WASSERSTOFF KOMPASS

Ramp-Up of the Hydrogen Economy

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acatech DECHEMA

Gefördert durch:

Bundesministerium für Wirtschaft und Klimaschutz
aufgrund eines Beschlusses des Deutschen Bundestages

Bundesministerium für Bildung und Forschung
aufgrund eines Beschlusses des Deutschen Bundestages

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WASSERSTOFF KOMPASS

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- 105 senate members
- ~ 200 people in acatech offices (Munich, Berlin, Brussels)

Outline

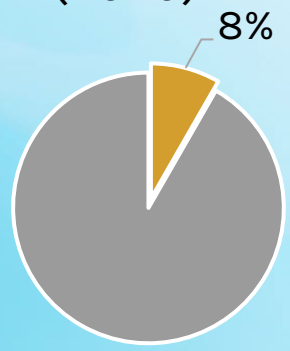
- Hydrogen – key to industrial transformation
  - Chemical industry
  - Steel production
- Infrastructure
- Electricity
- Electrolysis Ramp-up

1 TWh correspond to about 30 kt
33 TWh correspond to about 1 Mt

Chemical Industry

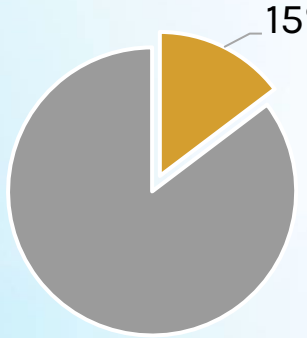
Facts and Numbers

Energy demand (2020)



215 TWh
> 20 % of industrial emissions

GHG emissions (2019)



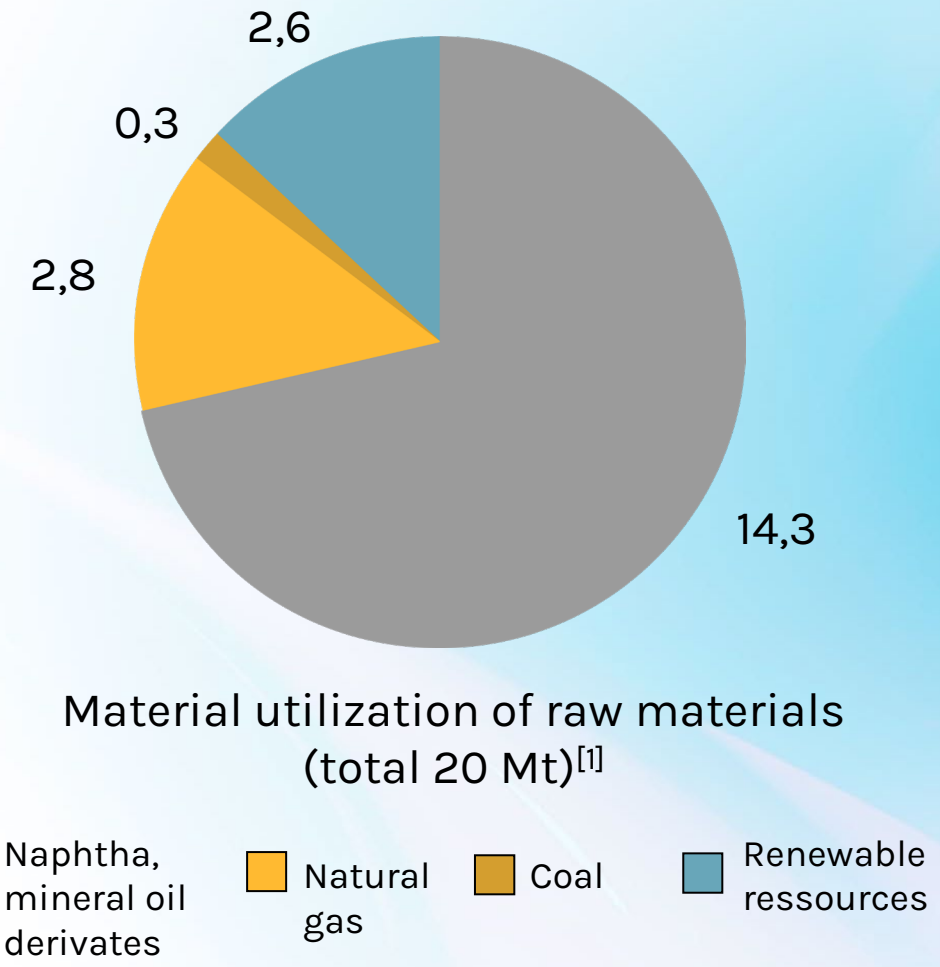
112,5 Mio t CO_2-eq.

Emissions caused by

- Cracking of fossil Naphtha
- Hydrogen production
- Provision of steam and heat
- End-of-life emissions

Chemical Industry

Material utilization of raw materials



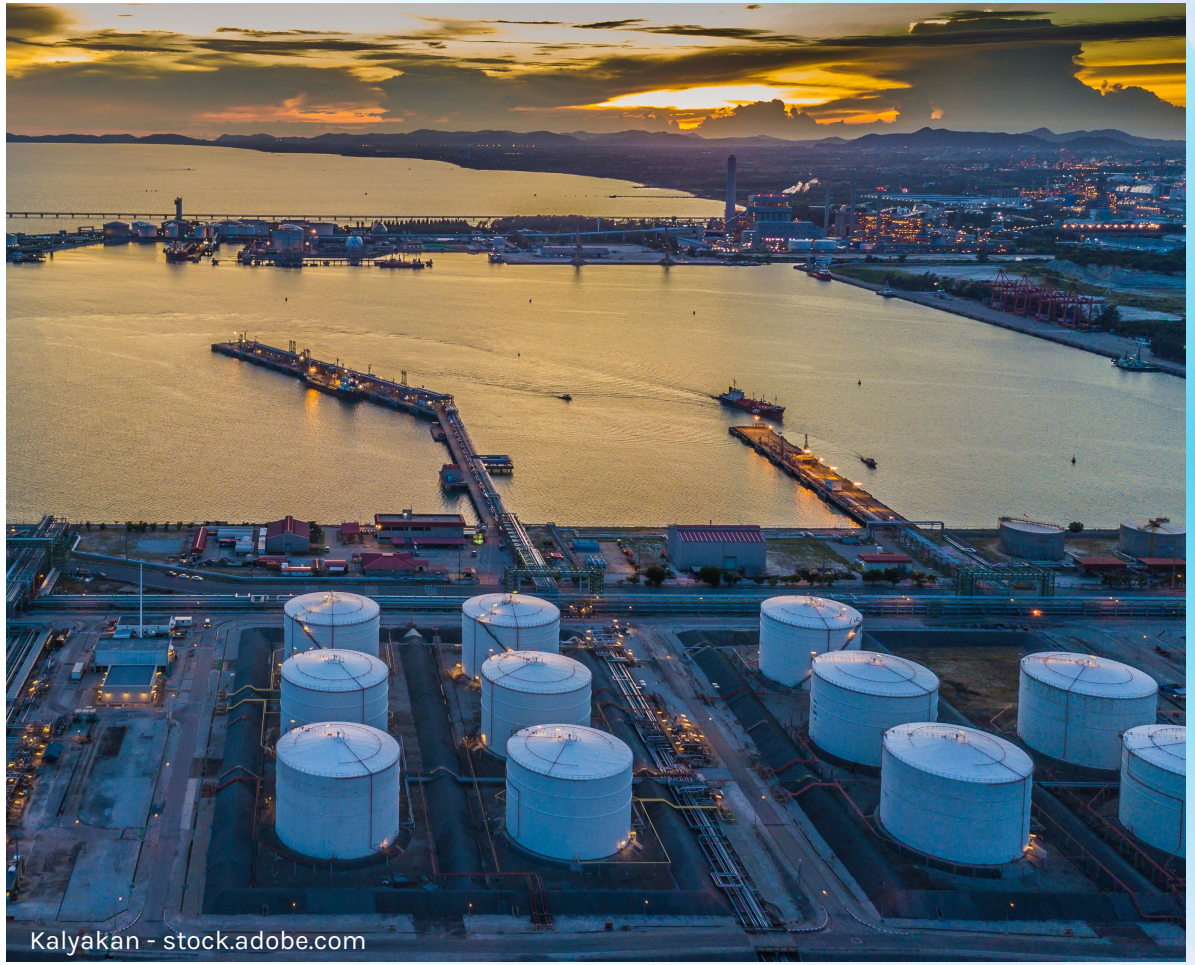
Material utilization of raw materials (total 20 Mt)[1]

- In 2020 **20 Mt raw materials** were utilized material-wise.[1]
- Material utilization of raw materials is dominated by **Naphtha and other mineral oil derivatives**[1]
- Renewable ressources contribute only **slightly more than 10%** to the raw material basis.[1]
- Recycling hardly plays a role.

