ENGINEERING TOMORROW

Case comparison:
Low vs *Lower* Temperature District Heating

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Research questions

- **What could be the design structure of the future CO2 neutral district heating supply system?**
- **How do the economics of different design structures compare?**
- **How different design structures compare on metrics such as:**
  - Energy supply security?
  - Flexibility?
  - Robustness?
  - Reliability?
  - Resilience?

Generations of district heating

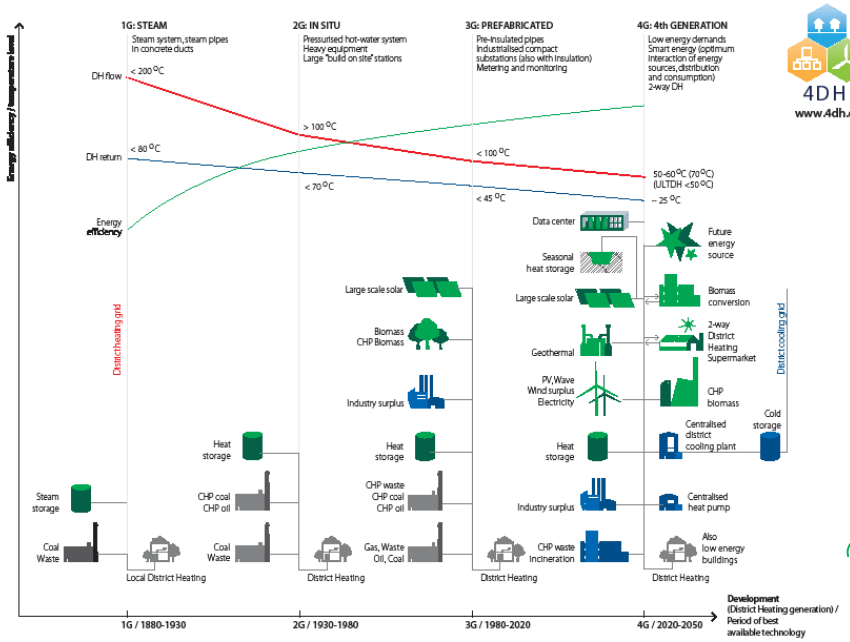
Digitalization
Value added services

1G **2G** **3G** **4G** ***5G***

Conversion potential

Conversion potential

Conversion potential?



4DH
www.4dh.dk

Flexible distribution medium
e.g. phase change

Source/sink distribution

Local temperature boosting in substations

?

Two-, three- and four pipe systems

Bi-directional heating and cooling

Pipe insulation concepts

Lower temperatures

Floating temperature levels

Other concepts

Generations of district heating

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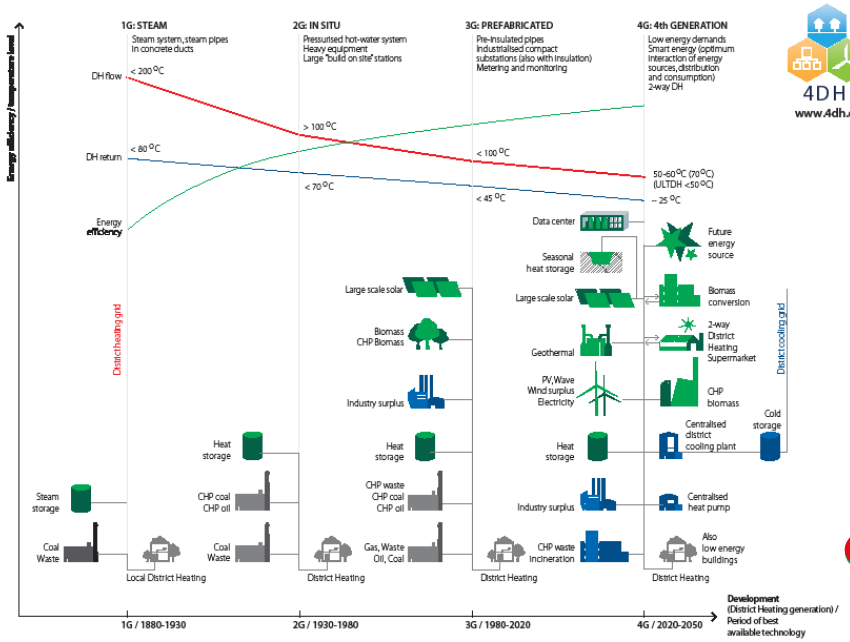
Conversion potential → Conversion potential → Conversion potential?



