Modelling of heating sector in Denmark with focus on local externalities

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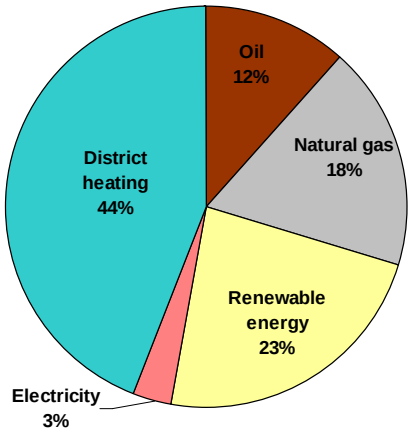
Introduction - motivation

- Reduction of energy use in general reduces pressure on environment and human health
- In heating sector demand side affects environment:
  - indirectly through district heating production (or el in case of el heating)
  - directly through individual heating technologies (DG)
- Often in energy system optimisation models focus is on technologies, that can reduce environmental impacts of the system
  - here I also included heat saving measures in buildings, which can be considered as energy technology, that only requires investments and has no operating environmental impact

Heating sector in Denmark

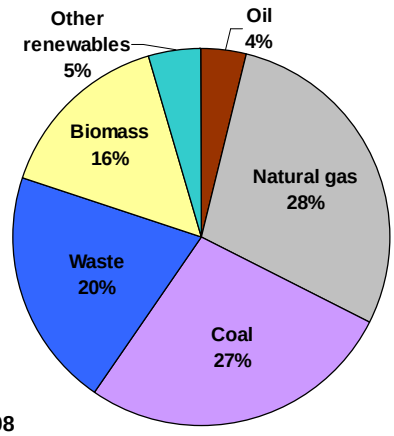
Supply of space heating



Heat demand for space heating 213 PJ –

24 % of primary energy consumption

Fuel in District Heating Production

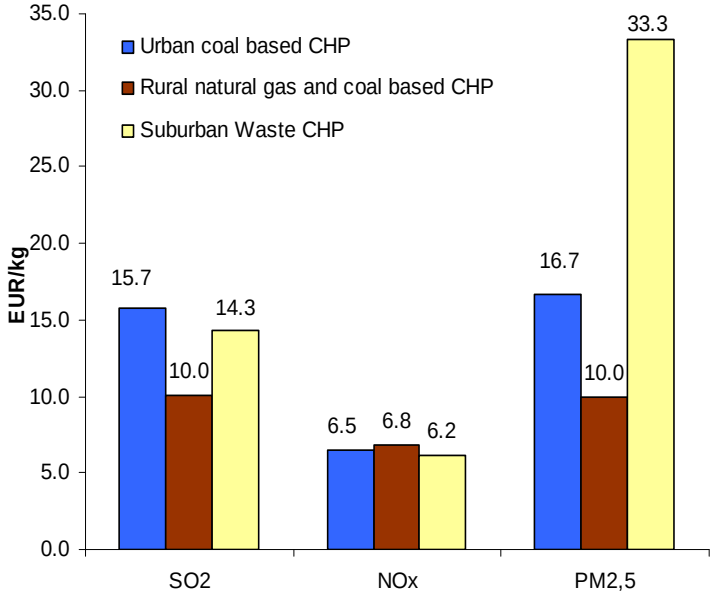


– Coal: SO_2 & NO_x
– Natural gas: NO_x
– Waste: SO_2, NO_x & particles
– Biomass: SO_2, NO_x & particles
– Oil: SO_2, NO_x

source: Danish Energy Authority, 2008

Health related externalities and energy production

- Health related externalities of energy production are location dependent:
  - Meteorology
  - Population
- Externalities differ for central (DH/CHP) plants and individual technologies.
  - Health related costs of pollution by individual technologies can be compared to transport related health external costs



