Energy policy scenarios for the German transformation pathways of the energy system by 2030 and 2045

A model analysis with the energy system model REMod

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Topic of this talk

Energy policy scenarios for the German transformation pathways of the energy system by 2030 and 2045

- Natural gas supply and energy prices have changed due to geopolitics.

➢ How do modelled transition pathways to 2045 (net zero) change under the current developments?

➢ Do we have to change our transformation strategies?

Destroyed North Stream pipeline for natural gas

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Recent central political and economic discussions on German energy strategy

Background

The long way from -40%-CO2 in 2023 to Net-zero in 2045

- How fast can we build up renewable energy capacity (wind and solar)?
- What is the role of hydrogen in the future energy system? (also where does it come from)
- How to transform the industry and heat supply (electrification, district heating, hydrogen)?
- How and how much do we import and transport energy/electricity (grid expansion, import countries, …)?
- How do we make the system smart and flexible? (-> communication, markets, smart meters)
- How do we overcome the resistance of the “old economy” towards the transformation? (losers & winners)
- And of course: what are the best-suited, politically and socially accepted measures to facilitate/accelerate the transformation?

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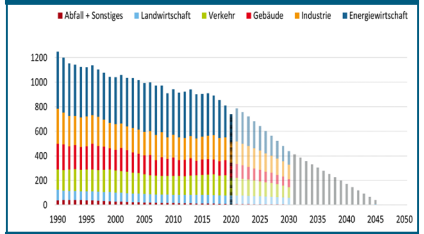
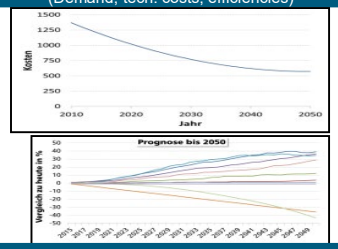
REMod – Cross-sectoral energy system model

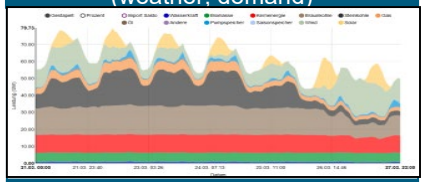
CO_2-target(-65 / -100%)



Data input
(Demand, tech. costs, efficiencies)



Hourly profiles
(weather, demand)

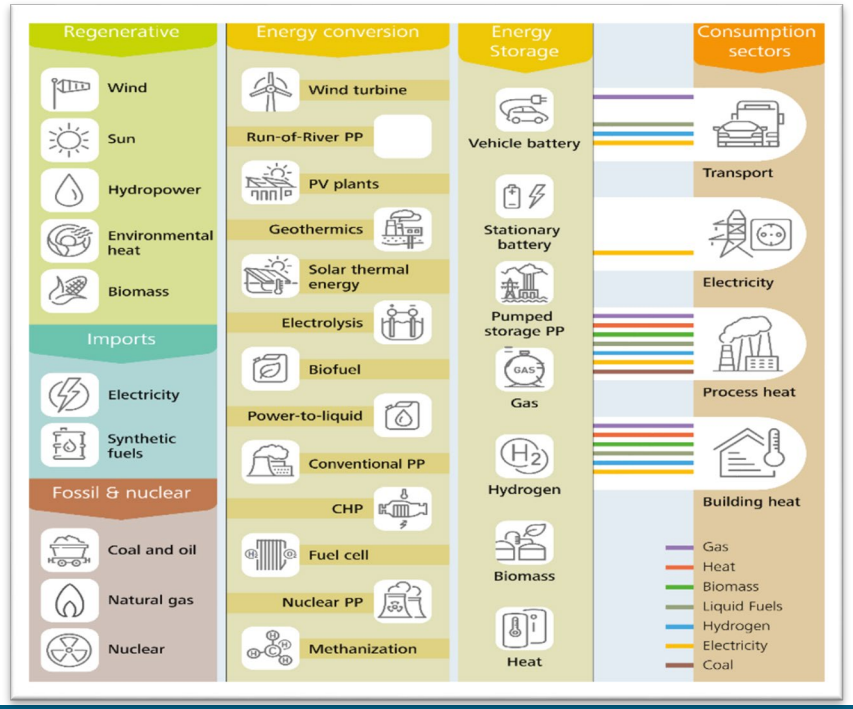


Energy converters today
(all sectors)

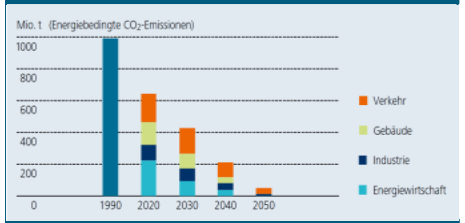
Core of the model

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

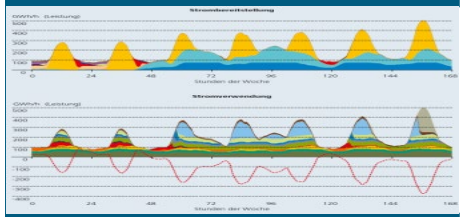
All energy sources, converters, storages and consumption sectors.
Target function: Minimization of total system costs
Boundary conditions: Security of supply and CO_2 emissions



