FEASIBILITY OF HEAT PUMPS SUPPLYING DISTRICT HEATING SYSTEMS

CASE STUDY FOR AUSTRIA AND DENMARK

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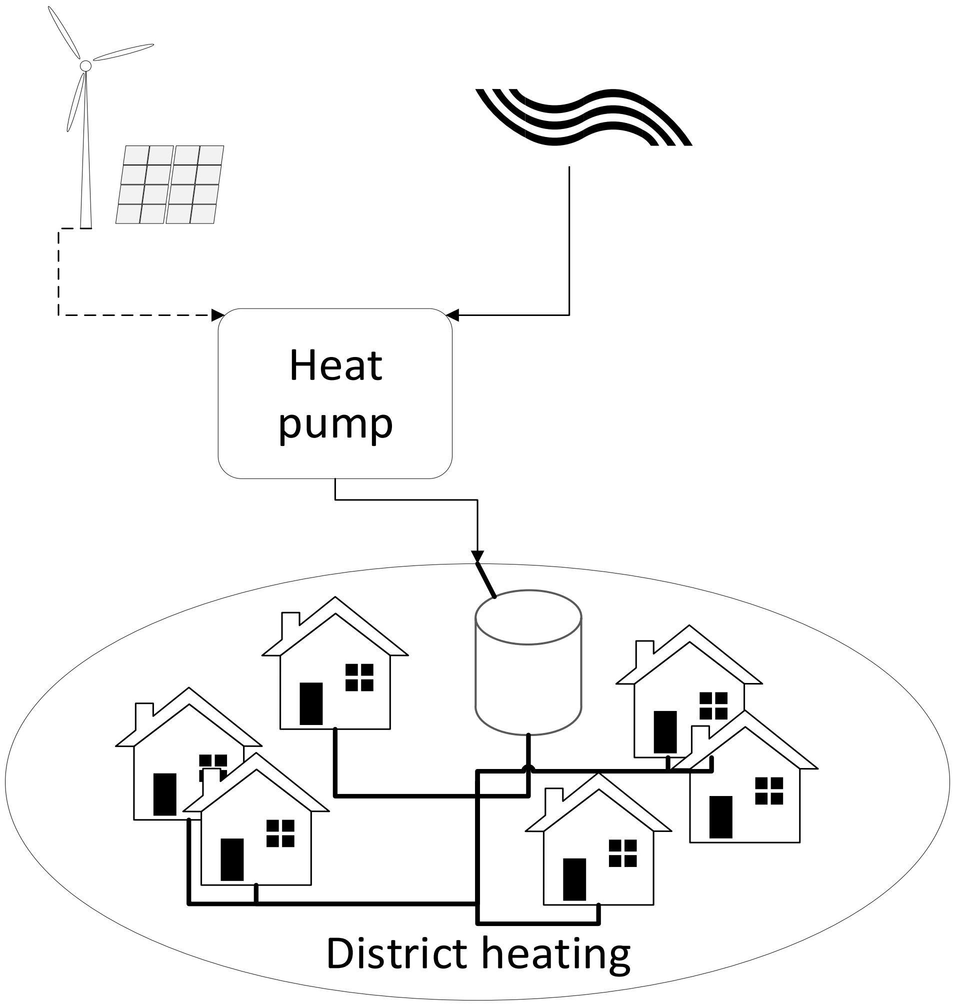
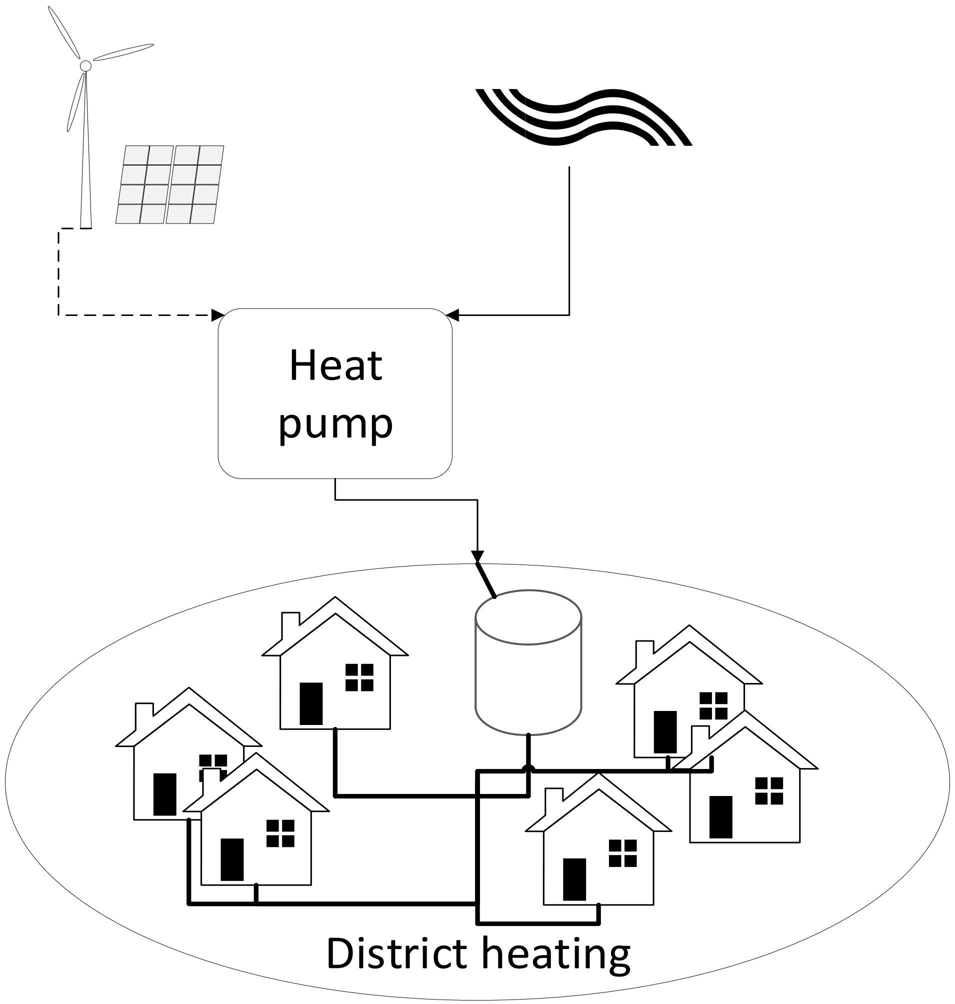
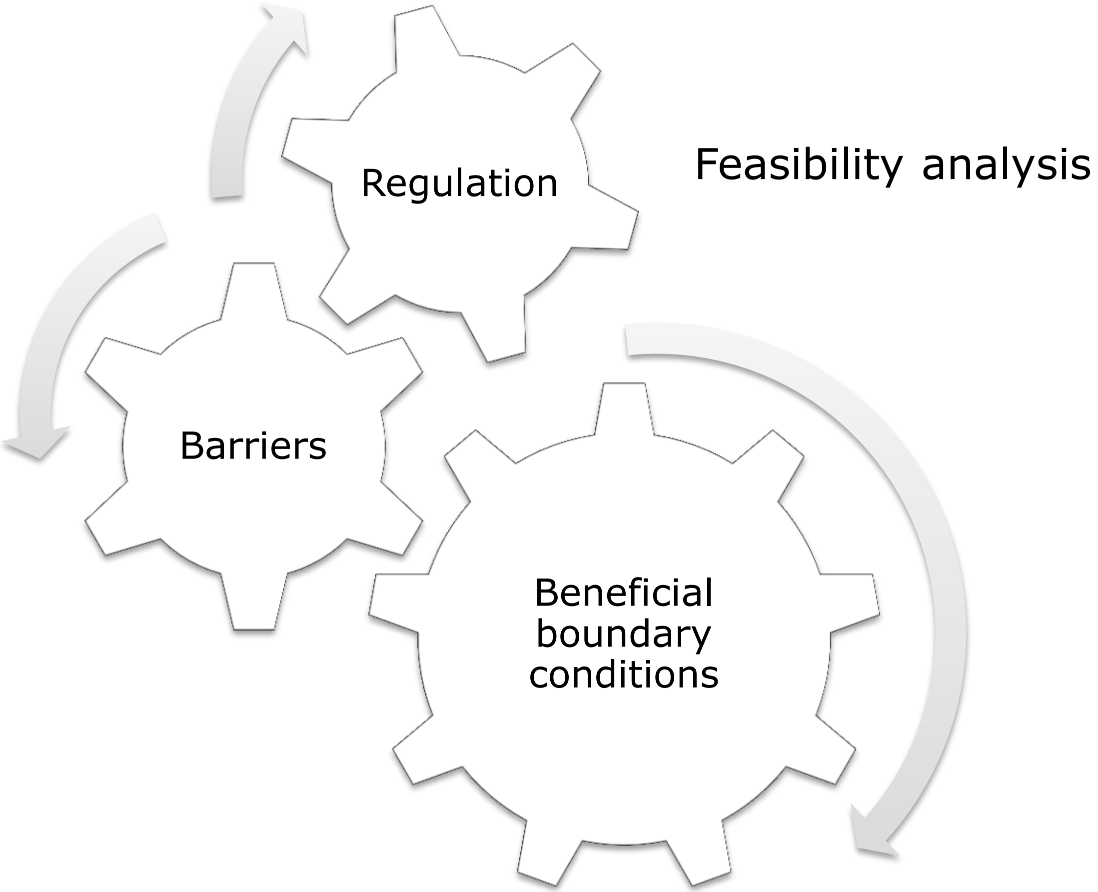
Motivation

