Current challenges of European supply security and perspectives of a hydrogen infrastructure

30.11. 2022 | TransHyDE Scientific Conference, Berlin

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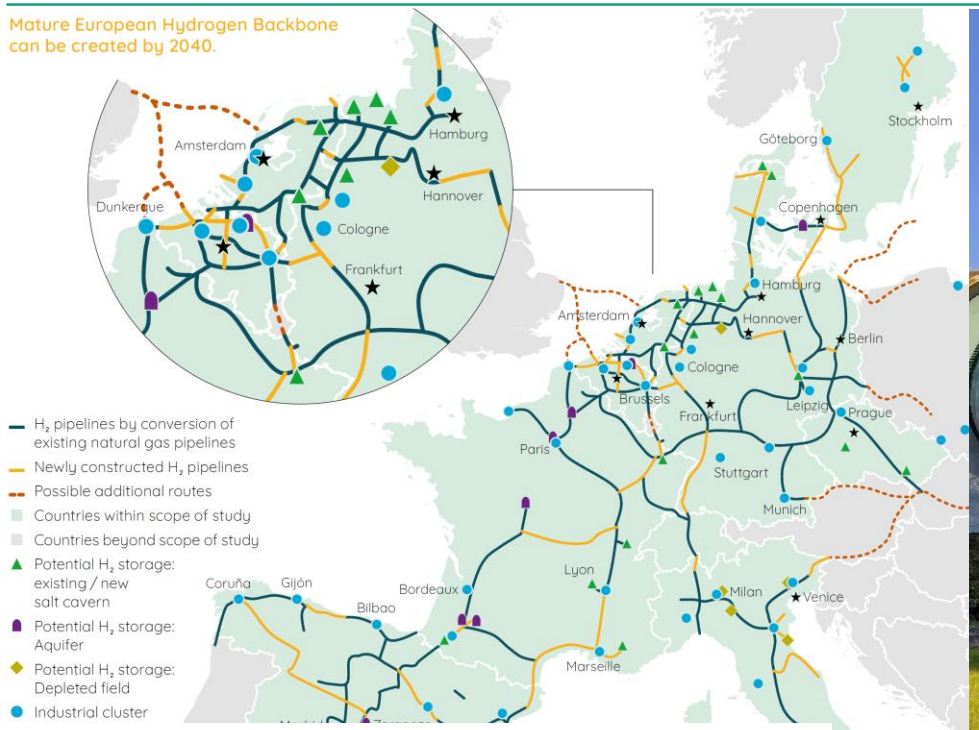

Quelle: Gas for Climate (2020): European Hydrogen Backbone.

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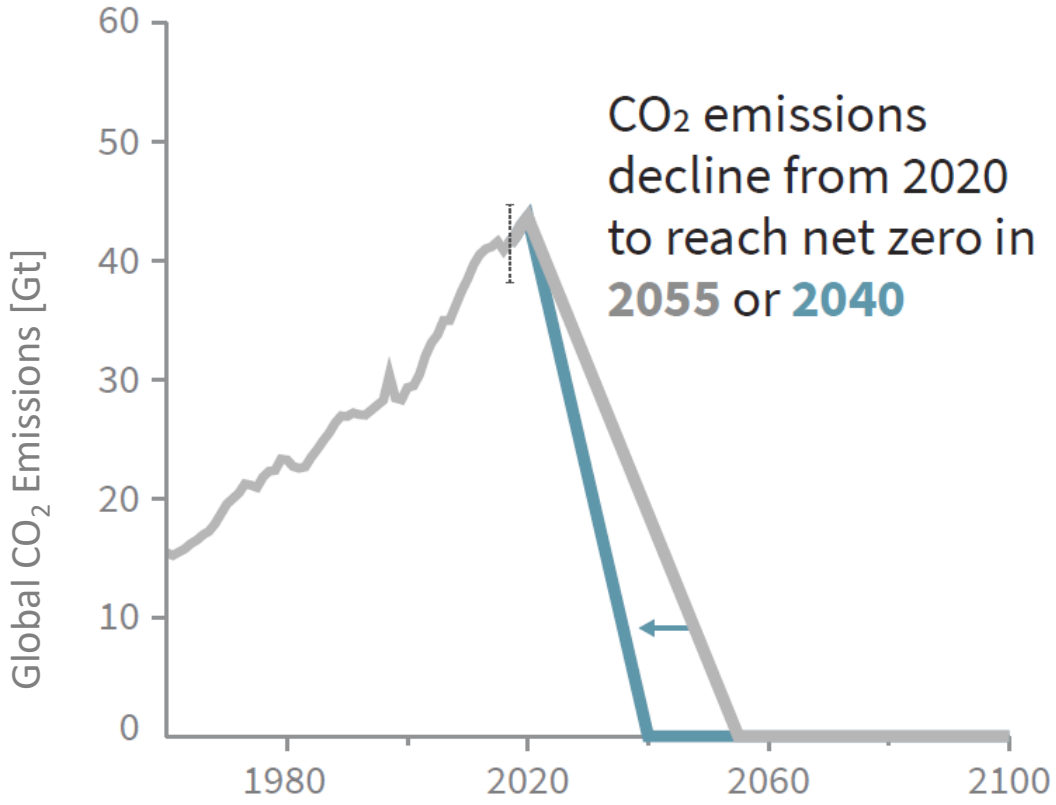
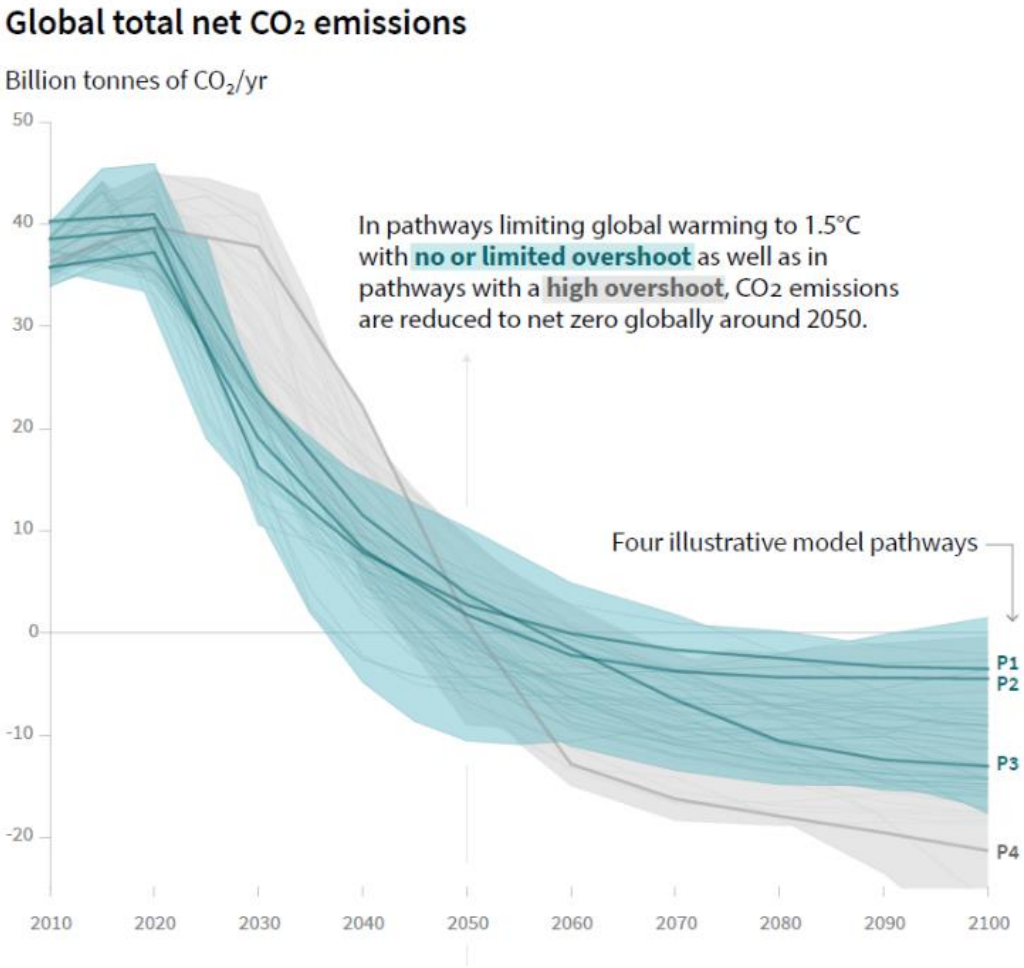
Climate targets require full climate neutrality between 2040 and 2055





