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Modeling regional impacts of large-scale waste heat utilisation – the case of south-western Sweden

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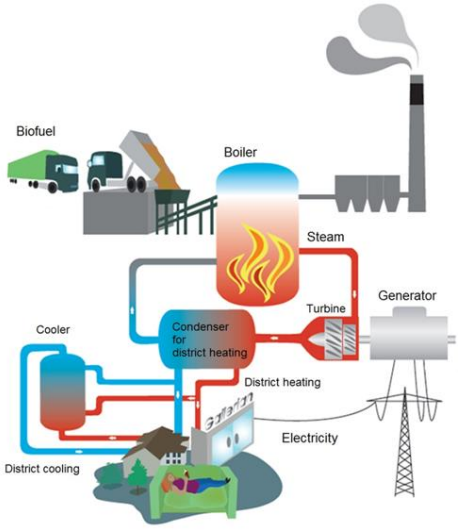
District heating (DH) system



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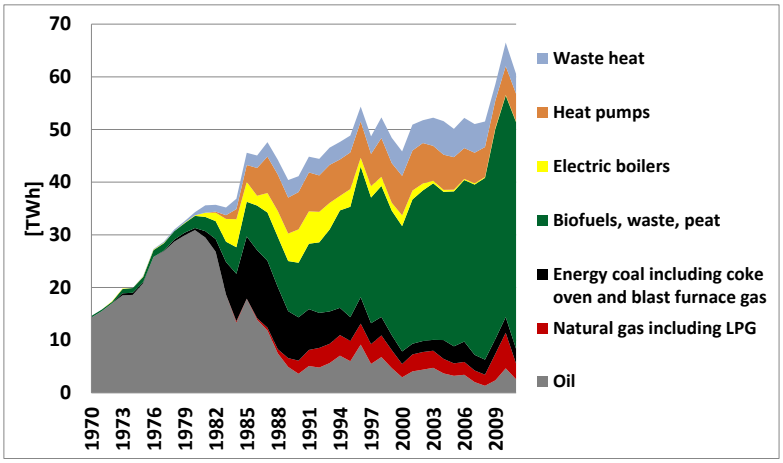
Swedish DH systems



Source: Statistics Sweden and the Swedish Energy Agency

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Future challenges

- CO2 mitigation likely to lead to competition for biomass (Bio CHP plants, transportation sector, etc)
- Difficulty of utilizing unused potential waste heat

➢ Could connection of local DH systems into regional DH systems be a solution?

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Purpose

- What are the potential effects of connecting industries and some DH systems with regards to:
  - Total system cost?
  - Environmental impacts (CO_2 emission and resource use)?
  - DH technology choices?
  - Biomass use in transport?

Case study: Connection of a large industrial chemical cluster to one large and two smaller DH systems in a Swedish region (Västra Götaland)

→ comparison of **"connection"** to **"no-connection"**

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Method

- MARKAL_West_Sweden (MARKAL_WS) model representing the energy system of the Västra Götaland region
  - Mixed-integer programming (MIP) model

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- Time horizon: 2004 – 2029
- 37 DH systems with different system characteristics:
  - Demand levels
  - Installed capacities and energy technology options
  - Available technologies and investment options for DH generation

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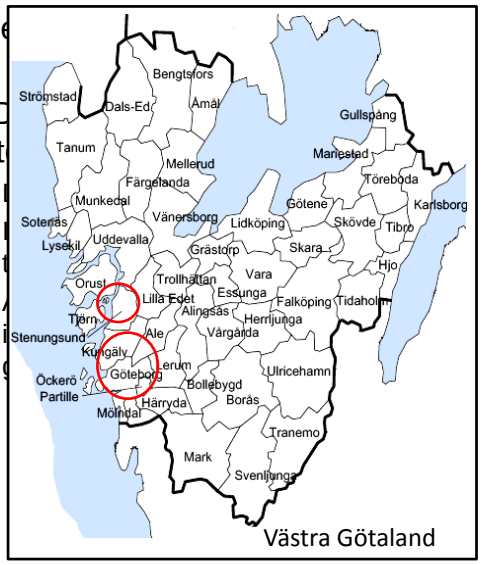

