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Effects of energy efficiency measures in district-heated buildings of different district heat supply systems

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Introduction

- In Sweden, district heated buildings are common:
 - about 84% floor area of apartment buildings are heated by district heat
 - consumed a half of the country's district heat in 2011
- District heating systems are of different scales with different operation units
- 👉 Changes of heat demand due to energy efficiency measures can influence the operation of district heat production systems and their related energy systems
 - => Effects can vary with contexts



Aims

- Evaluating effects of different energy efficiency measures in an existing district-heated building
- Considering different contexts: the building is located and connected to different district heating systems of different scales, and technical setup
- ☞ Evaluating how primary energy is being changed as a consequence of:
 - energy efficiency measures, taking into account the hourly variation of final energy saving
 - actual operation amongst different heat supply units of different district heat production systems.



Case study building

- A building in Växjö is used as a reference:
 - ❑ wood-framed
 - ❑ 4 stories
 - ❑ 16 apartments
 - ❑ 1190 m² floor area



Types of energy efficiency measures

<i>Description</i>	<i>Effect of improvement</i>
• Improved water taps	Reduced hot water used by 40%
• 10 cm additional mineral wool insulation to the roof	U-value from 0.13 to 0.09 W/m ² K
• Windows replaced by triple-glazed units	U-value from 1.9 to 0.90 W/m ² K
• Doors replaced by triple-glazed units	U-value from 1.19 to 0.90 W/m ² K
• 25 cm additional mineral wool insulation to external walls	U-value from 0.20 to 0.10 W/m ² K
• Ventilation heat recovery unit with 80% efficiency	Reduced ventilation heat loss by 57%
• Electric efficient household appliances	Reduced household electricity by 44%



Groups of energy efficiency measures

Measures are grouped in 3 categories

1. Measures to reduce district heat demand:
improvement of water tap and building envelope
2. Measure to reduce district heat demand but increase electricity use: ventilation heat recovery
3. Measure to reduce electricity use but increase district heat demand: efficient household appliances.

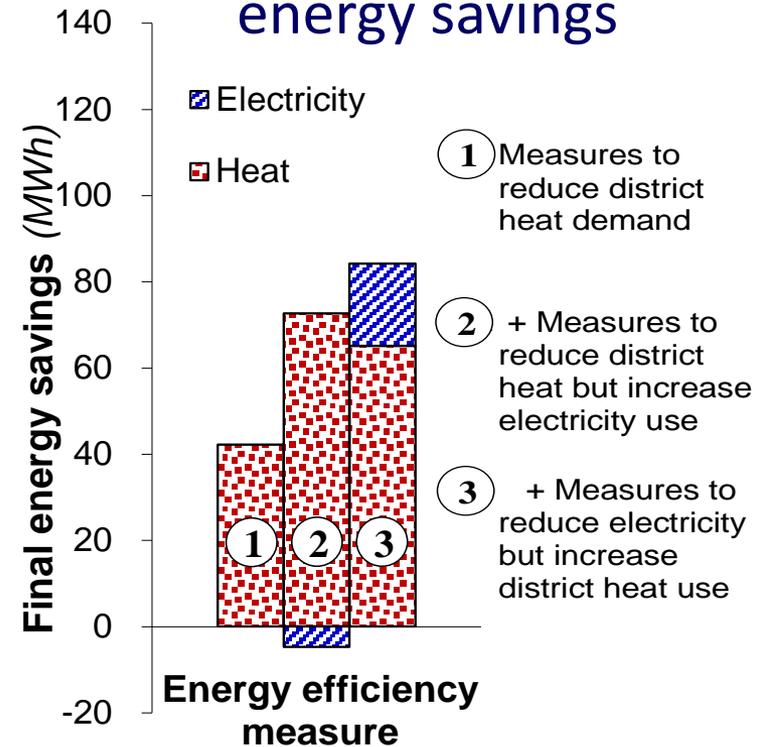


Final energy savings

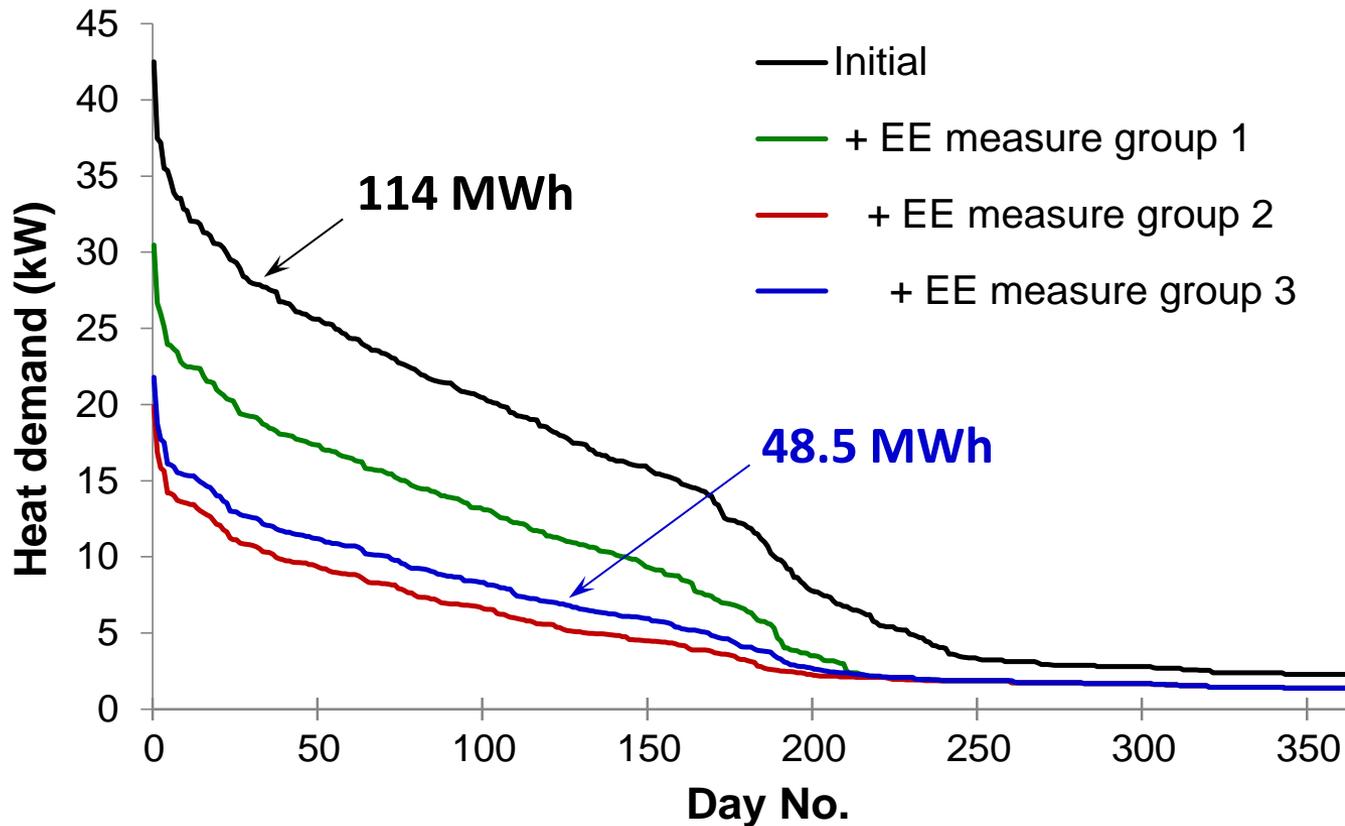
Effects of each EE measure group

Measure group	Savings (MWh)		
	Heat	Electricity	Total
- EE group 1	42,2		42,2
- EE group 2	30.5	- 4.8	25.7
- EE group 3	-7.6	23.8	16.3

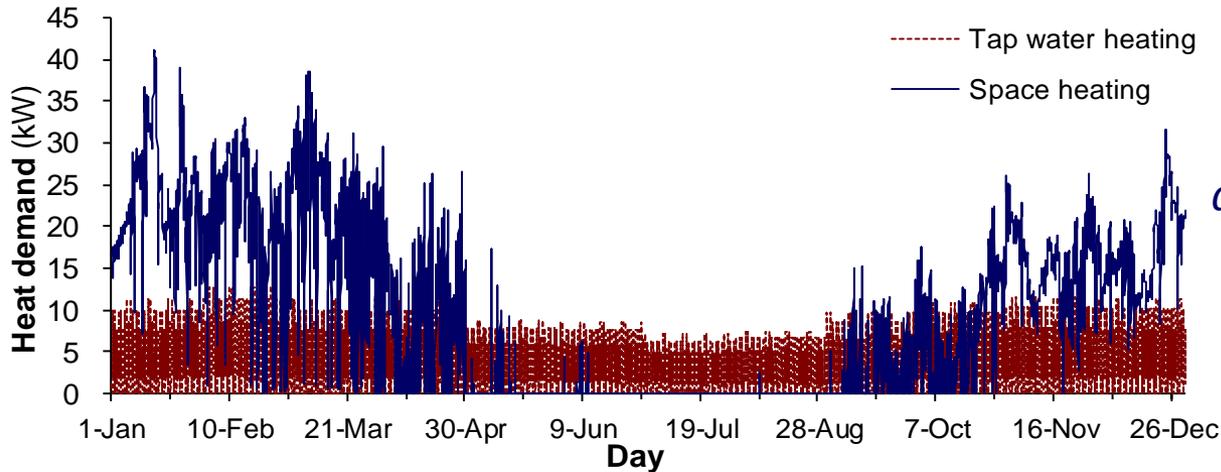
Accumulated final energy savings



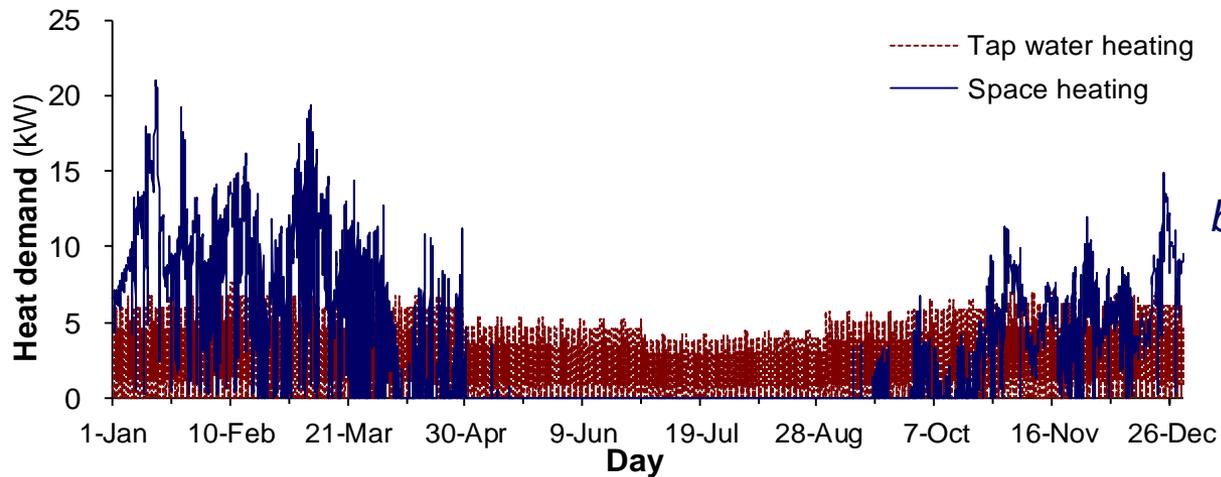
Final heat use of the case study building – arranging in a descending order