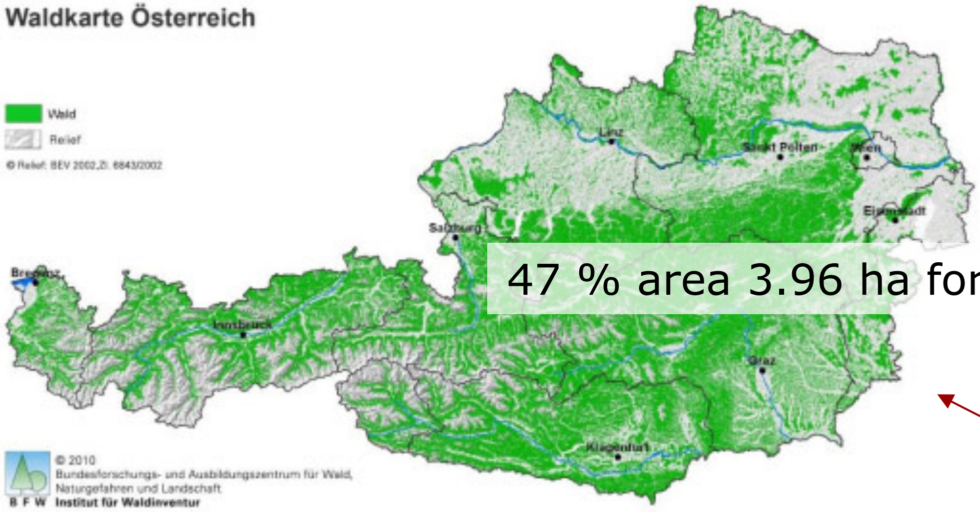


Motivation

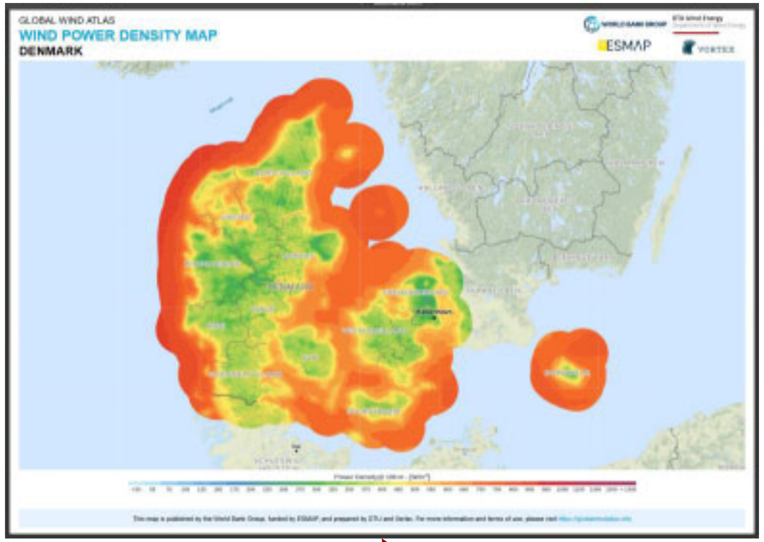

Heat pump
District heating

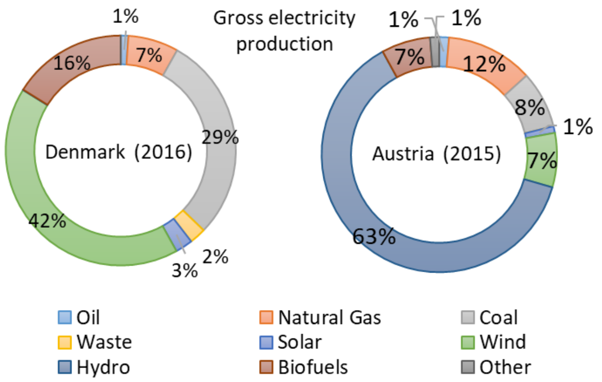

Regulation
Feasibility analysis
Barriers
Beneficial boundary conditions

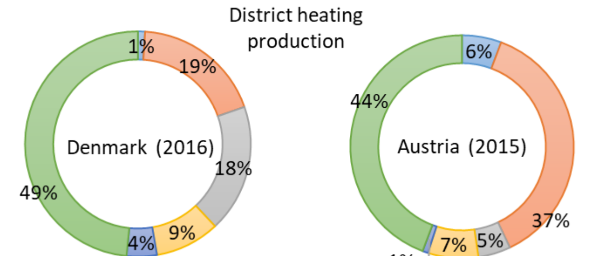
Boundary conditions



47 % area 3.96 ha forestland

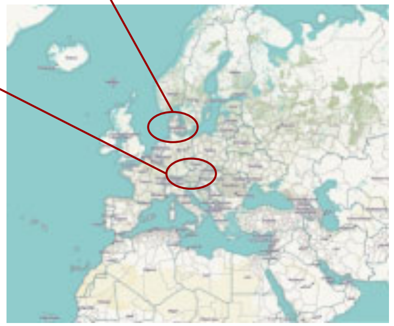






64 % of residential heat demand

25 % of residential heat demand



Frame conditions for large HPs

Tradition of biomass-based heating
- Local value chain
- Cooperation between biomass producers and DH suppliers

Biomass support
- Subsidy scheme for biomass based heating
- Quality management scheme for biomass-based units

Financial support for new heating networks

Barriers large-scale HP
- Lack of information and dissemination regarding large-scale HPs for DH supply
- Subsidies for large HPs only for industrial applications / waste heat

Integrated energy system strategy

Tradition of low heat demand density DH

Non-profit principle of DH companies
