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**IAEE Online Conference 2021**

# **Role of cogeneration and heating networks in renewable energy systems**

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# Motivation

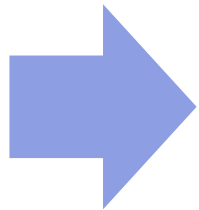
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## Open questions

- Where is H2 a cost-efficient option for decarbonization?
- How can residential and industrial heat supply be decarbonized?
- What kind of thermal backup capacities do high shares of solar and wind require?

## Connection with co-generation and heating networks

- Co-generation requires synthetic fuels like H2 (either with conventional turbines or fuel cells)
- Electrification in the heating sector greatly impacts backup requirements



Comprehensive analysis of question requires great spatio-temporal detail and a large sectoral and regional scope

# Deployed capacity expansion model

## Scope

## Detail

### Spatial

- European continent
- H2 import from outside of Europe possible at fixed price

- 96 regions
- Stylized transmission grid between regions

### Temporal

- Pathway from today to 2050 fully renewable system
- one year of weather data

- 16 representative days
- Different resolutions for each energy carrier
  - 4-hour steps for heat

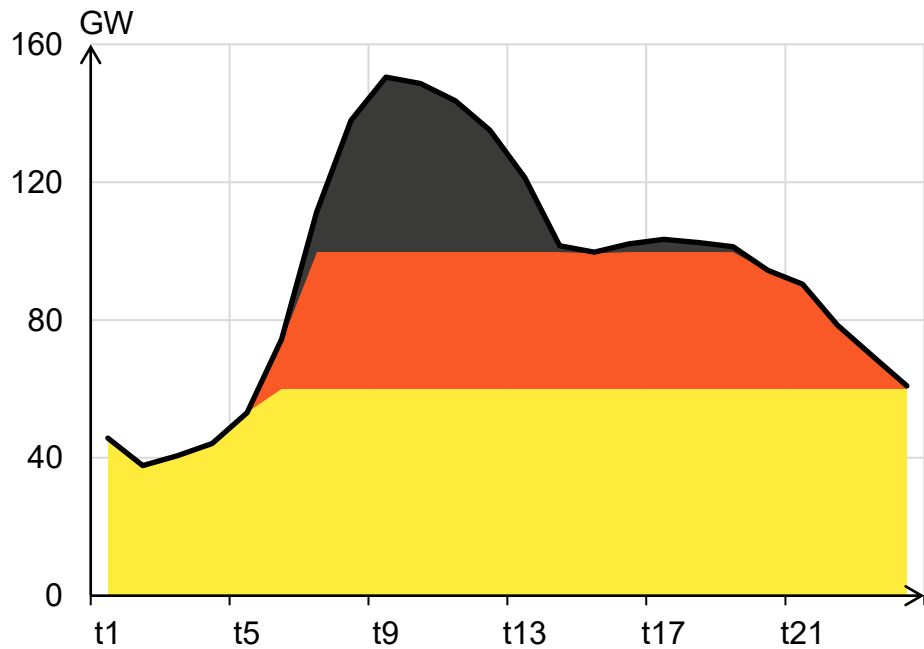
### Sectoral

- Electricity, transport and heat (residential and industrial)
- No non-energy use in industry