Final heat use of the case study building



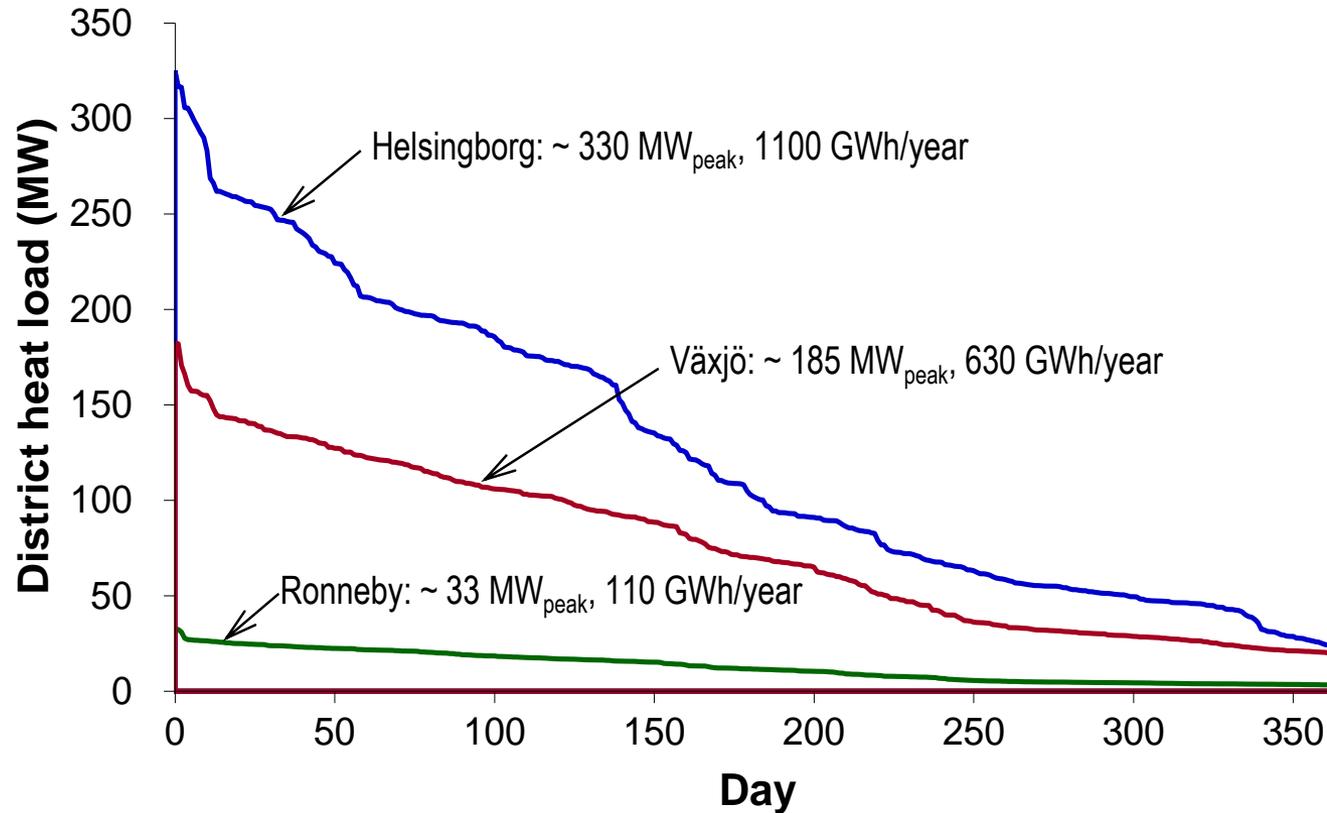
a) Before EE measures:
114 MWh



b) After EE measures:
48.5 MWh

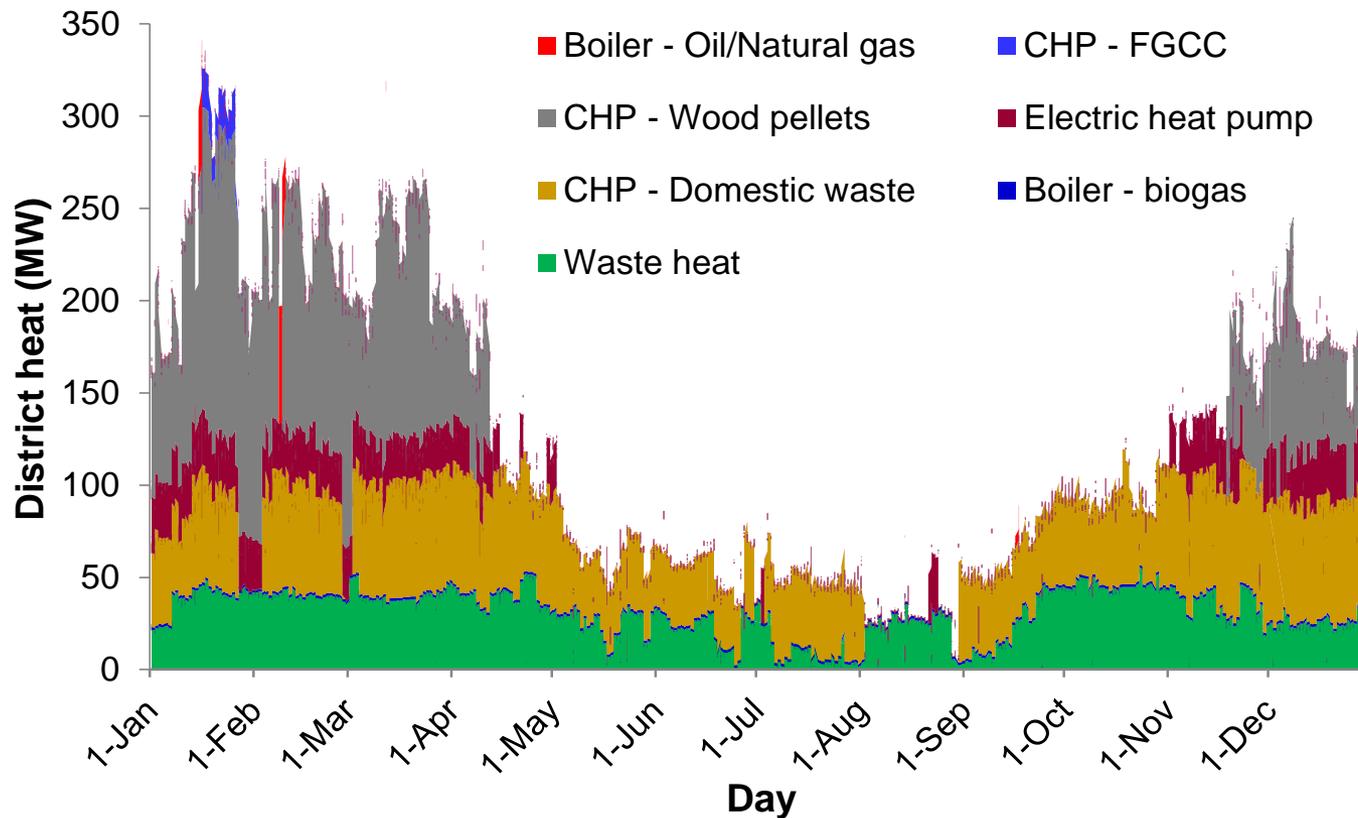


Considered district heating systems



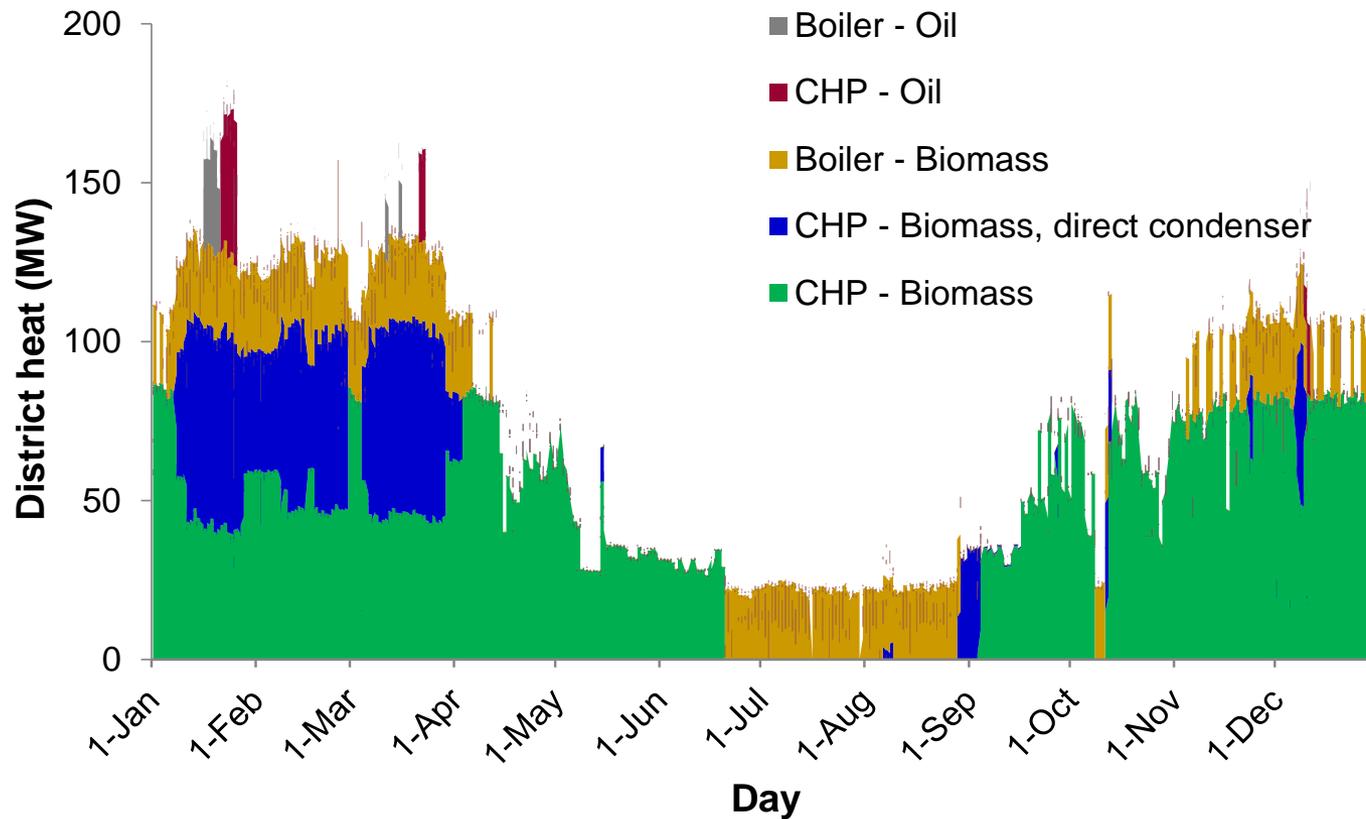
District heat production in Helsingborg