- Networks are cooperative or municipality owned
- National DH benchmark system

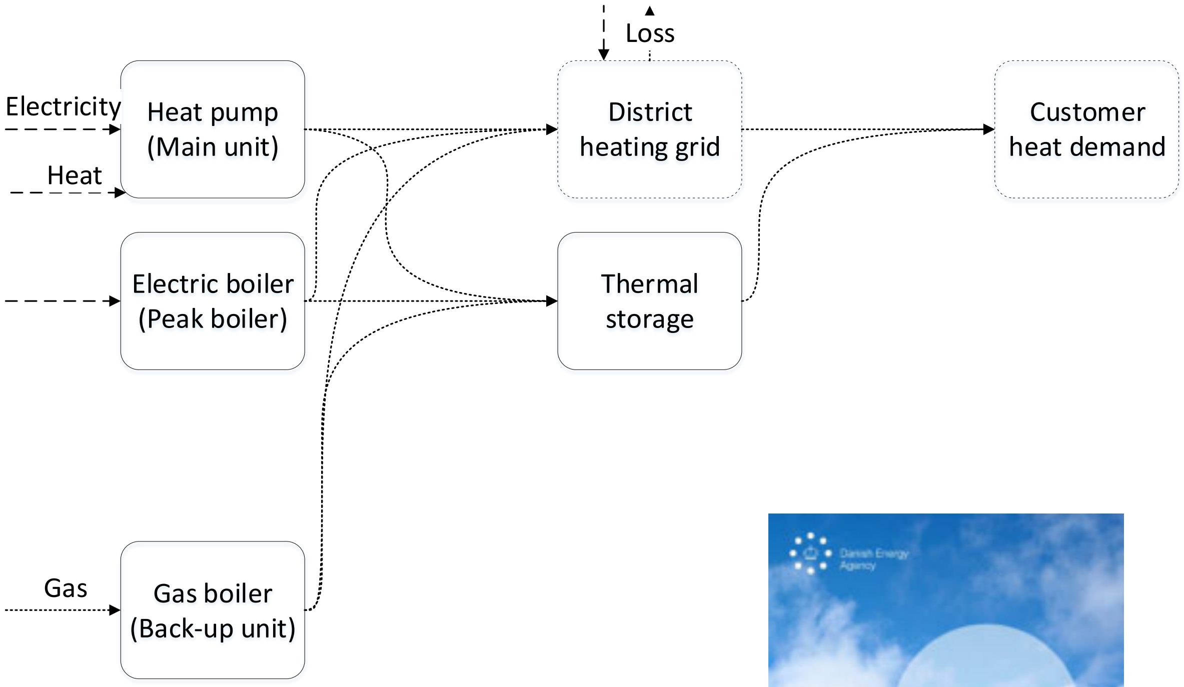
HP support
- Demonstration projects, collection & dissemination of knowledge
- Targeted tax reduction for HPs and financial support
- Dispensations from CHP requirement for large-scale HPs

Feasibility analysis

- Standard cost-benefit analysis evaluation method
  - Comparison DH solutions and individual heating supply
  - District heating assessment tool

- Levelized cost of energy for local society

- Socioeconomic net present value



https://ens.dk/en/our-responsibilities/global-cooperation/district-heating-assessment-tool-dhat

Cases

- Heat sparse areas
- Area 340 000 m²
- New development
  - No existing district heating grid
  - High energy efficiency standard of buildings

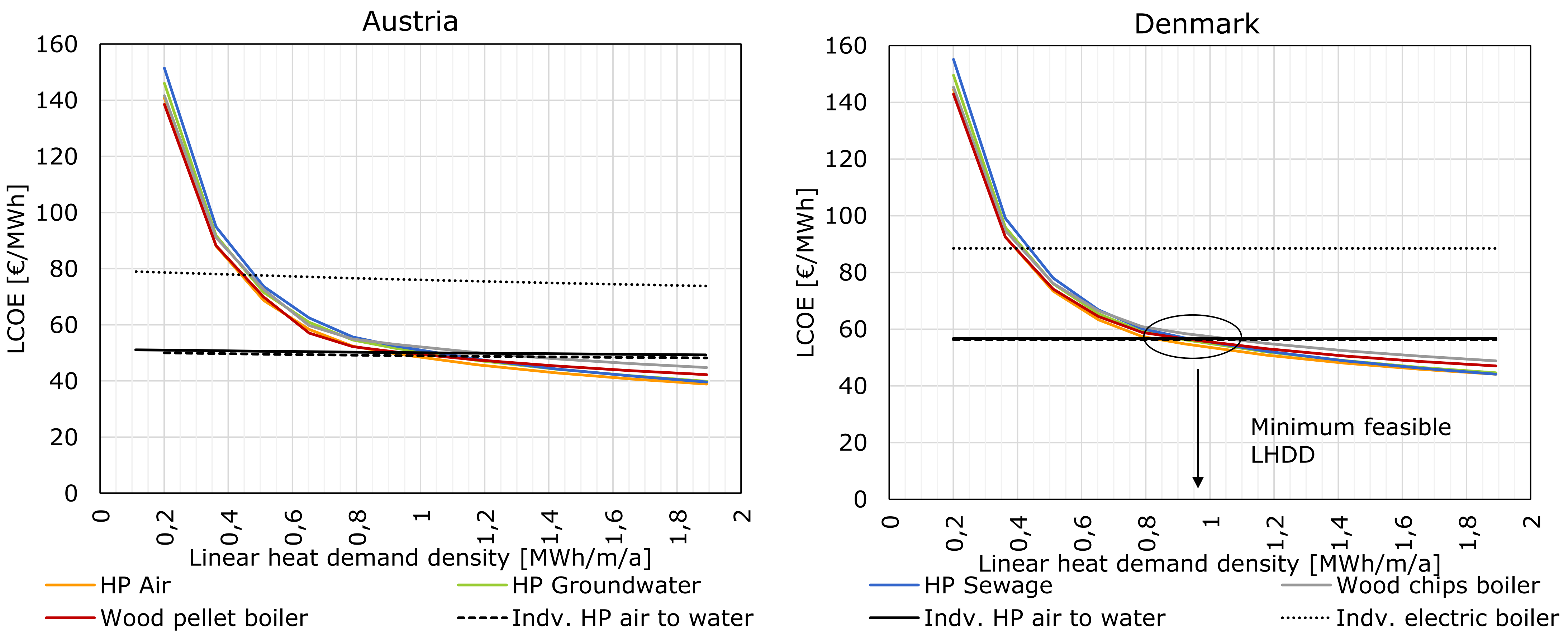
- Variable COP of HPs according to source temperature
- Sewage water temperature: $12.5\,°C$
- Ground water temperature: $10\,°C$
- Weather compensation below $5\,°C$ outdoor temperature

