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A broad sustainability assessment of utilization of industrial excess heat based on MARKAL modelling

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Sustainability performance of energy systems workshop

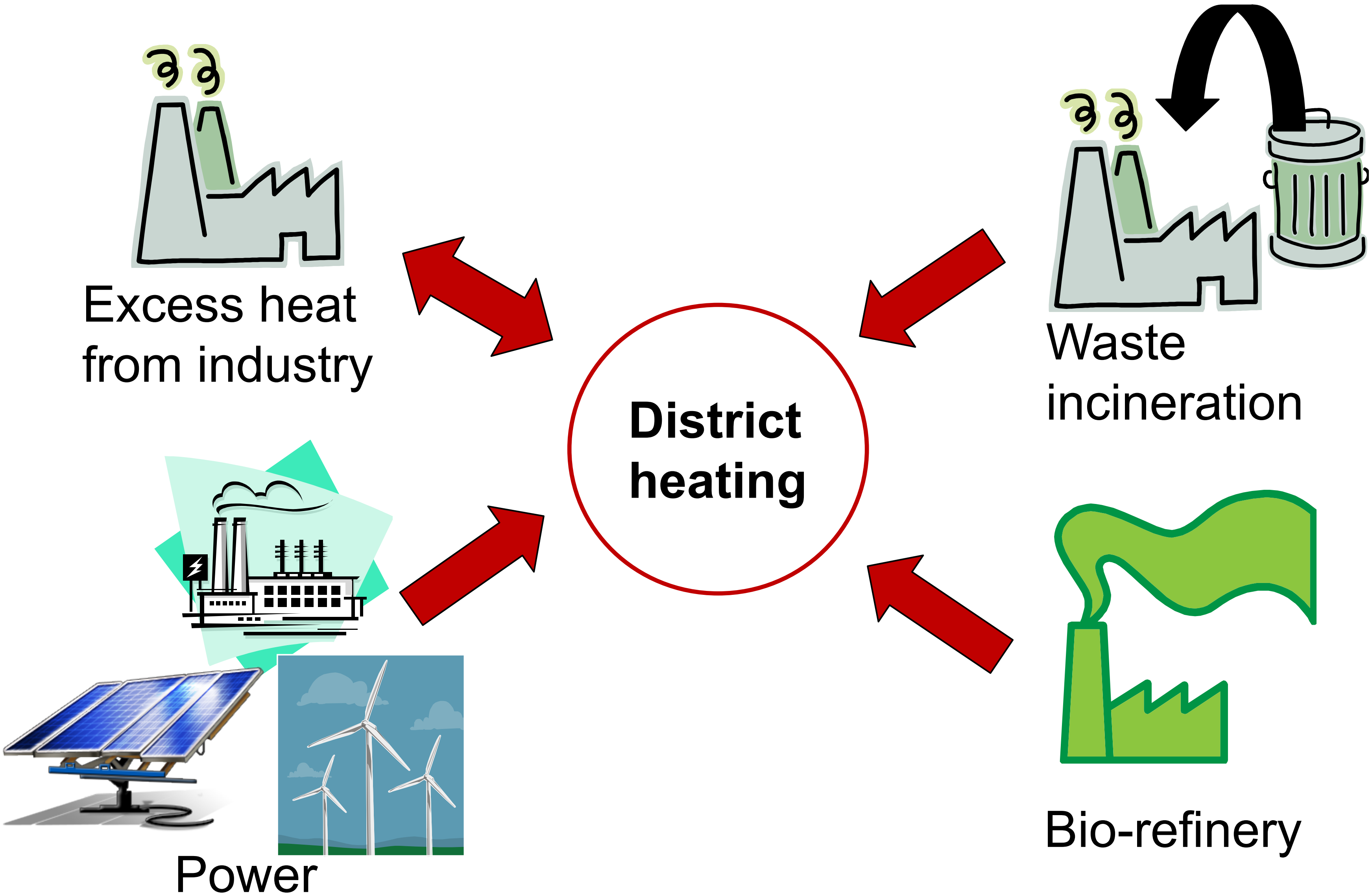
ETSAP

Madrid, May 29-30, 2017

Point of departure

4th Generation District Heating

Heat synergy collaborations



Industrial excess heat

Challenges

- Unknown energy system impacts
- Uncertain environmental impacts (of large importance for DH utilities)
- High investment cost
  - Lock-in effects ?

➔ Sustainable ?

Questions

Large-scale excess heat utilisation

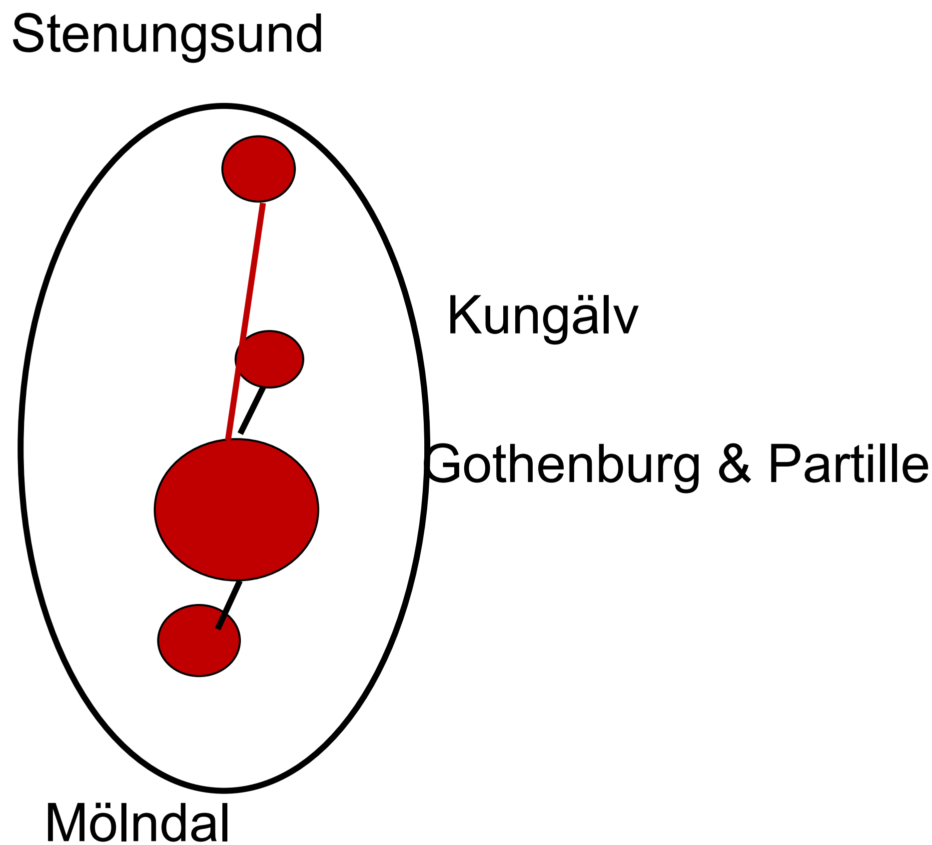
- Is it economically sustainable?
- What are the **CO_2-emissions** impacts?
- Are there other important sustainability impacts?