Production in 2013: 1100 GWh



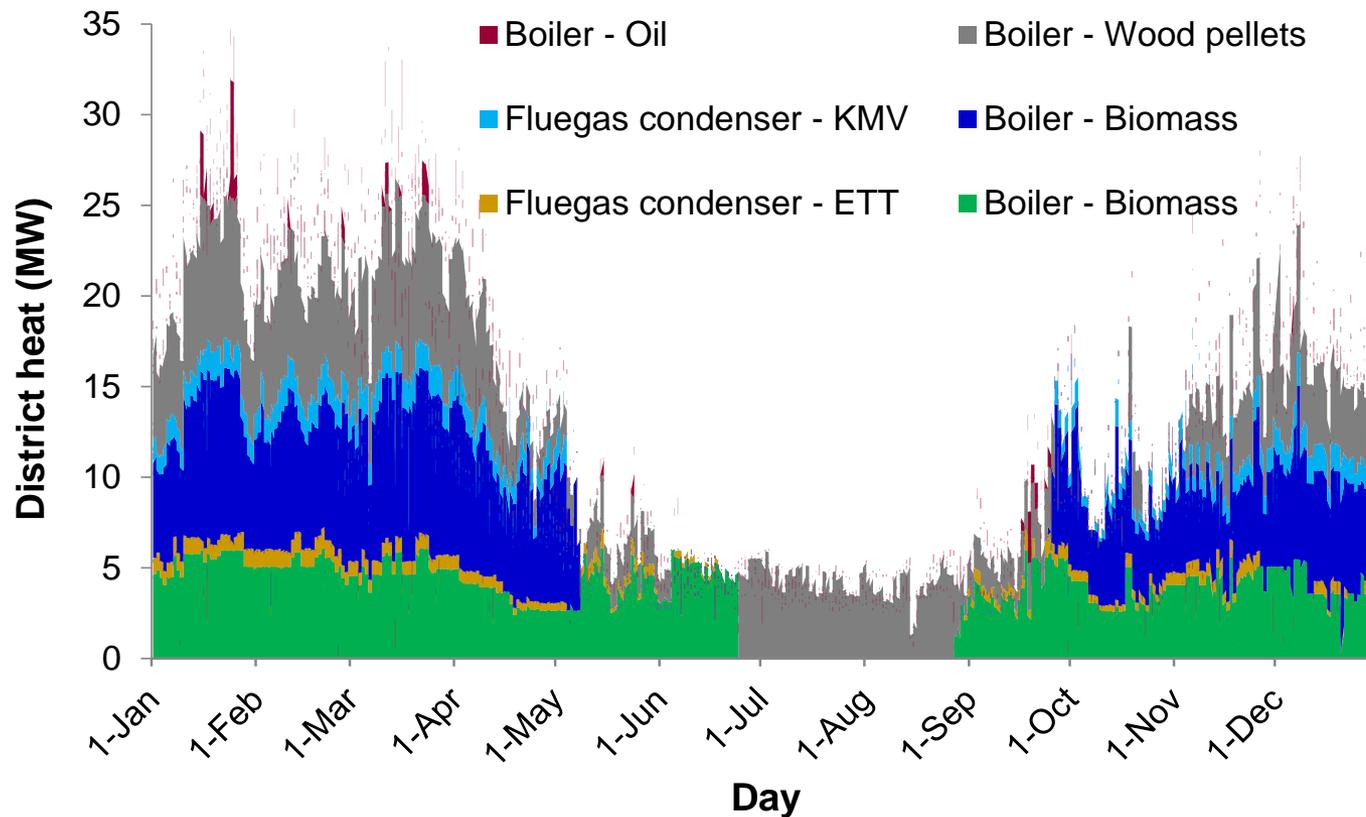
District heat production in Växjö

Production in 2013: 630 GWh



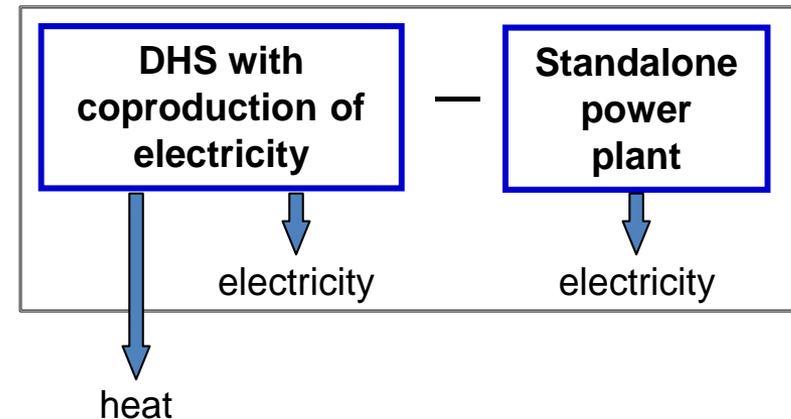
District heat production in Ronneby

Production in 2013: 110 GWh

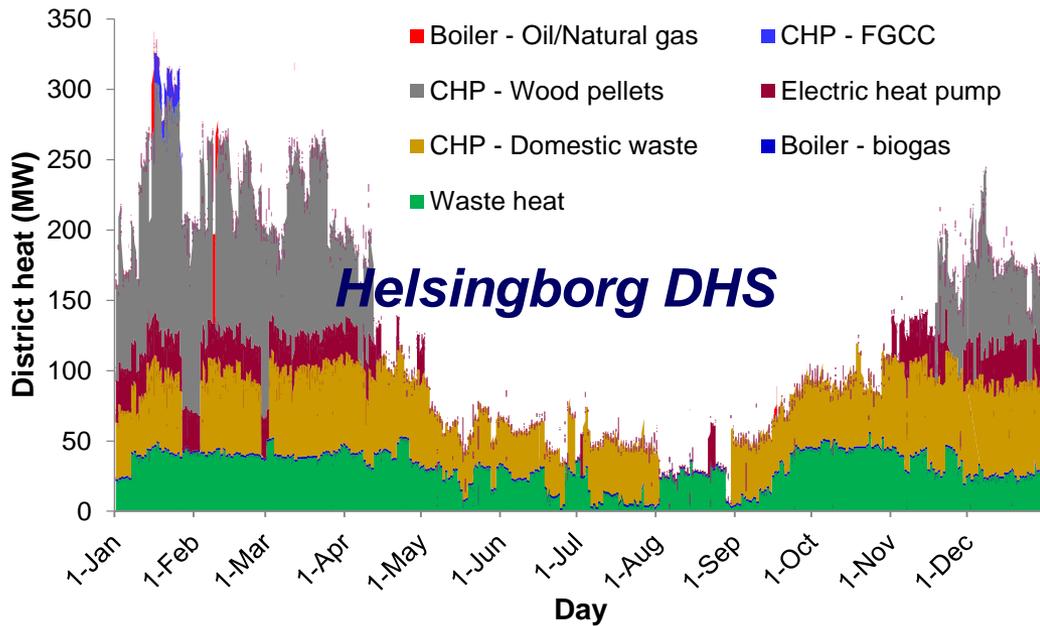
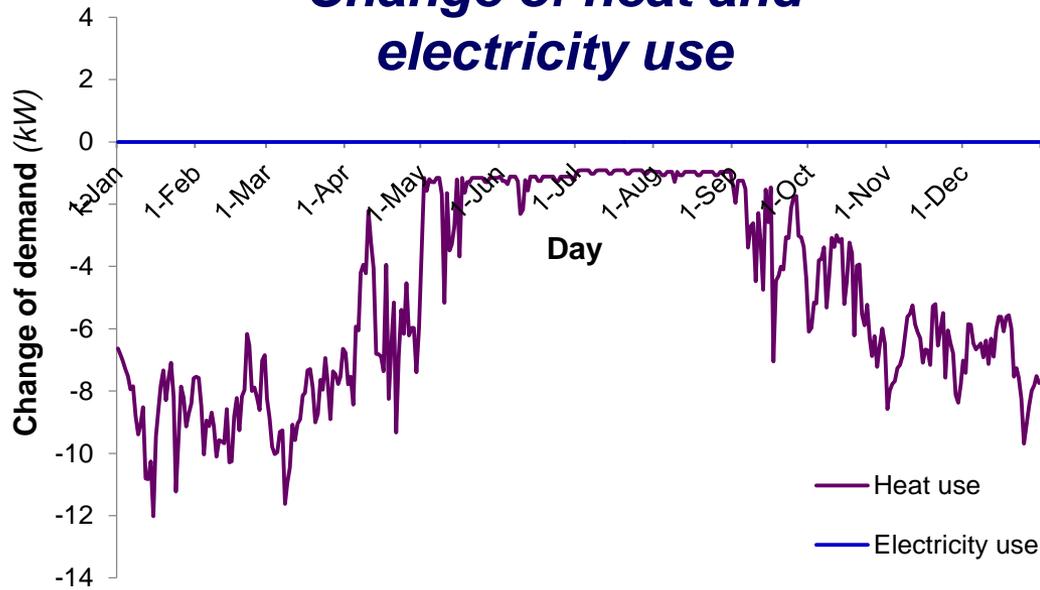


