The Impact of Energy Security on a German Energy System by 2030 and 2045 and the Role of Heat Pumps

Christoph Kost
Co-Authors: Markus Kaiser, Julian Brandes, Patrick Jürgens
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Topics of this talk

The Impact of Energy Security on a German Energy System by 2030 and 2045 and the Role of Heat Pumps

- Natural gas supply and prices have changed and will influence the energy transition.
- How do the transition pathways to 2045 change under the current developments?
- What is the impact of the increased heat pump development as one key solution?

The work on this paper was supported by the BMBF Ariadne project with sign 03SFK5D0.

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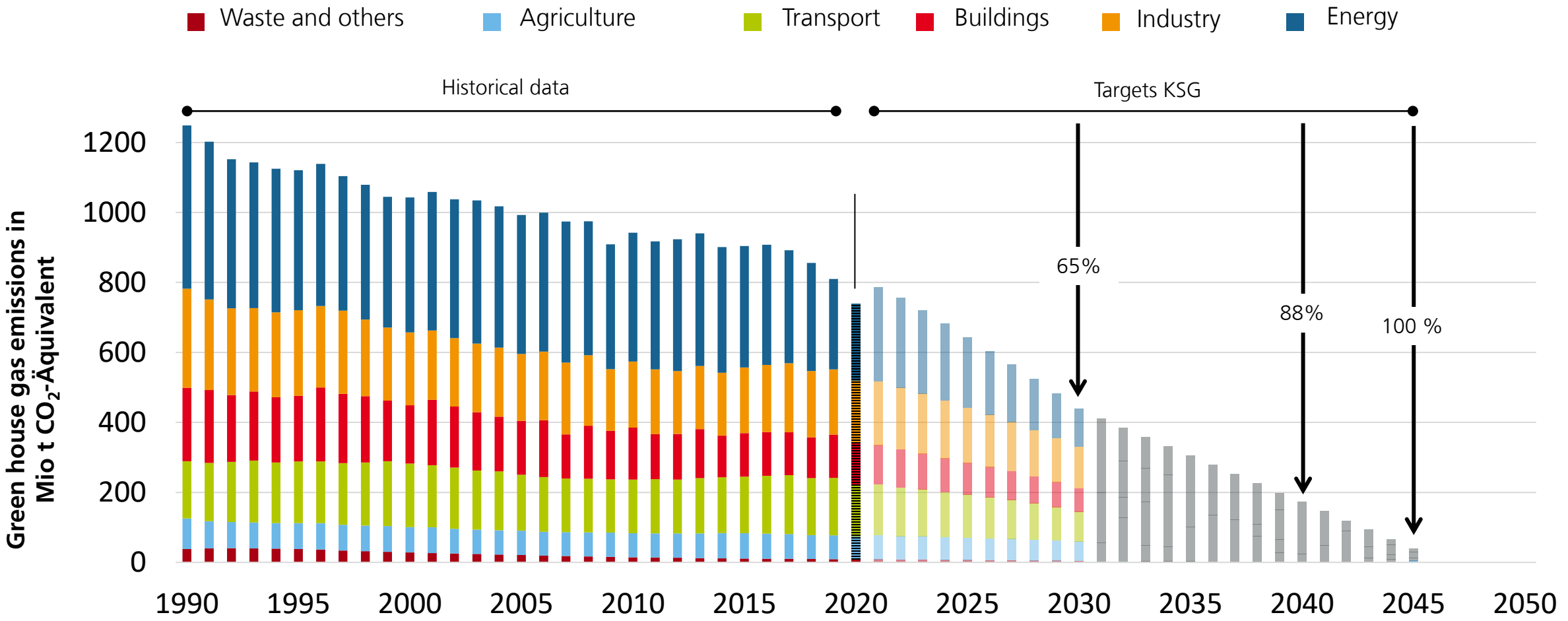
Scope of the analysis and its model

Emission path to climate neutrality in Germany



Historische Daten und VJS: Vorjahreschätzung (VJS) der deutschen Treibhausgas-Emissionen für das Jahr 2020. Umweltbundesamt, 15.3.2021

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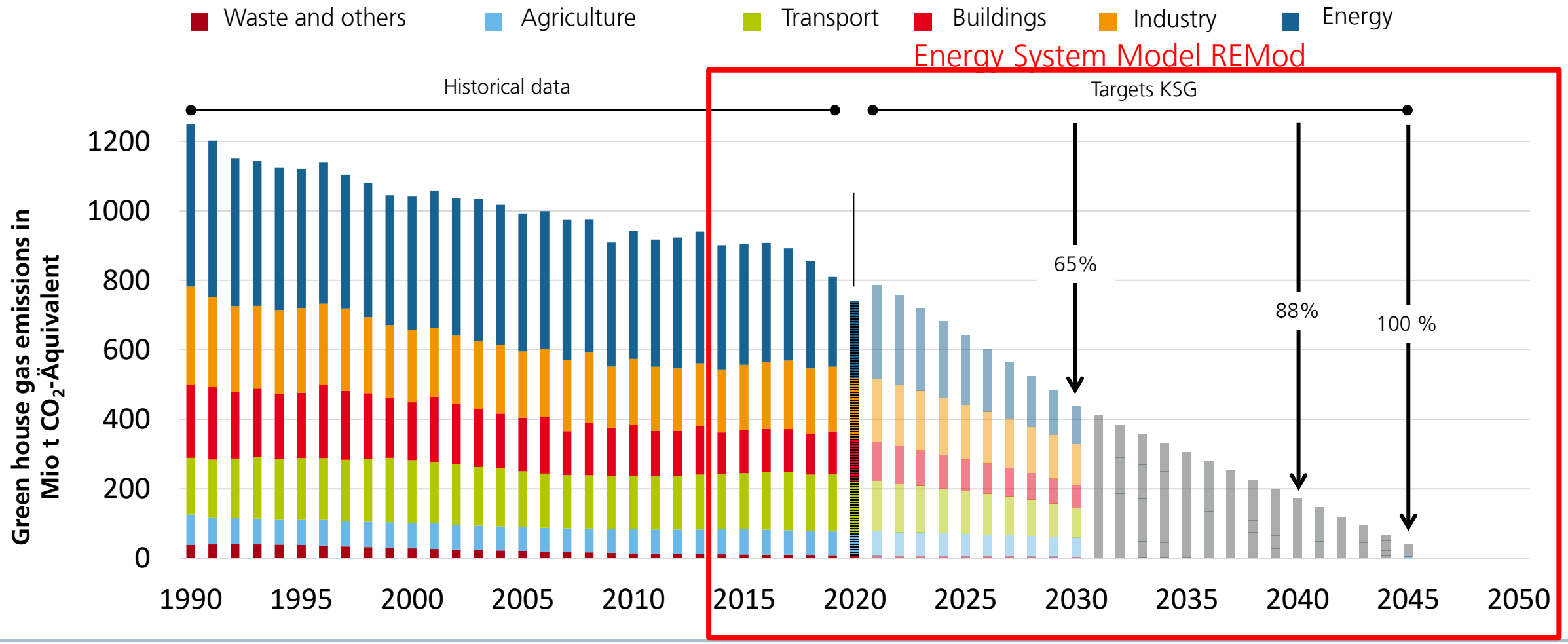

