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A SYSTEMS VIEW ON CARBON IMPACTS OF FUTURE HEATING

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Heating in Sweden

District

- Biomass (forest residues)
- MSW (municipal solid waste)
- Excess heat
- Heat pumps – large scale
- *Rather small amounts of fossil fuels*

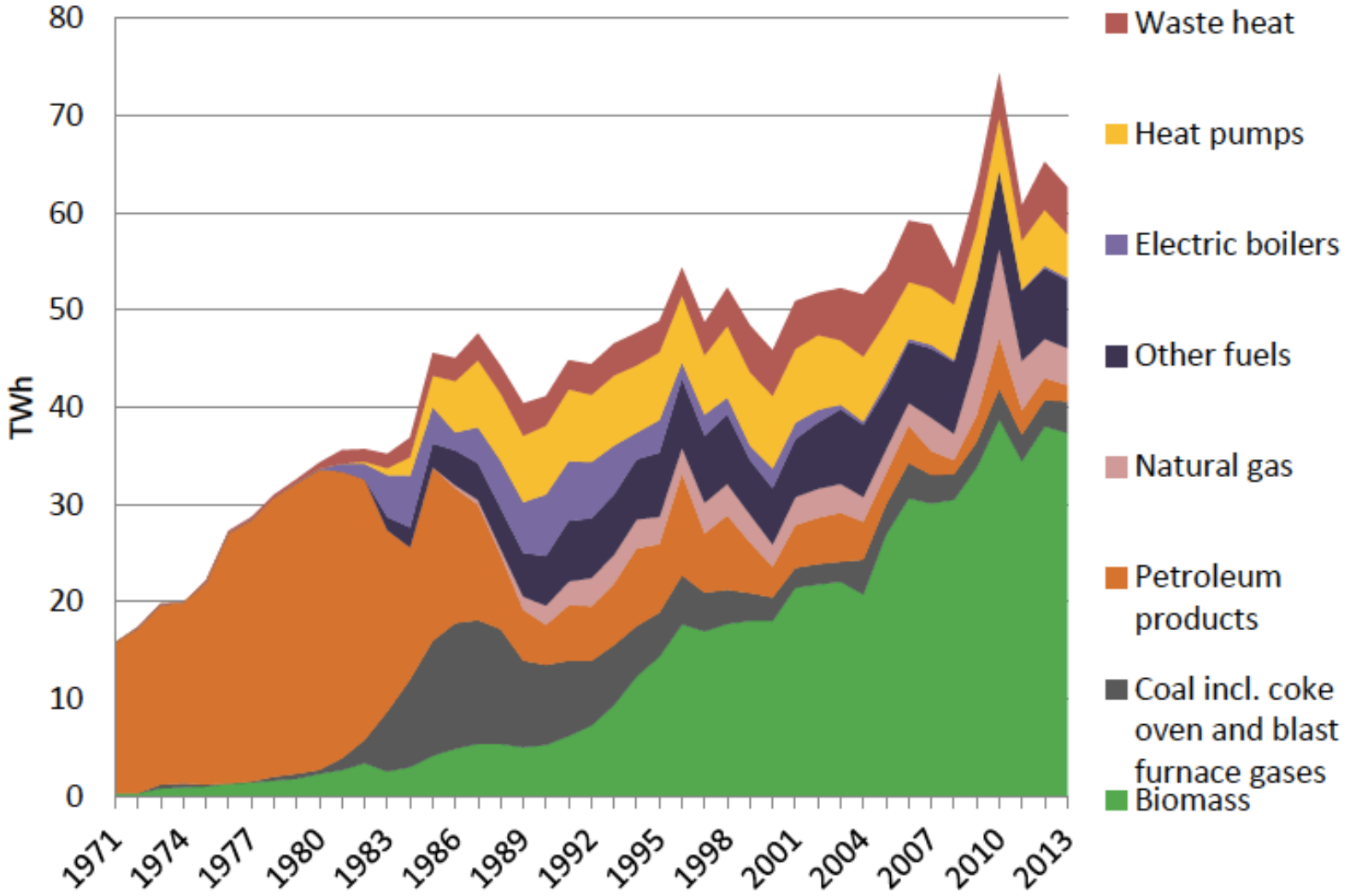
Residential

- Heat pumps – small scale
- Biomass (wood chips/pellets)
- *Oil boilers mainly phased out*

Heating in Sweden

⇒ **low carbon impact**

Energy used in district heating production



Source: Swedish Energy Agency and Statistics Sweden.