[1] VCI, Energiestatistik 2022

Chemical Industry

Process heat


Kalyakan - stock.adobe.com

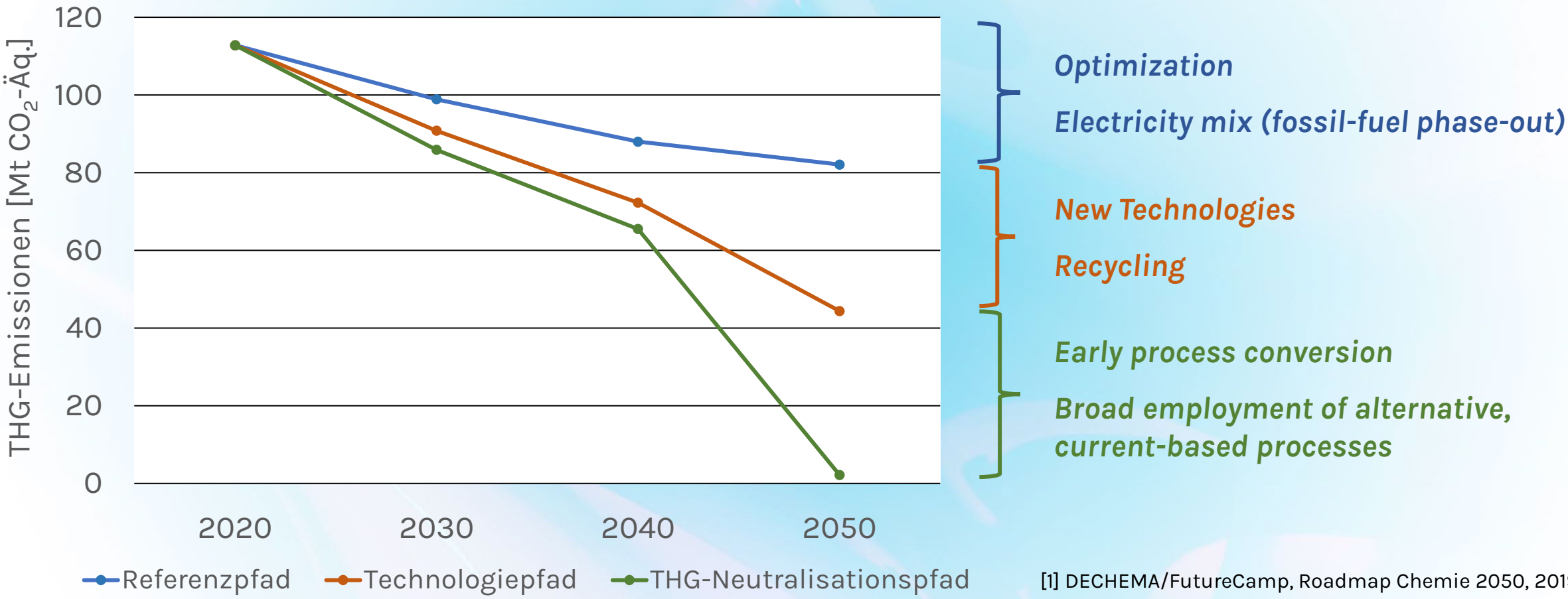
- Mainly **middle** and **high-temperature-processes**
- Low temperature processes hardly relevant

➢ Direct Electrification is challenging, **energy-related use of raw material** will be essential also in future

[1] BDI, Klimapfade 2.0, 2022

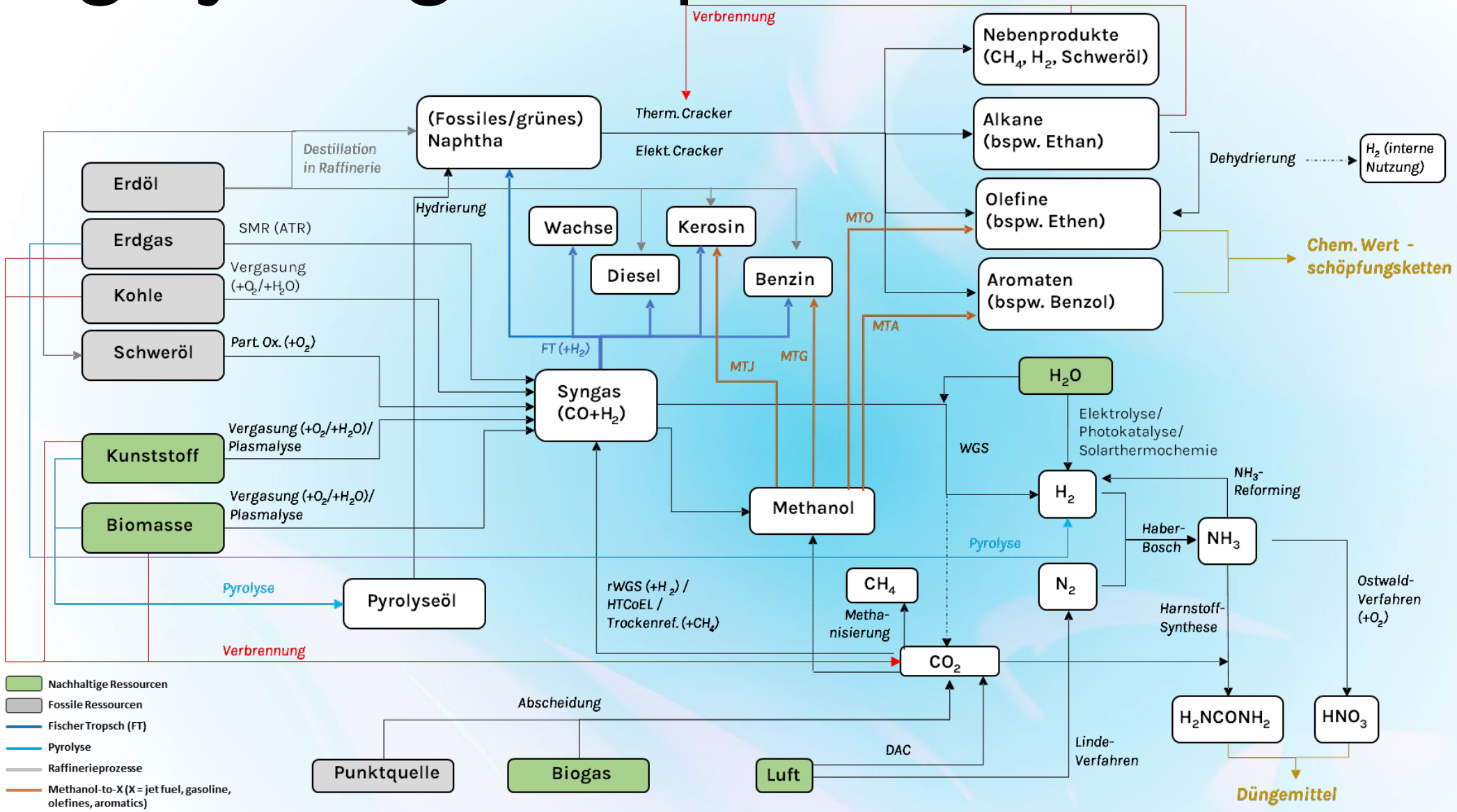
Green house gas emissions

Largest lever for reduction[1]



[1] DECHEMA/FutureCamp, Roadmap Chemie 2050, 2019.

