

EU Industrial Future in a climate neutral Europe

The role of electricity, power-to-X and renewable H2

Input II on hydrogen and renewable gases

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Introduction



Öko-Institut e.V.

- Independent research association
- Based in Freiburg, Berlin, Darmstadt
- Focussed on sustainable transition (Energy, Mobility, Ressources, Governance, Products, ...)

Christoph Heinemann

- 10 years with Öko-Institute
- Research focusses on electricity sector and PtX (flexibility, grids, DSM, RES-E, ...)

Focus of PtX Research

- Projects so far on Germany, discussion quite strong in Germany (Mobility)
- Publications on:
 - 2019: Sustainability criteria for electricity based gases and fuels
 - 2019: Relevance of electricity based gases and fuels in Germany (technologies, demand, potential for GHG-reductions, costs)
 - 2020: Climate Protection Scenarios Germany (upcoming)

Hydrogen and secondary products

It's a huge topic with a lot of open questions...



Demand for hydrogen and secondary products

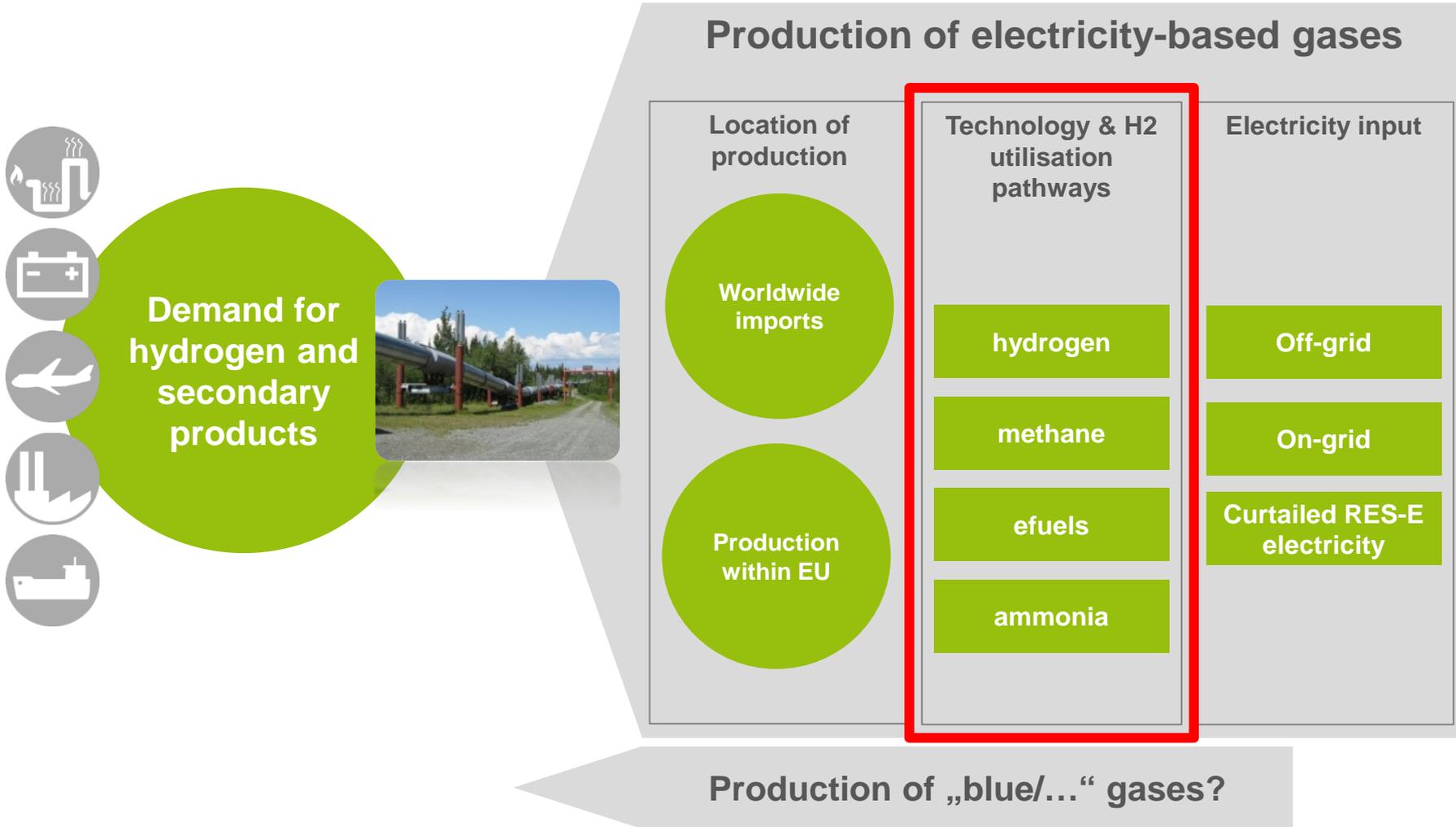


Production of electricity-based gases

Location of production	Technology & H2 utilisation pathways	Electricity input
Worldwide imports	hydrogen	Off-grid
Production within EU	methane	On-grid
	efuels	Curtailed RES-E electricity
	ammonia	

Production of „blue/...“ hydrogen?