based on Andersen et al., 2008

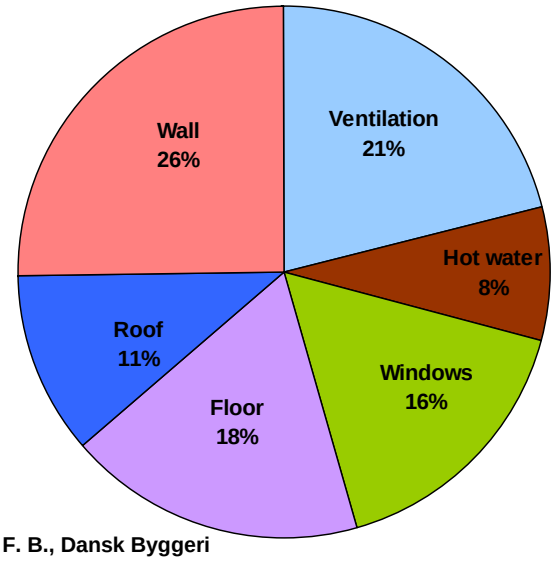
Heat saving potentials in buildings

- Profitable heat saving potential:
  - 80 % (over 45 years) in dwellings
  - 75 % in public buildings

- 75 % of residential and public buildings are built before 1979, when the first important tightening of building standards was introduced

- Heat saving measures:

Heat consumption in dwellings

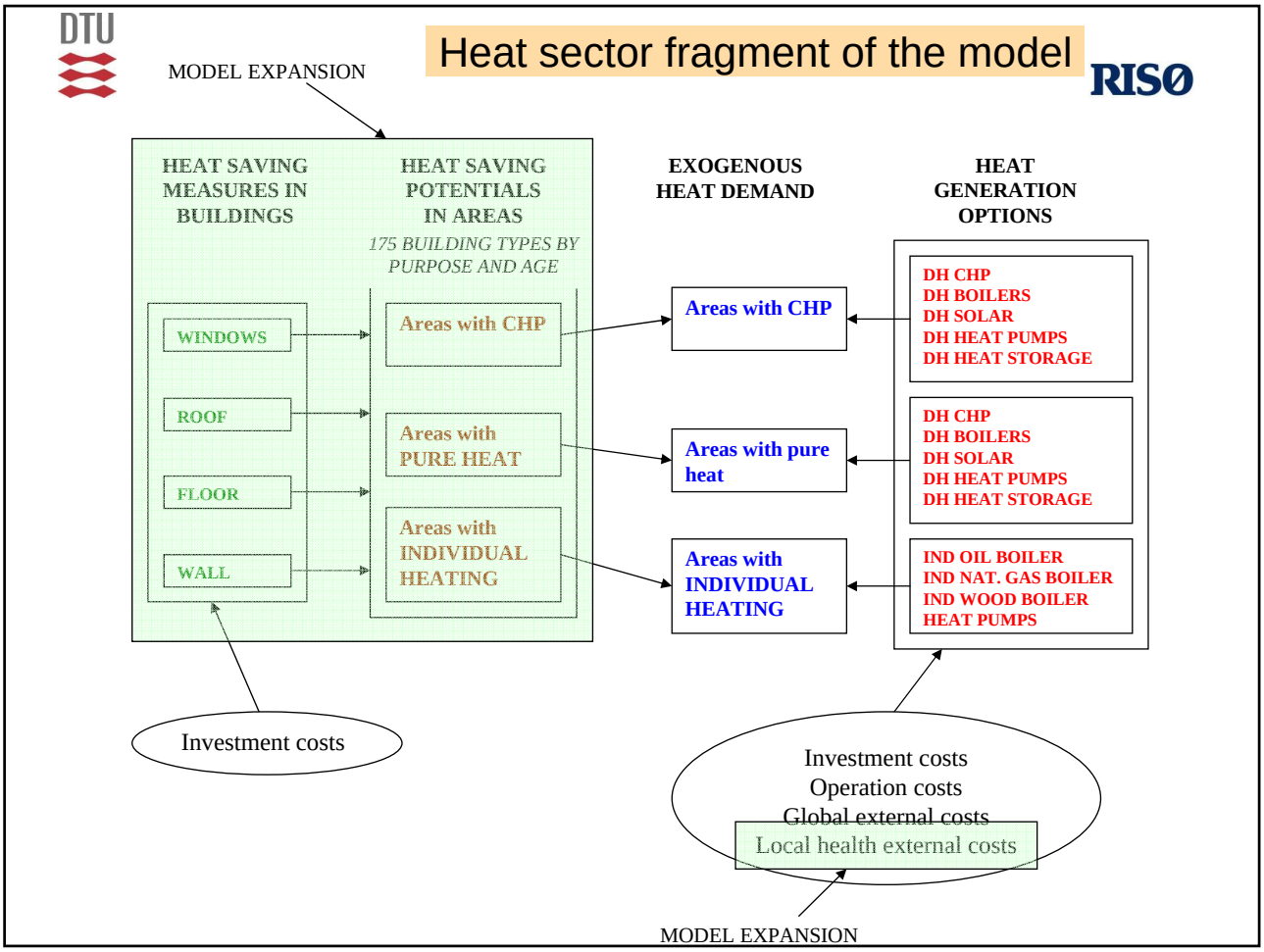


source: Frandsen, F. B., Dansk Byggeri

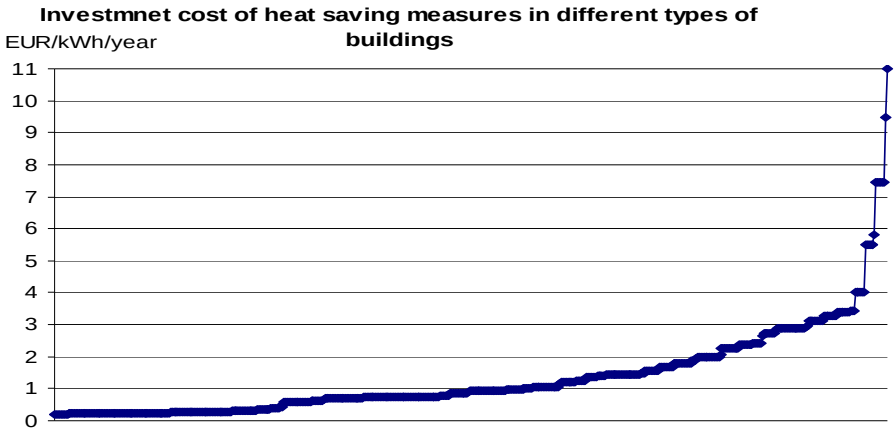
The model

- Model used: Balmorel (www.balmorel.com) – a linear optimisation model of heat and power sectors in the Baltic Sea Region
  - only the Danish heat and power sector is included in this analysis
- Sectors included in the analysis:
  - Electricity
  - District heating: CHP and pure DH
  - Oil and natural gas based individual heating (53 % of total individual heating)
- Division into areas – according to technology and geographical location:
  - 21 areas with district heating supply from CHP or PURE HEAT plants
  - 2 individual heating areas
  - in different areas – different health costs

