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

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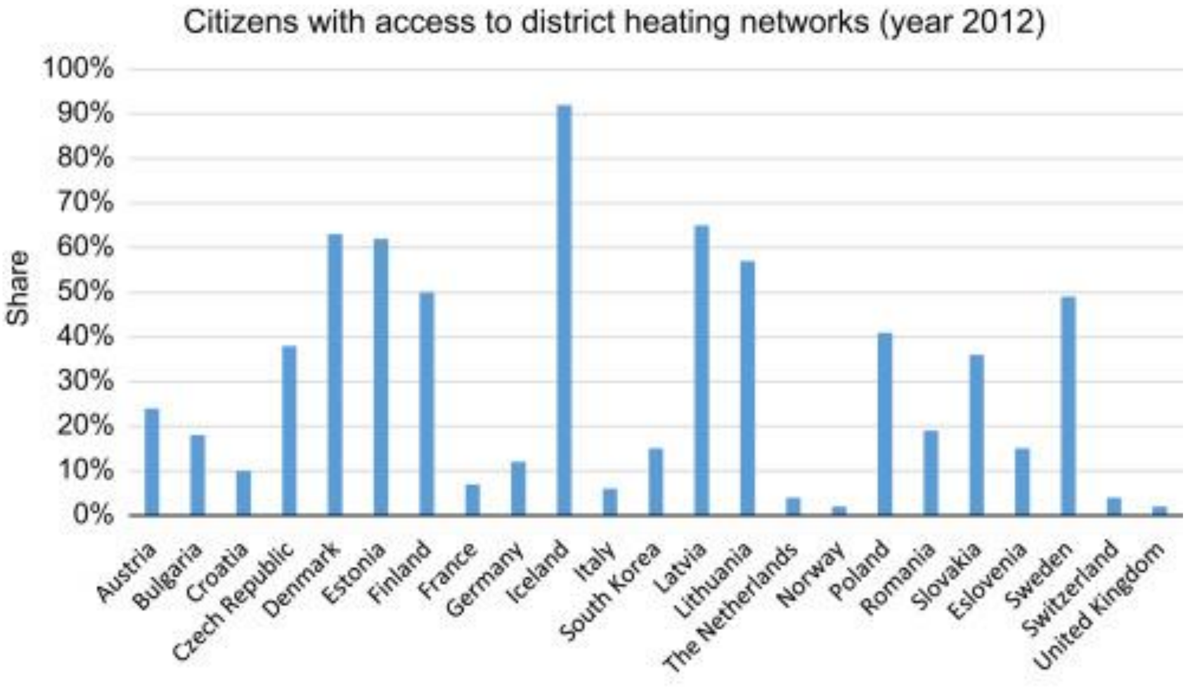
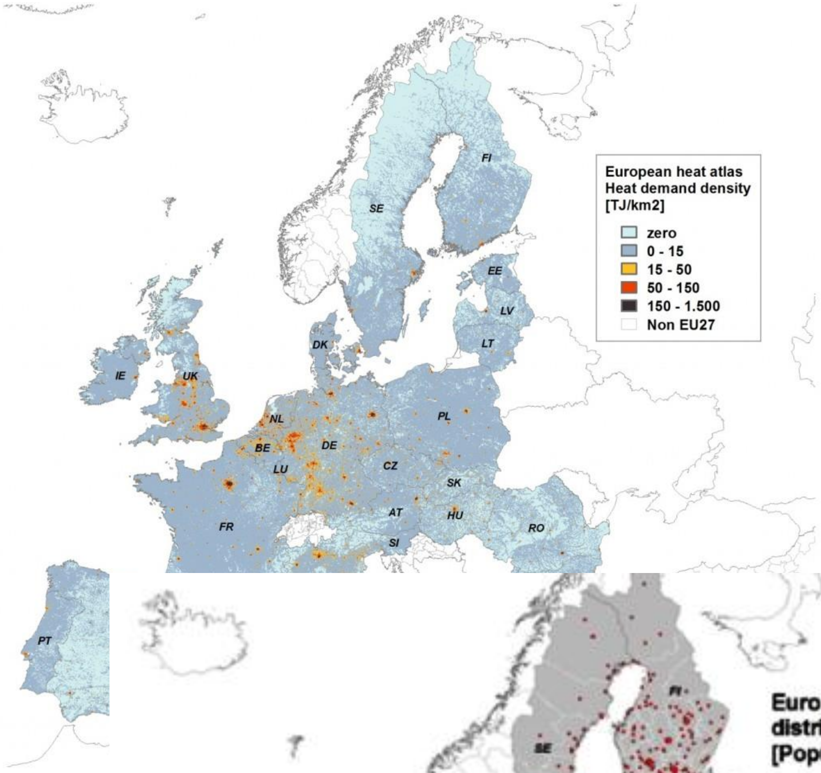
Agenda