Future heating

Why ?

Buildings heat supply

- Large share of energy demand
- Scale effects
- Strong potential integration with other sectors (electricity, transport)
- Long-term impacts on the entire energy system – thus impacts our carbon mitigation strategies
- District heating not always 1st option
- Policy relevant (green branding)
  - Biomass constrained resource!

Buildings heat supply

Strategic interest !

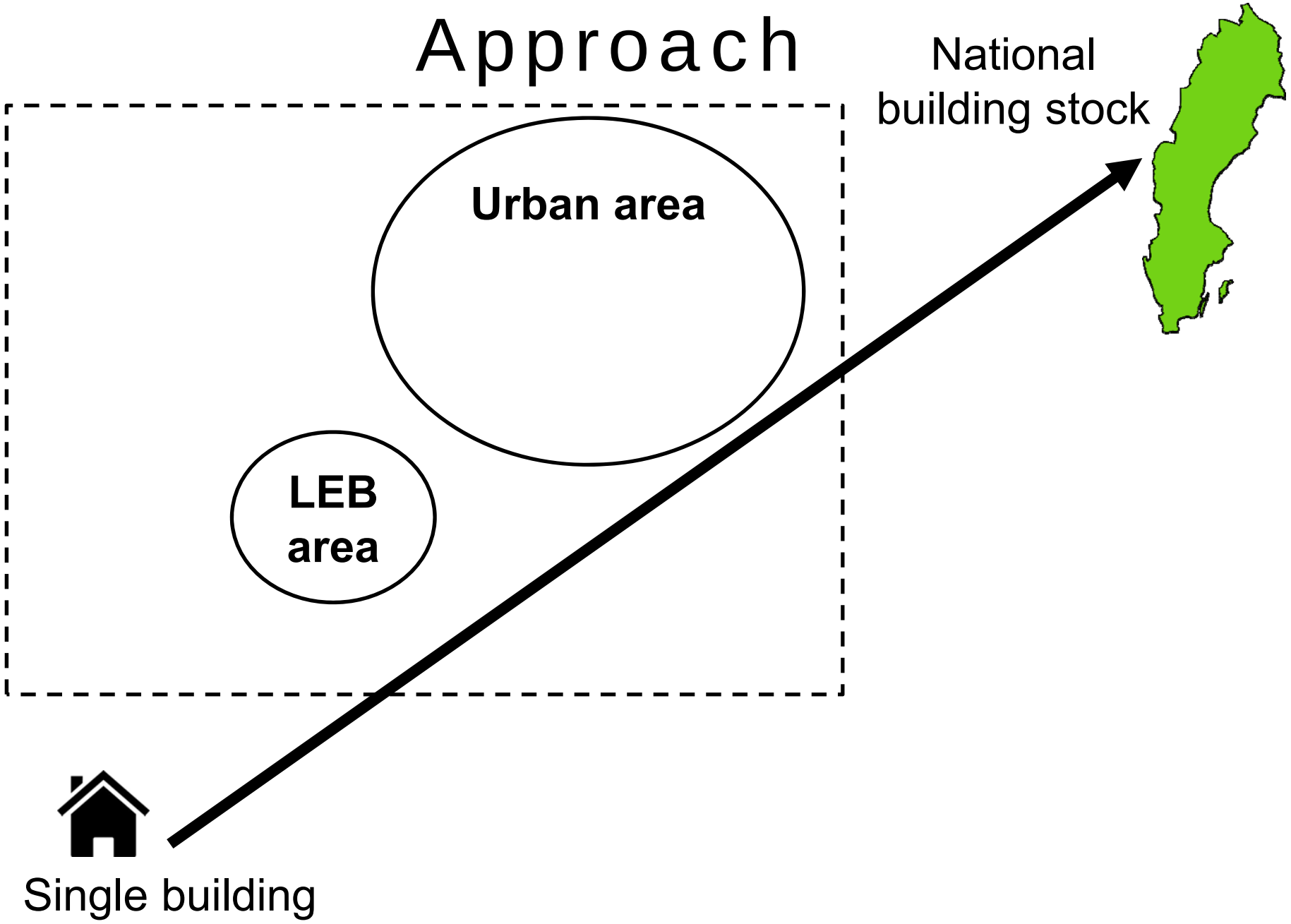
Aim

- Which (urban) heating option has the lowest **long-term** climate impact?
  - Analyze how the carbon impacts of heating of low-energy urban buildings depend on
    - spatial and temporal **scales**
    - system **views**