Source: IPCC 2018

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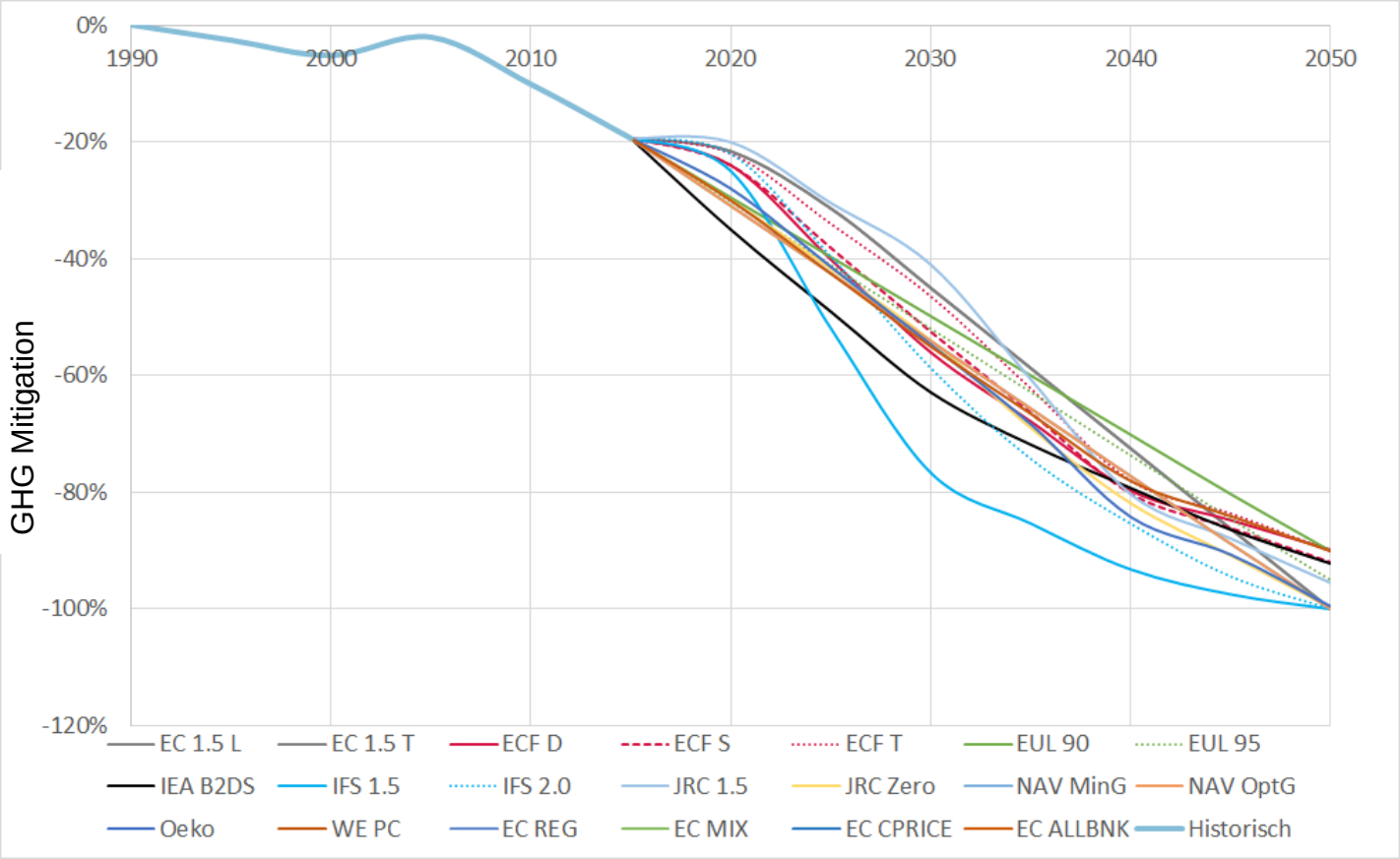
Meta-Analysis of main recent EU scenarios on GHG-neutral energy systems

Studie

EU

Kürzel	Studien
EC 2020	Commission Staff Working Document – Impact Assessment
JRC 2020	Towards net-zero emissions in the EU energy system by 2050
EC 2019	Industrial Innovation – Pathways to deep decarbonisation of industry Part 2
EC 2018	A Clean Planet for all

- 20 Scenarios
- GHG-Mitigation
  - 2030: 41 to 77 %
  - 2040: 70 to 93 %
  - 2050: 90 to 100 %



Source: Wietschel, Hebling, Ragwitz, et al. 2021, Study for the National Hydrogen Council (NWR)