Methodology

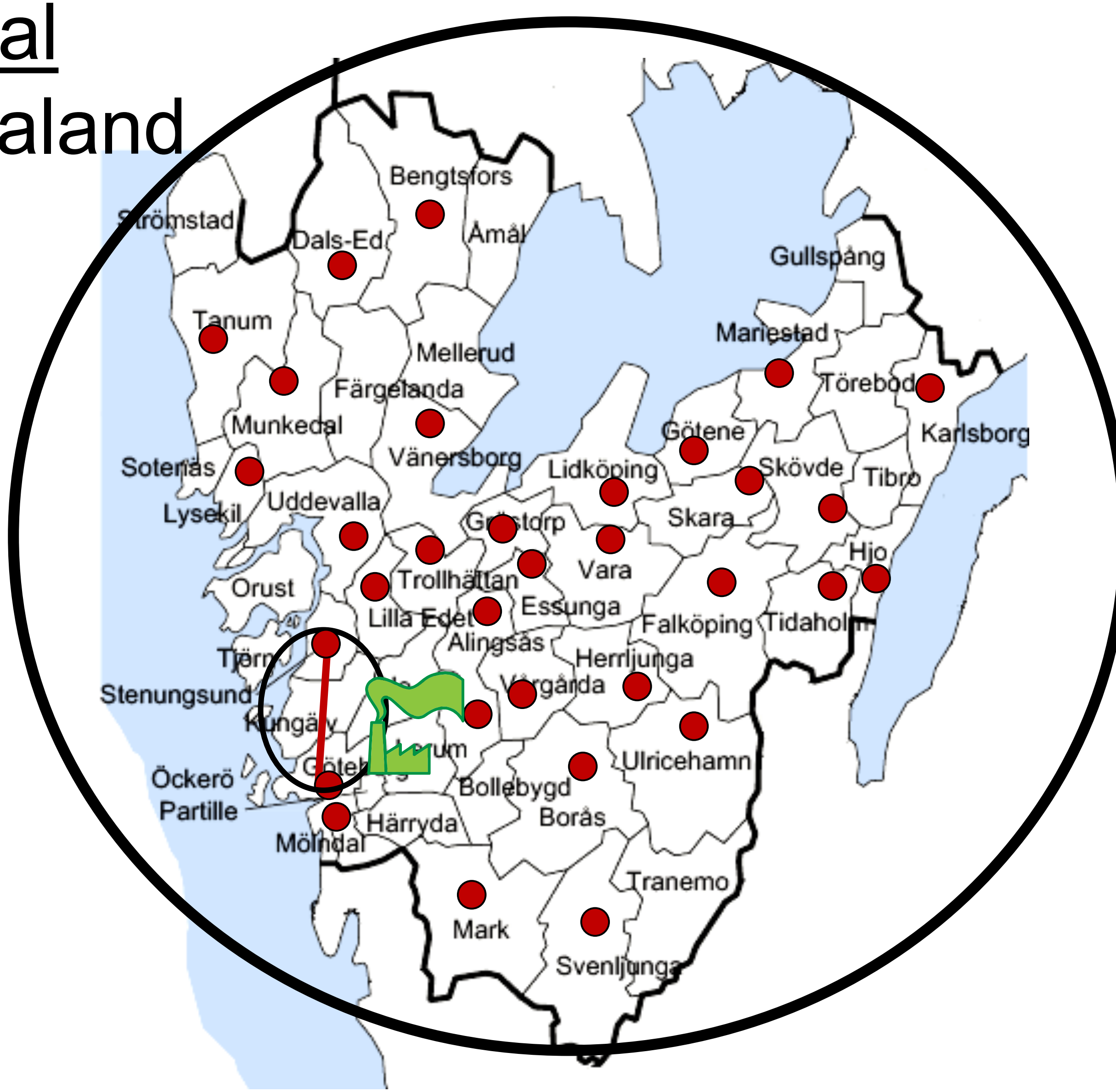
- Case study
- Scales
  - Local
  - Regional (regional biomass market)
  - National/International (electricity market with cross-border trade)

The case - local

50-55 km



<u>Regional</u>
Västra Götaland
(VG)



DH today

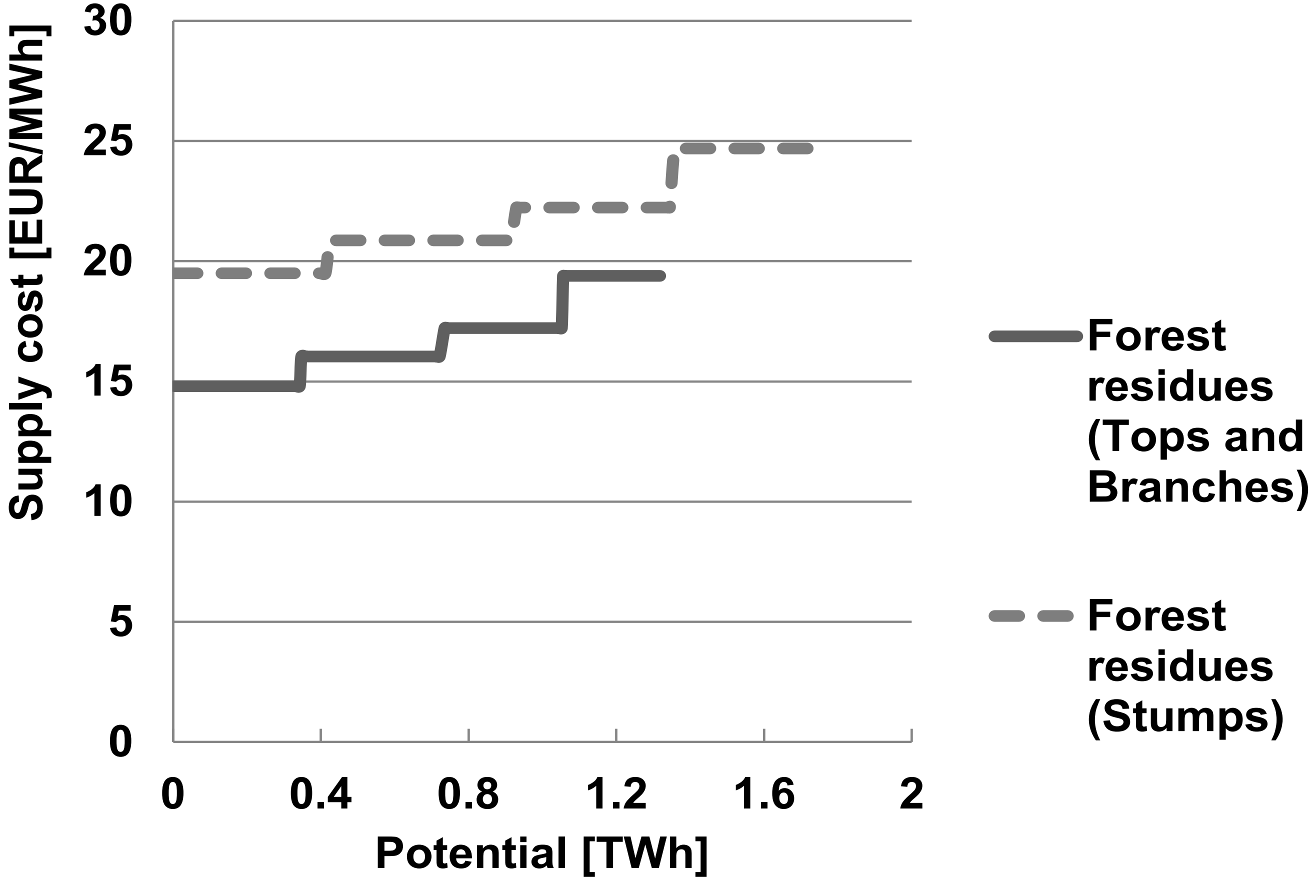
DH in the region:

