Technical challenges and solutions for the integration of low-grade heat sources into existing networks and buildings

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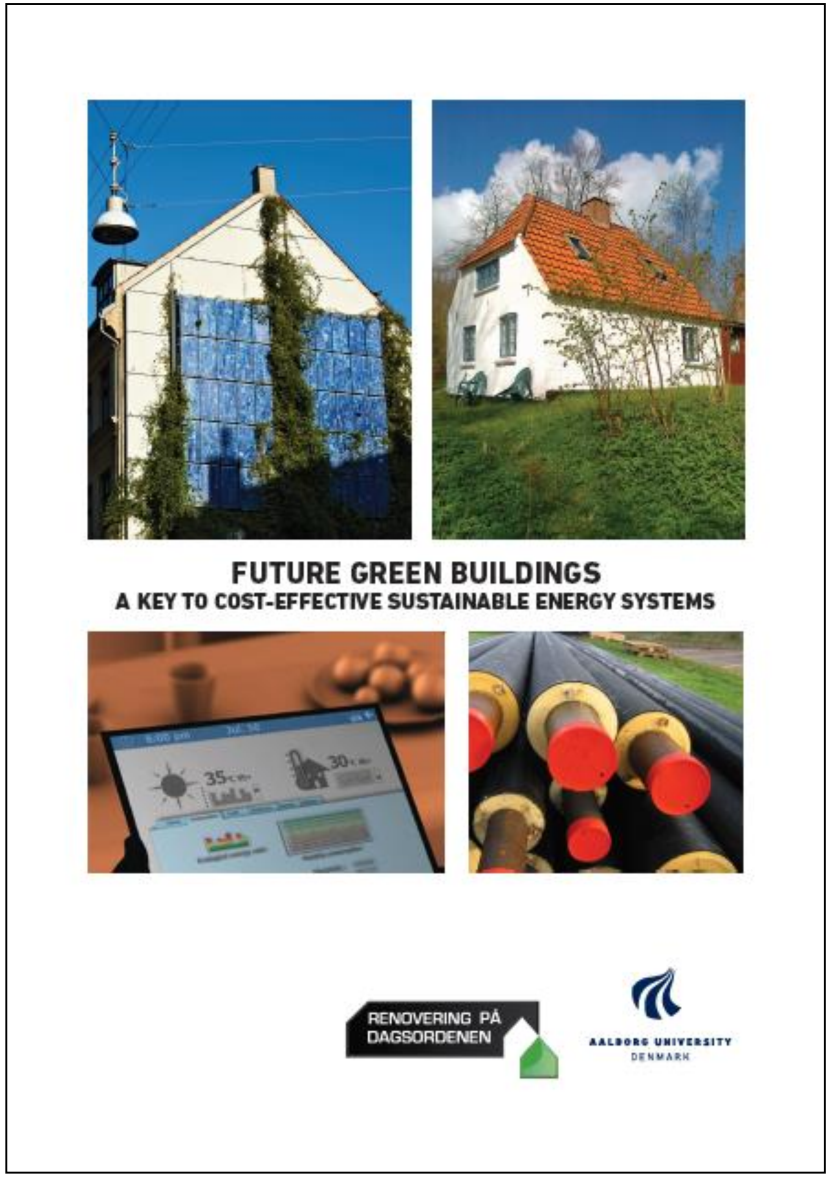
Three focus areas for buildings

STOP BEFORE PASSIVE HOUSE STANDARDS



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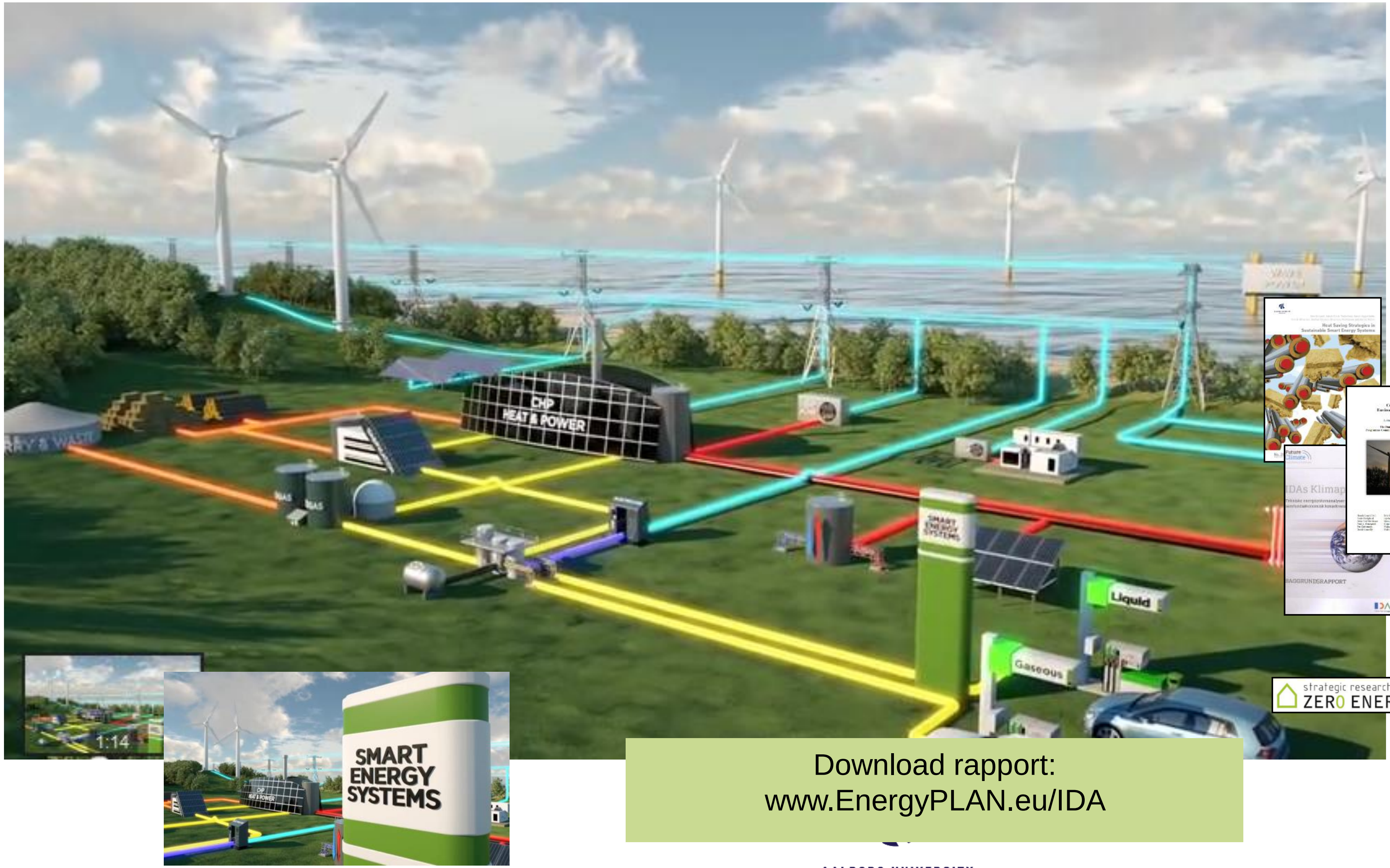
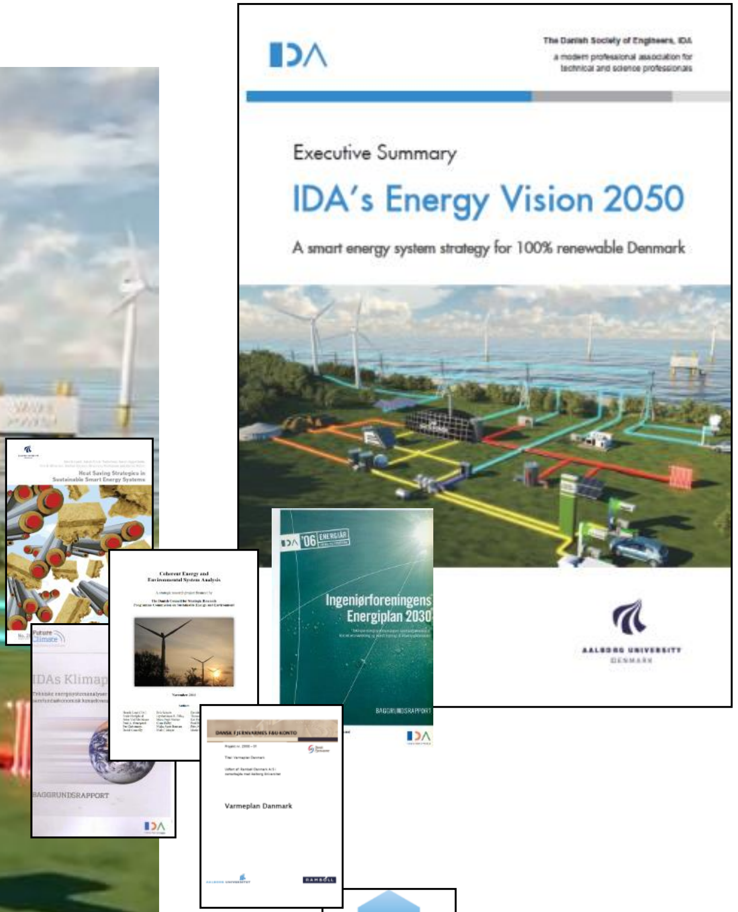
Smart Energy Systems





