CORALIS Workshop, 19th December 2022

Pathways to deep decarbonisation of the industry sector: Potentials and challenges for chemicals and steel production

Dr. Andrea Herbst, Dr. Matthias Rehfeldt
Fraunhofer Institute for Systems and Innovation Research ISI

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INDUSTRY IS RESPONSIBLE FOR ABOUT 23% OF GHG EMISSIONS IN GERMANY

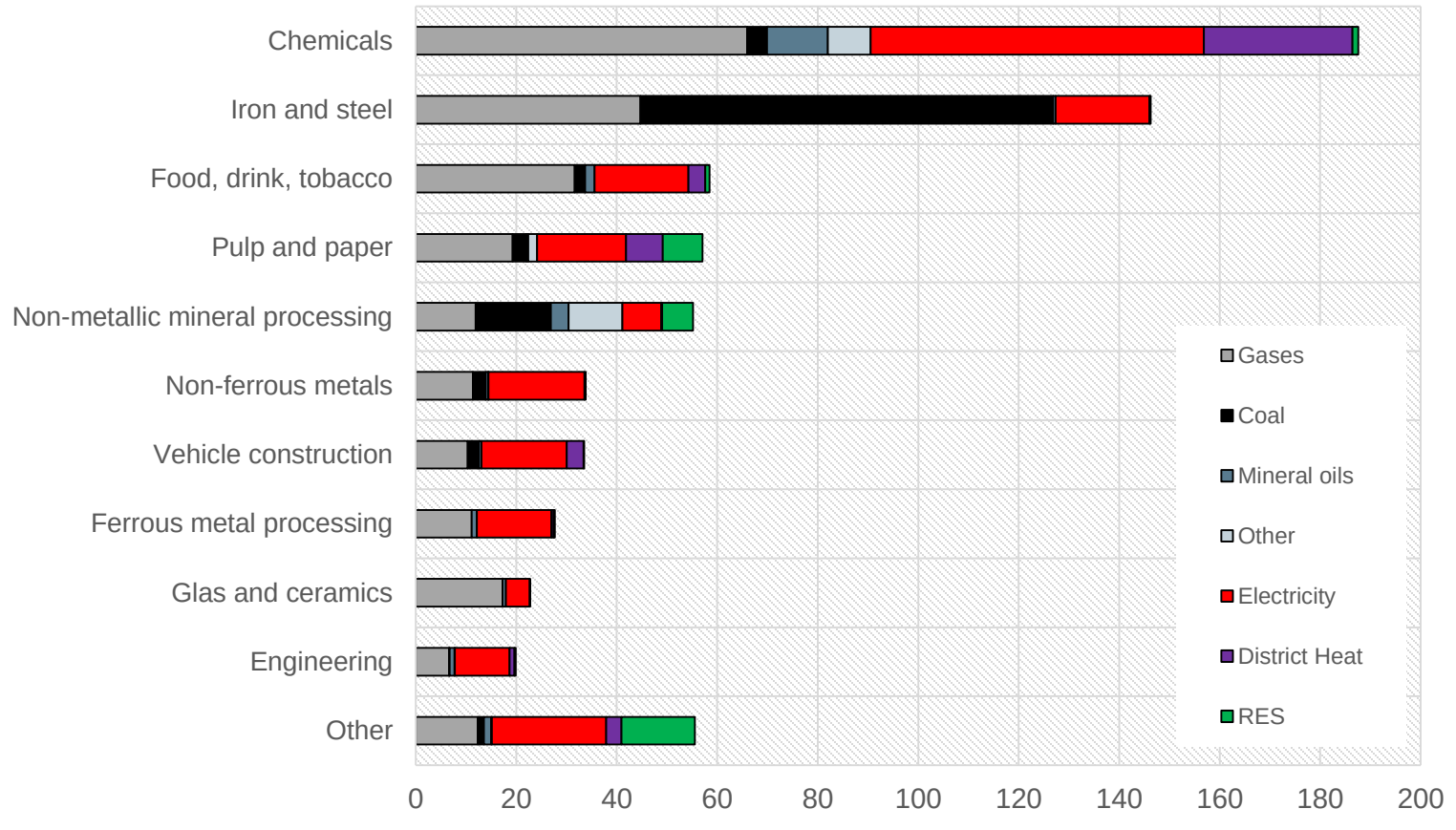
70 % of industrial energy demand is generated in energy-intensive industries

118 Mt-CO2eq. in 2030 as interim target for industry
Reduction of ~57 percent compared to 1990

Technology paths and political framework still under discussion

One third of industrial FED is covered by **natural gas today + feedstock**

German industrial final energy consumption by economic sector (2019) [TWh]



Source: AGEB 2020, own illustration

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ALTERNATIVE PATHWAYS TO A NEAR CARBON-NEUTRAL INDUSTRIAL PRODUCTION

All GHG-neutral Scenarios

- GHG reduction in the industrial sector >95%.
- Ambitious energy and material efficiency + high shares of secondary production
- Avoid use of biomass in technology focus scenarios
- Avoid large scale CCS

Mix

- No clear technology focus

Electrification

- Direct electric solutions preferred
- Hydrogen as feedstock

Hydrogen

- Hydrogen widely available
- Use preferred in terms of energy and feedstock

E-Fuels

- Synthetic methane widely available
- Preferred for energy and feedstock

EnSov

- “Natural gas bridge" is called into question
- Loss of confidence in natural gas as a reliable energy source
- Changes in the production and investment behaviour of companies

