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Dr. Jan Frederik Braun

Head of Hydrogen Cooperation
(MENA Region)
Cluster of Excellence Integrated
Energy Systems (CINES)

Europe's H_2 pathways:

Toward a balanced partnership with Saudi Arabia and the Gulf

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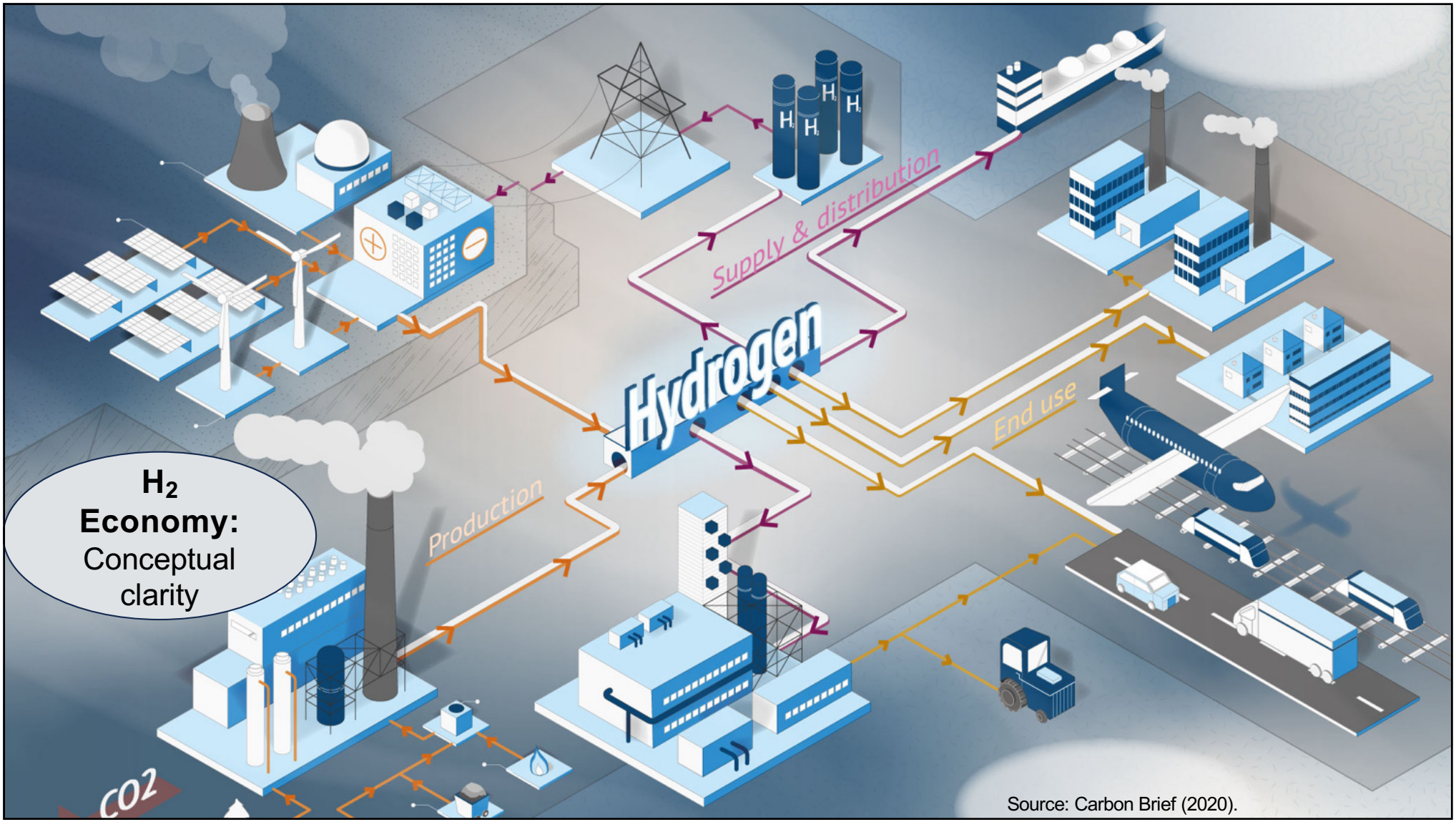

Source: Carbon Brief (2020).

H_2 Economy

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Characteristics:

- ✓ H_2 is a conversion and not an extraction business which can be produced anywhere in the world via electrolysis.
- ✓ Includes a variety of clean H_2 production pathways and different modes of transporting H_2 such as pipelines and shipping (e.g., pure form or in liquid organic hydrogen carriers and H_2-based derivatives such as ammonia and methanol).
- ✓ Strong synergies with electricity as H_2 will complement electricity in the energy transition and decarbonize hard-to-abate sectors & allow sector coupling (electricity, transport, industry, heat and natural gas sectors).
- ✓ H_2 will have to compete with the other decarbonization solutions in each sector, such as direct electrification and biomass.