Assumptions I

- New buildings are built based on LEB standards (*LEB = low energy buildings*)
- New LEB areas are built in, or in the vicinity of, urban areas

Approach


National
building stock
Urban area
LEB
area
Single building

Three heat supply options -to NEW buidlings

- Individual

  Each building has its own heat production device

- On-site

  Heat supply by a small local district heating (DH) system within the LEB area

- Large heat network

  Heat is produced in the DH system of nearby urban area and is transmitted to the LEB area by a transmission pipeline

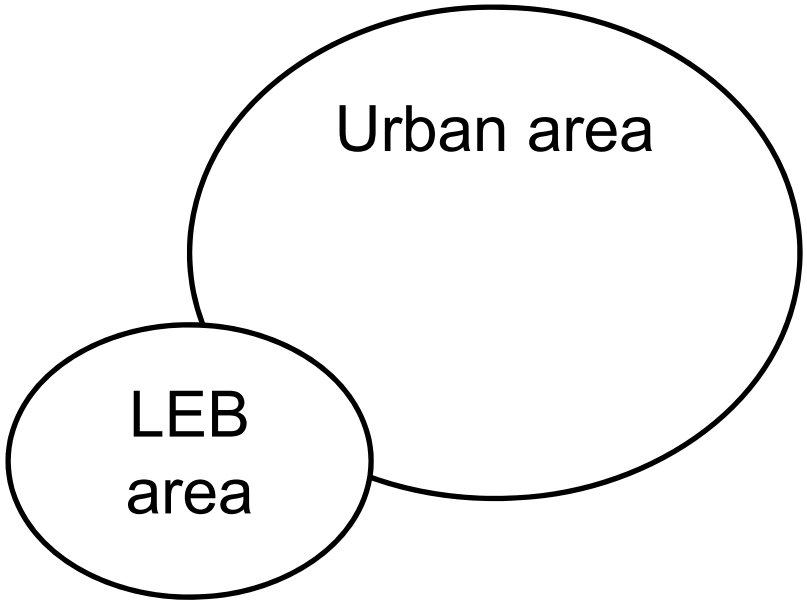
➡ Three disctinctly different ***scales***

Method

Systematic analysis

- based on
  - hypothetical LEB area,
  - hypothetical DH systems,
- **Dynamic energy systems modelling**
- Scenario analysis (450PPM, BAU)

Systematic analysis (scale effects)



Hypothetical LEB area

- LEB area
  - One-family buildings area, plot ratio 0.15 (PR-1A)

Hypothetical DH systems

- Urban DH systems
  - Small (Kungsbacka) – bio HOB (heat-only)
  - Medium (Linköping) – bio CHP (combined heat & power)
  - Large (Göteborg) – large bio CHP, industrial/MSW waste heat
- DH supply investment options available

Dynamic energy systems modelling

- Urban-TIMES – two regions
- TIMES – cost-minimising
  - MIP (capturing of economies of scale)
- Long-term perspective (until 2050)
- Simulating approach (options tested one by one):
  - 1. Individual heat supply in the LEB area
  - 2. DH supply in the LEB area (i.e. on-site)
  - 3. Diff (DH supply in both the nearby town and LEB area - DH supply in the nearby town)

Assumptions II

- Heat supply represented in detail
  - Existing DH production capacity in the DH systems
  - New investment options in the DH systems and the LEB area (discrete investments)
  - Individual devices and plants: bio pellets boiler, geothermal heat pump, electric boiler
  - Low temperature DH (55/25 C) in the LEB areas.

