Biomass-Based Energy Systems for Space Heating

By

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Aim of the study

To analyse bioenergy heating systems and energy conservation measures considering costs, net CO_2 emission and primary energy use

The reference house

- Built in 1974
- Situated in the middle of Sweden
- Heated area of 236 m^2 (varied $\pm$ 50 %)
- Resistance heaters
- Heat demand of 39 MWh per year
- Resistance heaters, hot water boiler and drainage system in need of replacement

Energy conservation measures

- Extra insulation on the attic floor
- Extra insulation on the outside of the basement walls
- Replacement of the existing windows

Energy supply

Transition from stand-alone coal-fired plants (steam-turbine technology) to:

- *wood-fired plants using steam-turbine technology*
- *biomass-fired integrated gasification combined cycle plants* (BIG/CC)

Transition from resistance heaters to:

- *pellet boiler*
- *heat pump (ground water, etc)*
- *district heating with cogeneration* (BIG/CC)

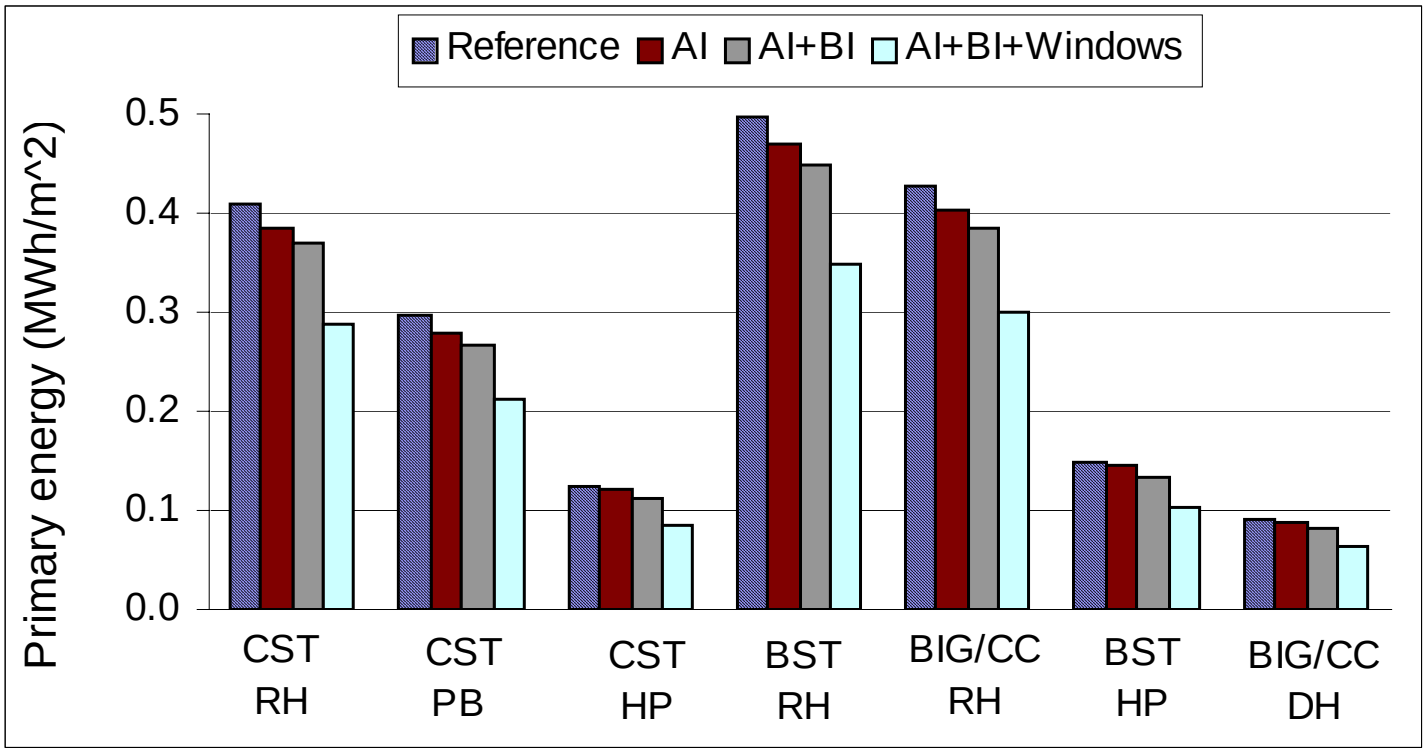
Methodology and assumptions

- The whole energy system chain included
  natural resources → heating service
- Reference entity: heat delivered per m^2/yr
- Remaining lifetime of house: 50 years
- Annualised investment costs
- 6 % real discount rate
- No taxes or external cost included