H_2 Economy

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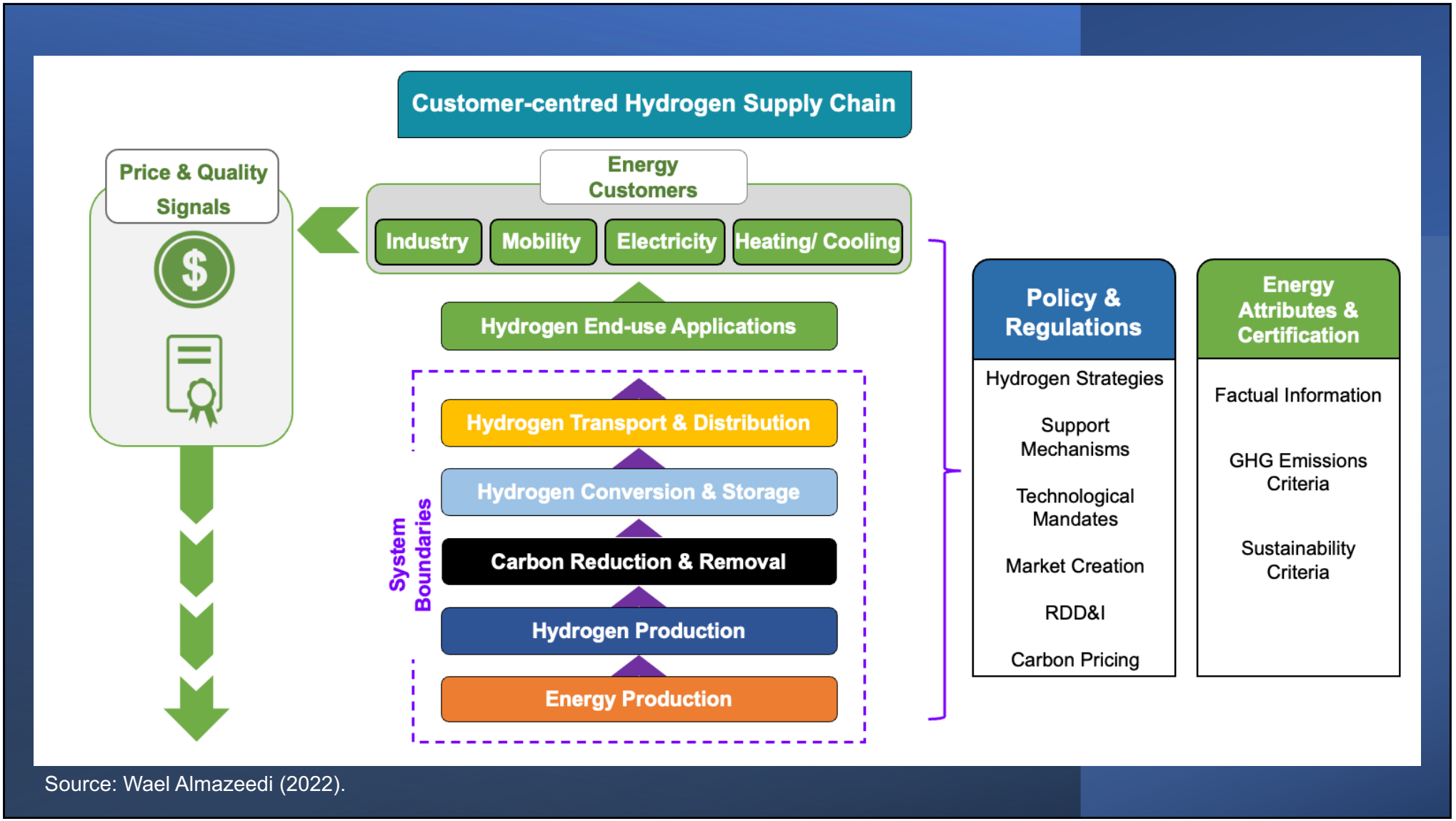
- ✓ Government support is required to kickstart the development of H_2 and create the necessary infrastructure and promote use cases via financial incentives.
- ✓ Major projects and large-scale production and consumption H_2 hubs in specific geographical areas will push governments to implement suitable policies and regulations.
- ✓ The H_2 market will initially be determined by long-term contracts and knowledge-driven. There is significant room for cost efficiency gains and innovation in hydrogen-based services and applications along the value chain.
- ✓ H_2 policy will be defined by specific GHG emissions and sustainability criteria, i.e., gCO_2 / kWh H_2 > standards and certification.



Source: Wael Almazeedi (2022).

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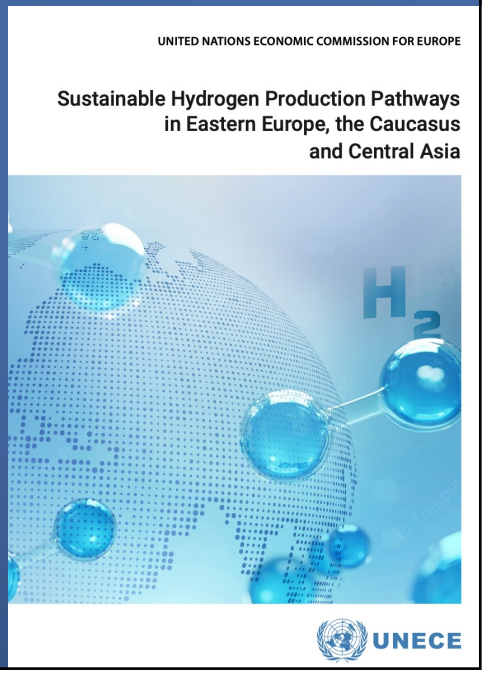
H_2 Economy: Constitutes either a regional or a global energy marketplace that complements that of electricity and plays a role in decarbonizing those parts of societies that electrification cannot. As a complement, the H_2 supply chain will be linked closely to that of electricity and most value will be created in the end-use sector in the long term.