- Electricity system, energy markets, biomass cost/price, climate policies and heat demand are included exogenously.
- Time resolution: Seasonal, Day-Night
- Inelastic heat demand

Scenarios

based on IEA World Energy Outlook

- 450PPM:
  - Increasing CO2 cost
  - Increasing biomass prices (biomass market)
- BAU:
  - Slowly increasing CO2 cost
  - Biomass supply cost

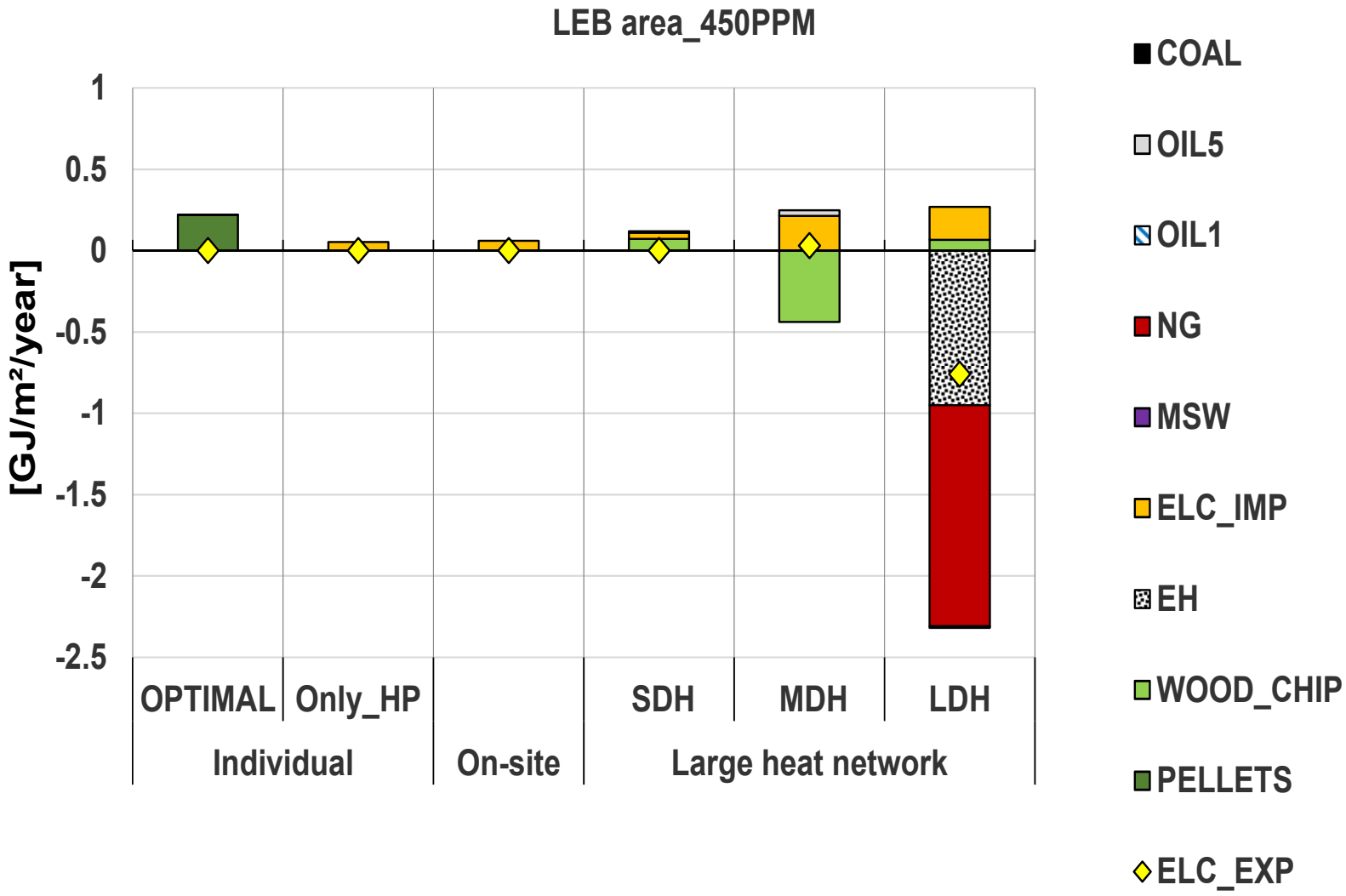