- Waste heat (MSW incineration + Refineries)
- CHP (biomass & natural gas) – produce electricity
- BioHOB
- Heat pumps – use electricity
- Oil and gas turbines

Unused biomass

- CHP elsewhere
- Co-combustion with coal (export)
- Transport biofuel production (SNG)

Regional biomass supply curve



Climate policy scenarios

- 450PPM (450 ppm)
- NEWPOL (New Policies)

Sensitivity analysis

- **No NG** (after 2030)
- **REHD** (reduced heat demand)
- **LIC** (50% lower pipline cost)
- **INTRATE**
- **REFINERY** (cont´d operation)
- **RES-S** (cont´d el.certificates)
- **NOSNG** (NO alternative regional biomass demand)

Optimisation modeling

- **MARKAL_West Sweden**
- Time horizon: 2010-2050
- Load curves
- 37 DH system represented
  - Investment opportunities
- Transport biofuel production

Assumptions I

Marginal electricity

- Short-term
- Long term (built) – calculated at the European level

Coincidence!

Parallell processes

- Academic project/s
  1. Industrial process engineering
  2. **Energy systems analysis**
  3. Energy market studies
- Actors
  - Chemical industries
  - DH utilities
  - The region

➔ Project + reference/stakeholder groups

- ➔ Common case

The Stenungsund case

- ➔ Project:

West Sweden collaboration on industrial excess heat

  - ➔ *LCSA study*

Assumptions II

Industrial heat extraction

- Different levels requires various degrees of collaboration
- Extraction costs input to system calculations
- Iteration?

Open space workshop

- Sustainability issues according to the stakeholders
  1. issues
  2. ranking

Open space workshop results

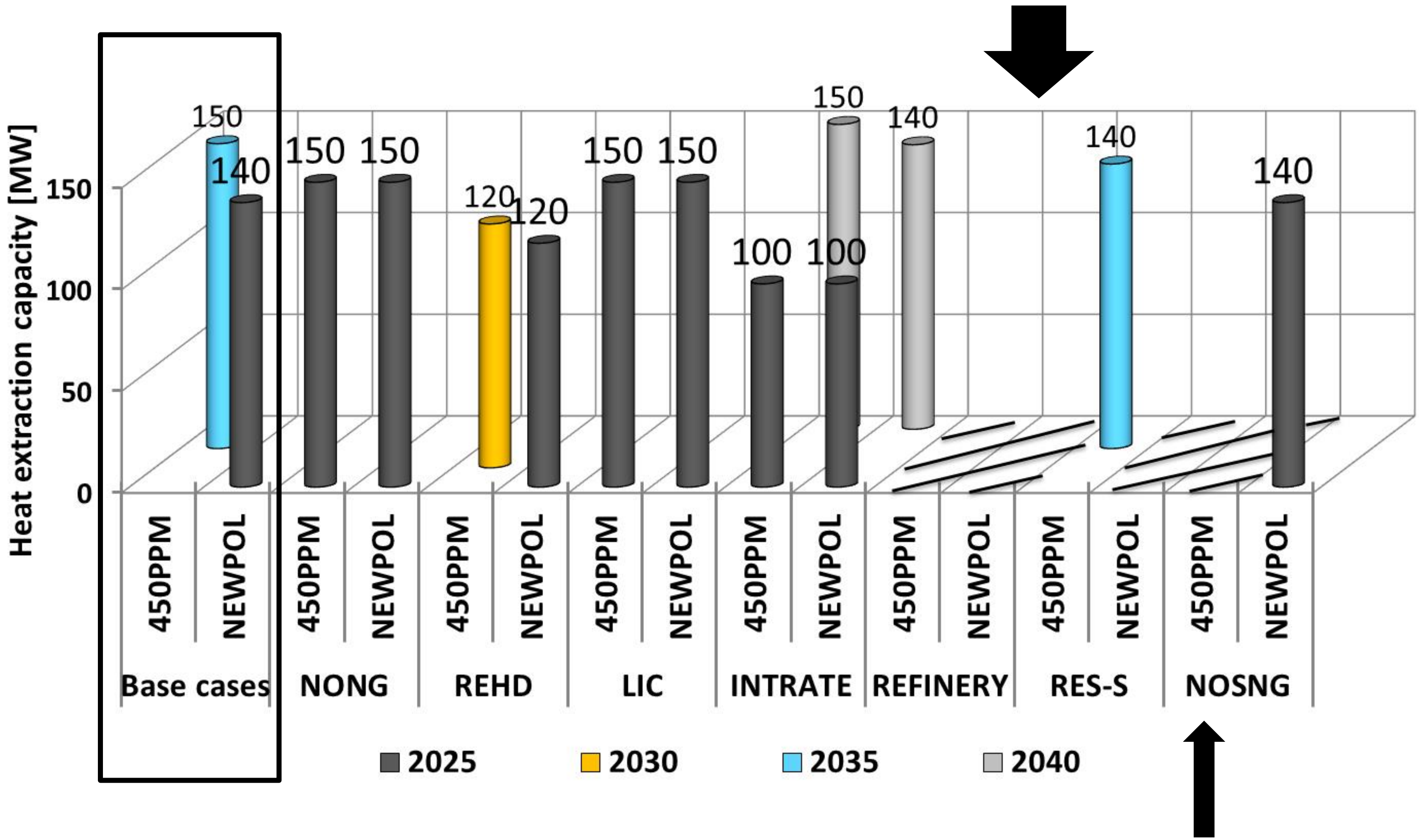
1. Investment principles and economic sustainability: 11 votes
2. Long-term profitability and competitiveness in all parts of the system: 10 votes
3. Heat demand all year? 5 votes
4. New heat sinks: 5 votes
5. Options and cost for the DH customer: 3 votes
6. Flexibility in temperature and demand for residual heat: 3 votes

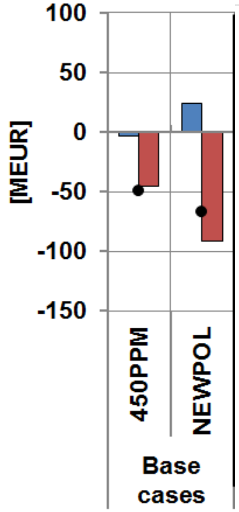
Modelling results

Does the model build the pipeline?

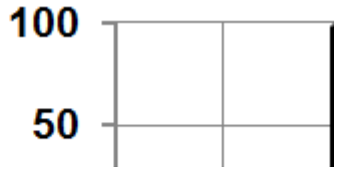
- Is this solution providing more welfare (more cost-efficient) that any other solution to supply the heat demand?