Technology & H2 utilisation pathways



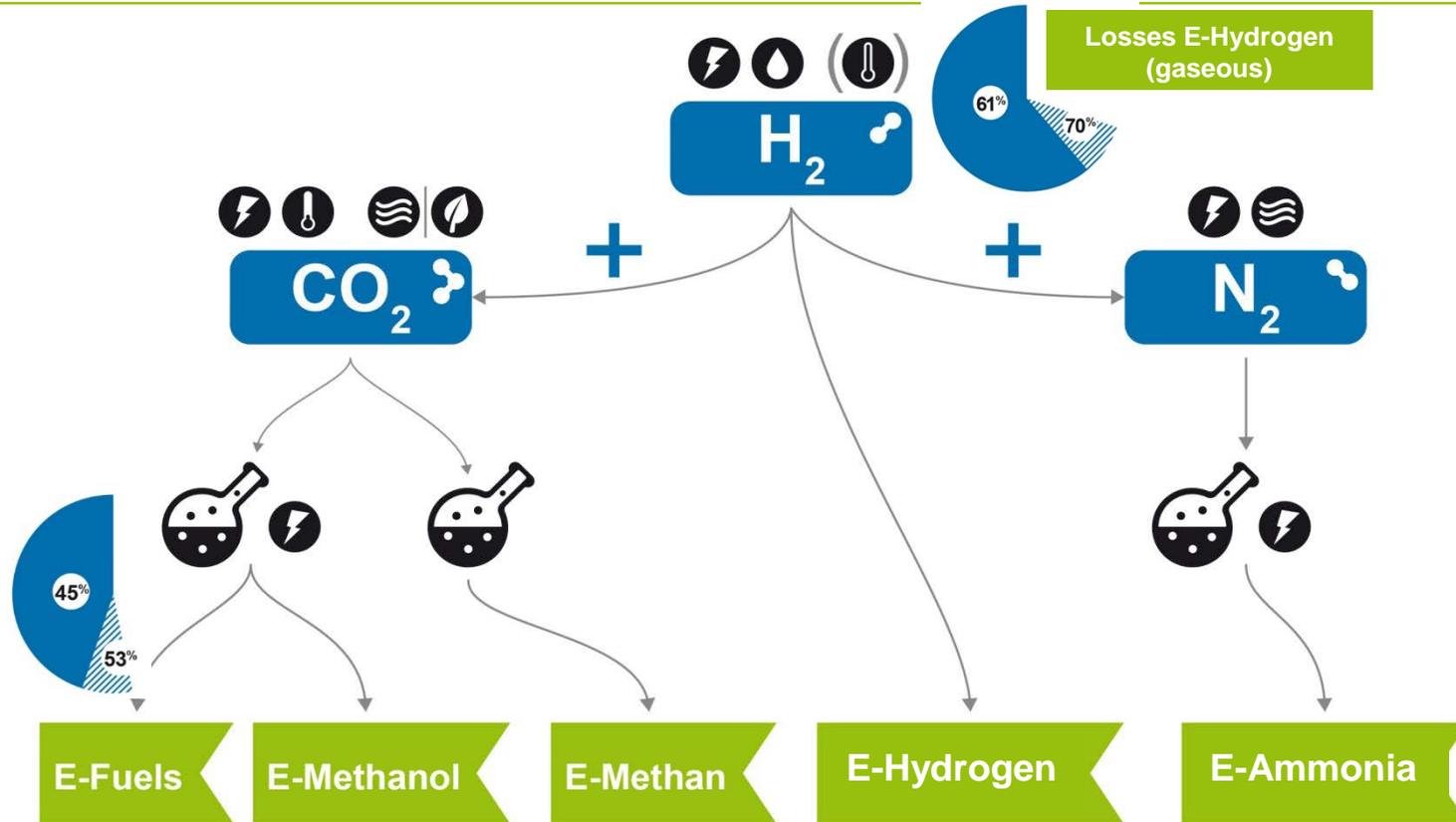
H₂ production pathways

- Conventional production: Reforming of **natural gas or other hydrocarbons**
 - CO₂-emissions of H₂ result from natural gas and other fossil hydrocarbons
- Blue Hydrogen: Splitting natural gas and storing CO₂ underground (CCS)
- Methane Pyrolysis: High temperature process resulting in fixed carbon

- **Electrolysis of water:**
 - CO₂-emissions of H₂ depend on specific CO₂-emissions of electricity generation

H₂ utilisation pathways

Short overview of secondary products



Zufuhr von:

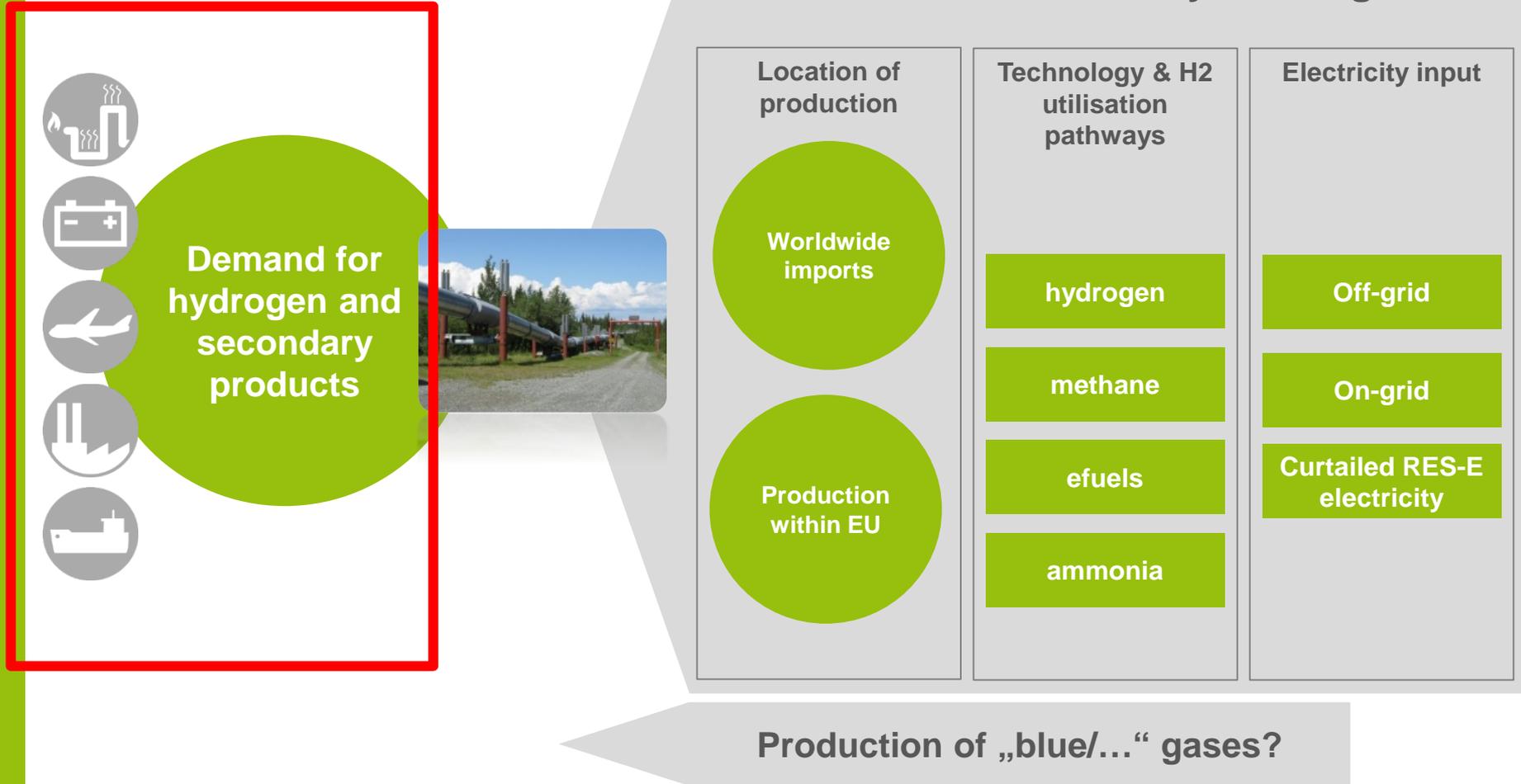
- Strom
- Wasser
- Luft
- Niedertemperaturwärme
- Hochtemperaturwärme
- nachhaltige Biomasse