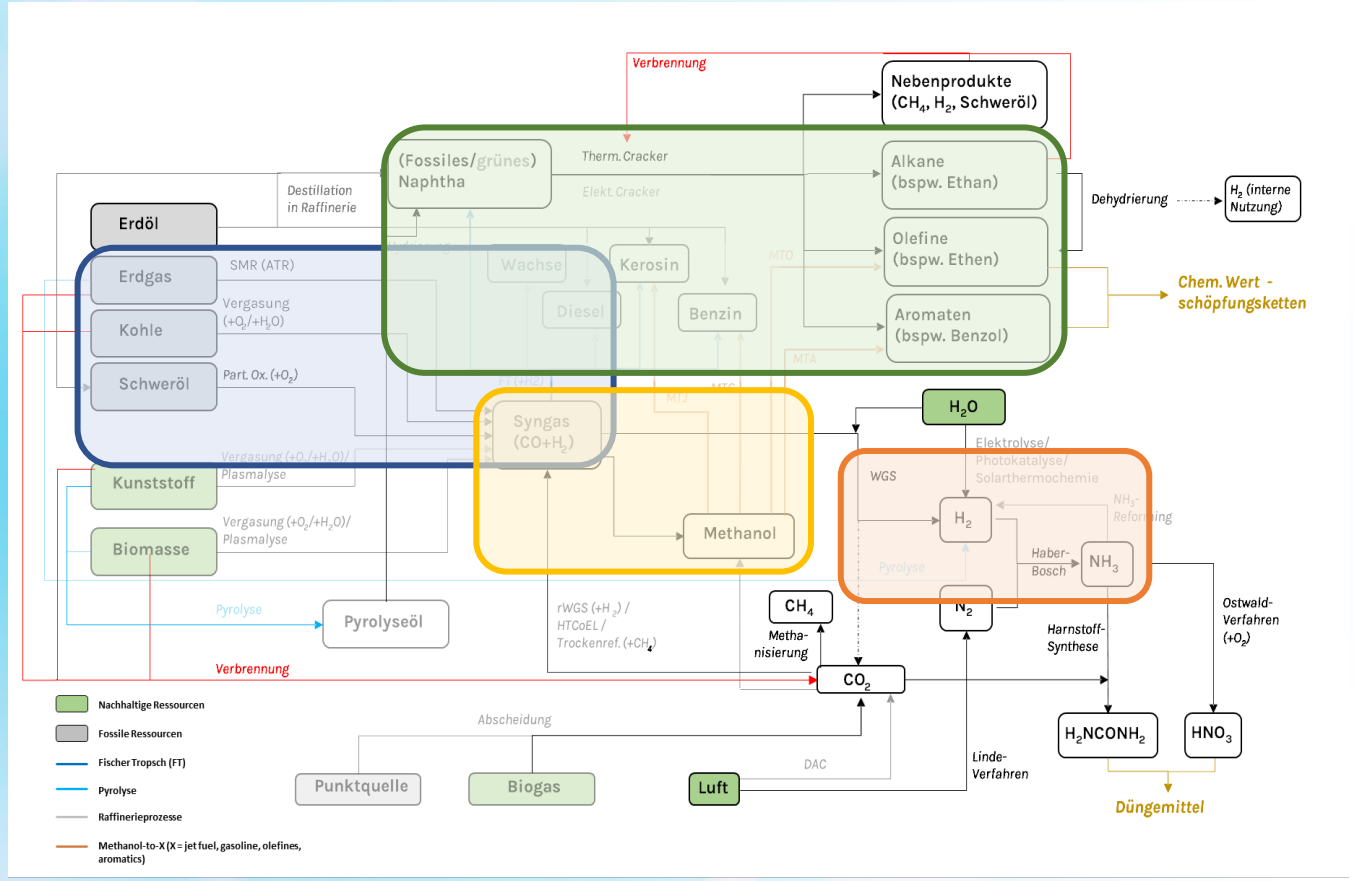
Highly integrated processes



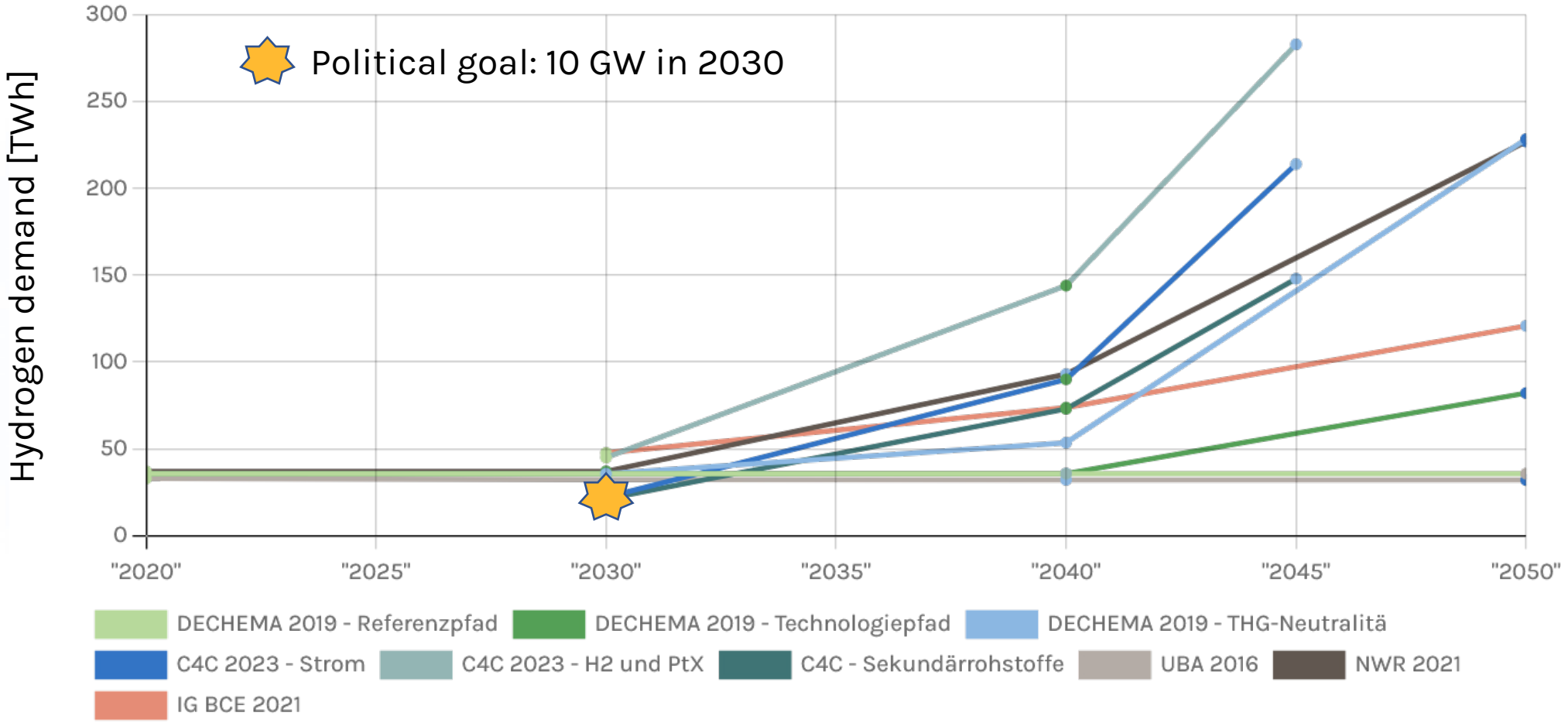
Highly integrated processes

Central Role of hydrogen

1. Substitution of hydrogen and synthesis gas production **(blue)**
2. Production of alkanes, olefines and aromatics from Naphtha and via alternative processes **(green)**
3. Production of methanol based on synthesis gas **(yellow)**
4. Production von ammonia with hydrogen (today mainly based on natural gas, in future based on electrolysis **(orange)**



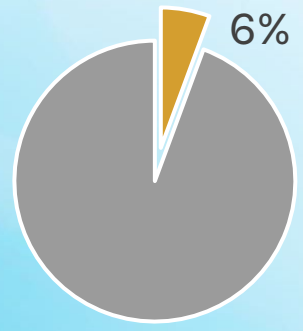
Chemical industry



Steel production

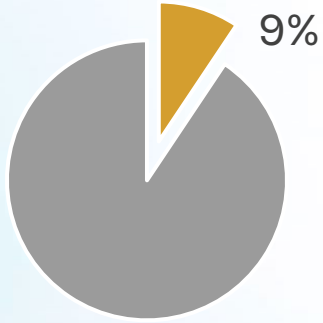
From Blast furnace to directly reduced iron

Energy demand



146 TWh

GHG emissions



70 Mt

- Germany: ~ **40 Mt steel per year**
  - 70 % primary steel (blast furnace)
  - 30 % secondary steel (recycling)
- Turnover in 2021: 41,4 billion €
- > 15 billion EUR investments needed to defossilize Germany‘s steel production

Steel production

- Ideal reactor width: ~6,7-7 m
  → annual production capacity of about 2,5…2,7 Mt iron
- Height: up to 35 m