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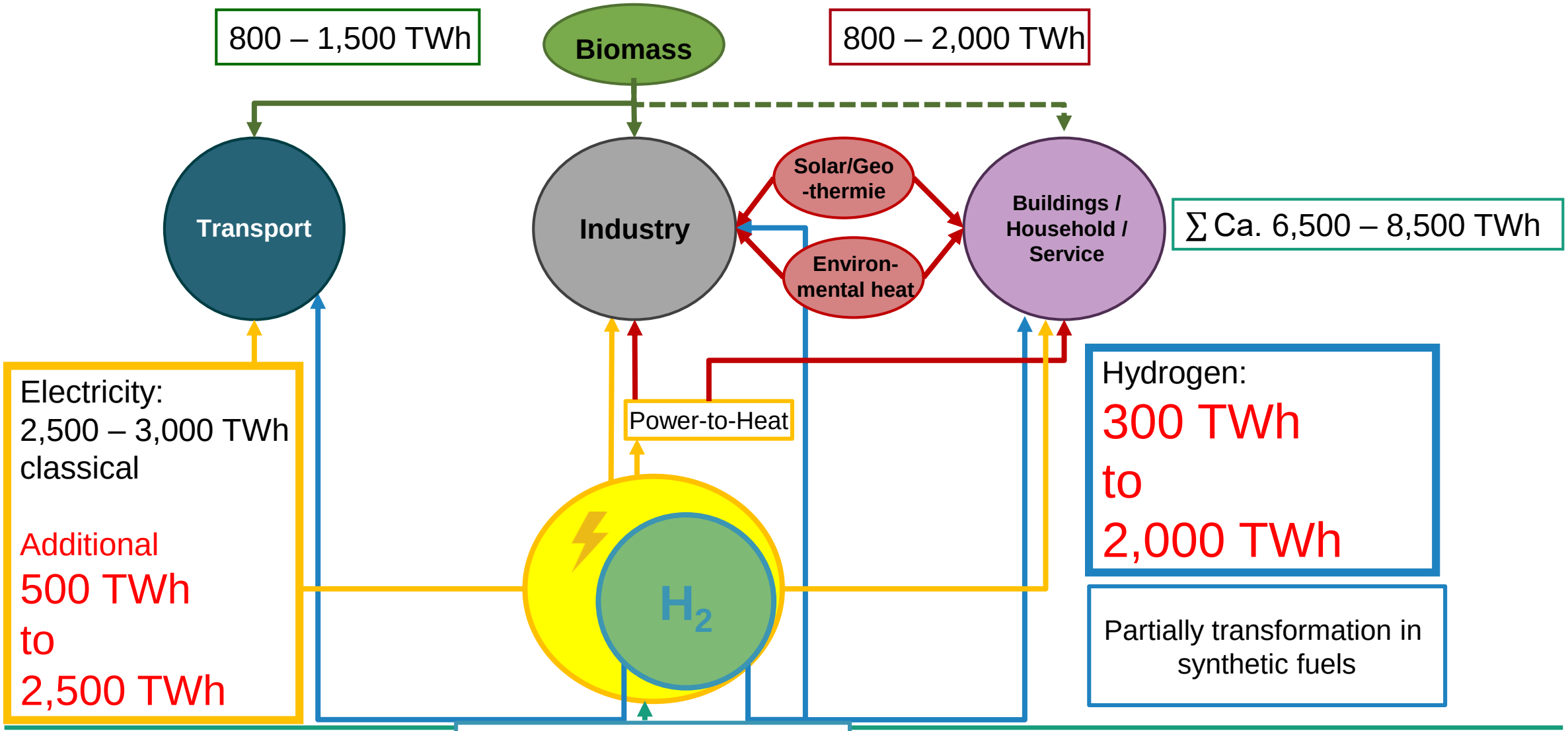
Climate neutral energy system - Europe



Source: Wietschel, Hebling, Ragwitz, et al. 2021, Study for the National Hydrogen Council (NWR)

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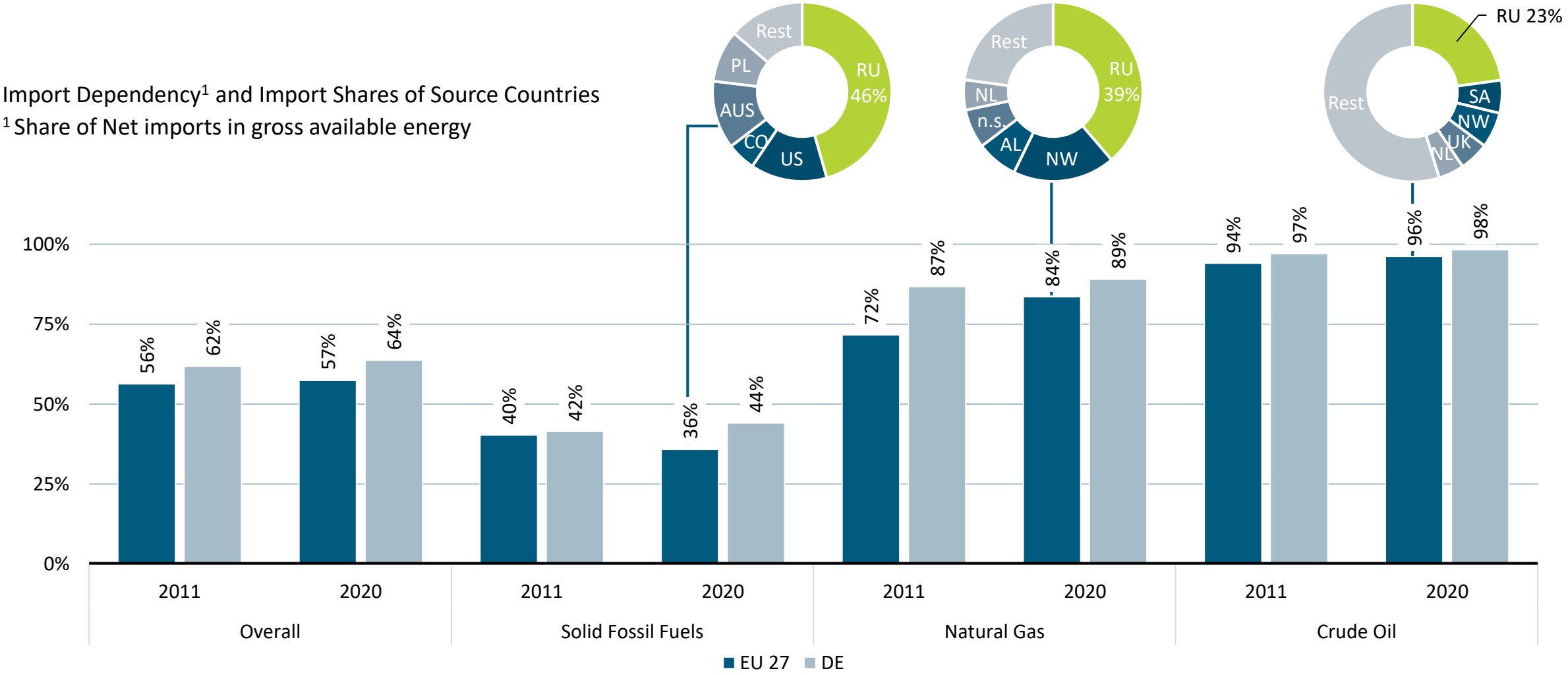
Security of Energy Supply