Syntheseprozess



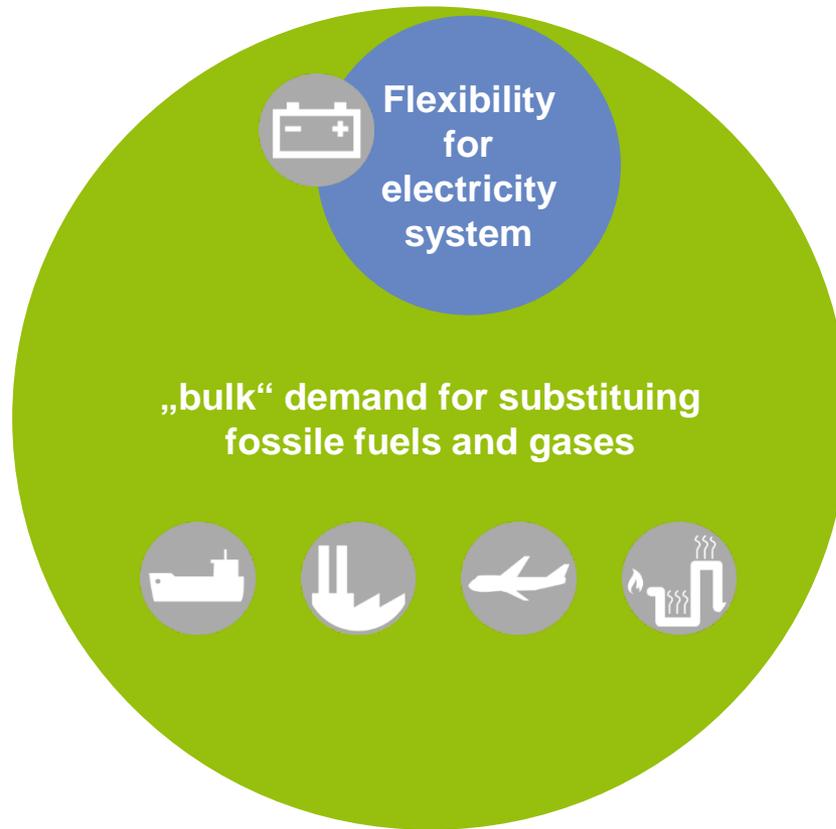
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Demand for hydrogen and secondary products



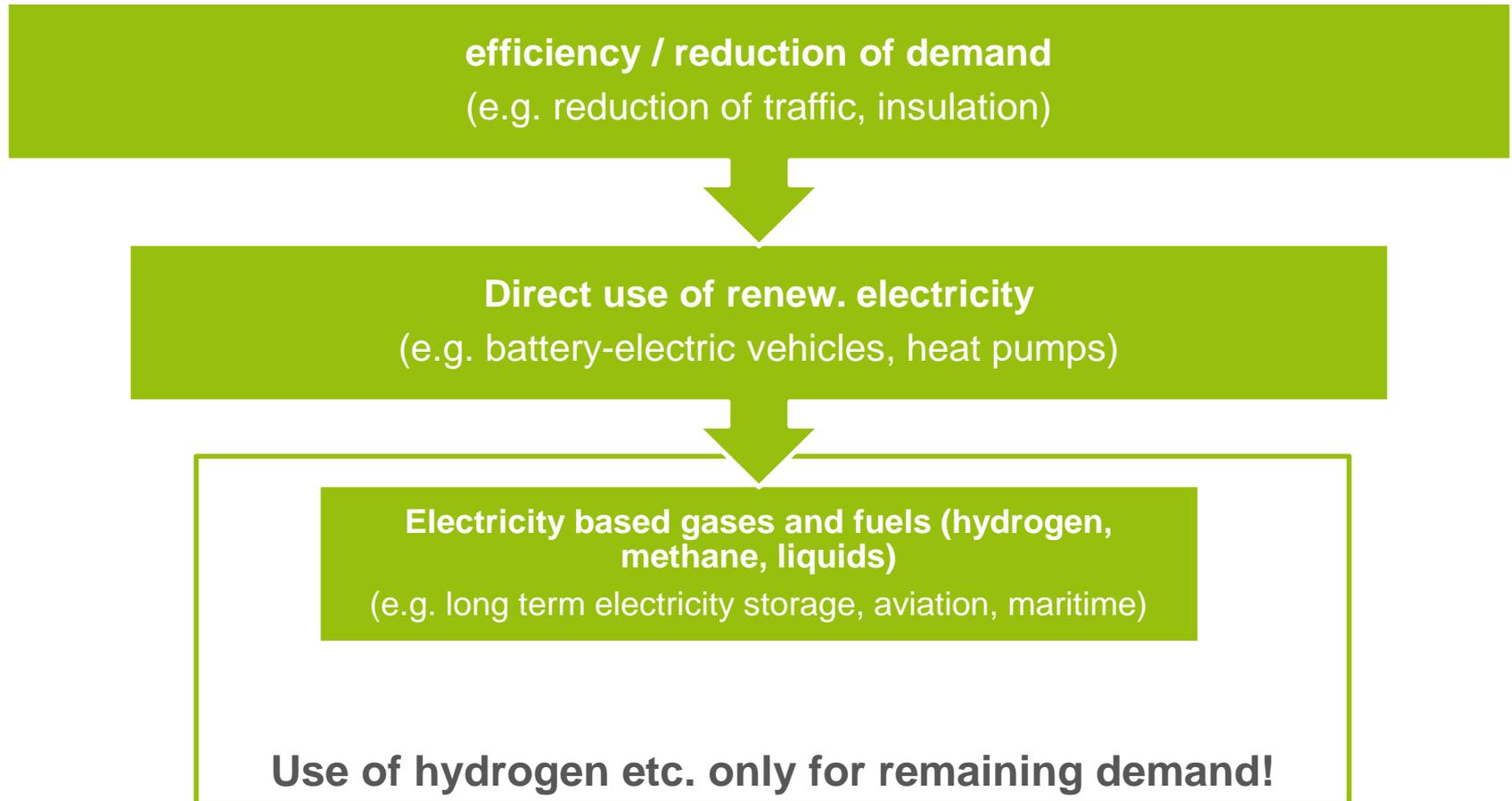
Demand for hydrogen and secondary products