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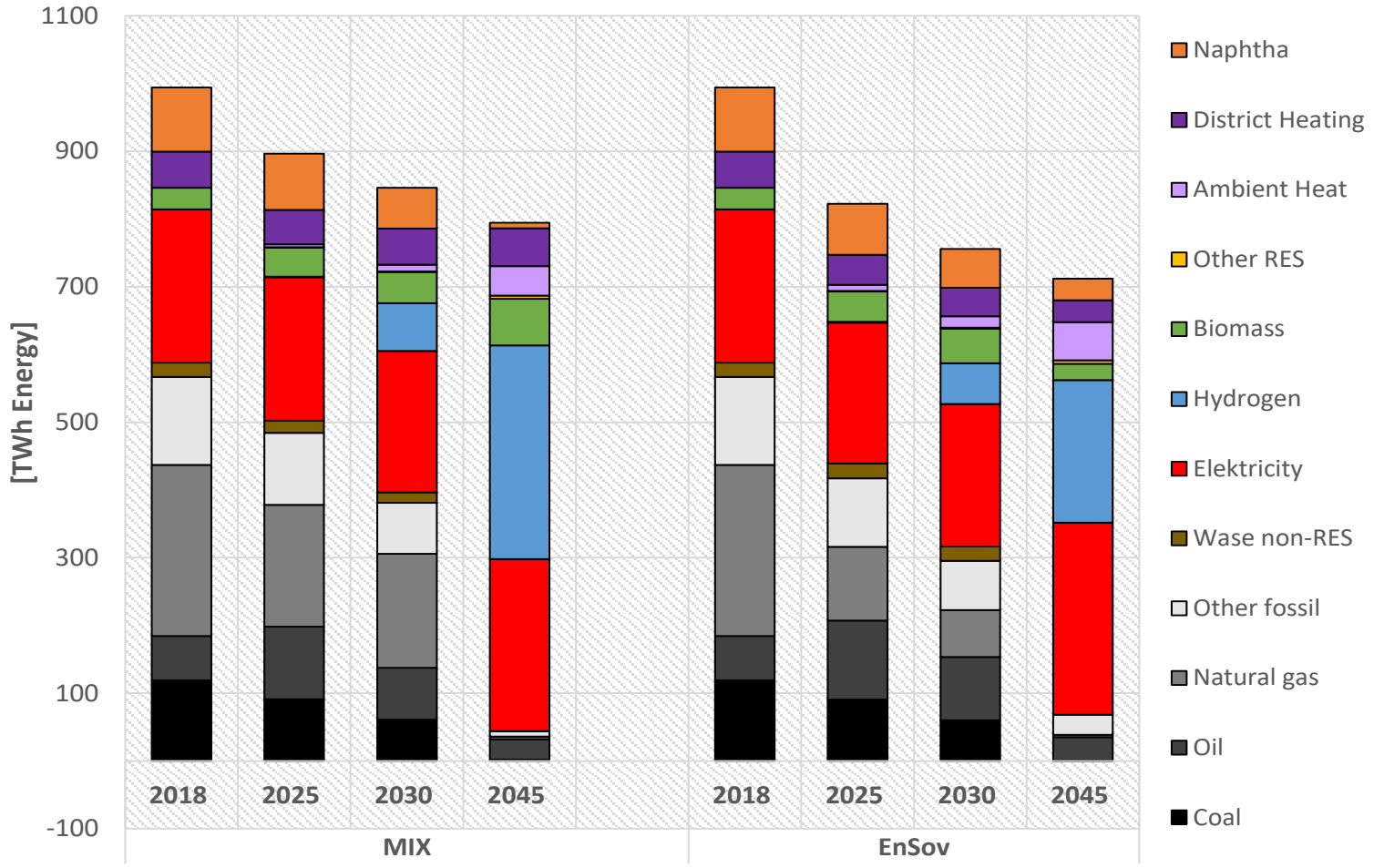
INDUSTRIAL TRANSFORMATION REQUIRES HIGH VOLUMES OF CO2-NEUTRAL ENERGY CARRIERS

Energy & material efficiency, circular economy and CCU/S

Industrial energy consumption: energtic and feedstock MIX & EnSov (DE, 2018-2045) [TWh]



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Energy and material efficiency, especially activity effects

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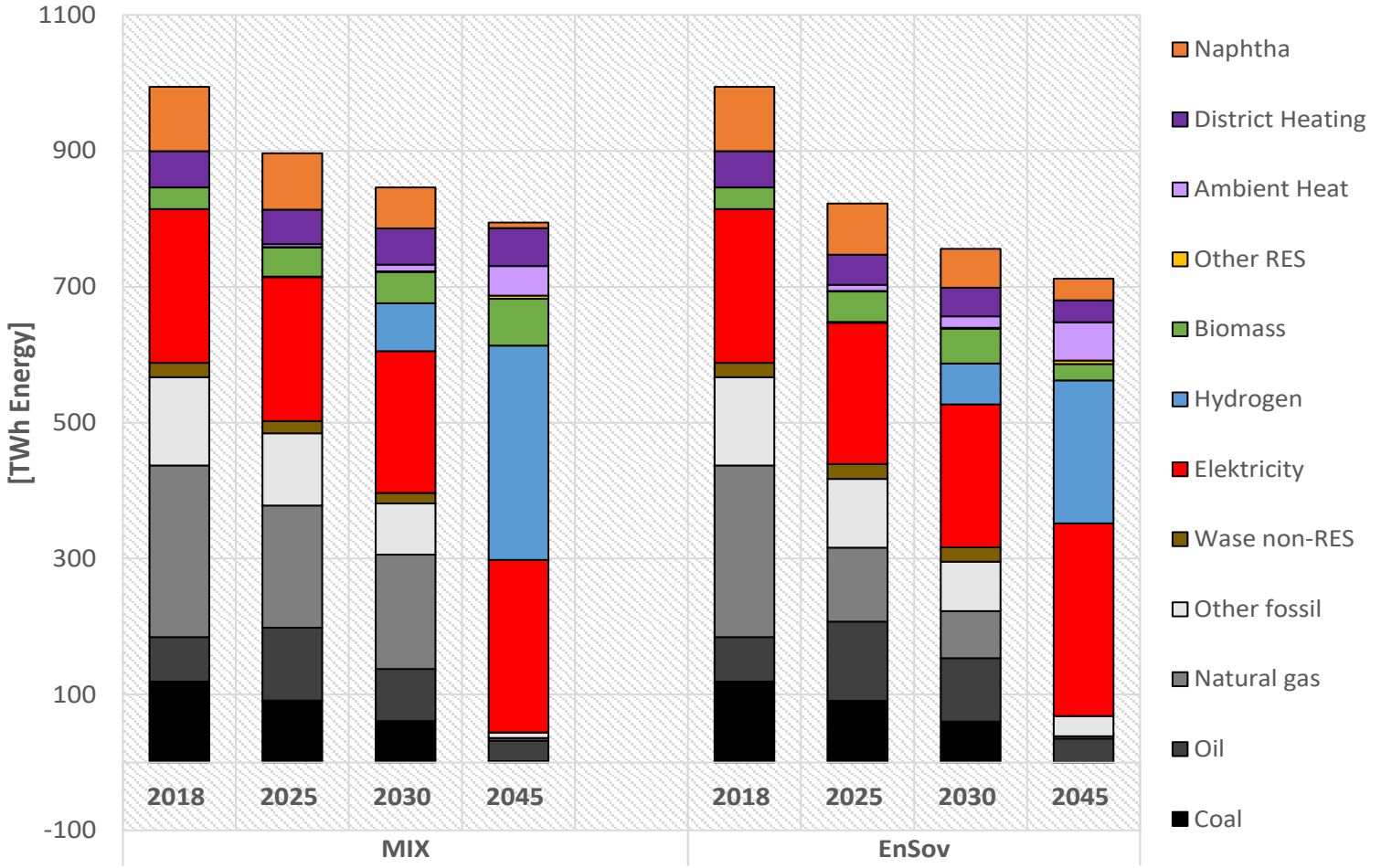