Land area	Plot ratio	DH temperature	Specific heat demand	Central unit	Individual units
• 340 000 m²	• 0.1 • … • 1.4	• $60\,°C$ / $30\,°C$ • $70\,°C$ / $40\,°C$ • $80\,°C$ / $50\,°C$	• DHW/SH: • $20\frac{kWh}{m^2a}$ / $3\frac{kWh}{m^2a}$ • $20\frac{kWh}{m^2a}$ / $22.5\frac{kWh}{m^2a}$	• Air-source HP • Groundwater HP • Sewage water HP • Wood pellet boiler • Wood chips boiler	• Air-source HP • Ground-source HP • Electric heater

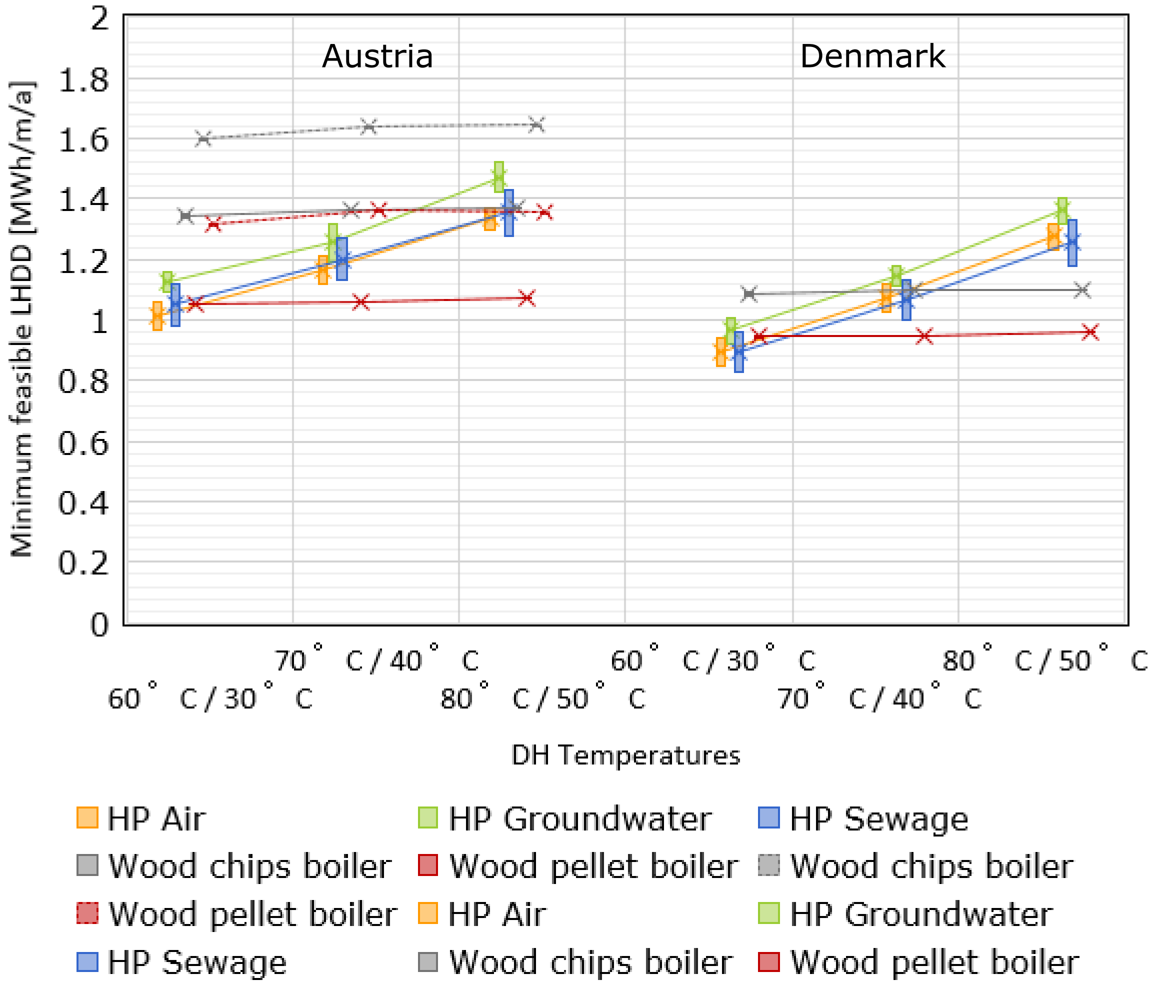
DHW – domestic hot water, SH – space heating, HP – heat pump