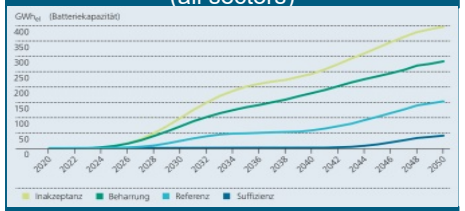
Decarbonisation per sector



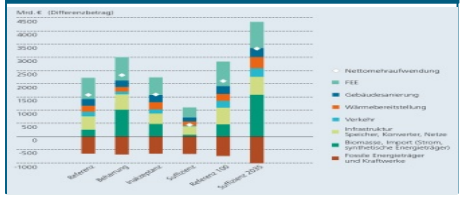
Sector-coupled operating results



Energy converters until 2050
(all sectors)



System costs of transformation



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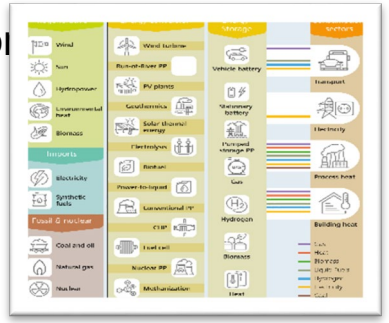
Energy System Model REMod

An optimization and simulation model to analyze transformation pathways of the complete energy system

Advantages of REMod



- ✓ Optimization of the structure of supply and demand in all energy sectors (electricity, heat, industry, transpo
- ✓ Simulation of the hourly operation from today to 2050 (temporal energy balance)
- ✓ Use of five different historical weather years in each transformation path (robustness)
- ✓ Parallel optimization of all sectors incorporates a high value for sector coupling (electrification, Power-to-X)

REMod is applied to

- Scenarios used by the current federal government and grid development plan of the TSOs
- Industry players analyze their products in the long-term scenarios (Heat pumps, batteries, Fuel cells, vehicles,…)

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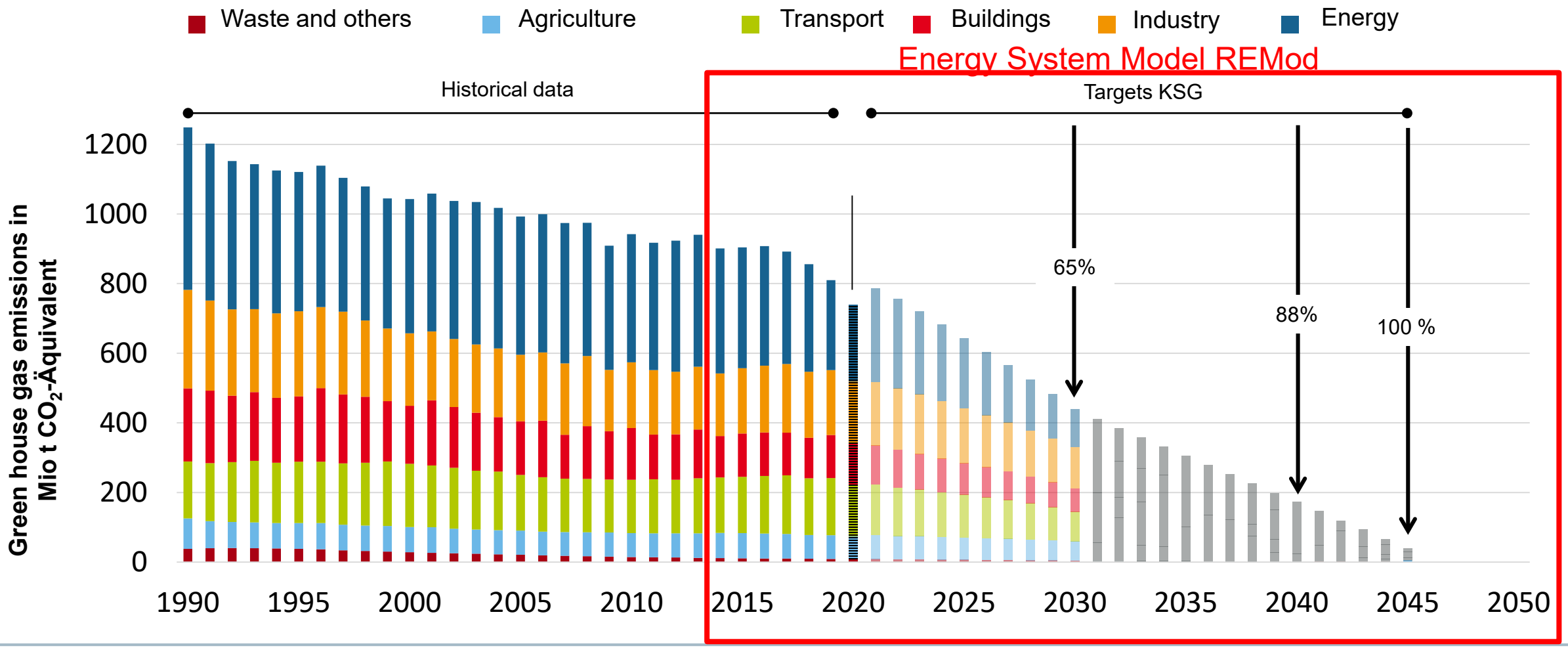
Scope of the analysis and its model

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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Change of environment: Gas supply and energy prices

Scenario assumptions

Approach:

- Compare a **Pre-2022 scenario** with a **After-2022 scenario**

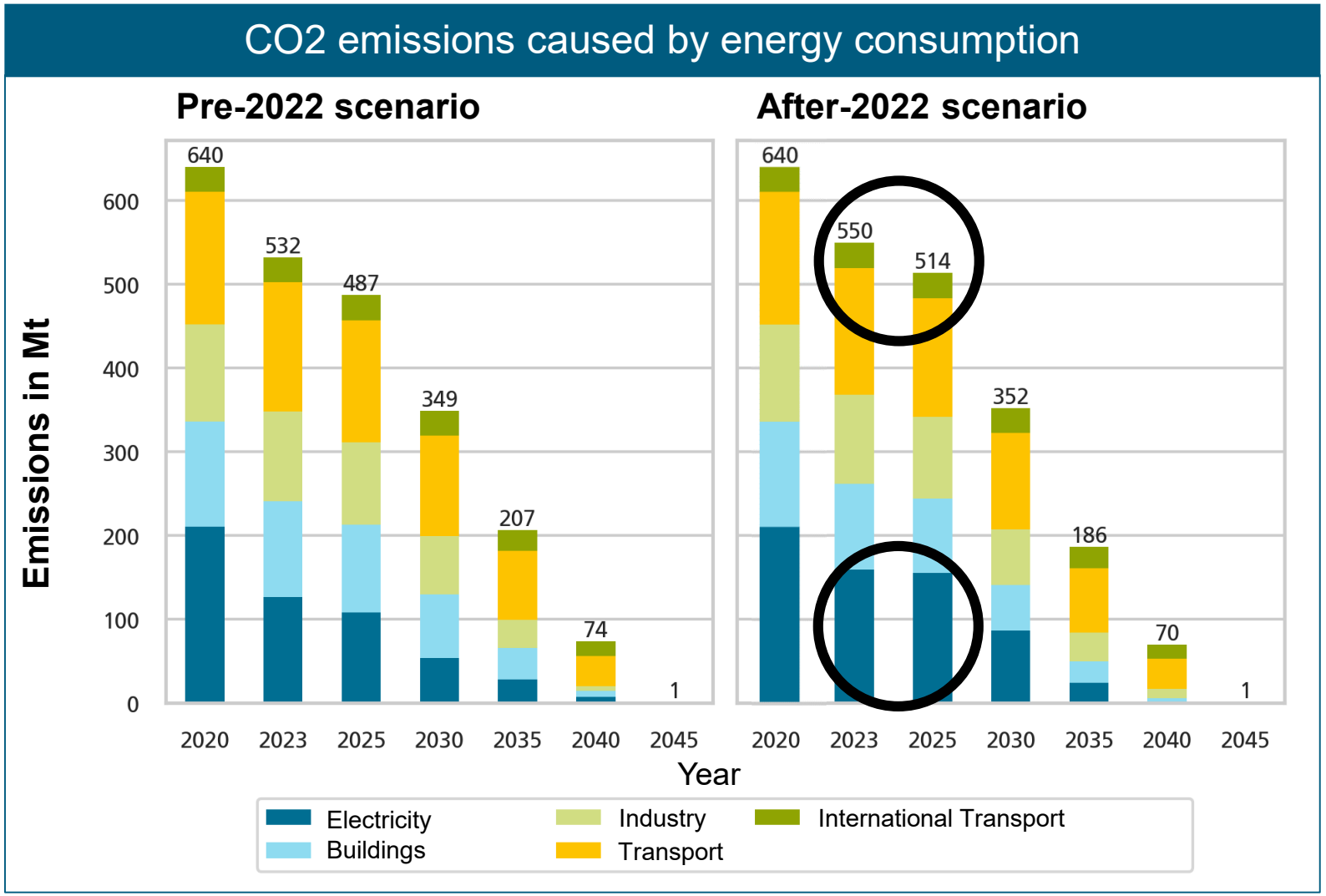
Key parameters of the After-2022 scenario:

- Higher prices for energy supply from natural gas (from about 2ct/kWh to 4-5 ct/kWh)
- Increasing price for larger volumes of natural gas
- CO2 budget is assumed to be identical (approx. 8 bn t of CO2 by 2045)

Changes influences the CO2 emission pathway

CO2 emissions until 2045

- CO2 budget is assumed to be identical
- CO2 emissions are slightly shifted to time period from 2022 to 2030
- Main reason: use of coal for electricity generation