"The H_2 economy deployment pace in countries will be determined not so much by their resource potential as by the strategic focus on low-carbon development, building appropriate regulatory frameworks, expanding markets, and technological development".
- Melnikov (2023) -




Europe's
H_2
Pathways

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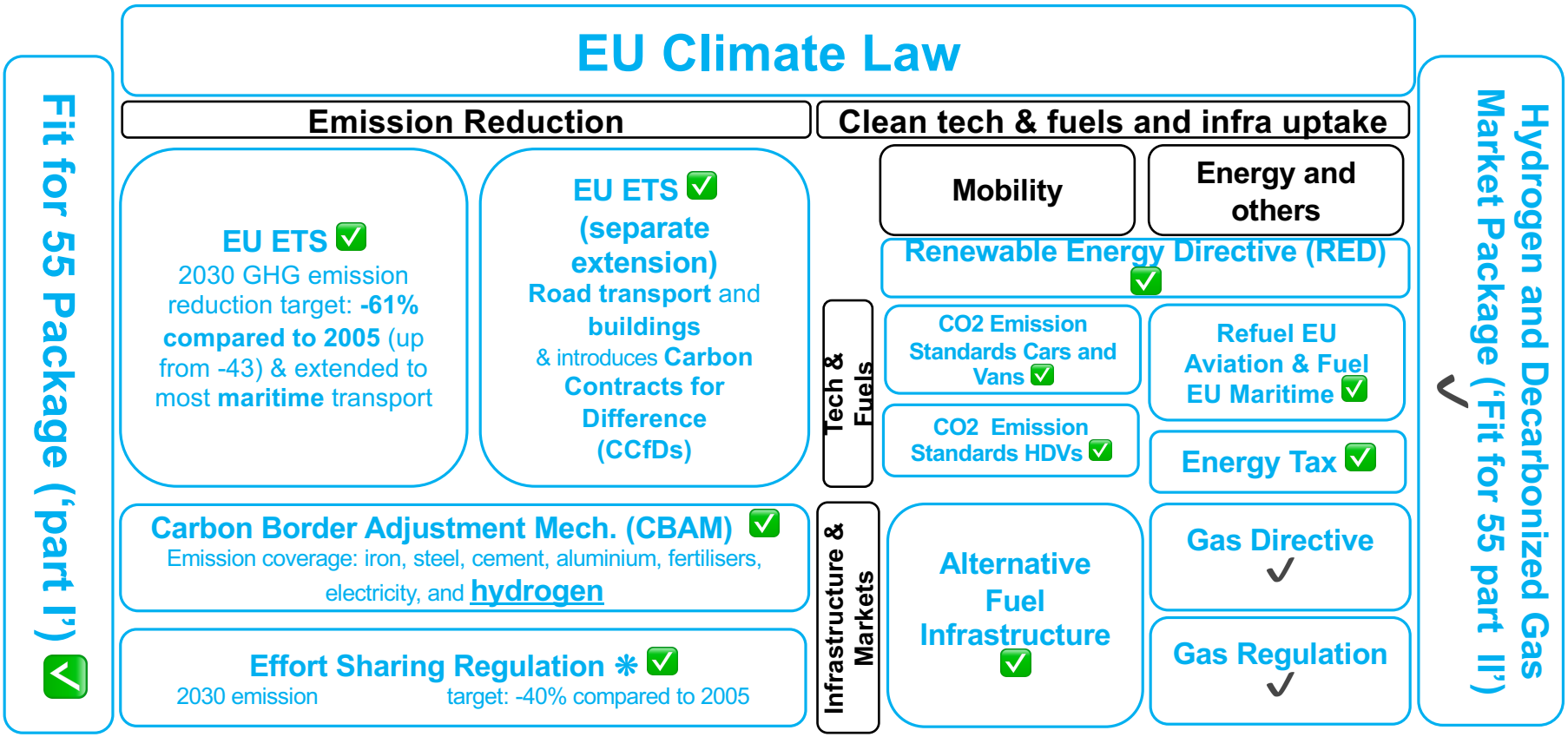

Source: Braun, Van Wijk and Westphal (2023).

Source: H2 Global Stiftung.