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Other concepts

System boundaries and supply systems considered

Supply system 1: Ambient loop – Heat pumps in each building

Source temperature

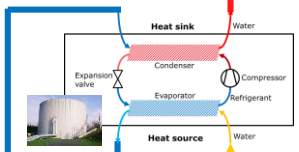
Ambient loop
Uninsulated pipes

Supply system 2: Ultra-LTDH
+ local DHW temperature boost

45°C

25°C

ULTDH
Insulated pipes

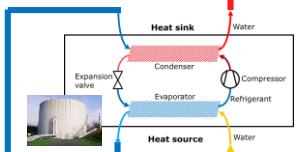


Supply system 3: LTDH

60°C

30°C

LTDH
Insulated pipes



Heat sources
10°C / 25°C / 45°C / 60°C

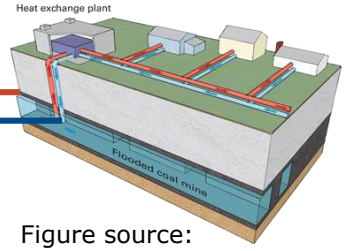
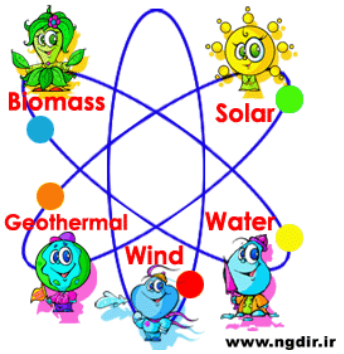
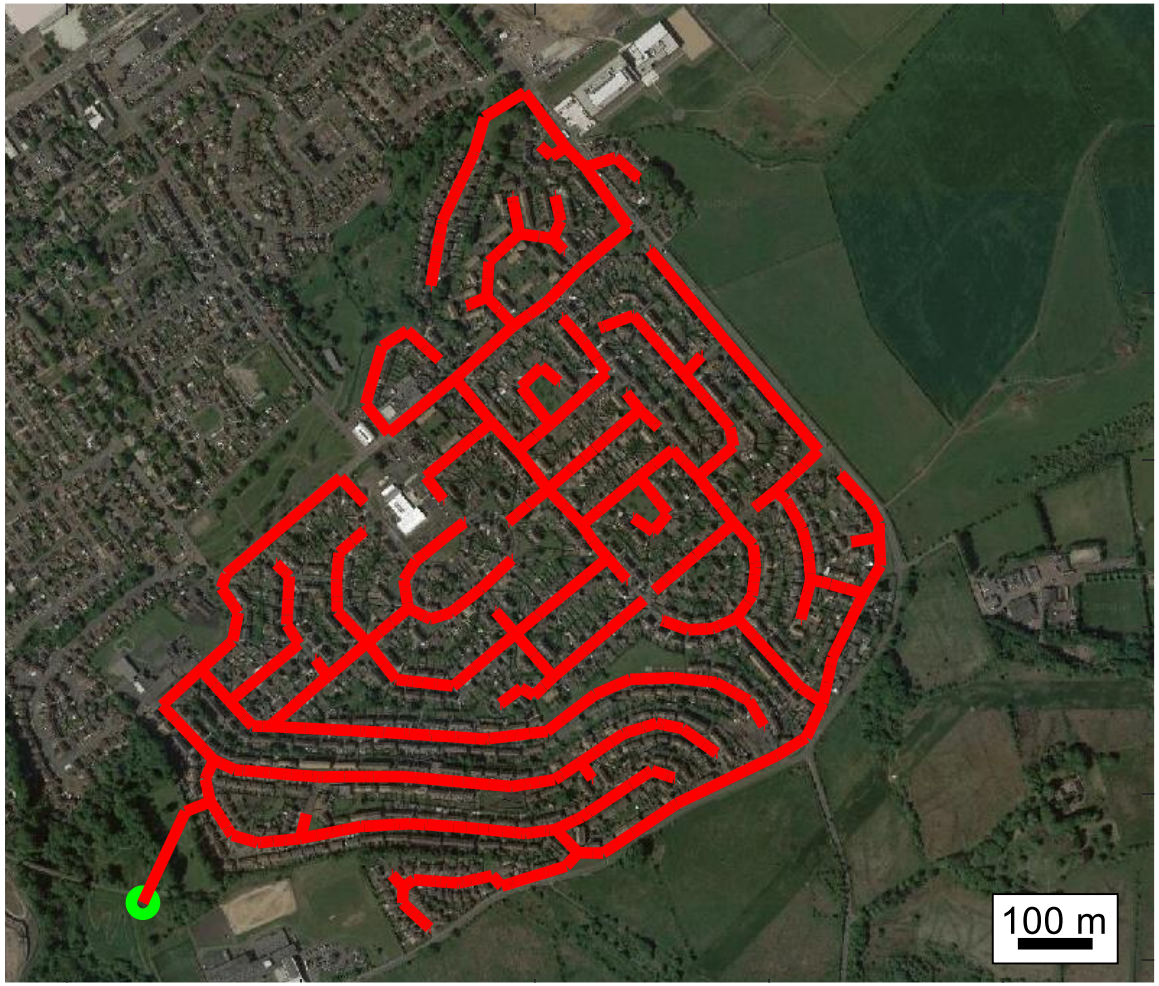


