HEAT SUPPLY TO LOW ENERGY BUILDING AREAS – MODELLING ECONOMICALLY OPTIMAL SOLUTIONS

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Heating in Sweden

- Biomass (forest residues)
- MSW
- Excess heat
- Heat pumps (two scales)
- Rather small amounts of fossil fuels

Buildings heat supply

Why ?

Buildings heat supply

- Large share of energy demand
- Scale impacts
- **Strong focus on local, decentral generation (electricity)**
- Long-term impacts on the entire energy system – thus impacts our carbon mitigation strategies
- Policy relevant

Buildings heat supply

Strategic interest !

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***

Questions

- Which is the most cost-efficient heat supply option to NEW buildings from a societal point of view (under various conditions)?

  - ✓ How do the various cost components of the long-term system cost compare between the three heating options?

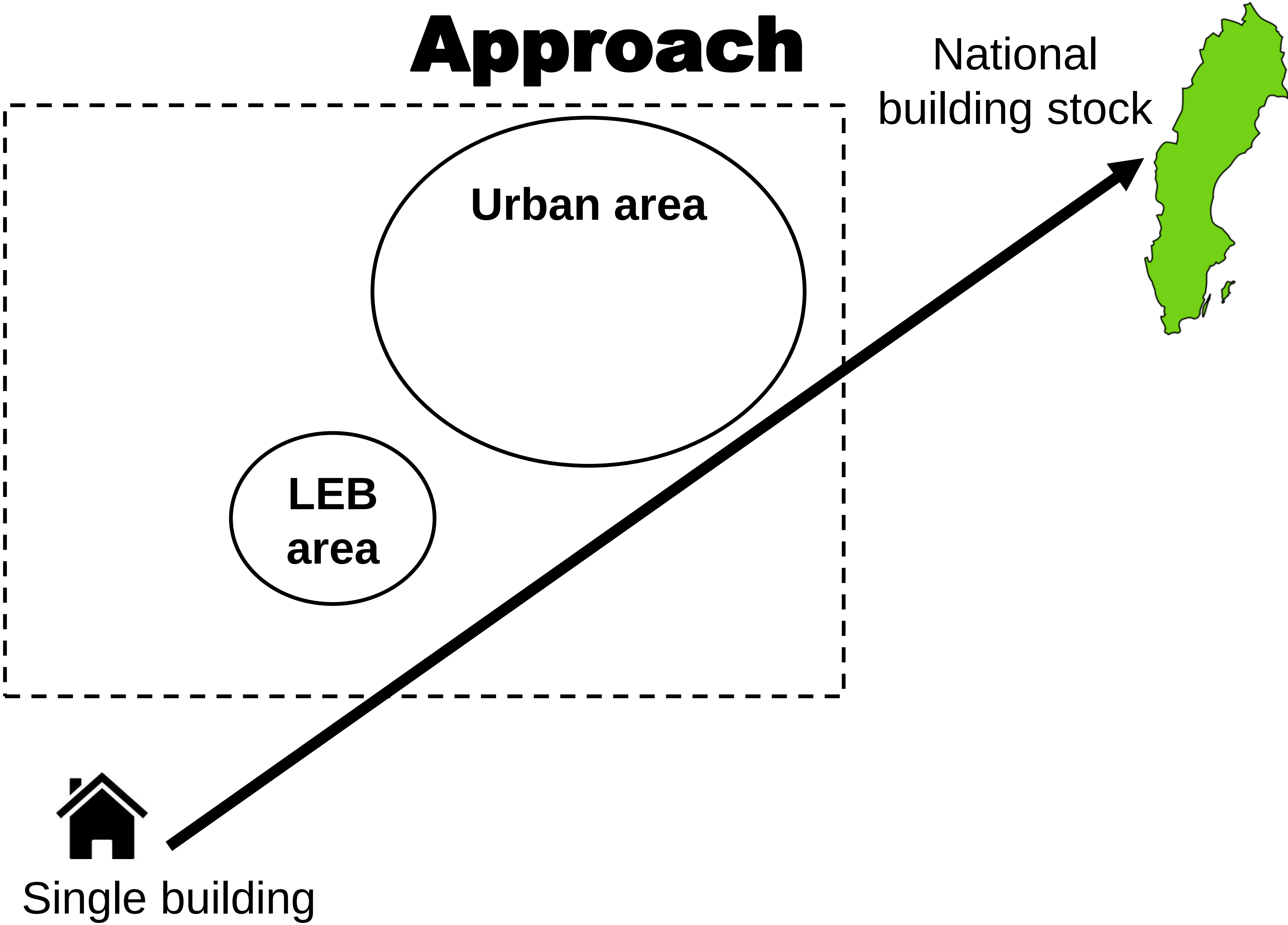
Assumptions I

- New areas are built based on LEB standards

(LEB = low energy buildings)