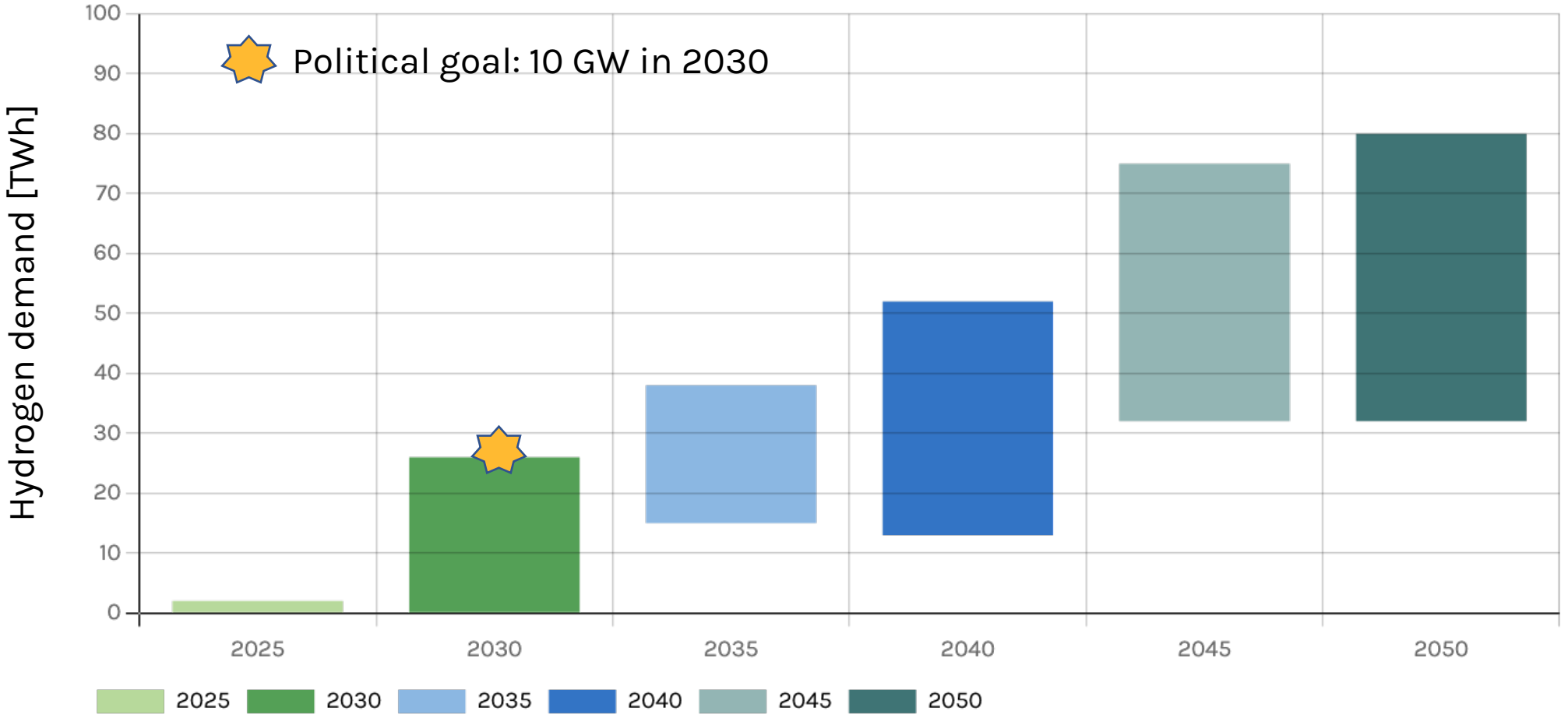
- March 2023: Thyssen-Krupp starts to build its first DRI-facility (2,5 Mt iron capacity)

- Operation shall start end of 2026

- H_2-premium: 280 € / t Stahl
  (Ann.: 4 € / kg H_2)

Steel industry

Hydrogen demands



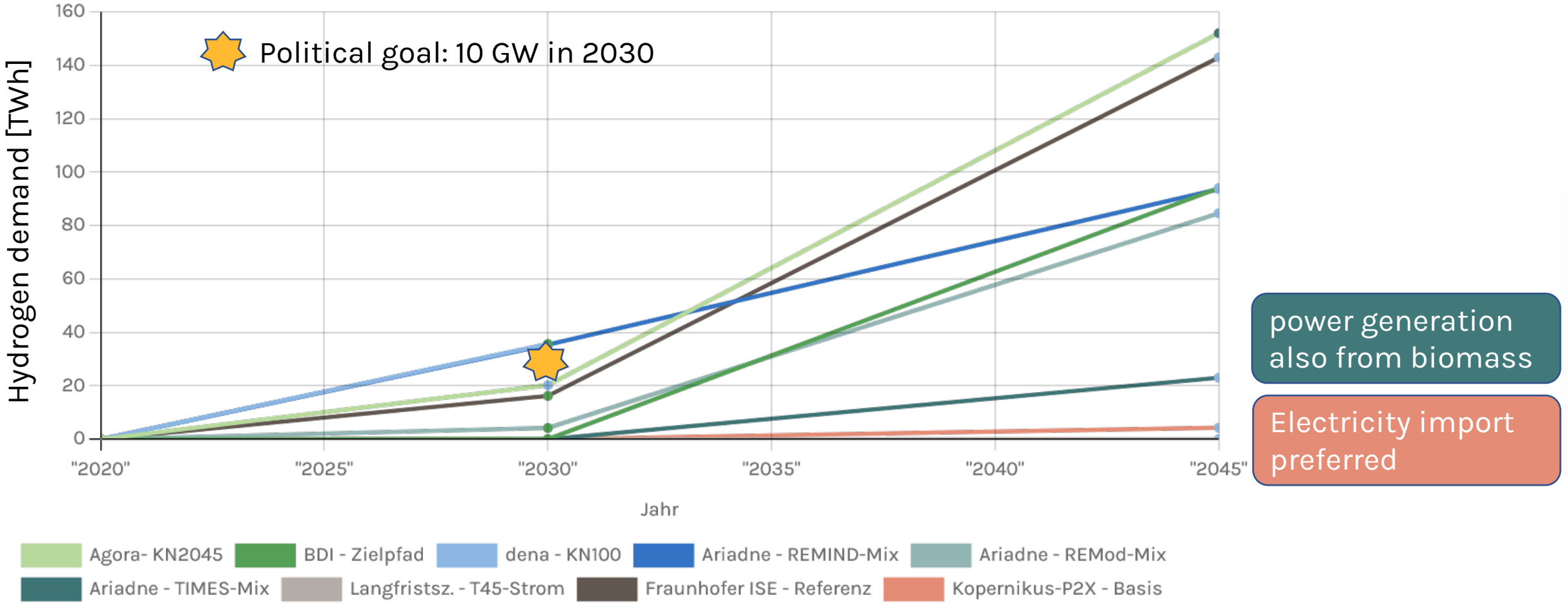
Electricity system


Countrypixel - stock.adobe.com

- High backup power needed:
  - **2019: 30 GW**
  - **2030: 32-106 GW**
  - **2045: 43-181 GW**
- Backup power plants will rarely be in use:
  - **2020: 3000 full load hours**
  - **2030: 1629-3333 full load hours**
  - **2045: 86-1166 full load hours**

Electricity

Hydrogen demands



power generation also from biomass

Electricity import preferred

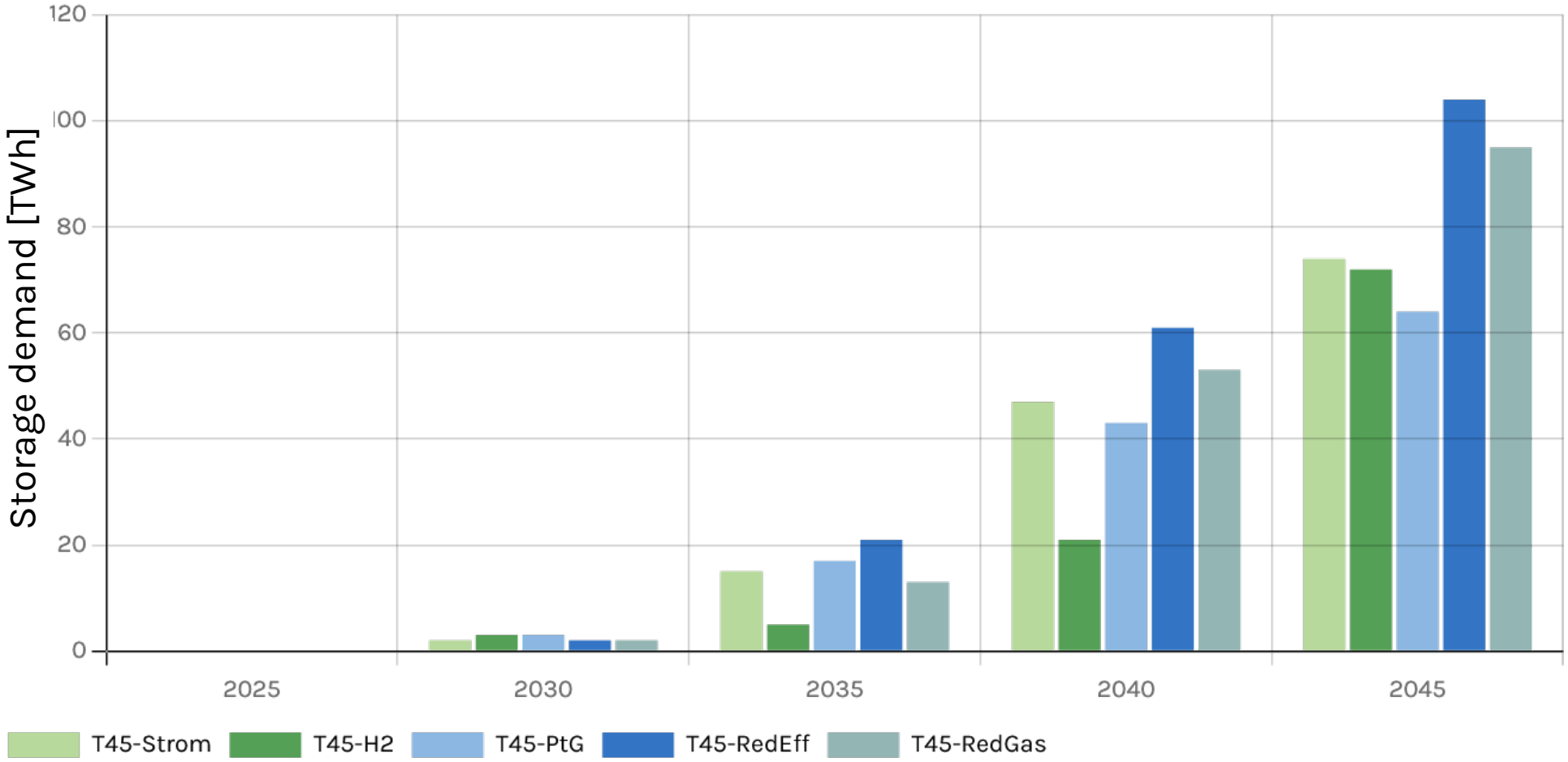
Infrastructure – H_2 storage

- **Total natural gas storage potential: 262 TWh**
- Distribution determined by geology
- Salt caverns (168 TWh) only in the north
- Pore storages very likely not suited
- Largest salt formation with storage potential in Europe
- Due to lower energy density and compressibility
  → H2 stores only 20% of the energy that natural gas does at the same volume