Assumptions of system operation

- At each instant, changes of heat demand marginally influence the operation of district heat production units
- Change of cogenerated electricity in DHSs is balanced by coal-based standalone condensing power plants.
- Subtraction method is used to estimate the primary energy use of heat production



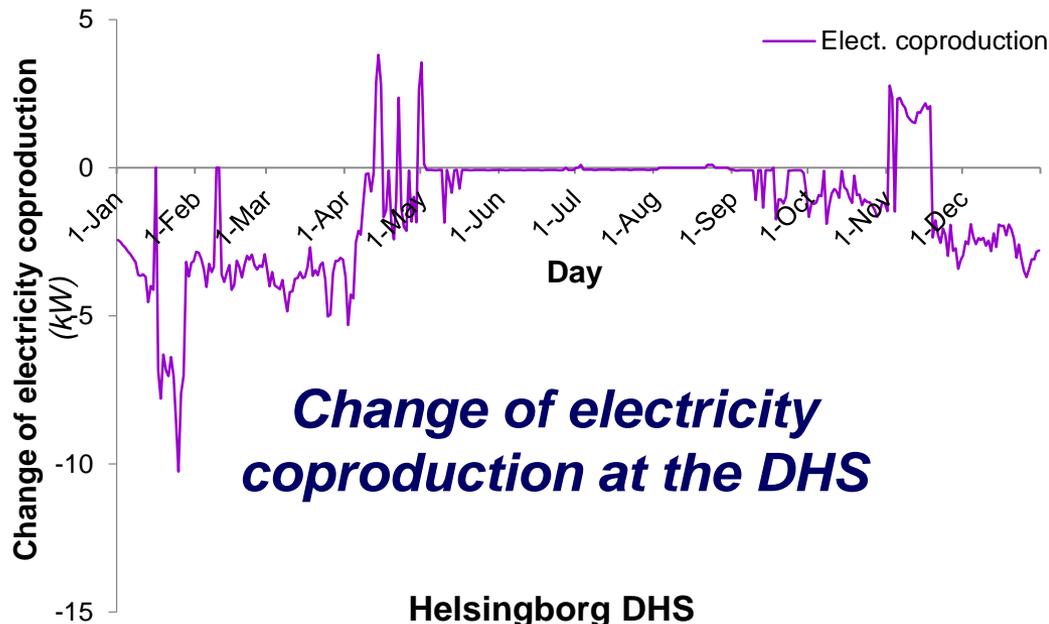
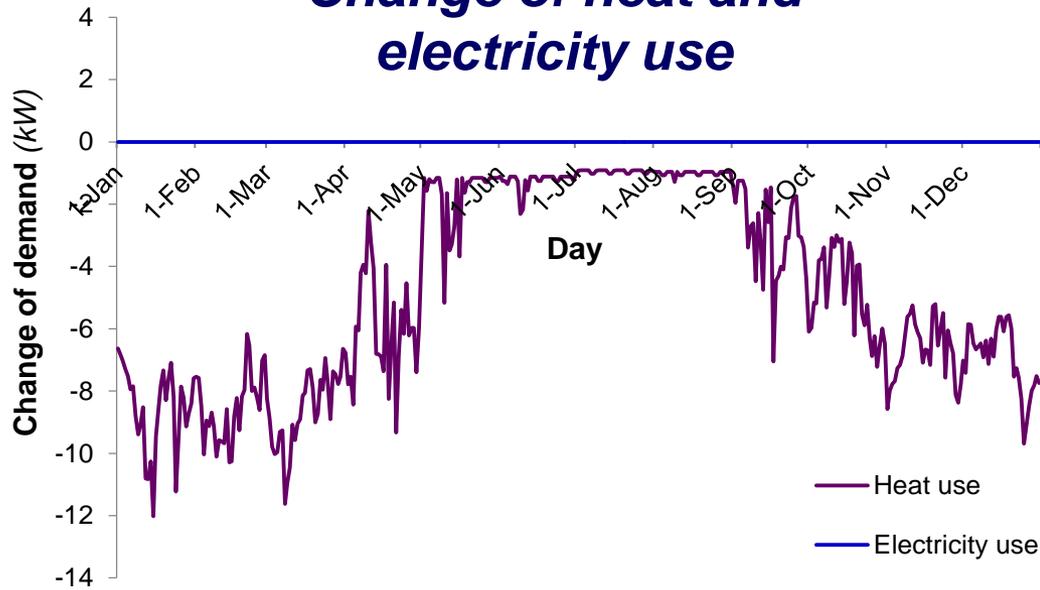
Change of heat and electricity use



EE measure group 1:
measures to reduce
district heat demand



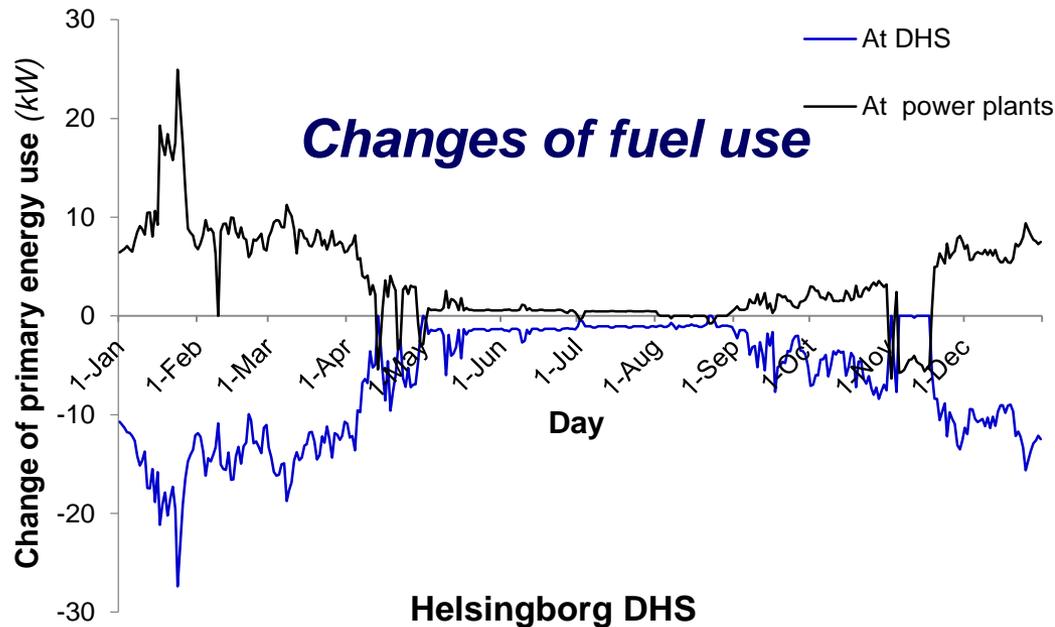
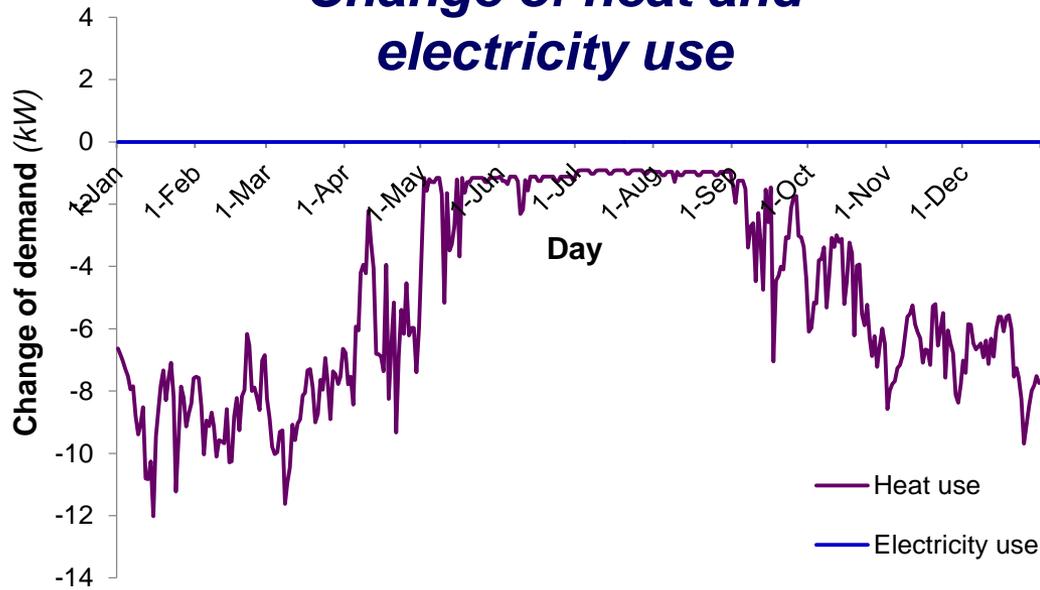
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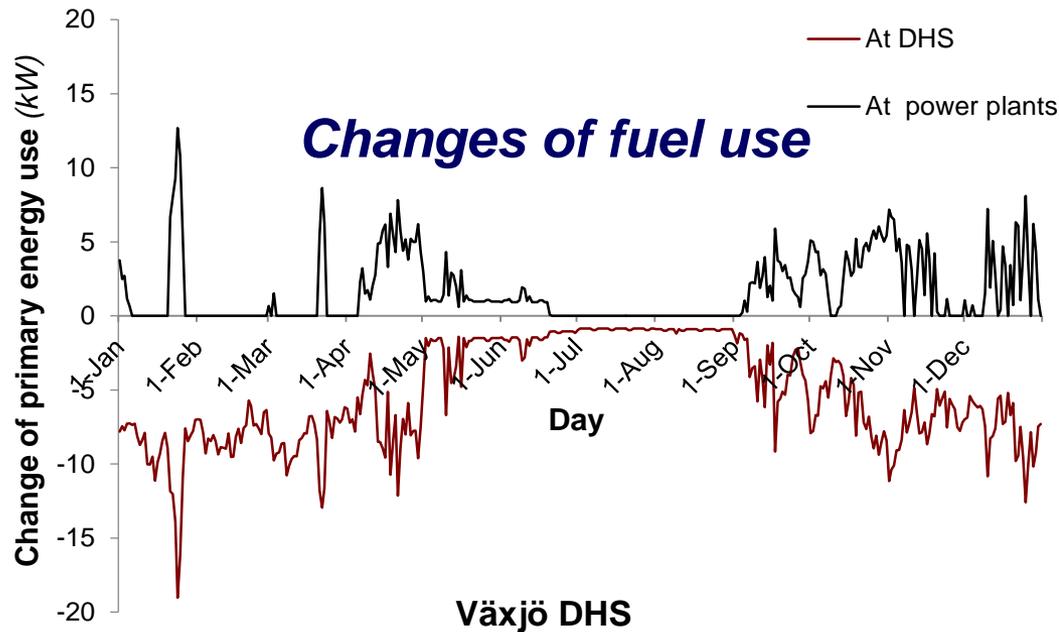
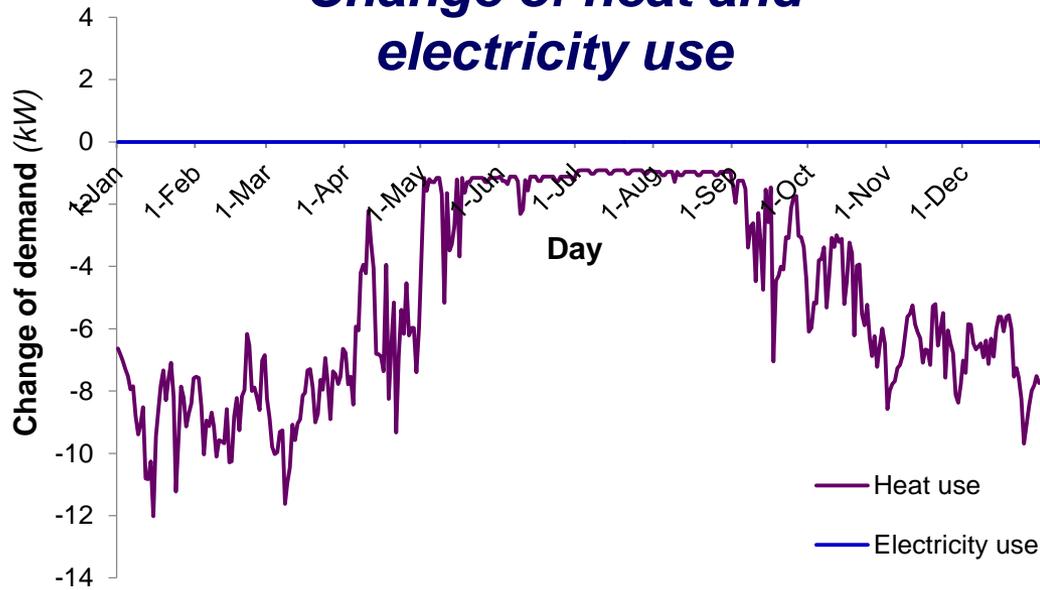
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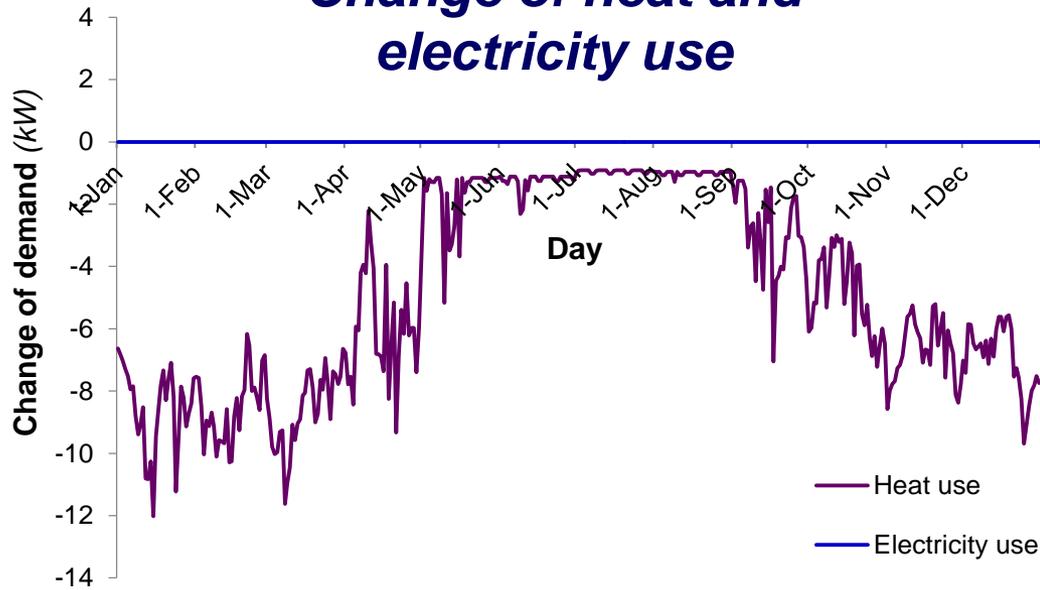