Mediocre diversification of European energy import sources

Import Dependency[1] and Import Shares of Source Countries

[1] Share of Net imports in gross available energy



Dependency due to lack of diversification

European import market for natural gas is dominated by Russia

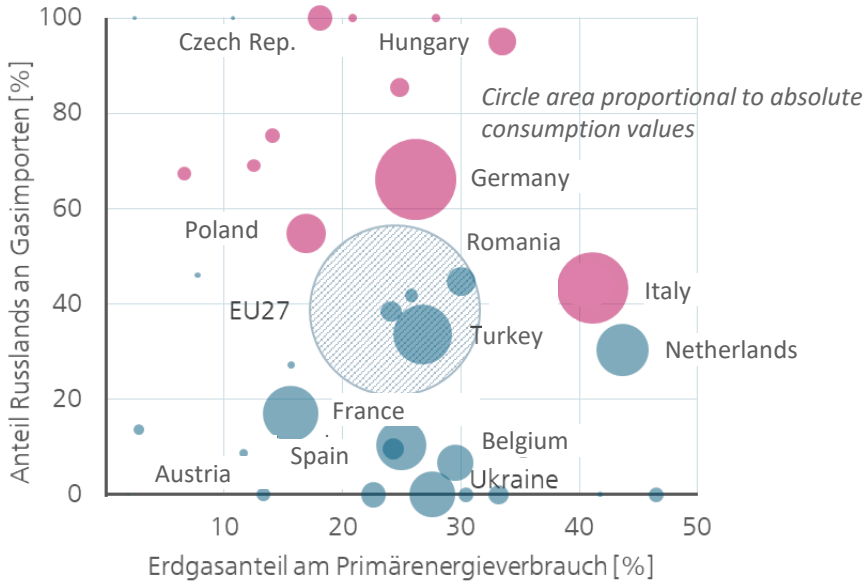
Share of Russian imports and relevance of natural gas for the domestic energy systems varies for European member states

- Great need for action in countries such as Germany, Italy, Hungary, Poland and Czech Republic.
- Other countries with high consumption can also contribute to the European independence by reducing their consumption.

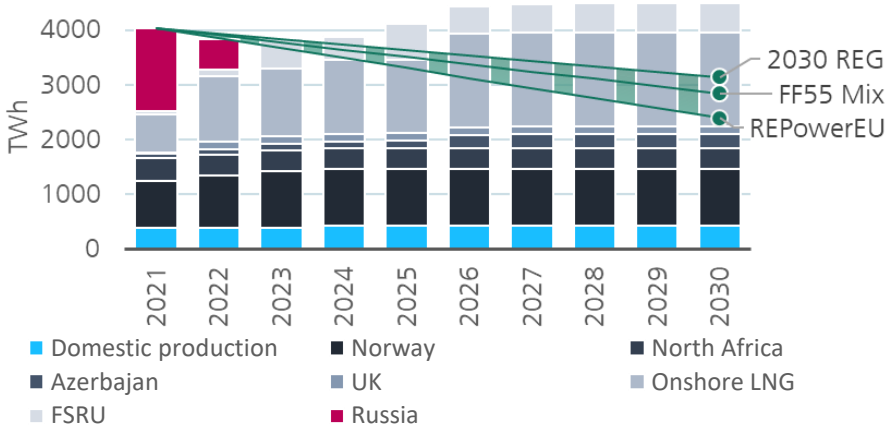
Ramp up of alternative supply options will likely be sufficient to effectively meet energy demand in 2 to 3 years

- Ambitious efficiency measures help in avoiding bottlenecks in the energy supply
- A detailed analysis of gas grids is necessary in order to guarantee the security of supply at any place and any time.

Dependency on Natural Gas in European Member States 2020[1]



Projections for the supply and demand of Natural Gas in Europe[2]



[1] Eurostat (2021): nrg_bal_c, nrg_ti_gas
[2] McWilliams, B., G. Sgaravatti, S. Tagliapietra and G. Zachmann (2022) 'A grand bargain to steer through the European Union's energy crisis', Policy Contribution 14/2022, Bruegel

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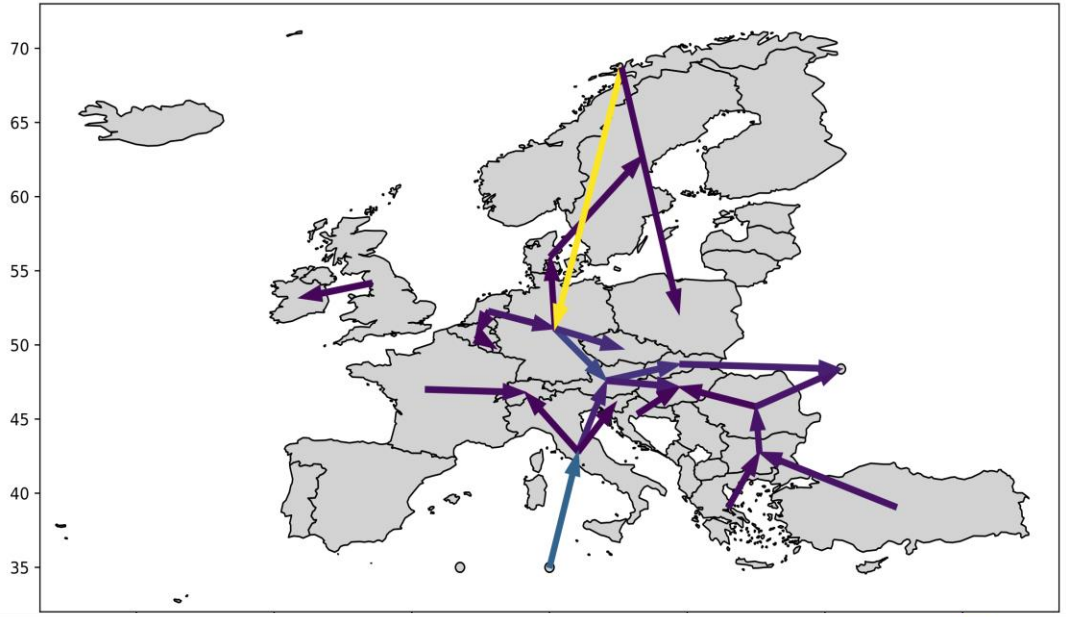
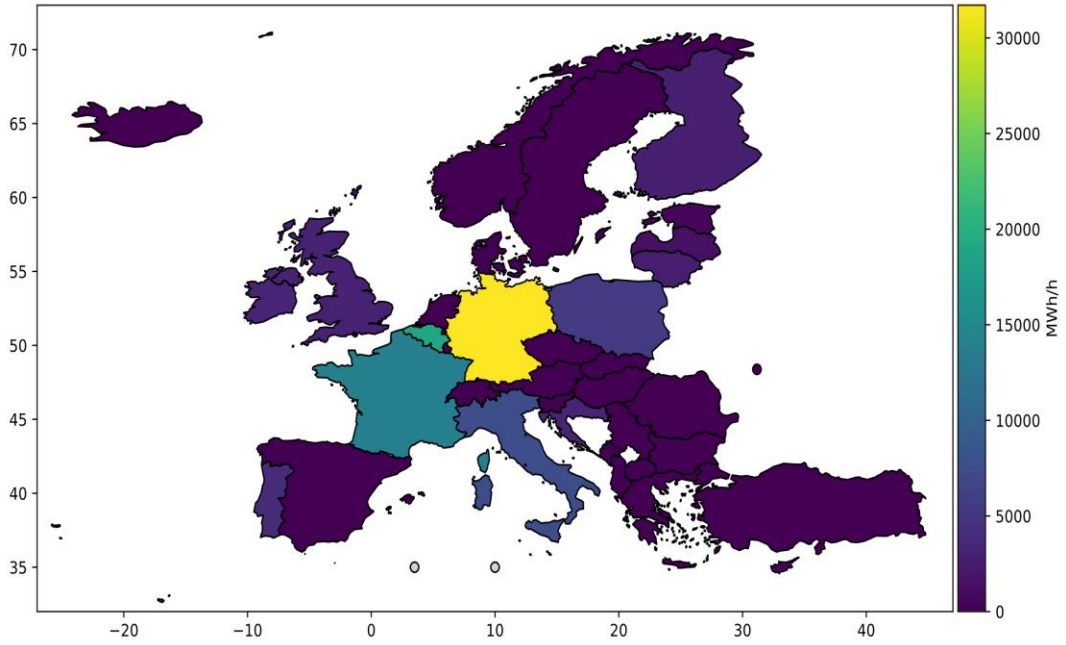
Important infrastructure measures to secure gas supply until 2025 / 2026