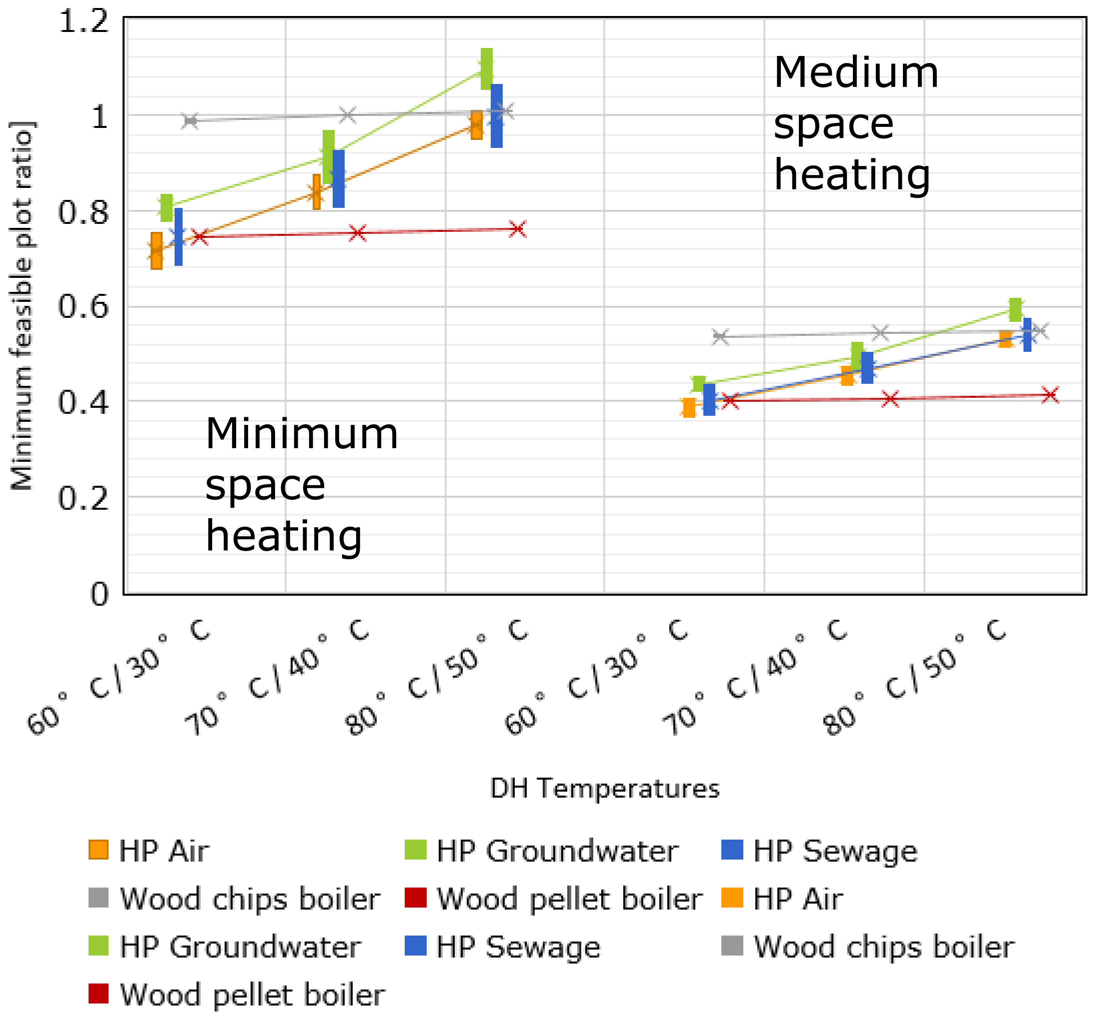
Levelized cost of energy

DH temperatures: 60/30 °C, Specific heat demand: minimum space heating



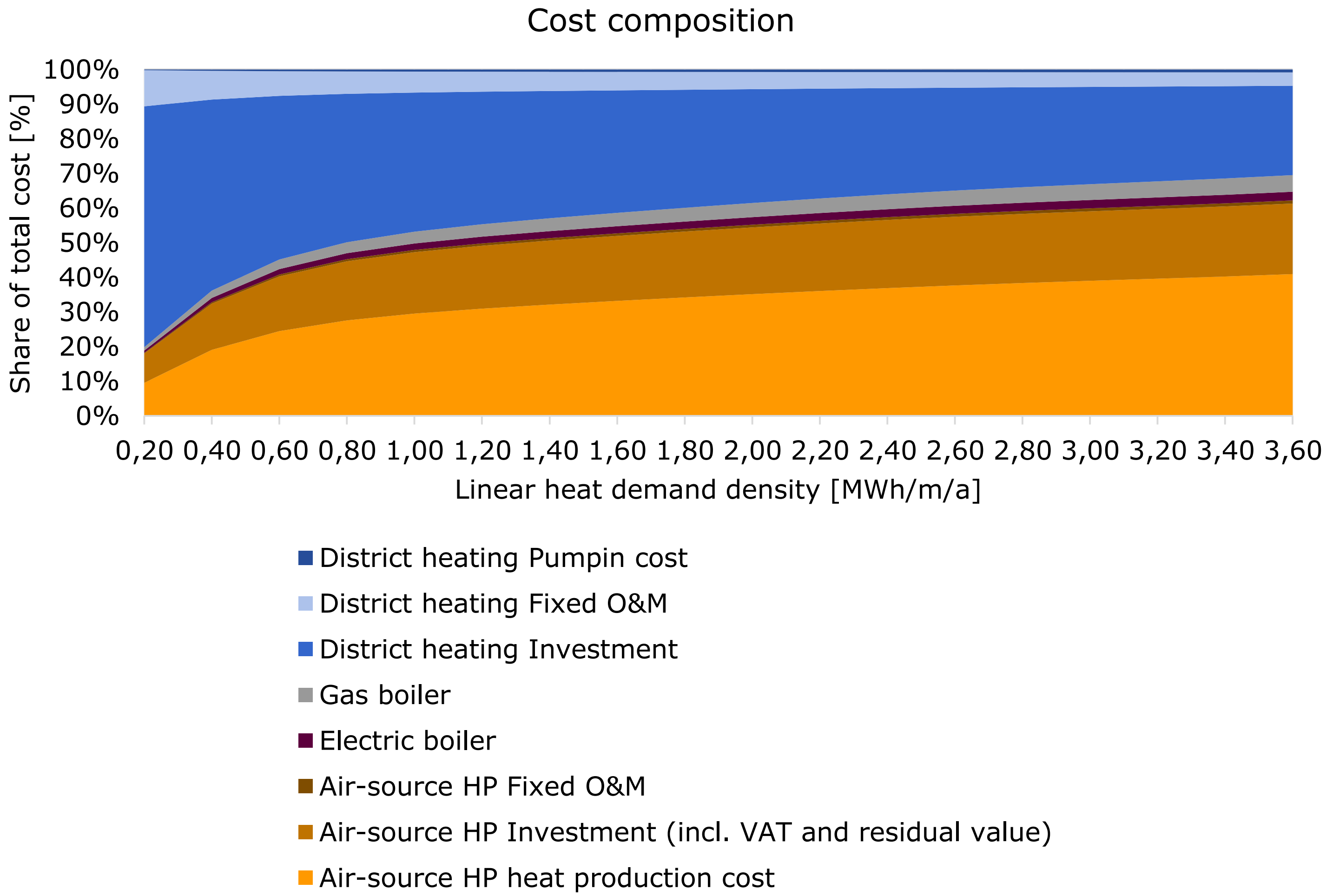
Influence of DH temperatures and fuel prices