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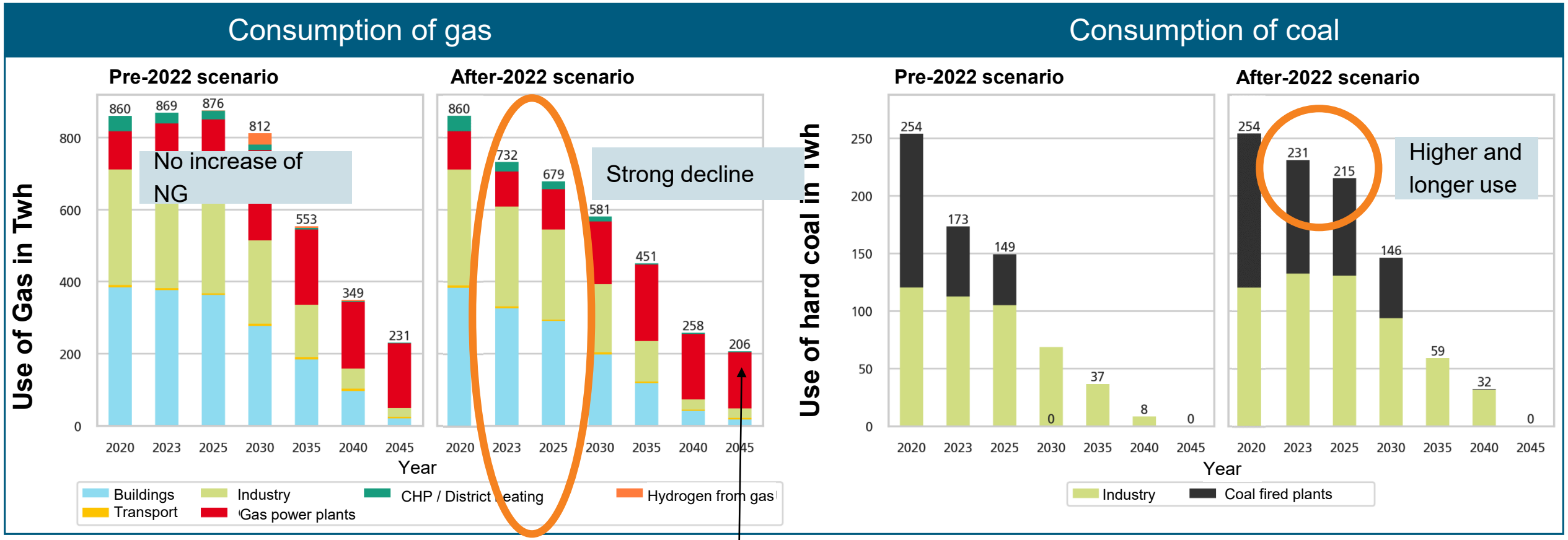
Change in the fossil fuel consumption

Use of gas (CH4) and hard coal



* In 2045, the gas is climate neutral.

Green CH4/H2 in 2045

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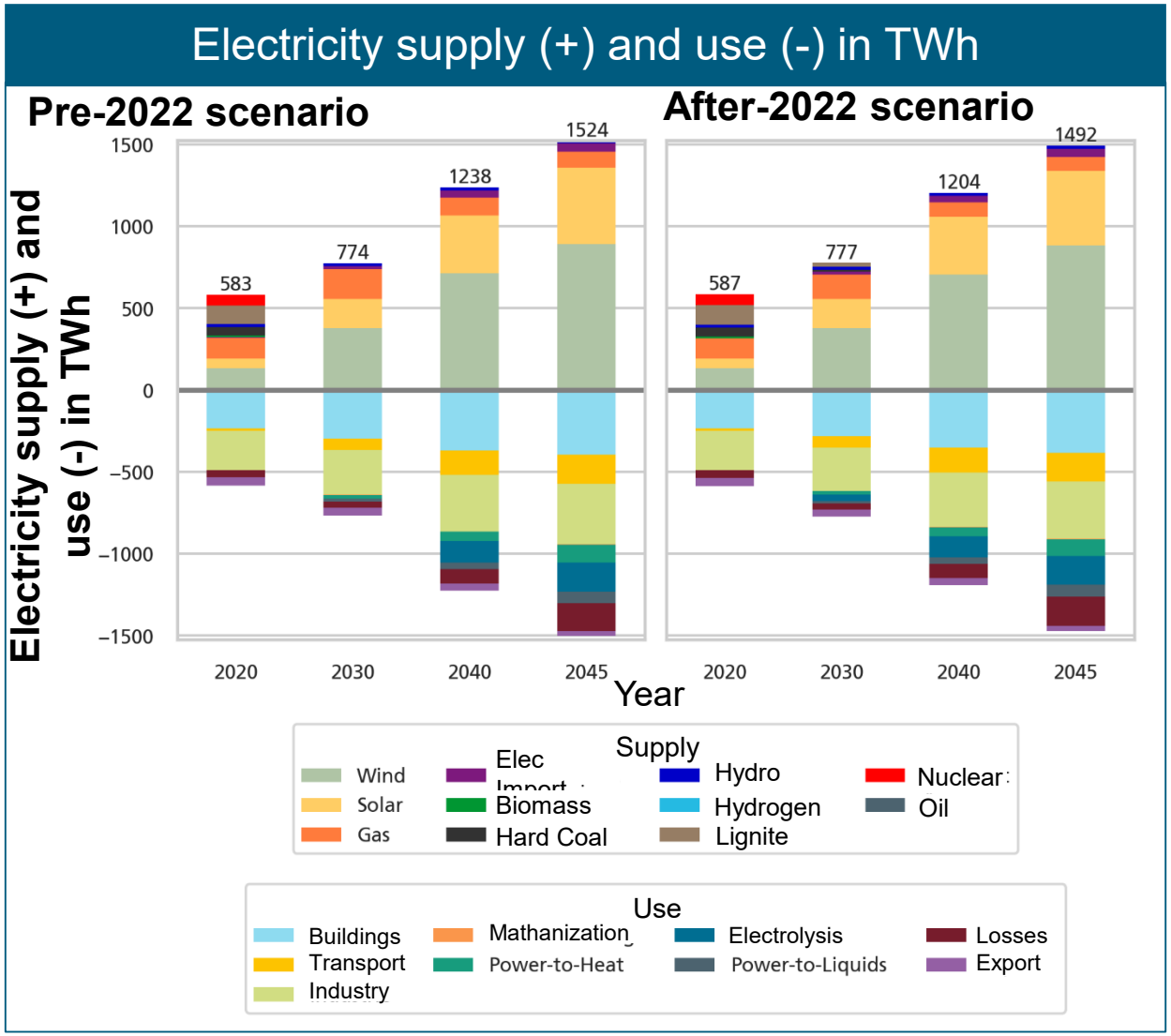
Increase of electricity supply and use

