Implication of low temperature district heating on network investment costs, primary energy savings and cost benefits

Ambrose Dodoo, Leif Gustavsson and Nguyen Le Truong
Linnaeus University, Sweden

Linnéuniversitetet Kalmar Växjö

This presentation is based on an on-going project on:

- **Low temperature district heating and new energy efficient building blocks**
- Project partners include Växjöbostäder, Växjö Energi AB and Växjö Municipality
- The presented results are preliminary

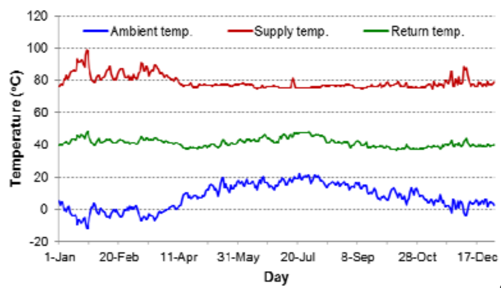
Implication of low temperature district heating on network investment costs, primary energy savings and cost benefits

- We consider three types of exploitation of a development area in Växjö, in southern Sweden
  - Low exploitation
  - Medium exploitation
  - High exploitation
- We consider two different energy performance of buildings
  - Swedish building code (BBR 2015)
  - Passive house criteria
- We consider three temperature levels for district heating network
  - 80/40°C
  - 65/30°C
  - 50/20°C

Project site in southwest of Växjö

- Växjö is a city of about 65 000 inhabitants
- District heating system (DHS)
  - ~ 185 MW_{peak} and ~ 630 GWh_{heat}/year
  - ~ 98% of production based on biomass
  - 2 CHP plants and several boilers

Measured temperature in DH-network in 2013



Project site

- A new developed area in Torparängen, Växjö
- Planning of ≈ 250 apartments/houses,
  - 125 apartments
  - 125 row houses and small houses
- 4, 6, 8 or 10 story-buildings
- Different building frames
  - Concrete
  - Wood
- Different heat supply options
  - District heating
  - Electric heat pumps in each building

3D models of different exploitation alternatives

Low exploitation of townhouses and villas, 9010 m^2 heated floor area

Medium-exploitation of apartment buildings and townhouses, 23 540 m^2 heated floor area

High-exploitation of apartment buildings, 29 350 m^2 heated floor area

Buildings heat demand

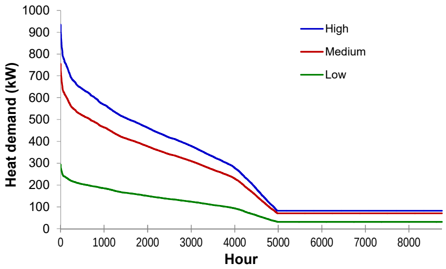
- Simulated based on current Swedish building code (BBR) and passive house criteria (Passive)
- Used for the design and calculation of district heat options
  - For apartment buildings:

Building type	Space heating load (kW / building)	
	BBR	Passive
o 6 storeys, 24 apartments	54.5	27.8

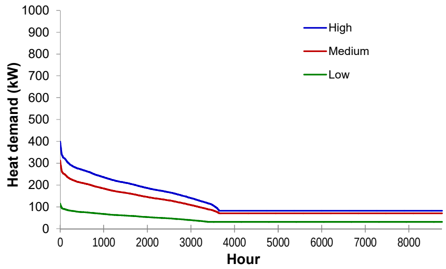
  - For row houses:

House type	Space heating load (kW / house)	
	BBR	Passive
o 2 stories, 6-13 houses/row, 140 m²/house	4.34-6.20	1.80-2.42

Profiles of total space and hot water demand for the different exploitation areas – hour by hour simulations