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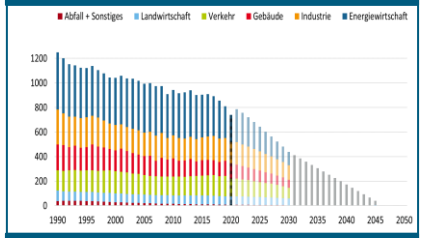
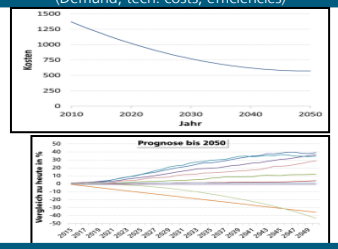
REMod – Cross-sectoral energy system model

CO_2-target(-65 / -100%)



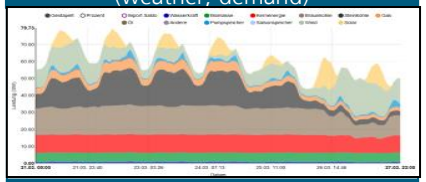
Data input

(Demand, tech. costs, efficiencies)



Hourly profiles

(weather, demand)



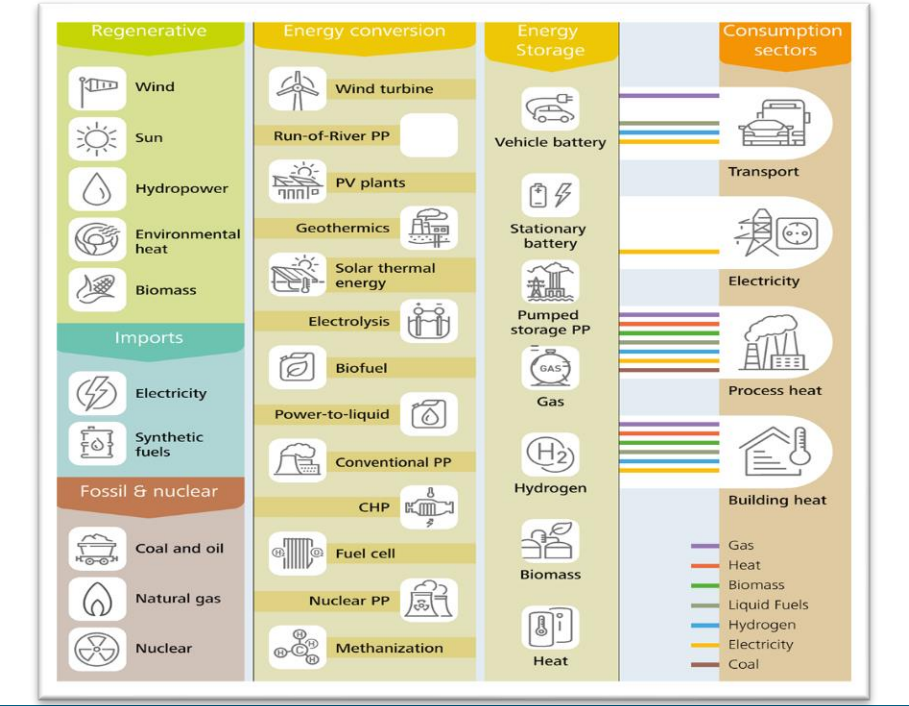
Energy converters today

(all sectors)

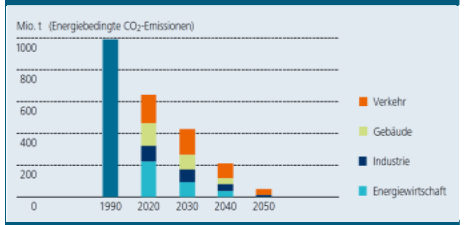
Core of the model

Yearly optimization and hourly simulation. Non-linear.
All sectors, all hours from today to 2050 and 5 weather years, no grid.

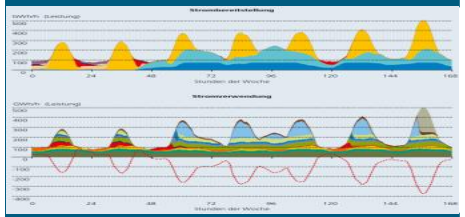
All energy sources, converters, storages and consumption sectors.
Target function: Minimization of total system costs
Boundary conditions: Security of supply and CO_2 emissions



Decarbonisation per sector



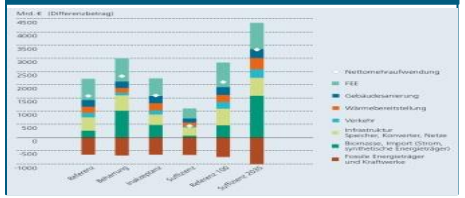
Sector-coupled operating results



Energy converters until 2050

(all sectors)

System costs of transformation



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Part 1: Energy System

The key number for the climate: CO2 emissions

CO2 emissions until 2045

- **Pre-2022 scenario** vs **Energysecurity scenario**
  - *Scenario assumptions and parameter definition in the modeling group of the Ariadne project*
  - *Key parameters of the Energysecurity scenario: limited availability of natural gas and higher prices*
- CO2 budget was assumed to be identical

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The key number for the climate: CO2 emissions

CO2 emissions until 2045

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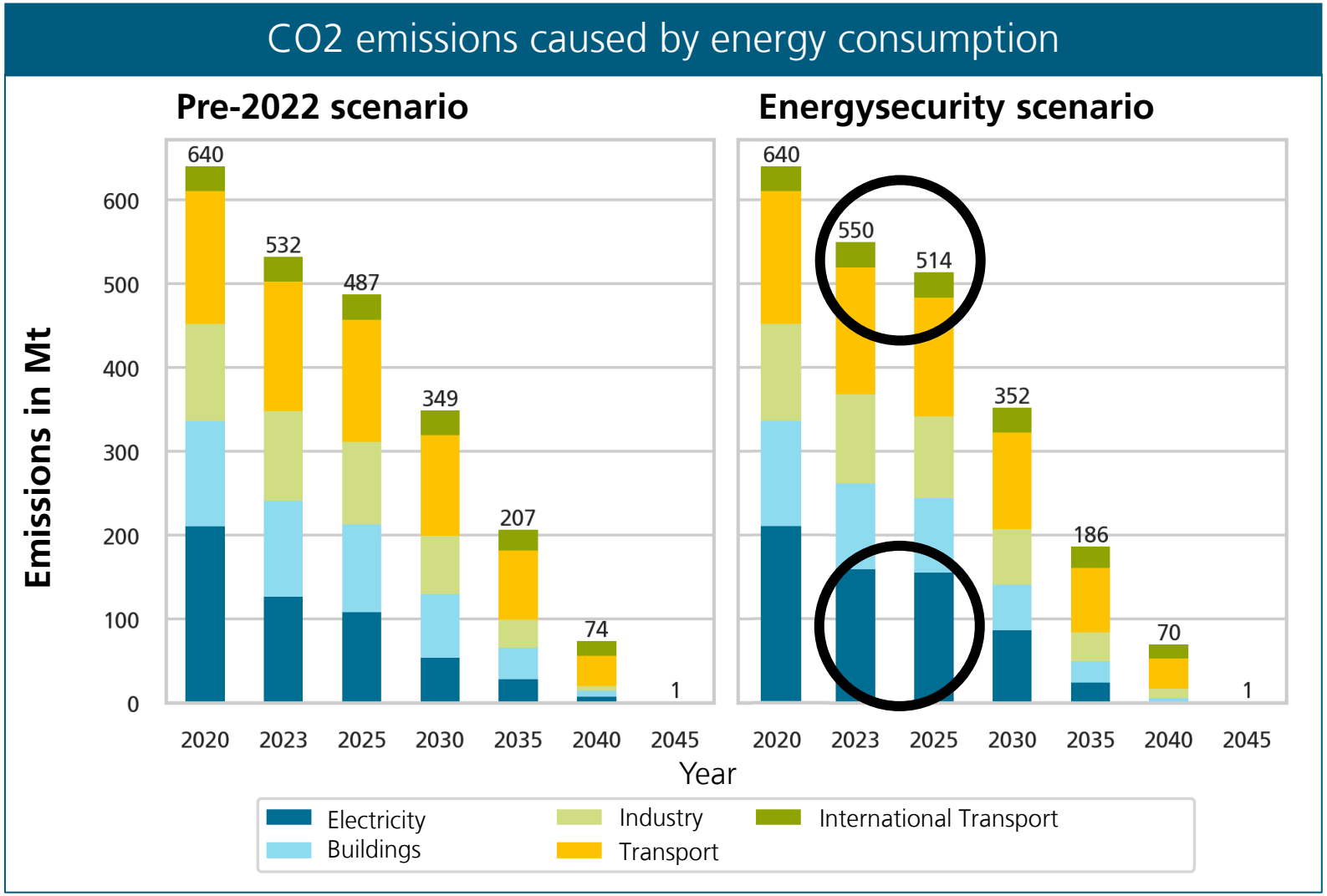
  - *Scenario assumptions and parameter definition in the modeling group of the Ariadne project*
  - *Key parameters of the Energysecurity scenario: limited availability of natural gas and higher prices*
- CO2 budget was assumed to be identical
- CO2 emissions path increased by 2030