strategic research centre for ZERO ENERGY BUILDINGS

4DH 4th Generation District Heating Technologies and Systems

Download rapport:
www.EnergyPLAN.eu/IDA

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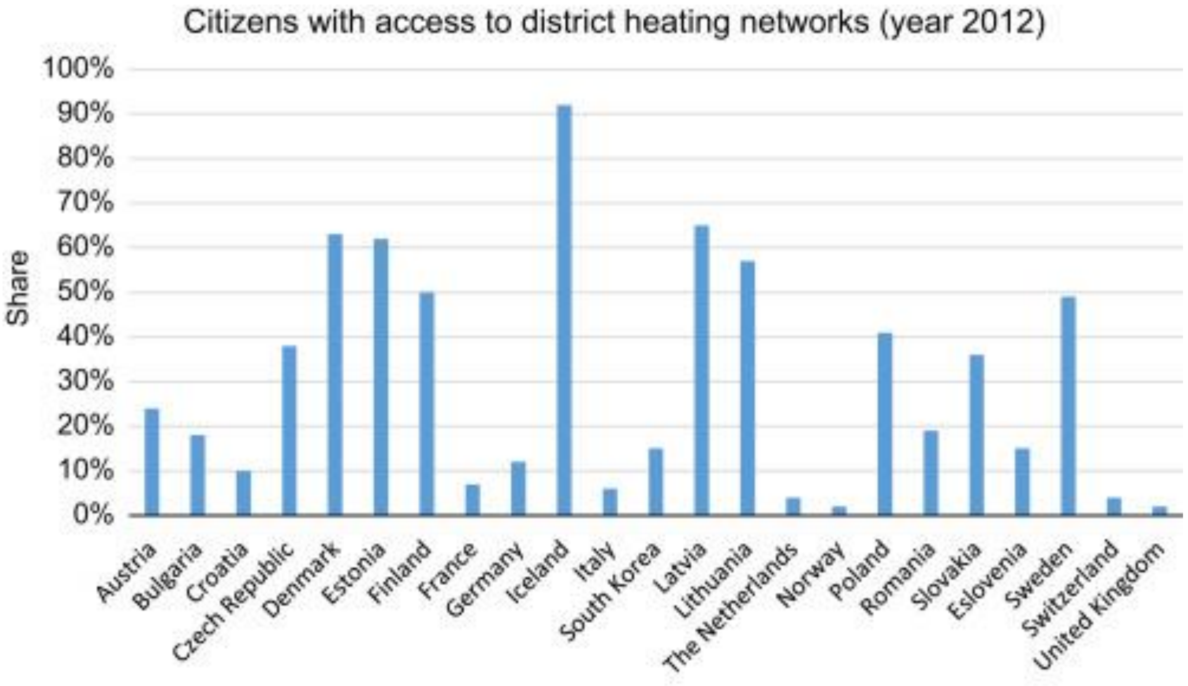
Agenda

- Current status on district heating

- Low temperature district heating
  - Technical aspects
  - Utilisation of renewable sources

- The role of low temperature district heating in Smart Energy Aalborg

District heating in Europ



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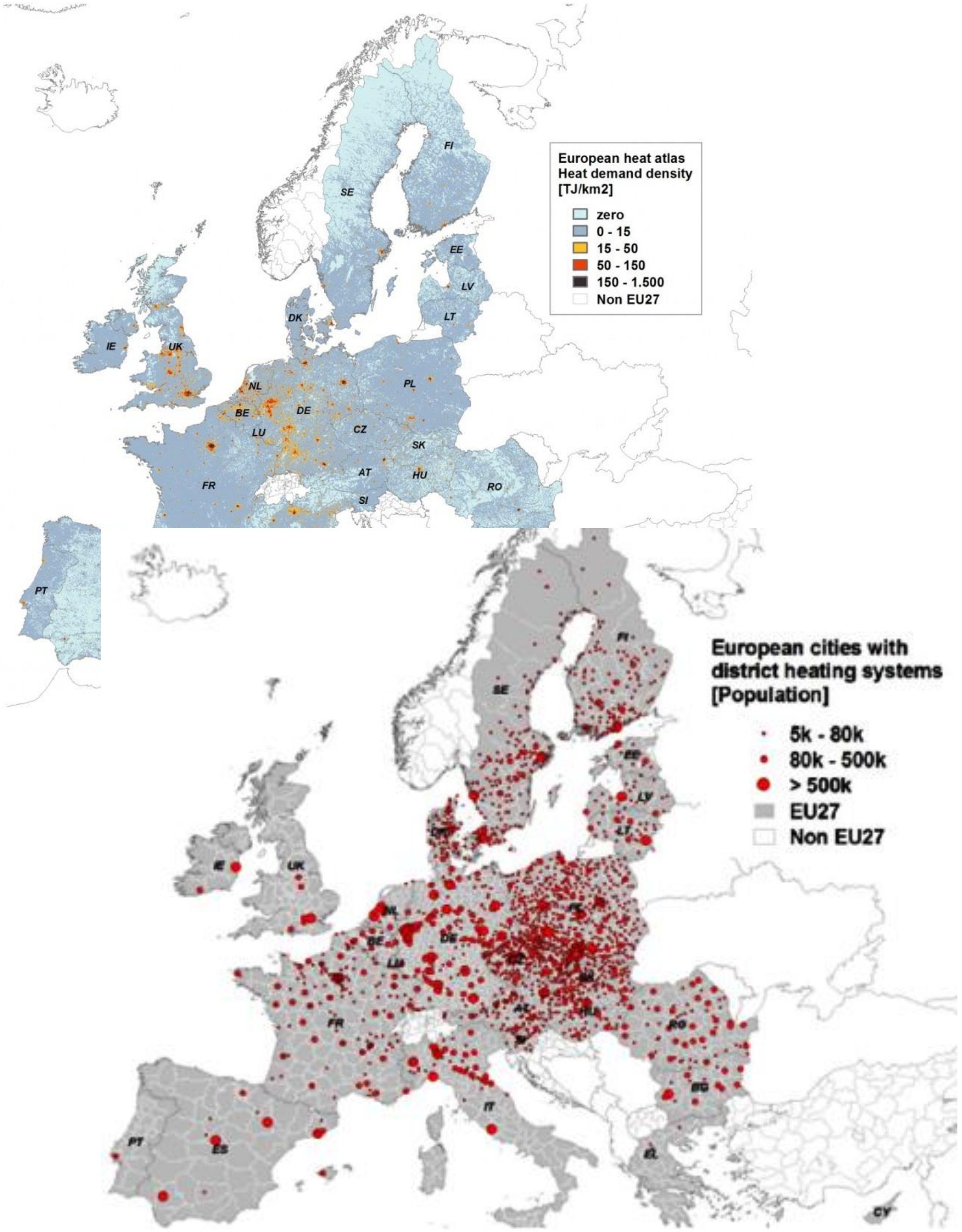