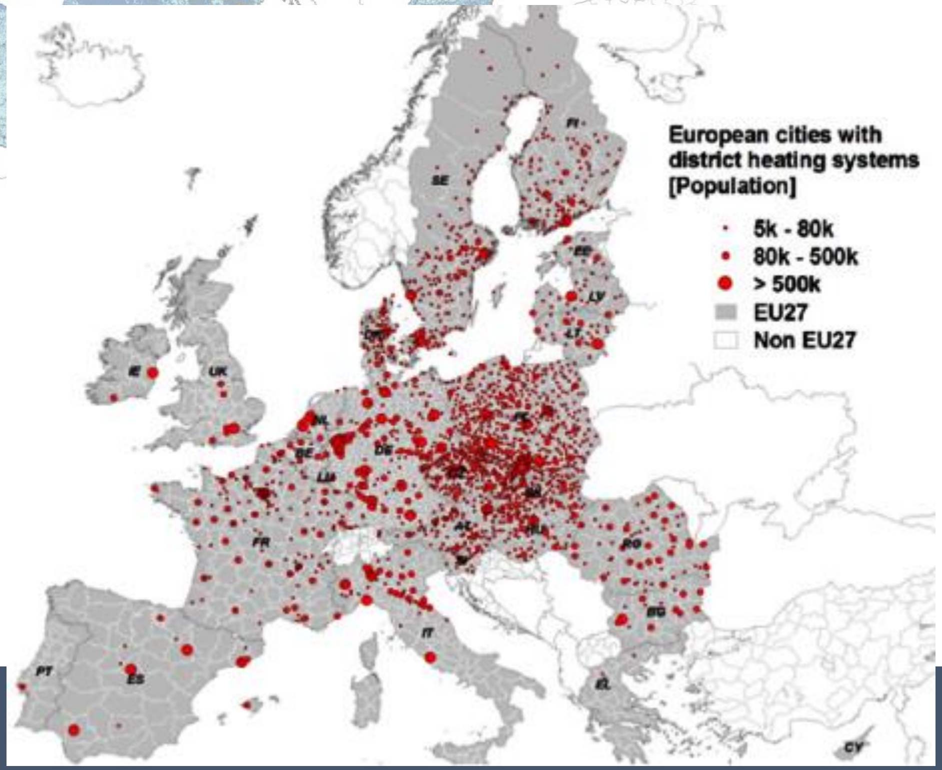
- Current status on district heating
- Low temperature district heating
  - Technical aspects
  - Utilisation of renewable sources
- The role of low temperature district heating in Smart Energy Aalborg

District heating in Europe



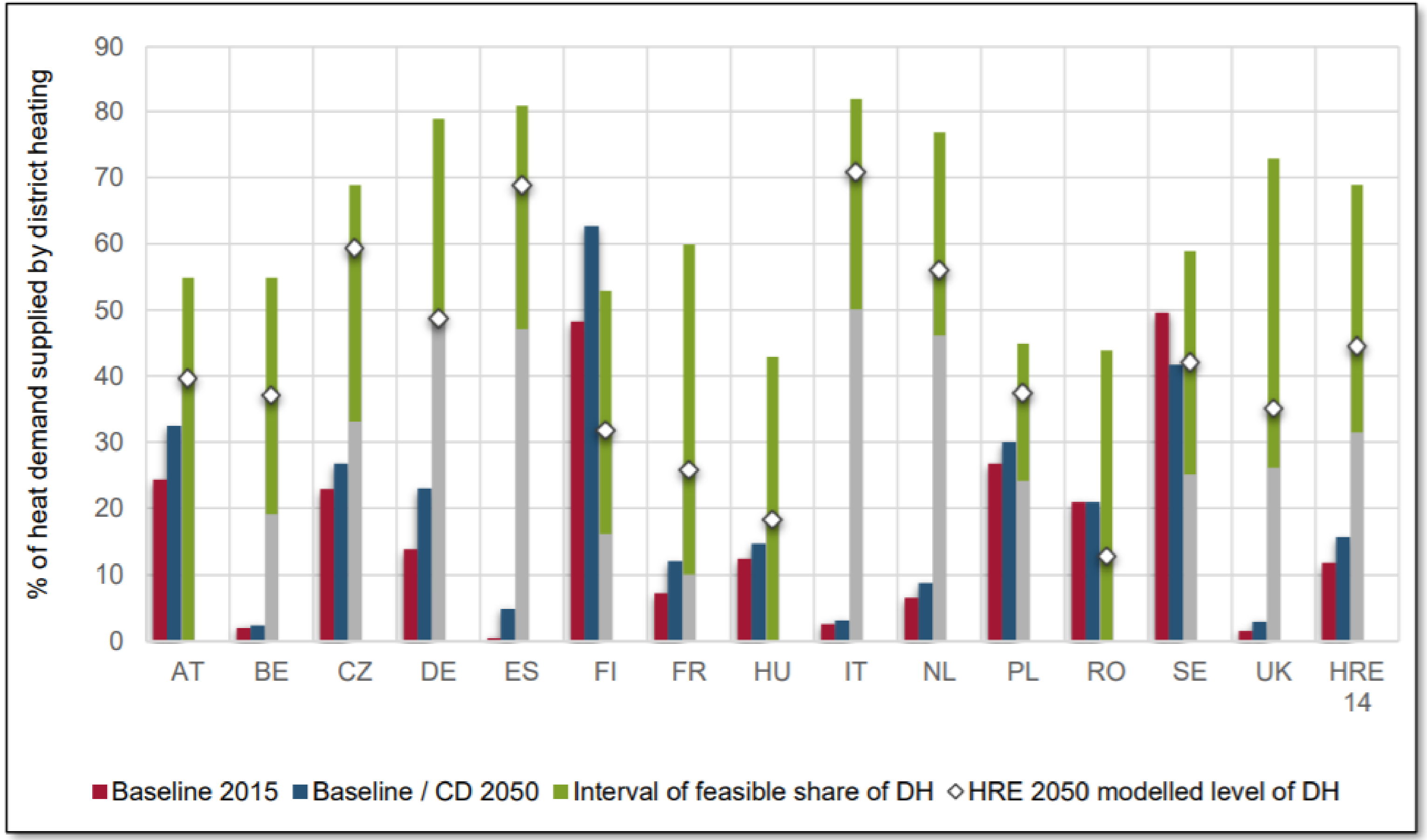
https://www.sciencedirect.com/science/article/pii/S1364032116301149