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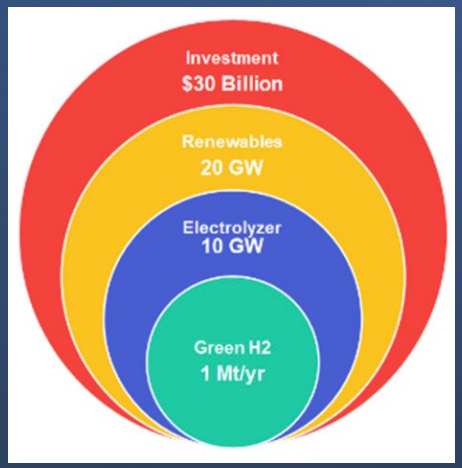
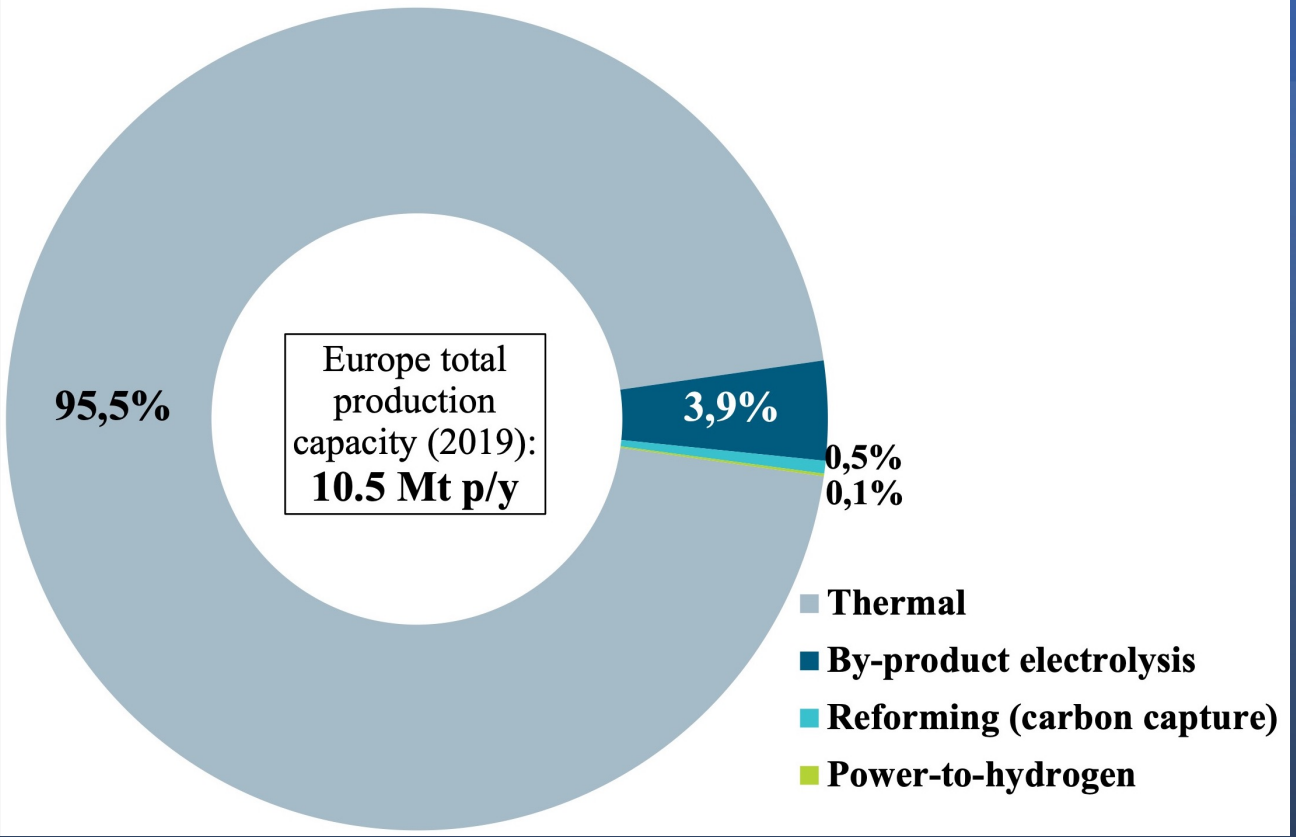
Target: 20 Mt of green H_2 production and import, i.e., 10 Mt of production and 10 Mt of imports (or 660 TWh H_2 /y) p/y by 2030



20 Mt green H2 ("1-10-20-30" rule):

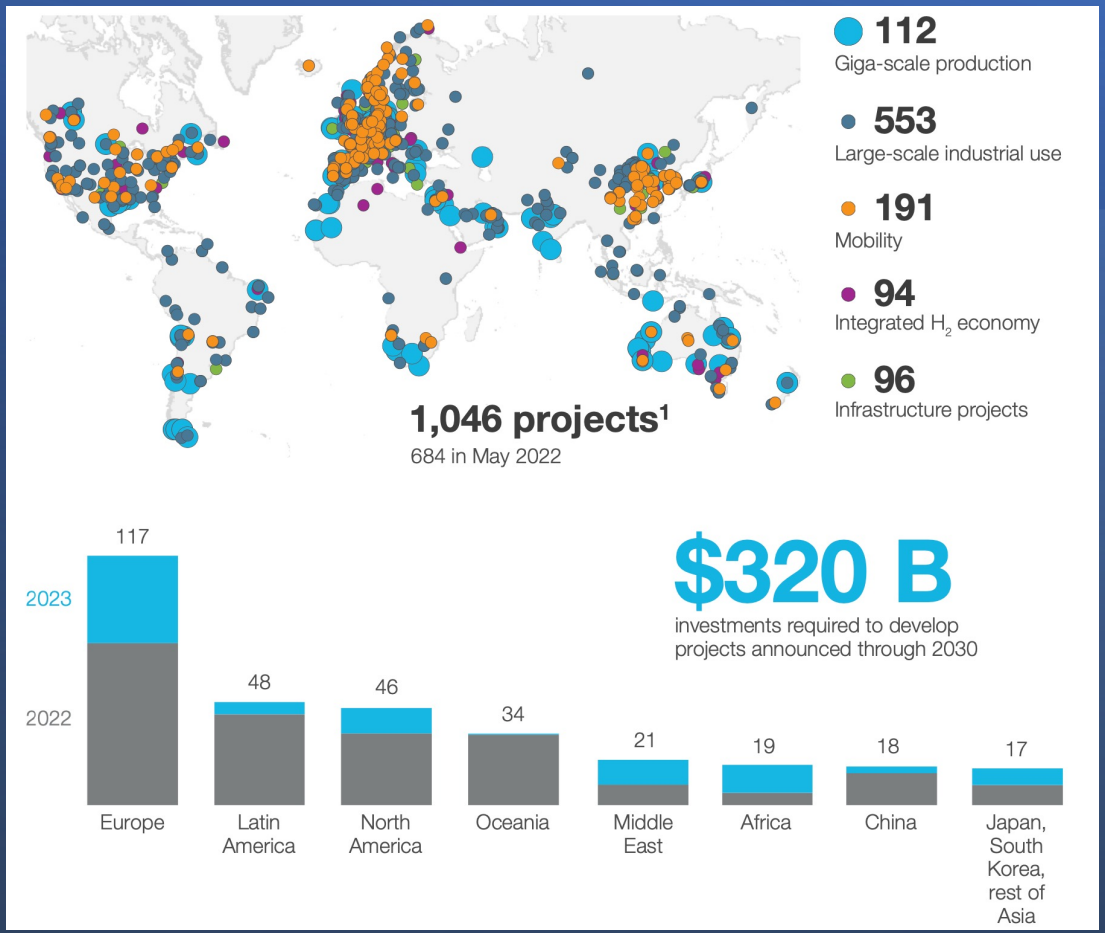
- 200 GW electrolysis
- 400 GW renewables
- 600 billion USD investment