- 160 technologies
- 6 modes of transport
- 4 types of heat

# Concept of technology deployment

## Merit-order

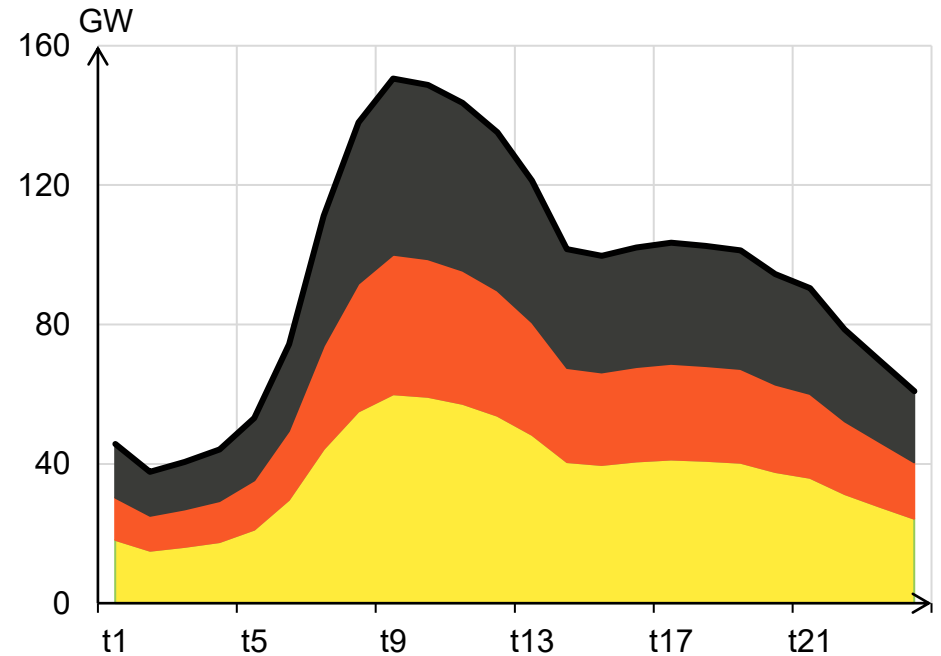


heat-pump gas boiler oil boiler heat demand

$$\sum_{te \in Te} Gen_{te,t} = dem_t \quad \forall t \in T$$