Heat sector fragment of the model



Heat saving measures



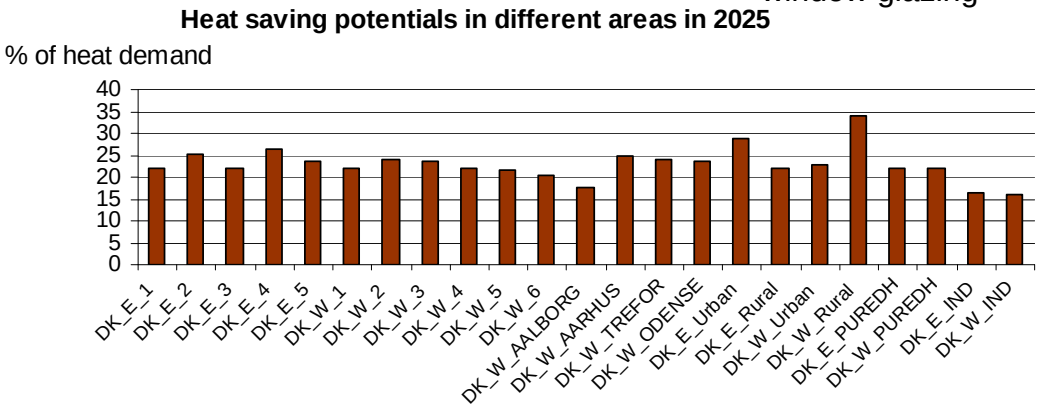
SAVING MEASURES

– insulation of walls

– insulation of roof

– insulation of floor

– replacement of window glazing



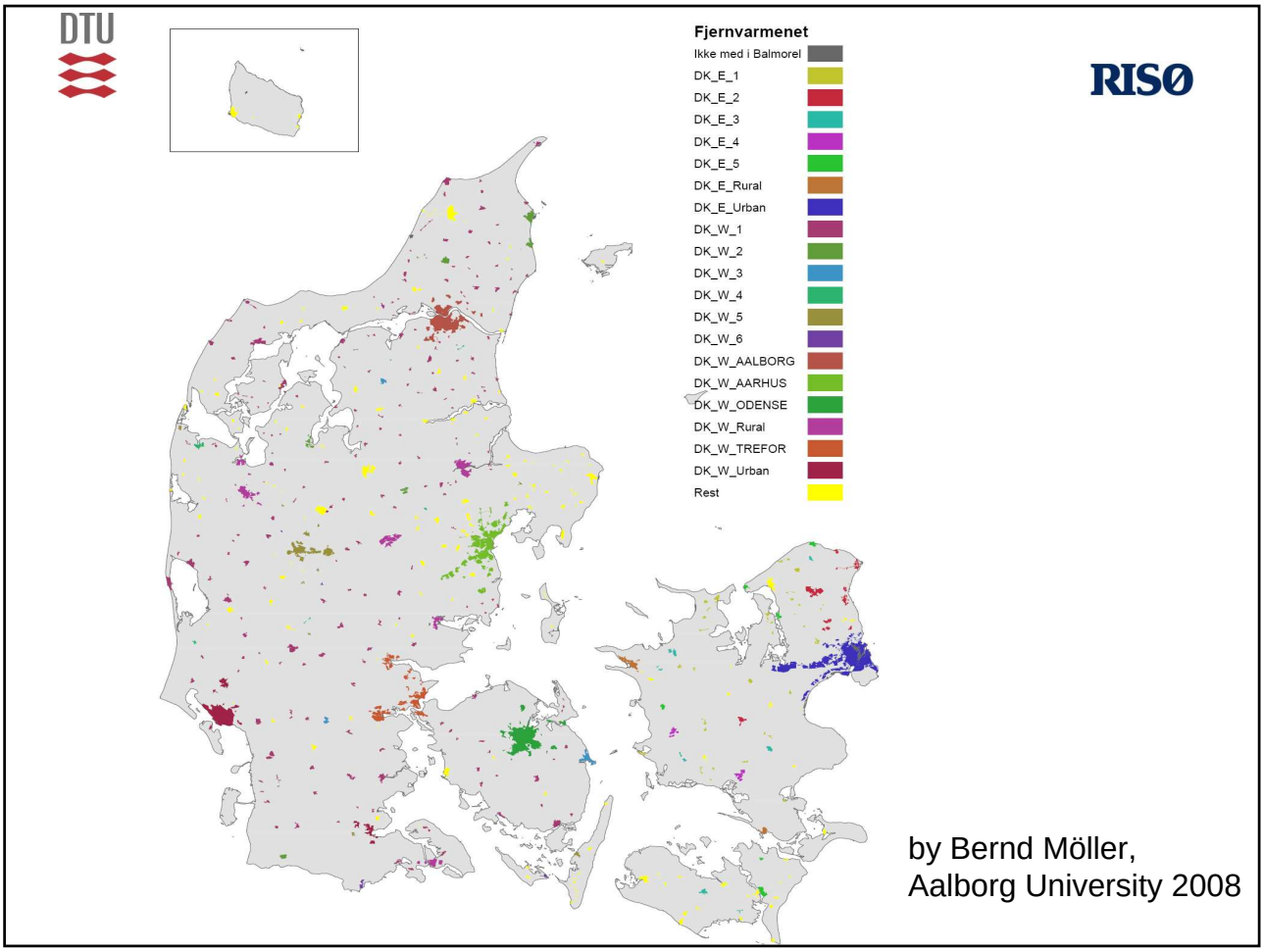
Scenarios - 2025

Scenario	Description
A	**No health externalities included and no heat saving investment possibilities**
B	**Health externalities included, but no heat saving investment possibilities**