Source: Author based on Hydrogen Europe (2021).

Europe's H_2 production capacity (2020) was approximately **11.5 Mt per year**, of which almost a hundred per cent (99.3%) constituted conventional capacity.

- Hydrogen Europe (2022) -



Source: Hydrogen Council (2023).

Europe:

(+) Global leader in H_2 project proposals.

(+) Largest government funded scheme (IPCEI – EUR 10.6 billion).

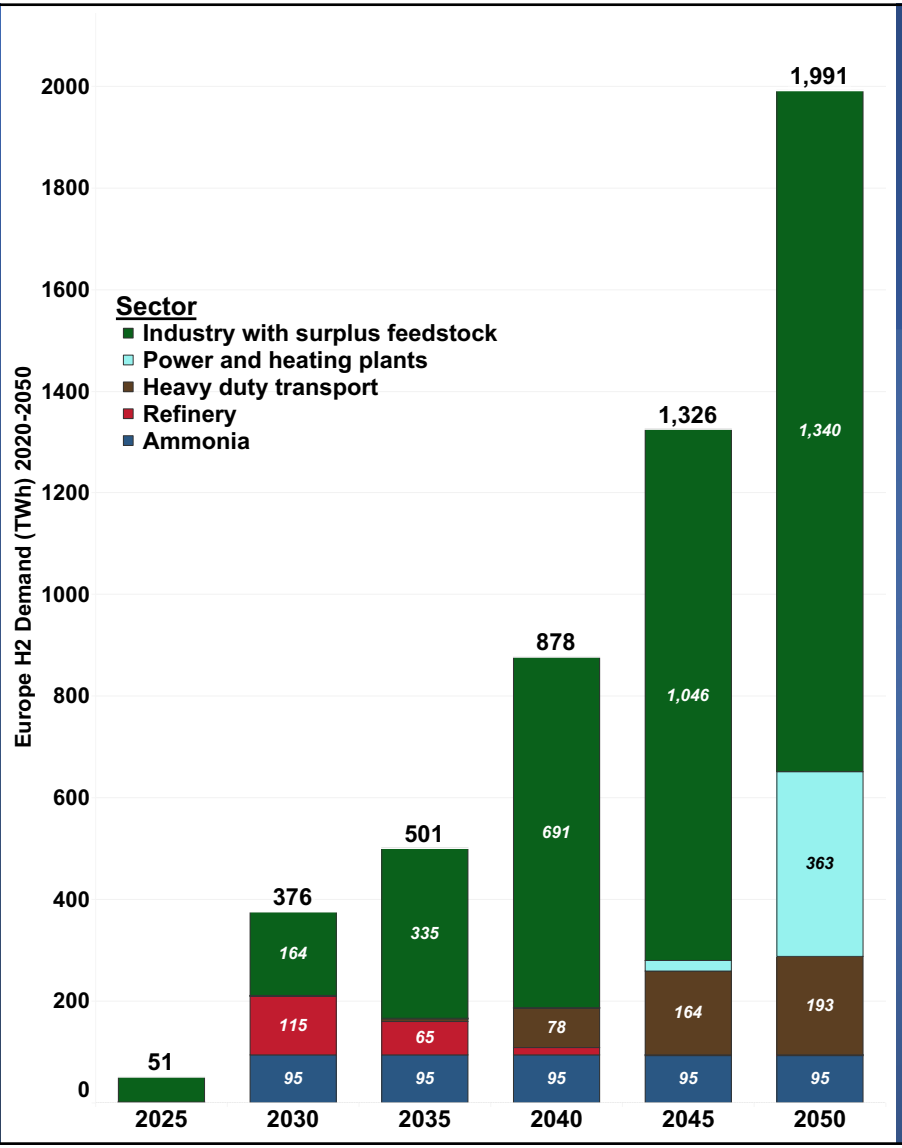
(-) Largest market with over 3rd of global announced capacity (+/- 80 GW) yet **less than 1.5 GW** has passed FID (i.e. less than 2%).

Noé van Hulst (vice-chair IPHE):

- Uncertainty about subsidies (in particular OPEX).
- Uncertainty about offtake (demand creation still lagging).
- Elaborate licensing procedures (despite much talk about the need to shorten these).
- Focus in Europe should be on getting announced projects to FID.