- Securing gas supply requieres **gas-savings of at least 20%** compared to 2021
- Specific aspects of European gas supply need to be considered
  - Highest demand in midle and central Europe
  - Gas-production focused on Norway
  - LNG-Imports strong in UK, ES, FR, IT
  - Largest storage volumes in Germany
- The most important infrastructure measures
  - **realisation** of **already planned pipeline projects,**
  - **building LNG-terminals**,
  - convert **compressor stations** for **reverse flow**.





Quelle:
ESYS Gutachten 2022: »Europäische Gasversorgungssicherheit aus technischer und wirtschaftlicher Perspektive vor dem Hintergrund unterbrochener Versorgung aus Russland«
https://www.ieg.fraunhofer.de/content/dam/ieg/deutsch/dokumente/pressemitteilungen/Gutachten_Gasversorgungssicherheit_bei_unterbrochener_Versorgung_aus_Russland__Fraunhofer_TUBerlin__14072022.pdf/

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European Background: REPowerEU

Dimensions of action

Reduce Dependency on Russian energy imports by means of four fields of action

REPowerEU adresses four fields of action

- Incentivise the **reduction of energy consumption** and take emergency measures in case of supply disruptions
- **Diversify** energy import sources, in the short term by means of fossil alternatives, rapid ramp-up of hydrogen market (**20 Mt of H_2 by 2030**)
- Fund and accelerate the **scale-up of Renewable Power Generation** in Europe (1000 GW Wind and PV by 2030)
- **Investment** of 210 billion Euros by 2027 to ensure independence of national energy supply plans and facilitate respective **reforms**

Reduce consumption

Diversify

Fund Clean Energy

Investment and Reform

Three components will define the future of hydrogen transport options

None of these questions can be answered independently! Therefore new models are needed to consider the relevant interactions.

Demand	Infrastructures	Supply
What is the hydrogen demand expected in different sectors?	To which extent should energy be transported by electricity and gas?	Where will green hydrogen be produced? At which costs?
Which spatial distribution of demand will be expected?	What is the impact of the interaction between gas and electricity grids on their topology?	What is the contribution of transport cost compared to generation costs?

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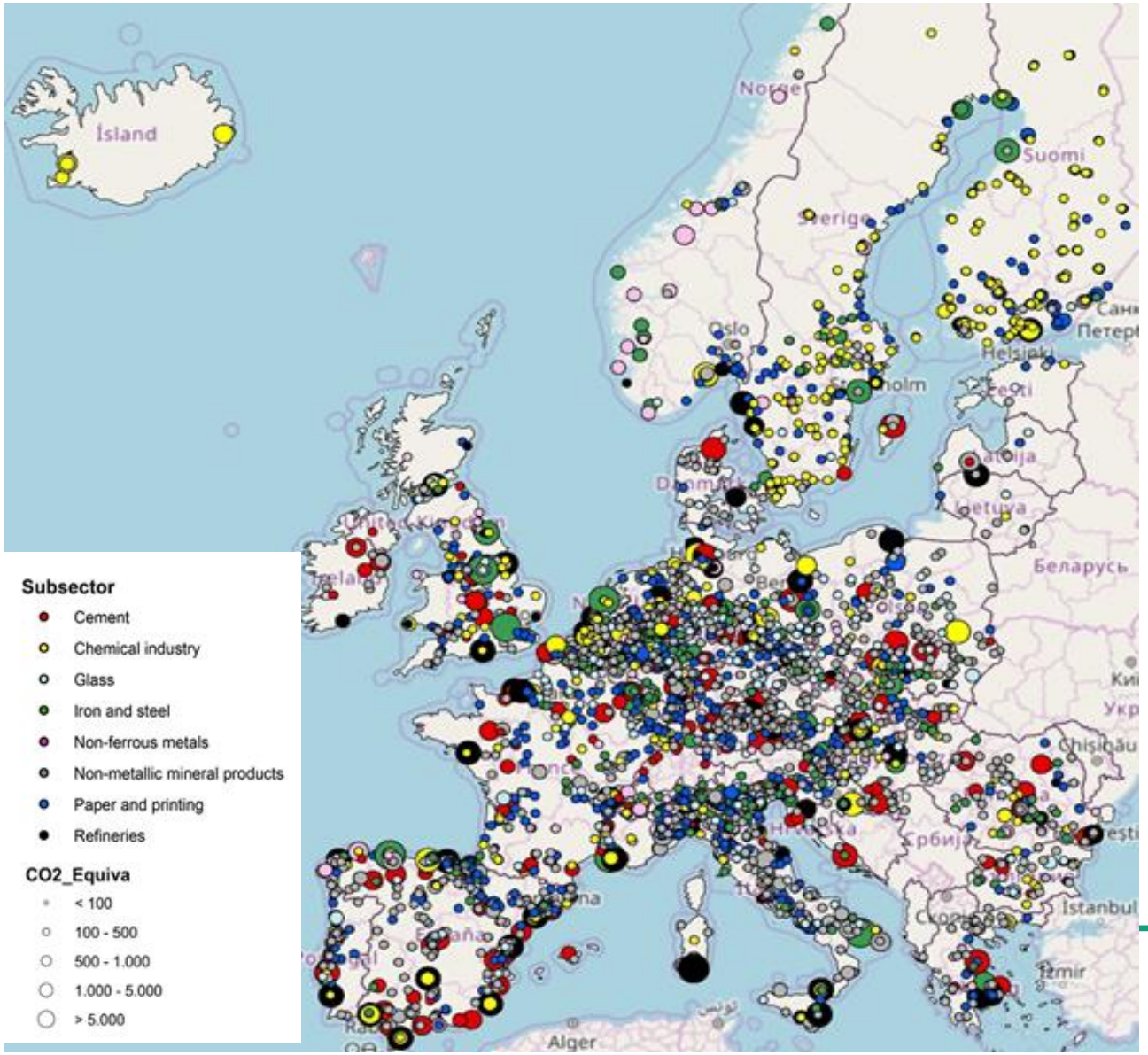
Which industry sectors will use hydrogen as a feedstock or fuel?