$$Gen_{te,t} \leq Capa_{te} \quad \forall t \in T, te \in Te$$

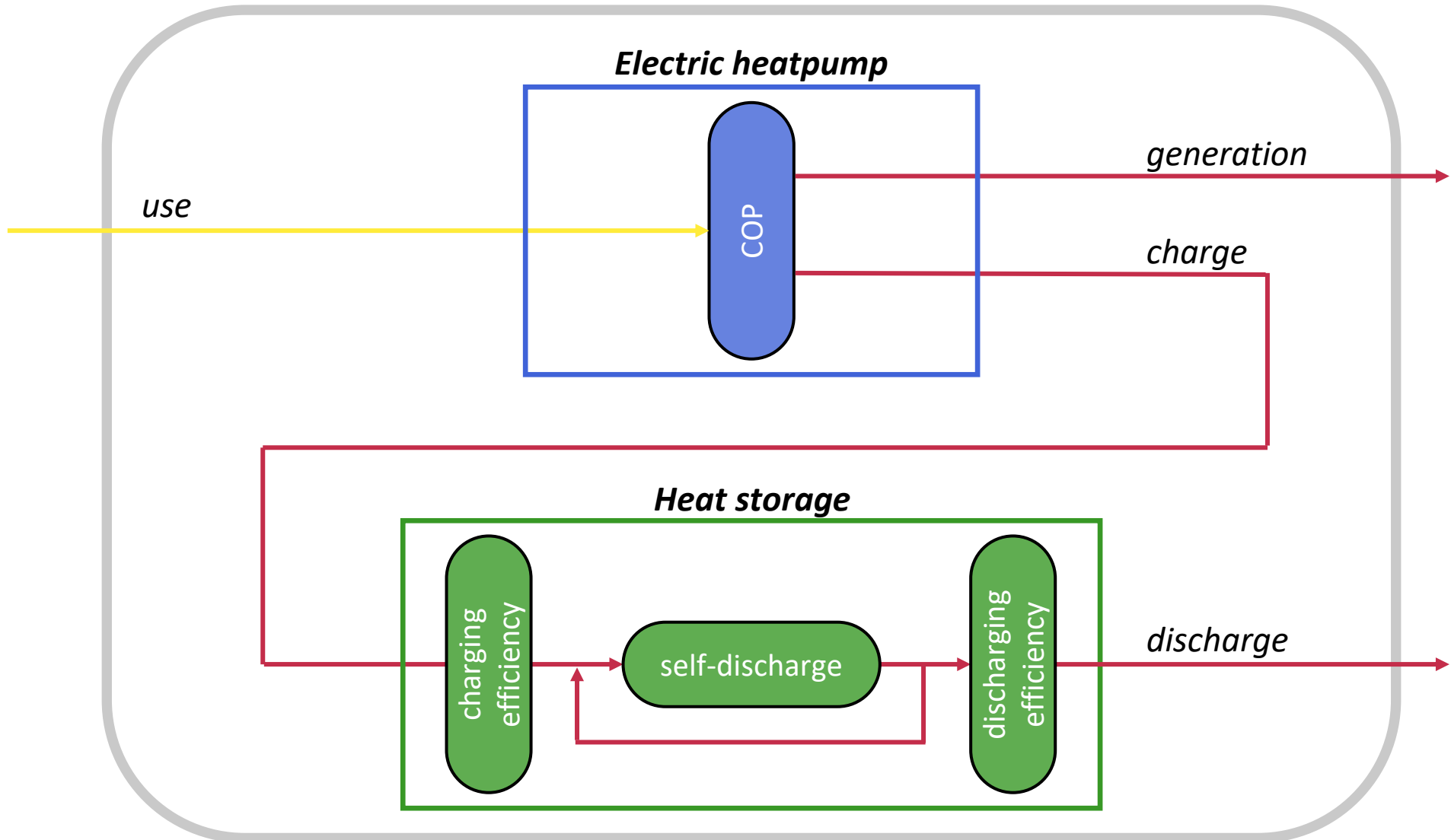
## Must-run



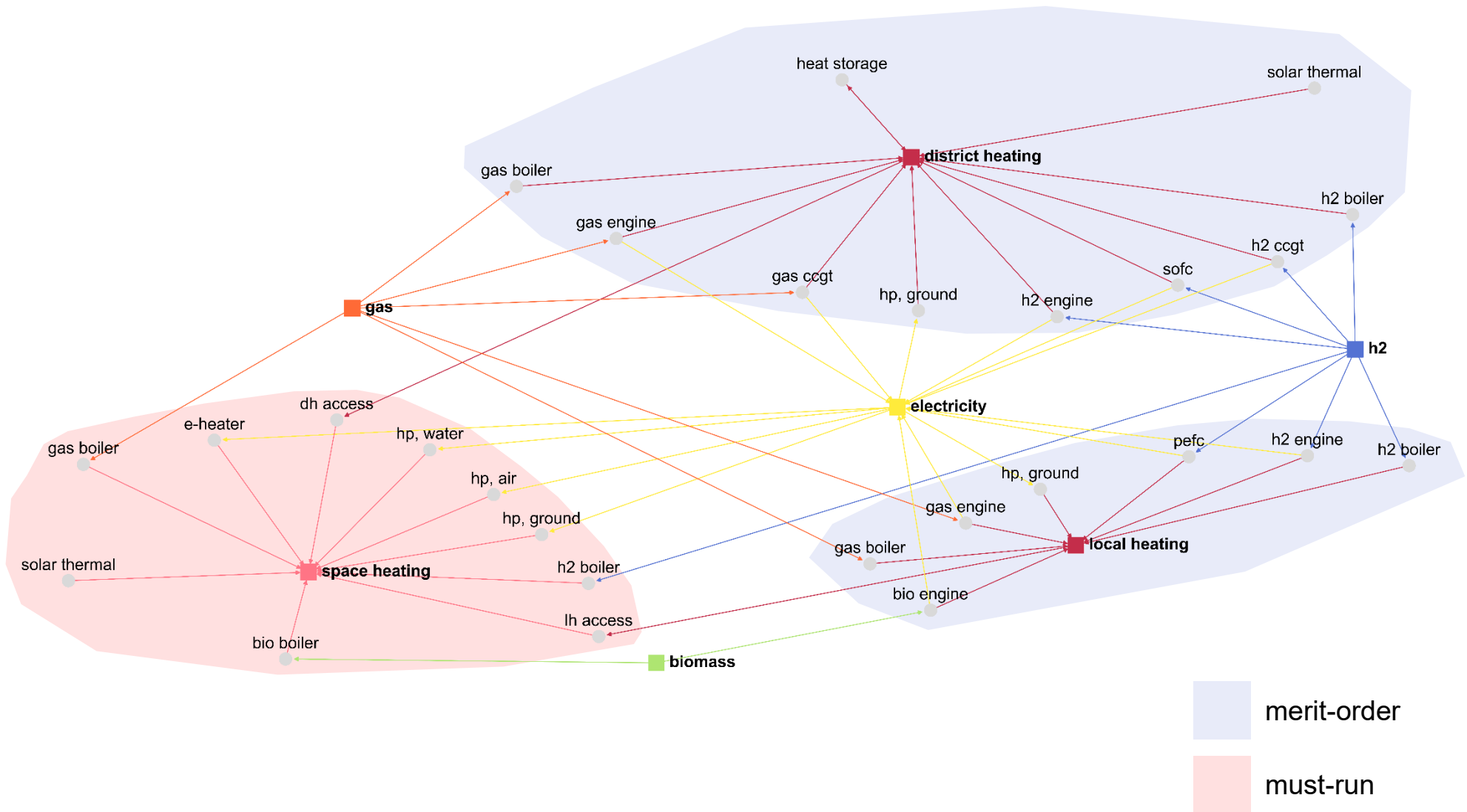
$$\sum_{te \in Te} Capa_{te} = peak$$

$$Gen_{te,t} = \frac{dem_t}{peak} \cdot Capa_{te} \quad \forall t \in T, te \in Te$$