→ **33 TWh H_2 storage potential** in available storages
- there is potential for more storages

Infrastructure

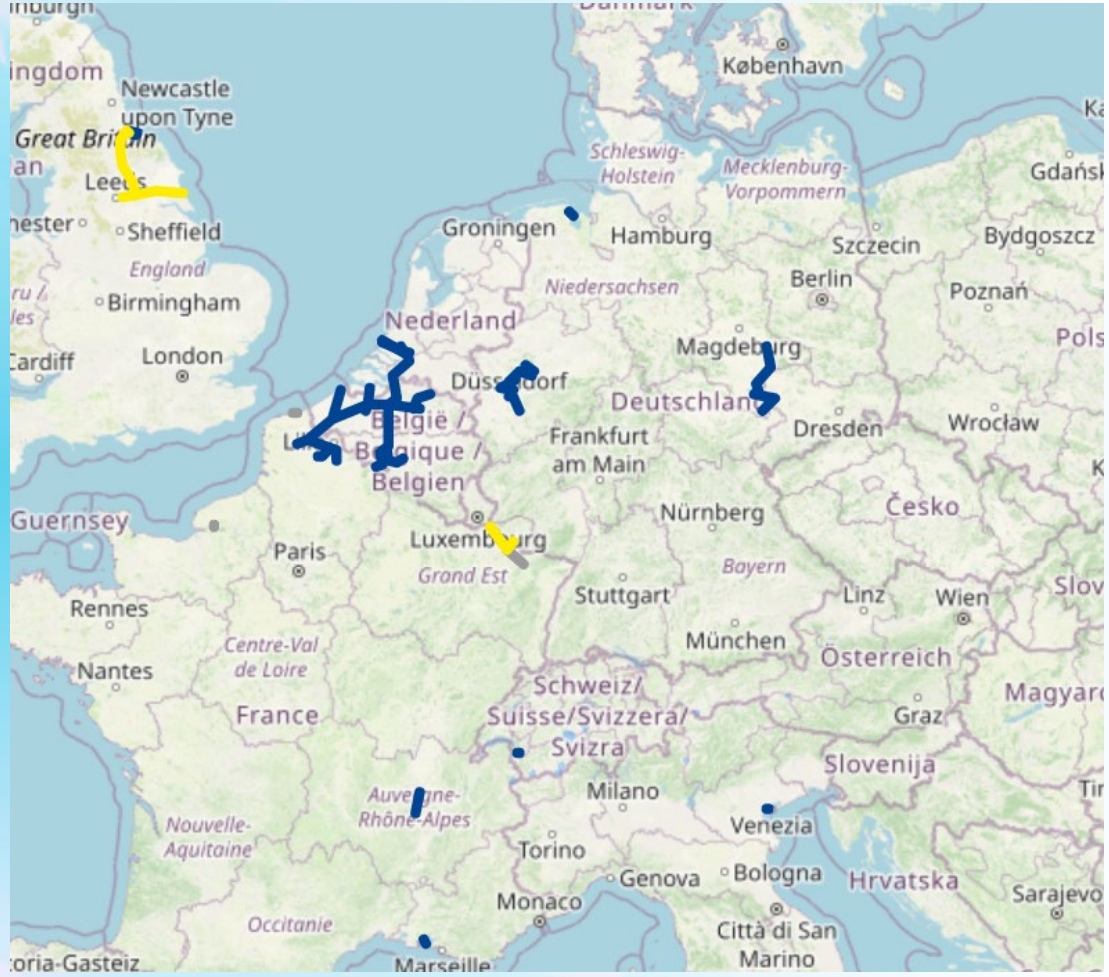
H2 storage



Existing H2-pipelines

- Blau: existent
- Gelb: geplant

1.458 km in Europa gelistet
190 km geplant
56 km Status unbekannt



European hydrogen backbone

2030 und 2040

2030

- ~ **28.000 km length**
- Energy transport of up to 65 TWh / yr
- Substantial amount of new construction

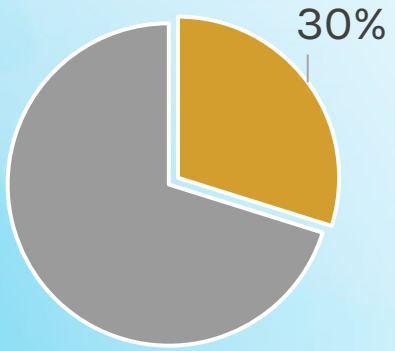
2040

- Almost 53.000 km length
- 60% repurposed
- 40% new

Karten siehe: https://www.ehb.eu/page/european-hydrogen-backbone-maps

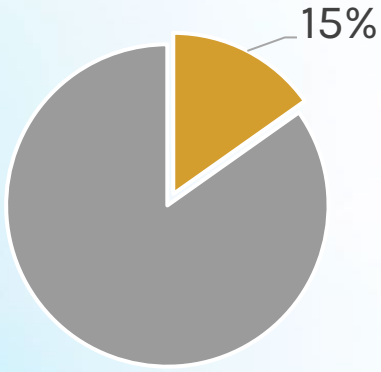
Building heat

Energy demand



773 TWh

GHG emissions



118 Mt

Building heat

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Energy retrofitting of buildings