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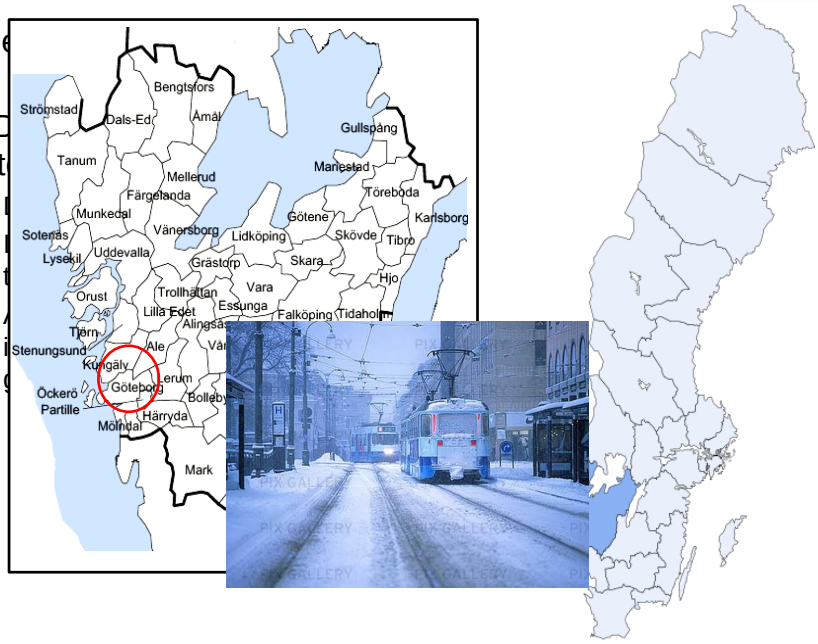

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- DH demand should be fulfilled in each local DH system.
- MARKAL_WS model is further developed to include:
  - Waste heat (WH) capacity from the large industrial chemical cluster in Stenungsund
  - **New DH transmission pipeline connecting industrial WH source to the Göteborg and Kungälv DH systems (cost not included in optimization)**
  - New biorefineries for production of synthetic natural gas (SNG) used as transport fuel.

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Scenarios

- BASE (Rigid climate policy)
  - CO2 tax, green electricity and SNG subsidy
  - Long-term marginal electricity production
    - Natural gas combined cycle plant (57% efficiency)
  - Waste heat delivery assumption 125 MW
- COLLAPSE (Climate policy collapse)
  - No taxes and subsidies
  - Short-term marginal electricity production
    - Natural gas combined cycle plant or coal condensing plant
  - Waste heat delivery assumption 125 MW

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Sensitivity analysis

- FASTSNG (20% learning rate)
- Waste heat delivery
  - 225 MW
  - 175 MW
  - 75 MW
- REHD (25% reduction of heat demand)

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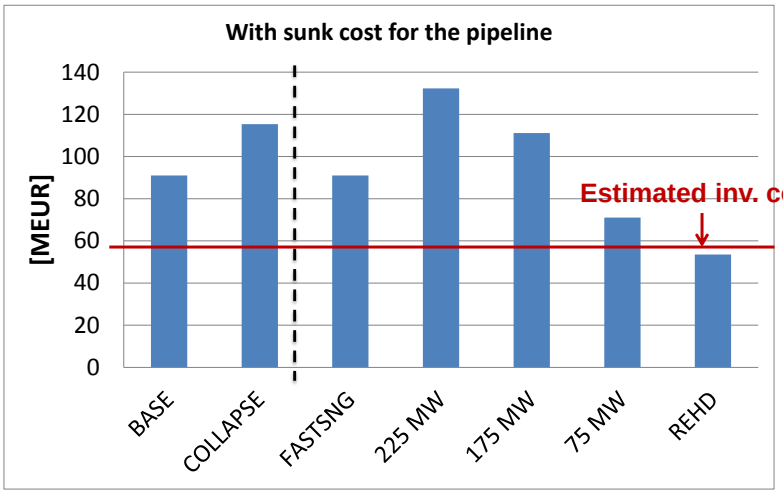
Total system cost reduction (net of taxes) "connection" compared to "no-connection"



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Conclusion 1

In most scenarios and sensitivity analysis:

- The DH connection reduces the total system cost.