Methodology and assumptions

- Cogenerated electricity credited to the heat production
- Daily heat demand calculated with Enorm
- Cost, emission and primary energy use calculated with ENSYST
- The same heat pump, pellet boiler and subscriber service center were assumed in all scenarios

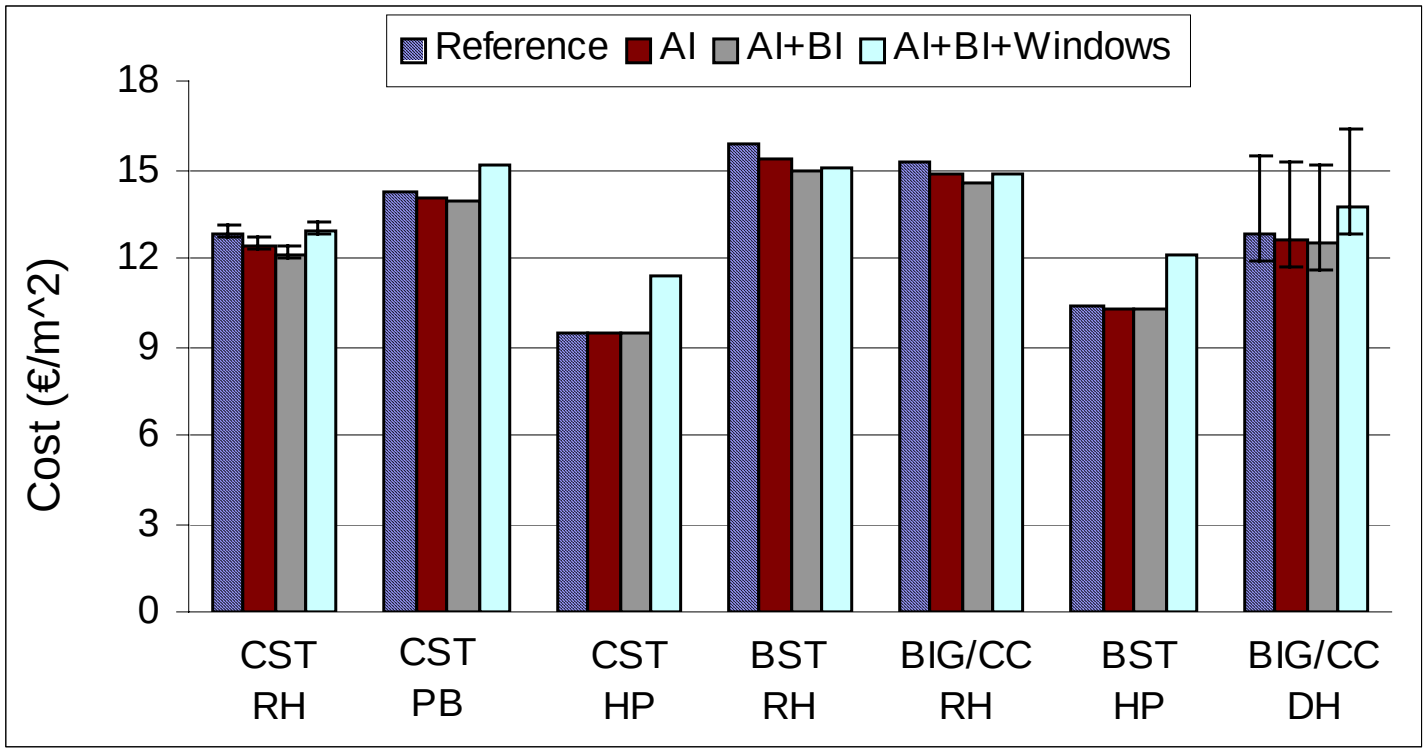
Primary energy use



BI= Basement insulation
AI= Attic insulation
HP= Heat pump
PB= Pellet boiler
RH= Resistance heaters

