WHEN TRUST MATTERS

ENERGY TRANSITION OUTLOOK

PtX for Deep Decarbonization

Hydrogen and PtX 3rd European Conference

June 15, 2022

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Energy Systems North Europe

Our Hydrogen Future

Meeting the Paris Agreement

Leading sectors and regions

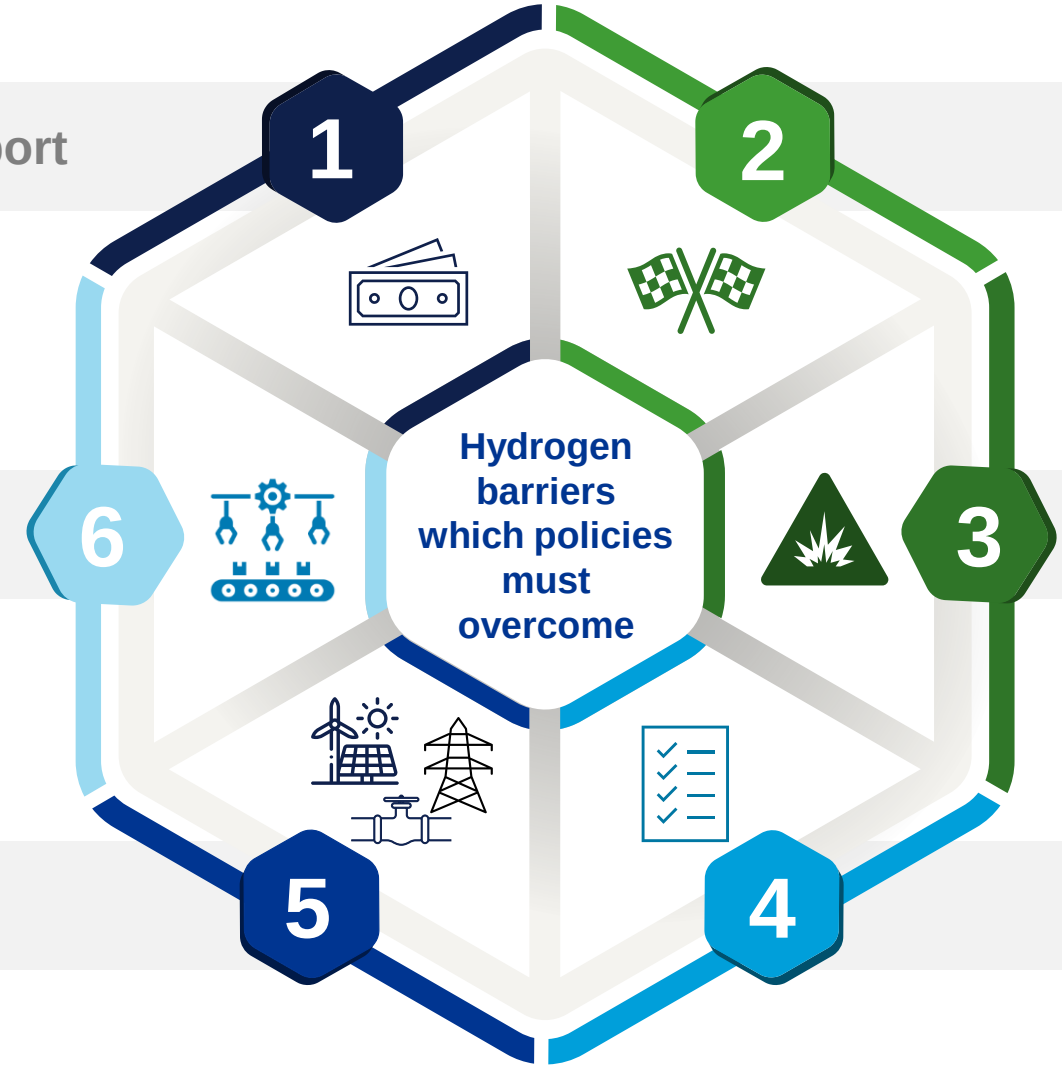
Greener than blue

Local or global

DNV

Safety Moment

The barriers for policies to overcome



Costs and financial support

Demand and competition

Technology and manufacturing

Safety and hazards

Infrastructure and indirect enablers

Standards & Certification

The world’s total future hydrogen demand is broadly divided into three categories