- New LEB areas are built in, or in the vicinity of, urban areas

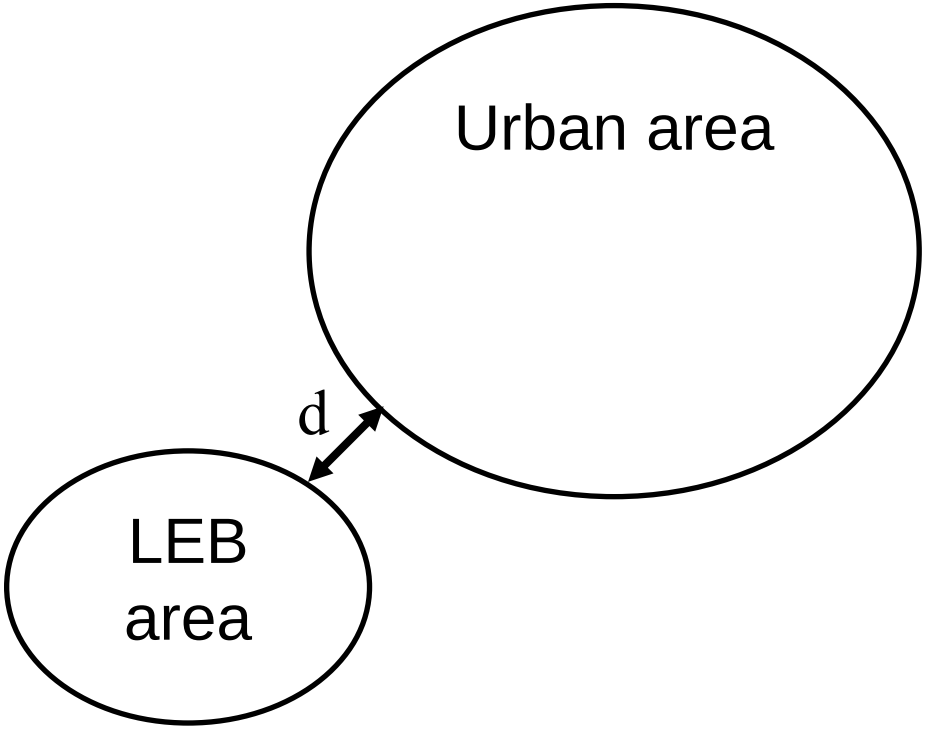
Approach


National
building stock
Urban area
LEB
area
Single building

Method

- Systematic analysis
  - threshold for the most cost-efficient heat supply
- Based on hypothetical LEB areas and hypothetical DH systems, and the distance between them (d)
- **Dynamic energy systems modelling**
- Scenario analysis (450PPM, BAU)

Systematic analysis (scale effects)