- Electrification is crucial and leads to an strong increase of supply from RES (>1000 TWh from solar and wind)
- Increase of demand in all sectors (sector coupling)
- Demand of PTX/H2 (production in GER plus imports)
- Higher prices lead to small overall reduction of electricity demand in the long-term



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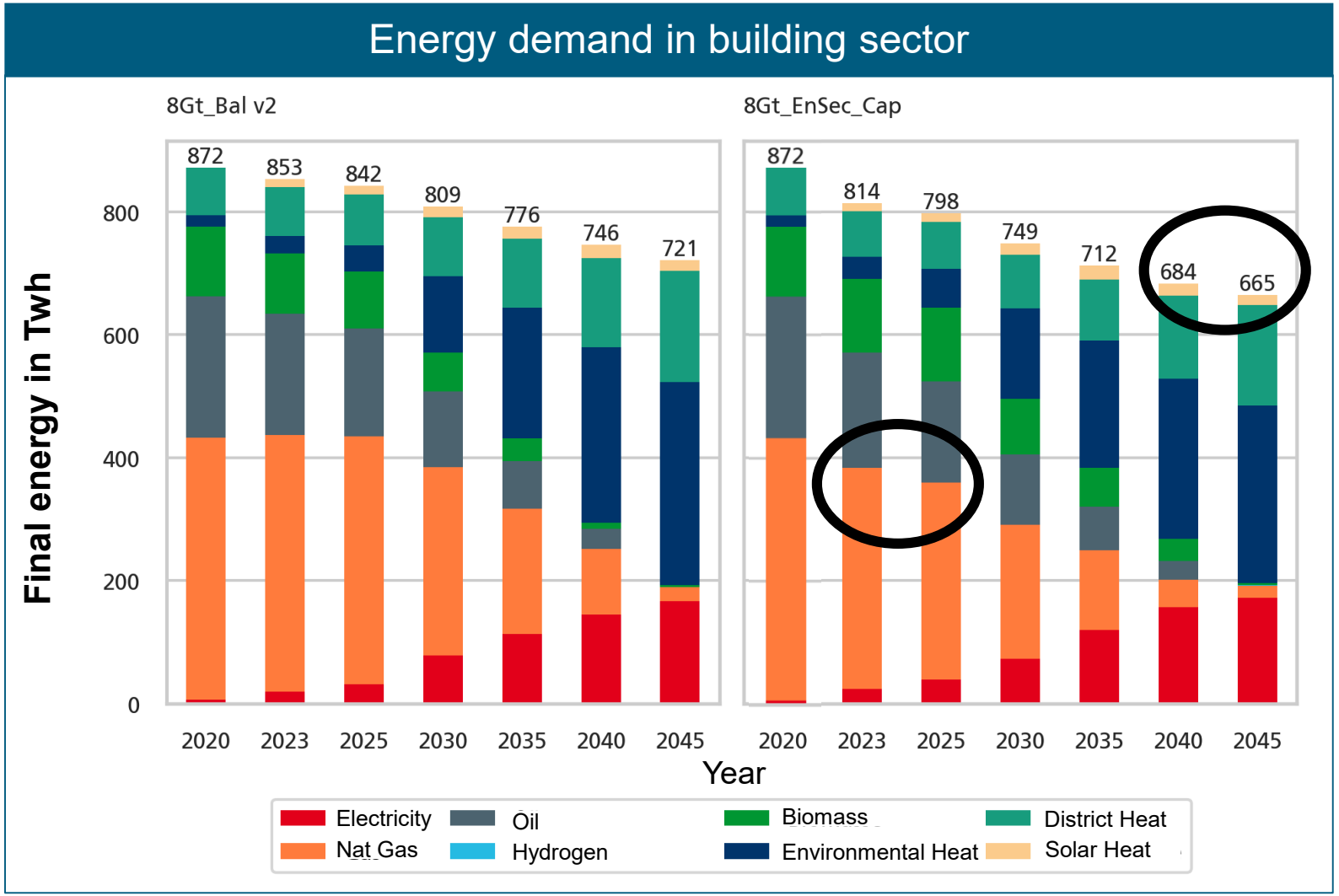
Reductions in the heating demand plus more heat pumps and biomass

Building sector until 2045

- Lower final energy demand due to higher renovation rate and reduced consumption due to higher prices
- Stronger reduction of natural gas in 2025 and 2030
- More heat pumps and biomass/biogas