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/



Steam systems (1st generation)

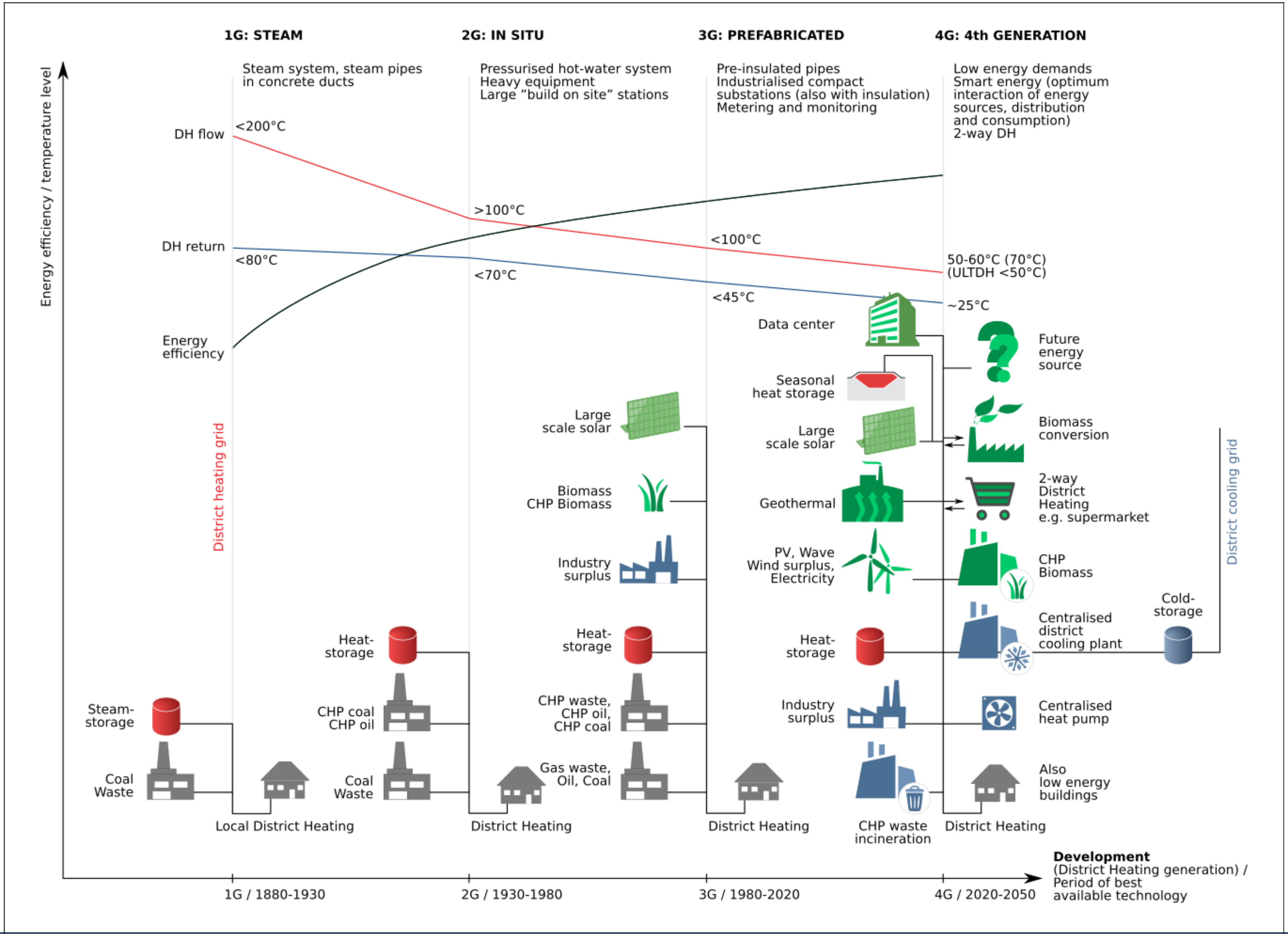
- High temperature
- Predominantly in systems before 1930
- High losses
- Can be used for industrial processes

High temperature water systems (2nd generation)

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

Medium temperature water systems (3rd generation)