# Consequentially representation of heat storage

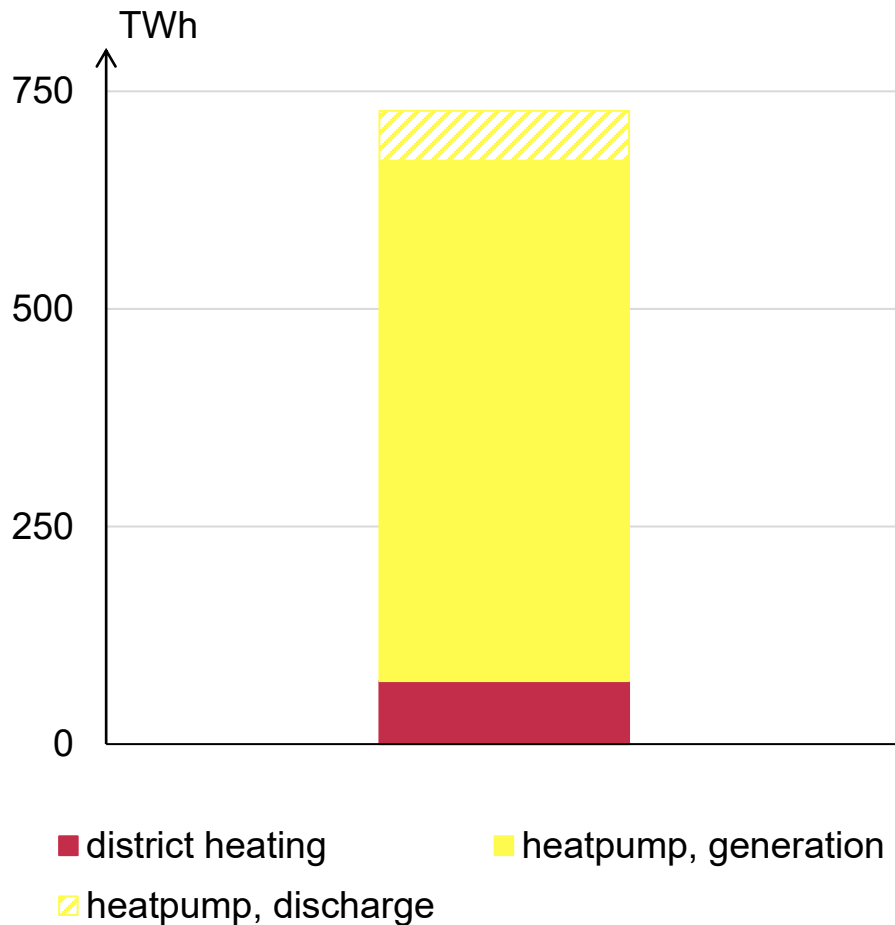


# Installed heating technologies

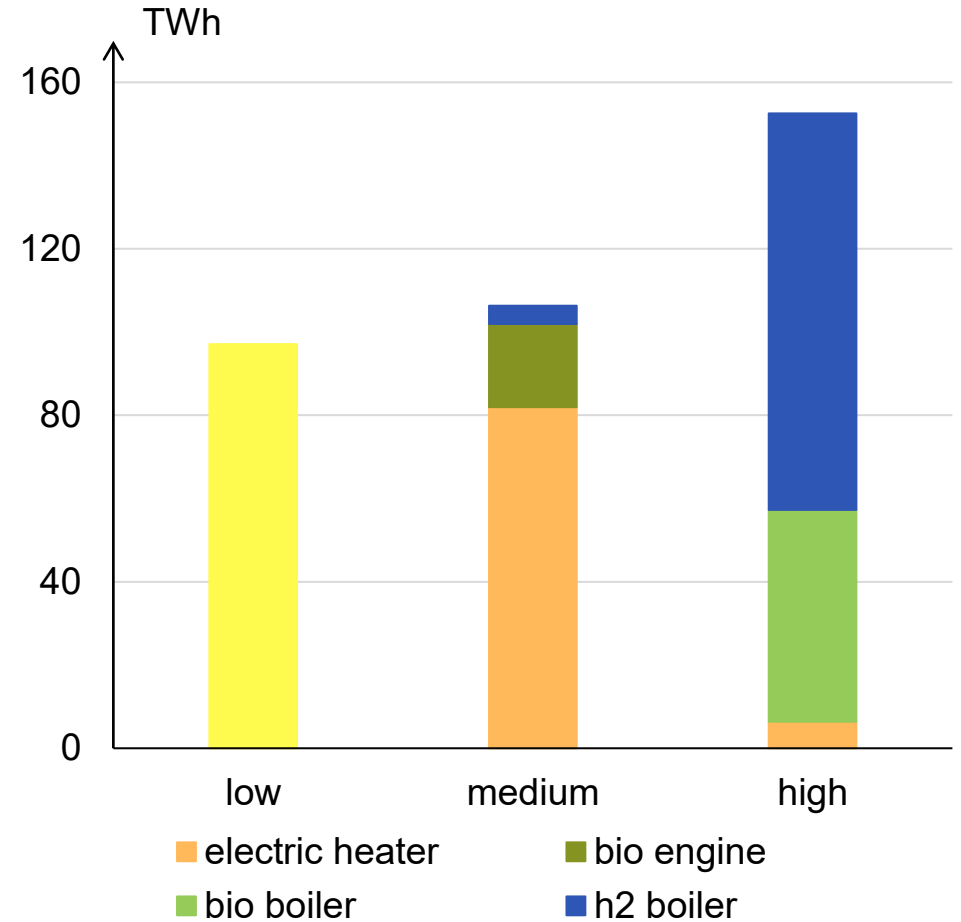