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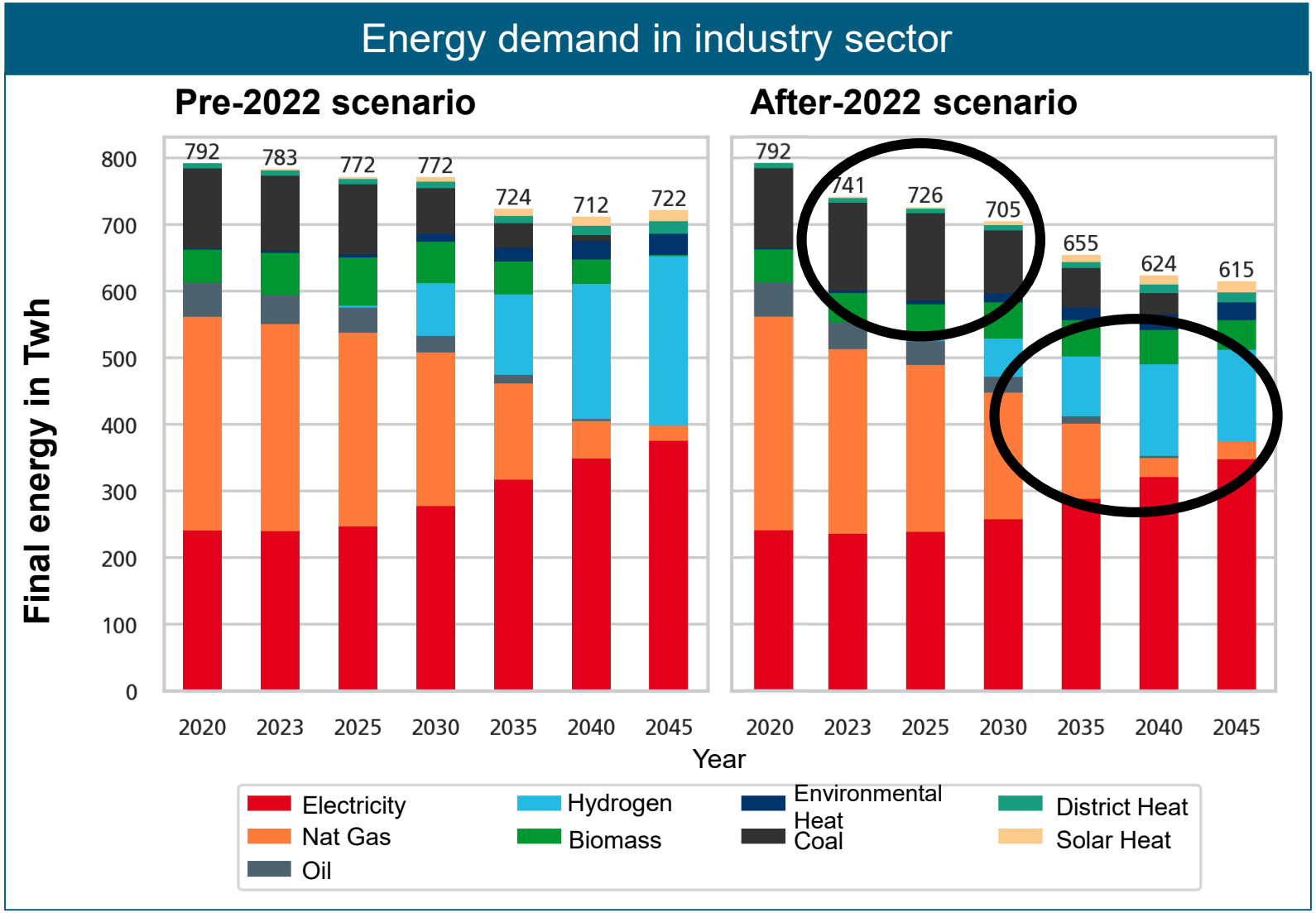
Different choices in the industry

Industry sector until 2045

- Energy consumption decreases
- Coal extends it use in terms of time
- Hydrogen is used less as role of natural gas smaller and demand also