Figure source:
http://geosurvey.ohiodnr.gov/extra-news-archives/2014-articles/geothermal-wrap-up



Distribution system layout

- **Main parameters of the distribution system**
  - 21 km long
    - 11 km of distribution pipes
    - 10 km of service pipes
  - 618 connections points
    - 1.693 households
- **Pipeline dimensioning**
  - Pipes are dimensioned for each type of a supply system
  - For each supply system two cases are considered
    - High energy buildings (50 W/m^2)
    - Low energy buildings (25 W/m^2)

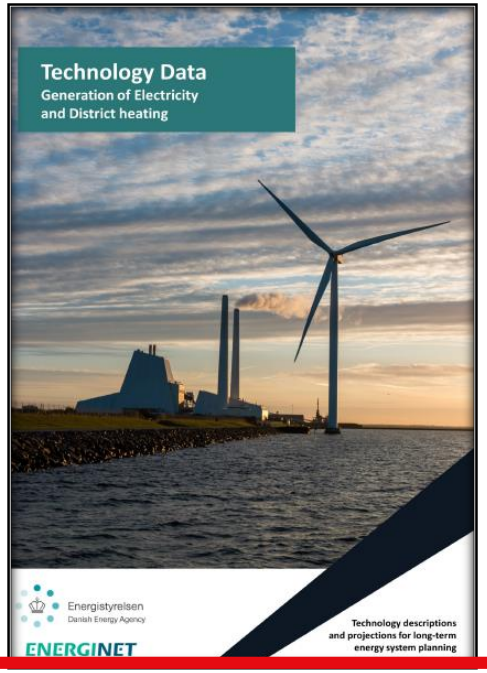


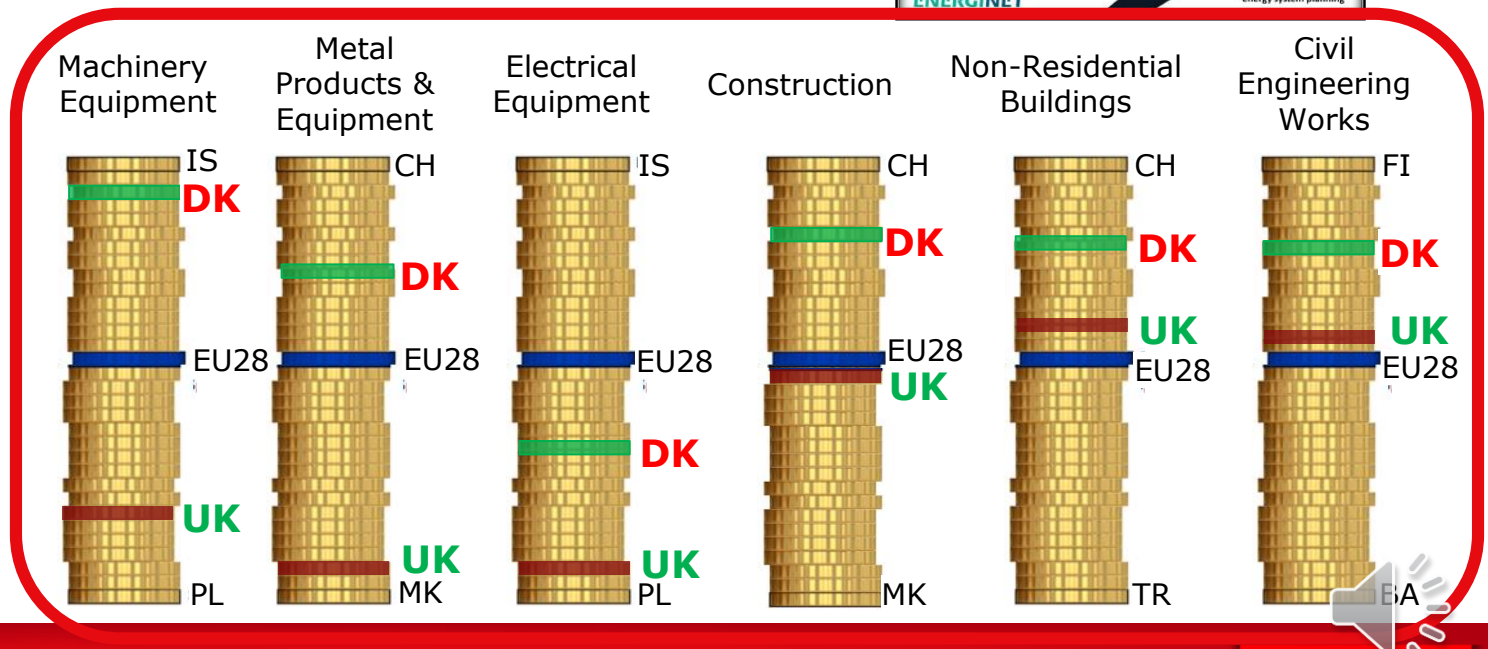
Heat demand

- **Space heating demand:**
  - Estimated based on standard climate weather profiles from EnergyPlus for high and low energy buildings
- **Domestic hot water demand:**
  - 2 MWh/year for all cases considered
- **Locations considered:**
  - Copenhagen, Denmark
  - London, United Kingdom

Technological and Economical sources

- **Country specific data when possible:**
  - Heat transfer units and individual heat pumps (Danfoss)
  - Investment cost of distribution pipelines (IEA)
- **In case of lacking country specific data:**
  - Danish Energy Agency Technology Catalogues
    - Central heat generation plants
    - Central heat exchanger stations
- **Transferring prices between countries:**
  - Eurostat – Purchasing Power Parities (PPP)
  - In general Denmark is a high cost country and price adjustments are needed.

