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Emission reduction in 4th generation district heat supply networks

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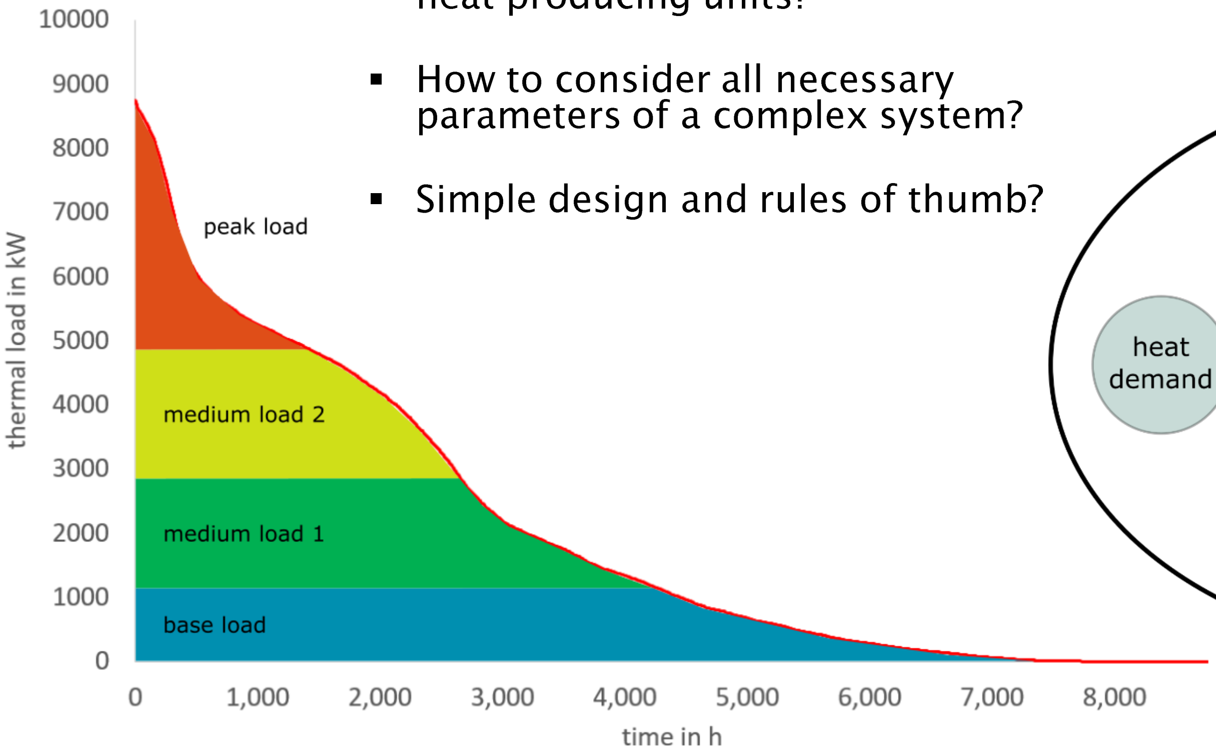
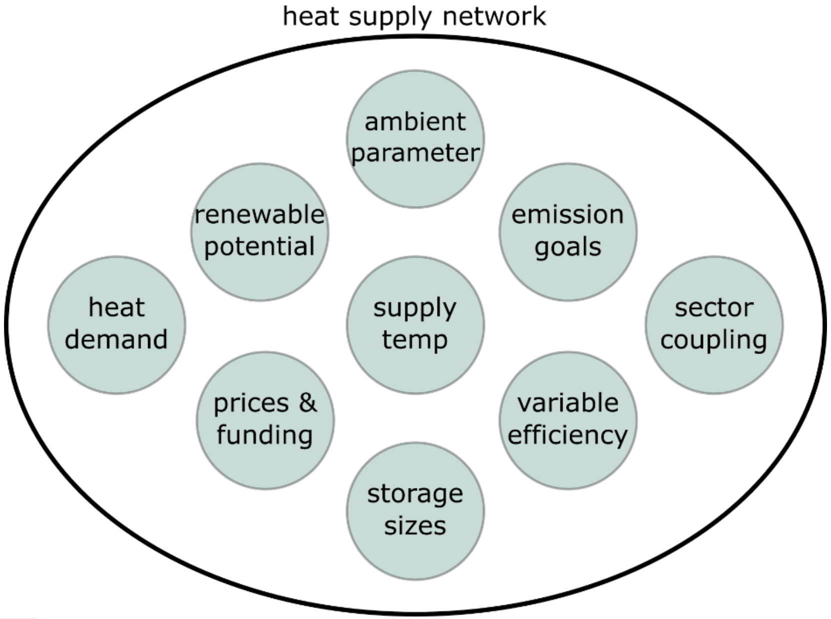
Overview