# Heat generation in 2050, Germany

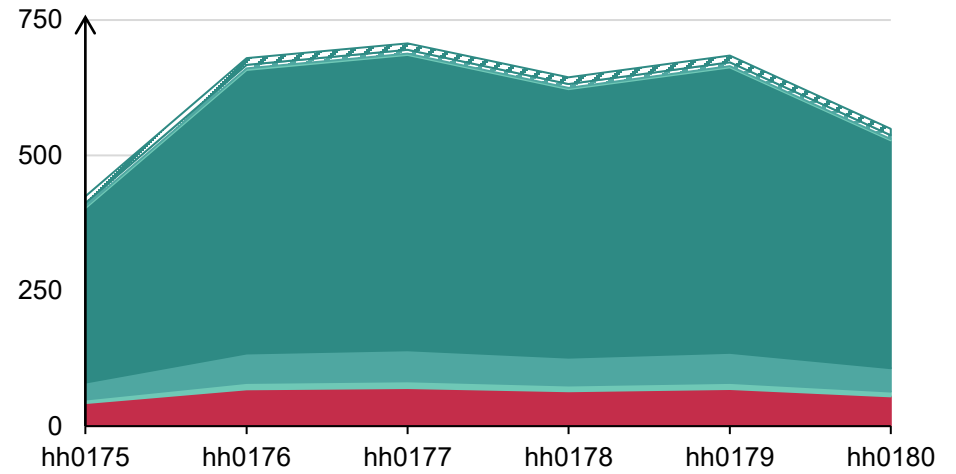
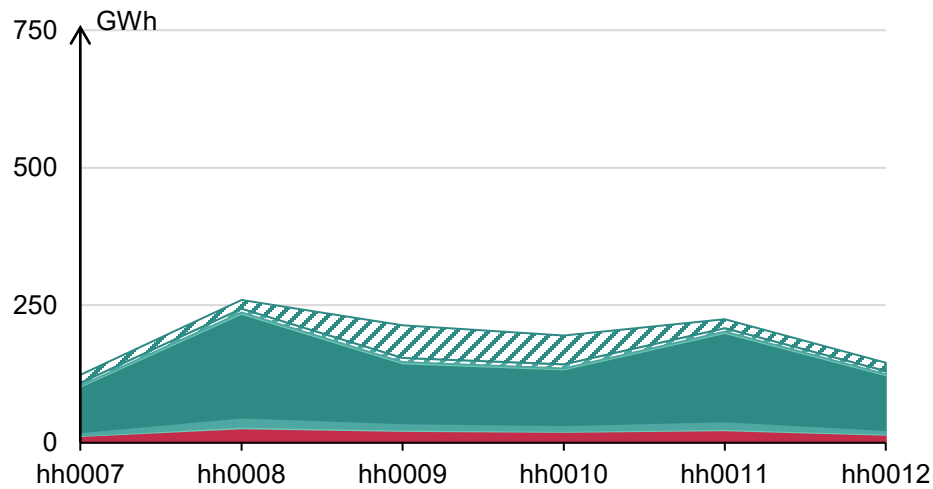
## Space heat