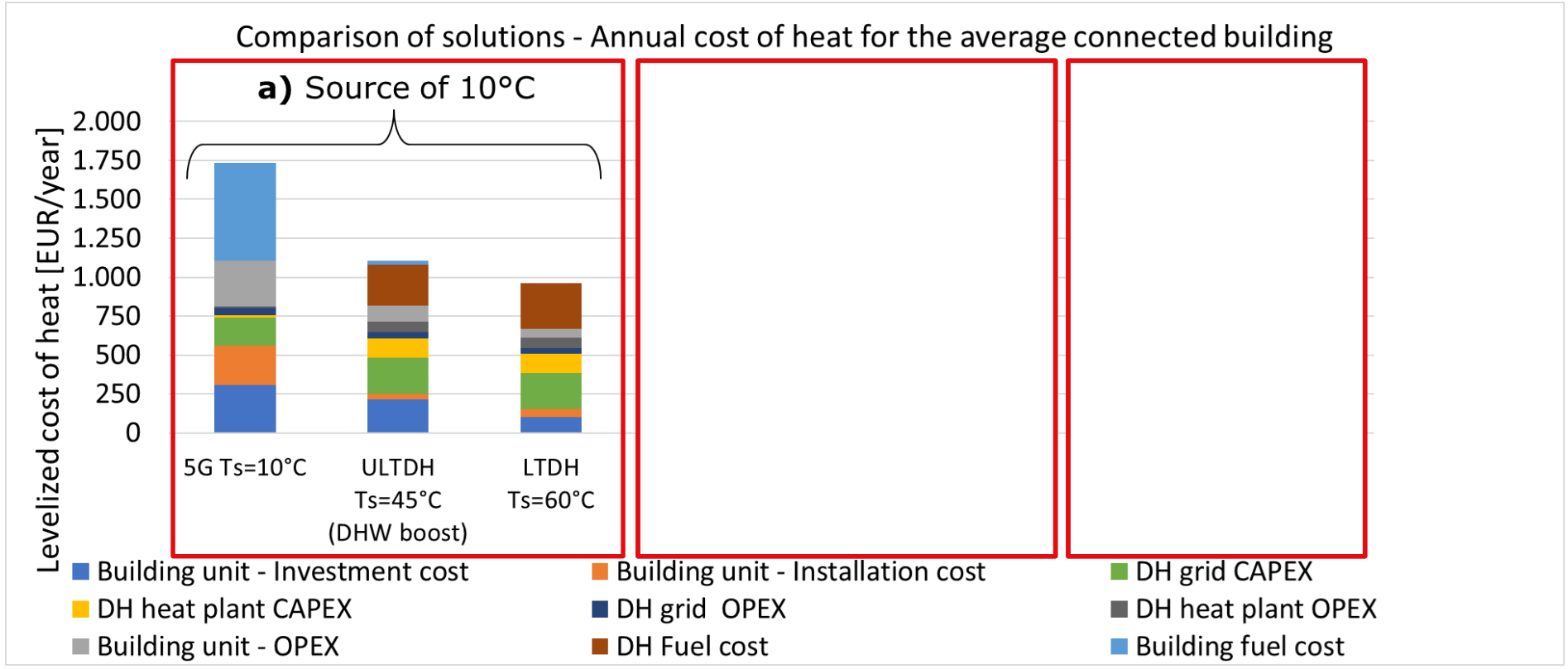




Economic results
- High energy buildings in Denmark

- The comparison is based on a levelized cost of heating, all main costs inclusive..
  … **Except** the development of the heat source!