Motivation

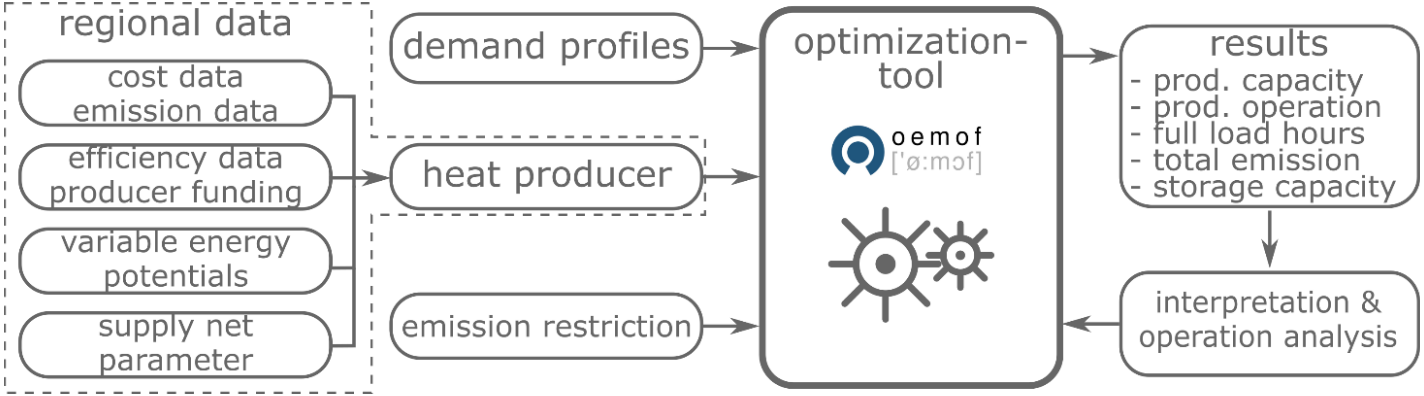


- Ordered annual load curve to choose heat producing units?
- How to consider all necessary parameters of a complex system?
- Simple design and rules of thumb?