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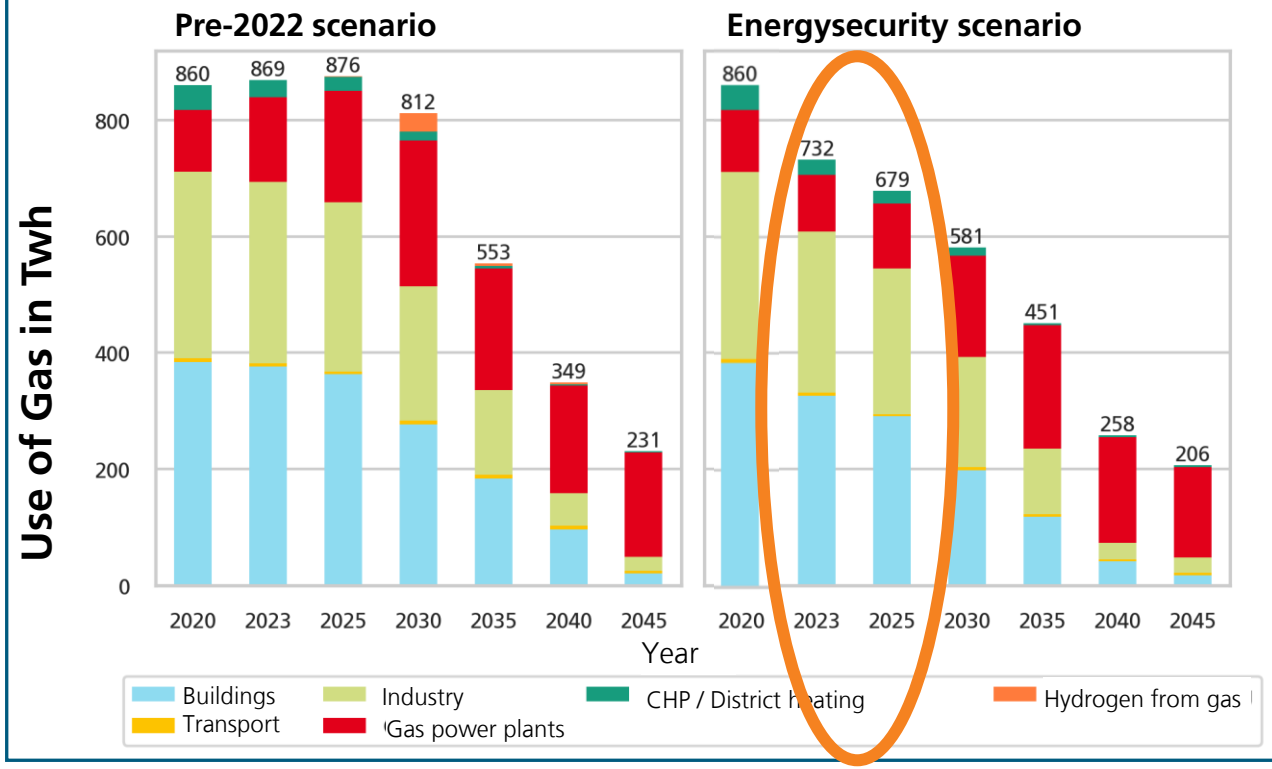
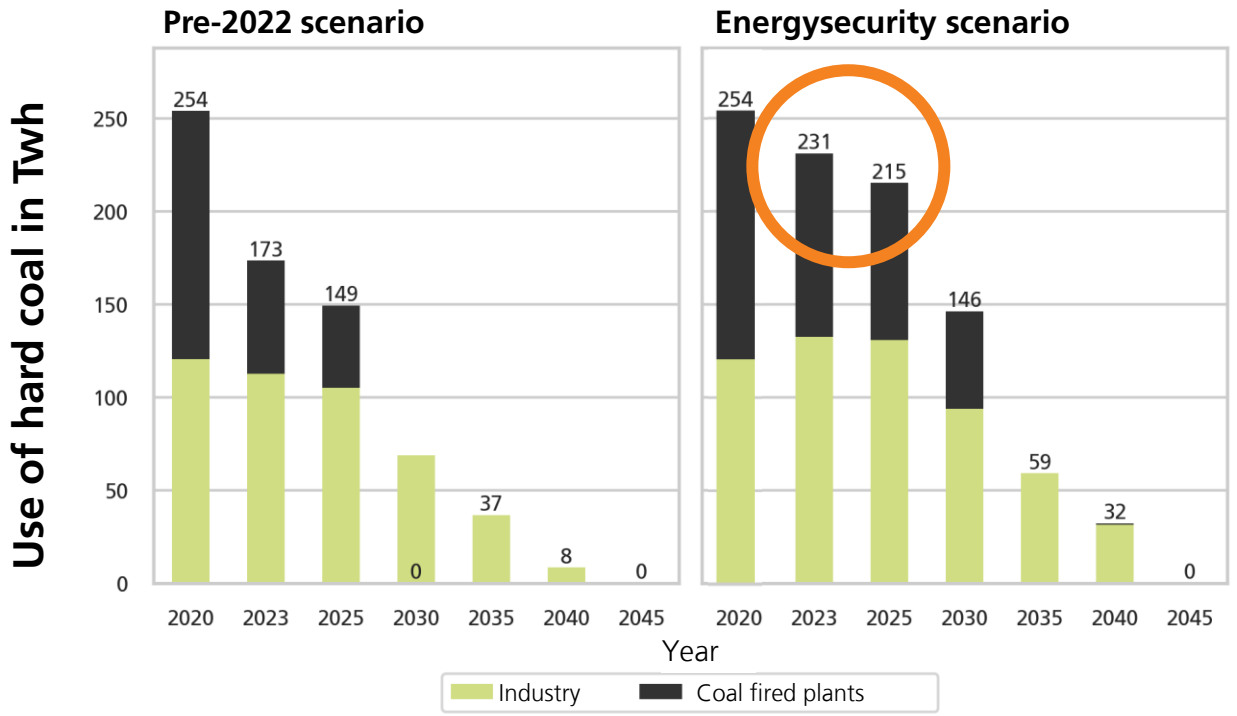
Change in the fossil fuel consumption

Use of gas (CH4) and hard coal

Consumption of gas and coal





* In 2045, the gas is climate neutral.