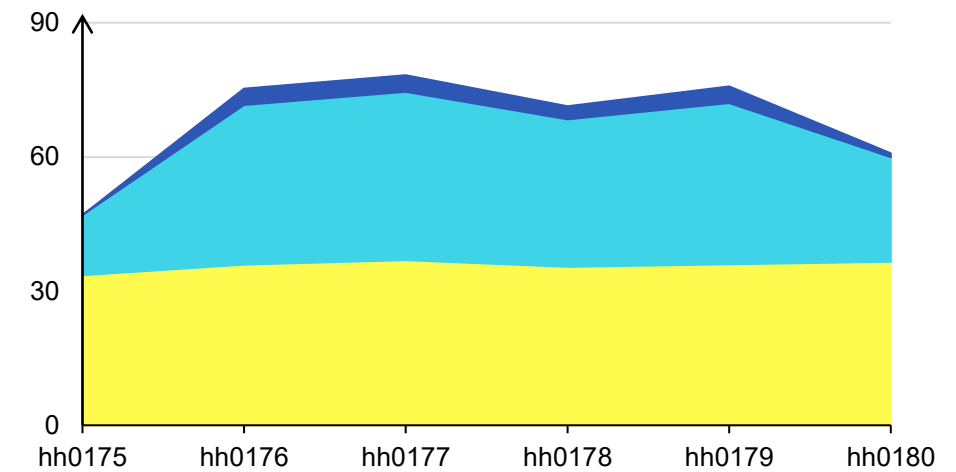
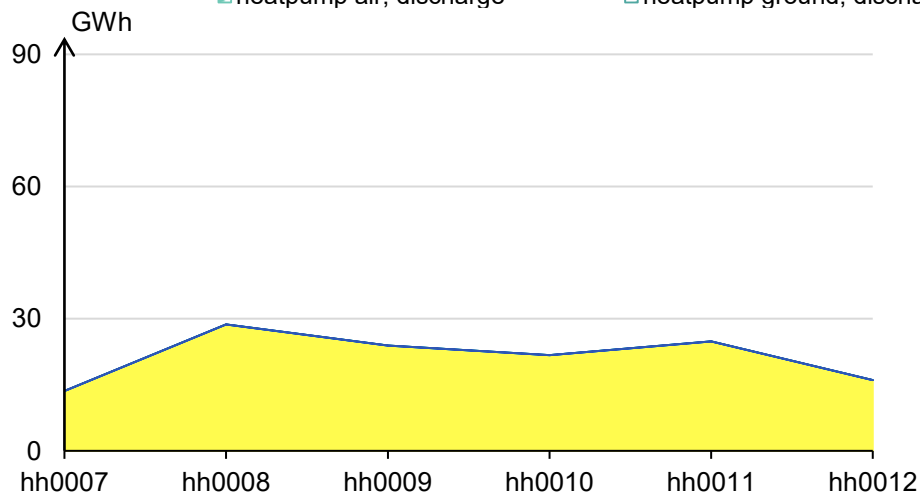
## Process heat



# Heat supply on low and high demand days



■ district heating     
 ■ heatpump air, generation     
 ■ heatpump ground, generation     
 ■ heatpump water, generation  
▨ heatpump air, discharge     
 ▨ heatpump ground, discharge     
 ▨ heatpump water, discharge



■ heatpump ground     
 ■ h2 ccgt, chp     
 ■ h2 boiler



# Conclusion

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## Current limitations

- Not included heating options due to missing data on potential
  - Geothermal, in particular co-generation
  - Waste heat
- Temporal detail and scope is expandable
- Today's demand levels assumed

## Findings

- Electrification is the cost-efficient strategy to decarbonize (district) heating
- Co-generation is useful to cover the highly correlated peaks of electricity and heat demand
- Results suggest a high benefits from renewable co-generation technologies with variable power-to-heat ratios

# Thank You for Your Attention!

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