D	**Health externalities included, possibility to invest into heat savings in buildings**
D1	Health externalities included, possibility to invest into heat savings in buildings and no possibility to invest neither into solar DH nor heat pumps

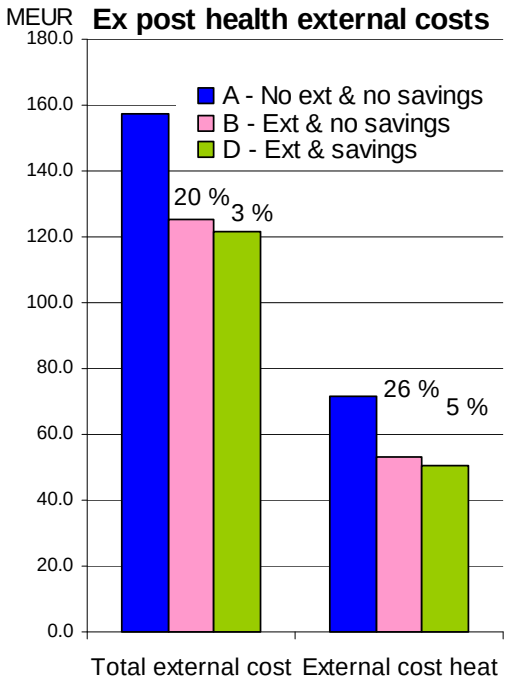
Health related external costs included in the model

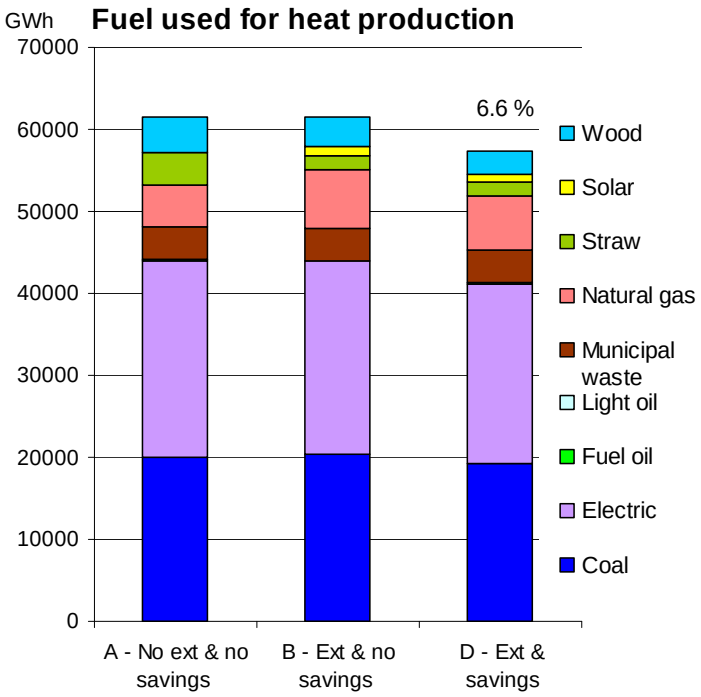
Area	SO2 Cost, EUR/t	NOx cost, EUR/t	PM2,5 Cost EUR/t
Average cost	9100	5870	10900
High cost	13542	10483	18533
Low cost	5962	2533	7595
Individual heating cost	32550	9222	29200