- **Denmark –** 15 MWh/y space heating and 2 MWh/y DHW demands



How does United Kingdom compare to Denmark?
- High energy buildings

- The comparison is based on a levelized cost of heating, all main costs inclusive..
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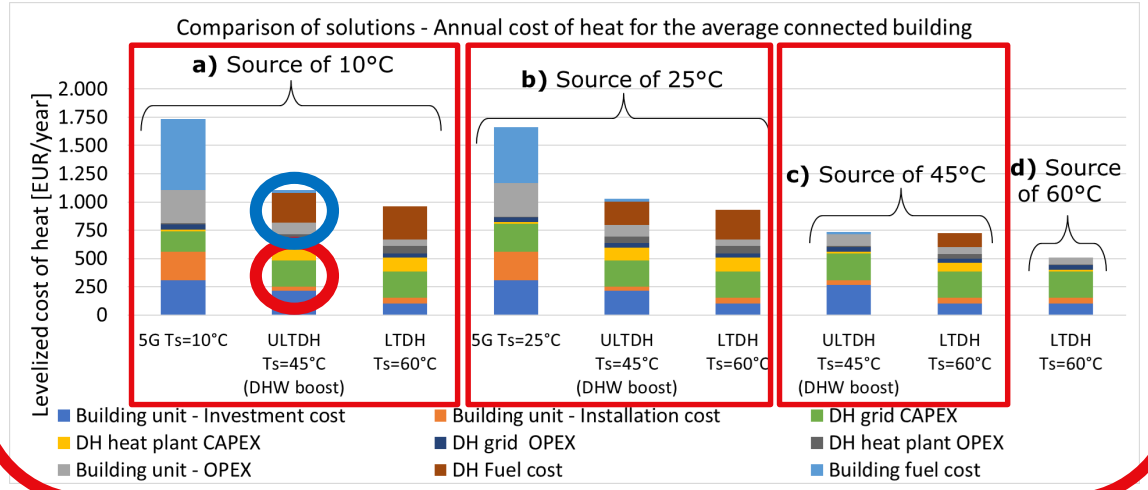
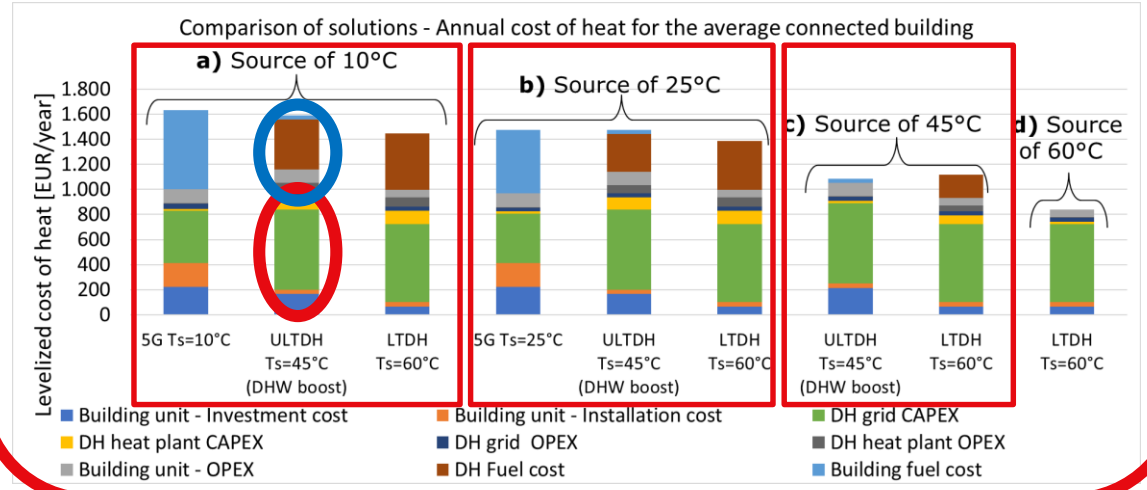
Denmark
– 15 MWh/y space heating and 2 MWh/y DHW demands



United Kingdom
–11,4 MWh/y space heating and 2 MWh/y DHW demands



- **Major differences:**
  - **Primary:** Cost of establishing the distribution network → From relative share of 20% in DK to 40% in UK
  - **Secondary:** Cost of input energy

Comparing economics of different solutions for a heat supply in Denmark and the United Kingdom