Forecast - Open database of energy-intensive industry in Europe

- Database of energy-intensive industrial sectors: cement, basic chemicals, glass, iron & steel, non-ferrous metals, non-metallic minerals, paper, refineries
- In particular hydrogen demand can be calculated, site specifically based on known reinvestment cycles
- Coverage: ca. 5500 companies in the EU – based on the emission registries E-PRTR** und EU-ETS***
- Spatial resolution: NUTS 3

Sources: P. Manz, et al. Sustainability 2021, 13(3), 1439, Fraunhofer ISI
European Pollutant Release and Transfer Register
European Union Emission Trading System

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Three components will define the future of hydrogen transport options

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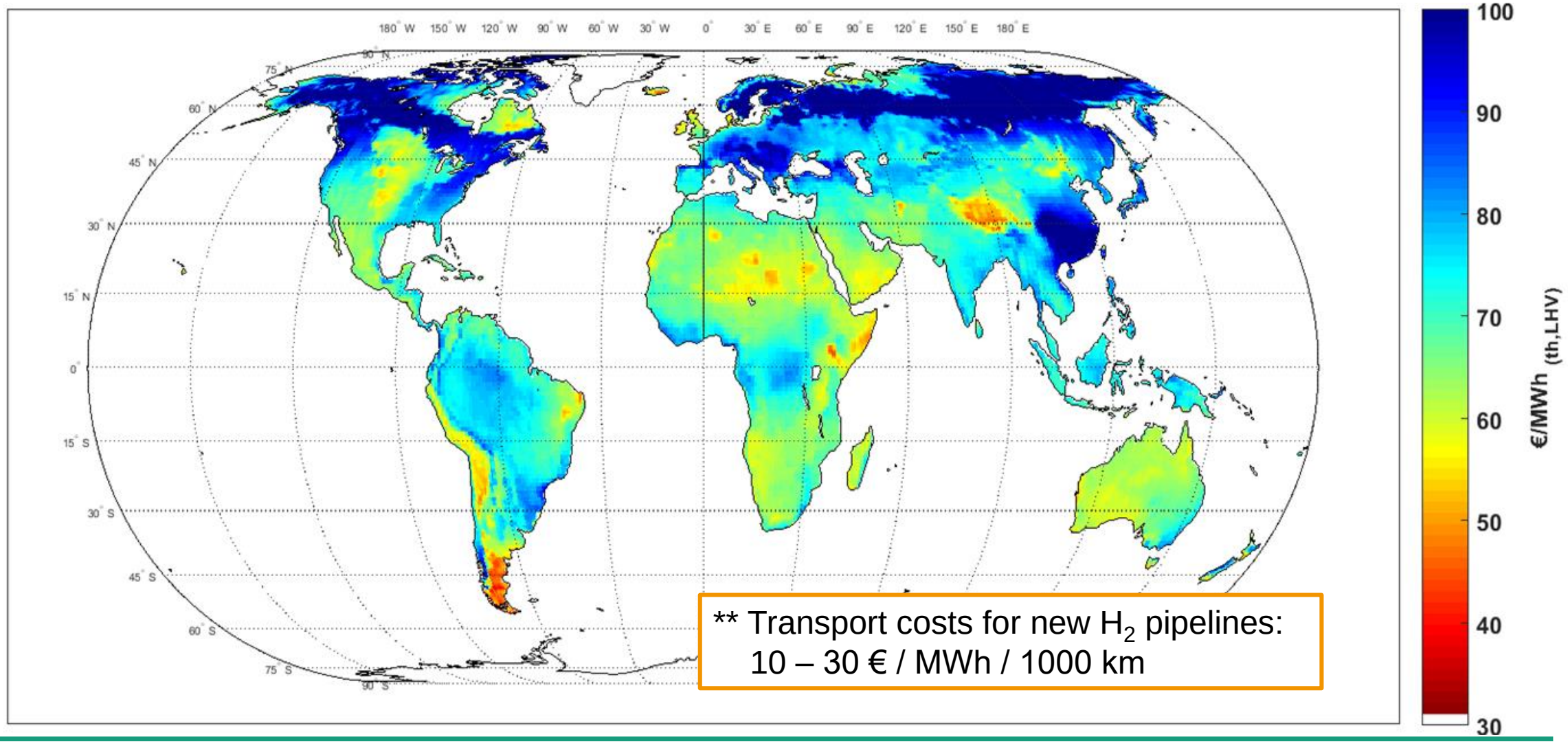
Import of synthetic fuels (E-fuels) - Generation costs of green hydrogen *



** Transport costs for new H_2 pipelines:
10 – 30 € / MWh / 1000 km

Source: * Jensterle et al. 2019 (LUT-model)

** Source: AGORA (2021)

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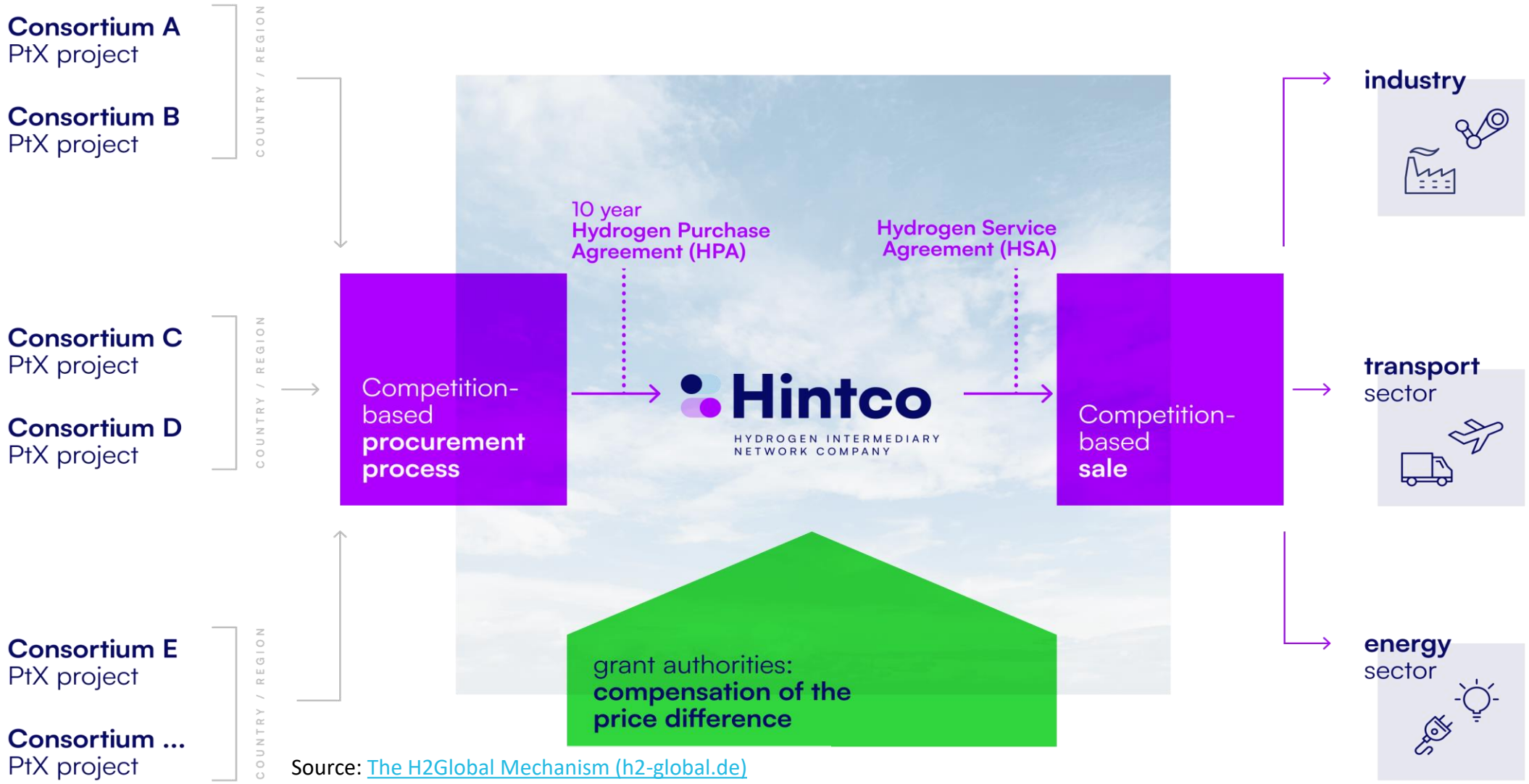
A KEY POLICY TO INCENTIVISE GLOBAL SUPPLY H2-GLOBAL