Växjö DHS

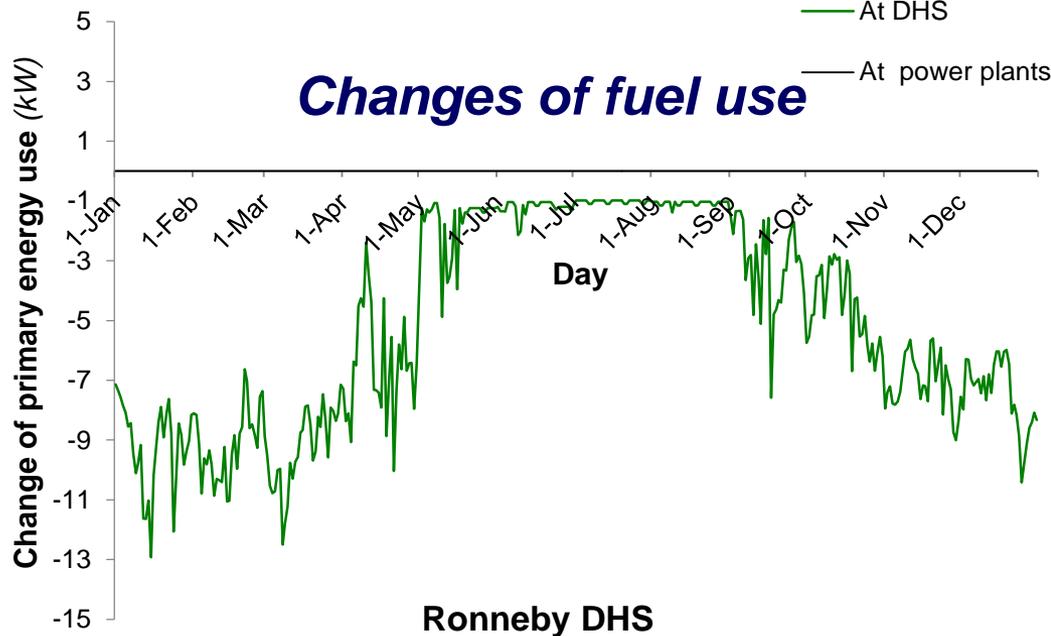
EE measure group 1:
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Change of heat and electricity use