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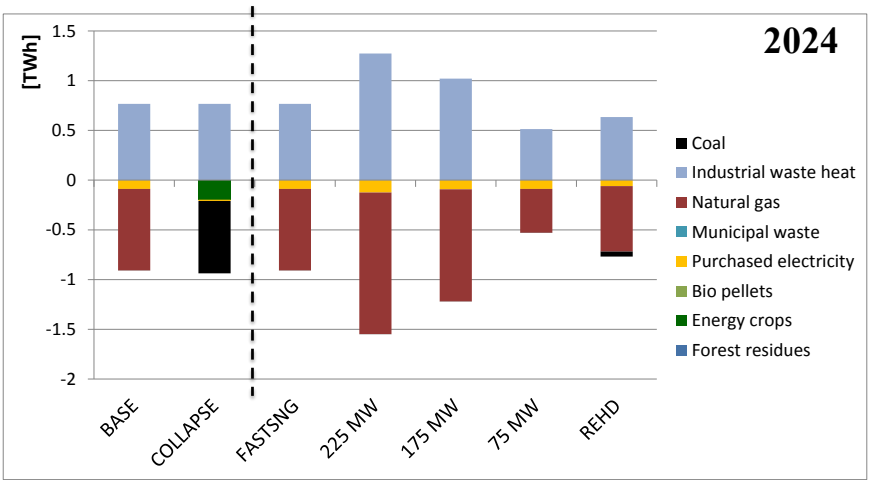
Change in fuel and electricity use "connection" compared to "no-connection"



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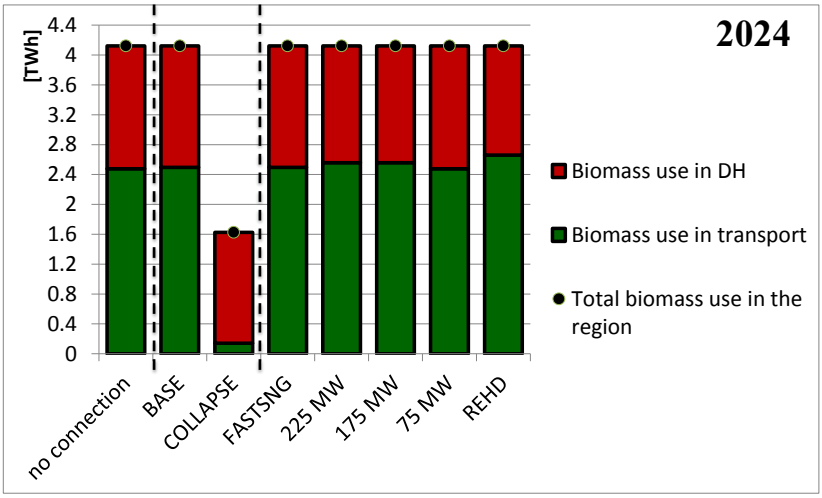
Biomass use in DH and transport "connection" compared to "no-connection"



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Conclusion 2

With the DH connection:

- Industrial waste heat replaces natural gas and biomass use.
- The saved biomass in DH systems is used for SNG production, but not in COLLAPSE scenario.
- In COLLAPSE scenario, the entire potential of regional biomass is not used.