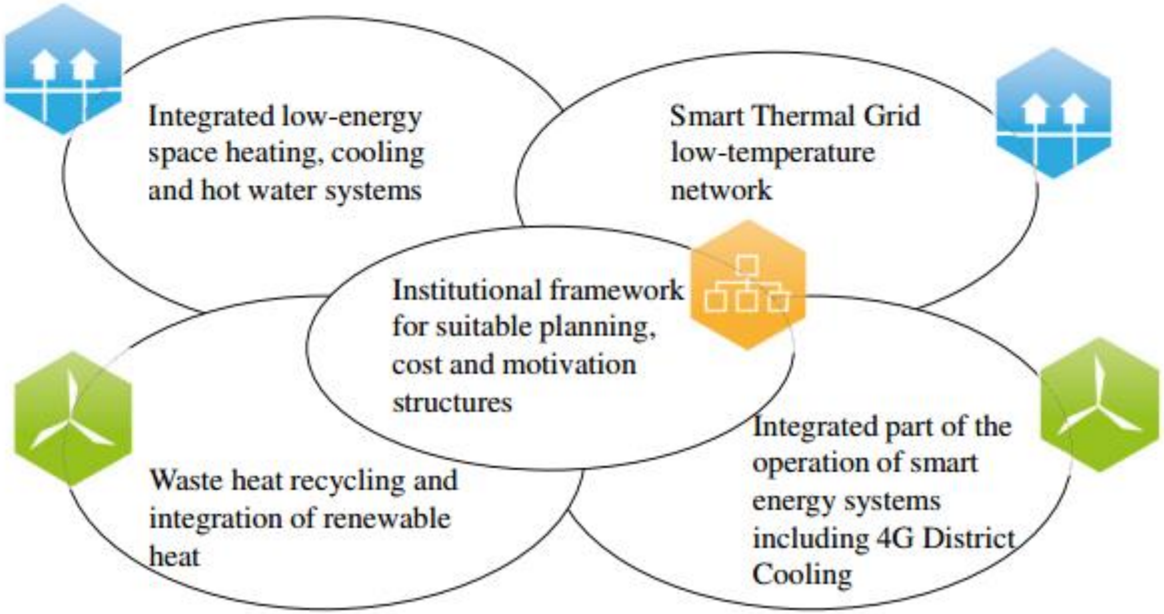
- 1980-2020
- The current system in most Scandinavian systems
- Between 70-95 ^{o}C



1G: STEAM
2G: IN SITU
3G: PREFABRICATED
4G: 4th GENERATION
Steam system, steam pipes in concrete ducts
Pressurised hot-water system
Heavy equipment
Large "build on site" stations
Pre-insulated pipes
Industrialised compact substations (also with insulation)
Metering and monitoring
Low energy demands
Smart energy (optimum interaction of energy sources, distribution and consumption)
2-way DH
Energy efficiency / temperature level
DH flow
<200°C
>100°C
<100°C
50-60°C (70°C)
(ULTDH <50°C)
DH return
<80°C
<70°C
<45°C
~25°C
Energy efficiency
District heating grid
District cooling grid
Data center
Future energy source
Seasonal heat storage
Large scale solar
Large scale solar
Biomass conversion
Biomass CHP Biomass
Geothermal
2-way District Heating e.g. supermarket
Industry surplus
PV, Wave Wind surplus, Electricity
CHP Biomass
Cold-storage
Heat-storage
Heat-storage
Heat-storage
Centralised district cooling plant
Steam-storage
CHP coal CHP oil
CHP waste, CHP oil, CHP coal
Industry surplus
Centralised heat pump
Coal Waste
Coal Waste
Gas waste, Oil, Coal
Also low energy buildings
Local District Heating
District Heating
District Heating
CHP waste incineration
District Heating
Development
(District Heating generation) / Period of best available technology
1G / 1880-1930
2G / 1930-1980
3G / 1980-2020
4G / 2020-2050

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 sutitable

Compatibility with existing building stock

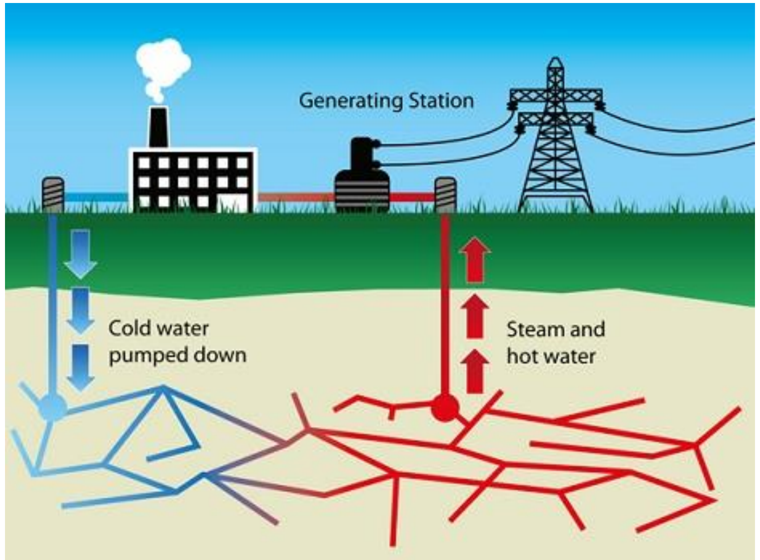
- Space heating
  - Poorly insulated buildings require more energy
  - Current equipment might not be scaled for low temperature district heating
    - Equipment changes
    - Renovation of the building stock
  - Introduce thermostatic valves to control comfort levels
- Domestic hot water
  - Low temperature 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