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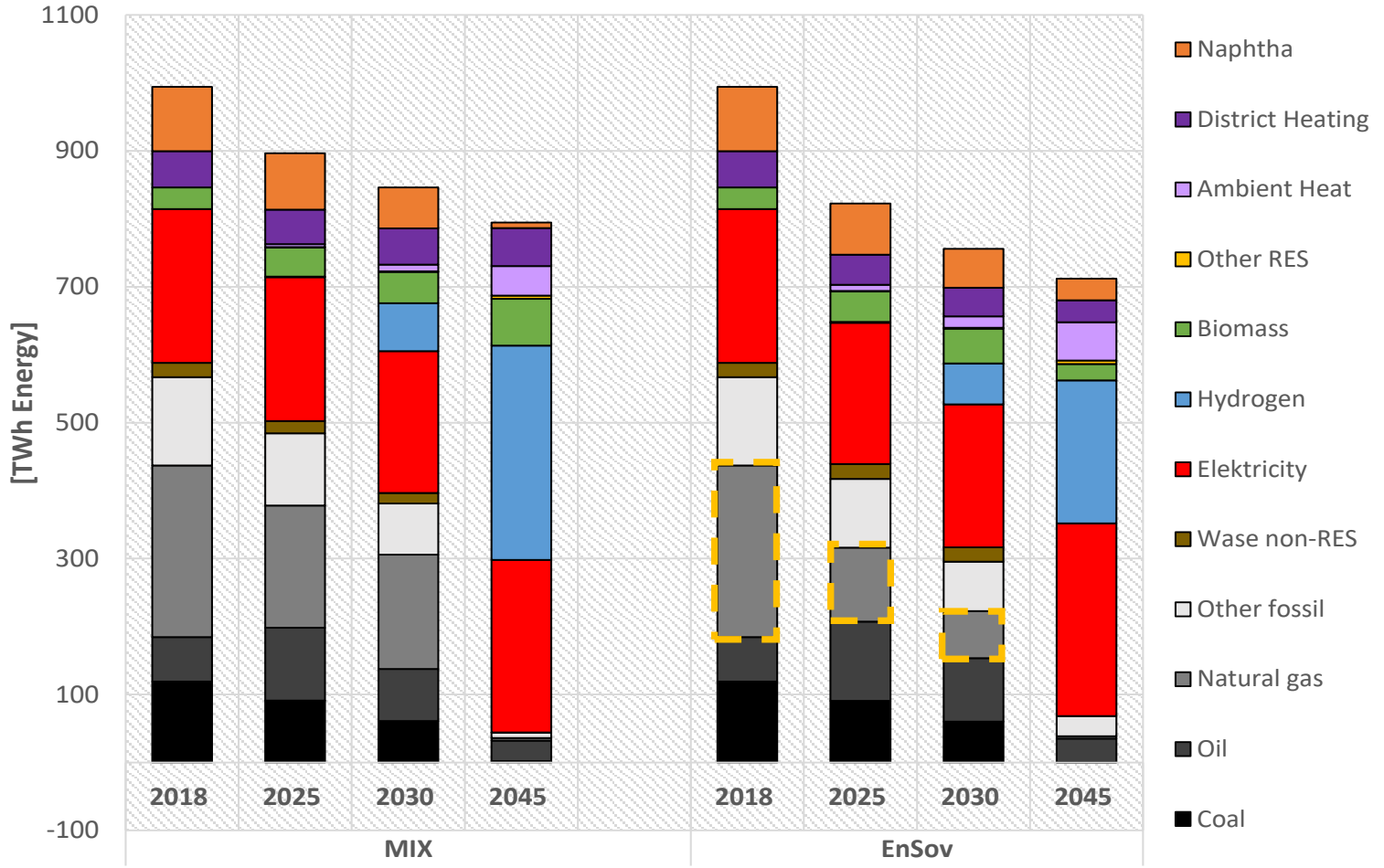

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Evasive movement to oil & biomass

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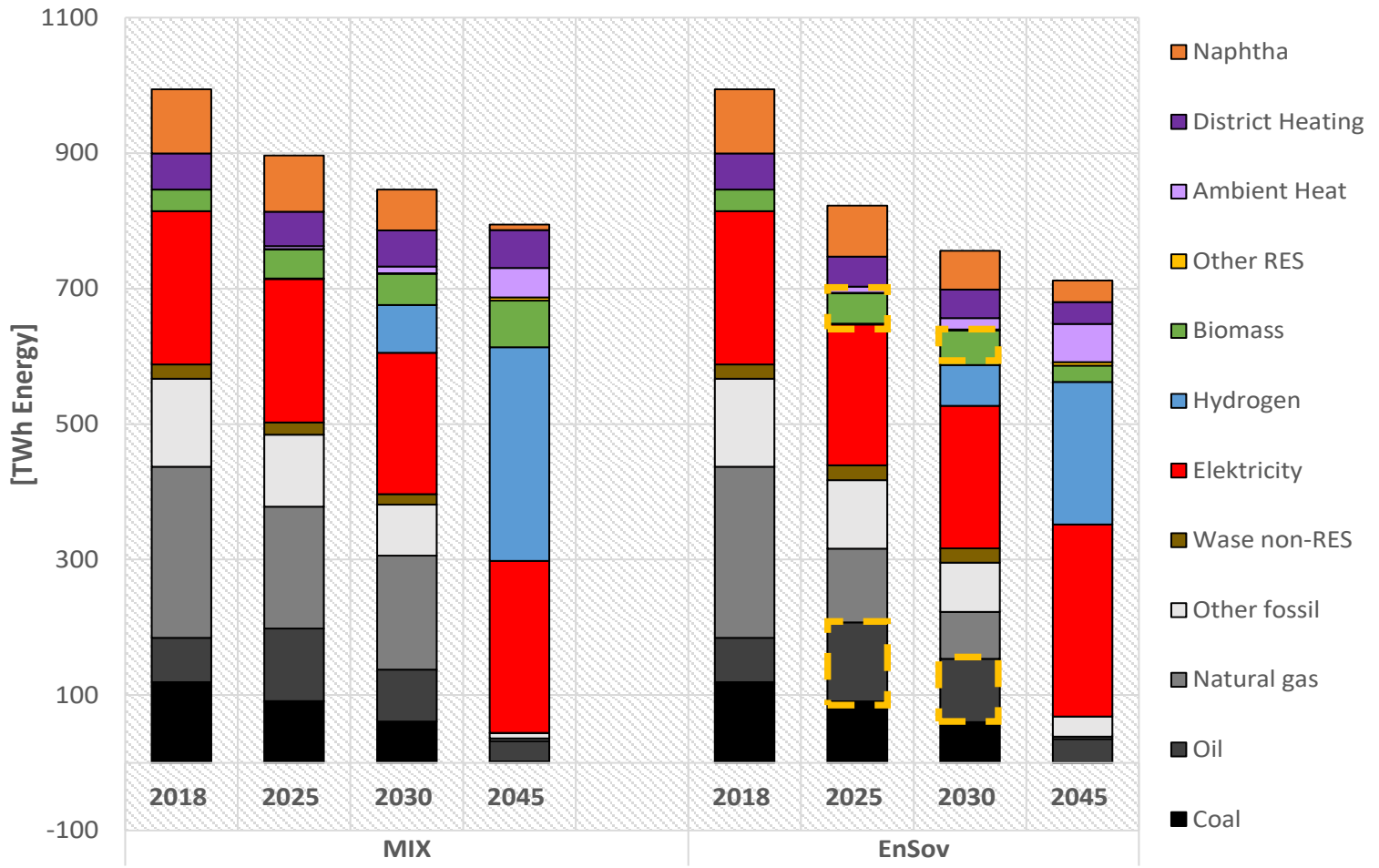