- Low energy buildings

- The comparison is based on a levelized cost of heating, all main costs inclusive..
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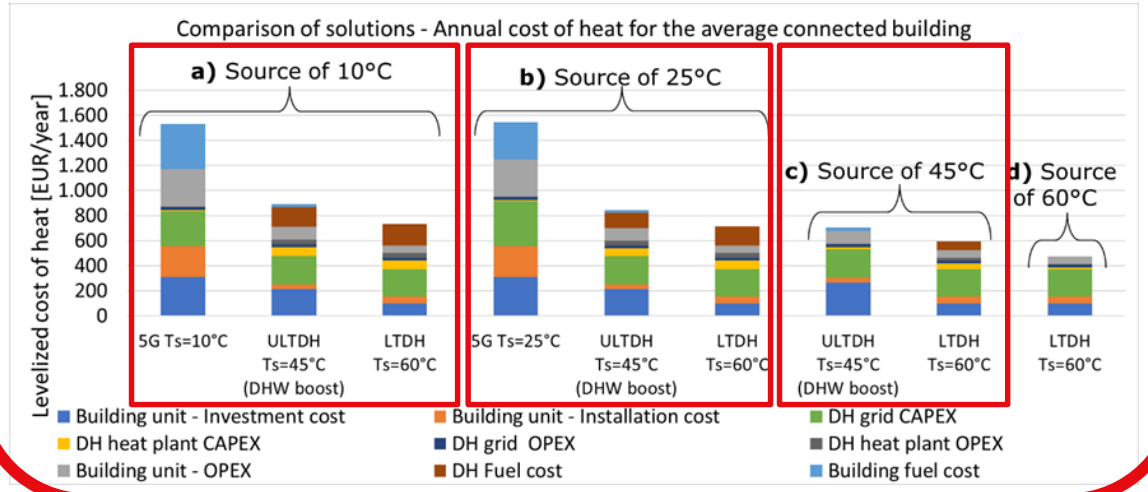
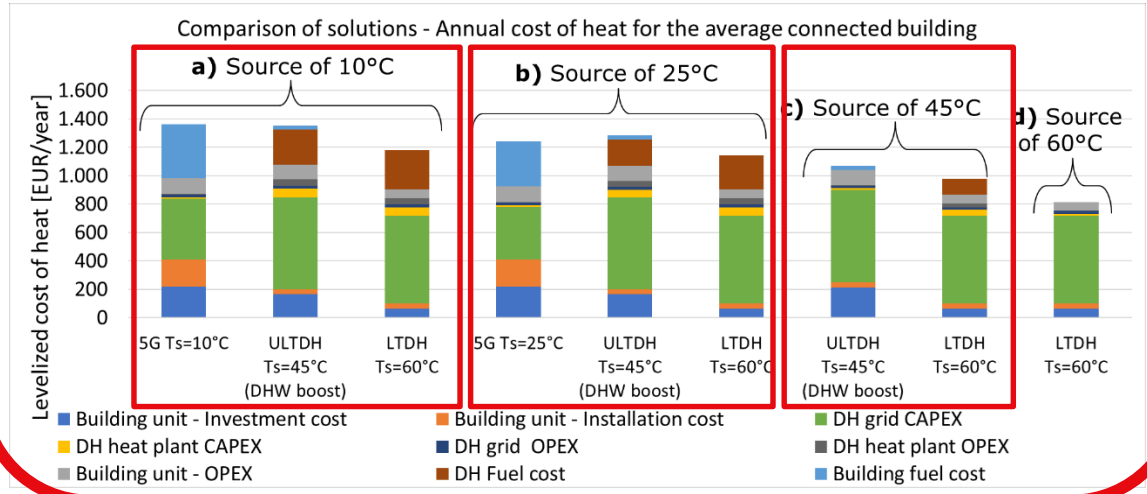
Denmark

– 7,5 MWh/y space heating and 2 MWh/y DHW demands



United Kingdom

– 5,7 MWh/y space heating and 2 MWh/y DHW demands



- Lower heating demand does not particularly influence the results

How do the solutions compare on other metrics?

"One can't predict the weather more than a few days in advance." – Stephen Hawking
- We however can prepare for the unexpected!

- **Energy supply security**
  - What if the future develops differently than we expect?
    - ***Stable cheap renewable power is a luxury for Norwegians***
- **Flexibility**
  - How flexible is the thermal supply to the expected "fuel" input?