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

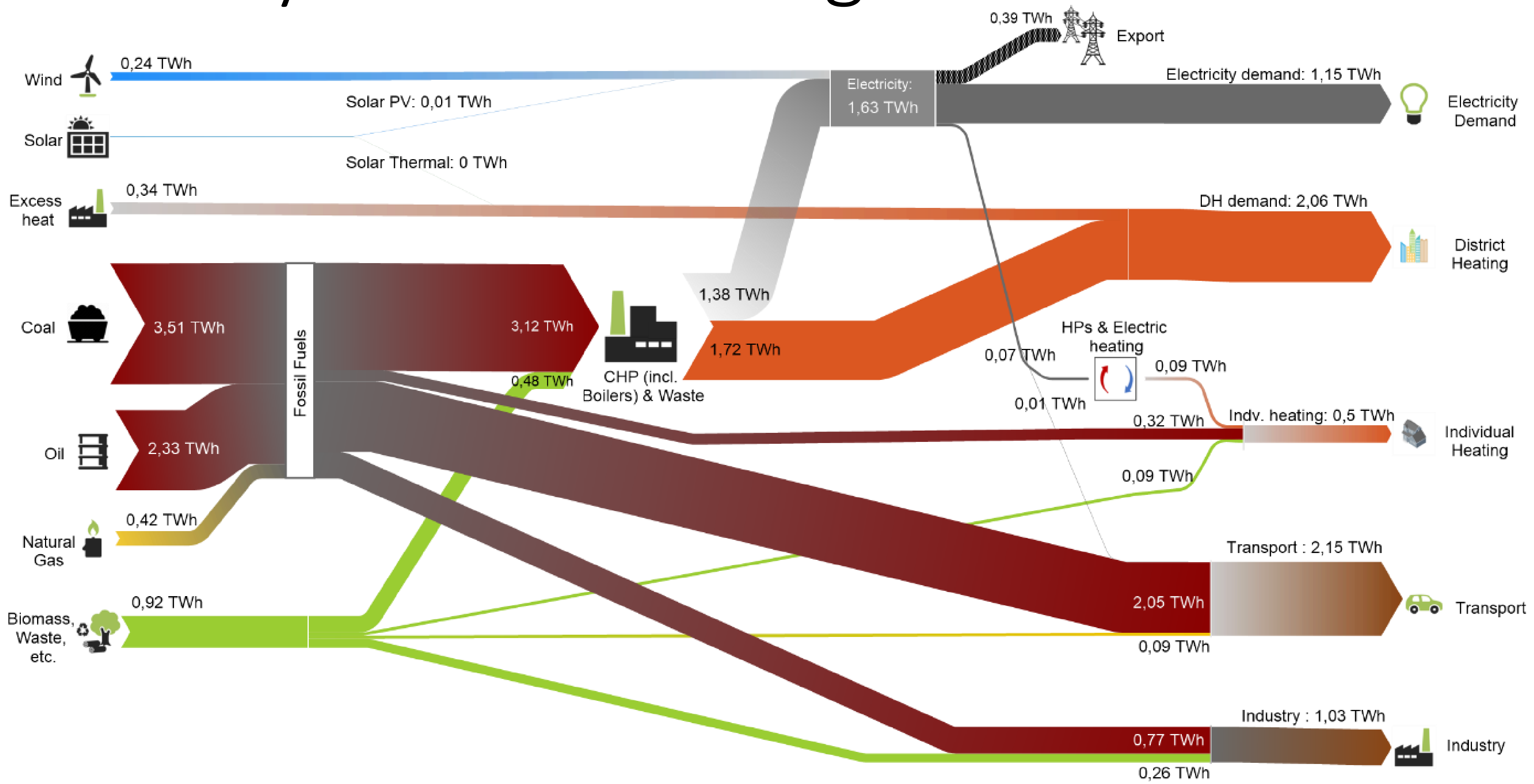
4GDH’s role in Smart Energy Aalborg

- 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

Current system in Aalborg



Transitioning to renewable energy

- The transition has to be done in away 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