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Electrification
Faster electrification of process heat hybrid-systems, partial-electrification

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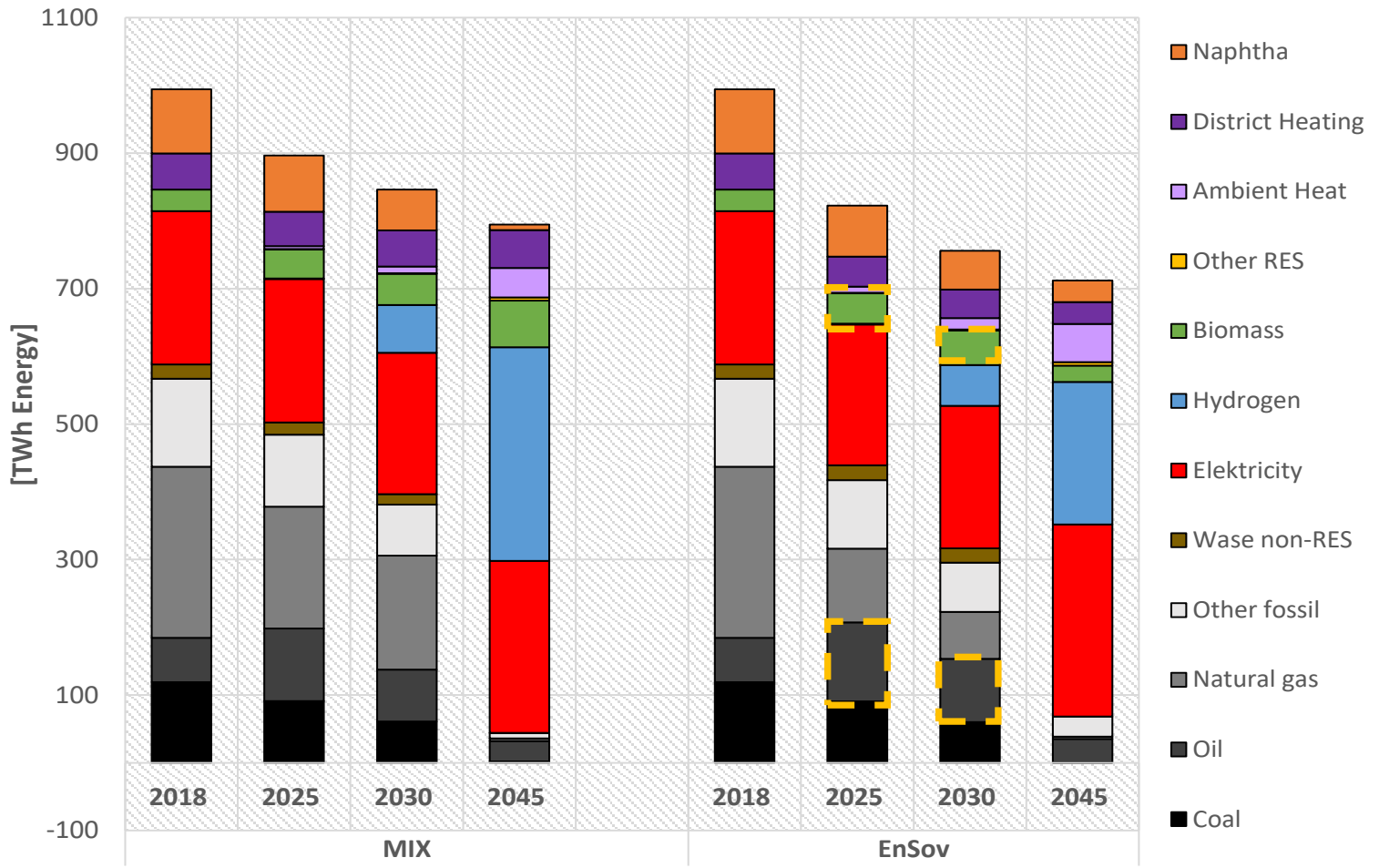

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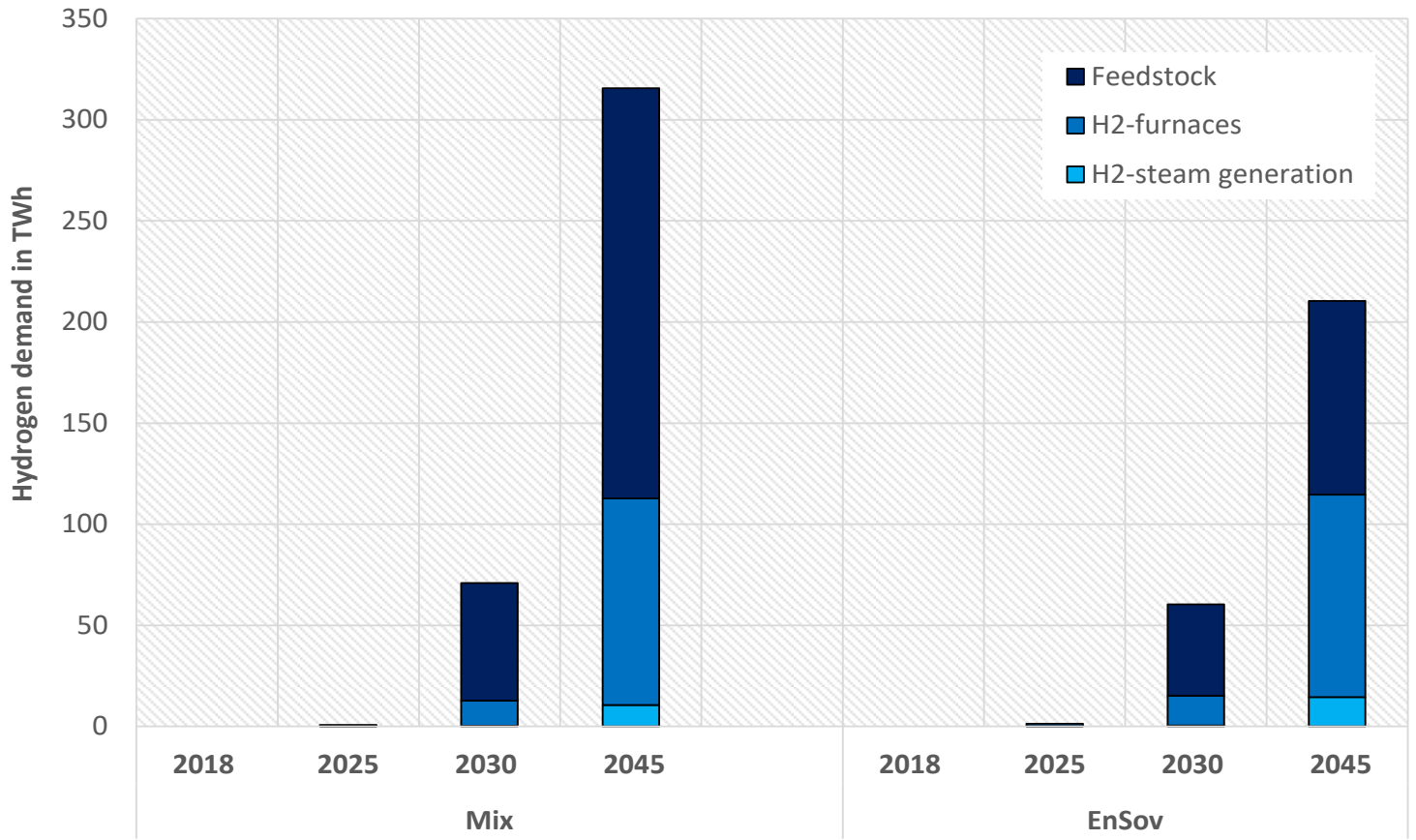
ROBUST HYDROGEN DEMAND IN THE STEEL AND CHEMICAL INDUSTRY

