District heating and heat savings in the future Danish energy system – insights from TIMES-DK model

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Model built by:
- Energy Systems Analysis group, DTU
- IntERACT group, Danish Energy Agency
- E4SMA
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Presentation plan

• Heat savings and district heating in the past 40 years
• Modelling of heat savings in TIMES-DK
• Modelling of district heating in TIMES-DK
• Heat savings and district heating until 2050 – results from TIMES-DK
Heat savings and district heating in the past 40 years

• Denmark was totally dependent on the import of oil in 1973
• Oil has been replaced by the mix of natural gas, coal and renewables
• Primary energy supply remained the same
• Despite the growth in building mass by more than 50%, primary energy consumed for heating decreased by more than 30%
• District heating share increased from 28% to 54%

Danish goals for the future

• 50% of electricity production from wind starting from 2020
• No fossil fuels in production of electricity and heat from 2035
• No fossil fuels in society starting from 2050
• What is the role of heat savings and district heating?
Supply of heat and DHW in TIMES-DK

District heating

Primary energy

HO and CHP plants

Expanded DH network

Existing DH network

Heat from pipeline

New heat exchangers

Existing heat exchangers

Residential heat boilers

Residential heat and DHW

Residential individual heating

Heat savings

Primary energy

District heat

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Heat savings in TIMES-DK

Heating Model

- Detailed calculations of potentials and costs are done for 72 building types
- Different levels for five different elements (walls, floors, ..) were considered
- Least expensive level was chosen for each element

Inputs to TIMES-DK

- Curves of potentials and costs have been grouped by:
  - region (DKE and DKW)
  - building type (Detached and Multistorey)
  - construction year (built before and after 1972)
  - position relative to existing district heating areas
    (Central, Decentral, Individual)
- Curves of potentials and costs have been approximated with three step-curves
Heat savings in TIMES-DK – potentials and costs
Heat savings in TIMES-DK

- Heat savings deliver "heating services" according to heat degree days without DHW
- Heat savings are delivering "heating services" without any operation costs
- Different "steps" of heat savings have different lifetimes ranging from 30 to 40 years
District heating in TIMES-DK

- Primary energy
- District heating
  - HO and CHP plants
  - Expanded DH network
  - Existing DH network
- Heat from pipeline
  - New heat exchangers
  - Existing heat exchangers
- Residential heat and DHW
- Residential individual heating
- Heat savings
- Residential heat boilers

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District heating in TIMES-DK

- Two geographical regions: DKE and DKW
- Two types of district heating networks: Central and Decentral
District heating in TIMES-DK – Central and Decentral areas
District heating in TIMES-DK

- Two geographical regions: DKE and DKW
- Two types of district heating networks: Central and Decentral
- Two types of district heating areas: DH and Next-to-DH areas
District heating in TIMES-DK – DH and Next-to-DH areas
District heating in TIMES-DK

- Two geographical regions: DKE and DKW
- Two types of district heating networks: Central and Decentral
- Two types of district heating areas: DH and Next-to-DH areas
- Two types of expansion of DH – within existing DH areas and to Next-to-DH areas
- Potentials and costs of expanding DH networks have been approximated with two-step curves
District heating in TIMES-DK – expansion curves

Potential 1: 0.65 TWh
Average cost 1: 4.26 DKK/kWh

Potential 1: 1.5 TWh
Average cost 1: 2.05 DKK/kWh

Marginal investment costs (DKK/kWh)

Cumulative DH expansion potential (TWh)
District heating in TIMES-DK

- Two geographical regions: DKE and DKW
- Two types of district heating networks: Central and Decentral
- Two types of district heating areas: DH and Next-to-DH areas
- Two types of expansion of DH – within existing DH areas and to Next-to-DH areas
- Potentials and costs of expanding DH networks have been approximated with two-step curves
- Lifetimes and invest. costs are different for distribution pipes and connecting pipes and heat exchangers
Results from TIMES-DK

Three analysed scenarios:

- **Base** – base scenario without any policy measures being implemented.
- **WLP (Wind Low Production)** – starting from 2020 at least 50% of electricity needs to be produced from wind power.
- **WLP-NFE (Wind Low Production – Non Fossil Energy)** – in addition to WLP scenario, no fossil fuels are used for production of electricity and heat after 2035 and no fossil fuels in the energy system from 2050.
Results from TIMES-DK – Heat supply

District heating and heat savings in the future Danish energy system – insights from TIMES-DK model
Results from TIMES-DK – District heating share

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Results from TIMES-DK – Central DH production

- Central DH production (P.J.)

- Scenarios:
  - Base
  - WLP
  - WLP-NFE

- Energy sources:
  - Other
  - Solar heating
  - Waste heat
  - Large Heat Pump
  - Waste CHP
  - Coal CHP
Results from TIMES-DK – Decentral DH production

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Conclusion

• Reduction of heating demand by 24-26% by 2050, corresponding to 33-35% reduction of specific heating demand

• District heating share is between 68 and 70% in 2050

• In WLP-NFE scenario Central DH production switches to large HPs, solar heat and waste heat from biorefineries

• In all scenarios Decentral DH production switches to large HPs, waste fuelled CHPs and waste heat from biorefineries

• Total system costs are only 2.5% higher in in WLP-NFE than in Base scenario
Thank you for your attention

• Questions
• Answers
• Comments
• Suggestions