Industrial waste heat

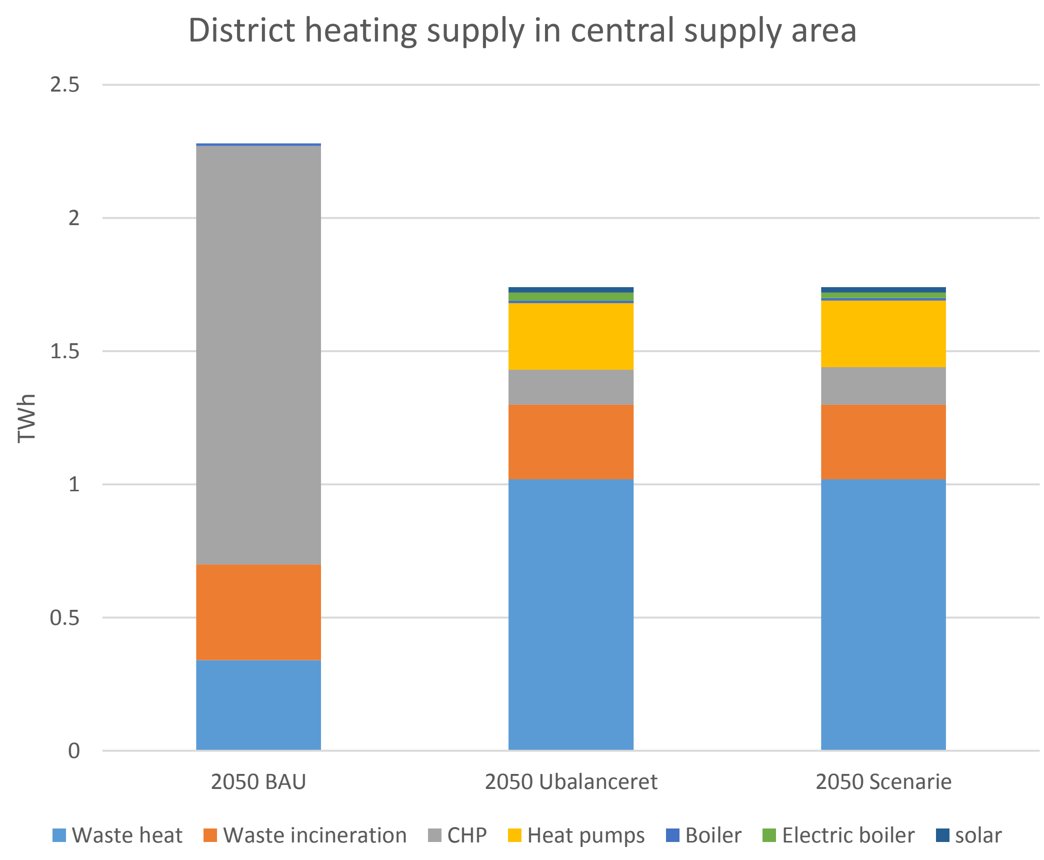
- Low temperature district heating enables increased use of industrial waste heat
- Cement industry in Aalborg
  - Currently 20% of the heat demand
- In total a potential to increase from 1200 TJ to 3100 TJ
  - We use 2600 TJ

	Projekt	Investering	Merproduktion (ift. 2016 produktion)
Forbedre udnyttelse af overskudsvarme ved eksisterende anlæg	Levere hele året ved 65°C (VG1 + VG2)	Ingen	500 TJ
	Optimering af eksisterende anlæg VG1	Investering ikke beregnet	313 TJ
	Optimering af eksisterende anlæg VG2	Investering ikke beregnet	75 TJ
Øge potentialet af overskudsvarme ved investering i ny teknologi/anlæg	Projekt 1: Varmegenvinding fra den grå ovn (grå cement)	DKK 48 mio.	350 TJ
	Projekt 3: Sænkning af returtemperaturen ved installation af varmepumpe (VG1)	DKK 16 – 25 mio.	3GDH: 122 TJ
	Projekt 4: Opsamling af strålevarme fra de hvide ovne med varmeskjolde	Forsigtigt skøn: DKK 225 mio.	540 – 610 TJ
	Projekt 5: Udnyttelse af varme fra filtratvand med varmepumpe	DKK 7 – 9 mio.	3GDH: 45 TJ

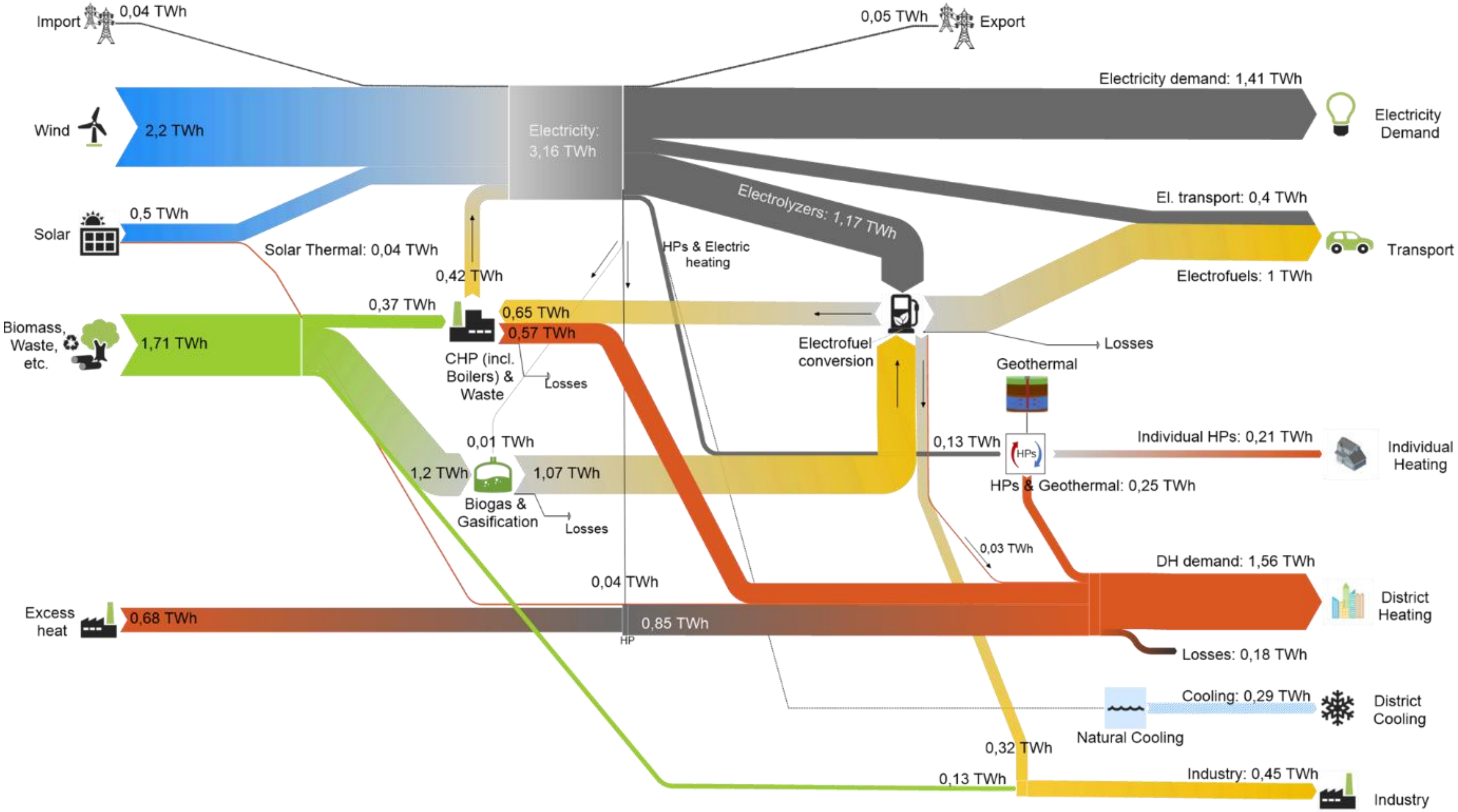
Tabel 2 – Nye overskudsvarmepotentialer ved Aalborg Portland [Aalborg Portland, 2018]