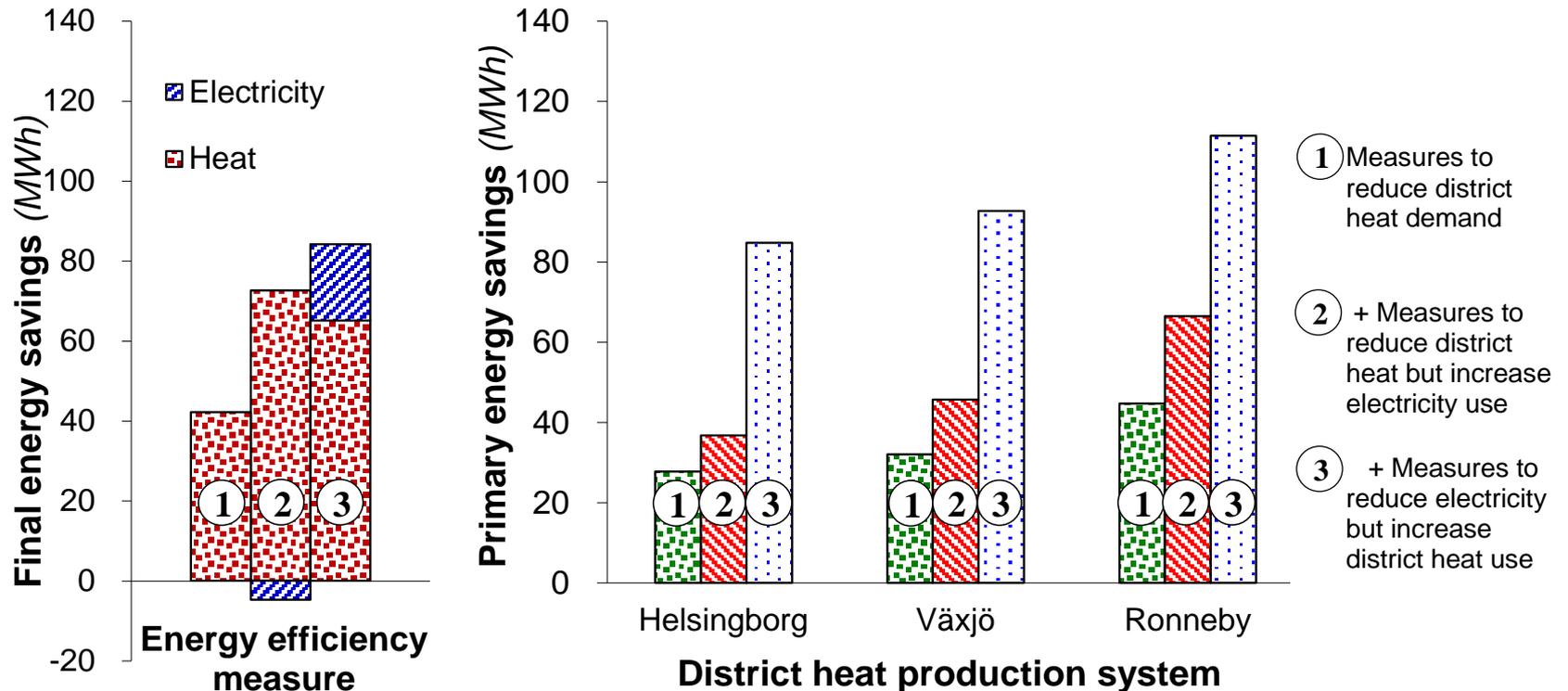
Changes of fuel use



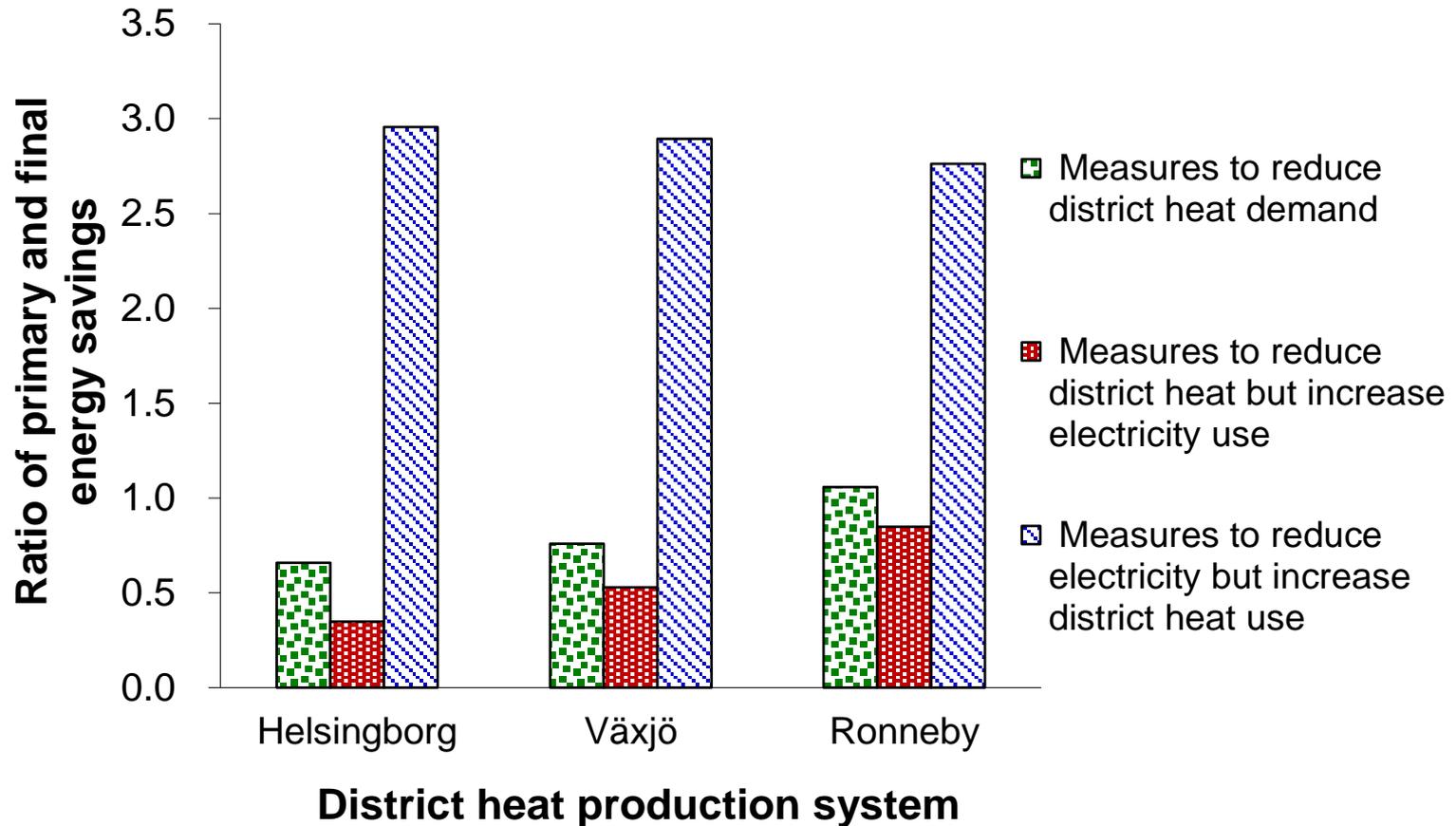
EE measure group 1:
measures to reduce
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Final energy savings and primary energy savings



Ratio of primary and final energy savings



Conclusions

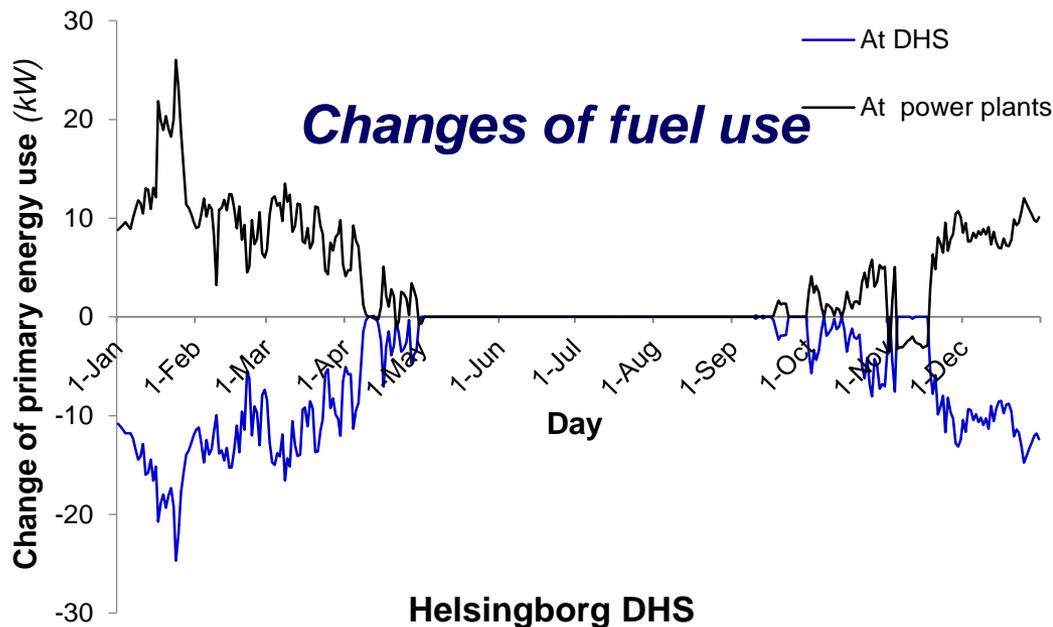
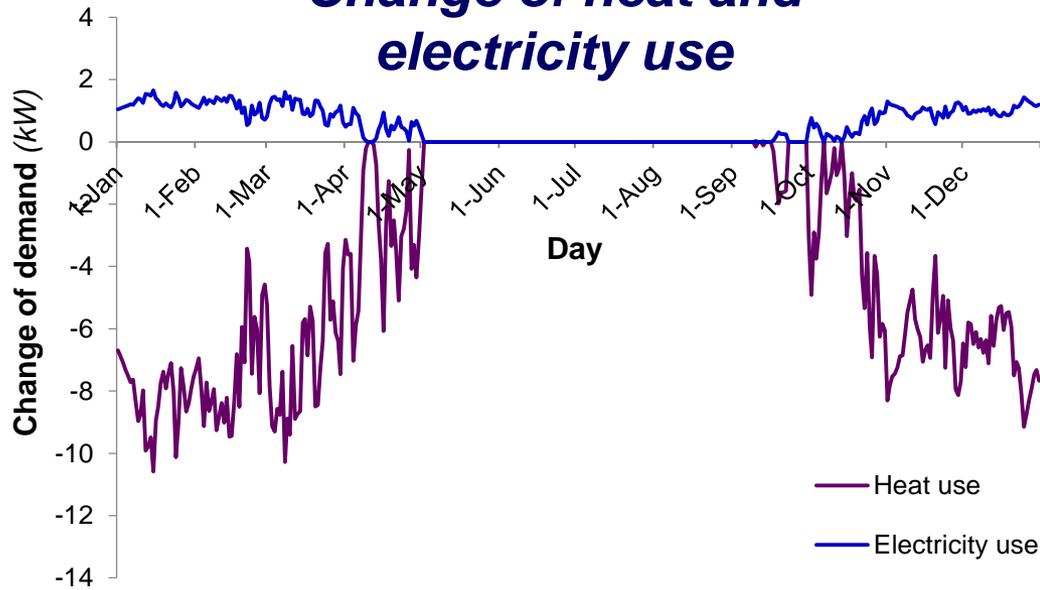
- Energy efficiency gives large final energy saving but the primary energy saving vary significantly, depends on:
 - the characteristics of the energy efficiency measure
 - the characteristics of the used district heat production system
- Energy efficiency in buildings connected to a small-scale DHS using heat-only boilers is more primary energy efficient
- 👉 Evaluation of energy efficiency measures in district-heated buildings requires a systems perspective where the final energy savings in buildings are matched to the actual operation of the connected DHS.



Thank you!