It's mainly about bulk demand, not flexibility



Crucial options for reducing GHG-emissions

→ Demand for hydrogen etc. depends on ambitions for other options



In which sectors are hydrogen and secondary products necessary in order to reach GHG-neutrality?

No-regret

- chemical industry (H2 feedstock)
- Steel production
- High temperature heat
- Aviation
- Maritime Transport
- Long term „storage“ for electricity sector (systems with high % of variable Res-E)

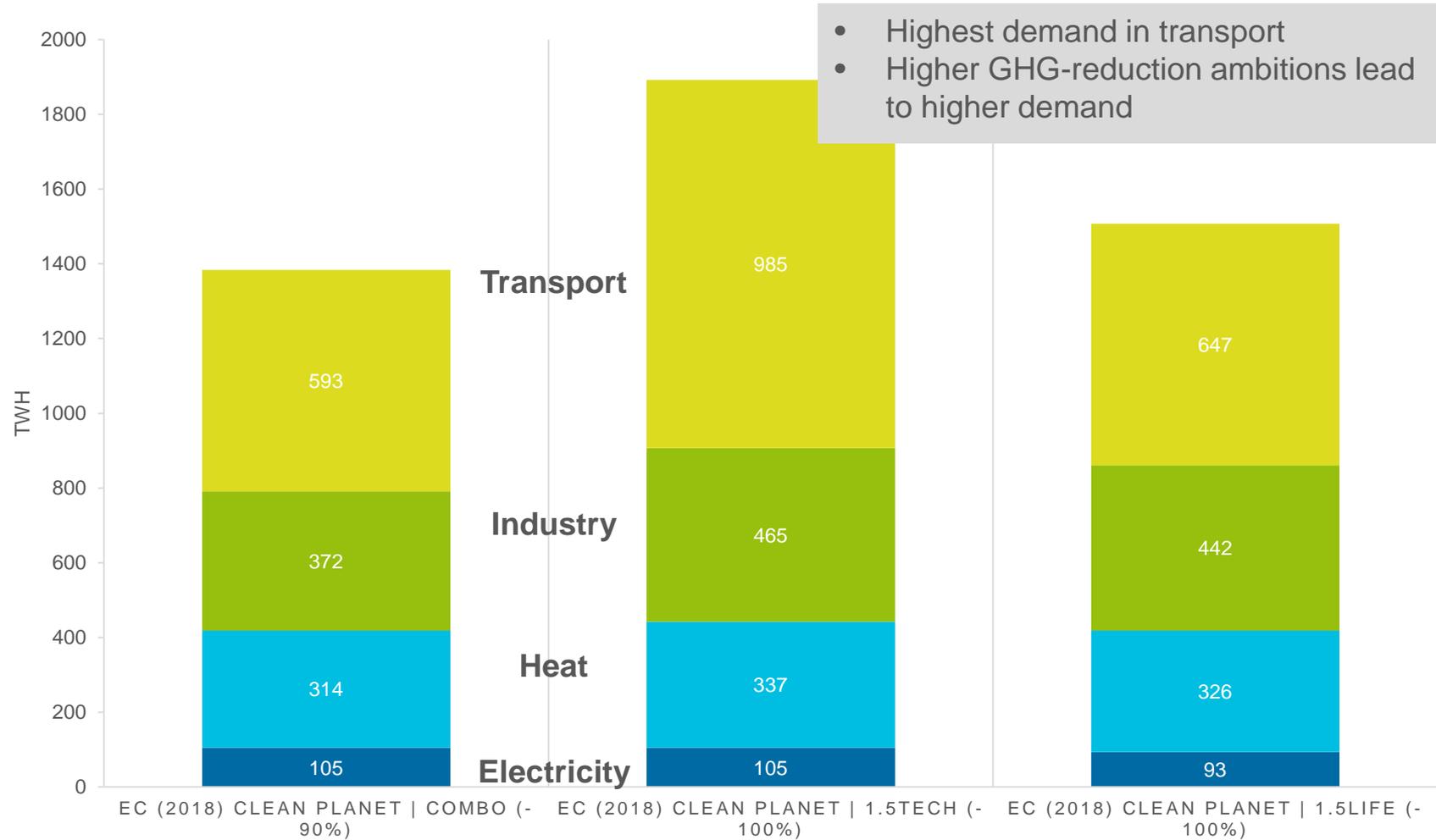


Possible further demand

- Long distance freight → if other innovations like trolley systems fail
- Spatial heating → if efficiency measures like insulation fail



Demand for Hydrogen and secondary products in EU



Focus industry-sector: Demand for hydrogen and secondary products

- Feedstock for chemical industry (ammonia, methanol, ethylene, ...)
- Steel production via h₂ direct reduction (e.g. voestalpine in Linz, <https://h2future-project.eu/>)
- Industrial high temperature processes (ca. 65% of total industry energy demand; 75% temp. need above 500°C → green fuels needed)
- Hydrogen for refineries → how is this in line with long term decarbonisation?