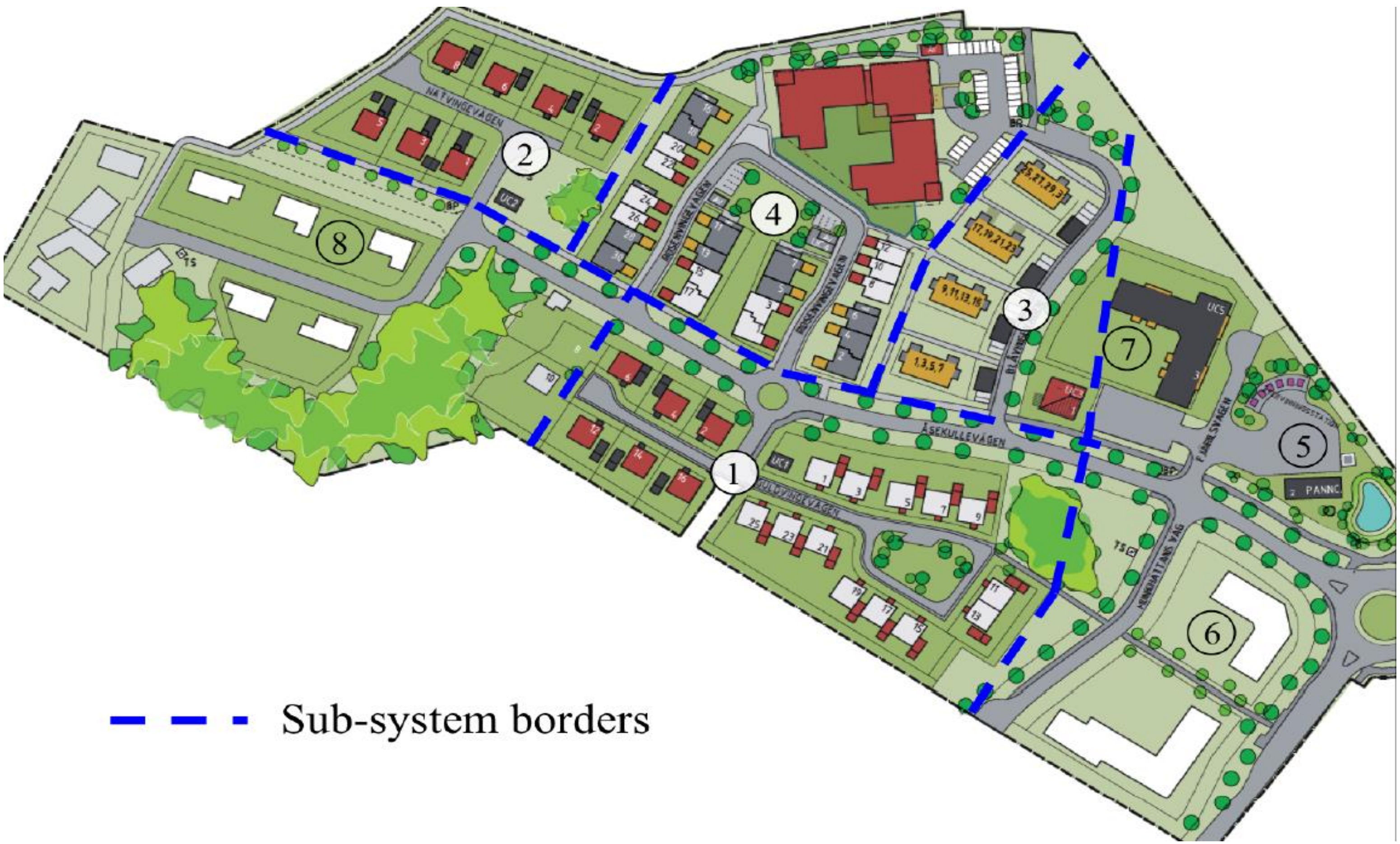


Hypothetical LEB area

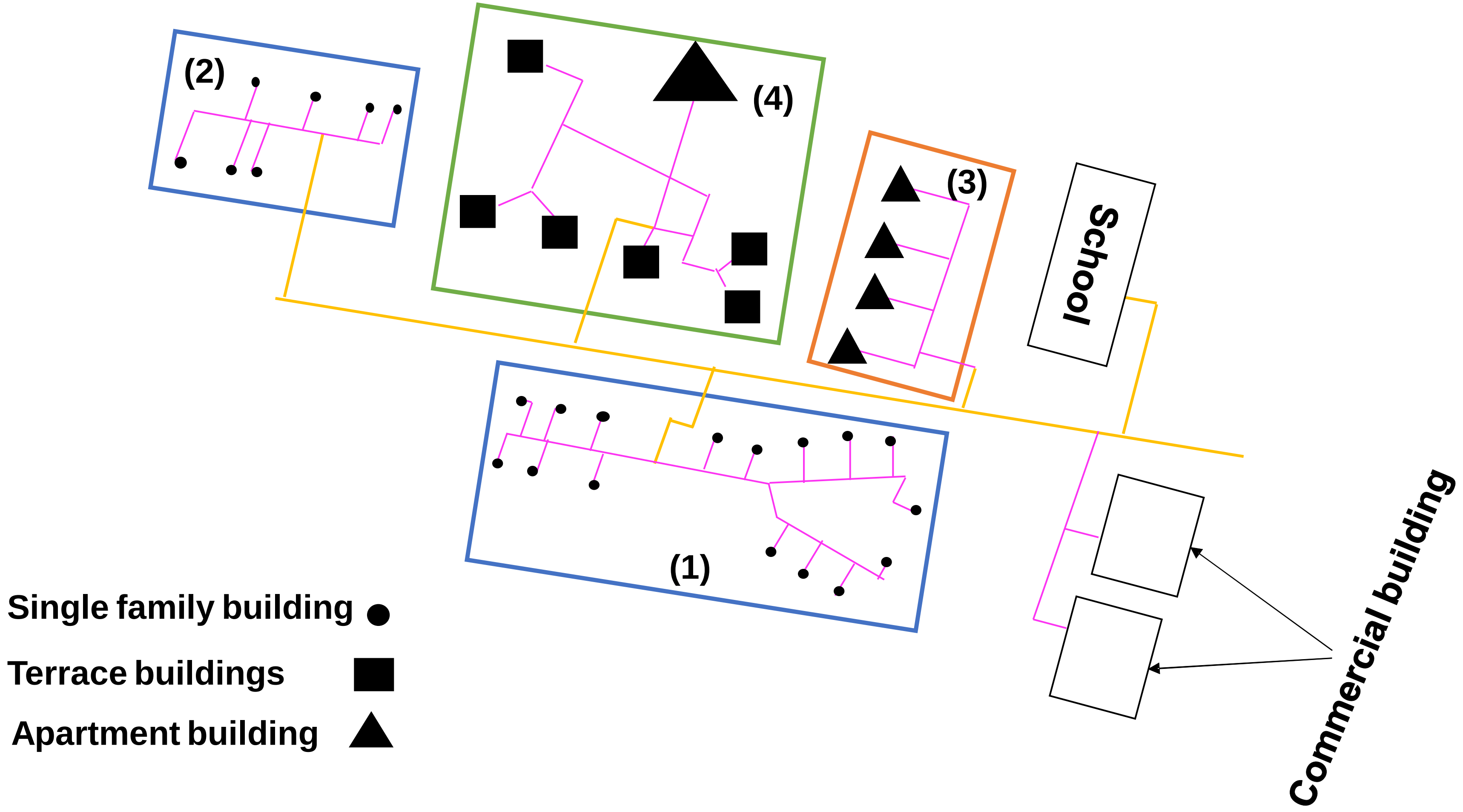
- LEB areas
  - One-family buildings area, plot ratio 0.15 (PR-1A)
  - Apartment building area, plot ratio 0.73 (PR-5A)
  - Large apartment building area, plot ratio 1.3 (PR-9A)

- PR (plot ratio) = heated area/land area (heating density)

Hypothetical LEB area inspired by Vallda Heberg



Area


(2)
(4)
(3)
School
(1)
Commercial building
Single family building
Terrace buildings
Apartment building

Hypothetical DH systems

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

Distances (d)
between LEB area and DH system

- 0-3 km (1 km steps)

Dynamic energy systems modelling

- Local TIMES – two regions
- TIMES – cost-minimising
  - MIP
- Long-term perspective (until 2050)
- Simulating approach (options tested one by one):
  - 1. Individual heat supply in the LEB area (i.e. individual)
  - 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.