DH= District heating
CST= Coal-fired steam turbine
BST= Biomass-fired steam turbine
BIG/CC= Biomass-fired integrated gasification combined cycle

Annual heating cost



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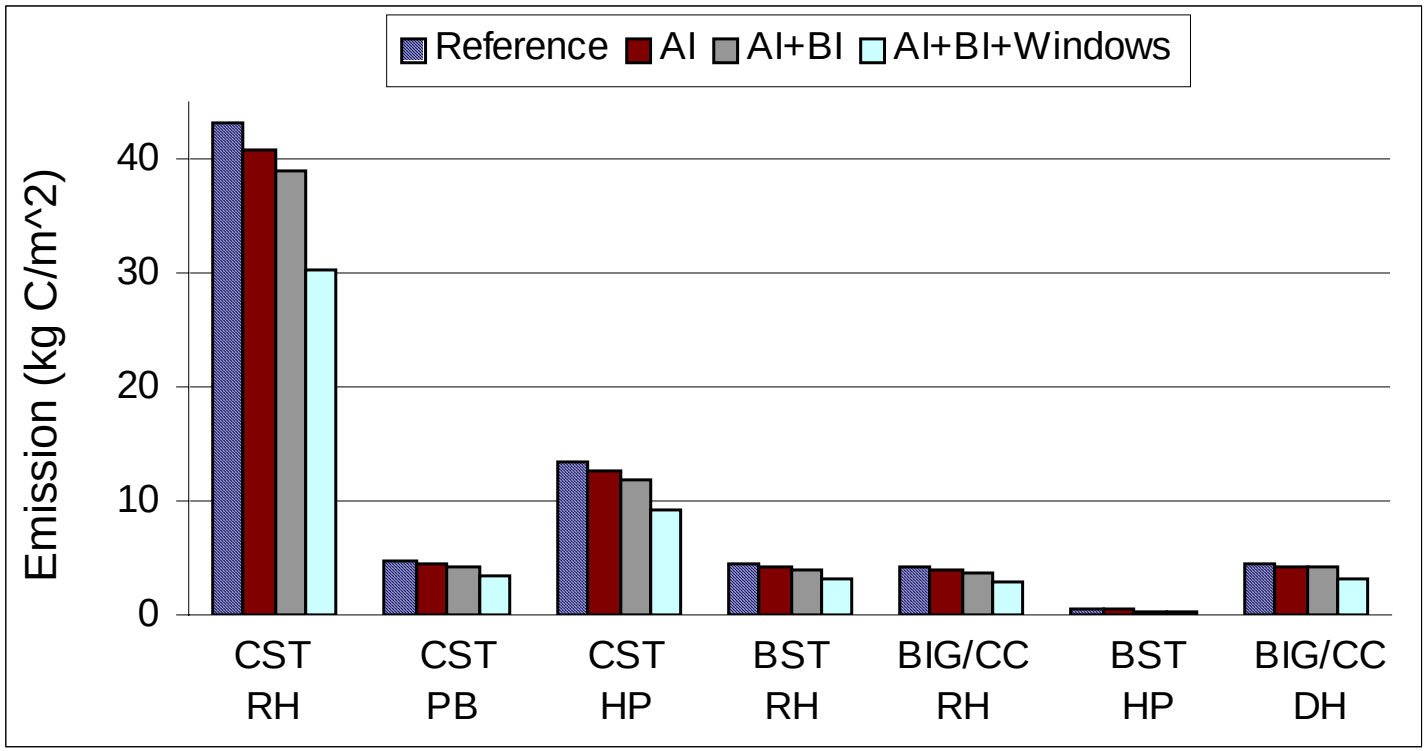
CO_2 emission