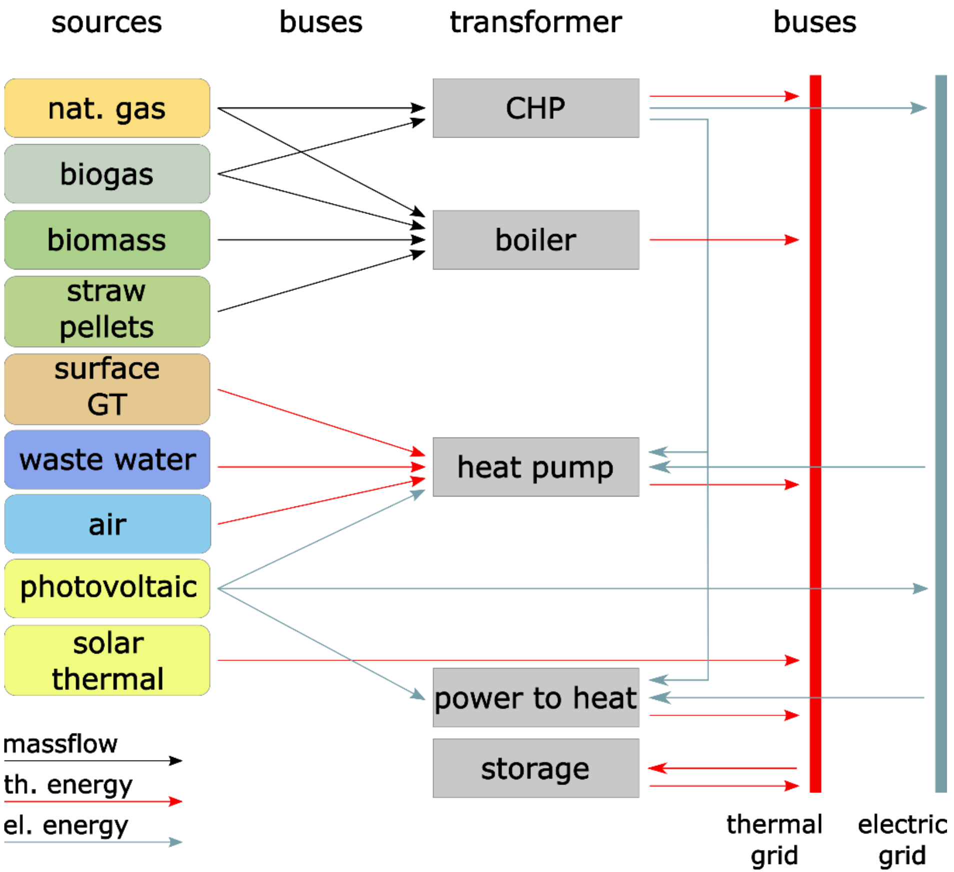
Workflow of energy system design

- Based on Open Energy MOdelling Framework (oemof)
- Developed by Reiner Lemoine Institute, originally for electricity sector
- Ongoing development to model more complex systems



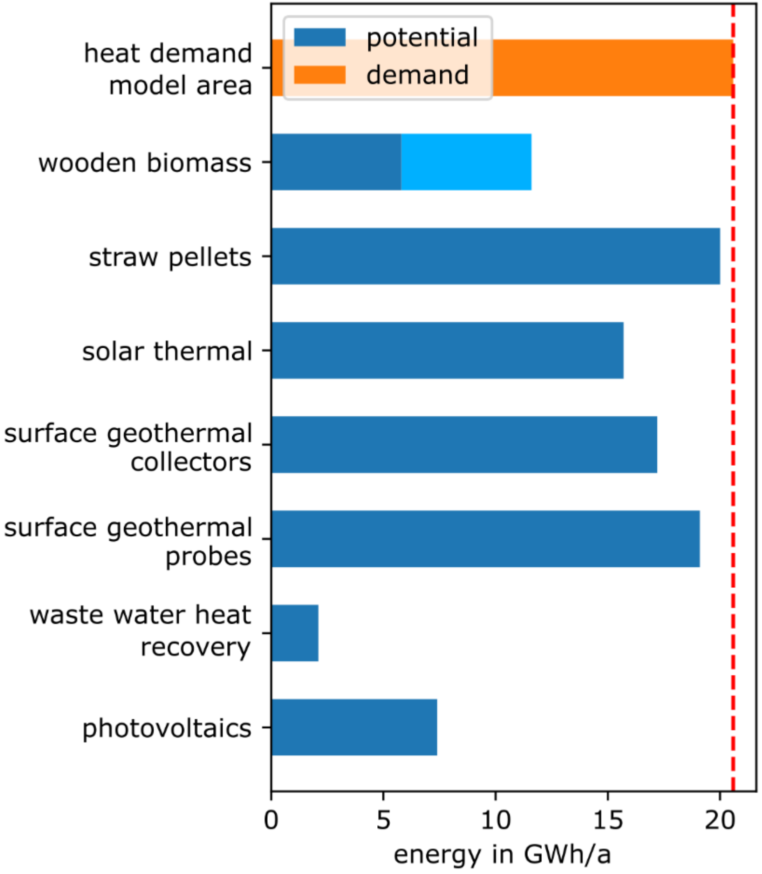
Design and optimization tool

- Each component represented by a „node“
- Sources, buses, transformers, storages and sinks
- Balance equations for each „node“ and timestep
- Hourly data (demands, potentials)
- Model parameters e.g.:
  - specific emissions of fuels
  - specific investment cost
  - variable feed-in revenues
  - variable funding parameters