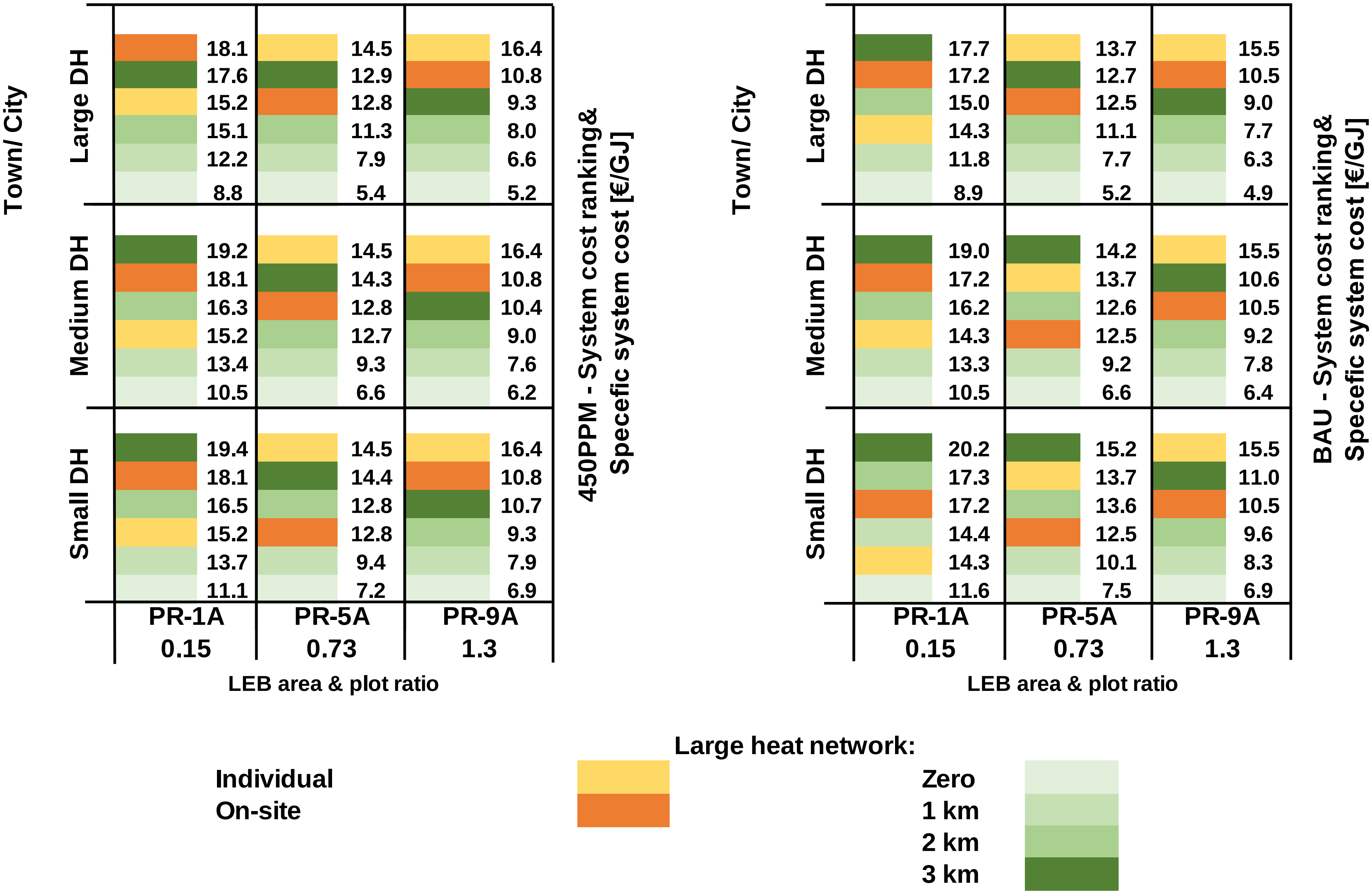
- Electricity system, energy markets, biomass cost/price, climate policies and heat demand are included exogenously.
- Time resolution: Seasonal, Day-Night
- Inelastic heat demand

Scenarios
based on IEA World Energy Outlook

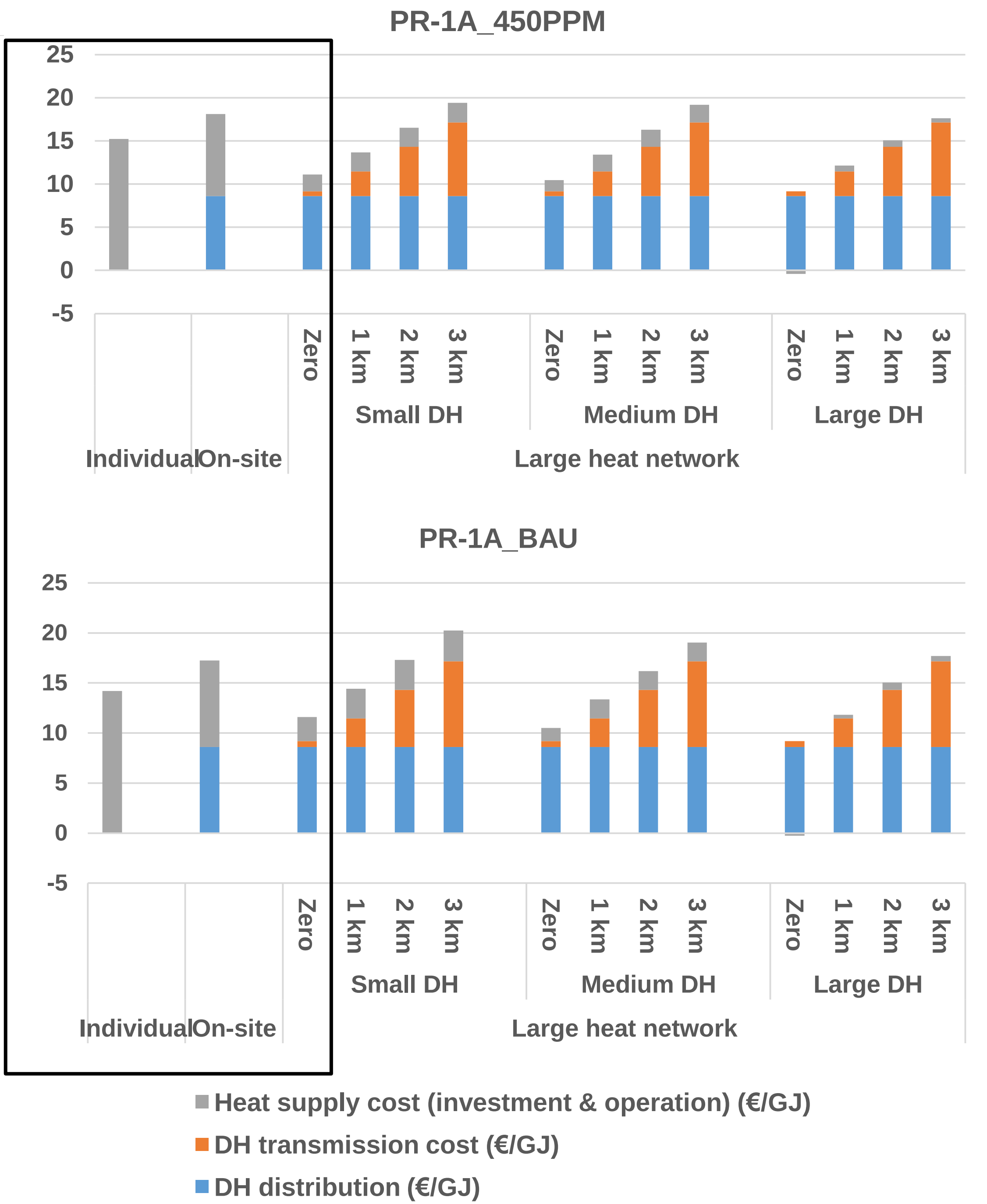
- 450PPM:
  - Increasing CO_2 cost
  - Increasing biomass prices (biomass market)
- BAU:
  - Slowly increasing CO_2 cost
  - Biomass supply cost