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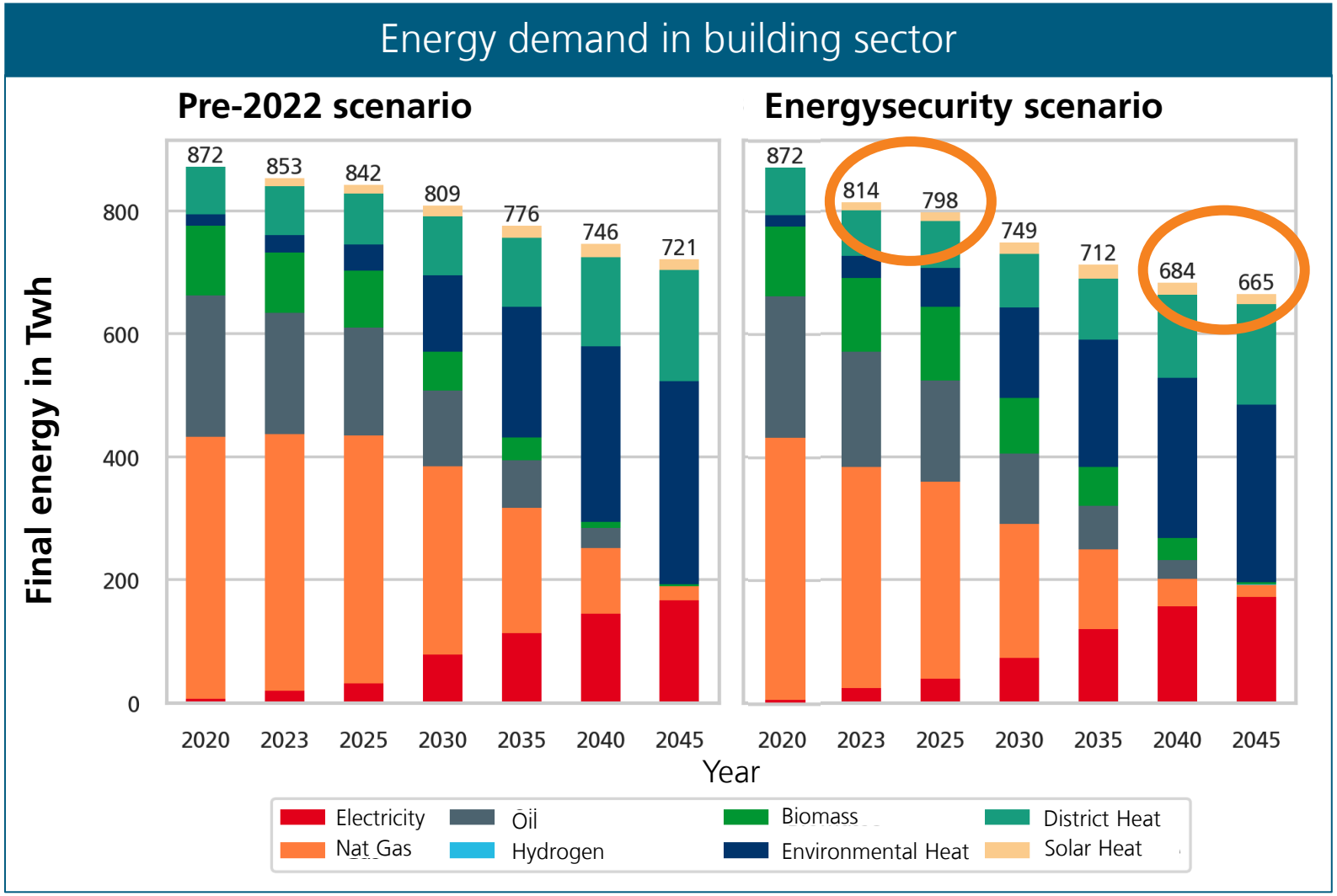
Reductions in the building plus more heat pumps and biomass

Building sector until 2045

- Lower final energy demand due to higher renovation rate and higher prices/reduced consumption
- Reduction of natural gas in 2025 and 2030



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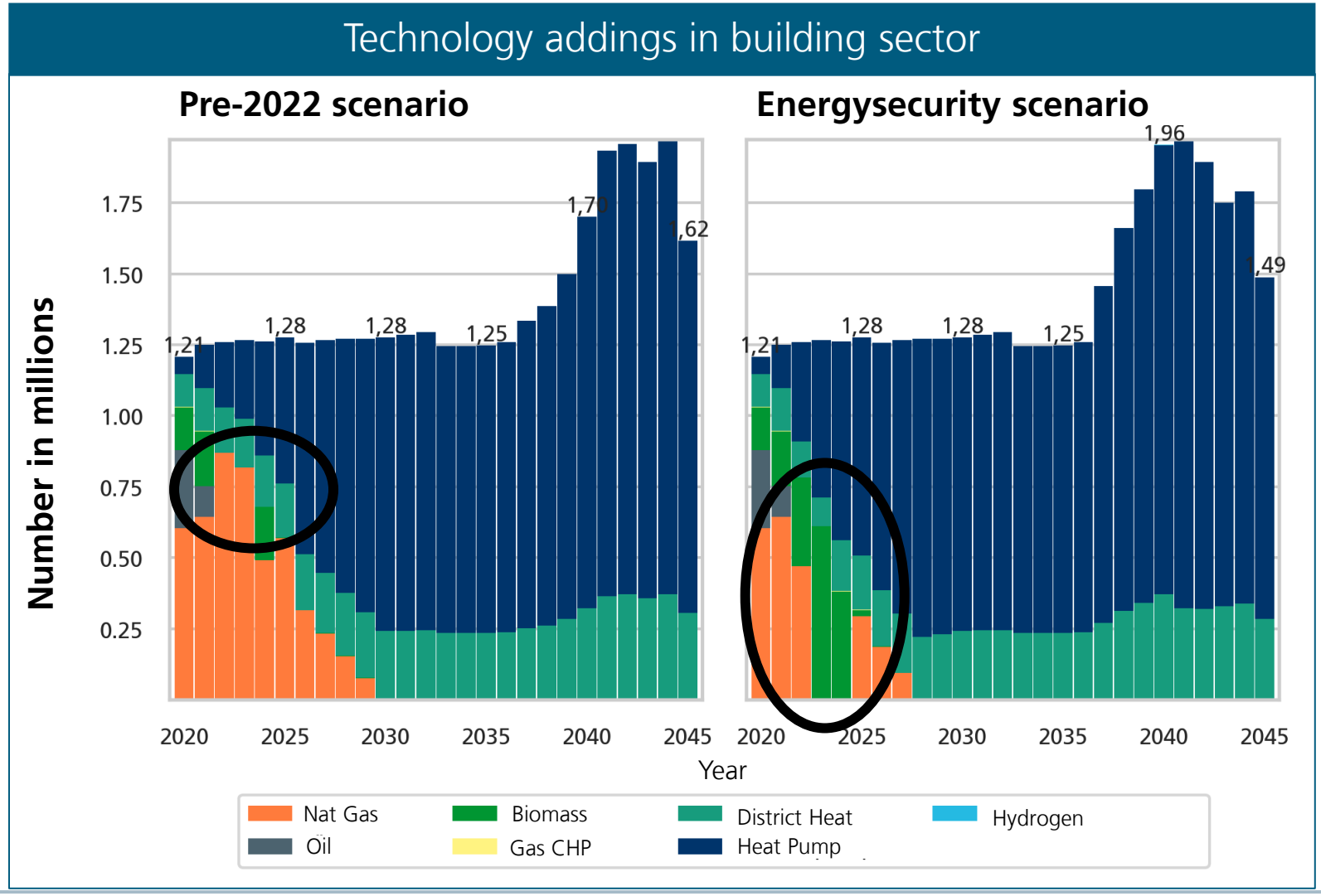
Strong change of technology preferences in the short-term