If we need hydrogen early due to reinvestment cycles of the industry (Steel), it is unlikely to have sufficient (cheap) hydrogen from renewable sources in time available

→ Blue (or other coloured) hydrogen will be in debate!

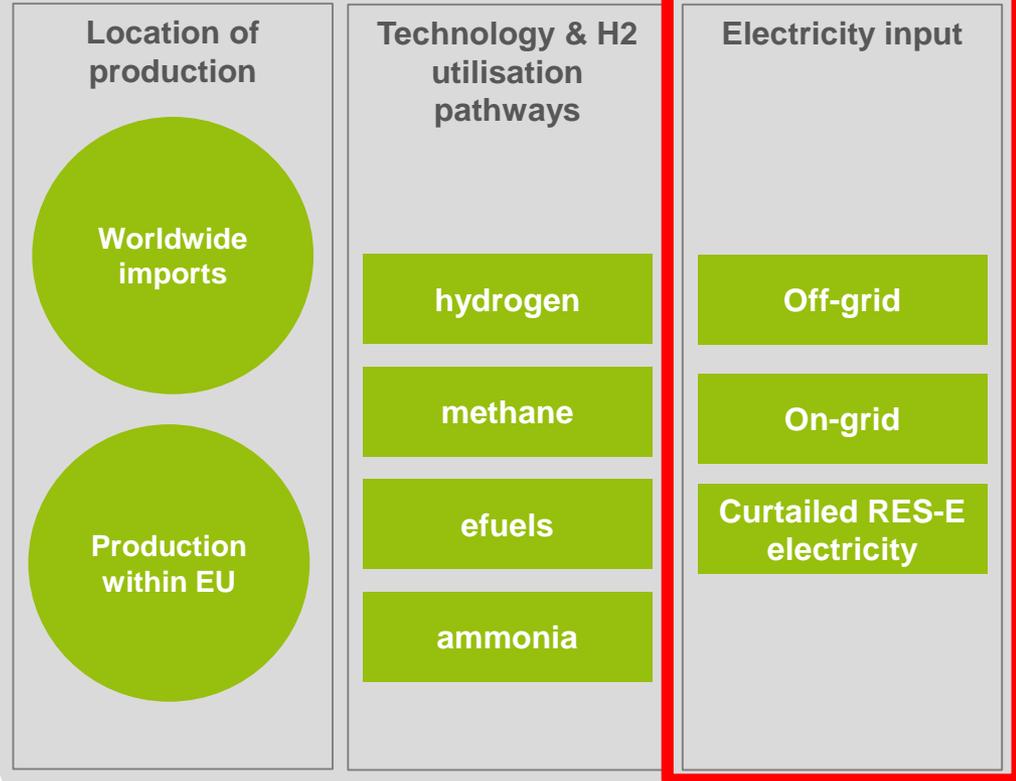
Electricity input



Demand for hydrogen and secondary products



Production of electricity-based gases



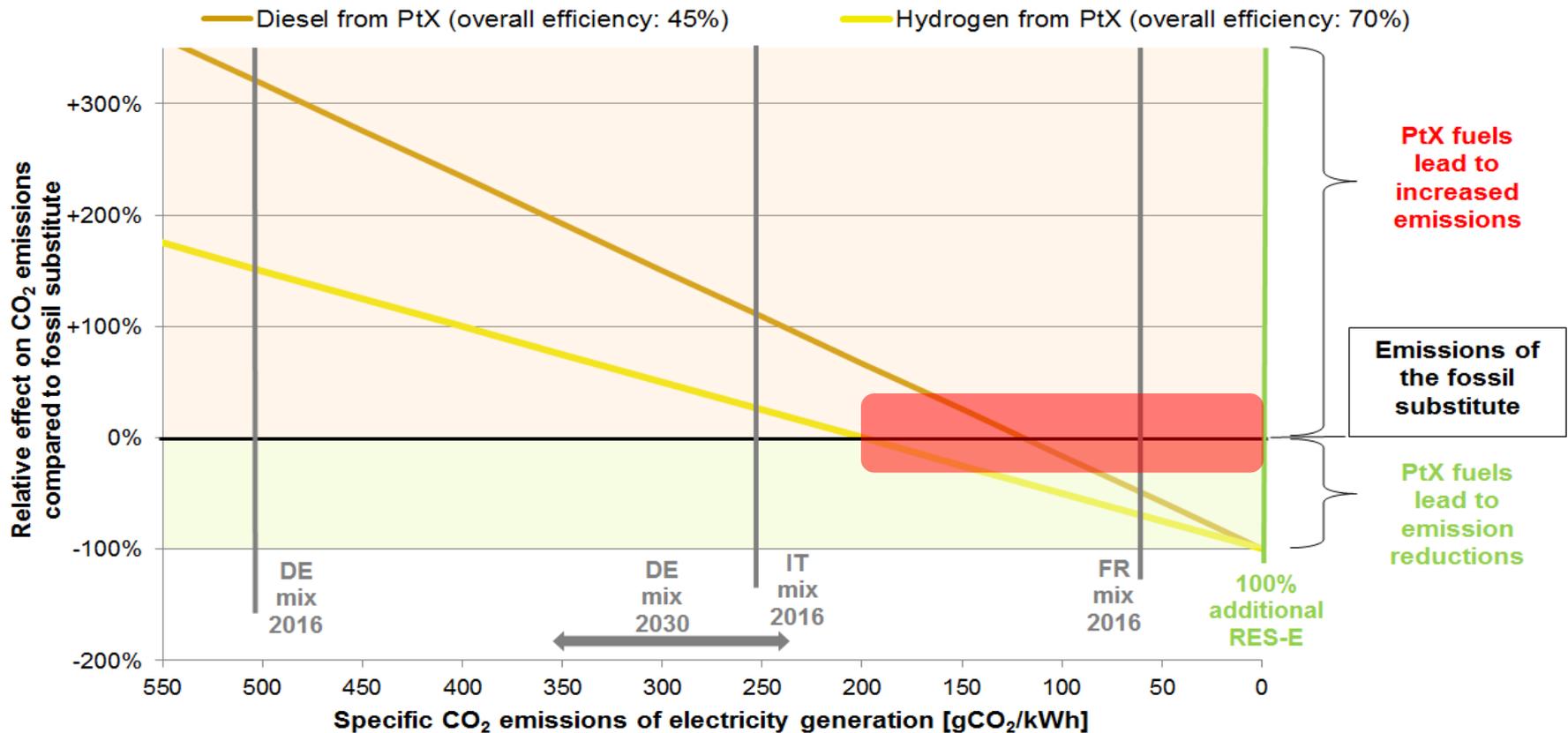
Production of „blue/...“ gases?