Current sub-urban energy system

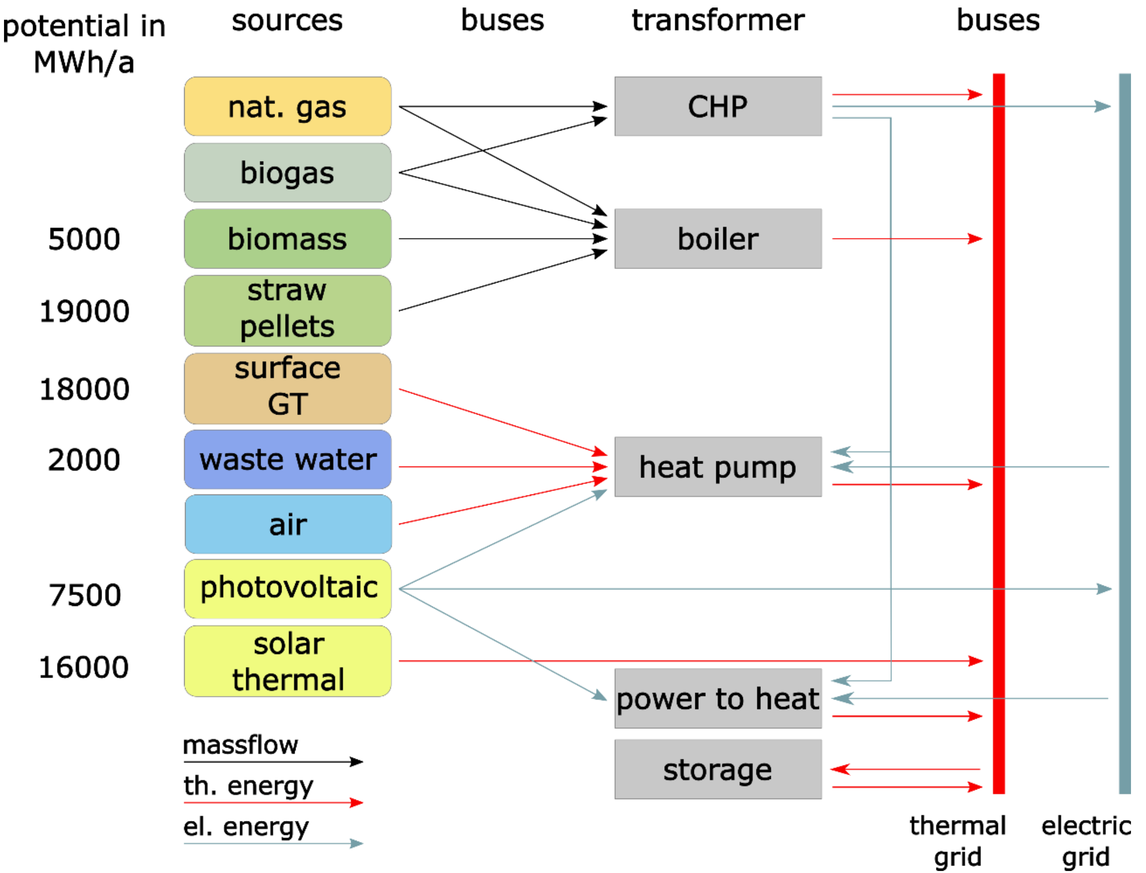
- No heat supply network, heterogeneous building stock
- Supply by individual units mainly using natural gas (approx. 215 g_{CO2}/kWh_{th})
- Mean LCOE approx. 11.5 ct/kWh_{th}
- High renewable potential in model area (availability of biomass will increase in future)
- How to design a better or the optimal energy system?