Building sector until 2045

- New gas boilers are strongly reduced
- Biogas and heat pump further increase
- However, strong heat pump market also without shock



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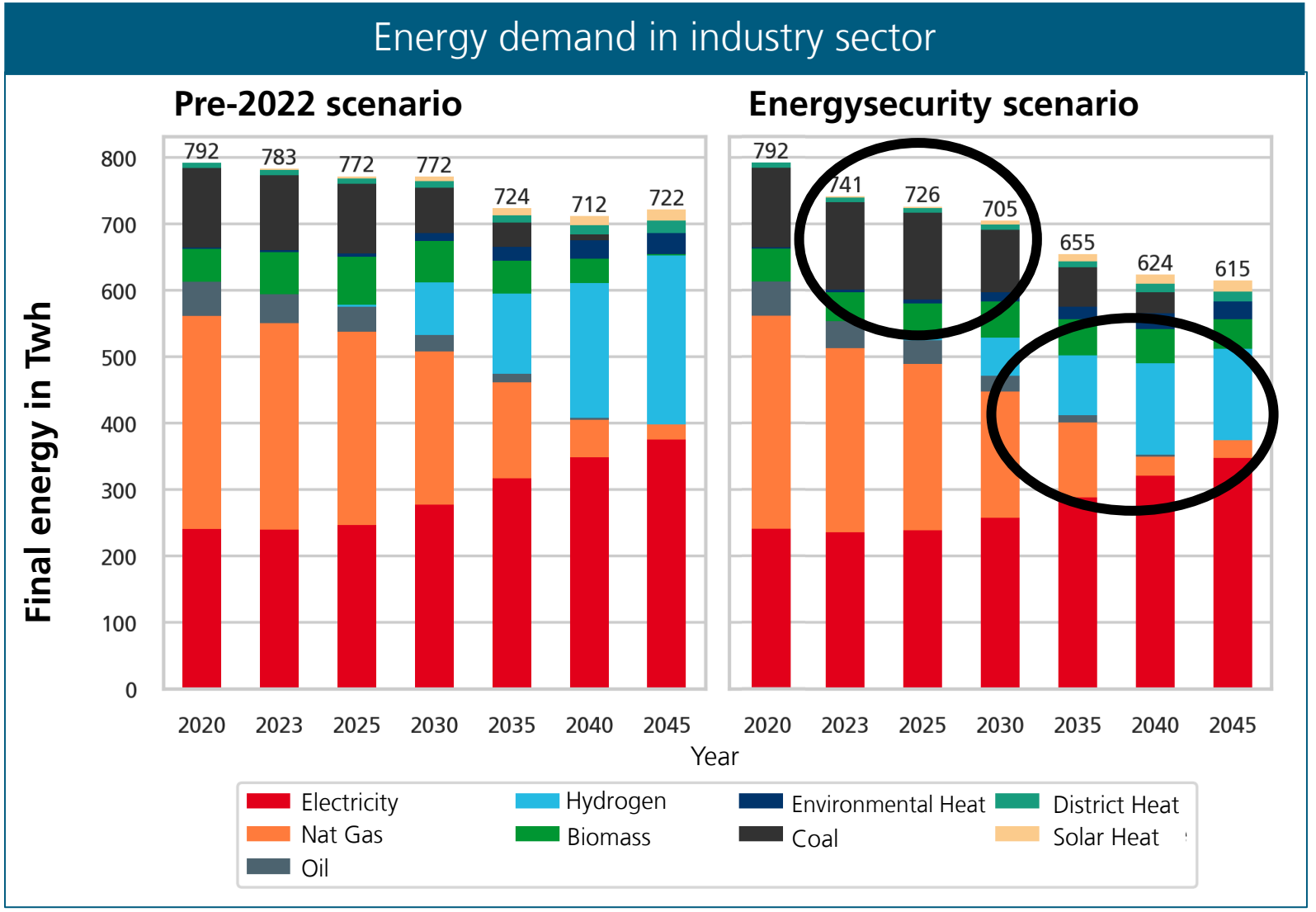
Different choices in the industry

Industry sector until 2045

- Energy consumption decreases strongly
- Coal extends it use in terms of time
- Hydrogen is then also less used as this also decreases dependencies