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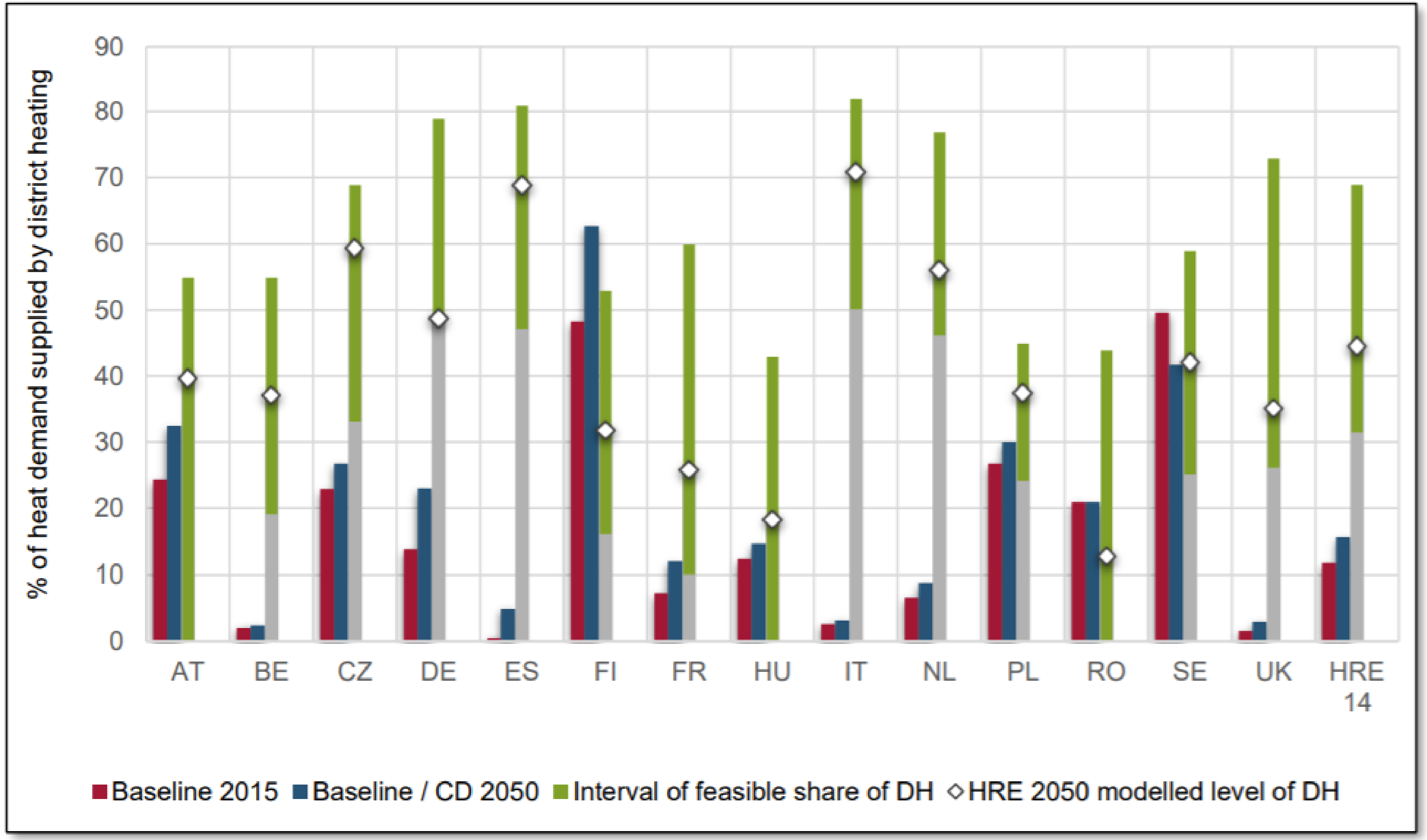
Potential for heating in Europe

- Heat Roadmap Europe 1 and 2. Focus on 27 EU countries together.
- Stratego / Heat Roadmap Europe 3
  - Concrete plan for 5 EU countries
- Heat Roadmap Europe 4
  - Concrete plan for 14 countries in EU.
- https://heatroadmap.eu/



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Steam systems (1st generation)

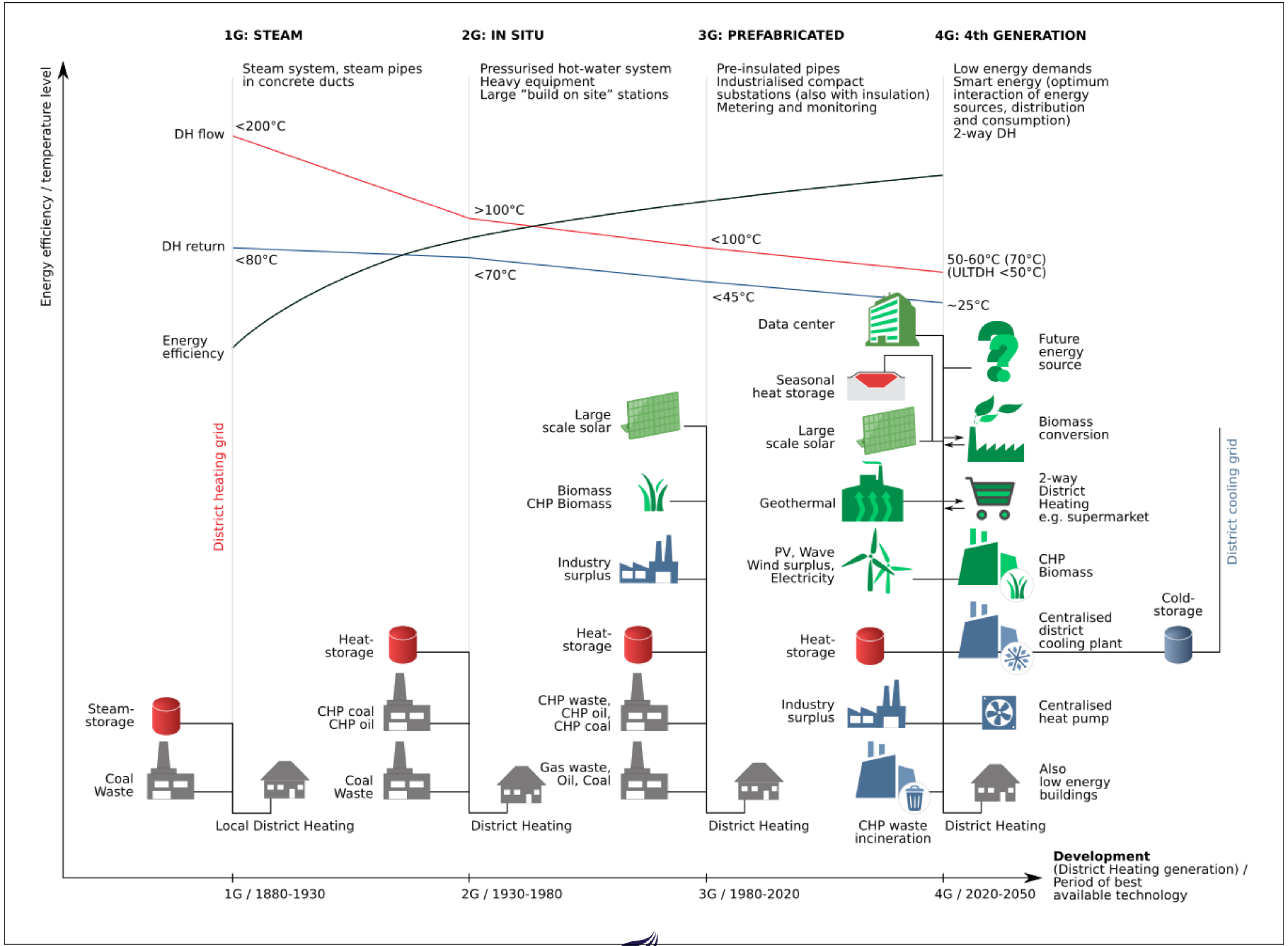
- High temperature
- Predominantly in systems before 1930
- High losses
- Can be used for industrial processes