MIX Scenario in 2045

- **Steel:** ~50 TWh in 2045
- **Chemical feedstock:** ~200 TWh
- Demand distributed among **few industrial locations**

Hydrogen demand by end-use and scenario (2018 – 2045) [TWh]



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Use for remaining process heat

- **Furnaces:** ~50 TWh
- **Steam:** ~ 10 TWh

=> 316 TWh total hydrogen demand

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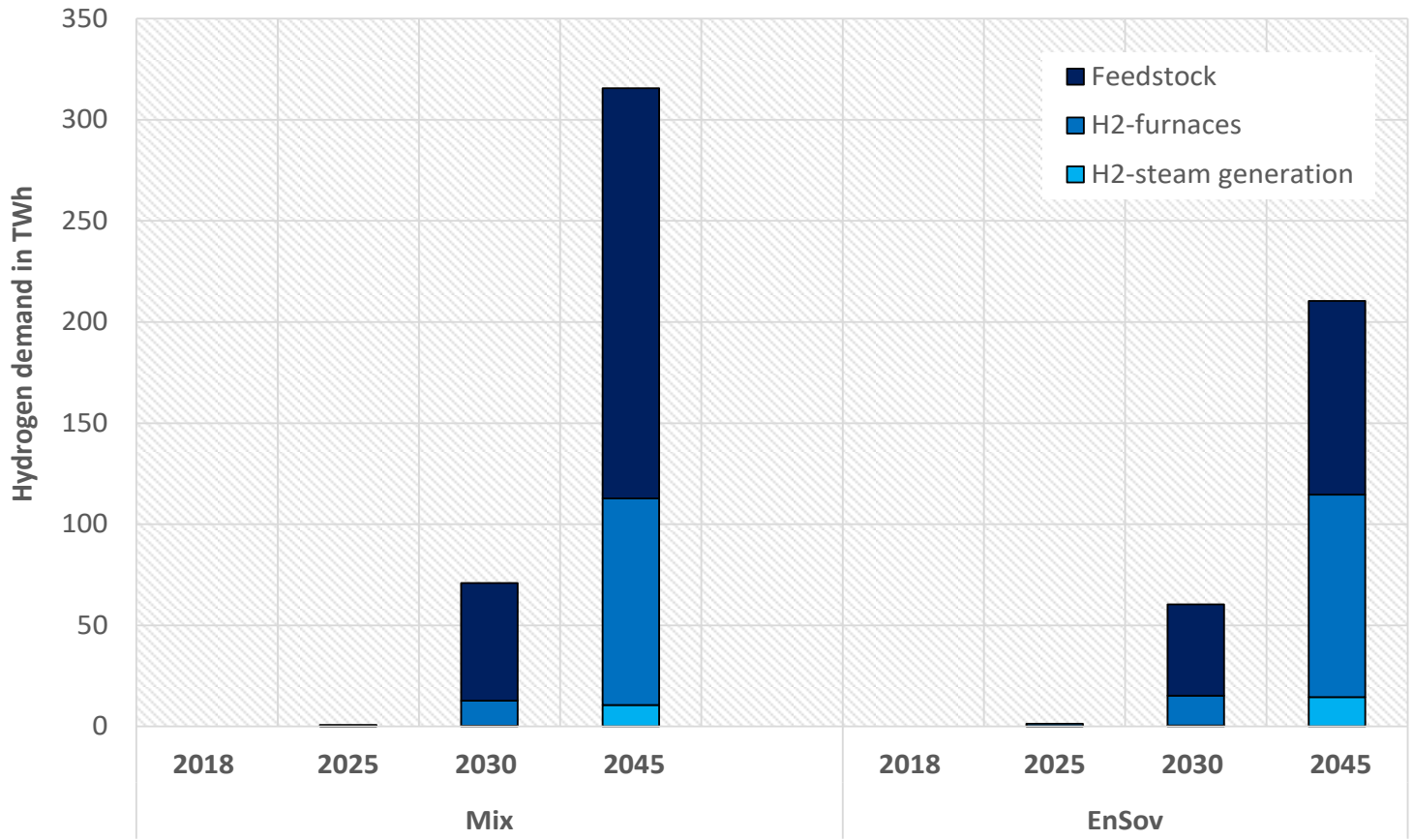