Heat pumps

H2 blending into gas distribution networks

100% H2 in gas distribution networks

H2 as module in self-sufficient buildings

Synthetic heating oil

Synthetic methane

Indirect use of H2: waste heat from electrolyzers

District heat networks

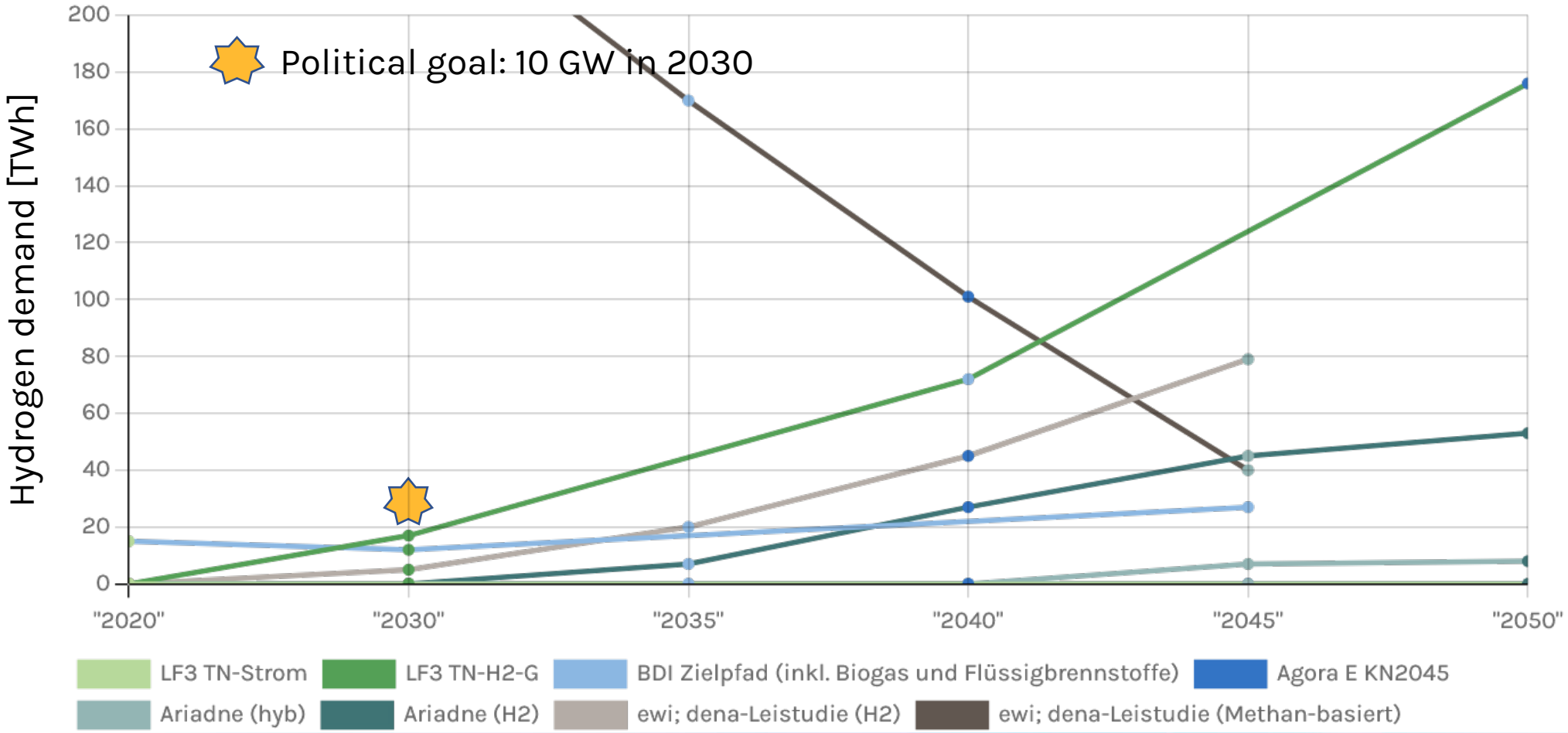
Energetic use of biomass

Biogenic heating oil

Bio methane

Gebäudewärme

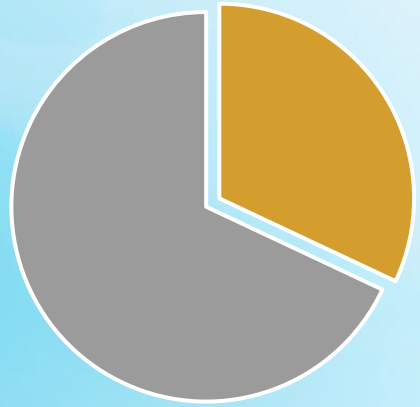
Wasserstoffbedarf



Mobility and logistics


Travel mania - stock.adobe.com

energy demand



770 TWh

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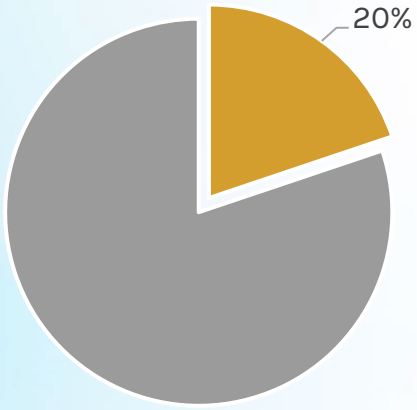
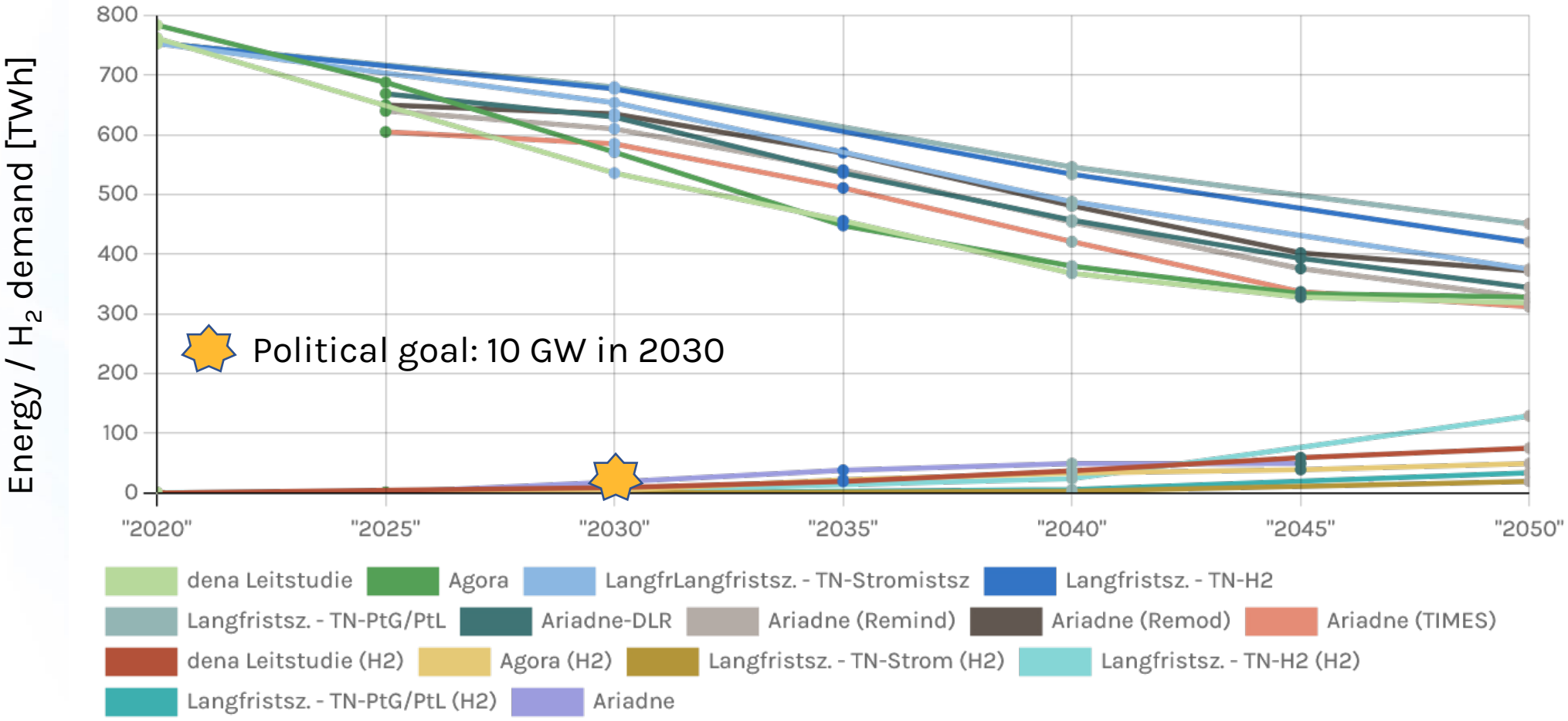
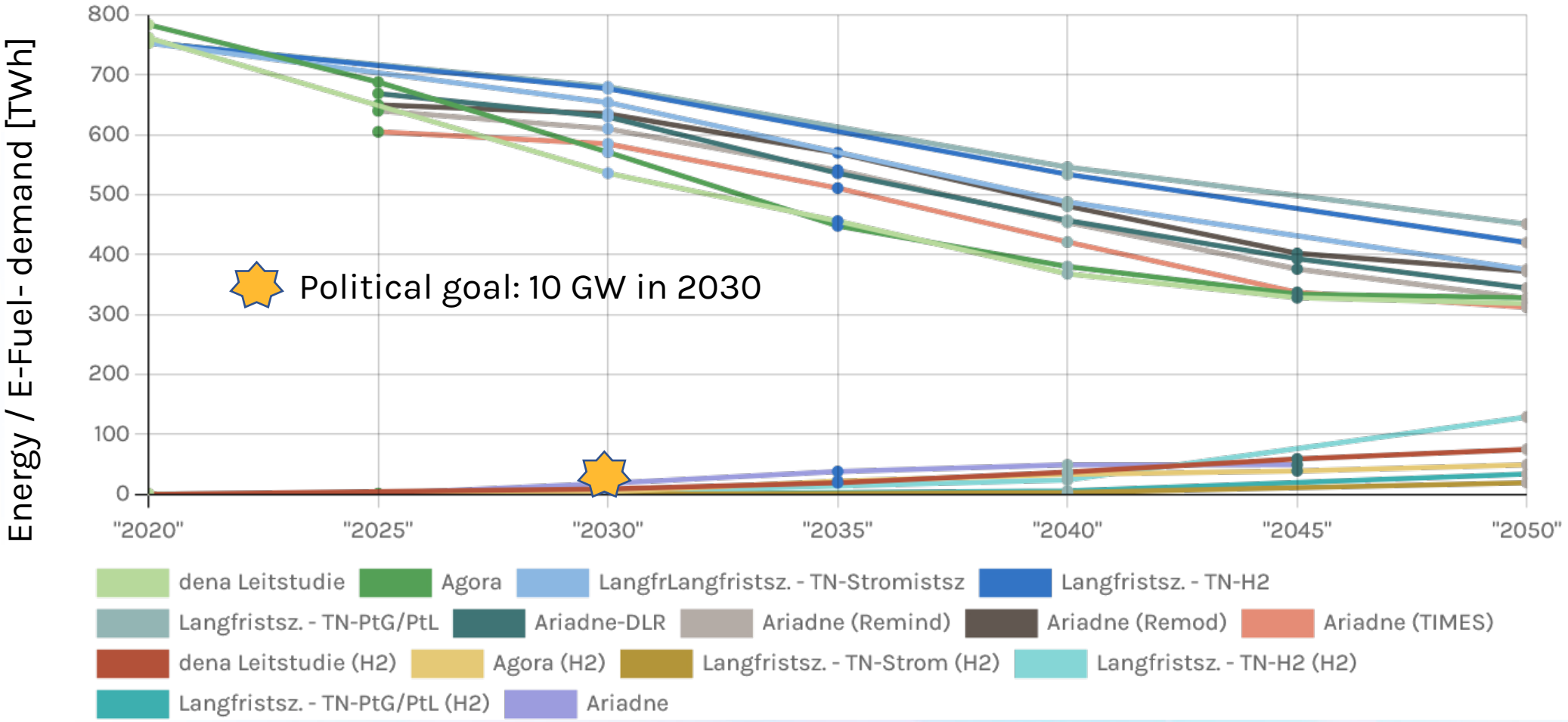