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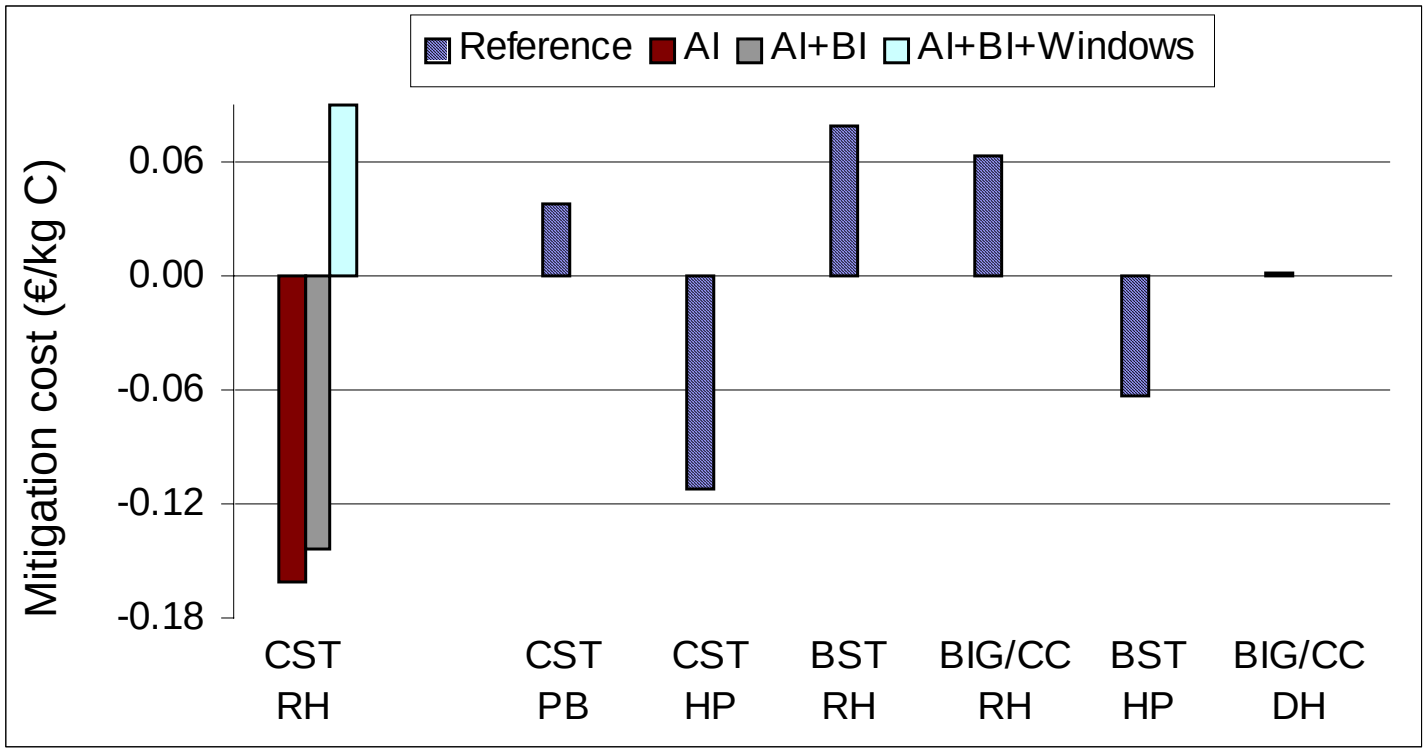
CO_2 mitigation cost



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Conclusions

- The choice of supply system and type of fuel has a greater impact on net CO2 emission than energy conservation
- Both attic and basement insulation are cost-effective and reduce the total heating cost (negative mitigation cost)
- The district heating system is most energy-efficient
- The heat pump system is most cost-efficient
- The district heating system is sensitive to heat demand changes
- Heat pump, pellet and district heating system are all important

Conclusions

- Combining insulation measures with district heating based on BIG/CC

  → primary energy use is reduced by 80%
  CO_2 emission is reduced by 90%
  mitigation cost of about zero

- Combining insulation measures with an electric heat pump using electricity produced in BST plants

  → primary energy use is reduced by 70%
  CO_2 emission is reduced by > 95%
  mitigation cost negative

- The reference system steer the results