Current sub-urban energy system

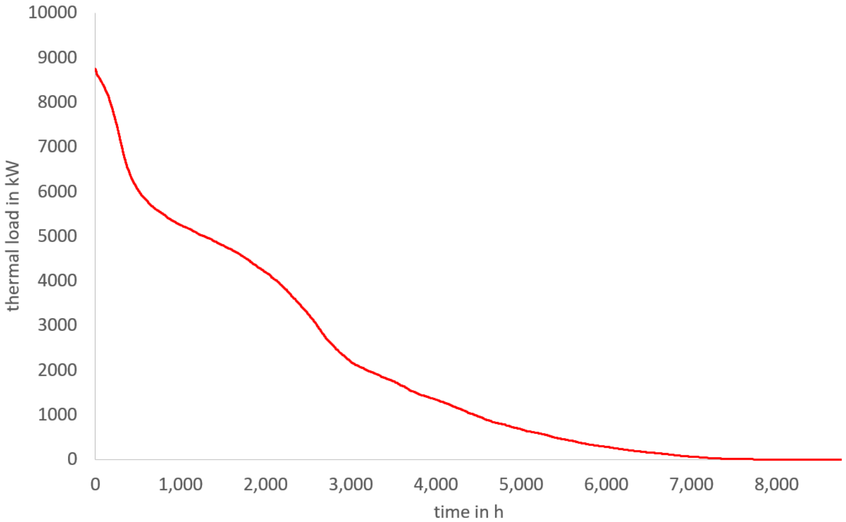
- Available technologies:
  - CHP (NG, BG)
  - boiler (NG, BG, BM)
  - heat-pumps (air, GT, waste-water)
  - power-to-heat
  - photovoltaics
  - solar thermal

- Own power consumption, funding, grid feed-in, emission goals



Case definition and main results

- Peak load approx. 9 MW_{th}
- Thermal demand approx. 20 GWh_{th}/a
- Grid supply temperature 95°C
- Economic system optimization



<u>Case 1:</u>

- no additional constraints
- only economic optimization

<u>Case 2:</u>

- fulfill federal funding requirements
- desired share of renewables approx. 90%

<u>Case 3:</u>

- high emission reduction
- max. annual emission approx. 770 t/a

Case definition and main results

Case 1 – economic optimization:

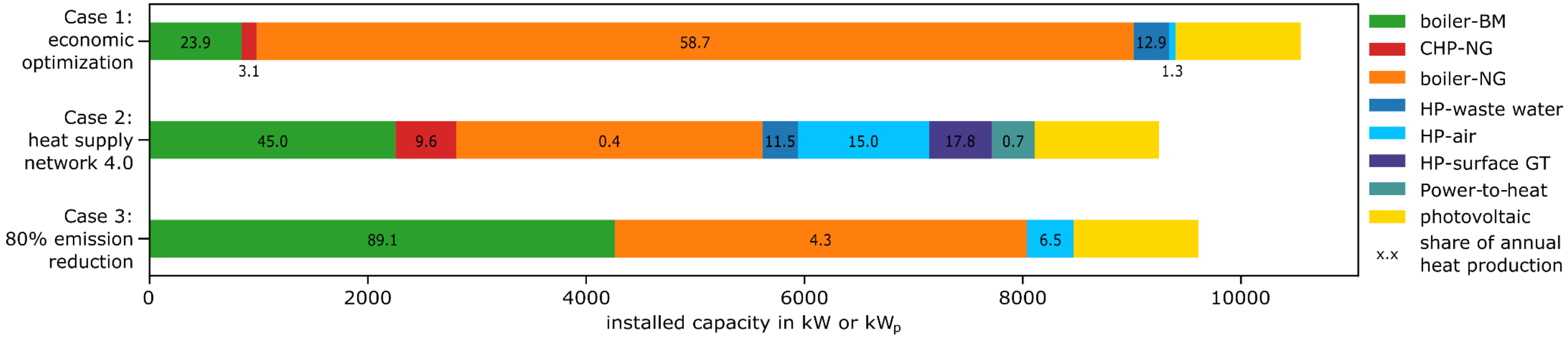
- approx. 160 g_{CO2}/kWh_{th}
- 27% reduction
- LCOE approx. 8.6 ct/kWh_{th}