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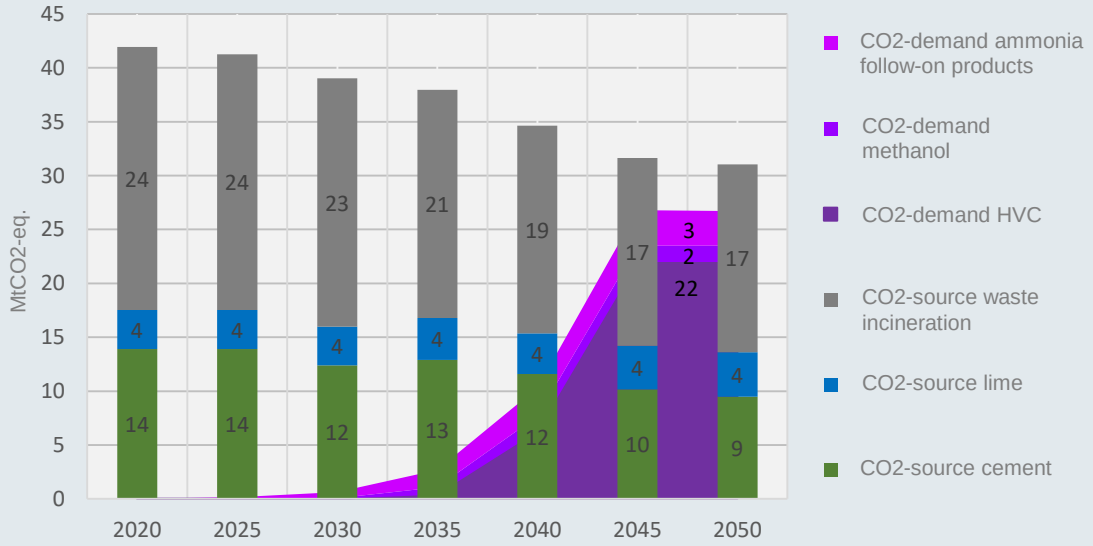
CO2 BECOMES RAW MATERIAL FOR THE CHEMICAL INDUSTRY – CCUS STRATEGY

CO2-demand and -sources (2018-2045) [MtCO2-eq.]



~30 Mt CO2-demand for Methanol/HVC
14 sites across Germany

~30-33 Mt CO2-sources
Cement: ~9-10 Mt, 32 sites; Lime: ~4 Mt, 52 sites;
Waste: 17 Mt, 55 sites

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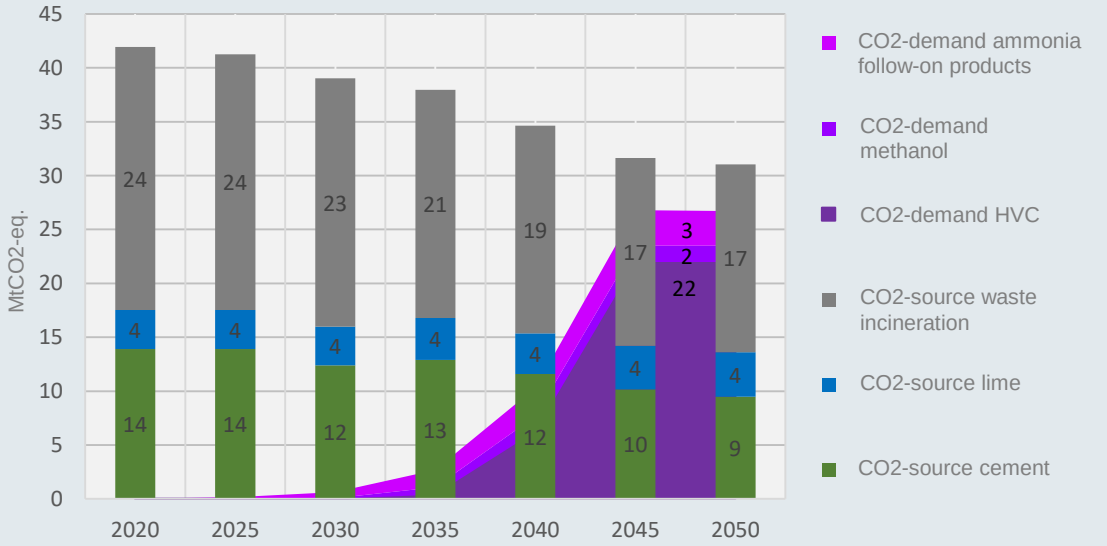

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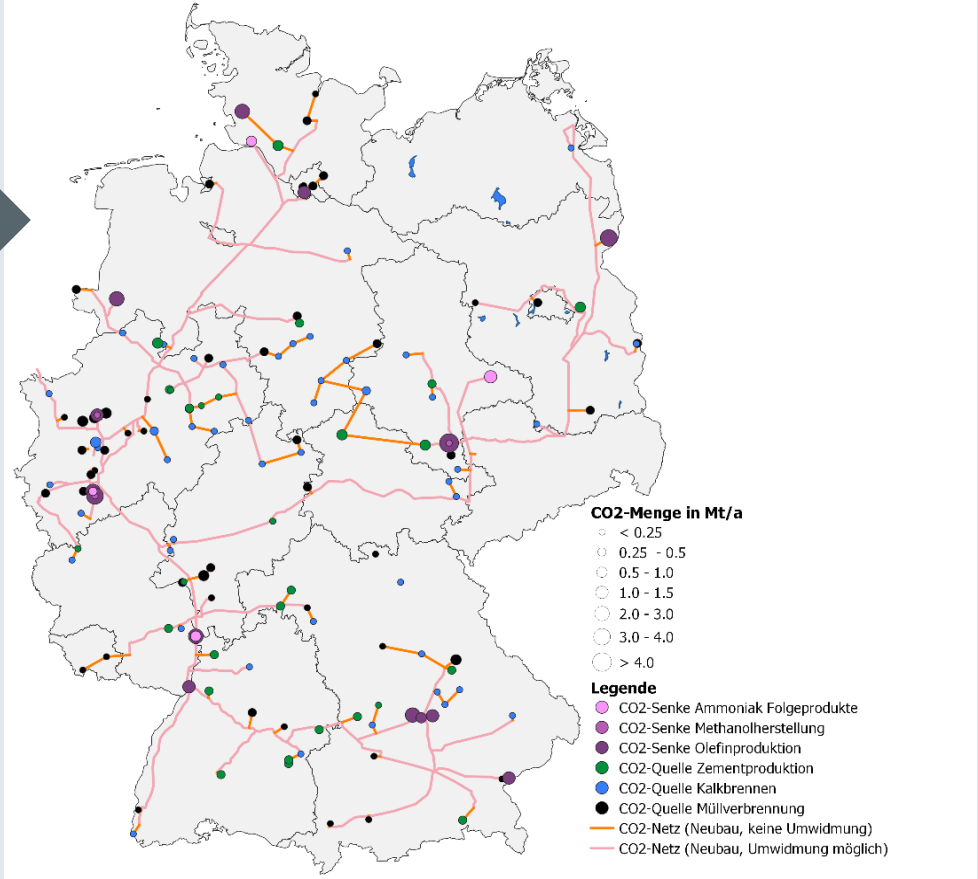

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THE GERMAN ‘INDUSTRIEWENDE’ STARTS WITH THE TRANSFORMATION OF THE STEEL INDUSTRY

FROM BLAST FURNACE TO IRON ORE DIRECT REDUCTION WITH HYDROGEN

Announcements of ~€15 bn investments:
>10 Mtpa crude steel production capacity converted to direct reduction by 2030 (~1/3 of current blast furnaces).