148 Mt

Mobility and logistics



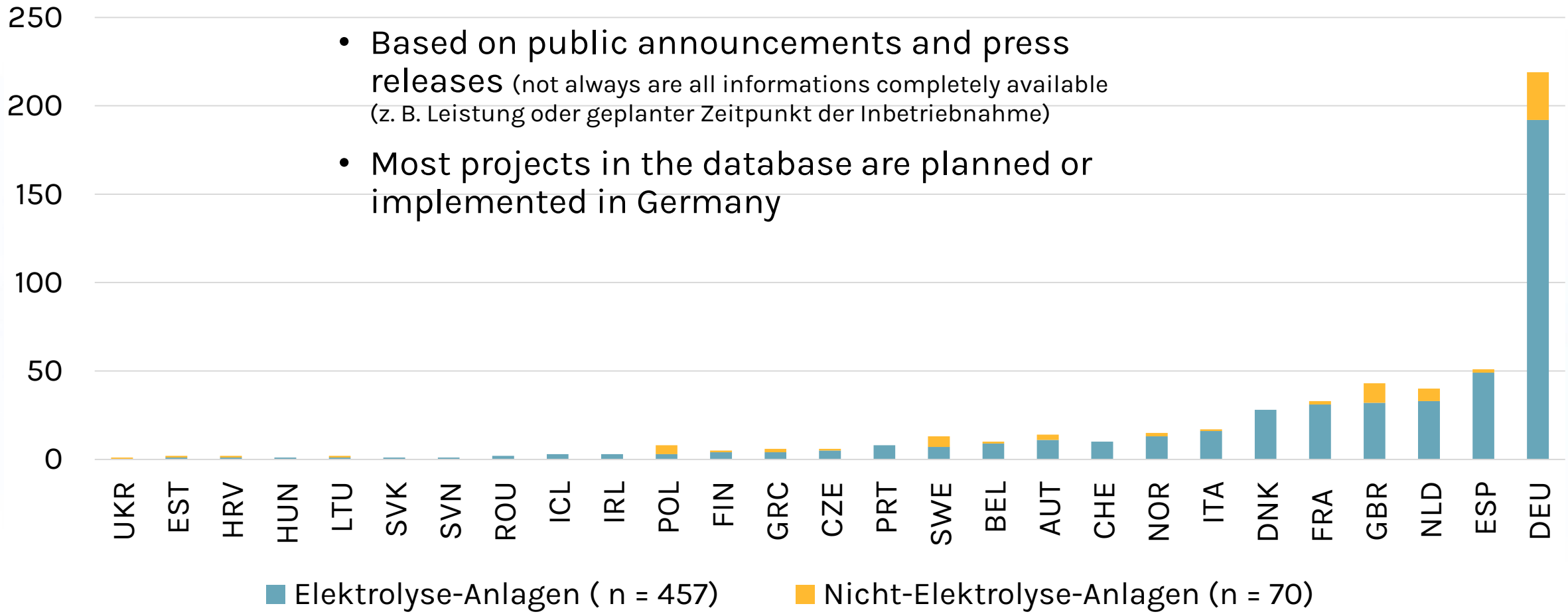
Mobility and transport



H_2-Electrolysis projects

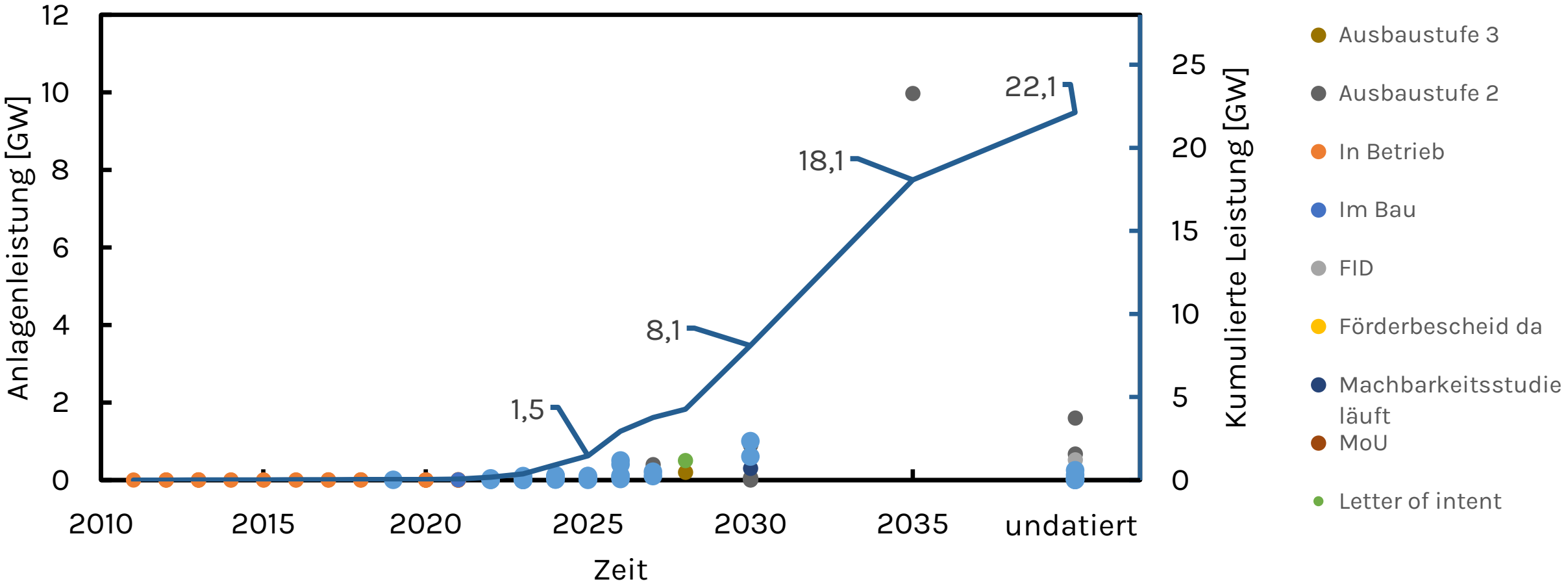
H_2-compass‘ project database

- Based on public announcements and press releases (not always are all informations completely available (z. B. Leistung oder geplanter Zeitpunkt der Inbetriebnahme)
- Most projects in the database are planned or implemented in Germany