The global CO_2 cost of 15 EUR/t is included in all scenarios

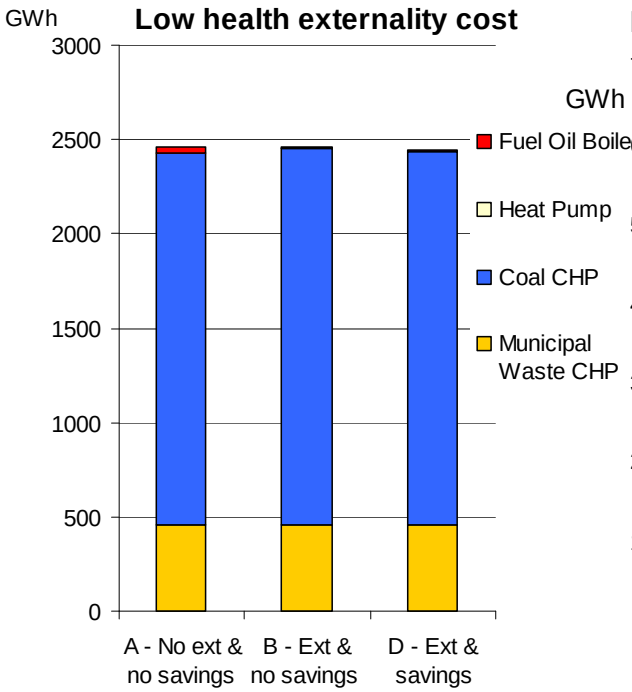

DTU
RISØ
Fjernvarmenet
Ikke med i Balmorel
DK_E_1
DK_E_2
DK_E_3
DK_E_4
DK_E_5
DK_E_Rural
DK_E_Urban
DK_W_1
DK_W_2
DK_W_3
DK_W_4
DK_W_5
DK_W_6
DK_W_AALBORG
DK_W_AARHUS
DK_W_ODENSE
DK_W_Rural
DK_W_TREFOR
DK_W_Urban
Rest
by Bernd Möller,
Aalborg University 2008

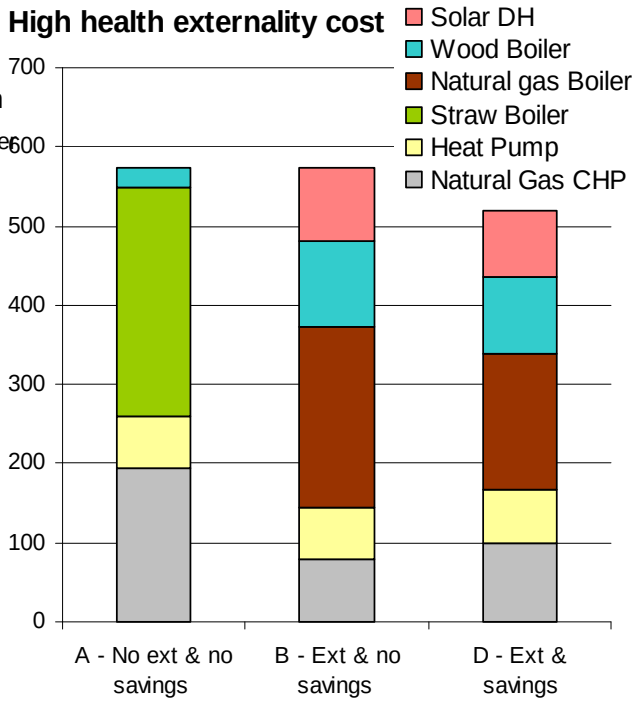
Results I


MEUR
Ex post health external costs
180.0
160.0
140.0
120.0
100.0
80.0
60.0
40.0
20.0
0.0
A - No ext & no savings
B - Ext & no savings
D - Ext & savings
20 %
3 %
26 %
5 %
Total external cost
External cost heat