Change of heat and electricity use

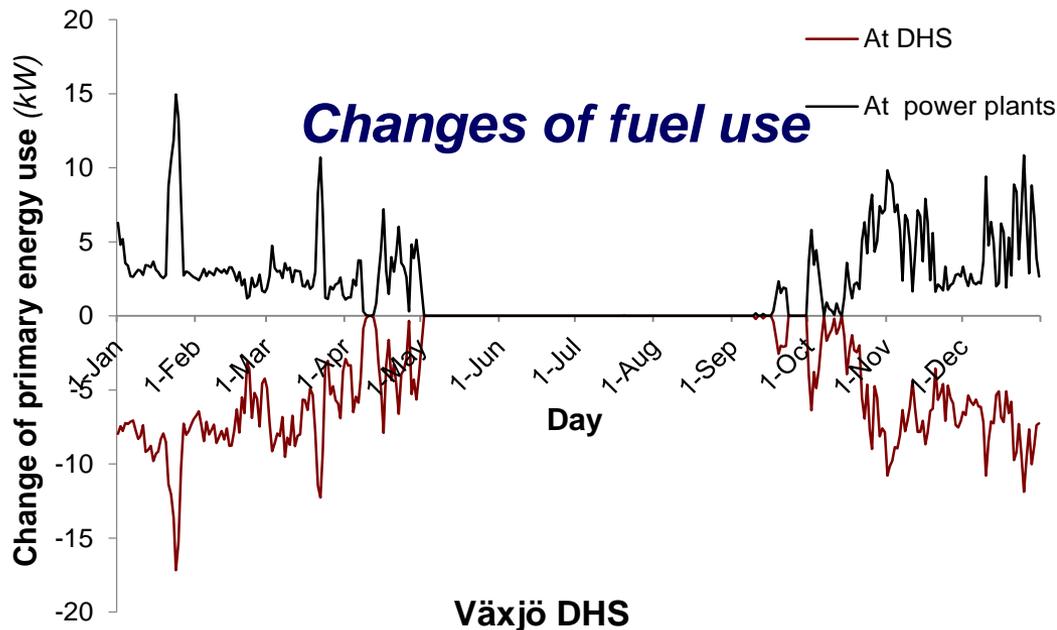
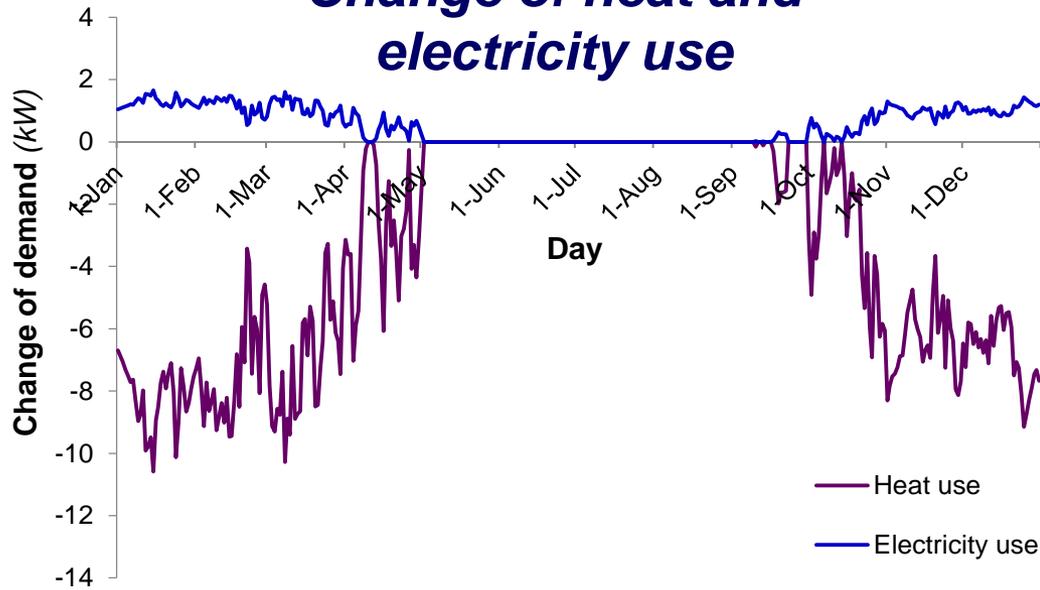


Helsingborg DHS

EE measure group 2:
measures to reduce
district heat but
increase electricity use



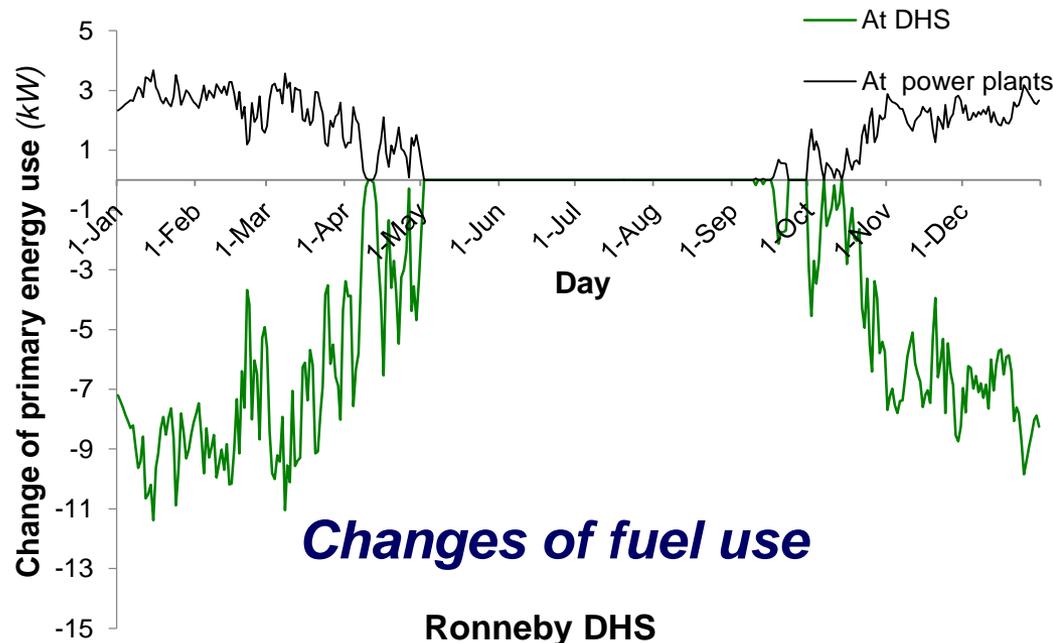
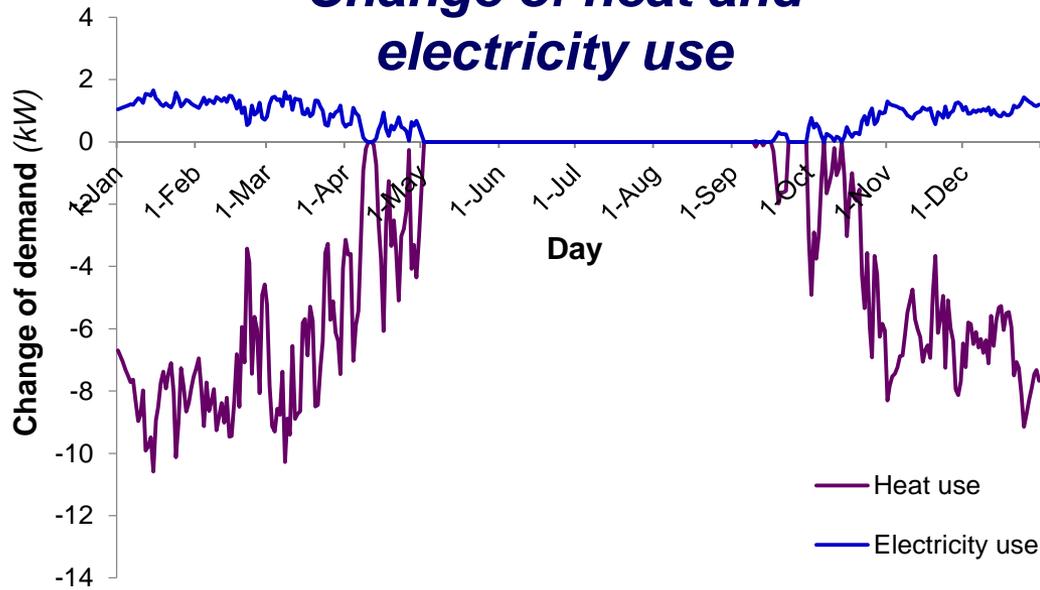
Change of heat and electricity use



EE measure group 2:
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Change of heat and electricity use



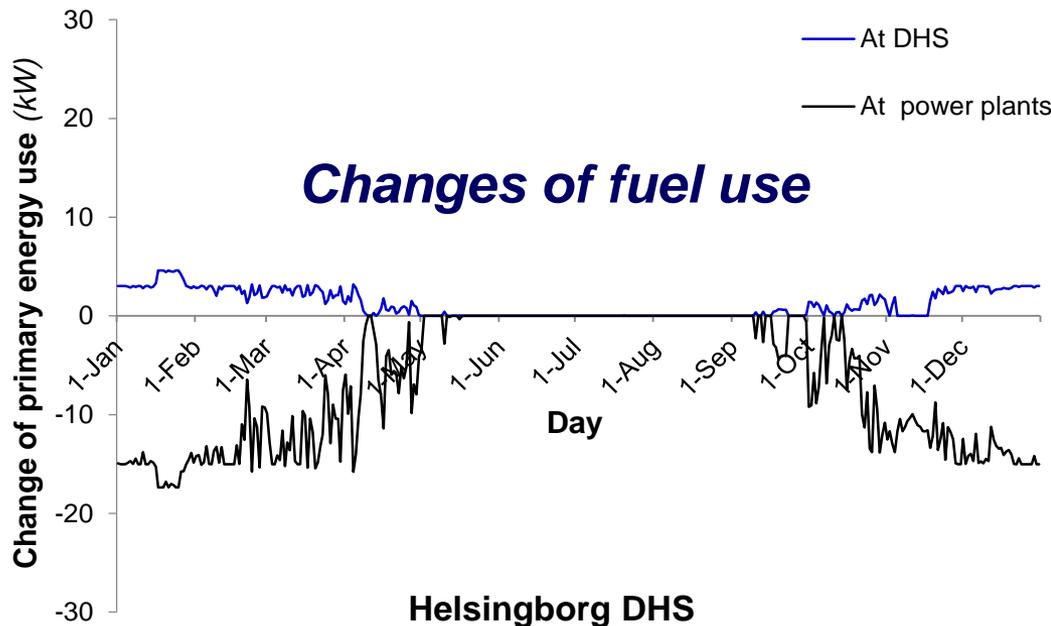
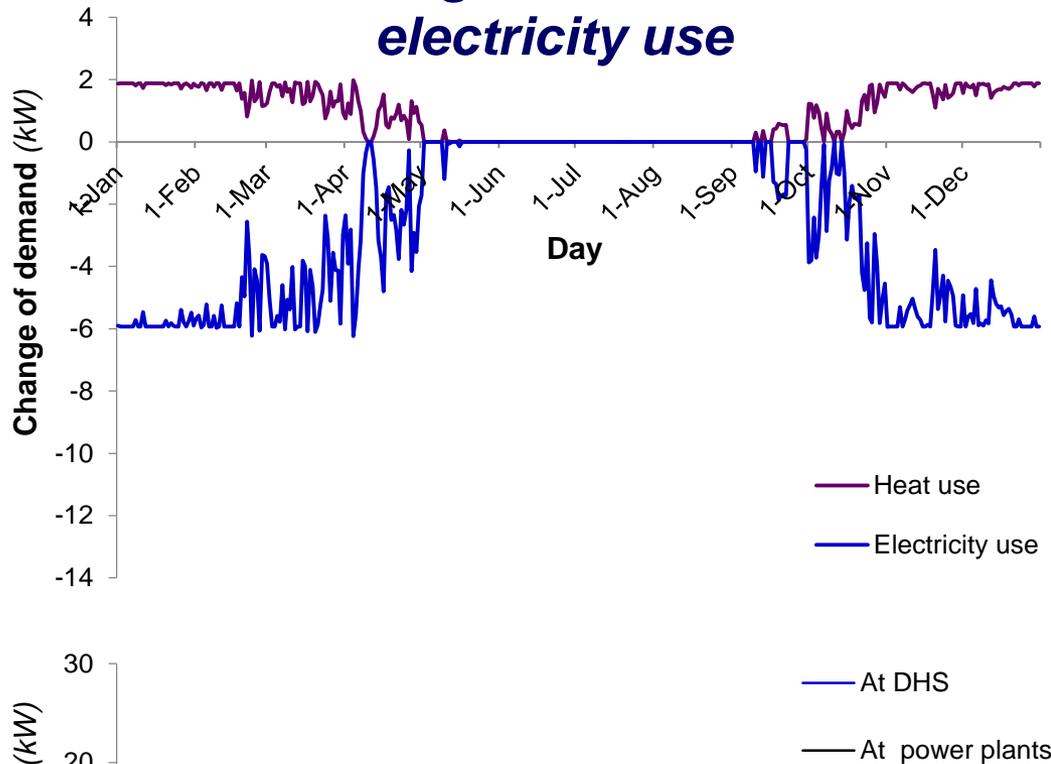
Changes of fuel use