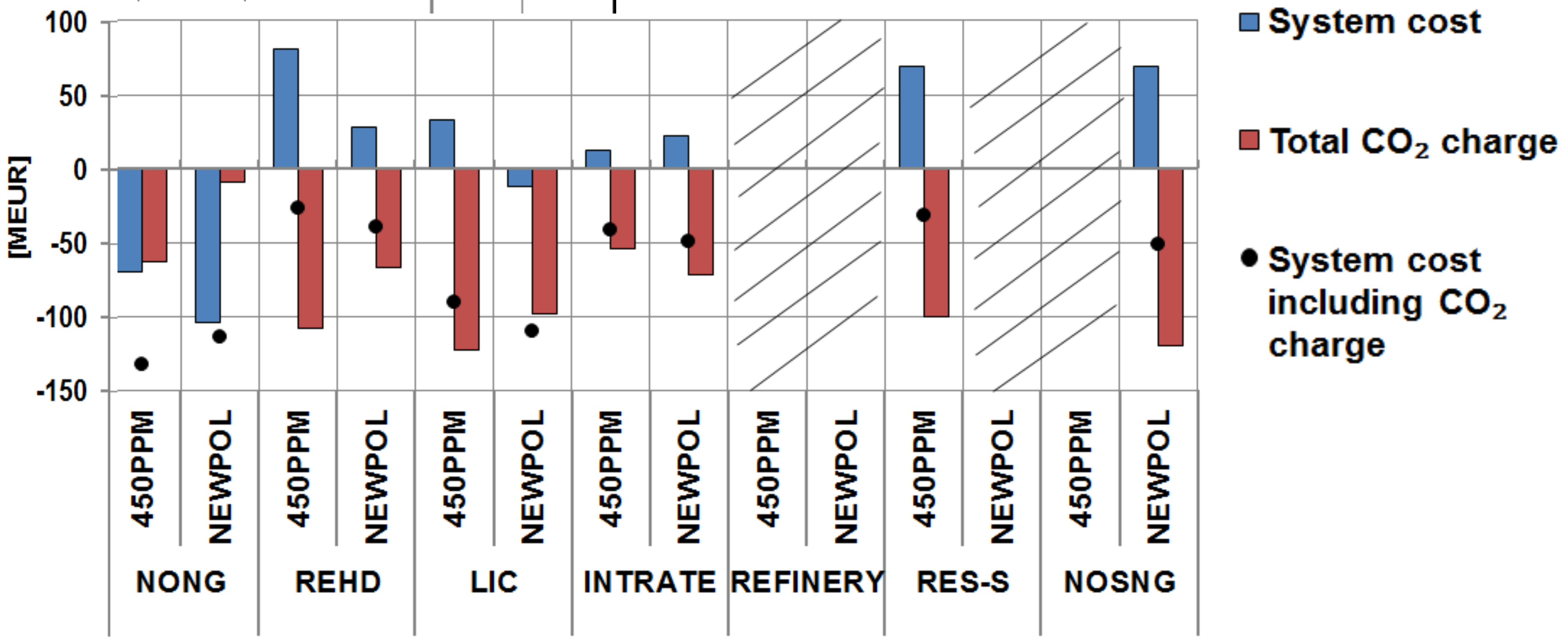
Resulting cost-optimized excess heat capacity