High temperature water systems (2nd generation)

- 1930-1980
- Still remains in parts of the current water based systems
- Pressurized high temperature water (>100 ^oC)

Medium temperature water systems (3rd generation)

- 1980-2020
- The current system in most Scandinavian systems
- Between 70-95 ^{o}C



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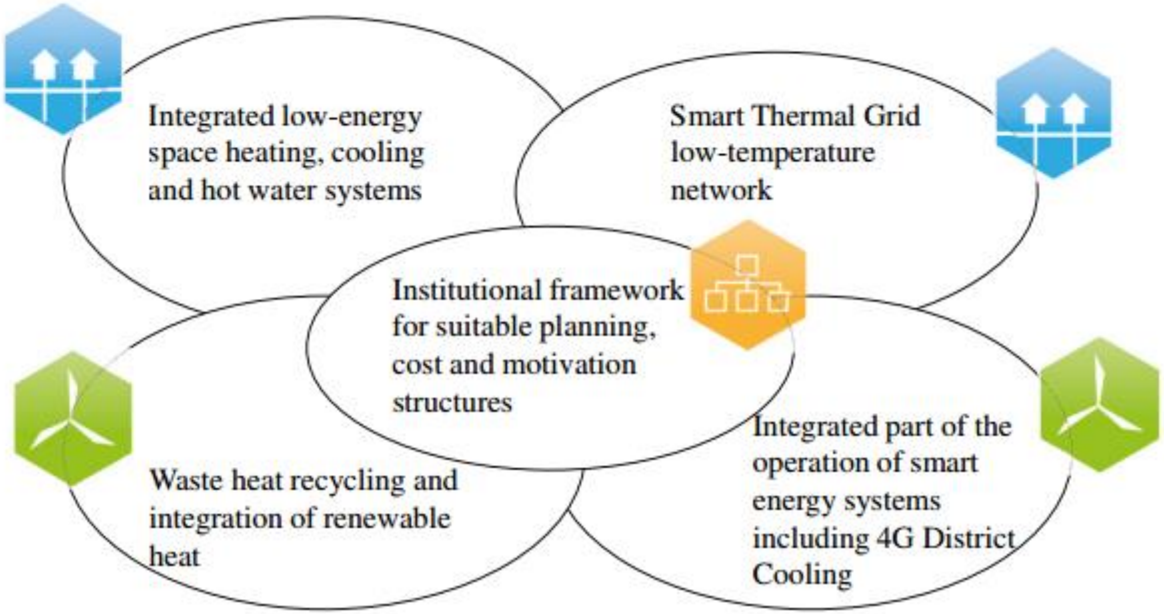
Low temperature district heating (4th generation)

- Utilise more of the energy
- Enable use of low temperature renewable sources



http://www.4dh.dk/

Transitioning to low temperature district heating

- Proper design of networks and consumer connections

- Right compatibility with the buildings stock

- Existing district heating systems
  - Adapting installations
  - Potential retrofitting of buildings

- New development areas and new district heating systems
  - In low energy buildings, low temperature district heating can be especially suitable

Compatibility with existing building stock

- Space heating
  - Poorly insulated buildings require more energy
  - Current equipment might not be scaled for low temperature district heating
    - Equipment changes
    - Renovation of the building stock
  - Introduce thermostatic valves to control comfort levels
- Domestic hot water
  - Low temperature can lead to legionella in the water tank
    - Plate heat exchanges can be a solution

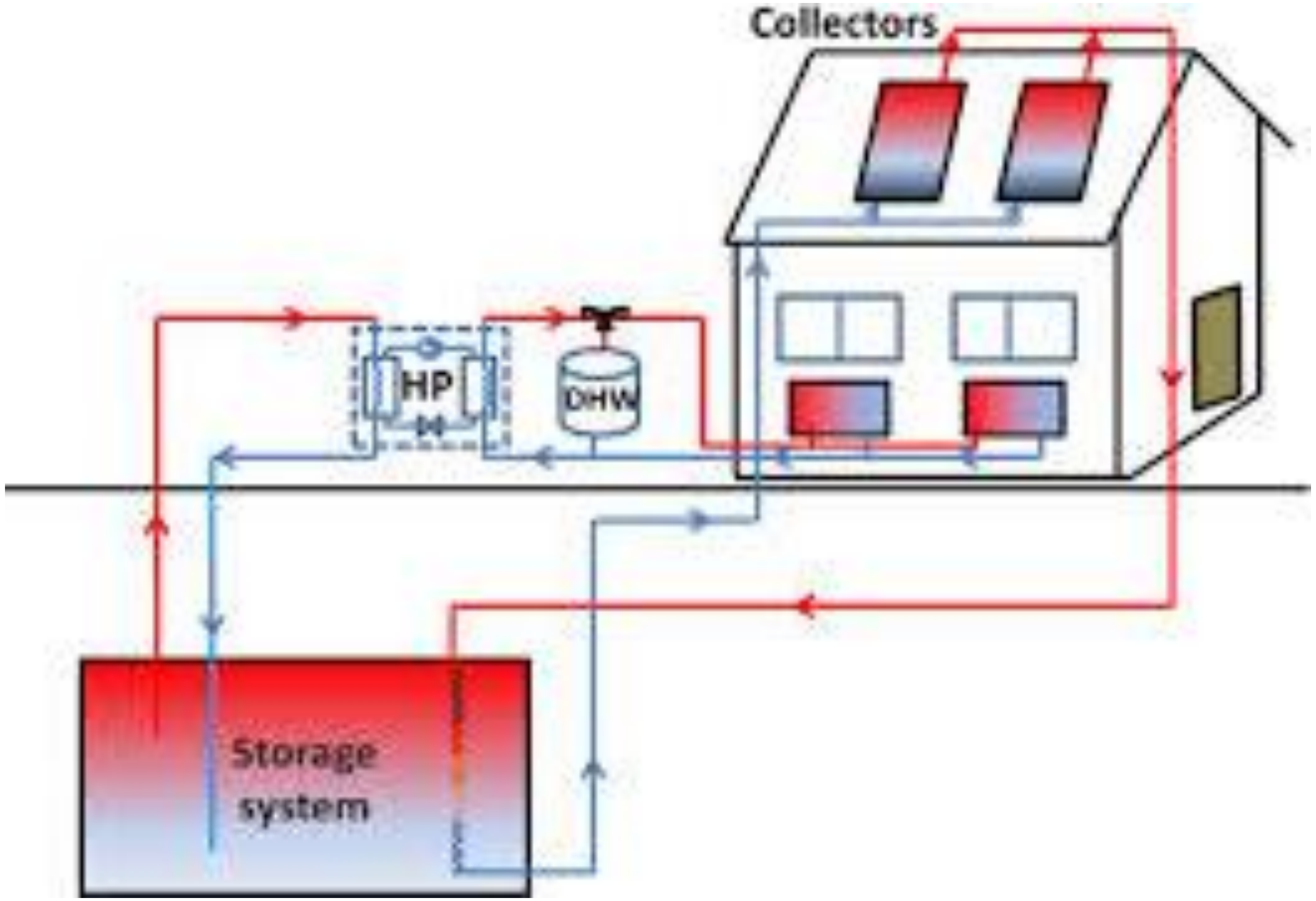
Compatibility with existing heat network