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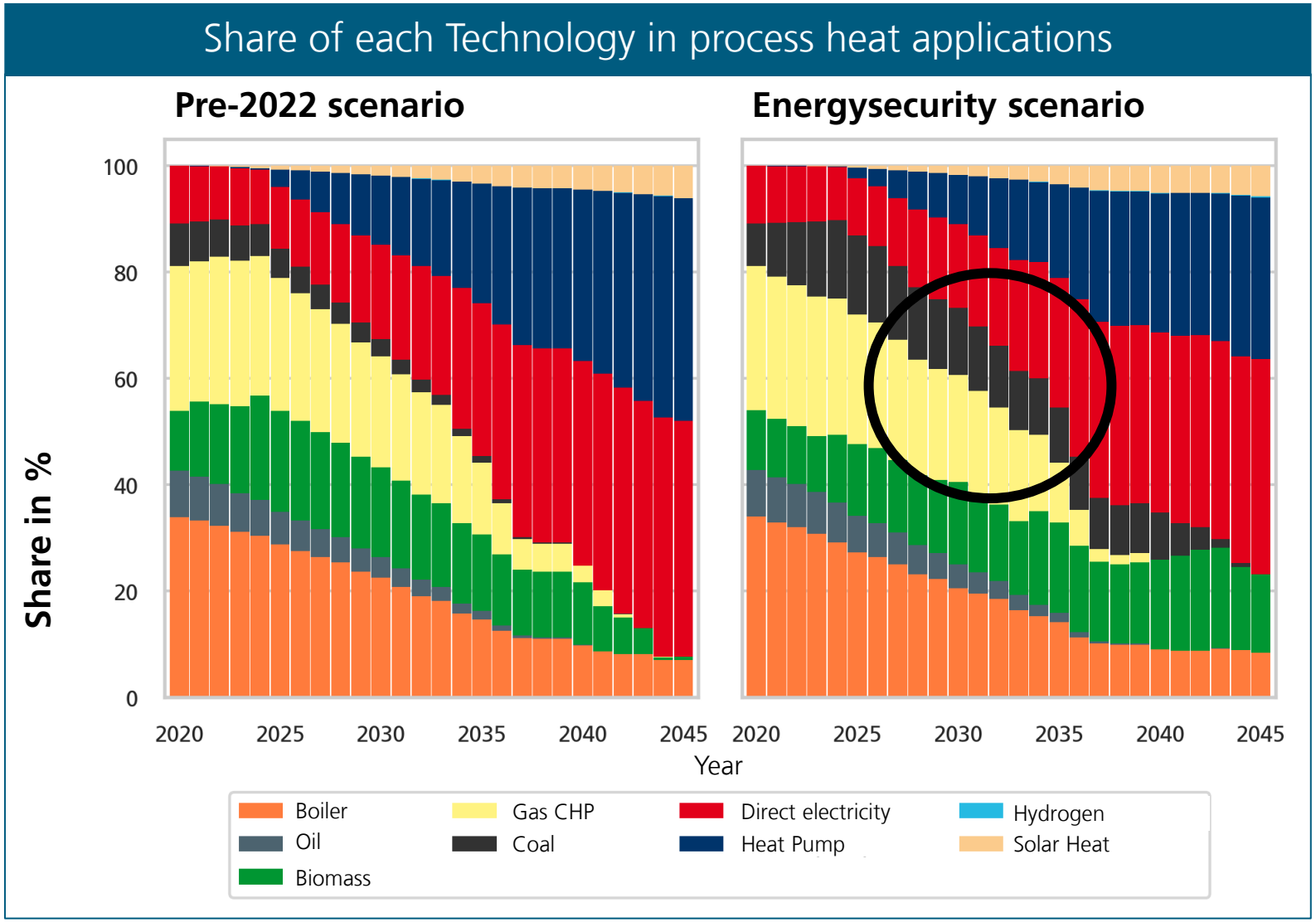
Different choices in the industry

Industry sector until 2045

- Coal and biomass with higher share in the technologies



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Findings of part 1

- Short-term and long-term transition pathways are changed.
- Price and availability of natural gas lead to different consequences in each sector
- Measures for climate protection (Klimaschutzmaßnahmen) have to take into account these findings immediately

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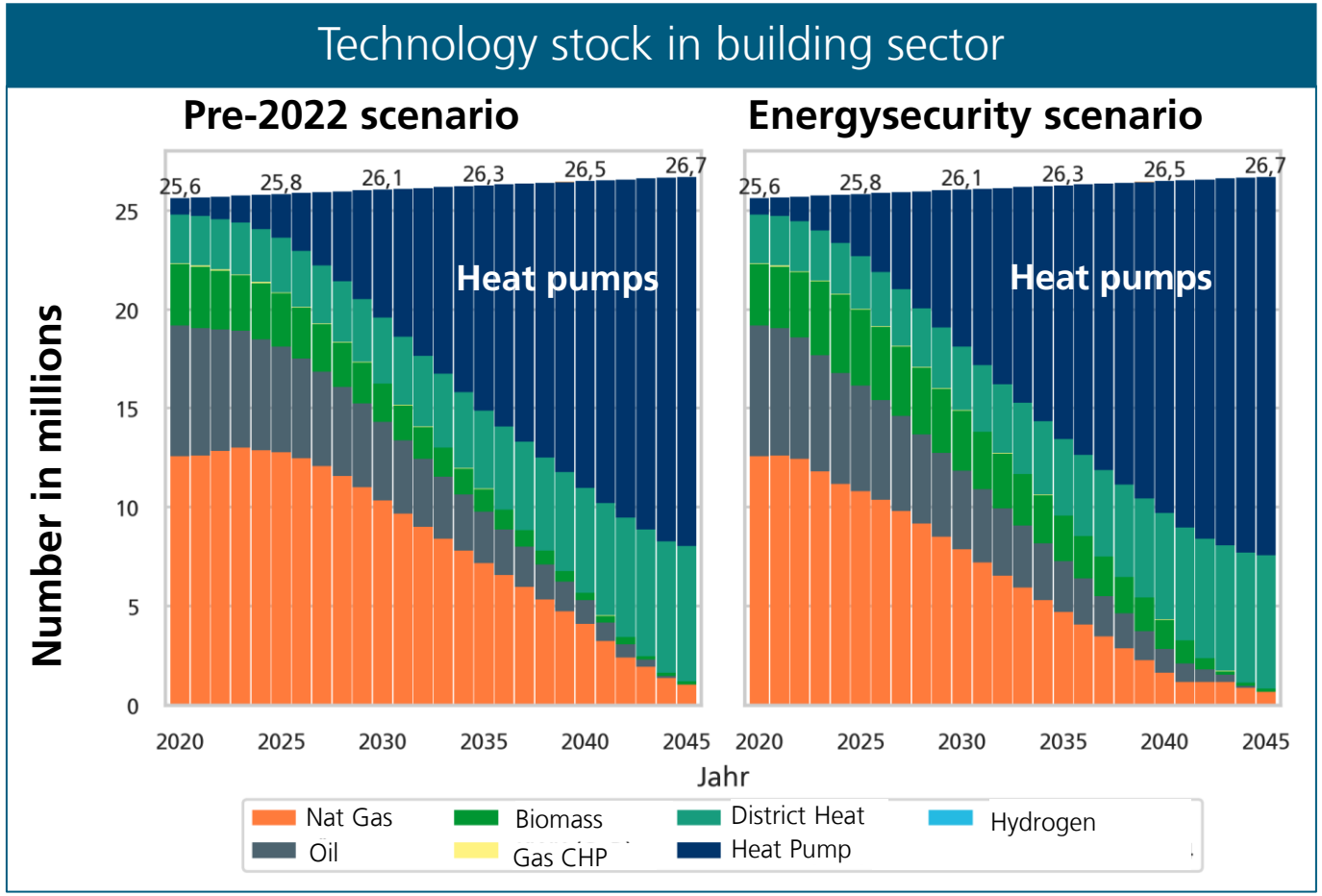
Part 2: Operation of heat pumps

Another Aspect on energy security: Electricity demand of heat pumps

All scenarios show high increase of heat pumps as best solution in building sector

- **Do heat pumps increase the demand for electricity? -> YES**
- **Do heat pumps increase the maximum load in the electricity system? -> YES**
- **Are heat pumps operated with electricity from fossil fuels as they are operated in cold seasons?**



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Hourly CO2 factor of electricity and heat pumps