Results

Ranking & threshold



Breakdown of cost components


PR-1A_450PPM
25
20
15
10
5
0
-5
Zero
1 km
2 km
3 km
Small DH
Medium DH
Large DH
Individual
On-site
Large heat network
PR-1A_BAU
Heat supply cost (investment & operation) (€/GJ)
DH transmission cost (€/GJ)
DH distribution (€/GJ)

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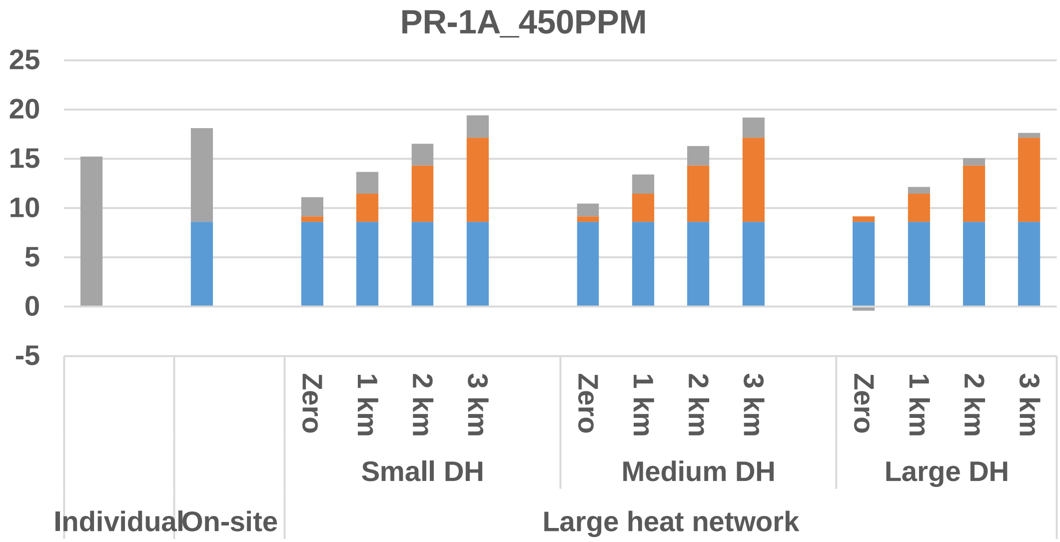