- Lower temperature can lead to higher flow rates
  - Low supply temperature requires that the return temperature is lowered too
  - From 80-40 to 50-20, still have a higher temperature difference

- New excess heat sources can require new networks

- Boosting technology can become relevant
  - To increase temperature from a supply source
  - To increase temperature certain places in the grid in cold seasons

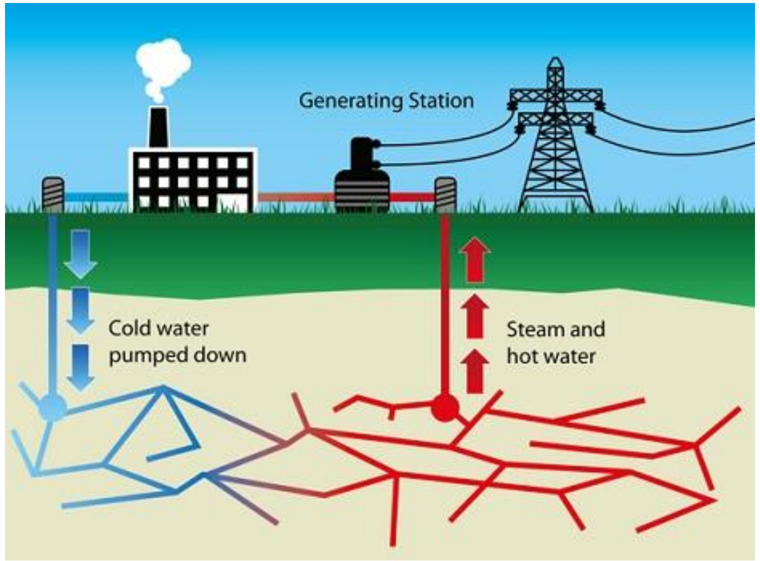
Heat pumps



- **Large scale heat pumps**
- Coupled with the DHC system
- Supports both heating and cooling
- Boost temperature of low-temp. sources
    - Data centre, Sea/lake/river water, Sewage water, abandoned coal mine, etc.
    - Energy recovery from thermal storage.
- Boost temperature at certain points in the networks
    - E.g. DHW supply
    - E.g. the furthest points

Integration of renewable energy

- Geothermal
  - Utilise heat either through heat pumps or directly in the network
  - Most resources are low to medium temperature

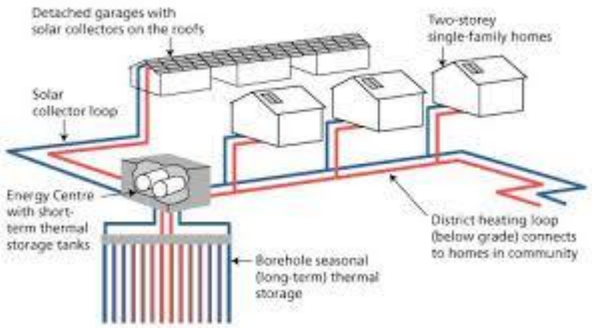


- Solar thermal
  - Seasonal by nature
  - Potential for large thermal storages
  - Requires space

Utilising storages in the district heating system

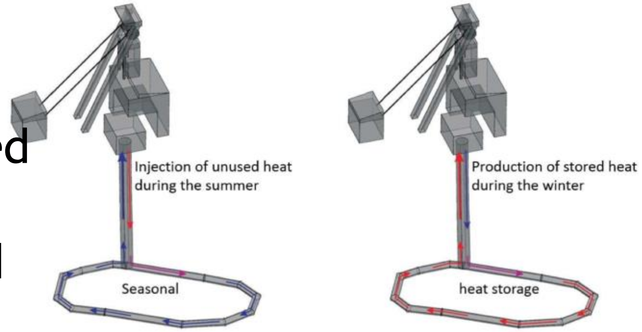
Borehole thermal energy storage (BTES)

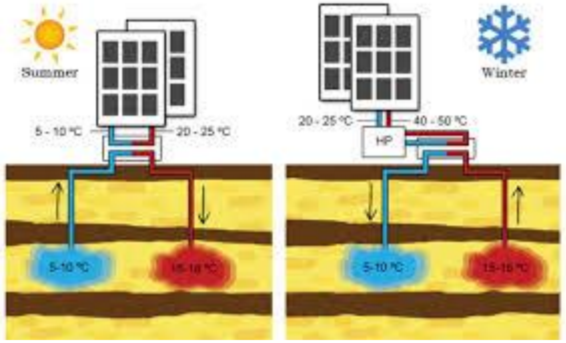
- Typically the upper 20-200m of the ground used for energy storage in the rock/soil.
- Up to 90°C can be stored



Mine thermal energy storage (MTES)

- Used for storage of surplus heat in abandoned coal mine.
- Co-location with demand for heating and cooling





Aquifer thermal energy storage

- Underground water reservoirs used for heat storage (<30 °C - >60 °C)

Tank thermal energy storage (TTES)

- Tanks installed on/under the ground and filled with thermal storage medium

4GDH's role in Smart Energy Aalborg

- The goal is to transition Aalborg to 100% renewable energy
- Utilising the principles of smart energy systems and low temperature district heating
- Current system is 3rd generation district heating