1

Decarbonizing existing use of hydrogen

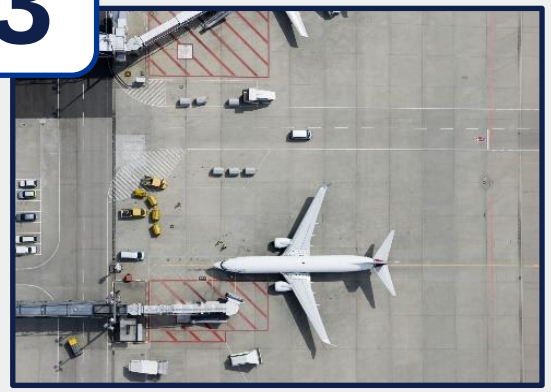
Replacing fossil hydrogen with renewable and low-carbon hydrogen

2

Fuel switching to hydrogen with blending

Retrofitting and modification of infrastructure

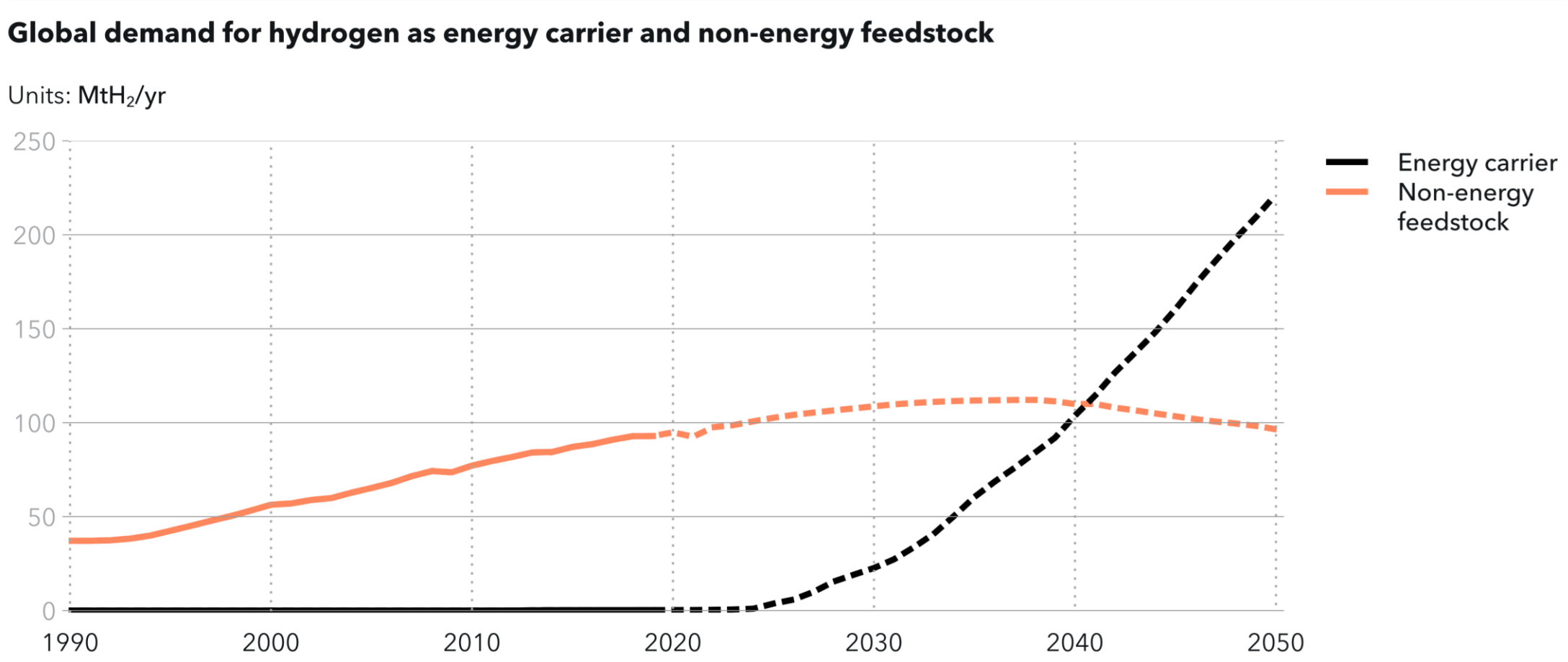
3



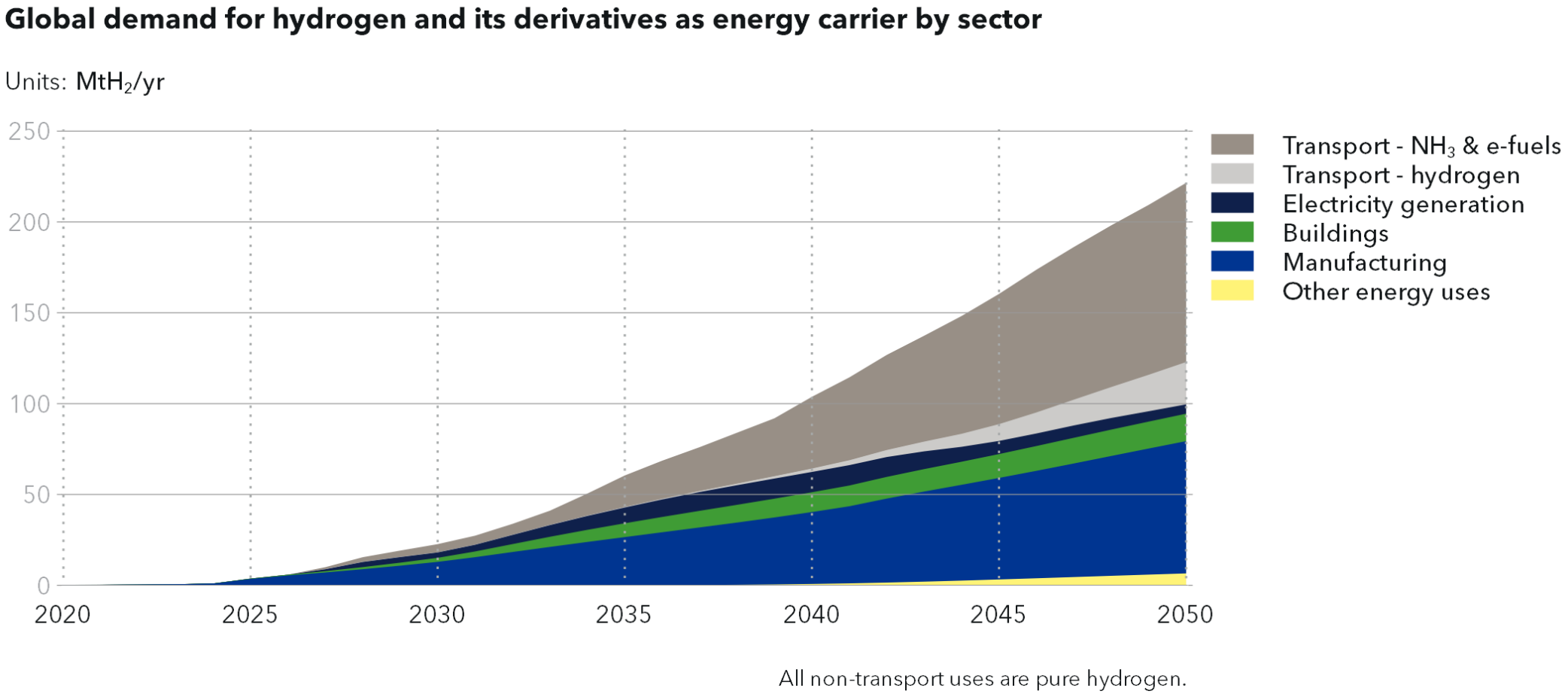
New use of hydrogen

Where new infrastructure has to be established

Energy use of hydrogen will overtake feedstock use in 2040