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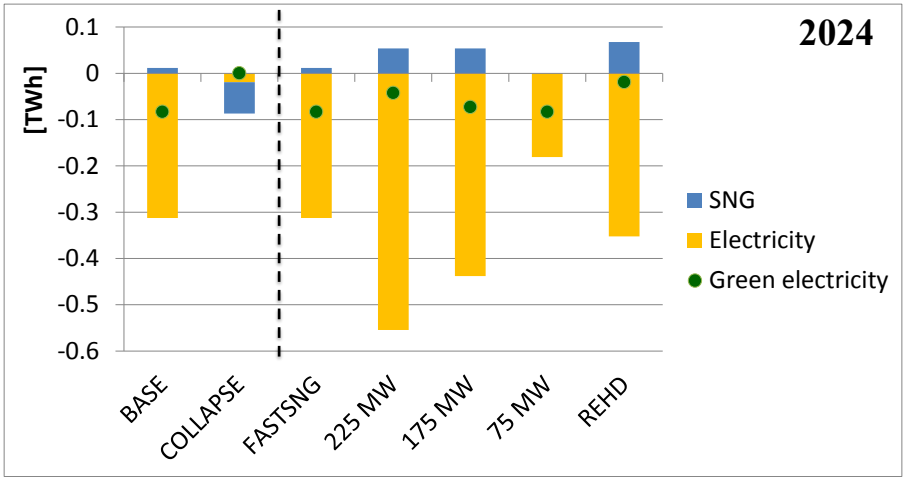
Change in SNG and electricity production

"connection" compared to "no-connection"



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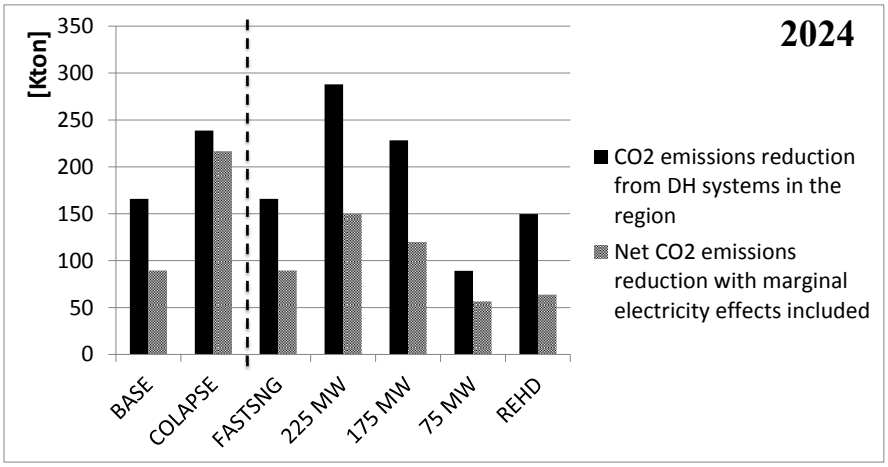
CO2 emissions reduction

"connection" compared to "no-connection"



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Conclusion 3

With the DH connection:

- Electricity generation reduction (mainly in natural gas CHP and, partially, biomass CHP plants)
- No new bio-refinery/ SNG plant in COLLAPSE scenario
- Reduced CO2 emissions (in all scenarios)

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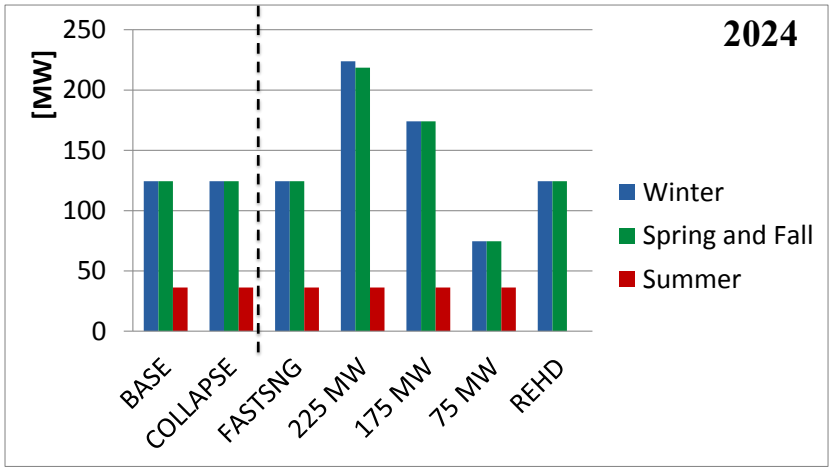
Seasonal heat delivery by the connection



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Conclusion 4

No influence on waste heat delivery due to:

- Climate policies
- Learning rate of SNG production
- Head demand reduction

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Thank you!

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