Fraunhofer CINES estimates that by 2030, a H_2 demand per sector of around 376 TWh (+/- 11.3 Mt) by 2030, which contrasts with the REPowerEU target of producing, importing, and transporting 20 Mt of H_2 by that same year.

(H_2 consumption in the industry refers to furnaces and feedstocks, and these are primarily the chemical and steel industry, but also the paper, food, non-metal, and non-metallic mineral industries).



Source: Fraunhofer CINES (2023). Clean Hydrogen Deployment in the Europe-MENA Region from 2030 to 2050.

Source: Informaconnect (2020).

National H_2 pathways in Europe are generally marked by:

i. A gap between ambition and policy.

ii. Discord between import- and export-oriented countries.

iii. An incoherent assortment of hydrogen colors and carbon intensity.

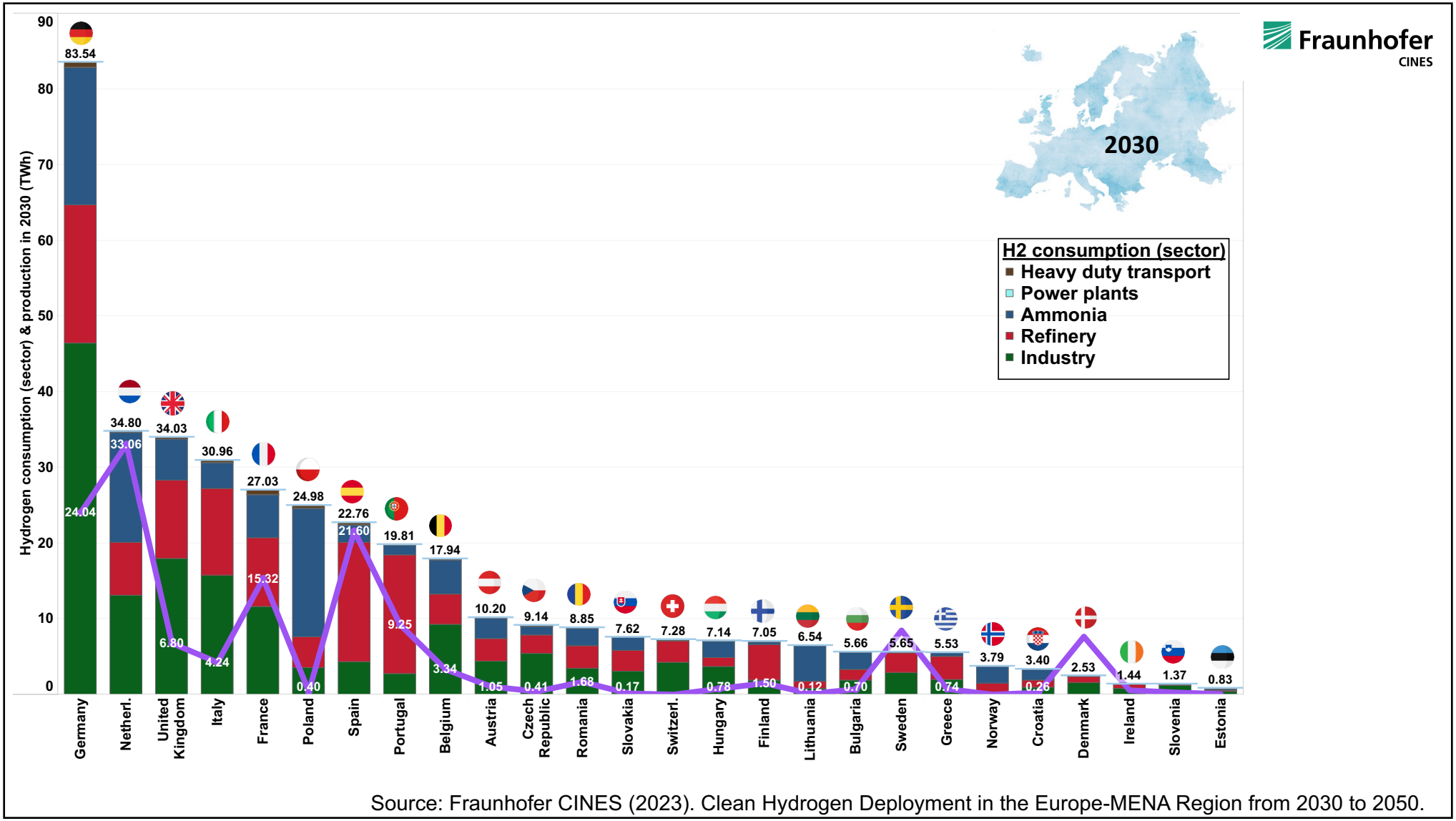
iv. A lack of proper infrastructure planning.

Source: Braun, Van Wijk and Westphal (2023).

Objectives of national H_2 pathways in Europe

Barriers	Key objectives
Production	Remove cost and regulatory barriers for production.
Demand	Drive critical mass through major hydrogen projects, leveraging efficient capital, long-term certainty, and sectoral targets.
Infrastructure	Ensure early ramp-up of 'no regret' infrastructure, including transport, storage, conversion, and trade facilities.
Pace of development	Accelerate the scale-up of electrolyzer manufacturing to drive economics of scale.
Standards and certification	Ensure clarity on carbon intensity, safety, and technical standards for projects across the value chain.

Source: IRENA and World Economic Forum (2023)



Source: Fraunhofer CINES (2023). Clean Hydrogen Deployment in the Europe-MENA Region from 2030 to 2050.