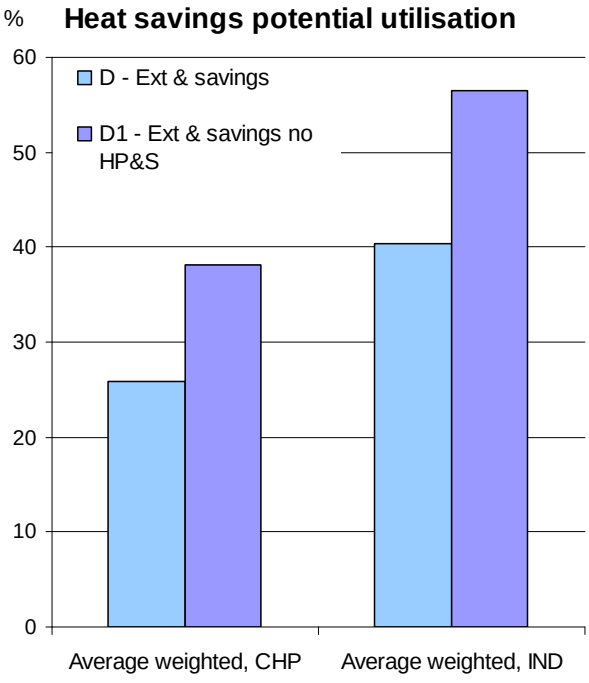

GWh
Fuel used for heat production
70000
60000
50000
40000
30000
20000
10000
0
6.6 %
Wood
Solar
Straw
Natural gas
Municipal waste
Light oil
Fuel oil
Electric
Coal
A - No ext & no savings
B - Ext & no savings
D - Ext & savings

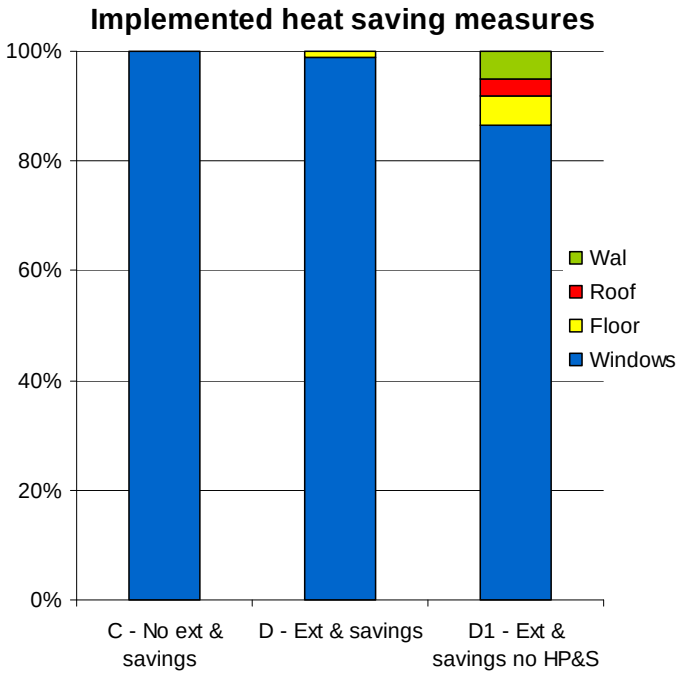
Results II – examples for different District Heating areas





Results III


%
Heat savings potential utilisation
60
50
40
30
20
10
0
D - Ext & savings
D1 - Ext & savings no HP&S
Average weighted, CHP
Average weighted, IND


Implemented heat saving measures
100%
80%
60%
40%
20%
0%
Wal
Roof
Floor
Windows
C - No ext & savings
D - Ext & savings
D1 - Ext & savings no HP&S

Conclusions and perspectives

- When health externalities are included, ex post total health external costs from heat and power sector are reduced by 20 %
- When health externalities are included, ex post total health external costs from heat production are reduced by 26 %. Heat savings in buildings contribute to further 5 % reduction in ex post health related external costs from heat sector.
- Biomass based heat production (one of the means to reduce CO_2 emissions) becomes less attractive when health externalities are included due to relatively high release of local pollutants – no renewable targets and relatively low CO_2 price
- For individual heating only few technological options are included, as well as further improvements should include possibility to connect to district heating supply

Thank you for attention!

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For more information visit www.ceeh.dk