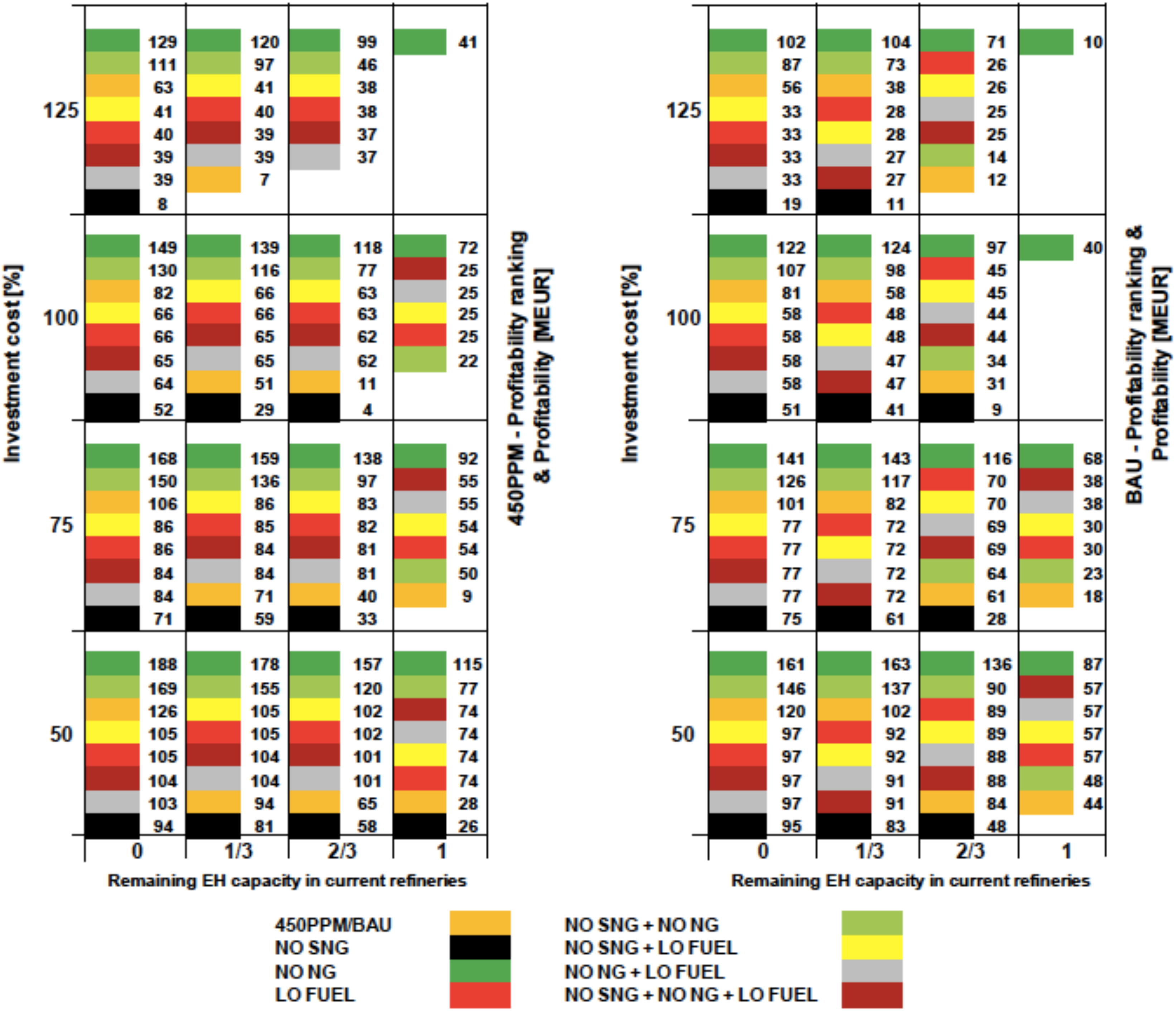




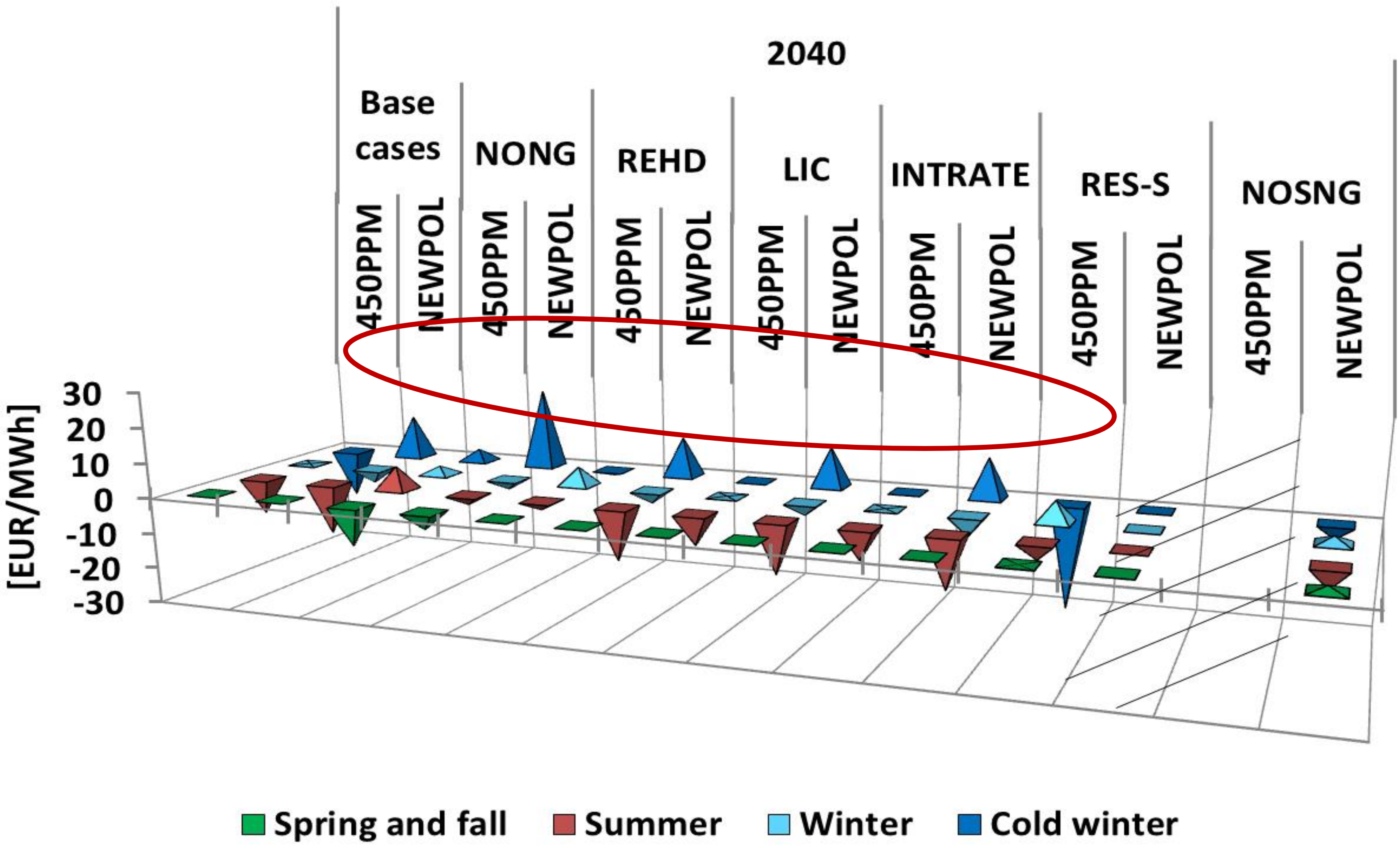
System cost change (I)



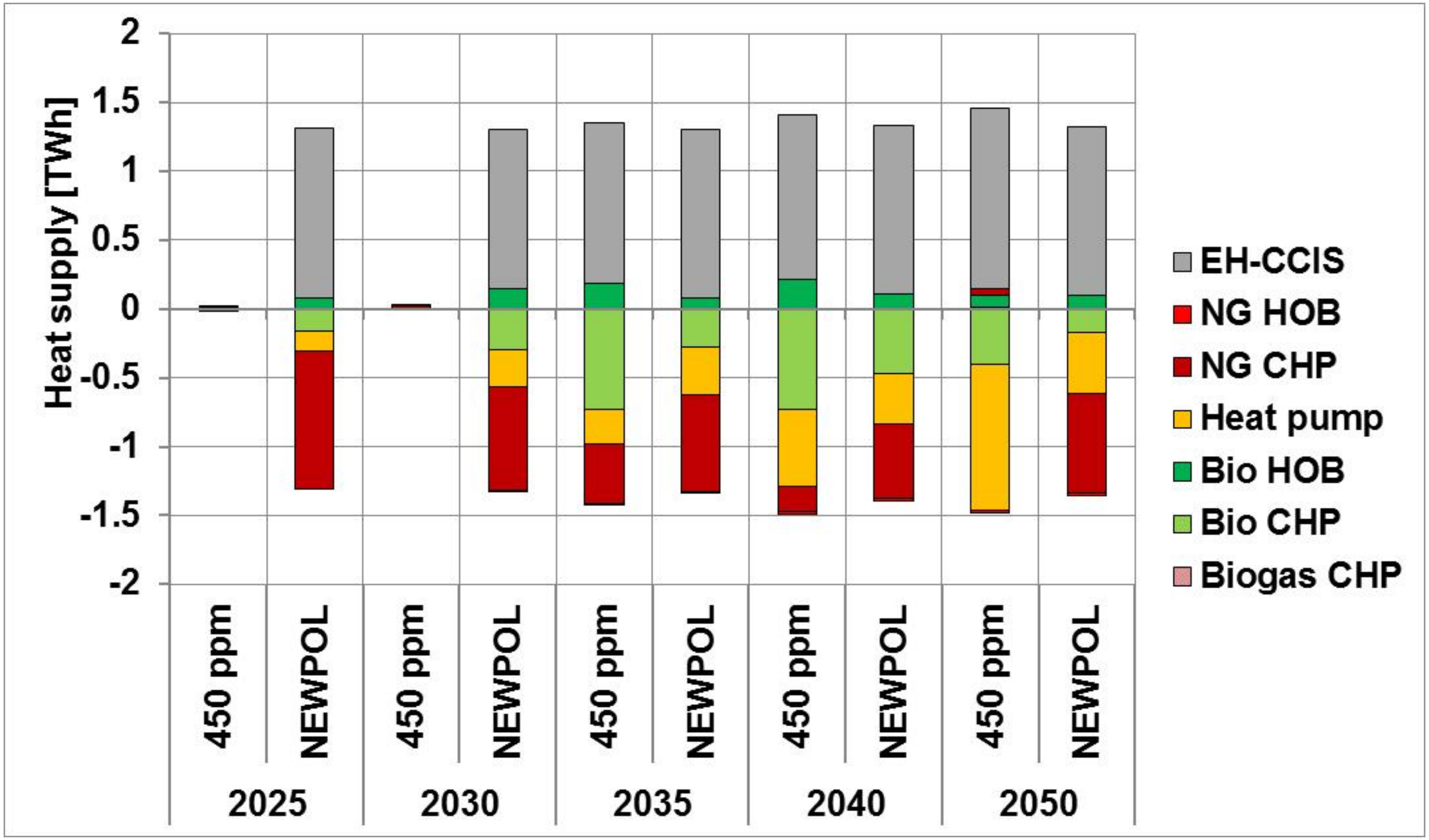



Investment cost [%]
125
100
75
50
0
1/3
2/3
1
Remaining EH capacity in current refineries
450PPM - Profitability ranking & Profitability [MEUR]
BAU - Profitability ranking & Profitability [MEUR]
450PPM/BAU
NO SNG
NO NG
LO FUEL
NO SNG + NO NG
NO SNG + LO FUEL
NO NG + LO FUEL
NO SNG + NO NG + LO FUEL