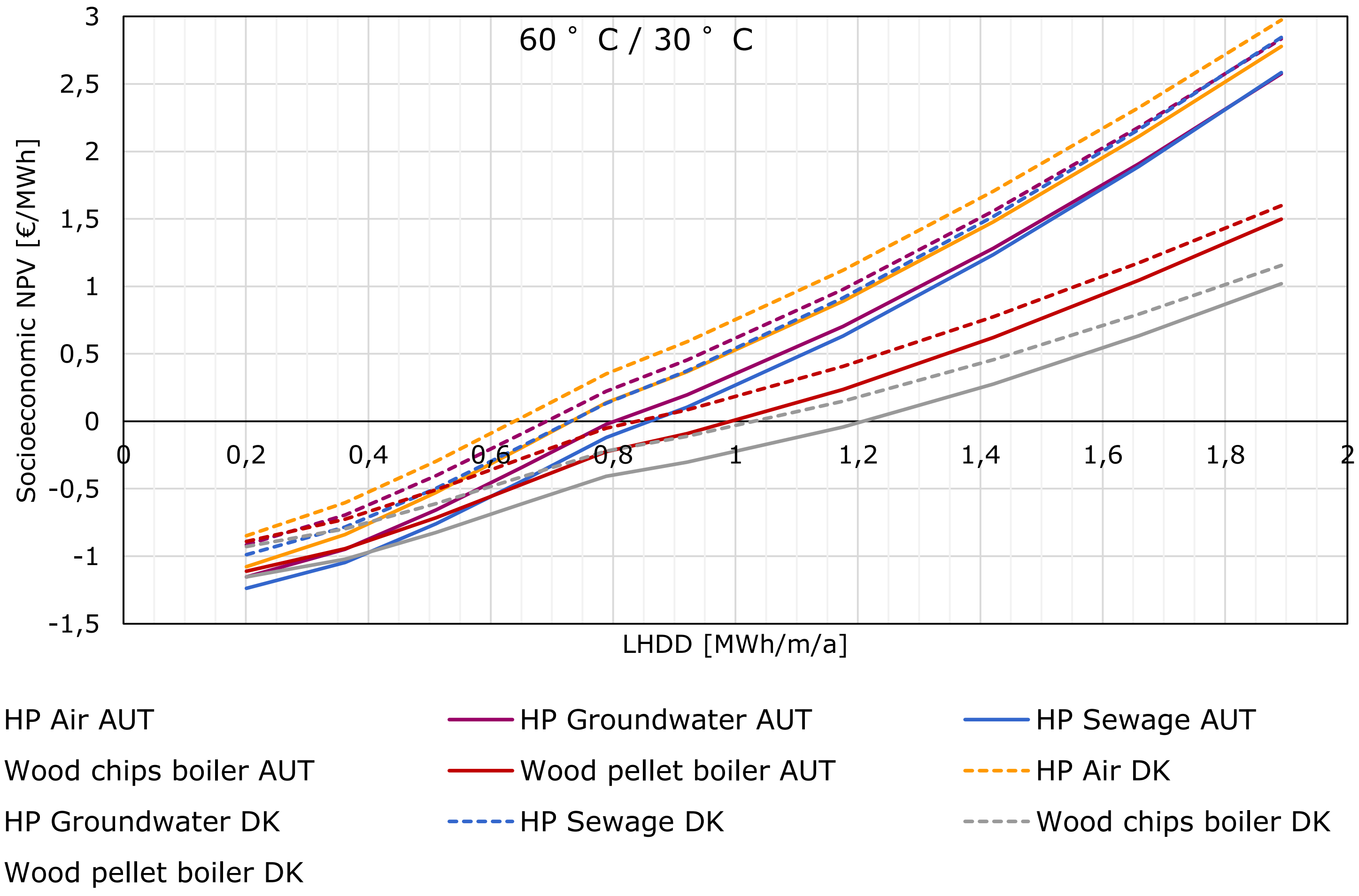


Cost composition

Denmark, DH temperatures: $60\,°C / 30\,°C$, DHW / SH: $20 \frac{kWh}{m^2 a}$ / $22.5 \frac{kWh}{m^2 a}$



Socioeconomic net present value



Conclusion feasibility study

Large-scale heat pumps are feasible supply solutions for heat sparse district heating grids.
The feasibility is influenced by:

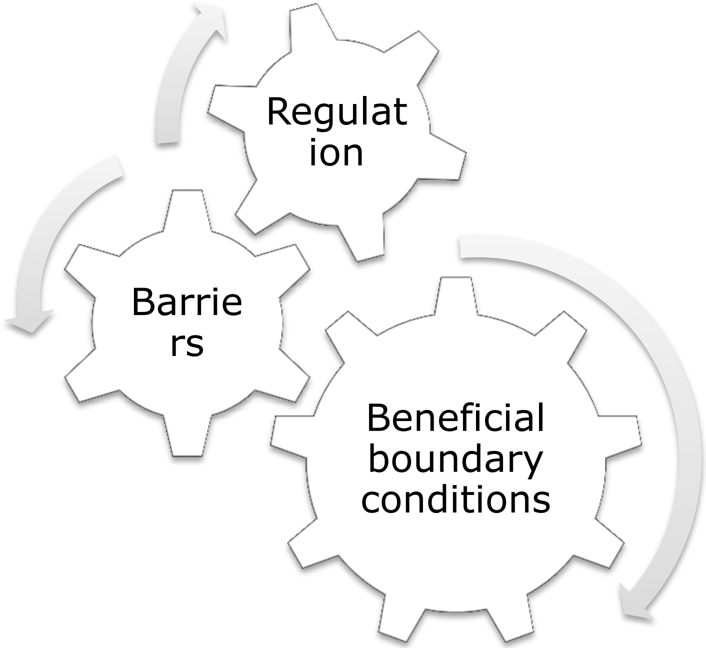
Positive

- large linear heat demand densities
- Low DH supply temperature
- Reduction in electricity price (compared to biomass)
- Low space heating shares -> reduced seasonal peaks

Negative

- Reduction in electricity price (compared to individual HPs)
- Reduction in alternative fuel prices
- Subsidies on alternative technologies
- Low space heating shares -> minimum feasible LHDD increases

Conclusion barriers and policy



- Requirement of private- and socioeconomic feasibility benefits large-scale HPs
- Non-profit principle -> no need for short payback time
- Balanced subsidy schemes
- Existing value chains and tradition for alternative technologies might benefit current technologies
- CHP requirement can be a barrier if applied
- Information, collection and dissemination of knowledge!