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

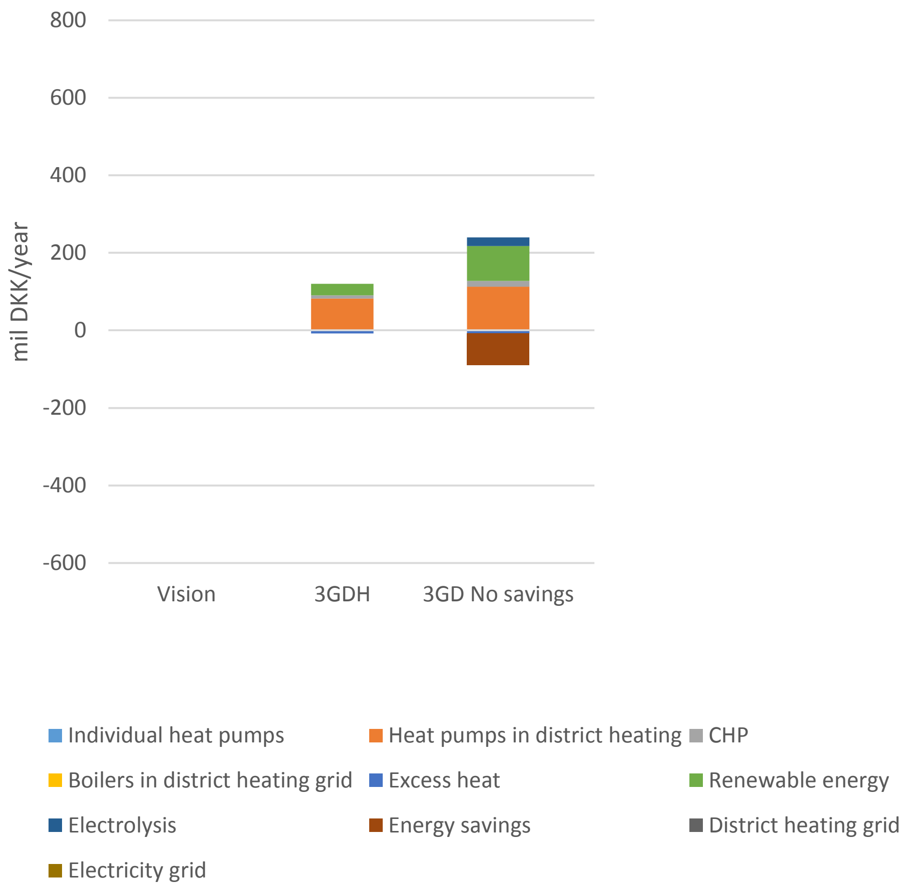


The 100% renewable Smart Energy Aalborg



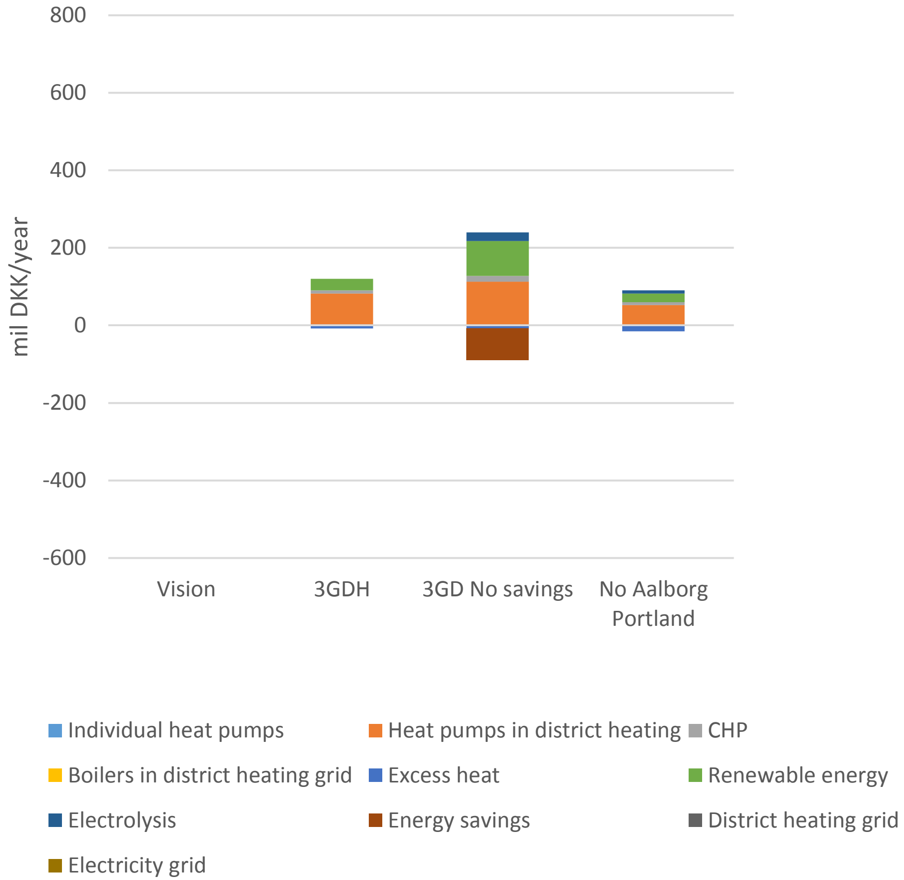
If no low temperature district heating