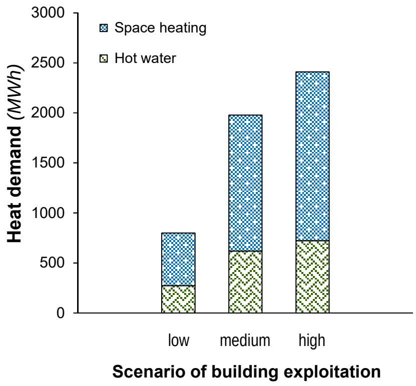
BBR



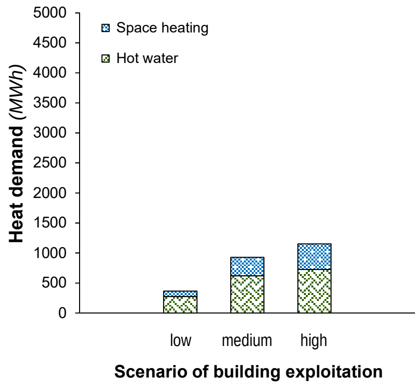
Passive

Annual space and hot water demands for the different exploitation areas

BBR

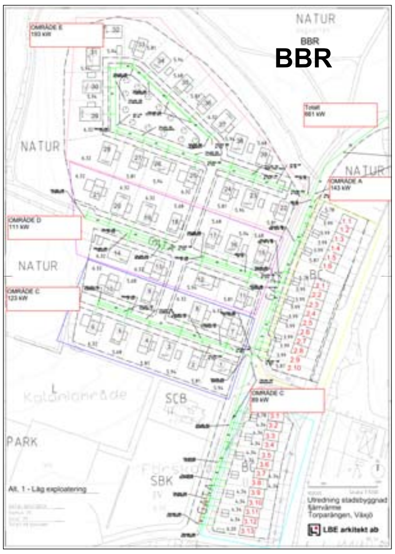


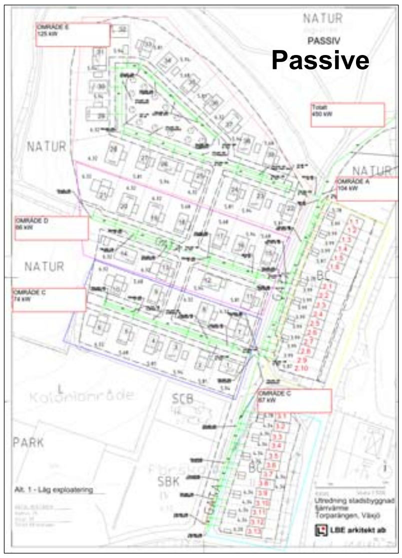
Passive



Layout of district heat distribution network:

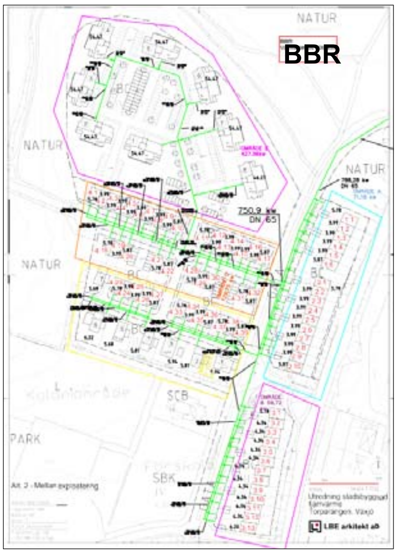
Low exploitation of townhouses and villas

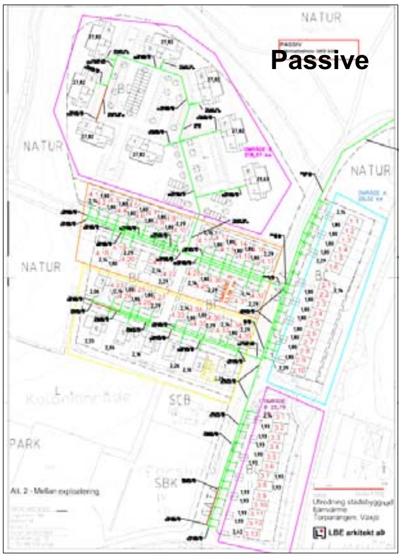




Layout of district heat distribution network:

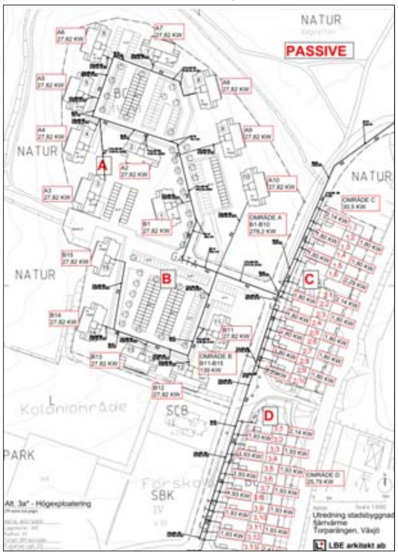
Medium-exploitation of apartment buildings and townhouses