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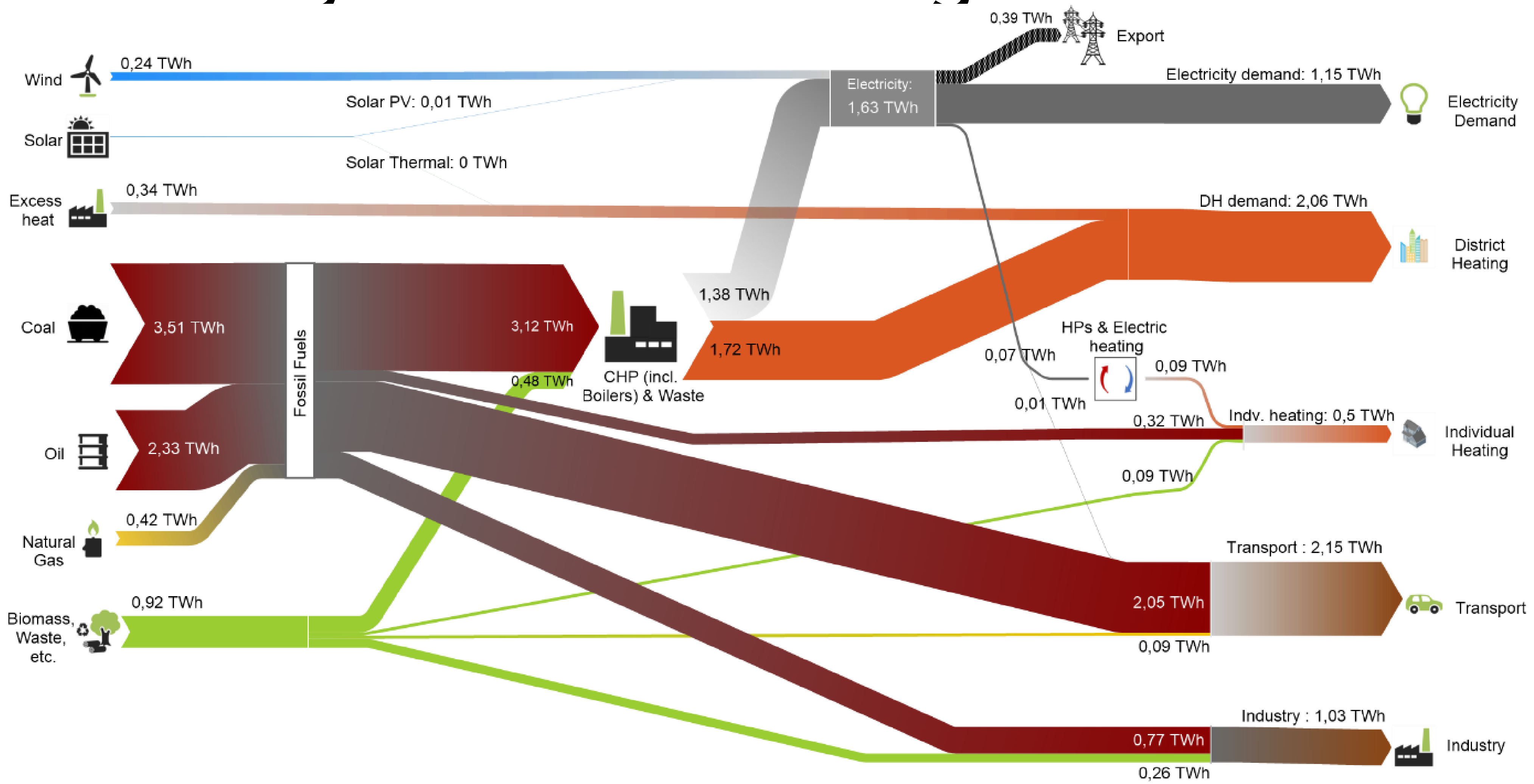
Current system in Aalborg



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Transitioning to renewable energy

- The transition has to be done in a way that does not limit other countries, cities and municipalities to transition to renewable energy

- Limiting biomass use
- Including transport based on both local and global transportation
- Defining the industrial demand related to inhabitants

Included benefits from low temperature district heating

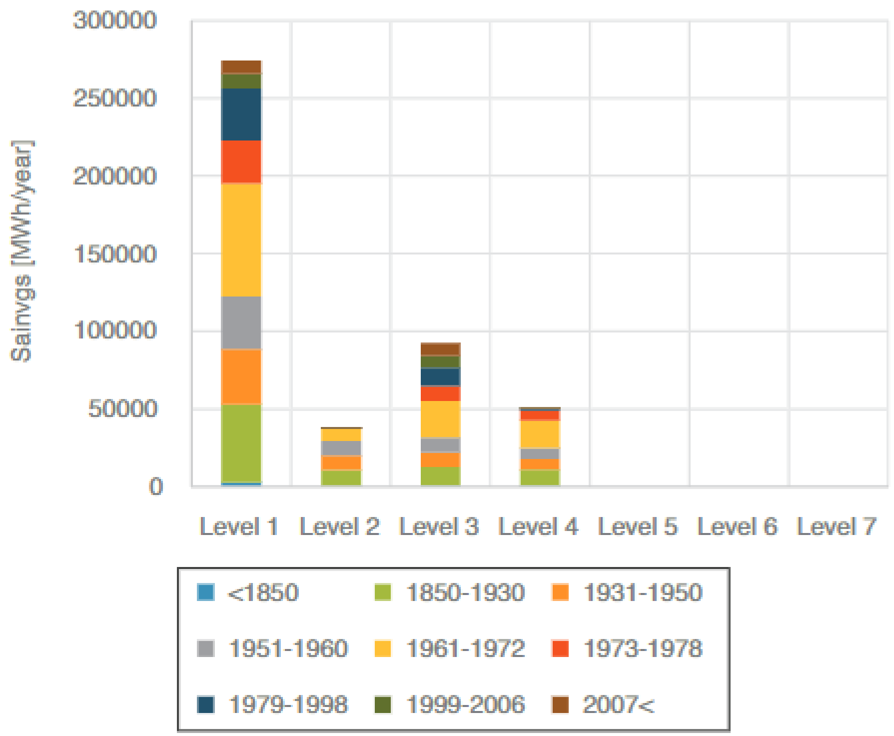
- Low temperature district heating is a key part of the vision

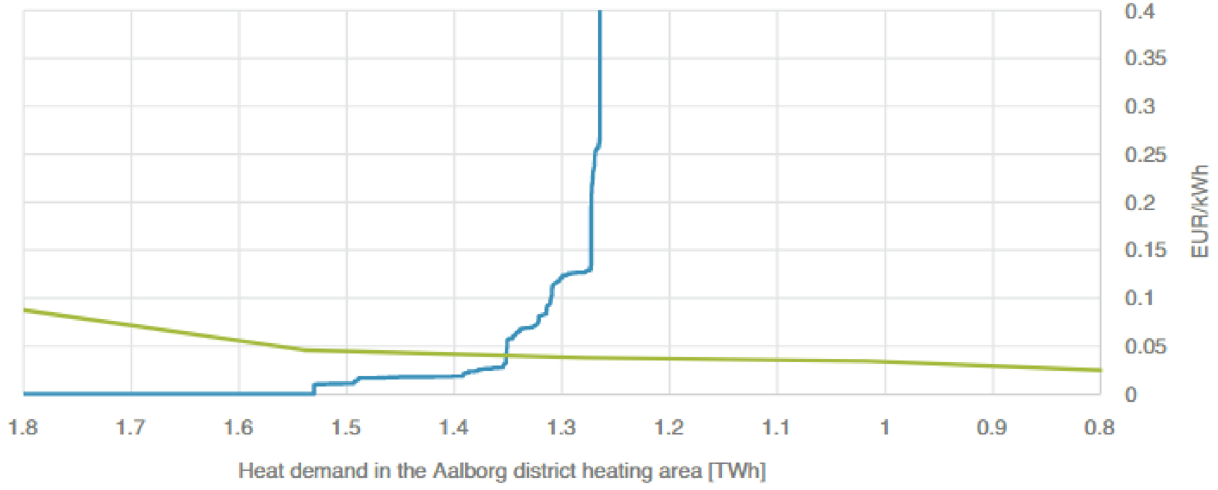
- Allows for better efficiencies in heat pumps
- Allows for lower losses in the district heating grid

- It requires investments in energy savings in the buildings

Retrofitting of buildings

- Savings implemented based on specific geographic analysis
- Investments in heat exchanges suited for low temperature heating





https://journals.aau.dk/index.php/sepm/article/view/3398/3184

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Industrial waste heat

- Low temperature district heating enables increased use of industrial waste heat
- Cement industry in Aalborg
  - Currently 20% of the heat demand