Case 2 – federal funding:

- approx. 75 g_{CO2}/kWh_{th}
- 65% reduction
- LCOE approx. 8.6 ct/kWh_{th} (depending on federal funding program „Heat supply networks 4.0“)

Case 3 – high emission reduction:

- approx. 40 g_{CO2}/kWh_{th}
- 83% reduction
- LCOE approx. 9.5 ct/kWh_{th}



Summary and outlook

- Tool to design and optimize smart energy systems (variable requirements)
- Applicable on other (sub-urban) regions
- Easy to handle and scalable

- Further development and automization of optimization tool
- Application for planning and optimizing new and existing systems
- Identification of parameters for future approximate/estimate design

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Thank you for your attention

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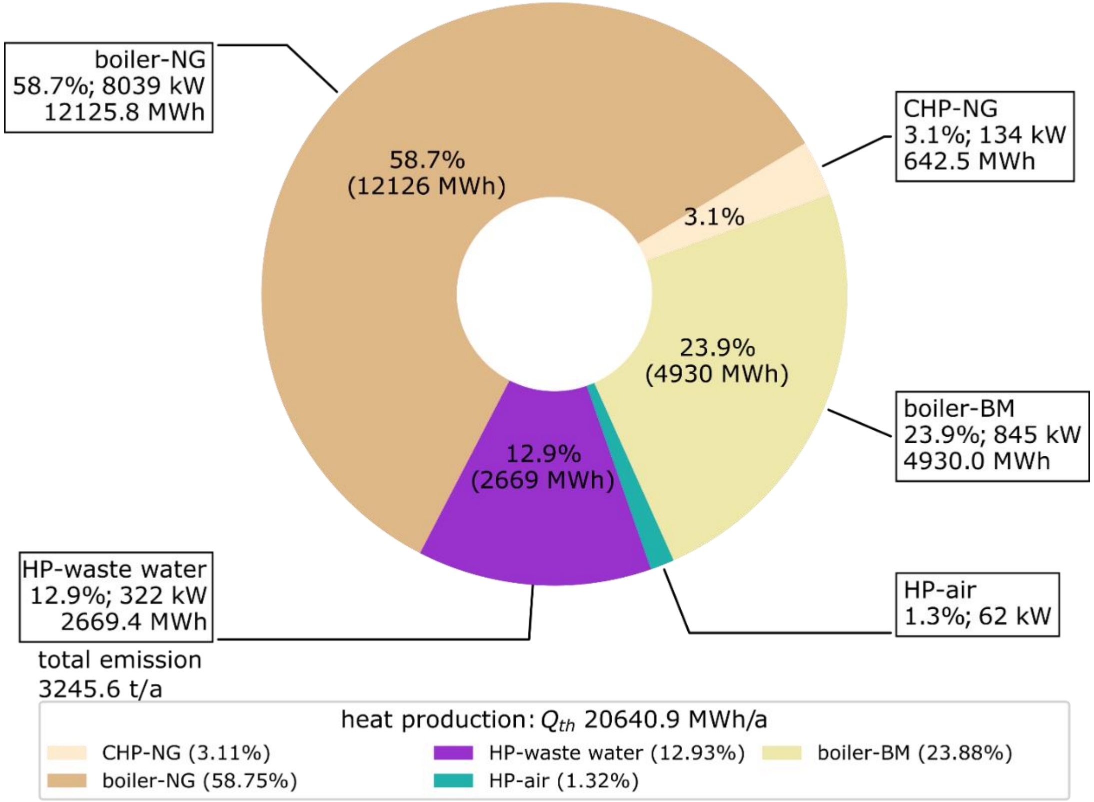
