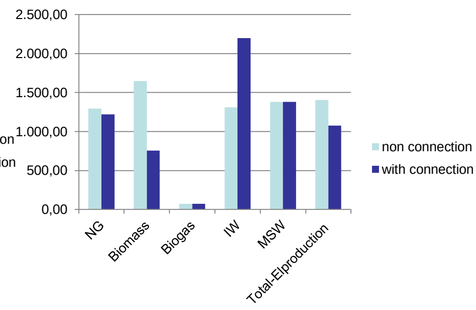
LCA

Input data
from energy system model





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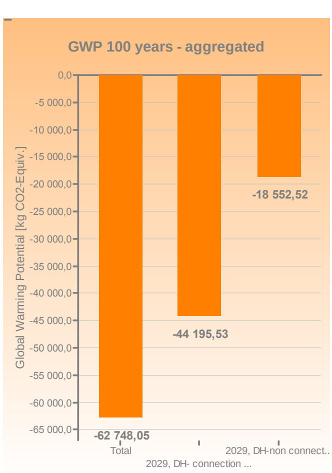
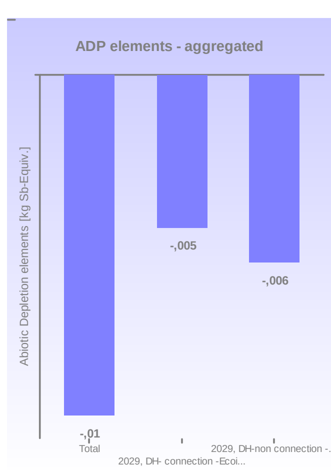
LCA results Global Warming Potential (GWP) and Resource Depletion –
highly dependent on marginal electricity assumptions





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Open-space workshop

Stakeholders:

- District heat utlities
- Industries in the industrial cluster
- Municipalities
- + environmental NGO

Environmental indicators	Economic indicators	Social indicators
Climate change	System cost of district heating	Local self-sufficiency with energy
Acidification	Distribution effects between stakeholders	Employment
Eutrophication	Economic resilience to external impacts	
Primary energy use	Establishment of new industries	
Biomass/land use		

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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*

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Thank you!

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