Electricity Input overview

- Using dedicated RES-Sources (see also Article 27 REDII: direct connection between RE and fuel production plant)
 - Might have impact on remaining RES-E potentials available for electrification
 - Option for bulk-production in unsettled areas (also North-Sea?)
- Using curtailed RES-E
 - can be an „add-on“ but will not provide „bulk“ hydrogen → expansion of grid will result in low curtailment/surplus
 - Expansion of electricity grid across Europe will be key to reach GHG-reductions
- PtX as standard electricity consumer
 - CO₂-emissions of H₂ depend on specific CO₂-emissions of electricity generation
 - GHG-reduction depends also on the substitution effect
 - guarantees of origin not sufficient → as they don't increase RES-E production

Electricity Input

Analysis of break-even points compared to fossil substitute



- CO₂-emissions of H₂ depend on specific CO₂-emissions of electricity generation
- In the transition phase, GHG-reduction depends also on the substitution effect

Sustainability criteria for producing hydrogen in an electricity system

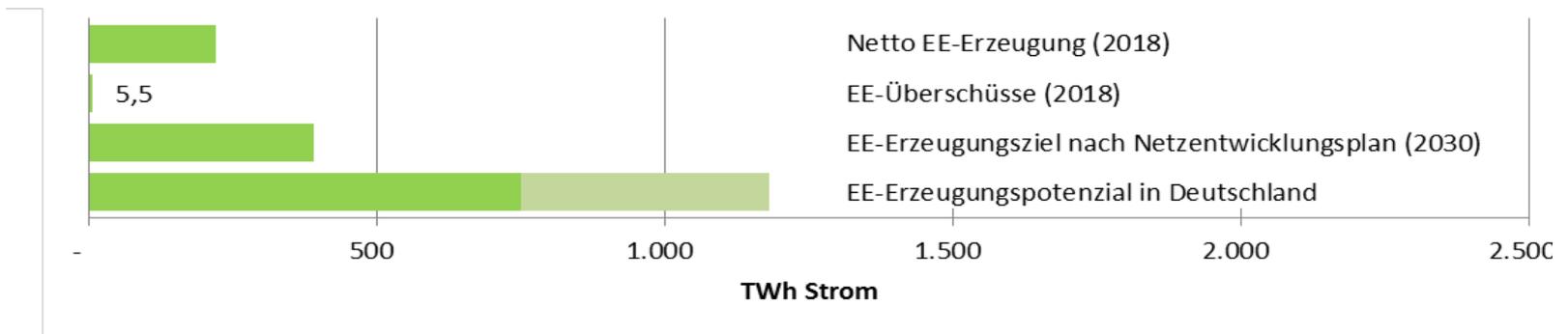
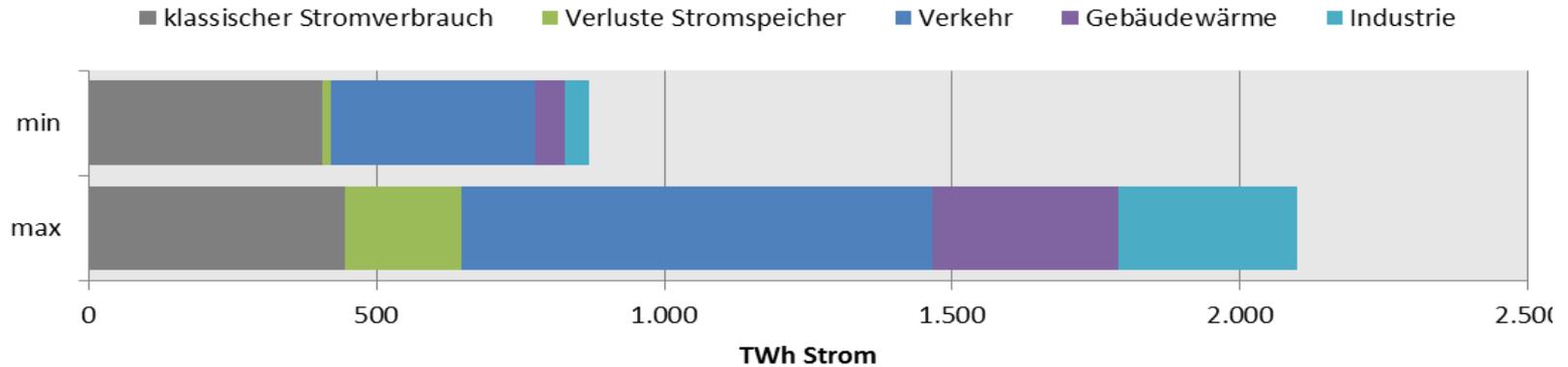
- 1. Additional RES-E production from un-subsidised, new plants**
 - guarantees of origin of origin not sufficient → as they don't increase RES-E production
- 2. Importance of flexibility**
 - Operation of electrolysis should adapt to feed-in of wind and PV
 - However, this will reduce full load hours
- 3. Importance of location**
 - PtX production facilities should not worsen grid bottlenecks

→ Some of this is part of Recital 90 (REDII)

Additional electricity demand exceeds surplus and production potential

Electricity demand in Germany 2050: minimum and maximum approximation

Source: Christoph Heinemann, Peter Kasten and others (2019) „Die Bedeutung strombasierter Stoffe für den Klimaschutz in Deutschland“



Electricity demand exceeds RES-E production potentials in Germany
 → imports of hydrogen and secondary products