- In total a potential to increase from 1200 TJ to 3100 TJ
  - We use 2600 TJ

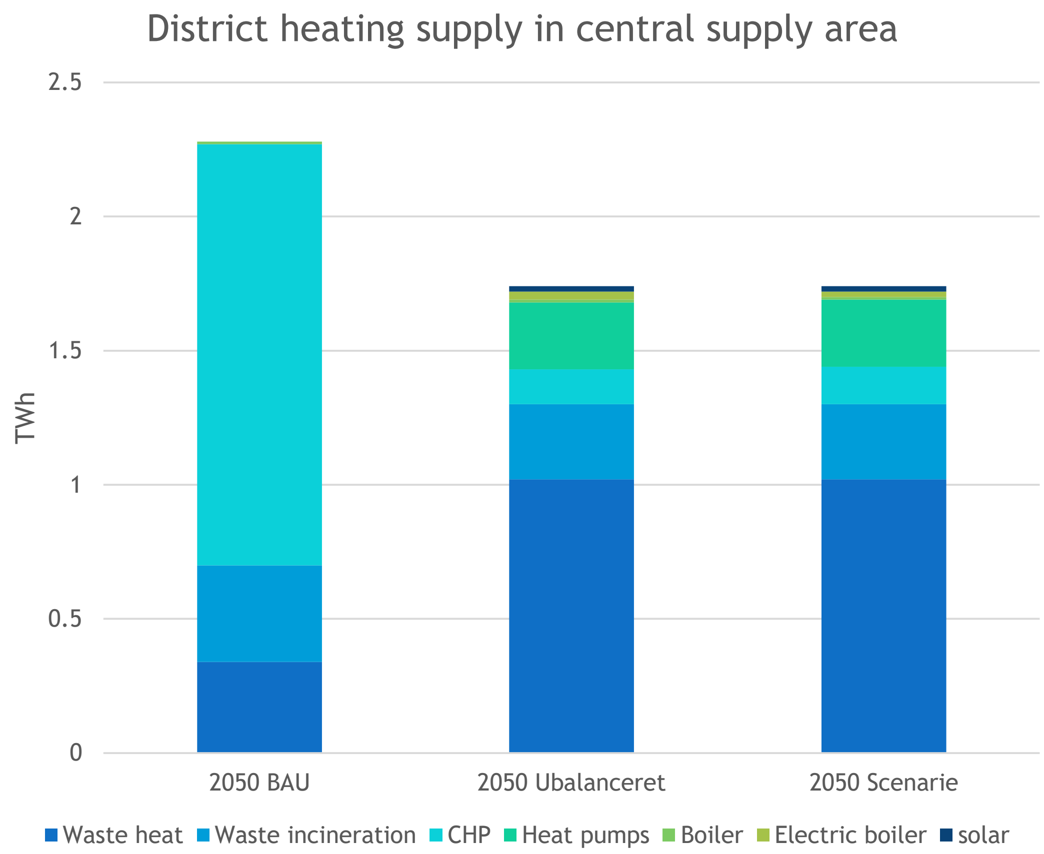
Project	Investment	Additional production
Delivery at 65 degree	None	500 TJ
Optimisation of existing facilities	None	385 TJ
New heat utilization from gray cement	48 mil. DKK	350 TJ
Lower return temperature by installing a heat pump	16-25 mil. DKK	122 TJ
Capture radiation heat	225 mil. DKK	540-610 TJ
Utilise heat from water filtration by by installing heat pump	7-9 mil. DKK	45 TJ

Heat pumps and geothermal

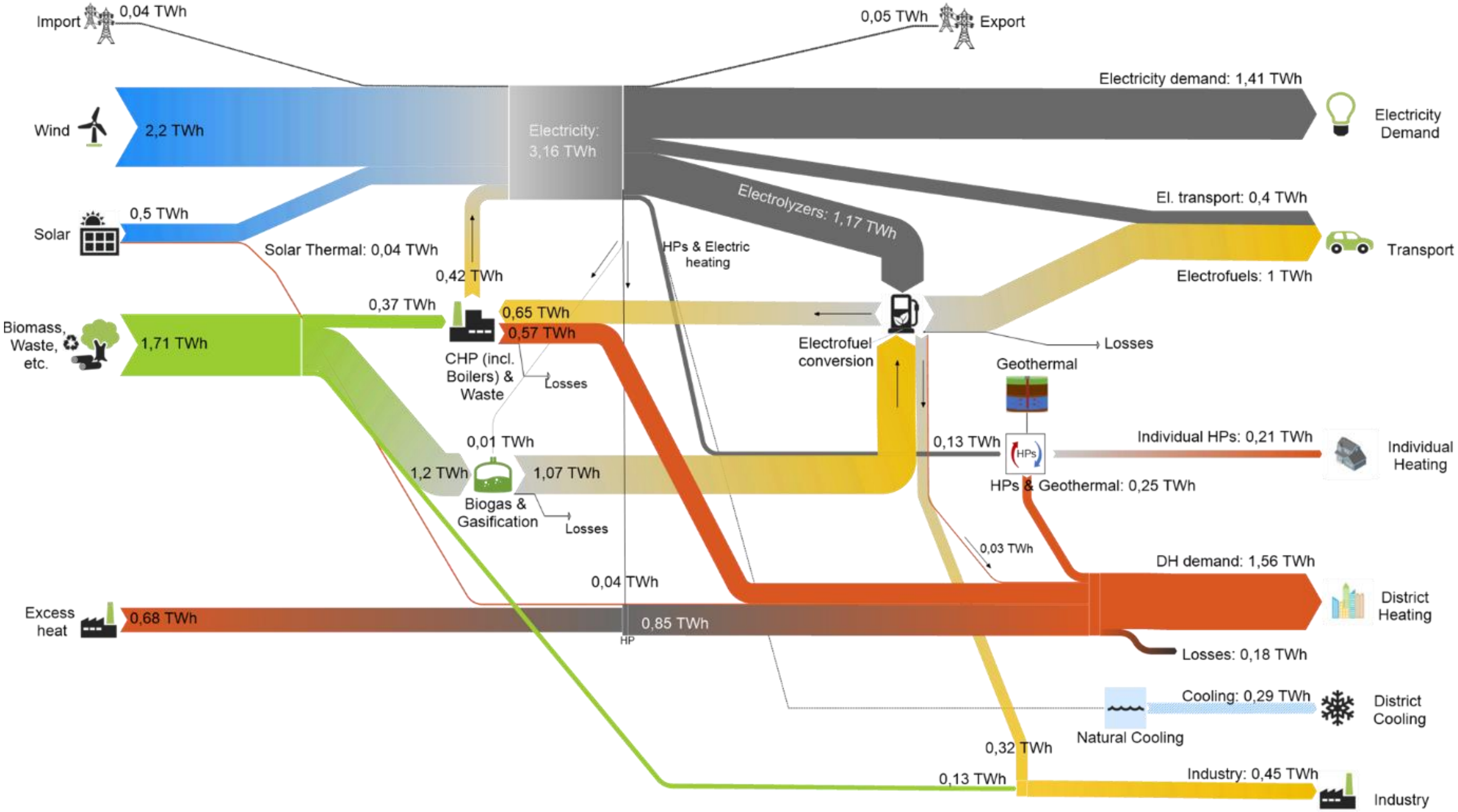
- Utilise 100 MW thermal capacity on heat pumps
  - Can be seawater heat pumps or geothermal