    - ***Even Norway experiences dry summer***
- **Robustness**
  - Is the supply system able to operate in case of unexpected beating?
    - ***Eventually everything gets kicked***
- **Reliability**
  - How frequently does the thermal supply fail to meet the demands?
    - ***Anything can fail, but two units failing at the same time?***
- **Resilience**
  - How quickly can the supply system recover from a disruption?
    - ***Century storms, floods, earthquakes, terror/cyber attacks, …***

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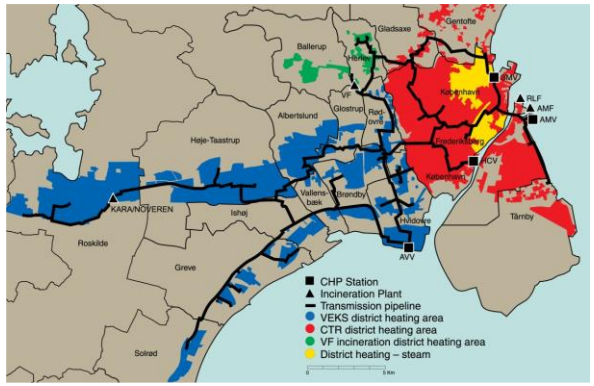
Urban areas:
Central heat generated district heating



Source: The District Heating System in Greater Copenhagen Area - in a free power market. Varmelast.dk

Rural areas:
Individual heat pumps

Heat pumps

Thank you for your attention

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