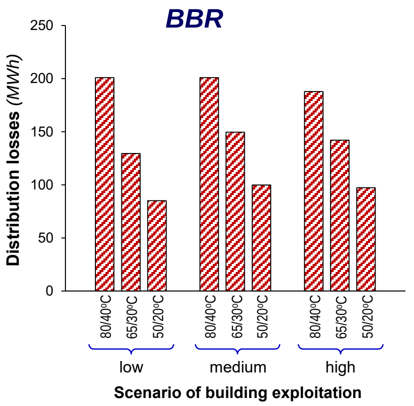


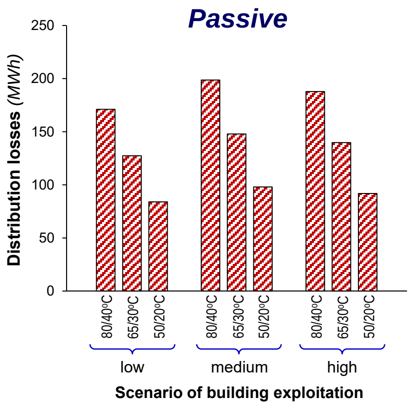
Layout of district heat distribution network:

High-exploitation of apartment buildings

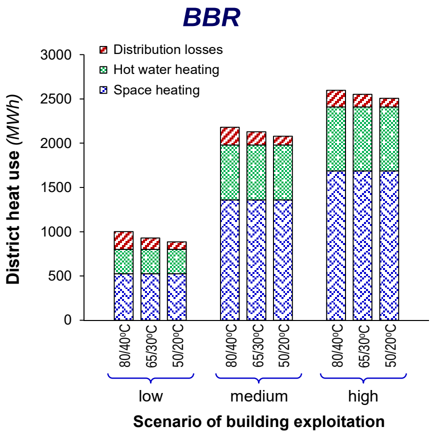


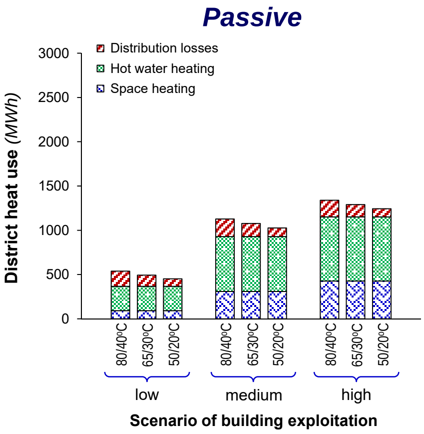
Local network heat losses for different alternatives and options





Local network heat losses, space and hot water heating demands for different exploitations

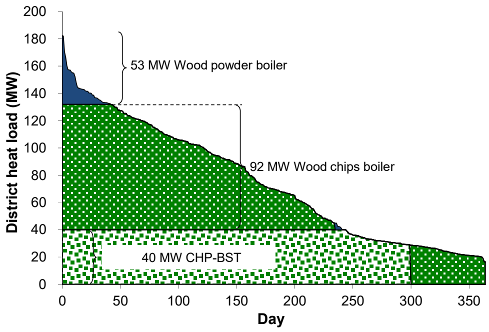




- Local network losses: ***3.9-20.1%*** in alternatives with BBR standard
  7.4-31.8% in alternatives with passive criteria

Primary energy use for local network losses

A biomass-based DHS using the heat load duration curve of Växjö is used for calculation

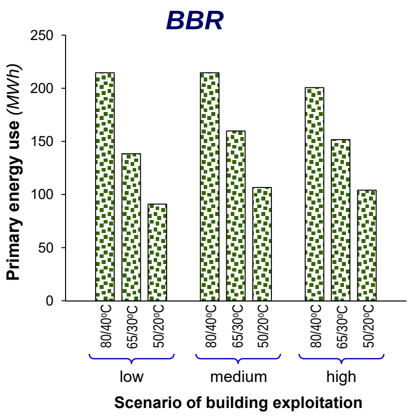


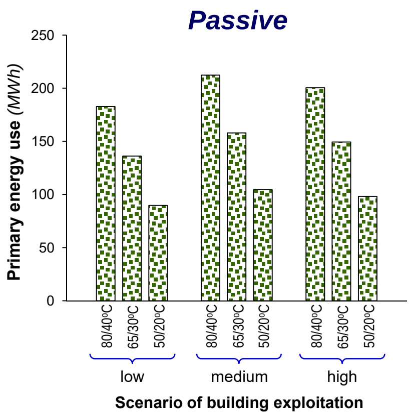
System:

- o ~ 185 MW_{peak}
- o ~ 630 GWh_{heat}/year

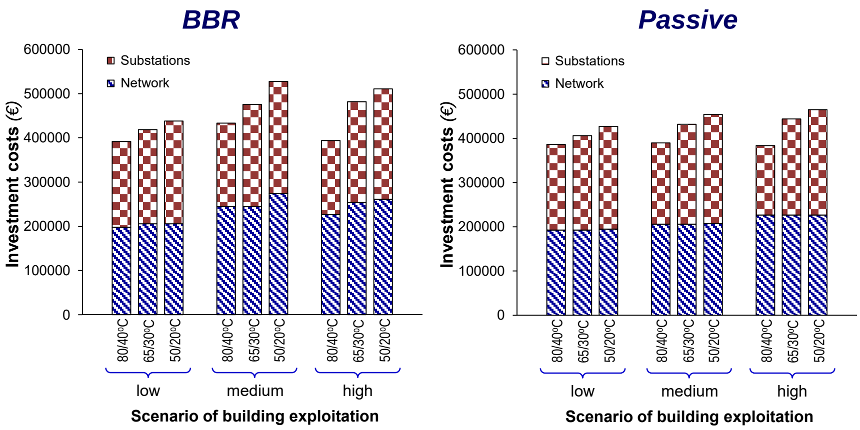
❑ The changed primary energy use is considered as marginal

Primary energy use for local network losses



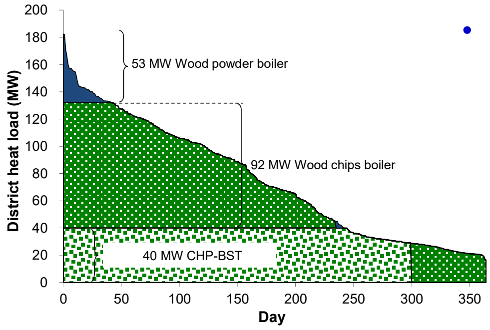


Investment costs for local network and substations



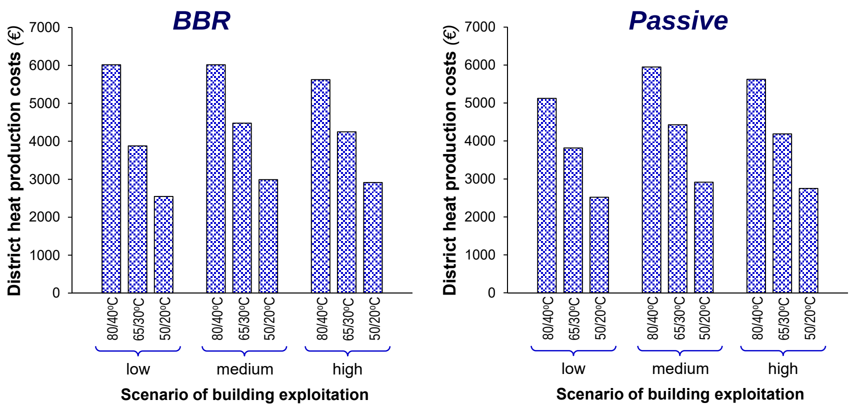
District heat production costs of annual local network losses

- Using biomass-based district heating system for all the scenarios
- Including capacity cost, fixed and variable O&M costs of each district heat production unit