Source: [The H2Global Mechanism (h2-global.de)]

Three components will define the future of hydrogen transport options

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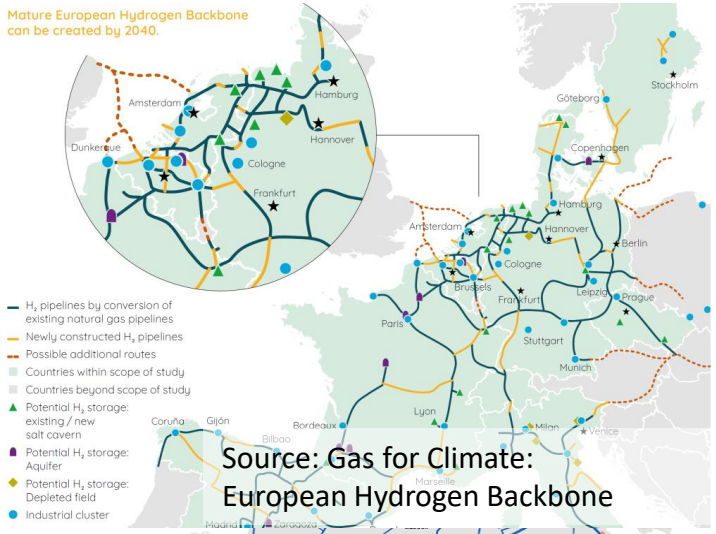
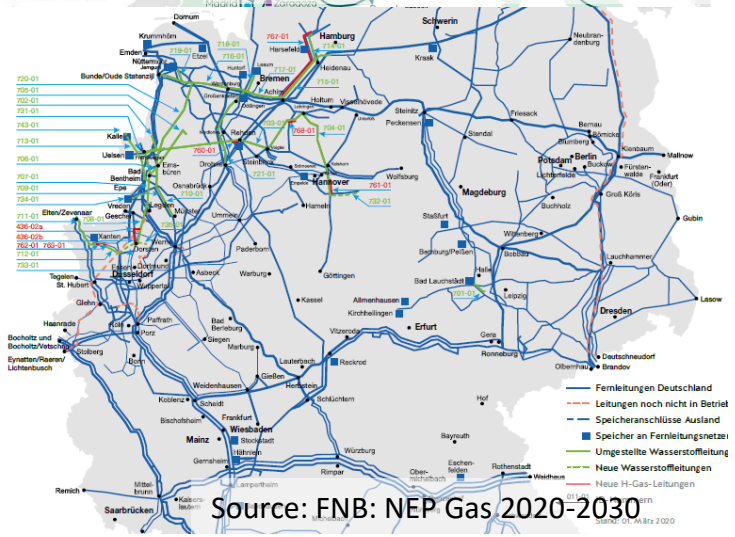
First plans for future hydrogen grids in Europe have been published

- Common features:
  - 70-90% of the future hydrogen network will be based on the conversion of existing natural gas pipelines.
  - The costs of retrofitted pipelines will be a factor of 3-4 below newly built pipelines.
- BUT, these plans do involve an integrated system planning.
- Modelling a more realistic structure requires
  - Considering the interactions between supply, demand and infrastructures for electricity, natural gas and hydrogen
  - Cost optimization of the energy system
  - Dynamics of storage, electricity and gas



Source: Gas for Climate: European Hydrogen Backbone



Source: FNB: NEP Gas 2020-2030

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Models for the analysis of integrated energy systems

Supply

Fix Portfolio of renewable energies, power plants, storage, imports.

Transport electricity

Transport natural gas

Transport H_2

Demand

Fix Portfolio electricity, natural gas hydrogen, liquid fuels, biomass.

Spatial resolution	Copper plate	Transmission	Distribution	District
Temporal resolution	Year	Hour	Second	
Field of application	Investment-Planning		Operation	
Modelling-Ansatz	Optimisation		Simulation	

Quelle: FNB (2021): Netzentwicklungsplan Gas 2020–2030

Quelle: ÜNB (2021): Netzentwicklungsplan Strom 2035, Version 2021

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Models for the analysis of integrated energy systems

Iteration

Supply

Variable Portfolio renewable energies

Transport electricity

Transport natural gas

Transport H_2

Transformation

Storage

Demand

Fix Portfolio
electricity, natural gas
hydrogen,
liquid fuels, biomass.

Spatial resolution	Copper plate	Transmission	Distribution	District
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Quelle: Pfluger et al (2018)

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Models for the analysis of integrated energy systems