Energy system & climate impact

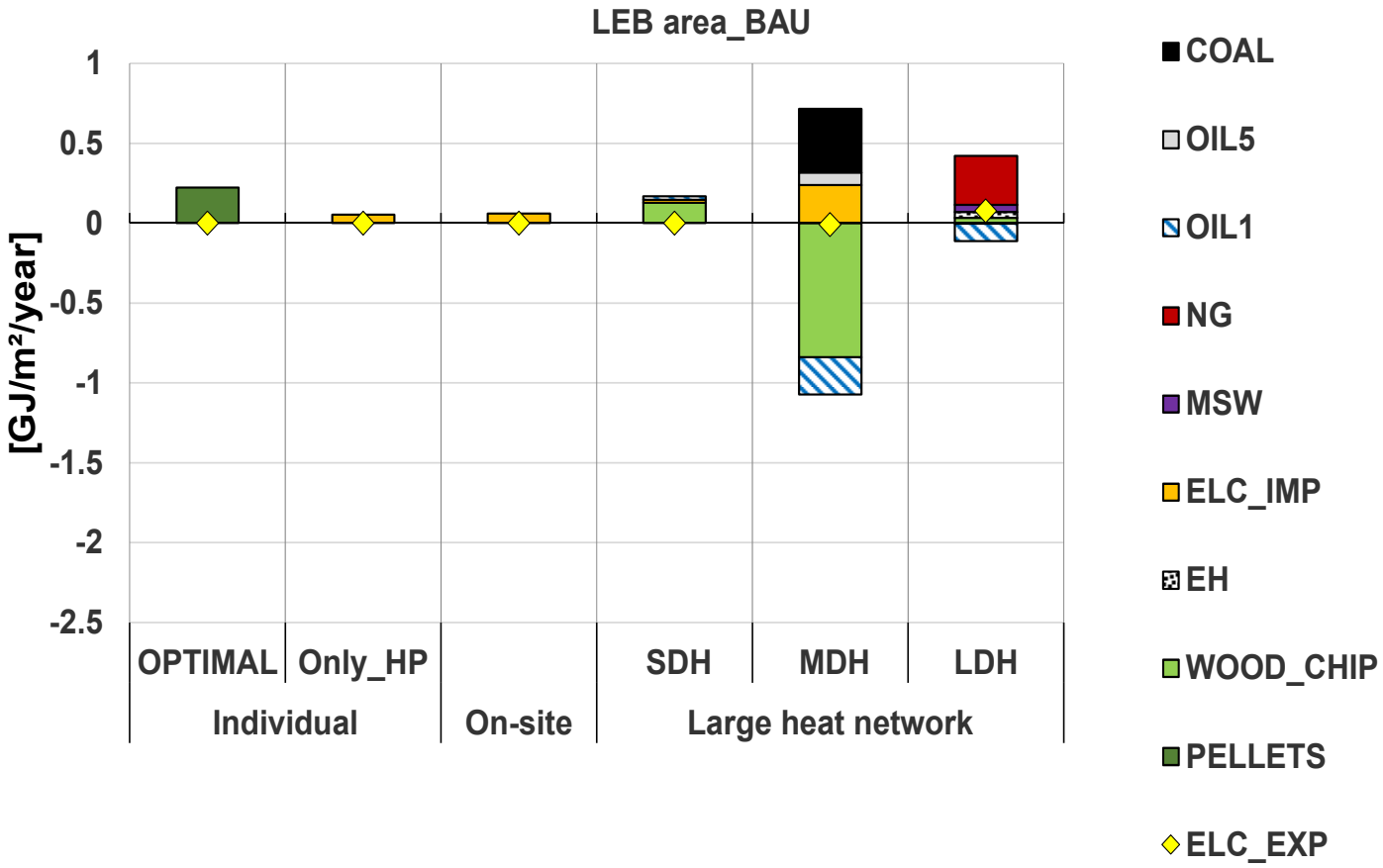
- **Marginal electricity generation**
  - Swedish electricity generation carbon neutral – but rest of Nordic countries/European NOT
    - TPP (thermal power plants)
    - WGT (wind + gas turbines)

- **Alternative use of biomass**
  - Unused biomass utilized elsewhere?
    - Fossil fuel based CHP
    - Transport fuel production