Ronneby DHS

EE measure group 2:
measures to reduce
district heat but
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Change of heat and electricity use

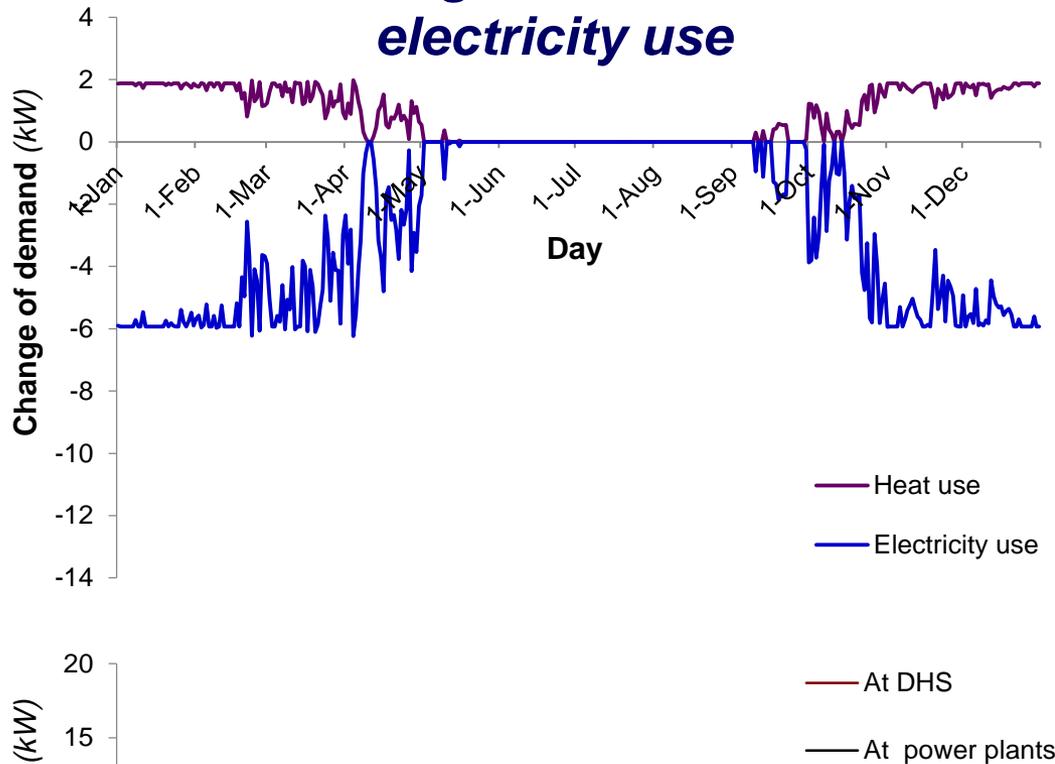


Changes of fuel use

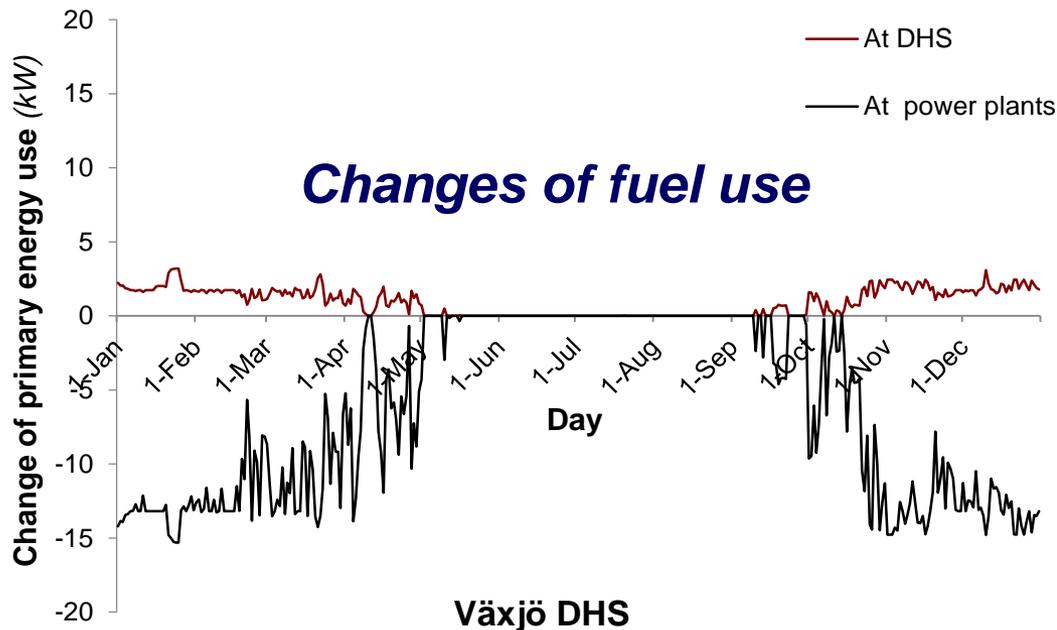
EE measure group 3:
measures to reduce
electricity but increase
district heat use



Change of heat and electricity use



Changes of fuel use

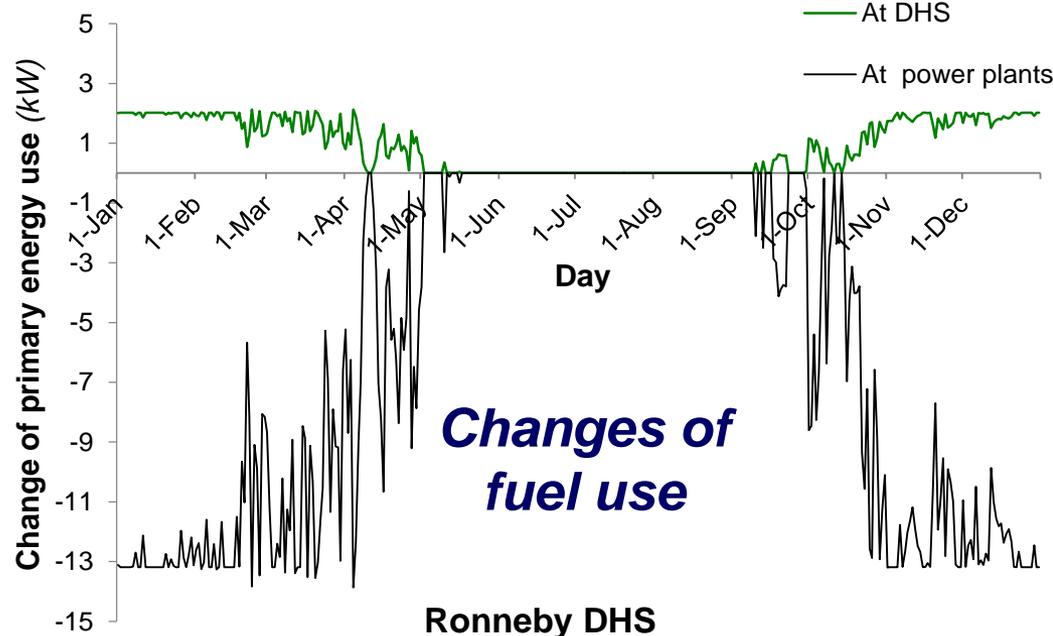
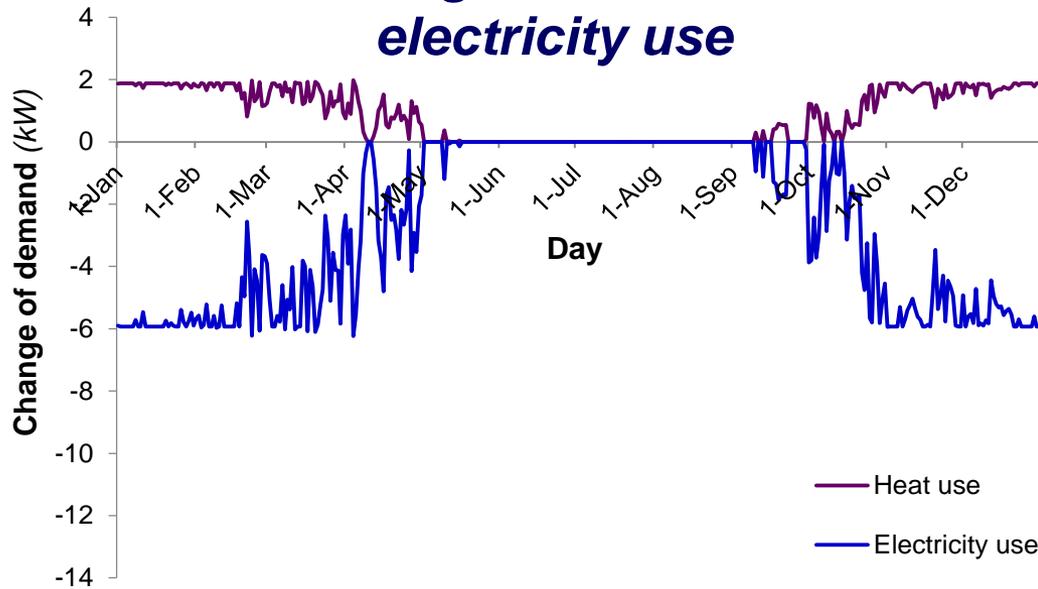


Växjö DHS

EE measure group 3:
measures to reduce
electricity but increase
district heat use



Change of heat and electricity use



Changes of fuel use

Ronneby DHS

EE measure group 3:
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