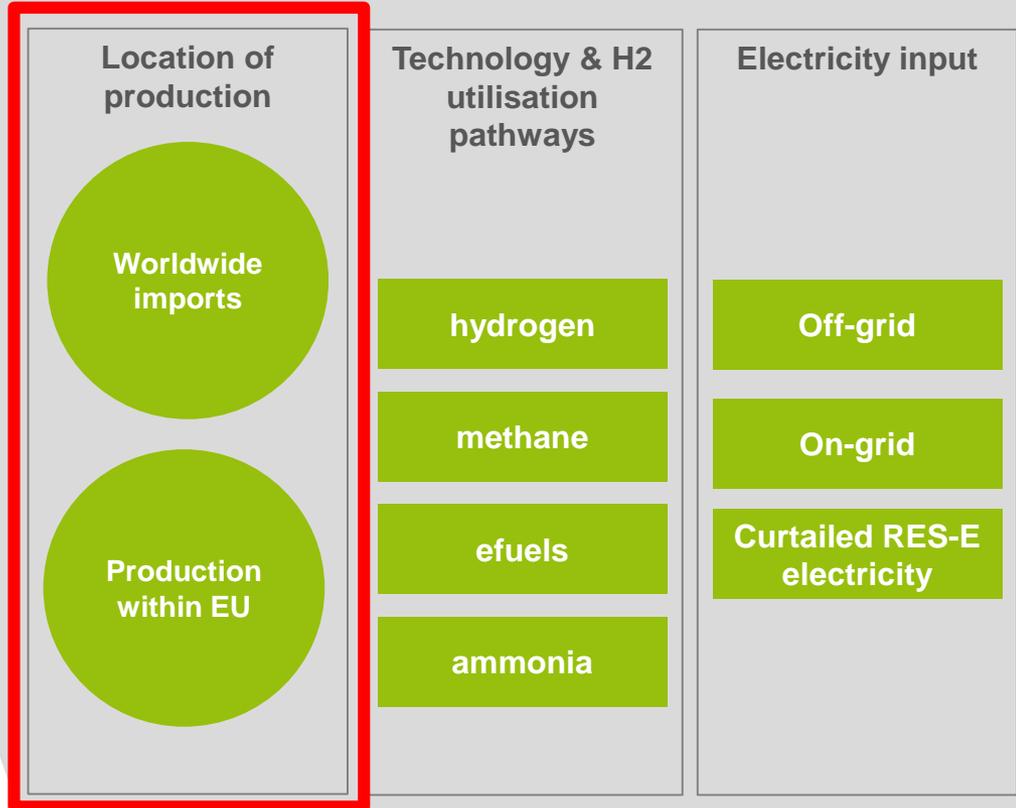
Location of production



Demand for hydrogen and secondary products



Production of electricity-based gases

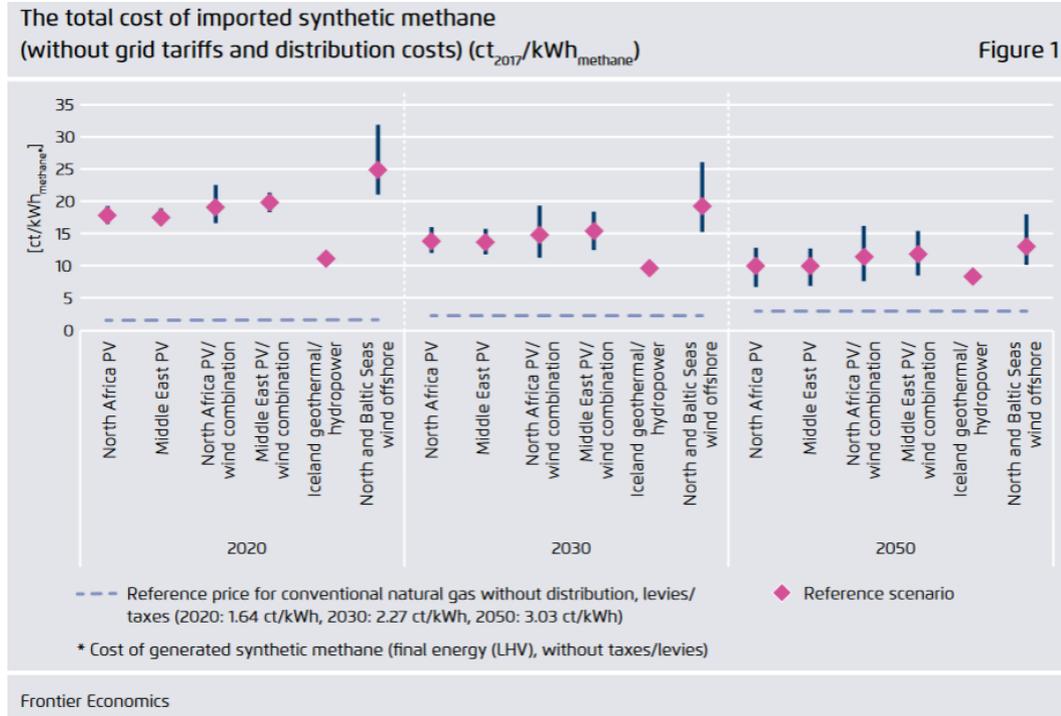


Production of „blue/...“ gases?

„Bulk“ hydrogen will likely be from world-wide imports

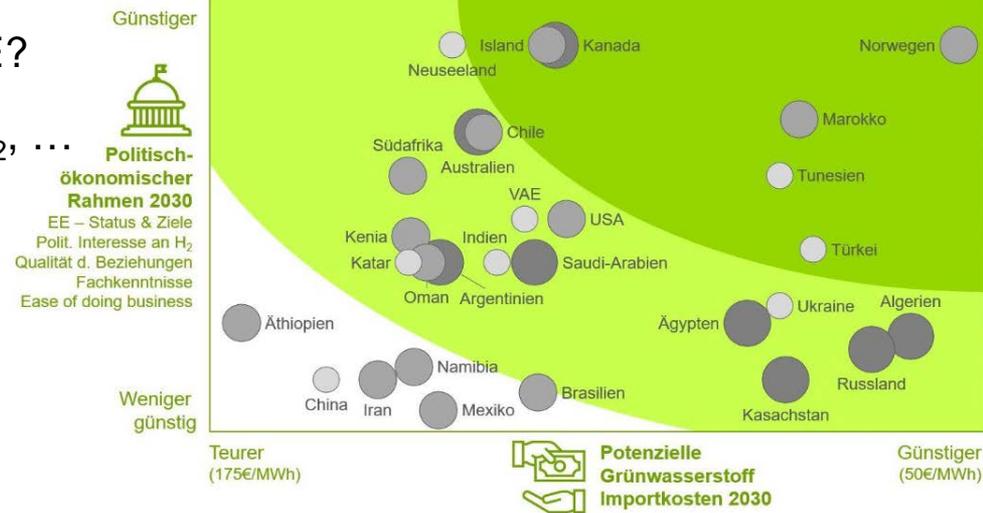
1. Available & accepted space for RES-E production
2. Costs
 - European production about ¼ more expensive
 - Most relevant for overall costs:
 - Investment (electrolysis) and WACC,
 - generation-costs of electricity from RES-E,
 - operating hours per year