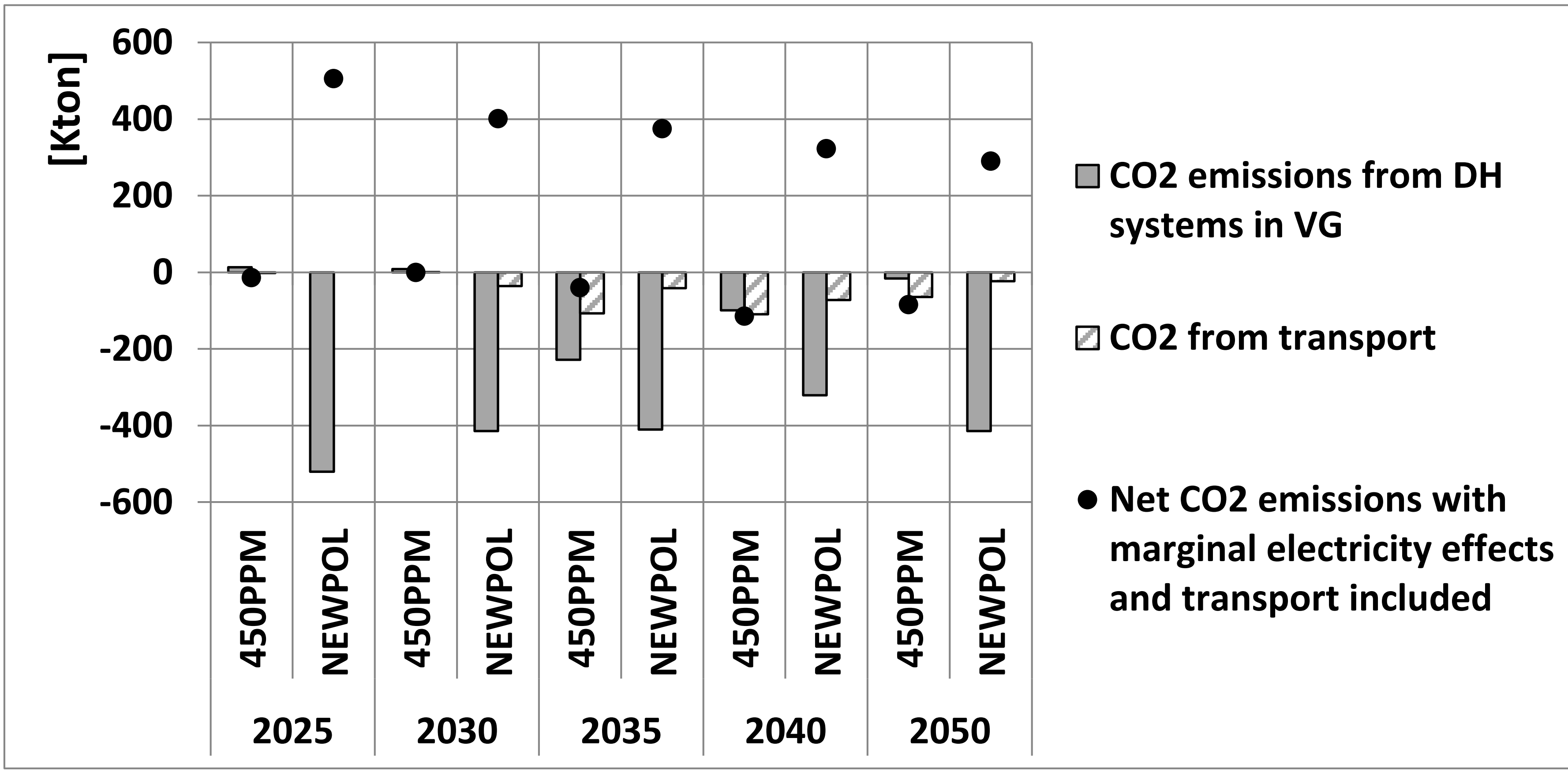
Marginal cost change (Göteborg)



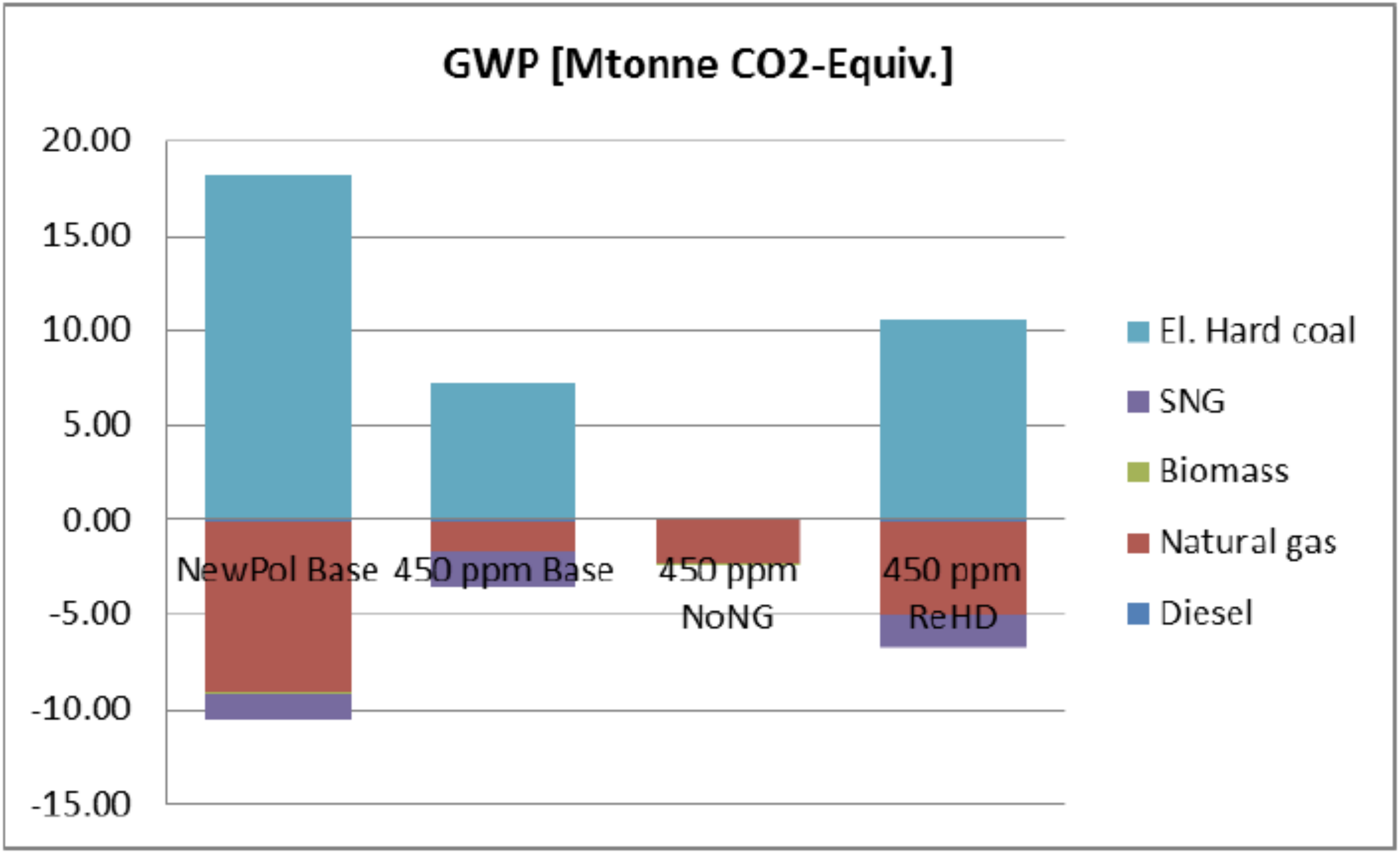
Change - regional district heat delivery