Toward a
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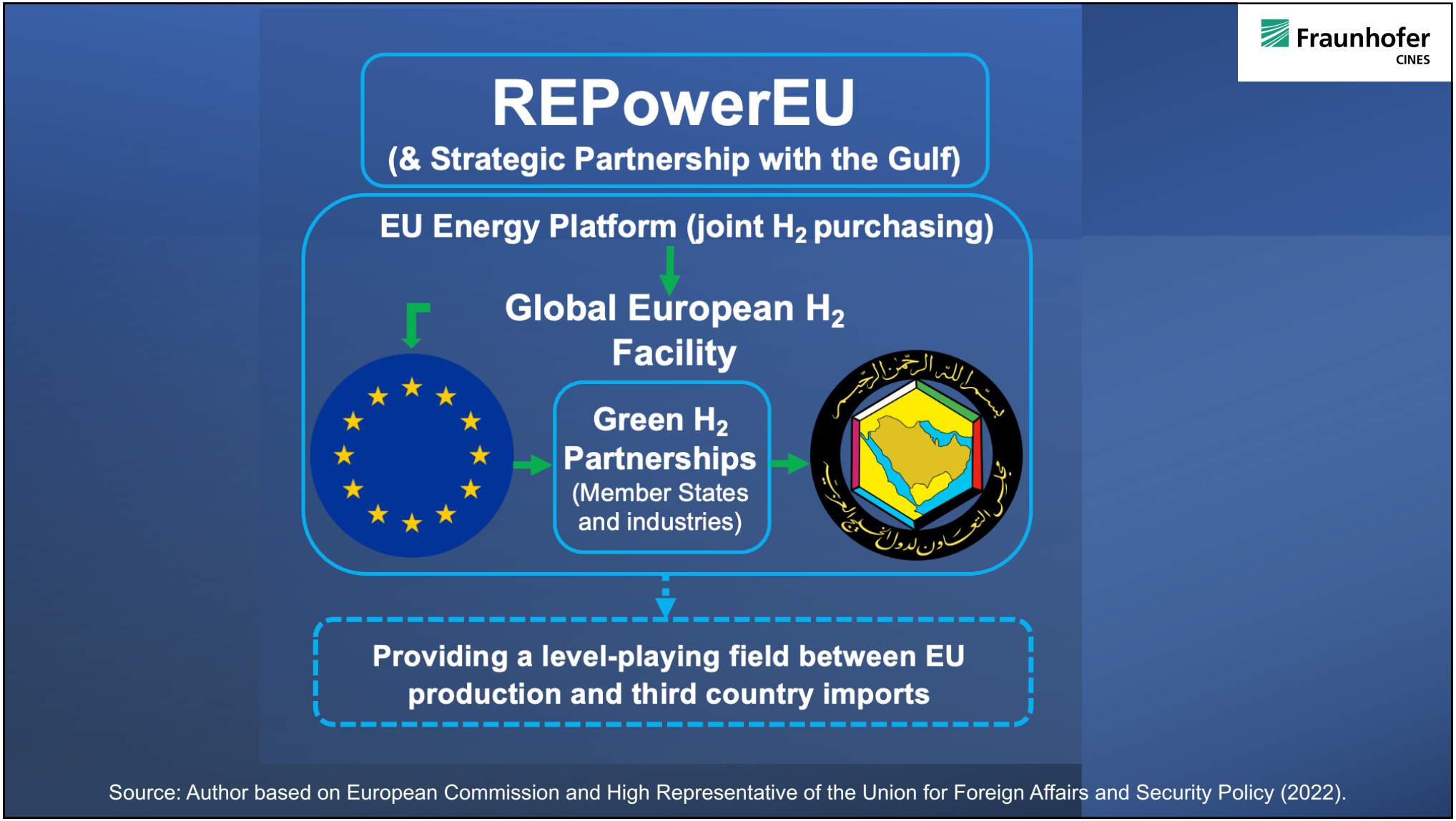
with the GCC



Source: Author based on European Commission and High Representative of the Union for Foreign Affairs and Security Policy (2022).

- Saudi Arabia and other Gulf players are long-standing energy partners and have the capacity and know-how to produce low-carbon H_2 and ammonia.
- Renewable energy production capacity and infrastructure challenges are massive.
- Need to consider primary energy demand and avoid competition between with renewable capacity required to decarbonize local electricity generation and renewable power capacity planned for green H_2 production.
- Strict sustainability criteria must be considered before any export potential from the GCC to Europe can be determined, incl. for low-carbon gases based on a life-cycle assessment of GHG emissions.