Thank you for your attention ☺

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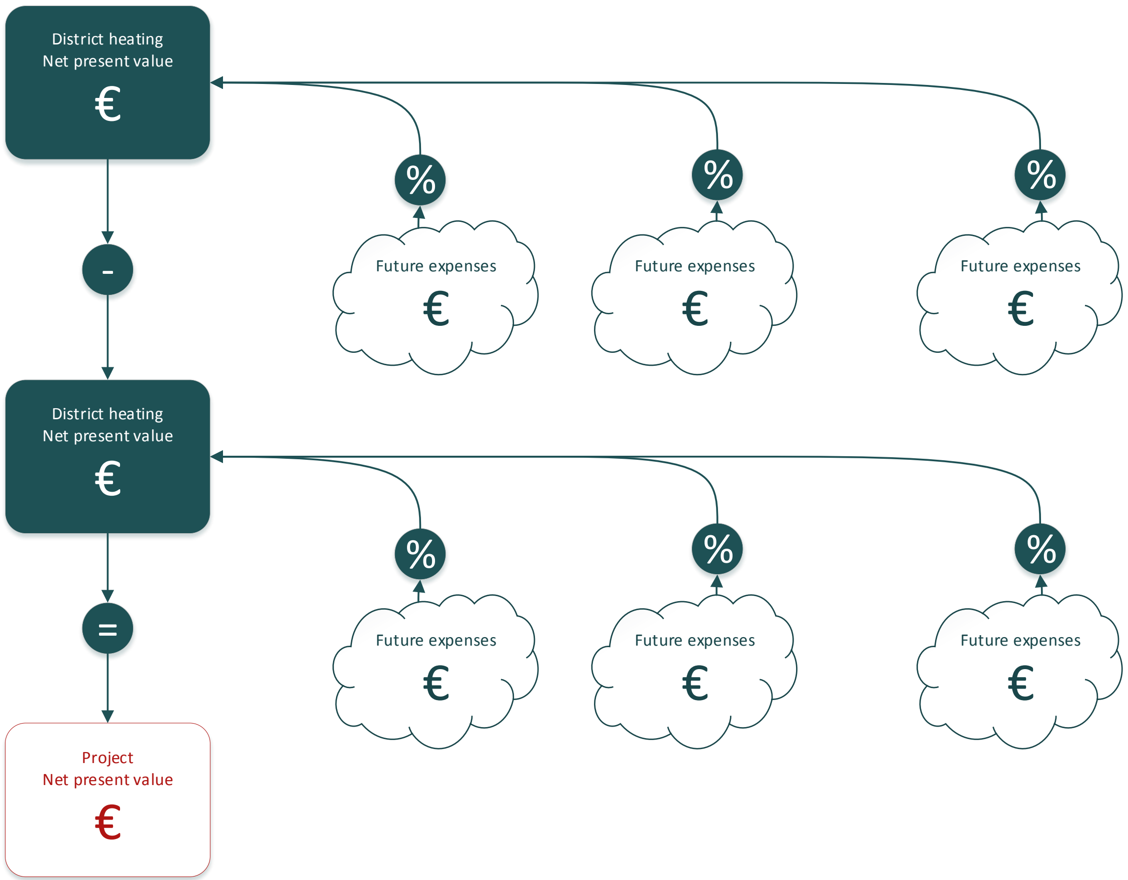
Socioeconomic net present value (NPV)

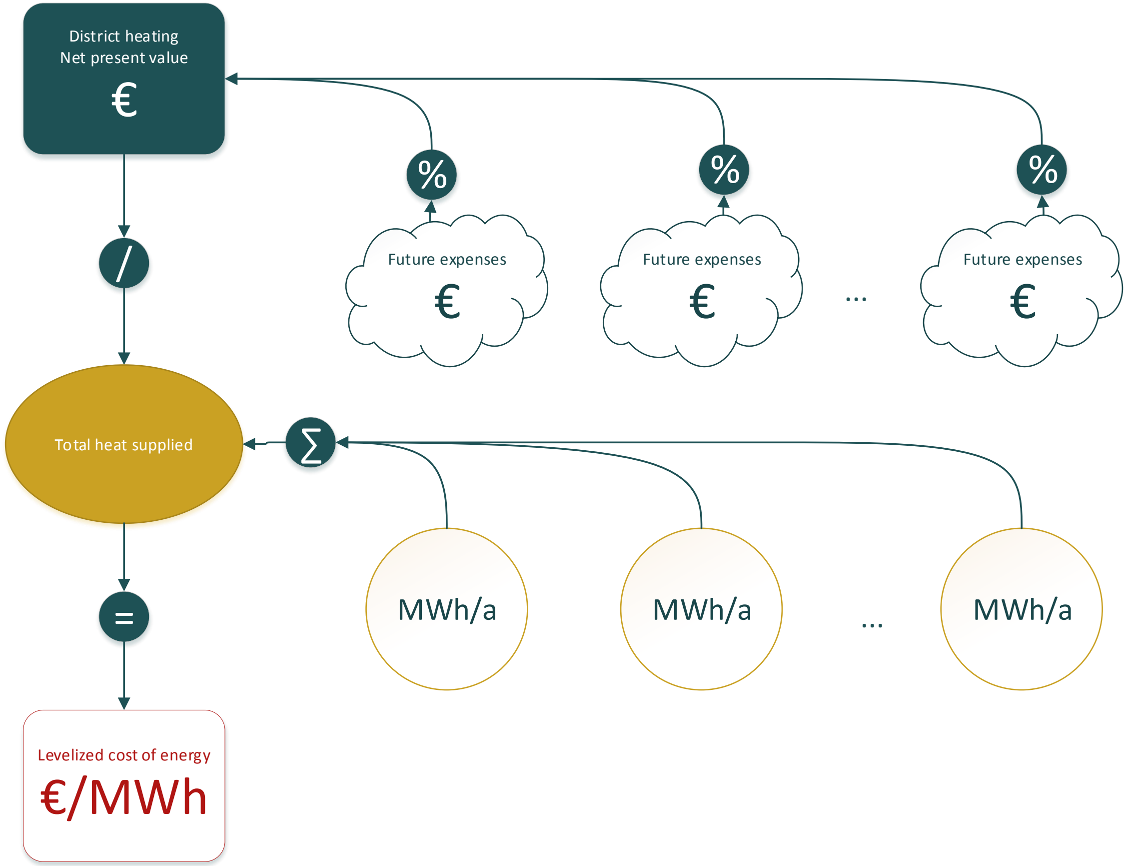


$$NPV_{project} = NPV_{DH} - NPV_{individual}$$

Includes societal costs

- No taxes
- Emission costs

Levelized cost of energy (LCOE)



$$LCOE = \frac{NPV_{DH}^{localsociety}}{\sum_{i=1}^{N}(Q_{tot,i})}$$

N – *project life time*

$Q_{tot,i}$ – *yearly heat supply*

$NPV_{DH}^{localsociety}$ – *local society NPV of the DH solution*

The levelized cost of energy (LCOE) methodology discounts all projected expenditures and revenues to their net present value in a specific year – equivalent to the average expected price for consumers in order to repay all costs. The methodology is useful from a societal perspective comparing alternative heat generation technologies.