Potential success factors:

- **Technologies ‘available’** and tested (direct reduction of iron ore using natural gas)
- Technological **alternatives** are **more uncertain**
- **Flexible operation** using natural gas/hydrogen enables lower-risk conversion and increases security of supply
- **Support programmes** enable investments
- **Demand for green steel** is emerging, e.g. from the automotive industry
- Window of opportunity for **upcoming modernisations**

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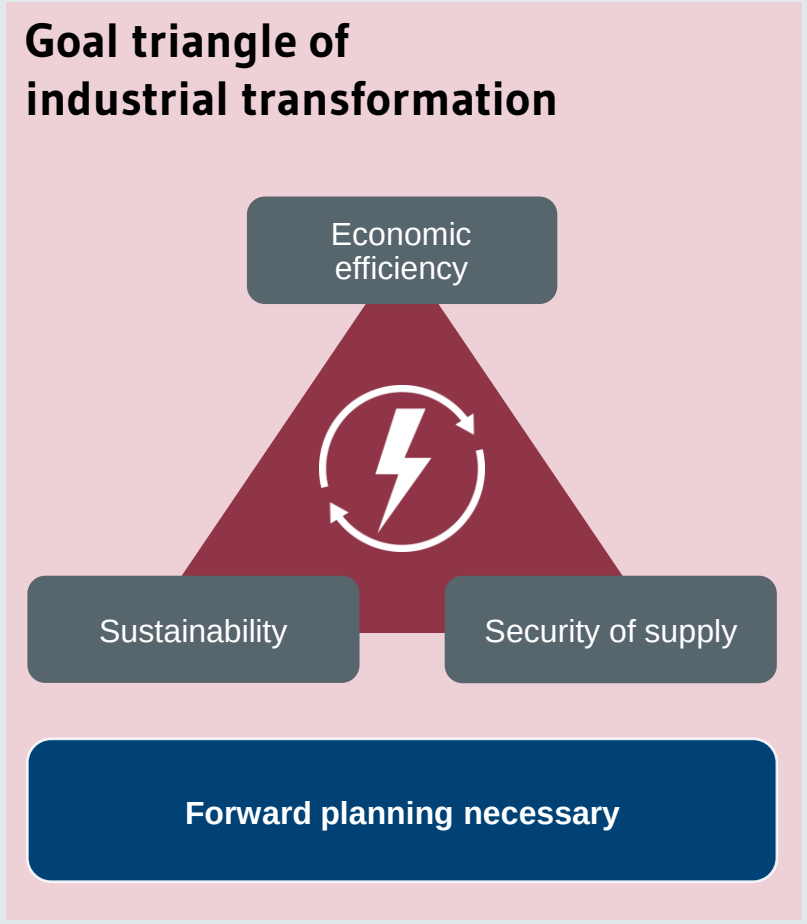

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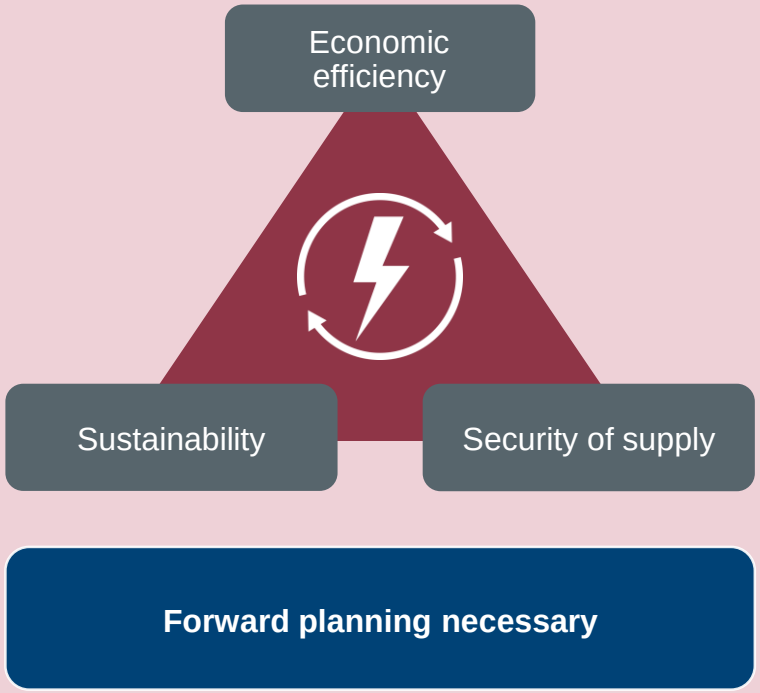
Goal triangle of industrial transformation



Early replacement:
Instruments should push the rapid entry into electrification via hybrid system concepts - e.g. through investment subsidies.

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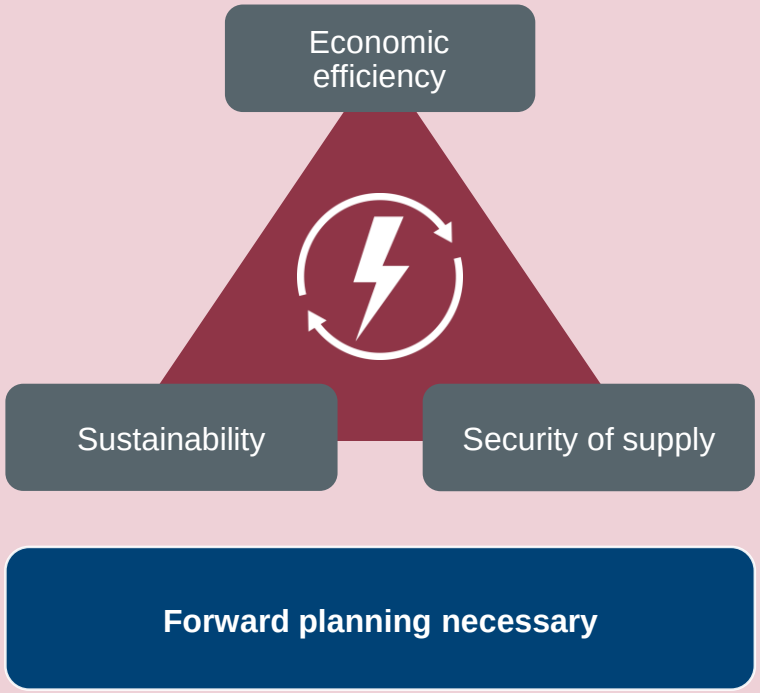

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Increasing economic efficiency of electrical process heat generation:
So that it can be chosen for the many upcoming replacement investments.