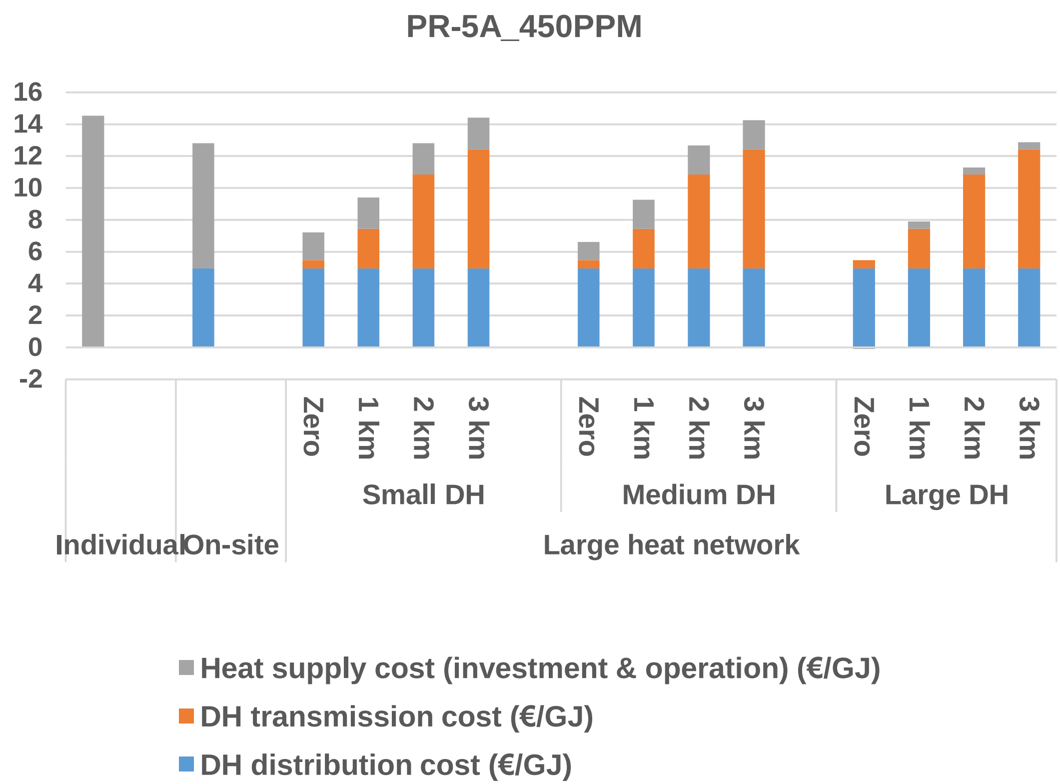

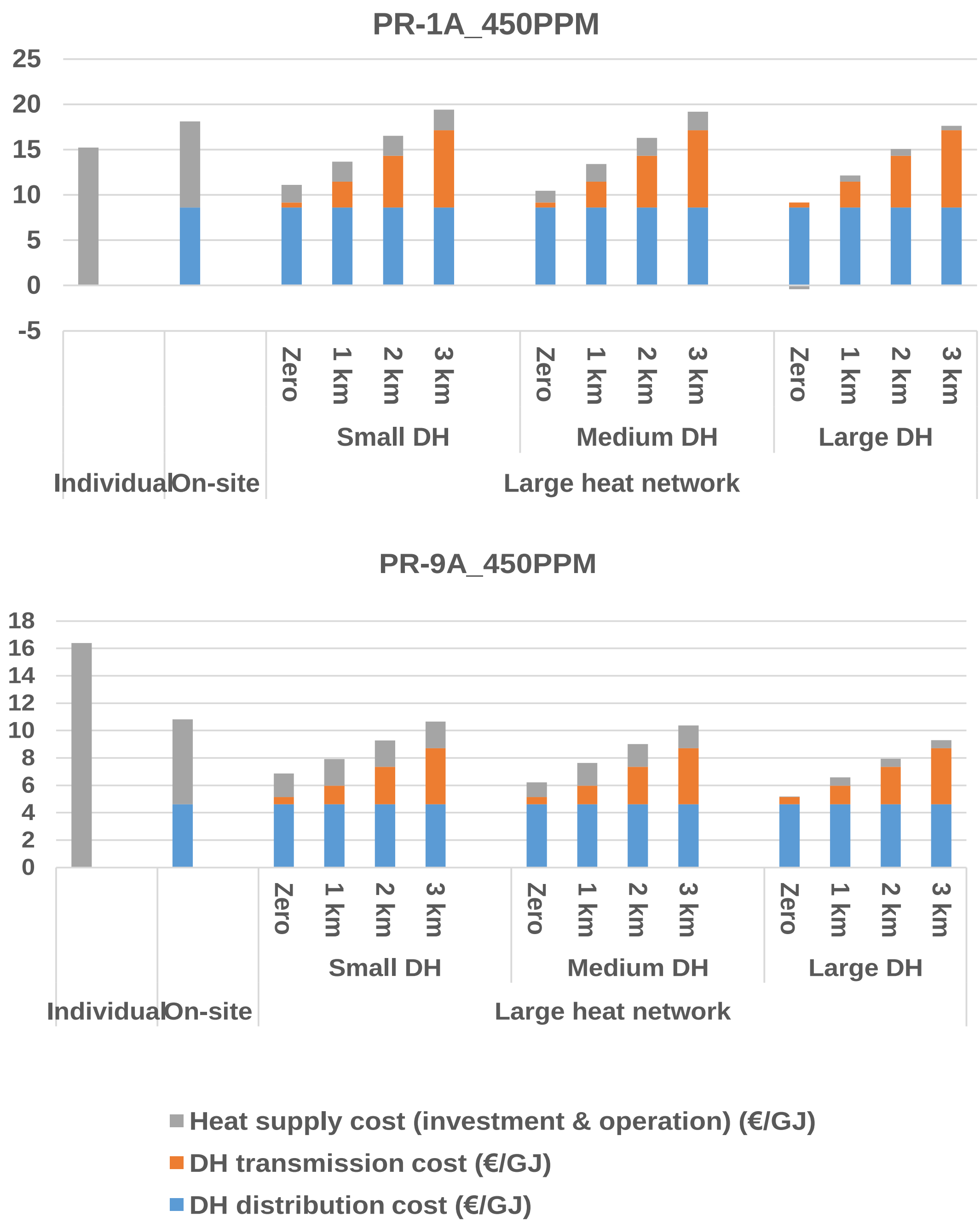
PR-1A_450PPM
25
20
15
10
5
0
-5
Zero
1 km
2 km
3 km
Small DH
Medium DH
Large DH
Individual
On-site
Large heat network
PR-9A_450PPM
18
16
14
12
10
8
6
4
2
0
Heat supply cost (investment & operation) (€/GJ)
DH transmission cost (€/GJ)
DH distribution cost (€/GJ)