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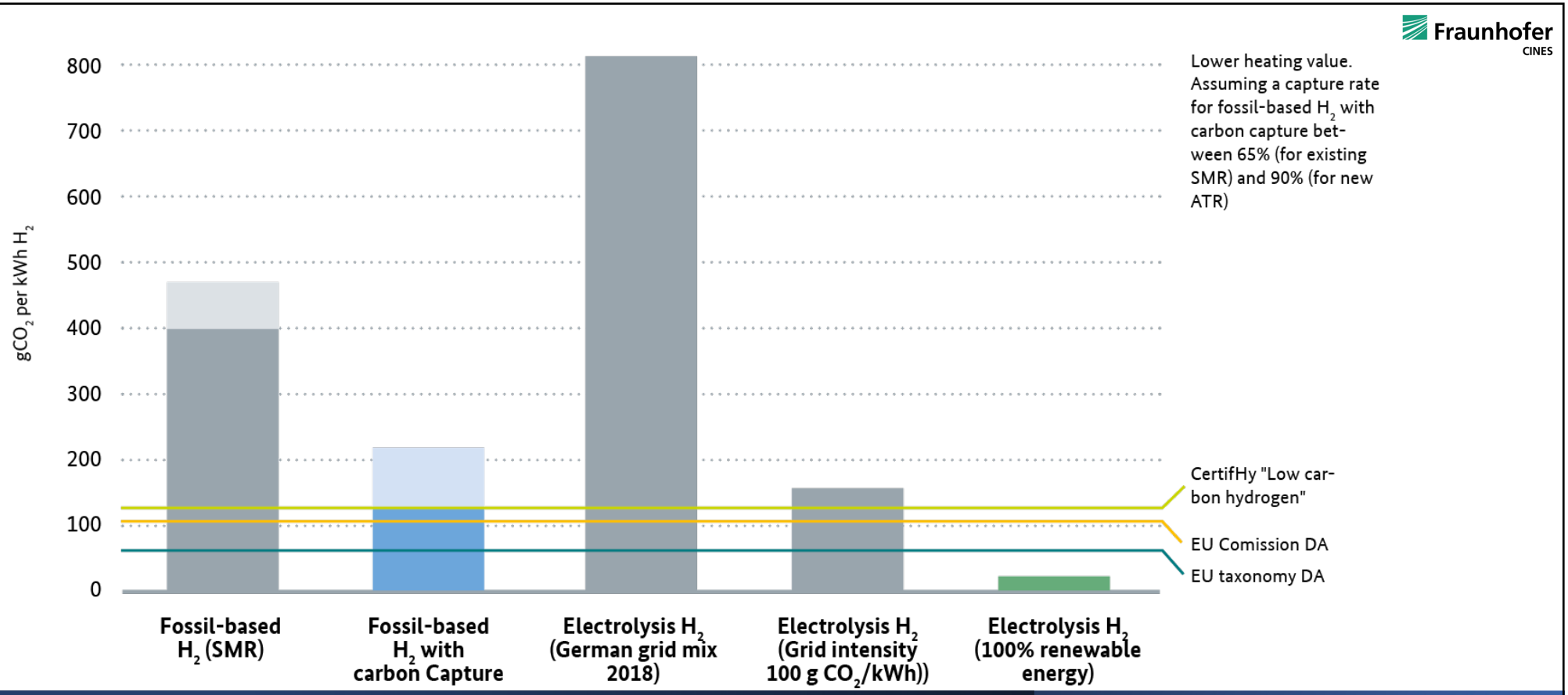

Average lifecycle CO_2 emissions of H_2 production in $_g$ CO_2 per KWh of H_2

Source: Braun et al. (2022).

Balanced approach EU-Gulf (and MENA at large):

"Clean H_2 refers to renewable and natural gas-based variants with extremely low methane emissions and high carbon capture rates. Very high capture rates imply a CO_2 capture rate of 95% by 2030 and 99% either well before or around 2050".

- Fraunhofer CINES (2023); IRENA (2022); House of Commons (2022) -

Clean H_2 'window of opportunity' allows the Gulf countries to move towards a sustainable growth model that is less dependent on hydrocarbons and their governments manage the transition to a global low-carbon economic environment that could significantly reduce energy revenues in the long-term.

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Engage in **projects of common interest** (e.g., CCUS. H_2 'hubs' or 'valleys')

Complement **natural and 'engineered' advantages across the GCC countries**

Saudi Aramco struggling to find buyers for its blue hydrogen due to high costs

World's biggest oil company is planning to produce 11 million tonnes of blue ammonia by 2030

Source: Collins (2023).

"It is very difficult to identify any off-take agreement in Europe [for blue hydrogen] because of the the high cost"
(Amin Nasser)

- Most subsidies planned around the world are focused on green production and not usage
- Blue H_2 is not part of H2 Global
- Strengthen 'pivot to Asia'

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Conclusions
&
Recommendations

Conclusions

- As a key import market, Europe has the ambition in becoming the world's industrial leader in renewable H_2 while fueling the continent's decarbonization efforts.
- Overarching focus on renewables-based production has prematurely excluded technological routes related to other H_2 options as a temporary solution that could be more carbon-effective.
- Key factors (e.g., primary energy demand, infrastructure challenges and dedicated capacity build-out), suggest that renewable energy derived H_2 should be supplemented by fossil fuel-based options.
- Next to moving to a sustainable growth model domestically, Saudi Arabia and other Gulf players have the additional geopolitical and climate incentive to position themselves as reliable providers of clean H_2 imports for Europe.

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Recommendations

- The EU Strategic Partnership with the Gulf should depart from a balanced strategy between renewables-based and low-carbon H_2, incl. a harmonized certification scheme that defines a life-cycle analysis that considers upstream and transport-related emissions.

- Offer know-how and support on the EU's Important Projects of Common European Interest approach. (e.g., regional CCUS hubs and H_2 valleys).

- Avoid mixed signals (along the value chain): Europe needs to provide a coherent policy framework that validates the necessary investment for a coherent scale-up of clean H_2 in the Gulf.

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Dr. Jan Frederik Braun

Head of Hydrogen Cooperation
(MENA Region)
Cluster of Excellence Integrated
Energy Systems (CINES)
Fraunhofer Society

jan.braun@ise.fraunhofer.de

+49 162 1300693

www.cines.fraunhofer.de

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