Elektrolysekapazitäten

Deutschland, Stand Februar 2023



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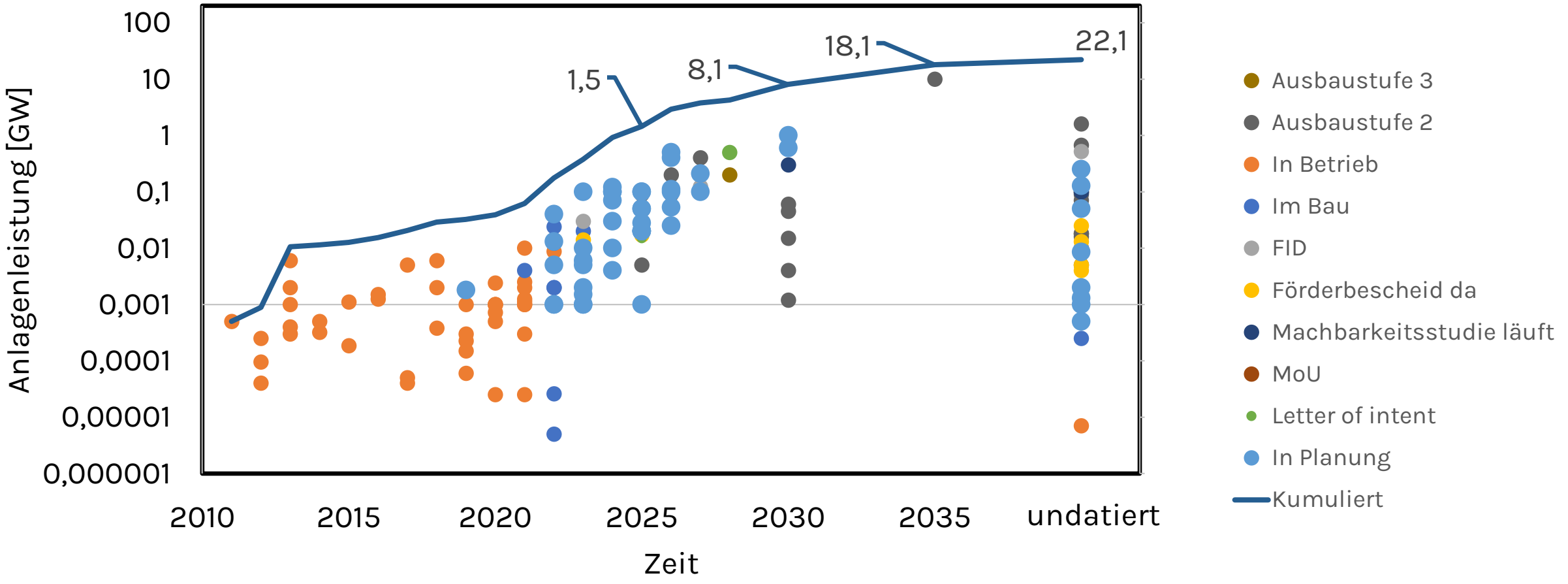
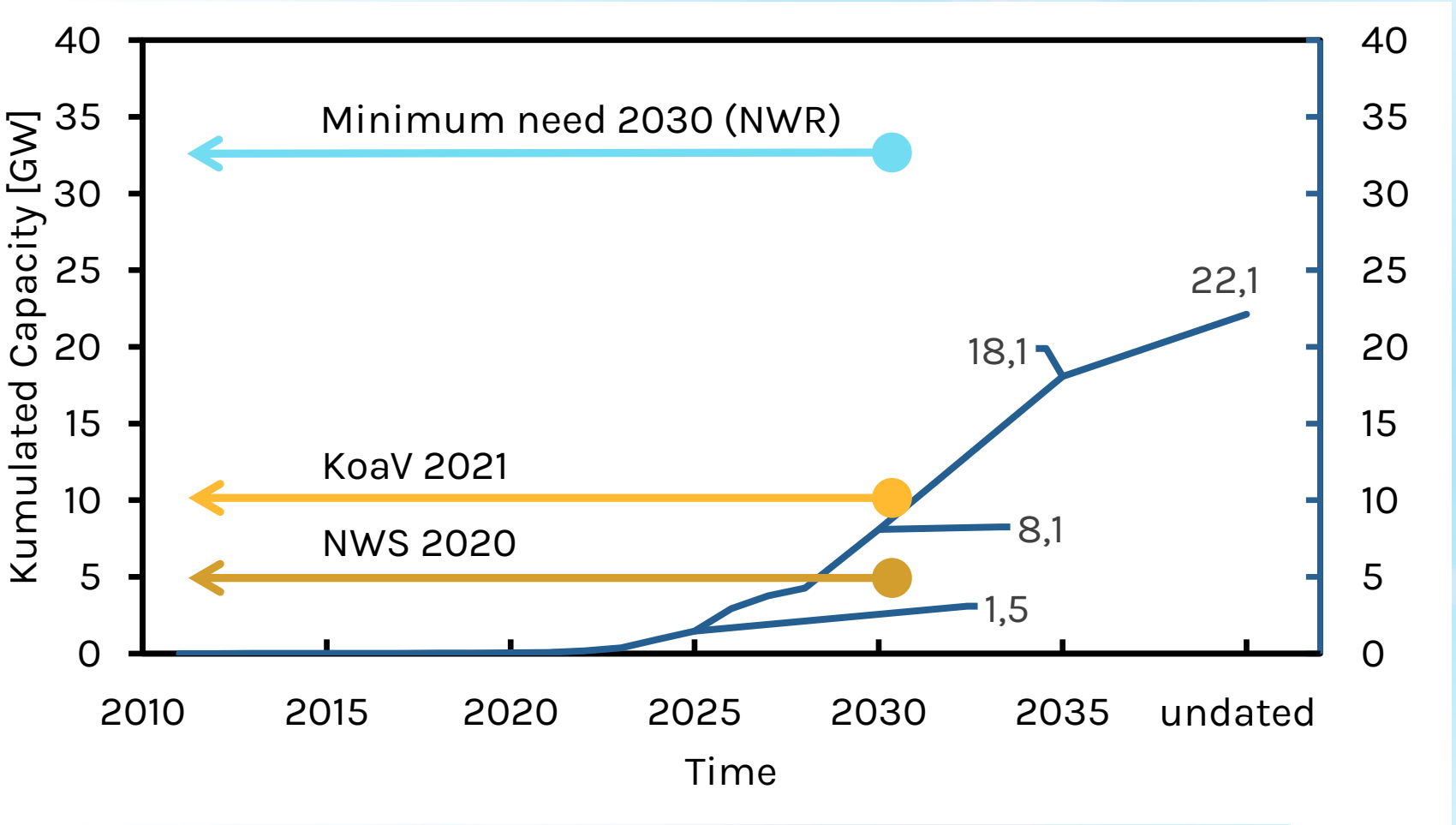


Elektrolysekapazitäten

Deutschland

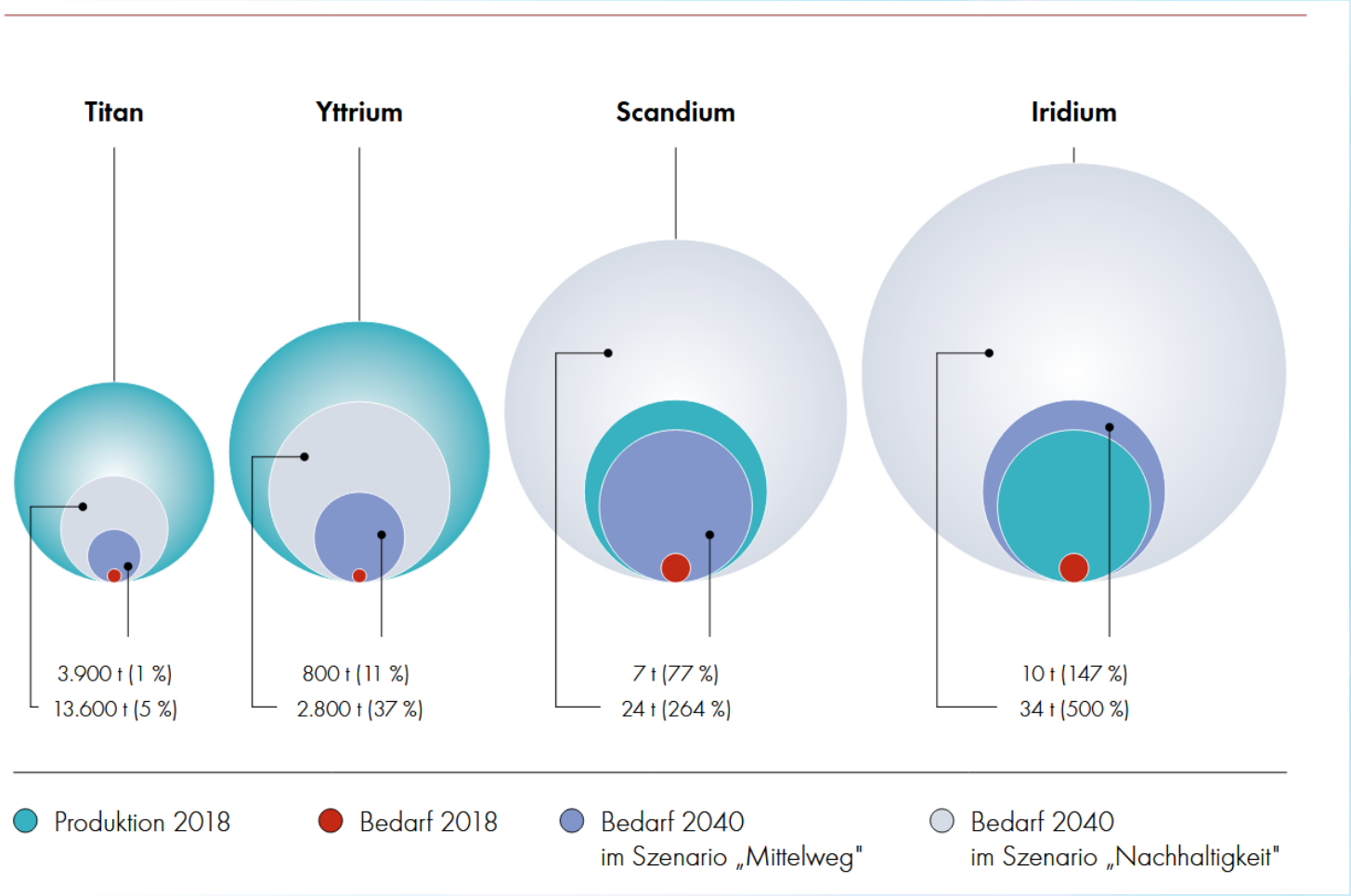


- Optimistic assumptions:
  - 4000 full load hours
  - 70 % efficiency
- Minimum needs 2030:
  - 92 TWh (NWR)
  - Corresponds to 33 GW

State: February 2023

Raw materials for electrolyzers

AEL, PEMEL and SOE



Dera-Themenheft:
[Mineralische Rohstoffe für die Wasserelektrolyse, DERA]

Conclusions

- Ramp-up of Germany‘s Hydrogen economy is on ist way.
- 10 GW electrolysis capacity by 2030 is within reach
- Germany‘s electrolysis projects can serve at most 1/3 of the German hydrogen needs in 2030
- Import of energy / hydrogen is further needed
- Transformation is challenging (infrastructure built-up, Upscale of electrolyzer production, raw material supply, man-power)

Thank you very much for your attention

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