→ However, market prices can be much higher



„Bulk“ hydrogen will likely be from world-wide imports

- Market prices:
 - Depend on costs of production but also number of exporting countries in the market!
 - Because of high WACC in many countries with high RES-E potential, only a few countries worldwide will be major exporters of hydrogen and secondary products
- Sustainability criteria is crucial
 - Decarbonisation of electricity sector in exporting countries
 - Occupation of best sites for RES-E?
 - Other resources: water, land, CO₂, ...



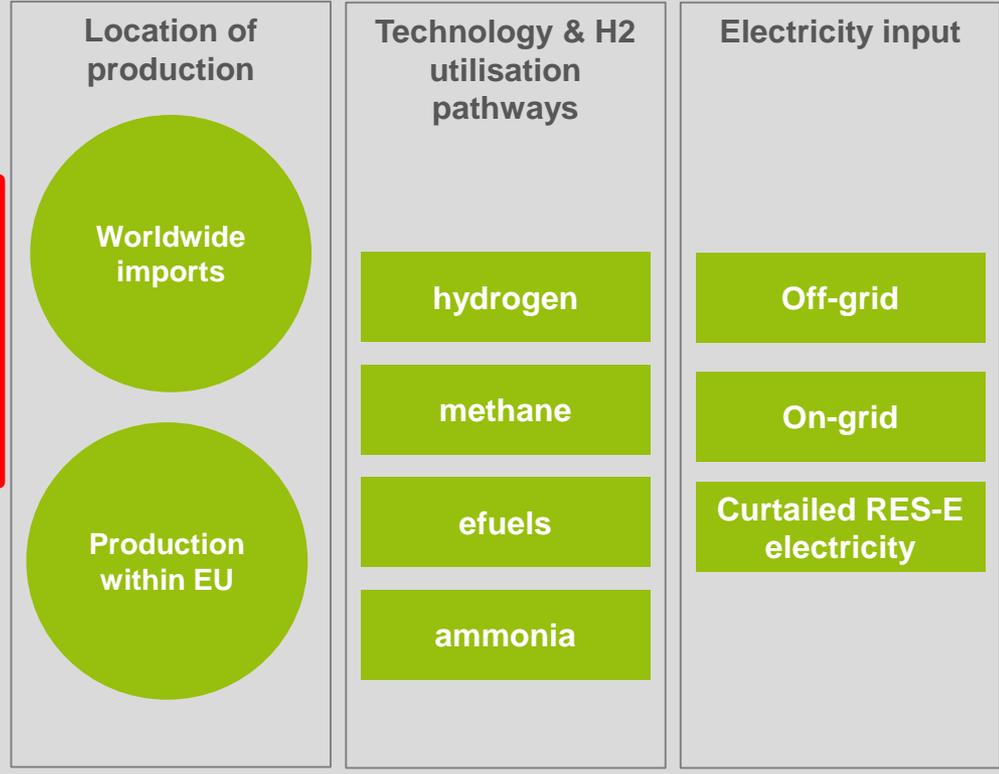
Infrastructure



Demand for hydrogen and secondary products



Production of electricity-based gases



Production of „blue/...“ gases?

Infrastructure

Grids & Appliances

- H2 readiness
 - Gas grid:
 - parallel pipelines can be repurposed for hydrogen
 - Blending can be done in existing infrastructure but for use in e.g. heating this does not trigger the transition needed towards electrification
 - H2 readiness ambitions for appliances already in place (e.g. gas turbines source: EU-Turbines)
 - LNG Terminals H2 ready? (international perspective)
 - New Power hubs in the north-sea?



<https://www.tennet.eu/our-key-tasks/innovations/north-sea-wind-power-hub/>

Important side-notes

- Distribution of hydrogen easier for regional industry-clusters within EU, compared to feeding households and mobility
- eMethane in gas-pipelines can still contribute significantly towards GHG-emissions due to leakage (about 4 Mt CO₂e in Germany)

Conclusions

What is relatively safe to say?

- There will be a significant demand for hydrogen, even if efficiency and electrification is being used to high potentials
- The use of renew. hydrogen in some industries (e.g. feedstock) seems to be a long-term sustainable option to reduce GHG → no-regret
- If no sustainability criteria for electricity input are being installed, the production of electricity-based gases can increase GHG-emissions!
- Due to lower costs and availability of land, imports of electricity based gases and fuels will play a major role
 - Sound sustainability criteria is essential (also for security of invest & credibility of “GHG-reduction instrument hydrogen”)
 - We assume a world-wide market for electricity based gases in which only few countries will play a major role

Our thoughts on future regulation... & open questions

- If there will be a world wide market for hydrogen
 - Sustainability criteria have to be in place
 - european standards for imported hydrogen vs. International certificates
 - Early partnering up with future exporting countries
 - Readiness of infrastructure (pipelines, LNG terminals etc., what is no-regret)
- Which potential can be seen for hydrocarbons (methane, efuels)?
- Integrated regulation needed:
 1. Technology development in Europe (make large scale projects possible, decrease prices of technology)
 2. Production in Europe (Issues: flexibility, grid-bottlenecks, electricity input)
 3. International Market (Governance for sustainability, security of investment, secure a functioning market)
 4. Directing valuable green gases into no-regret sectors
- RED II will be have a major impact on regulation, even though manly focussed on transport

Thank you very much for your interest!

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