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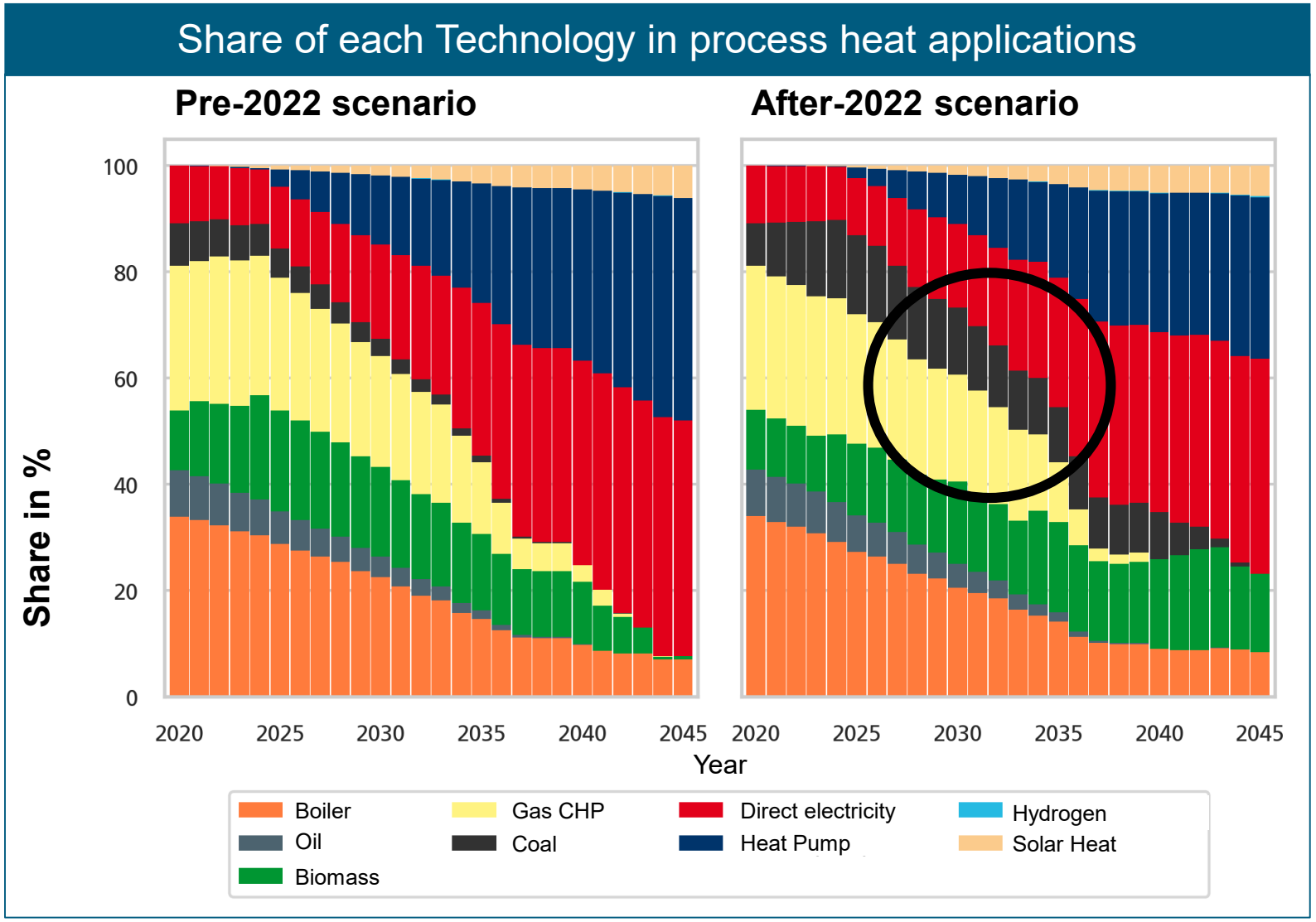
Different choices in the industry

Industry sector until 2045

- Coal and biomass with higher share in the technologies



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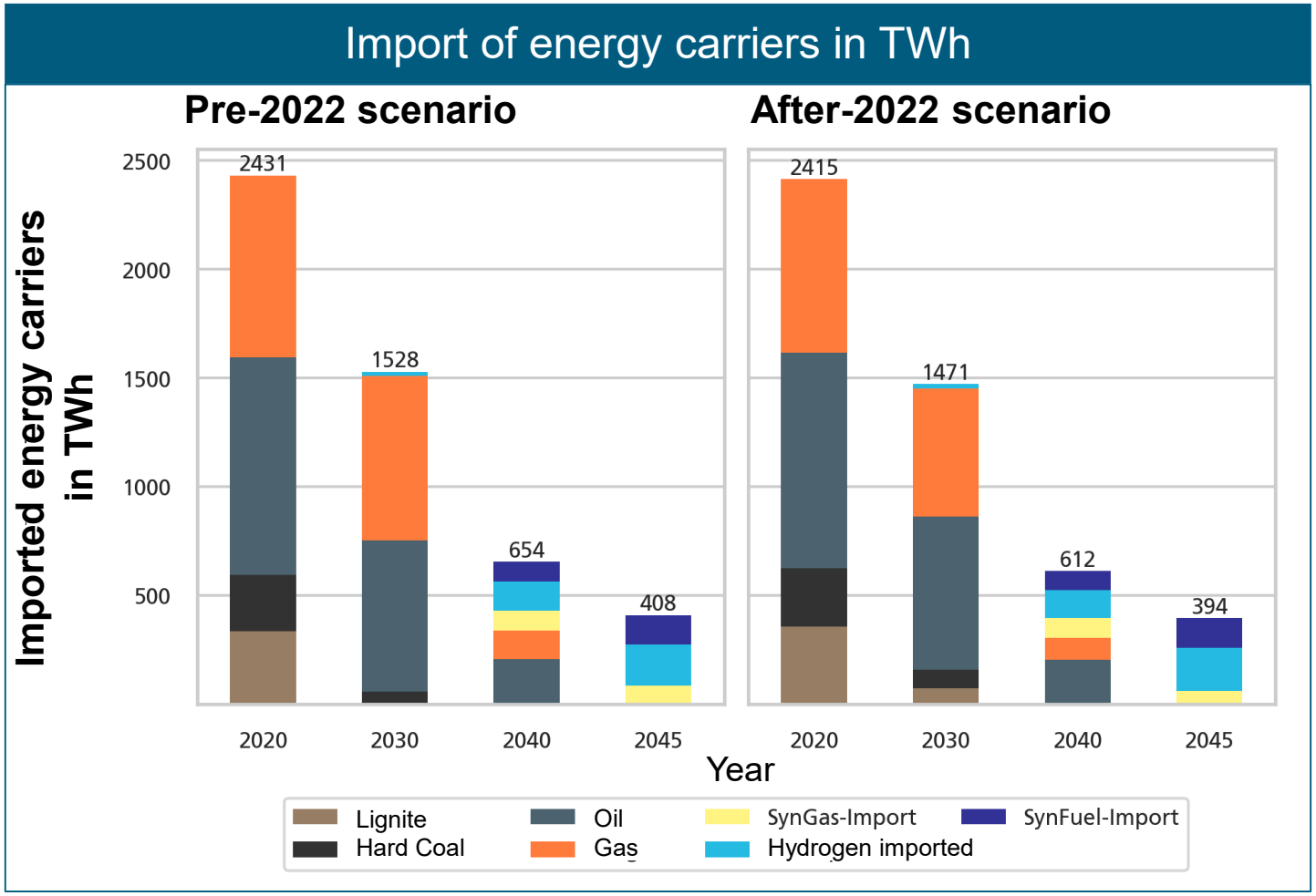
Import dependency is reduced for natural gas and slightly for e-fuels/H2