Year 2030

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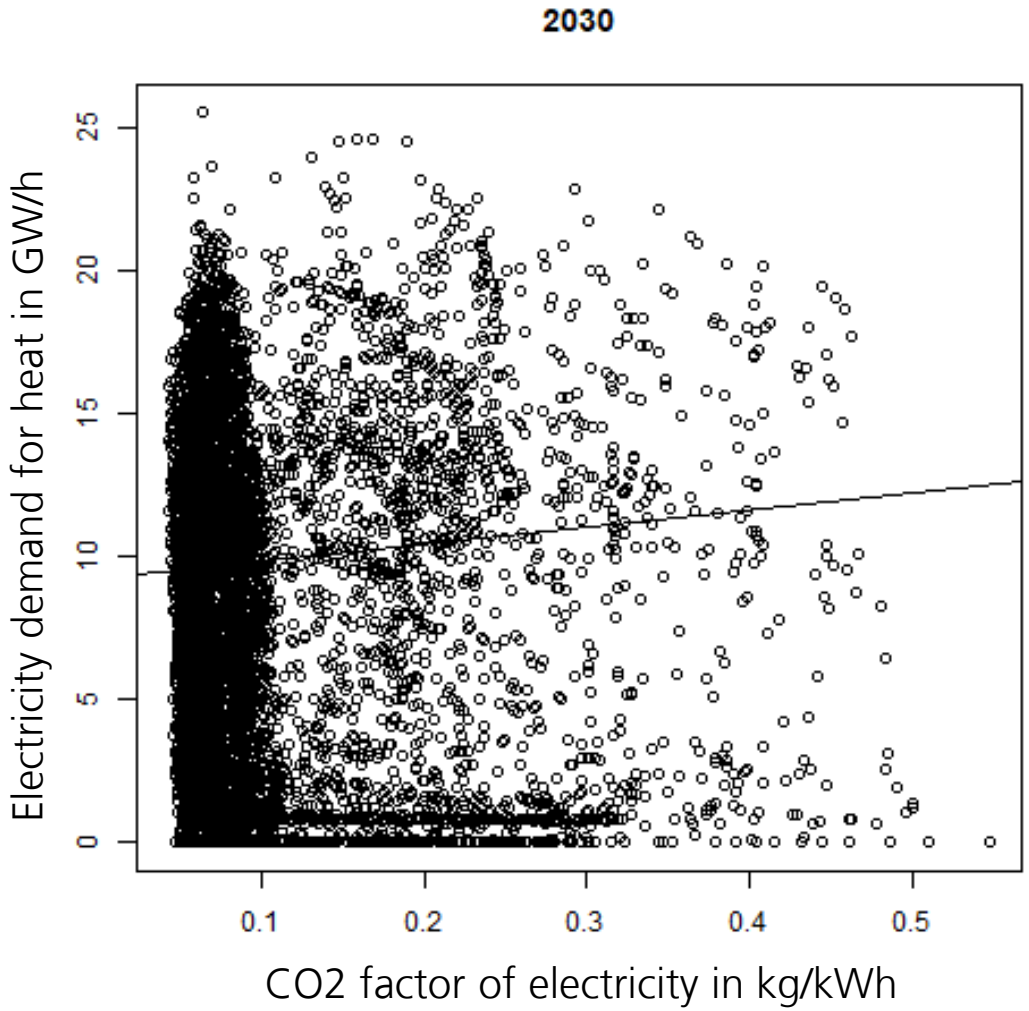

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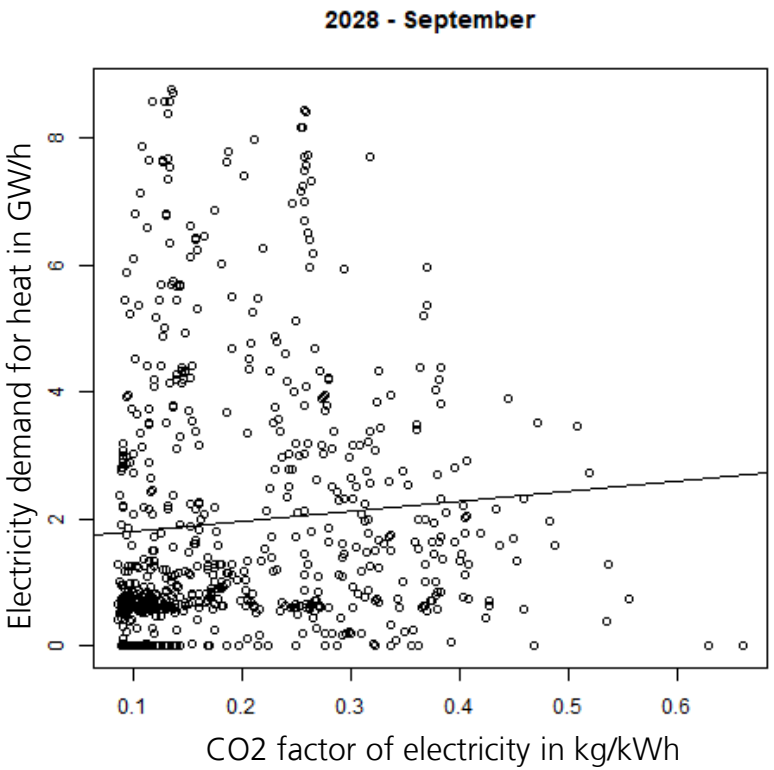
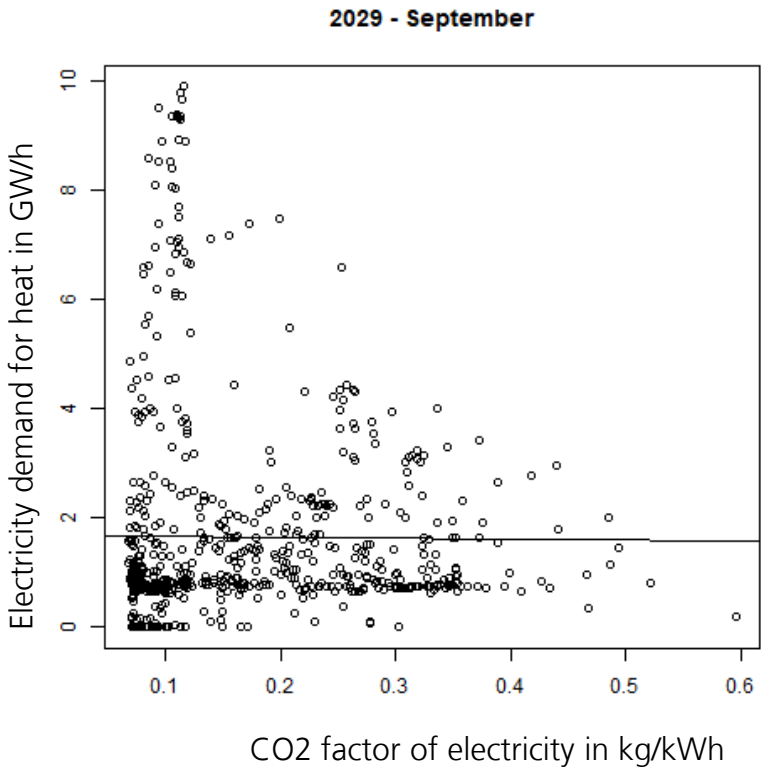
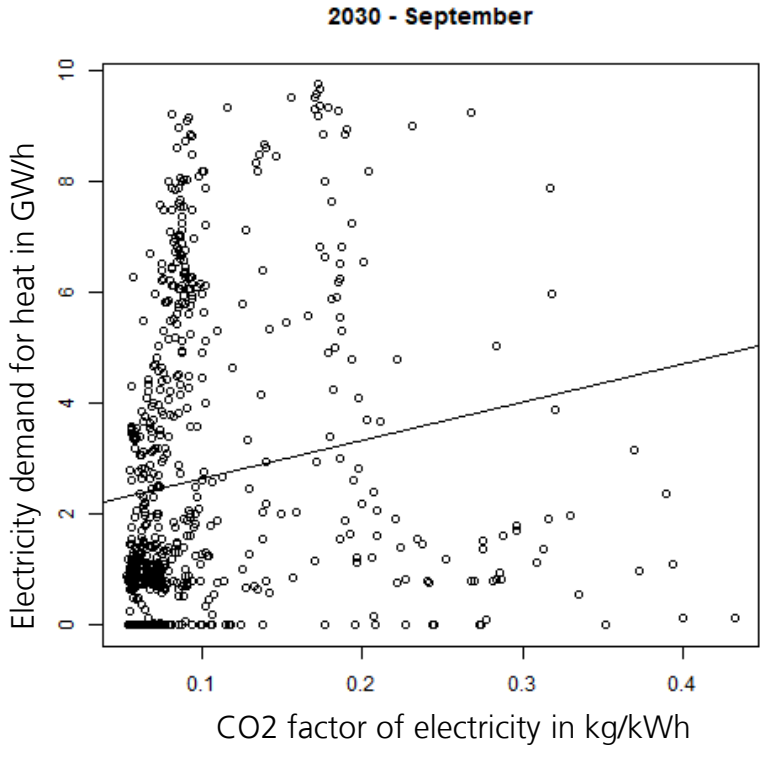
Hourly CO2 factor of electricity and heat pumps