Supply

Variable Portfolio renewable energies

Transport electricity

Transport natural gas

Transport H_2

Heat grids

Transformation

Storage

Demand

Variable Portfolio Final energy demand

Integrated models for **Grid-based Multi-Energy-Systems**

[1] **PyPSA**, [2] Calliope
[3] oemof, [4] urbs

Spatial resolution	Copper plate	Transmission	Distribution	District
Temporal resolution	Year	Hour	Second	
Field of application	Investment-Planning		Operation	
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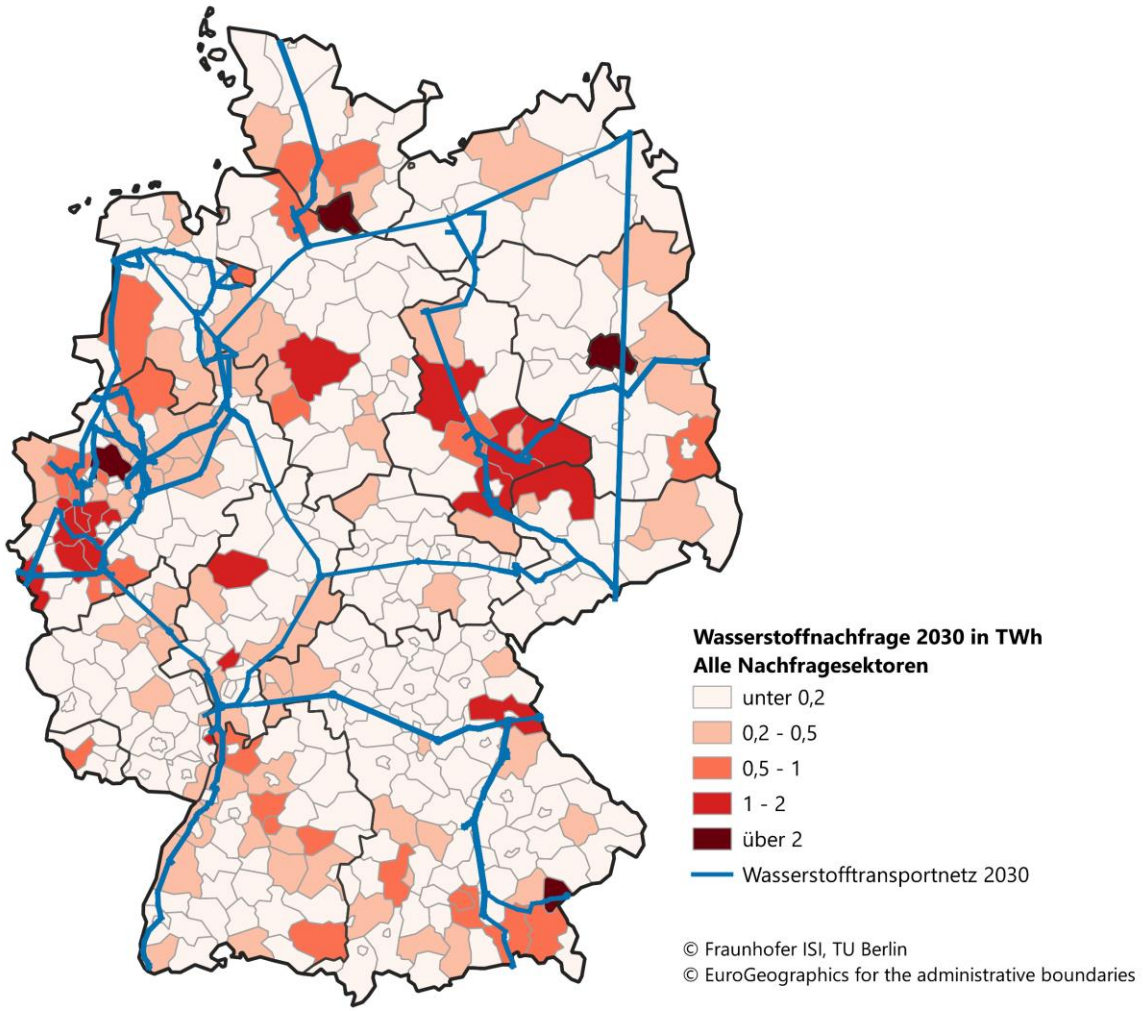
1st draft assessment of an H_2 backbone in 2030 within TransHyDE

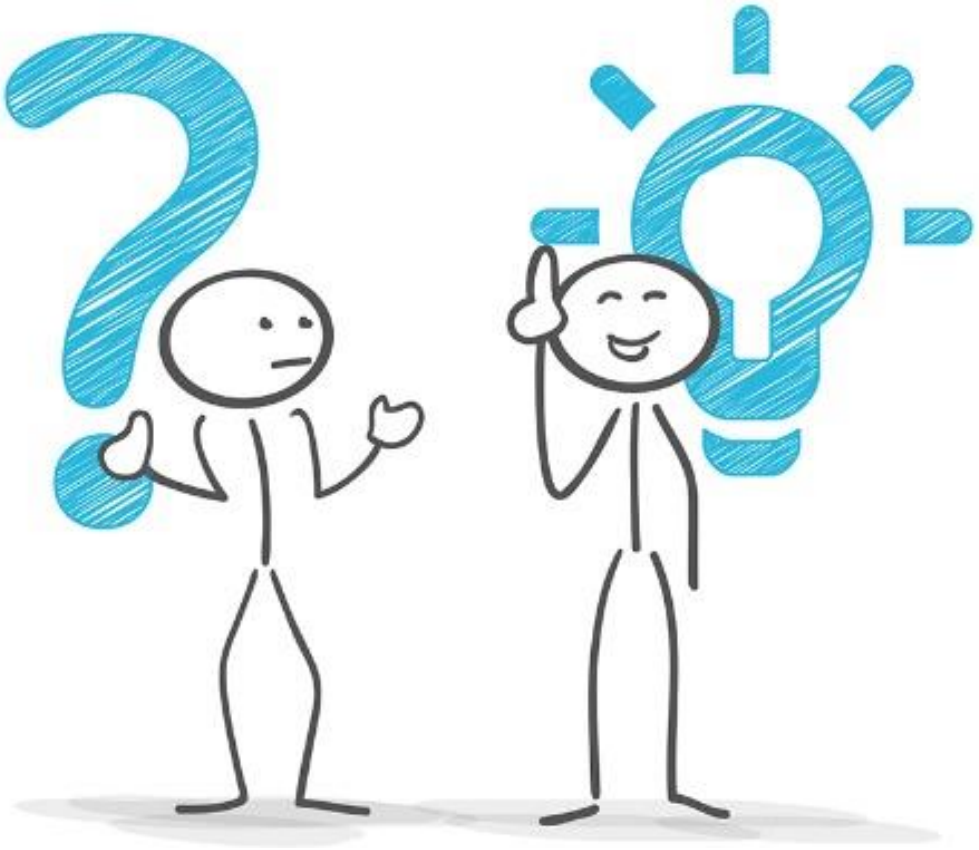
- First model-based assessment of a hydrogen backbone and hydrogen demand per year in 2030
- First draft of a hydrogen backbone based on the demand assessment for the energy intensive industry (steel, chemical and process heat)
- Modelled hydrogen grid of 8000 km, which is also capable for further transport needs



Conclusions

- Sector coupling will be a dominant property of future climate neutral energy systems.
- Sector coupling will serve climate neutrality and security of supply.
- The share of electricity based sector coupling, hydrogen and synthetic fuels is characterized by high uncertainty in current studies.
- Besides uncertainties in general input data the challenge of fully integrated modelling of sector coupled infrastructure is a main reason for the broad spectrum of results.
- Most studies show a high demand of hydrogen, therefore dedicated hydrogen infrastructures will be needed.
- The detailed assessment of hydrogen demand and supply at high spatial resolution is needed in order to determine the topology of the infrastructures.
- Fully integrated modelling of demand, supply and electricity, gas / hydrogen / heat infrastructures at high resolution are required to assess the optimal energy infrastructures.
- Therefore models for grid-based multi-energy-systems are needed.

Q&A



Source: Rheumalis 2019