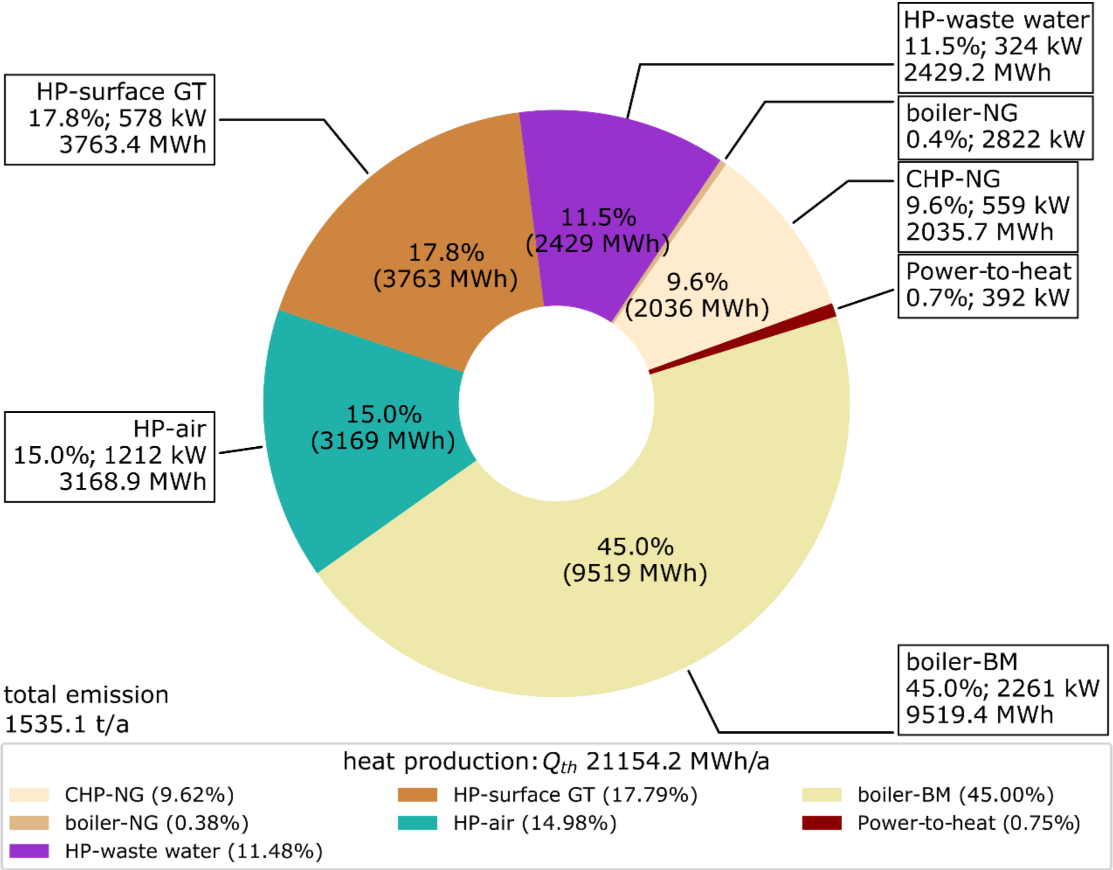
Appendix – results

- share of heat production for economic optimization without additional requirements
- approx. 160 g_{CO2}/kWh_{th}
- 27% reduction
- LCOE approx. 8.6 ct/kWh_{th}
- high share of fossil heat, low emission reduction



Appendix – results

- share of heat production for economic optimization to fulfill federal funding requirements
- approx. 75 g_{CO2}/kWh_{th}
- 65% reduction
- LCOE approx. 8.6 ct/kWh_{th} (depending on federal funding program „Heat supply networks 4.0“)
- high producer diversity, low share of fossil heat



Appendix – results

- share of heat production for economic optimization to fulfill high emission reduction requirements
- approx. 40 g_{CO2}/kWh_{th}
- 83% reduction
- LCOE approx. 9.5 ct/kWh_{th}
- highest emission reduction, strong dependency on wooden biomass