- 20 MW heat pumps running on waste heat from industry

- Utilisation of a large 40 GWh seasonal storage



The 100% renewable Smart Energy Aalborg



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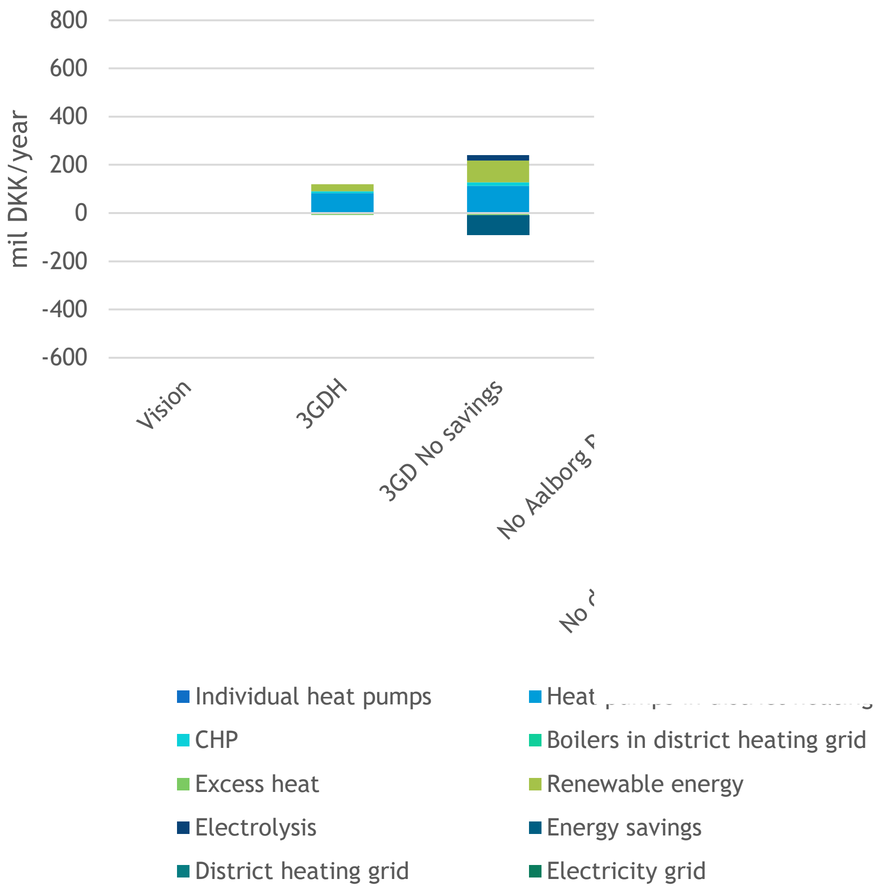
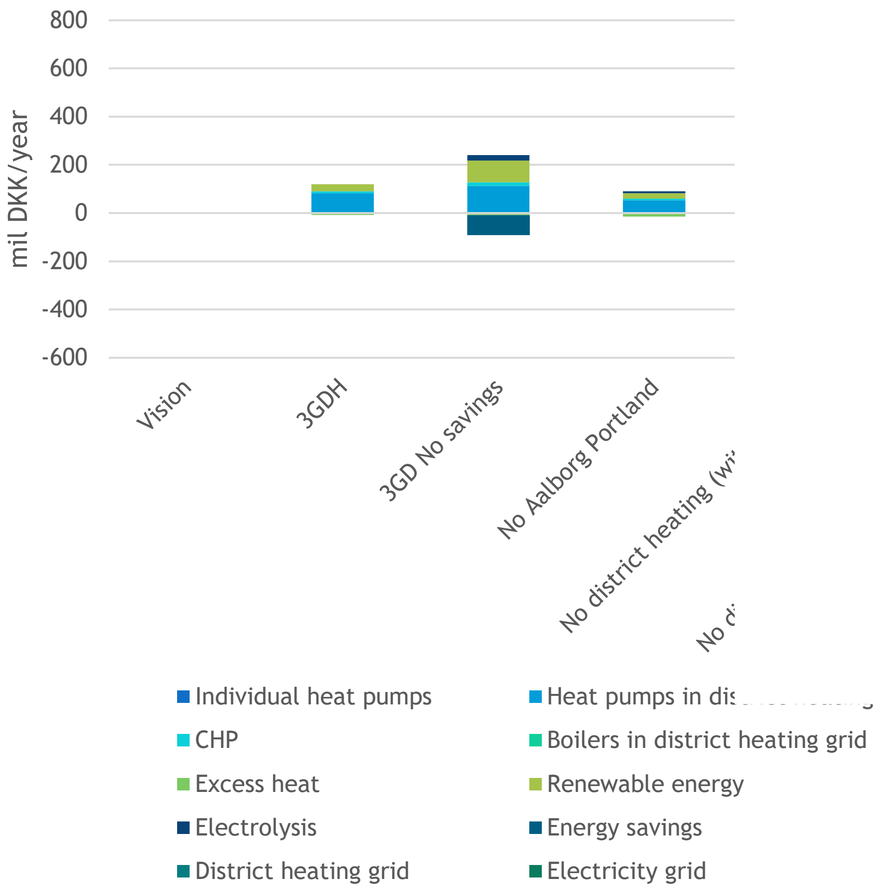
If no low temperature district heating

- We do not gain benefits from reduced losses and increased efficiencies
- Result of not achieving savings



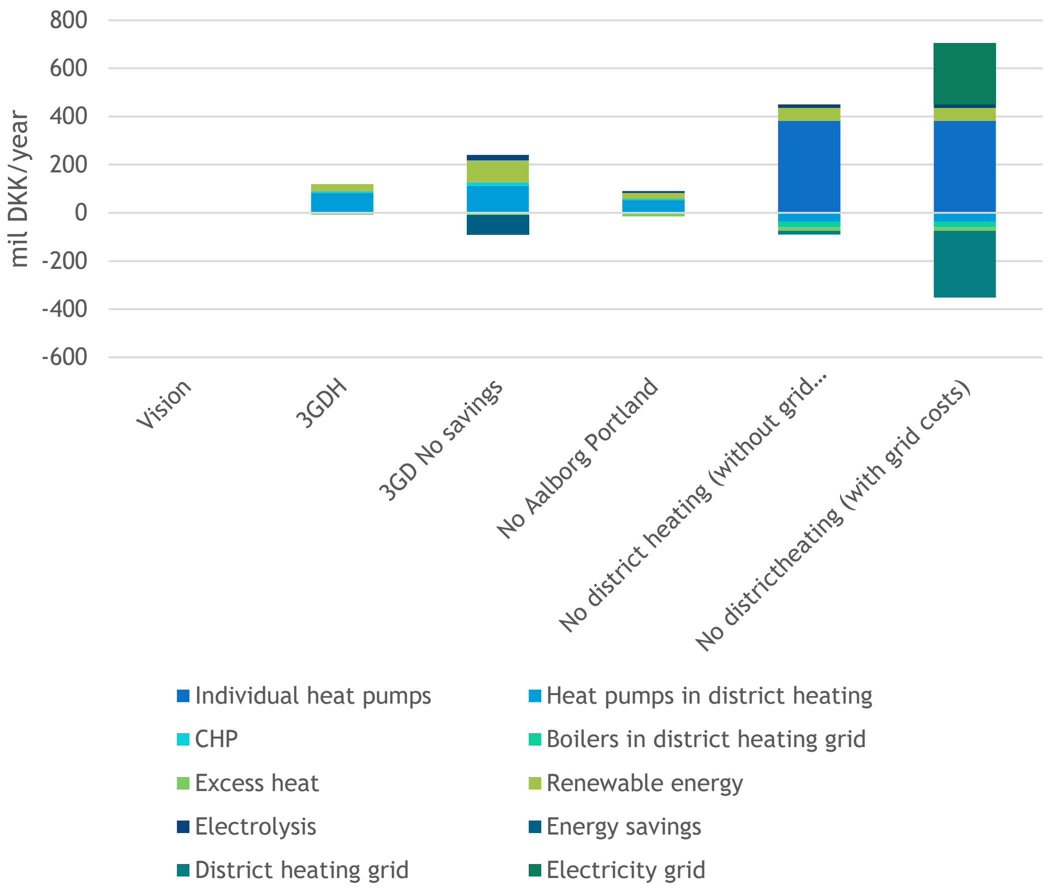
If no industrial excess heat

- We might not be able to rely so much on excess heat from the cement industry



If no district heating

- If we do not have district heating, what is the consequence of changing to individual heat pumps



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Summary

- It is technical possible
- It gives technical and socio economic benefits
- It requires planning