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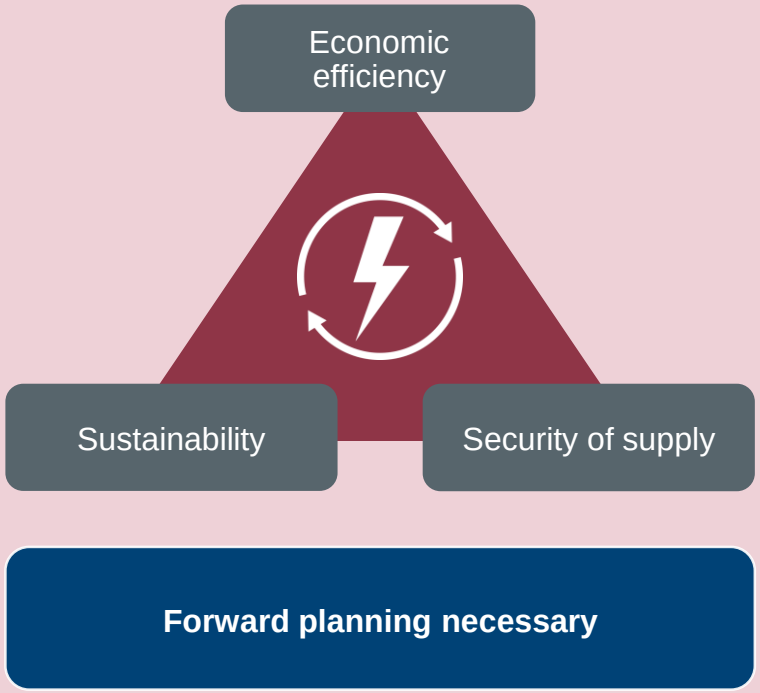

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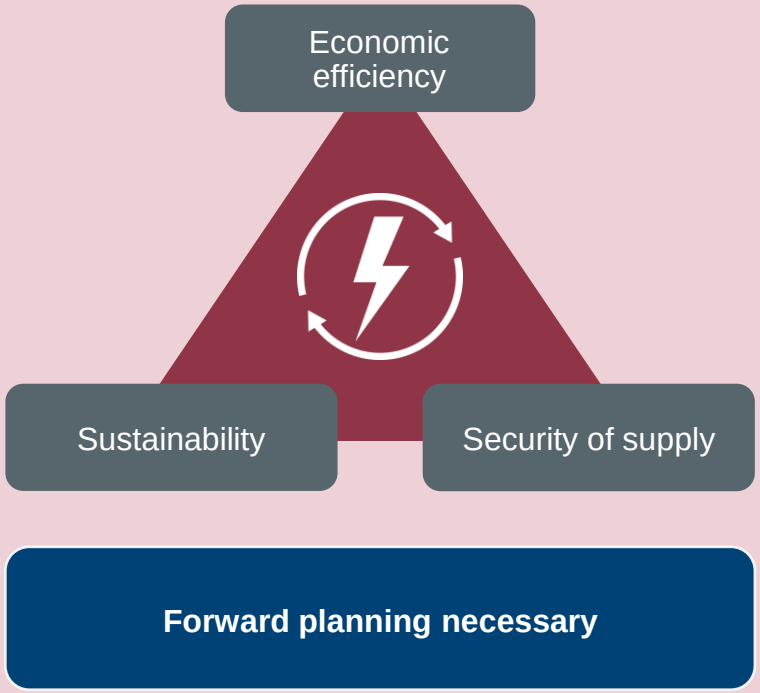

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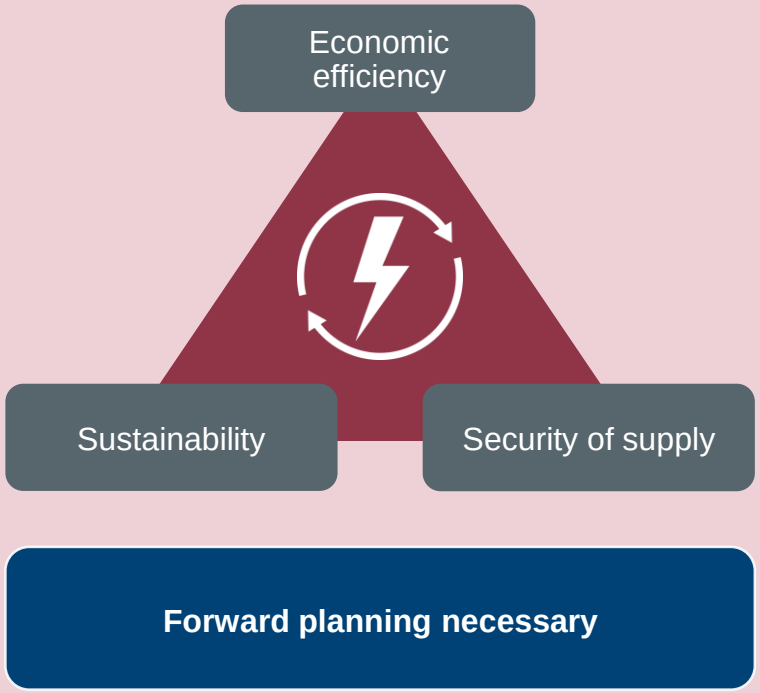

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e.g. grid connection capacity at the site, H2-/CO2-infrastructure

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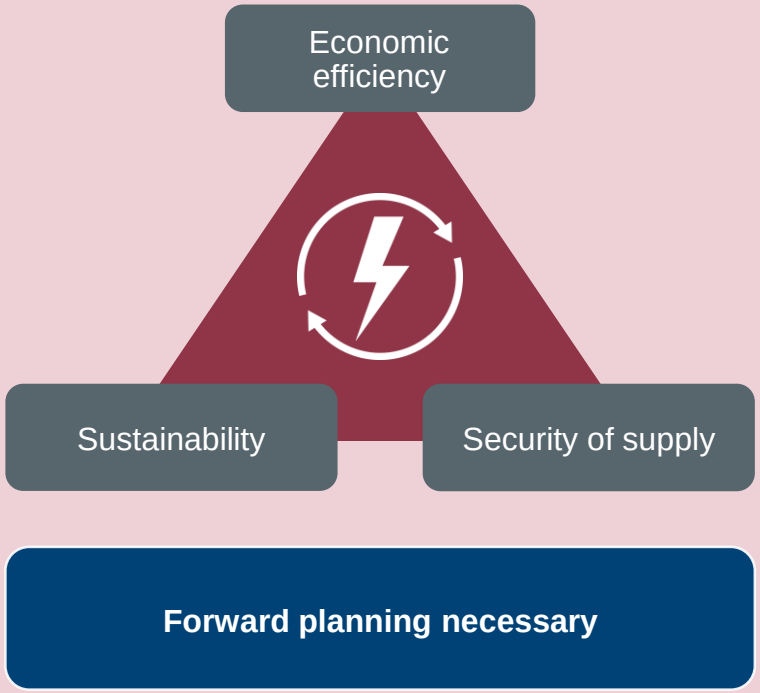

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Implementation of CO2 price signals along the value chains
e.g. GHG-labelling, green lead markets.

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THANK YOU FOR YOUR ATTENTION!

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