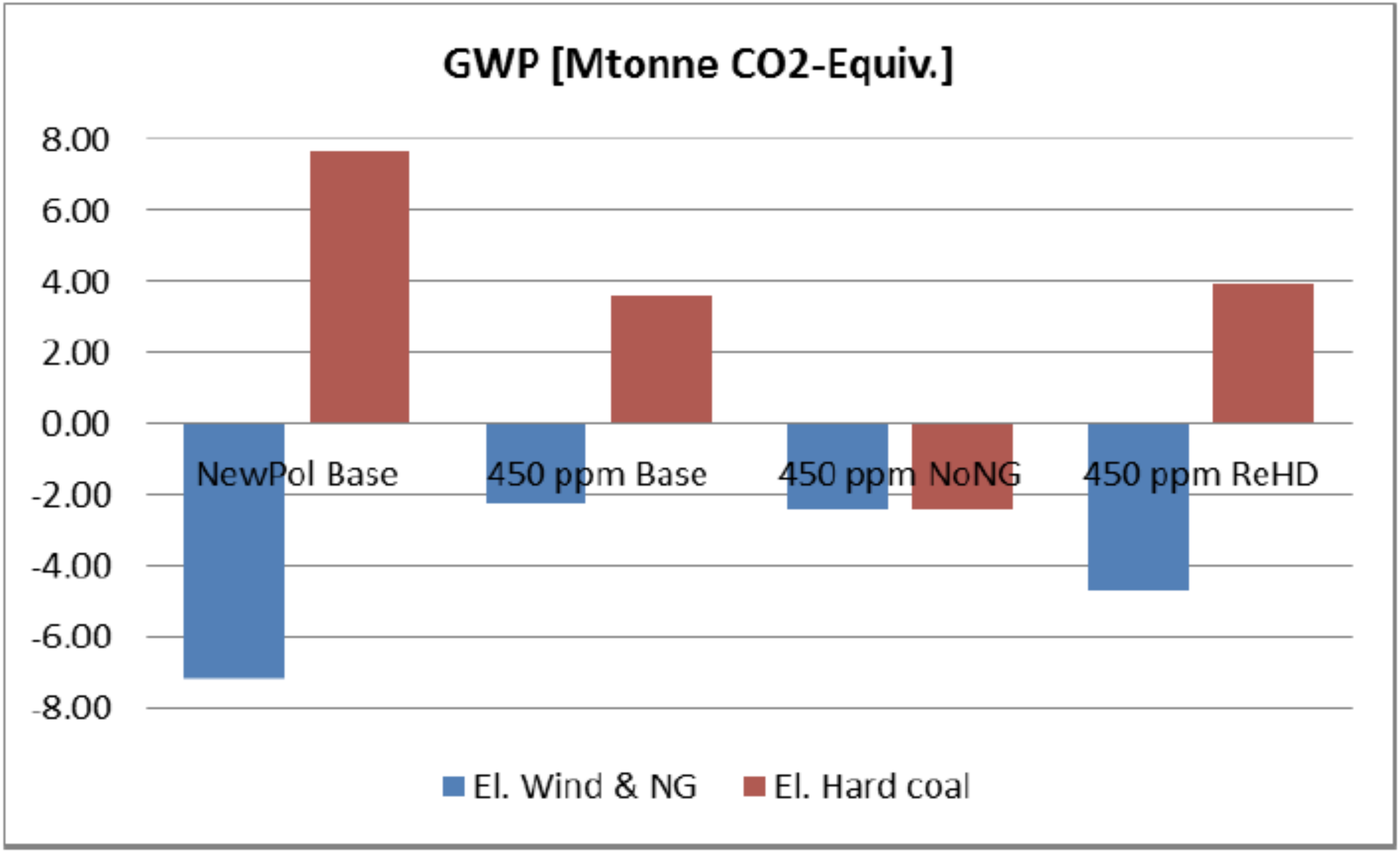
Change CO2-emissions



Change CO2-emissions until 2040

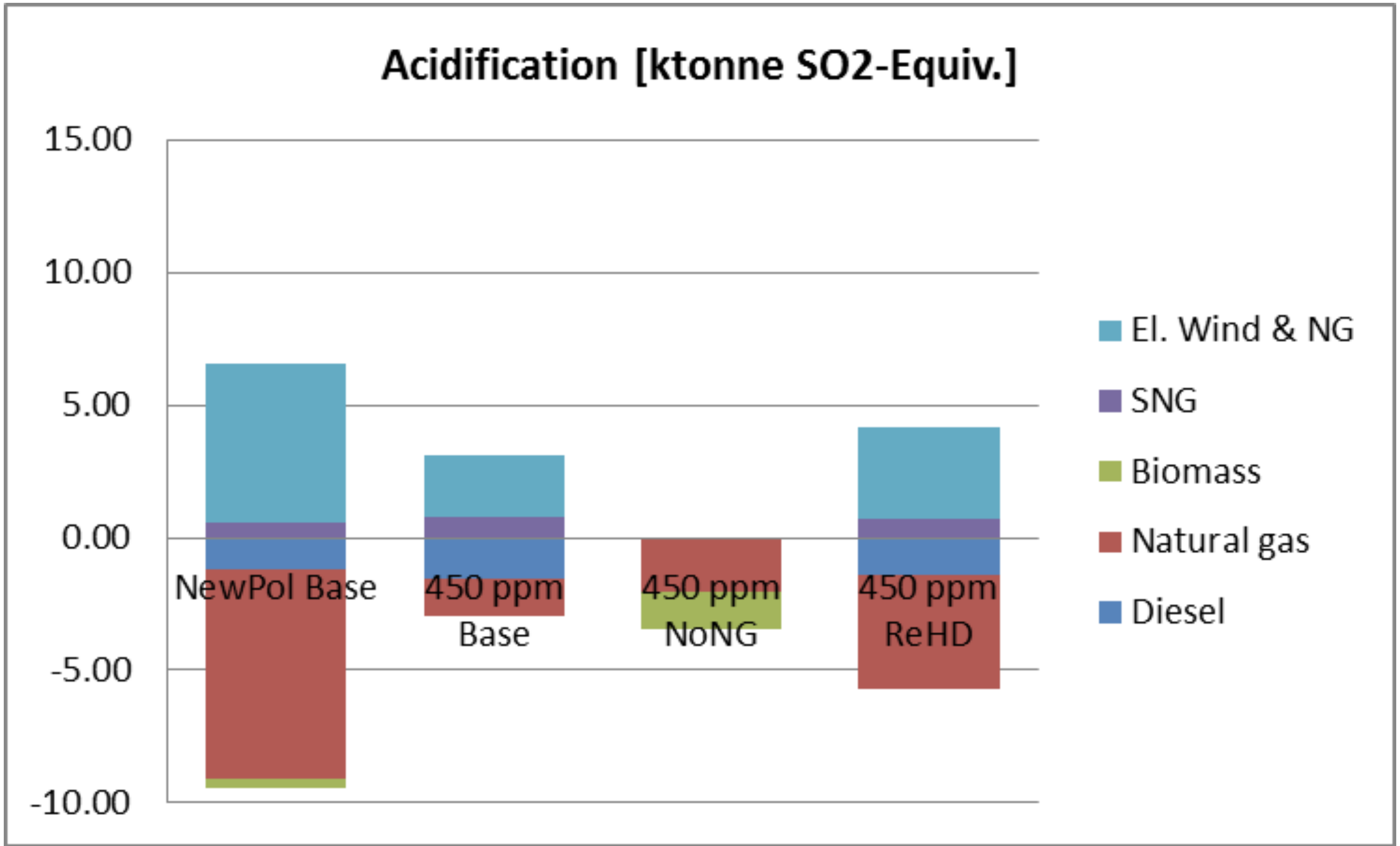


Net climate effect until year 2040



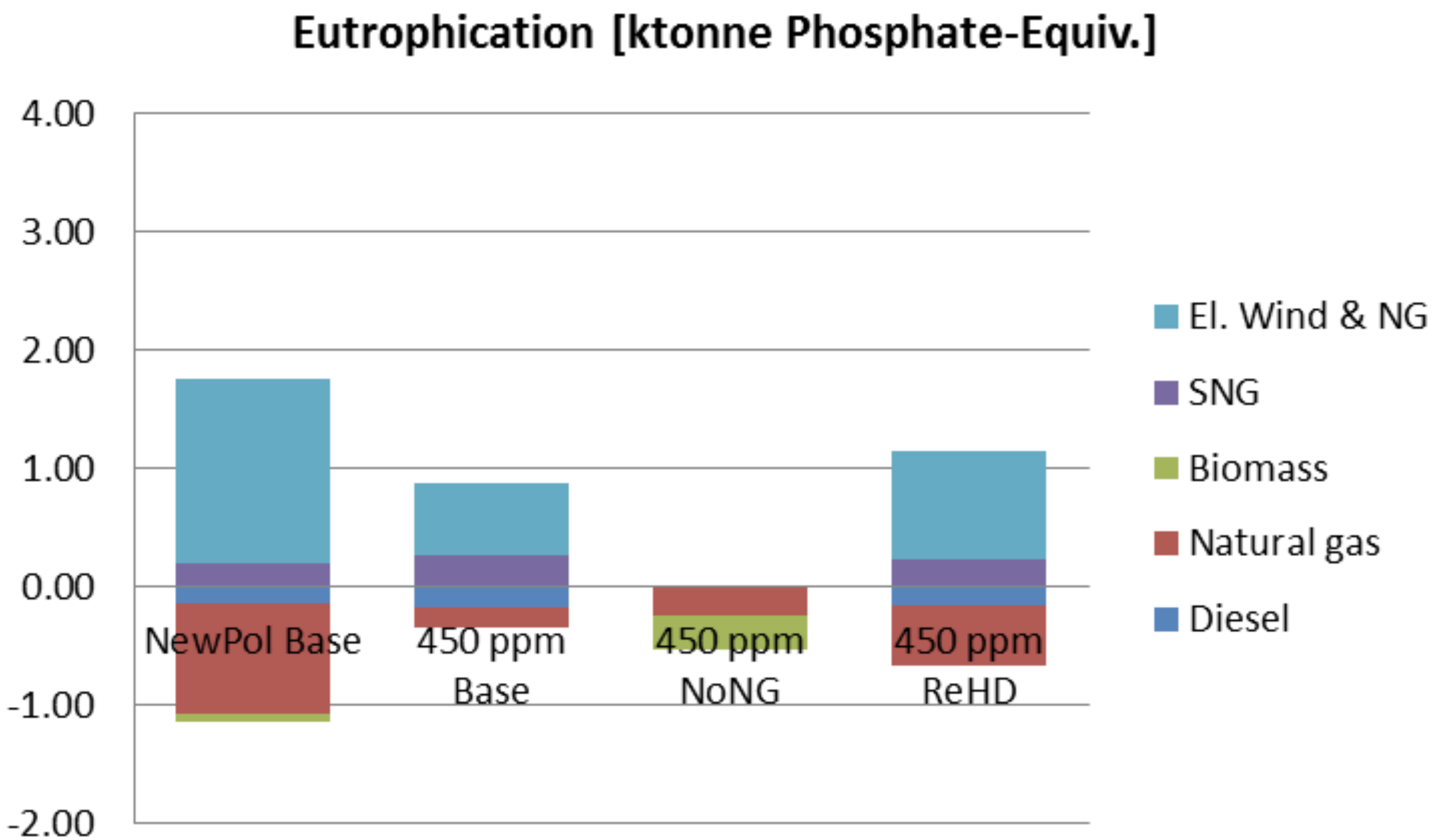
Acidification

Acidification potential impact in the four scenarios until the year 2040, assuming marginal built power is produced from wind power (80%) and natural gas turbines (20%).



Eutrophication

Eutrophication potential impact in the four scenarios until the year 2040, assuming marginal built power is produced from wind power (80%) and natural gas turbines (20%).



Other sustainability impacts?

- ✓ Acidification
- ✓ Eutrophication
- ➢ Job creation
- ➢ **Risk**

Conclusions

Investment profitable?  In most tested cases

Climate?  Dependent on perspective and marginal electricity

Generally? Complex system effects

Resource efficiency!

Process learning

- Collaboration
- Round-table discussions
  - Energy system model

Will it be built?

Thank you!

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the 4DH-project

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Two papers already published

- Sandvall AF, Ekvall T, Ahlgren EO (2016). System profitability of excess heat utilisation - a case-based modelling analysis. *Energy* **97**: 424–434.
- Sandvall AF, Börjesson M, Ekvall T, Ahlgren EO (2015). Modelling environmental and energy system impacts of large-scale excess heat utilisation - a regional case study. *Energy* **79**: 68-79.