Findings

- Large heat network option economically optimal
  - DH distribution and transmission costs account for large cost share
- Scales important
- Results rather robust with respect to climate policies

Next step

Climate impacts?

Thanks!

Energimyndigheten

4DH
4th Generation District Heating Technologies and Systems

Assumptions

	Unit	450PPM	BAU
		2014/2020/2030/2040/2050	**2014/2020/2030/2040/2050**
Policy tools			
CO2 charge	€/tonne	16.9/25.2/68.4/110/153	16.9/14.4/23.8/33.5/43
Renewable electricity subsidy	€/MWh	20/20/0/0/0	20/20/0/0/0
Energy prices/costs [a]			
Natural gas	€/MWh	28.7/28.3/25.1/22/18.5	28.7/29.2/30.2/32/33
Fuel oil, light	€/MWh	64.2/64.7/61.8/58/54.9	64.2/66.2/70/75/80
Fuel oil, heavy	€/MWh	41.6/42/39.8/37.2/34.6	41.6/43.1/46/50/53.5
Coal	€/MWh	8.8/8.9/7.6/6/4	8.8/9.4/9.7/9.7/9.7
Bio-oil[b]	€/MWh	42/44.5/53.9/62.5/71.5	42/42.6/47.7/53.9/59.5
Wood chips[c]	€/MWh	20/20/20/40.5/55	20
Bio pellets	€/MWh	35/44/50/59/78	35/41/45/50/53
Excess heat[d]	€/MWh	0.56	0.56
MSW[e]	€/MWh	-14.5	-14.5
Electricity[c]	€/MWh		
Winter cold (1 month)		55.2/62.9/98/122.2/74.4	55.2/54.6/63.8/72.5/80.9
Winter (2 months)		54.3/61.4/93.2/122.2/74.4	54.3/53.7/62.1/70/77.6
Spring and fall (3 months)		51.3/57.9/73.1/80/74.4	51.3/50.8/57/60.8/67.5
Summer (6 months)		51.3/64.2/73.1/80/74.4	51.3/50.8/63.2/61.4/67.8

Background

- EU Directives (2010 &2012)
- National goal by 2050
- In 2015 the Boverket forecasted that 700,000 new homes are needed in ten years.
- Boverket has set standards and rules for the heat demand of new buildings.
- Construction of buildings with very low energy use is supported by the Swedish Energy Agency

→New areas are built based on LEB standards