Hydrogen share of global energy mix
0.5% 2030 and 5% in 2050



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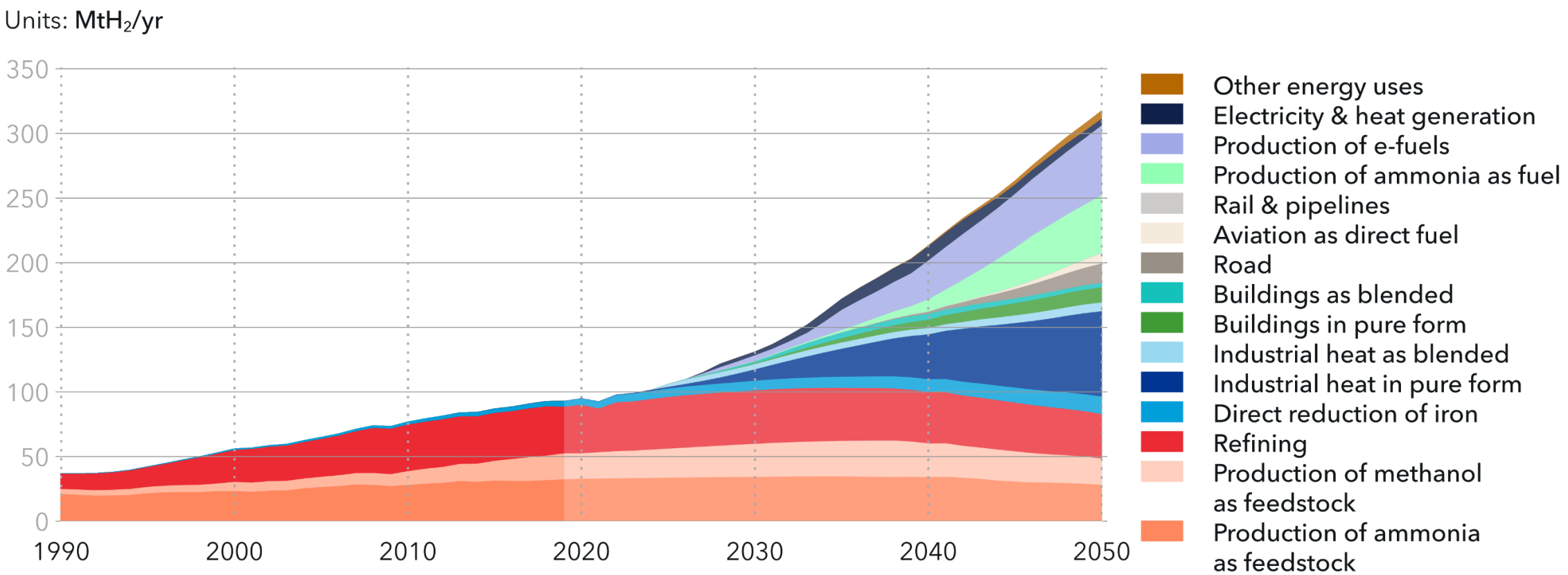
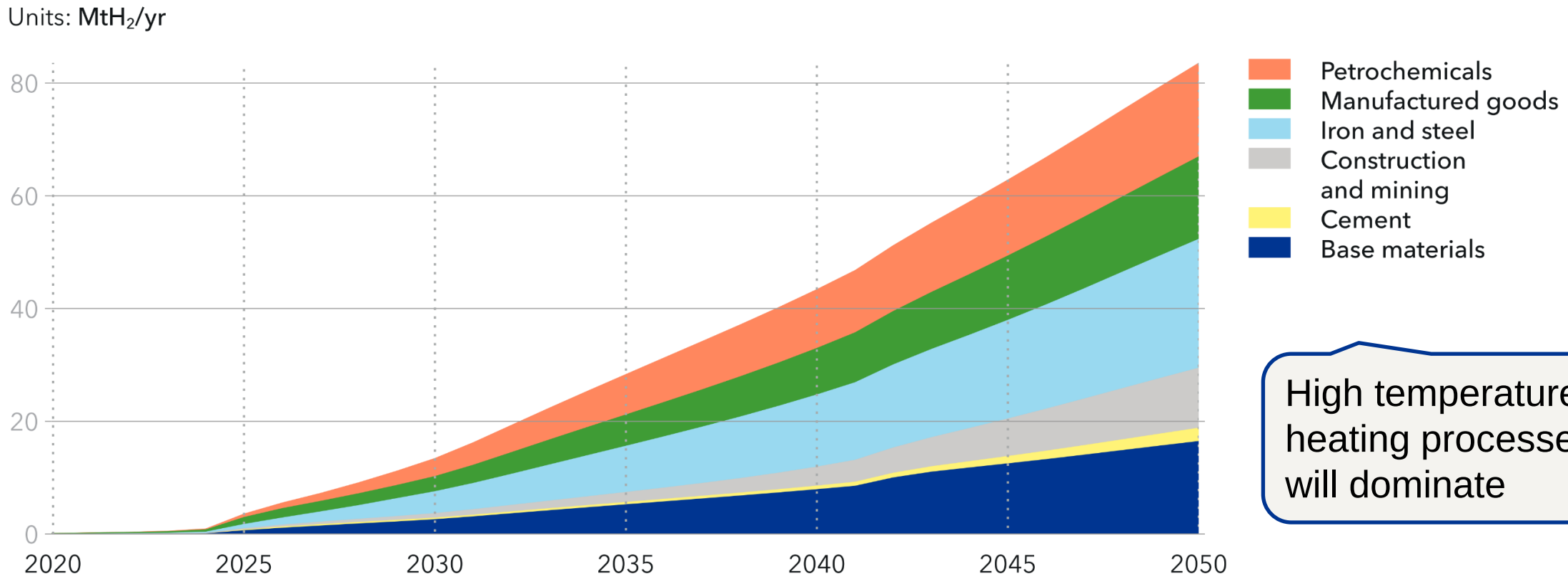
Global hydrogen demand by sector