- Based on marginal cost calculation

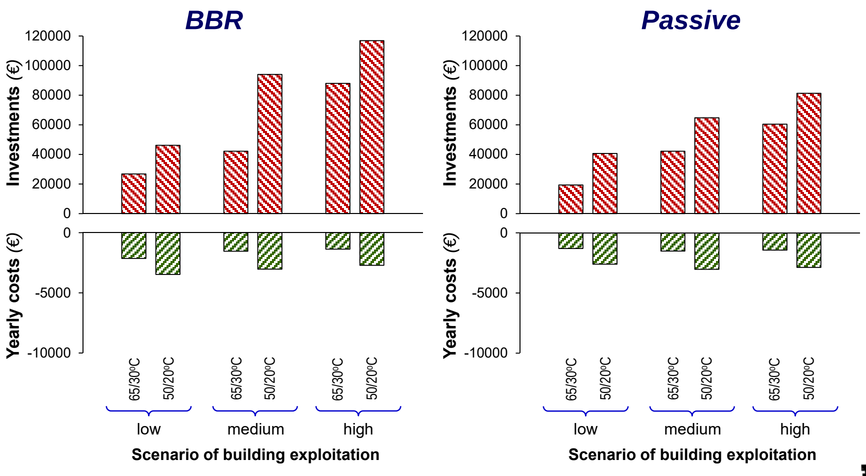
District heat production costs of annual local network losses



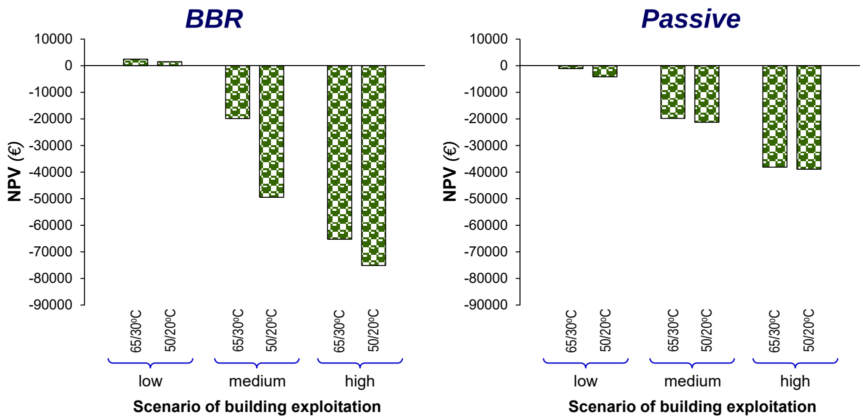
Cost implication of reduced supply/return temperatures in local network with 80/40ºC as baseline

- The difference in annual district heat production cost relative to the baseline is calculated.
- The net present value of the cost difference is calculated assuming different real discount rates and lifetimes
  - 6% and 30 years
  - 3% and 40 years
- The net present value of the cost difference is compared to difference in investment costs

Changes of initial investment costs (read) and yearly district heat production costs (green) with 80/40°C as baseline



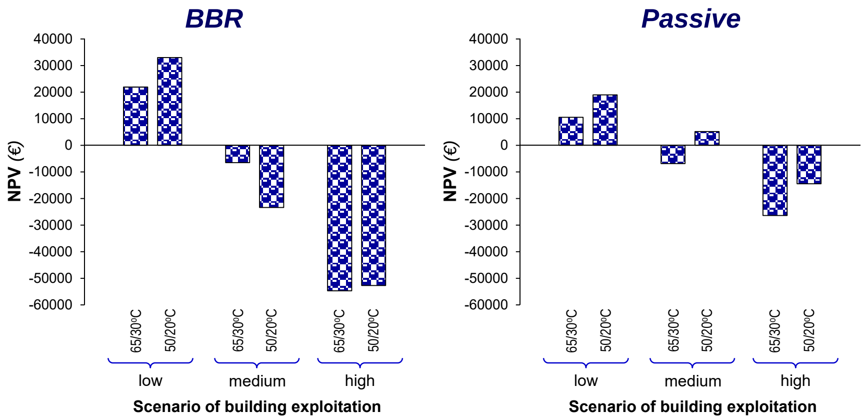
Increased investment cost minus net present value of reduced local network heat losses with 80/40°C as baseline



Discount rate of **6%**

Lifetime **30 years**

Increased investment cost minus net present value of reduced local network heat losses with 80/40ºC as baseline



Discount rate of **3%**

Lifetime **40 years**

Not so far considered in the analysis

District heat production benefits of operating CHP-plants at lower district heating temperatures

Reduced distribution heat losses in the whole distribution system due to reduced supply/return temperatures

Implications of investment cost for internal distribution of heat in buildings due to different supply/return temperatures