- Import of synthetic energy carriers produced in other countries remains relatively small compared to imports of conventional energy carriers in the past



* Lignite is not imported today

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What can be concluded from this analysis?

- Short-term and long-term transition pathways are slightly changed. (use of coal, less natural gas, more CO2 in 20s)
- Price and availability of natural gas lead to demand reduction.
- Impact on use of hydrogen and imports.
- Higher prices might reduce potential for investments in sustainability (but this is included in the model).

- In general strategies are not changed but must be adapted slightly.
- However, “pre-2022 strategies” (e.g. natural gas bridge actually did not exist, expansion speed of many technologies) were not in line with the targets. So, these pre-2022 strategies must be adapted to a “climate neutral strategy”.

Thank you for your kind attention!

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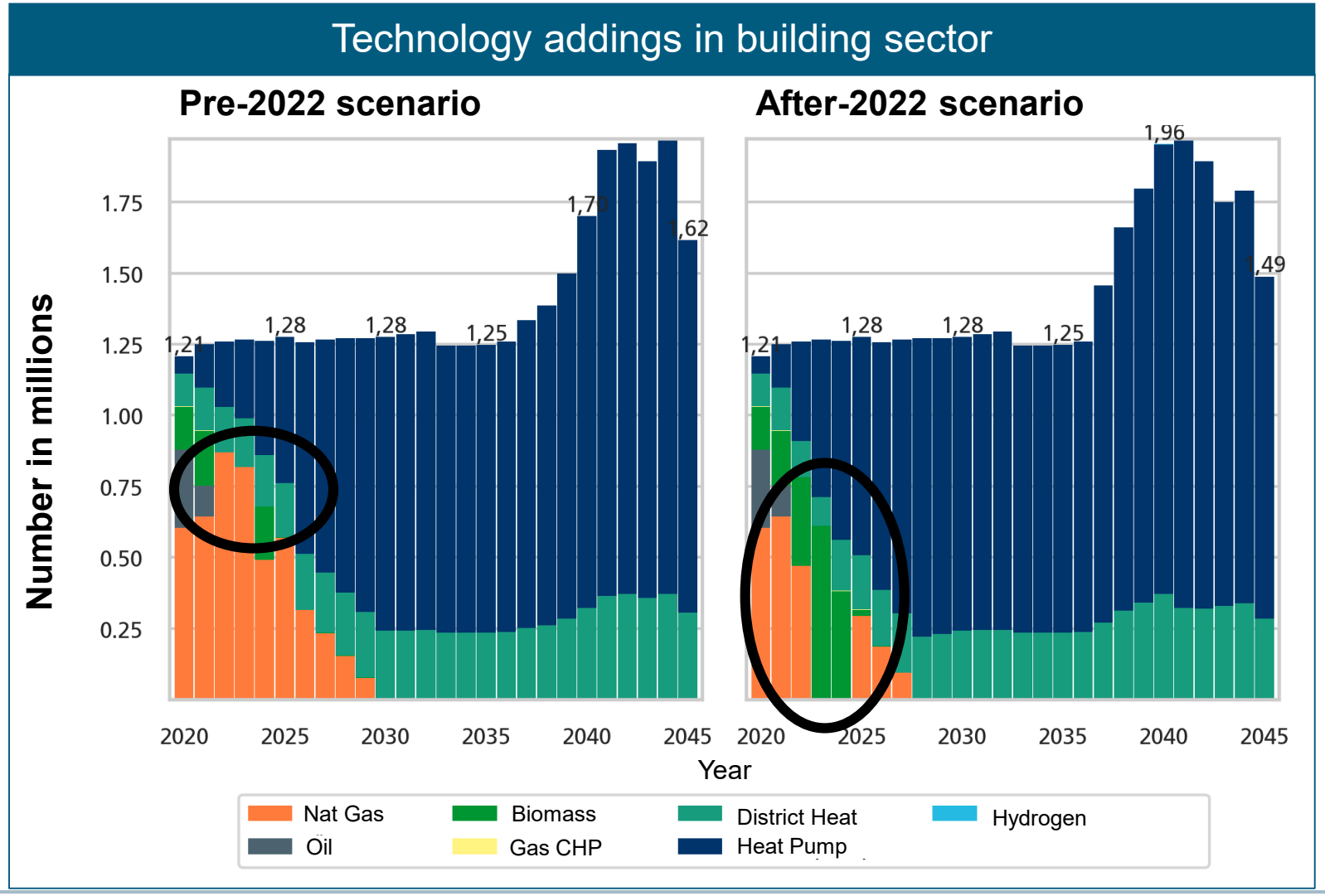
Strong change of technology preferences in the short-term

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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