September







- Different weather years are used!

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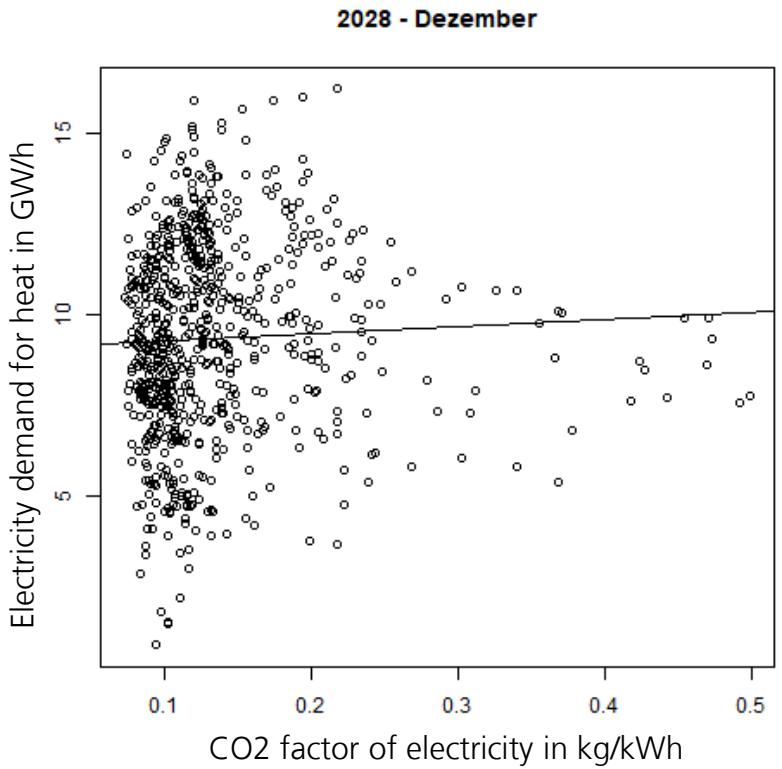
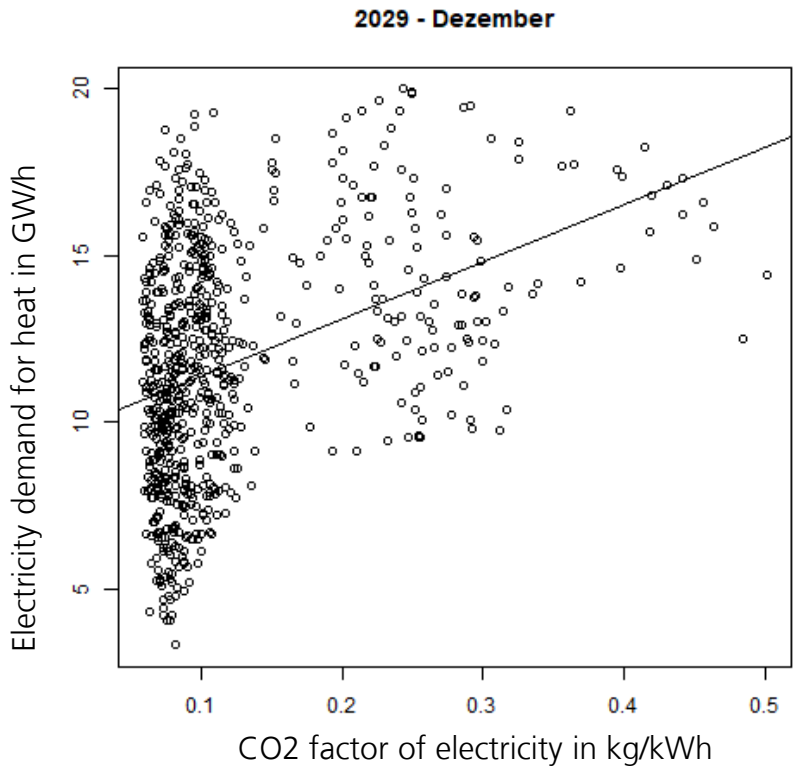
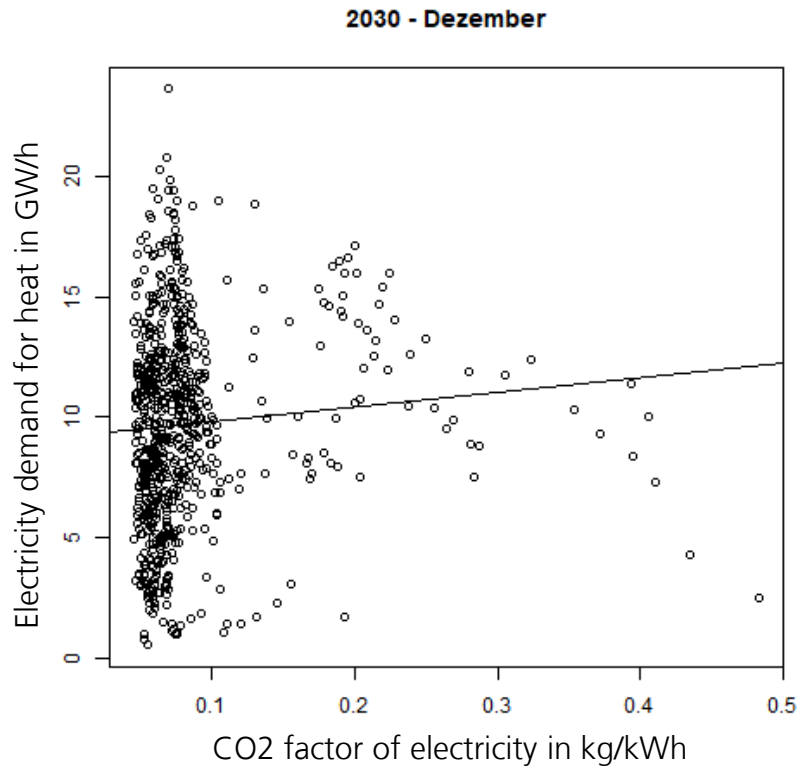
Hourly CO2 factor of electricity and heat pumps

December







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Thank you for your kind attention!

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