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



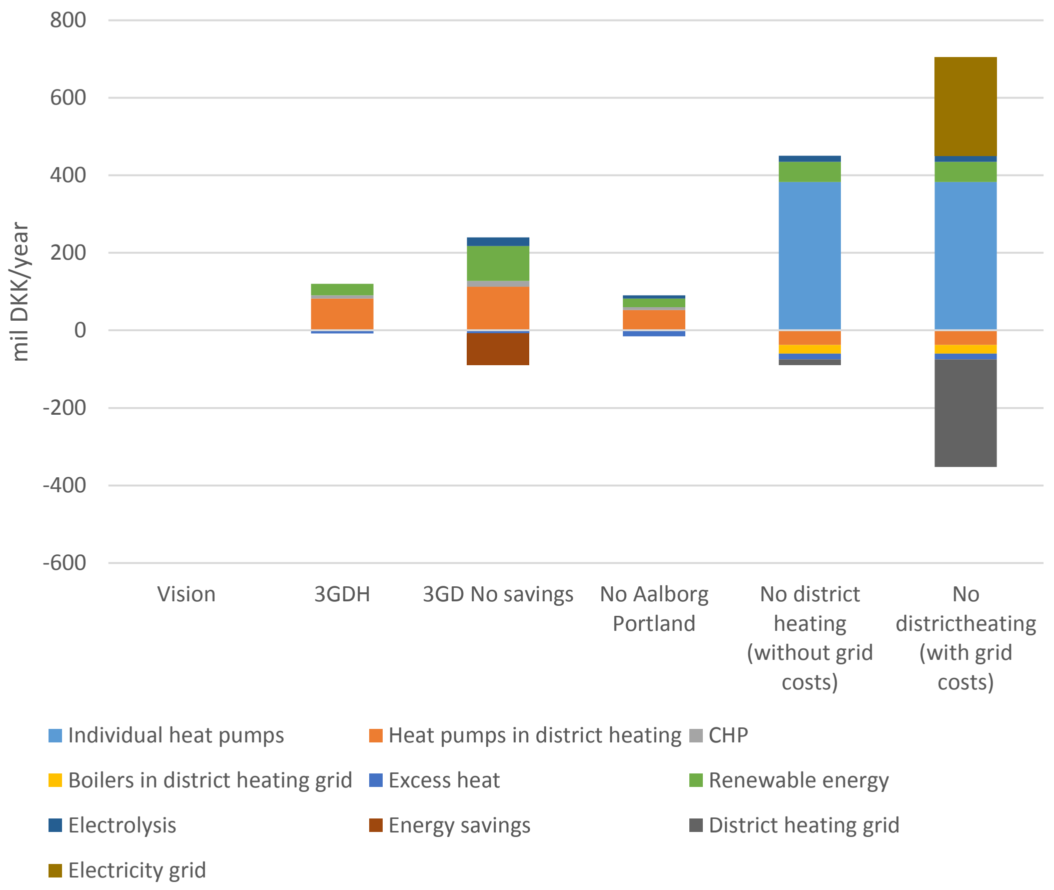
If no industrial excess heat

- 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



Summary

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