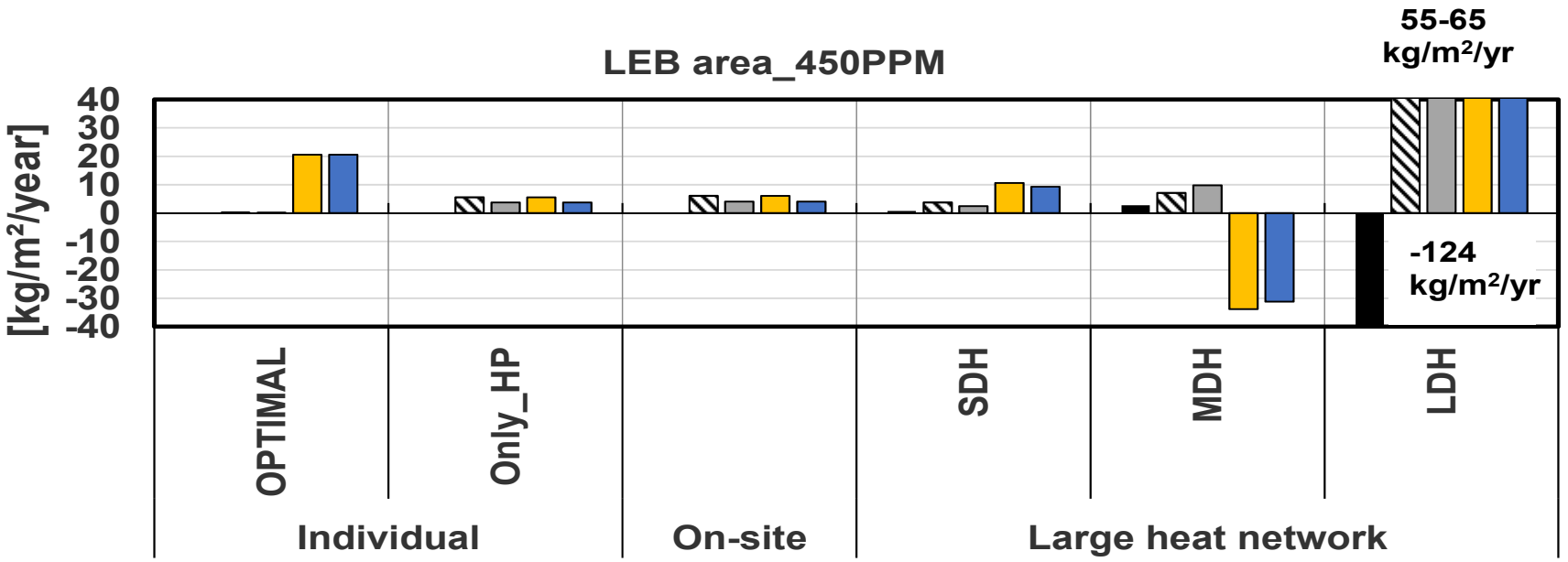
Results

Energy system impact

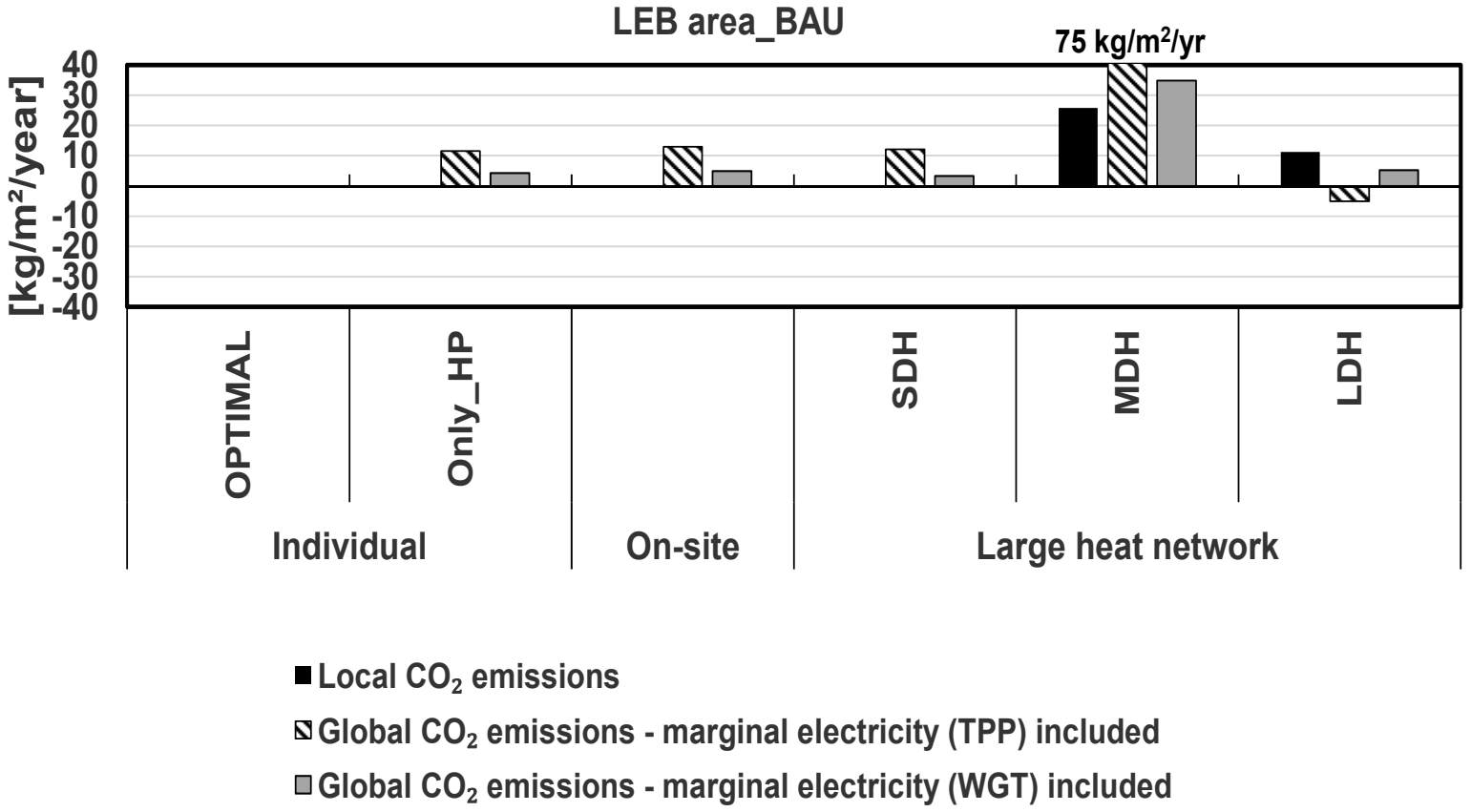



LEB area_BAU
[GJ/m²/year]
1
0.5
0
-0.5
-1
-1.5
-2
-2.5
OPTIMAL
Only_HP
On-site
SDH
MDH
LDH
Individual
Large heat network
COAL
OIL5
OIL1
NG
MSW
ELC_IMP
EH
WOOD_CHIP
PELLETS
ELC_EXP

Climate impact



- Local CO_2 emissions
- Global CO_2 emissions - marginal electricity (TPP) included
- Global CO_2 emissions - marginal electricity (WGT) included
- Global CO_2 emissions - marginal electricity (TPP) and biomass included
- Global CO_2 emissions - marginal electricity (WGT) and biomass included


LEB area_BAU
75 kg/m²/yr
[kg/m²/year]
40
30
20
10
0
-10
-20
-30
-40
OPTIMAL
Only_HP
SDH
MDH
LDH
Individual
On-site
Large heat network
Local CO2 emissions
Global CO2 emissions - marginal electricity (TPP) included
Global CO2 emissions - marginal electricity (WGT) included

Findings I

- Generally, it is not possible, based on this study, to make a general statement that district heating is better for the climate than individual or on-site solutions in low-energy building areas.
- However, for climate-concerned futures (the 450PPM scenario), and for LEB areas situated within or close to **larger DH-systems**, **the wide systems approach** applied to the MDH indicates much lower carbon emissions than the other heating options.

- A wide systems perspective is important to account for indirect effects of residential heating

Findings II –
bottom-up approach

- Modelling the consequences of a small additional heat demand in a larger DH system is difficult.
  - Discrete investments
  - Capturing of economies of scale

- The study is limited to the heating sector and its rather straight-forward impact on power sector emissions through alternative use of biomass and built marginal electricity generation. Long-term carbon emissions impacts of more complex interactions between the heating sector and the electricity and transport sectors are disregarded.

Thanks!


Energimyndigheten


4DH
4th Generation District Heating
Technologies and Systems