Cost functions

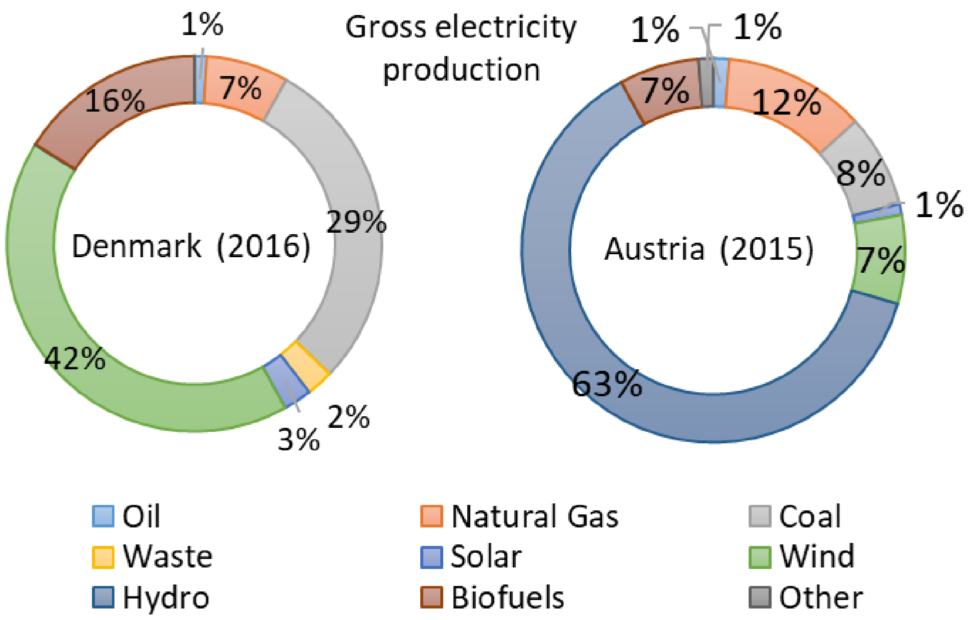
Table 2 Investment cost and lifetime for central and decentral units

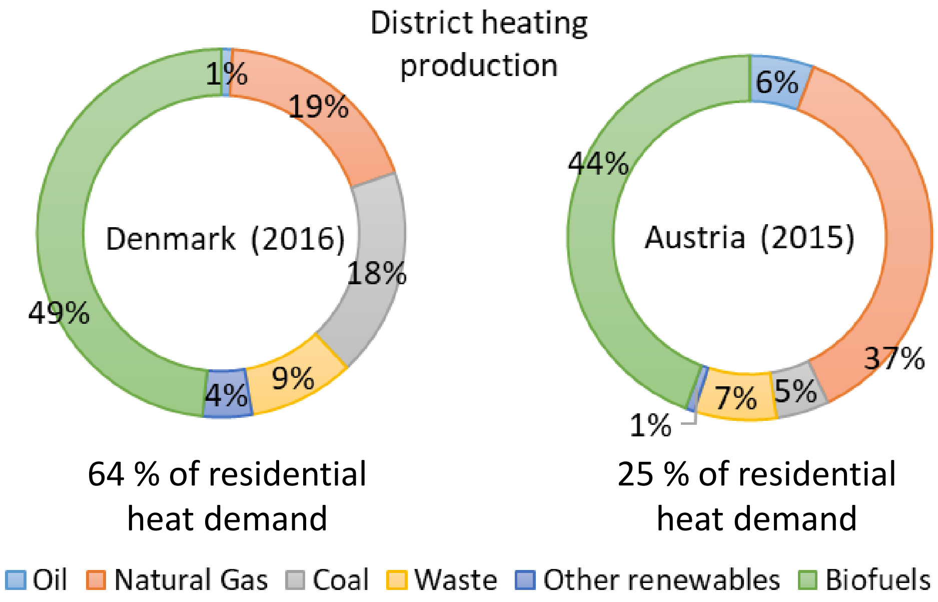
Technology	Investment [M€/MW] linear	power function	Lifetime [a]	Sources
HP Groundwater	$1.1117\ \dot{Q}_{nom}^{-0.23105}$	$1.236\ \dot{Q}_{nom}^{-0.2599}$	25	[31]
HP Sewage water	$1.2166\ \dot{Q}_{nom}^{-0.33122}$	$1.1038\ \dot{Q}_{nom}^{-0.2435}$	25	[31]
HP Air	$0.9366\ \dot{Q}_{nom}^{-0.1418}$	$1.0503\ \dot{Q}_{nom}^{-0.3078}$	25	[31]
Wood chips boiler	0.9		20	[32]
Wood pellet boiler	0.48		20	[32]
Electric boiler	0.11		20	[32]
Gas boiler	0.06		25	[32]
Indv. Air to water HP	0.95		15	[32]
Indv. Brine to water HP	1.52		20	[32]
Indv. Electric heater	0.86		30	[32]

[31] H. Pieper, T. Ommen, F. Bühler, and B. Lava, "Allocation of investment costs for large-scale heat pumps supplying district heating Contact information :," vol. 00, p. 64014, 2017.

[32] Energinet.dk, "Technology Data for Energy Plants," 2016. [Online]. Available: www.ens.dk. [Accessed: 12-Oct-2017].

Boundary conditions





Sources:

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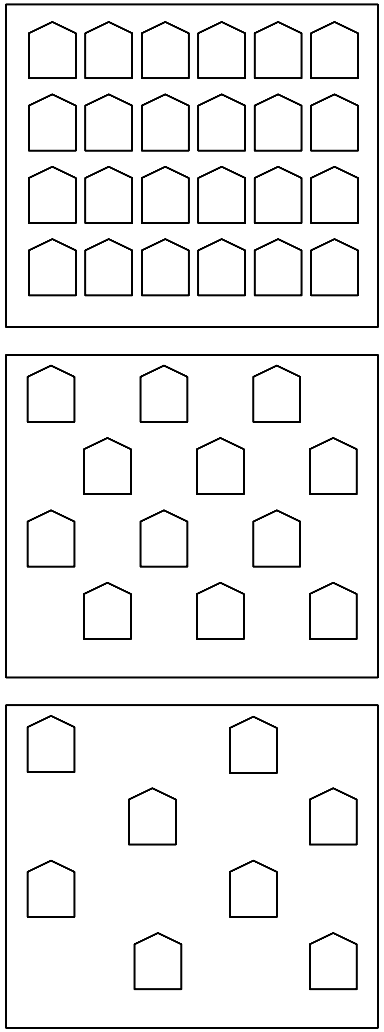
Energie-Control Austria, “Key Statistics 2016,” 2016.

Bundesministerium für Wissenschaft, Forschung und Wirtschaft, “Energie in Österreich - Zahlen, Daten, Fakten,” 2017.

Case study



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