Does not include hydrogen use in residual form from industrial processes. Historical data sources: IEA Future of Hydrogen (2019), IEA Global Hydrogen Review (2021), USGS Mineral Commodity Summaries (1990-2022), IFA (2022)

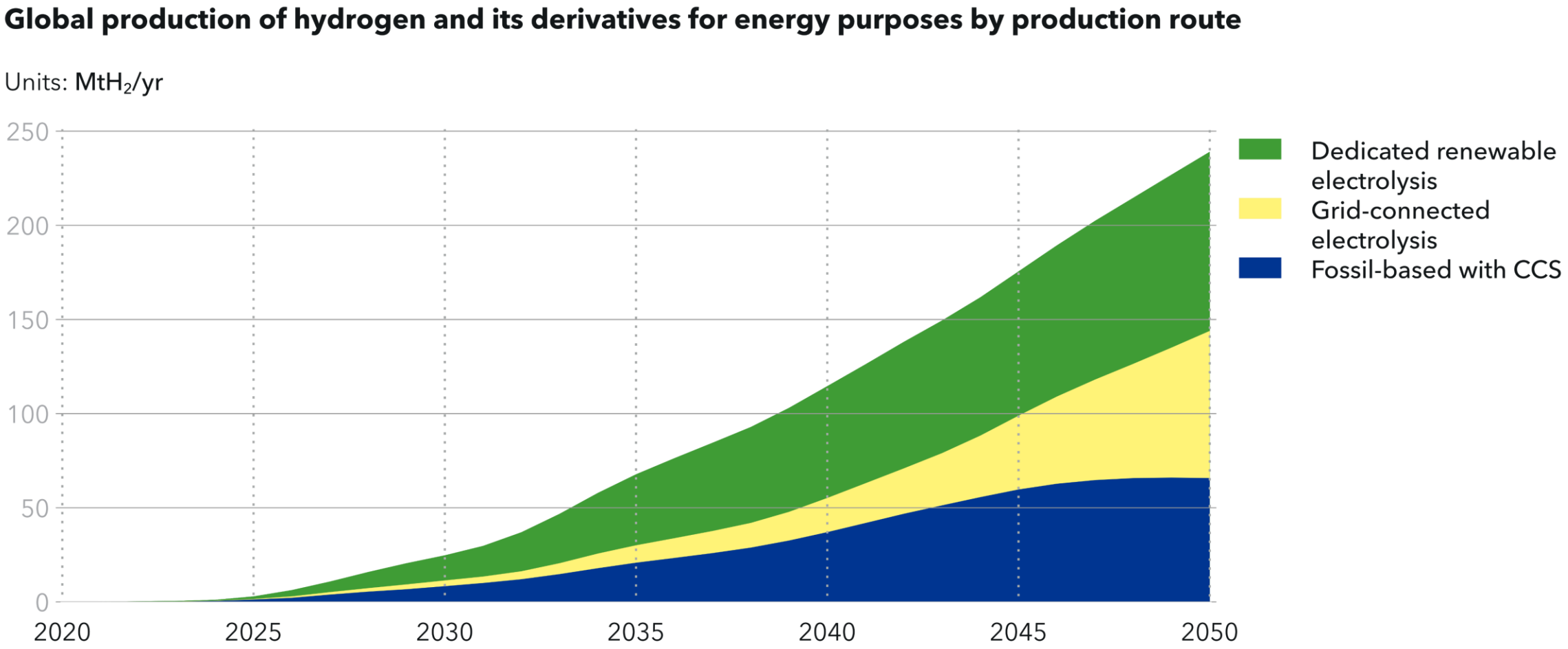
Hydrogen in manufacturing
7% of sector's energy demand in 2050

Global hydrogen demand in manufacturing by subsector

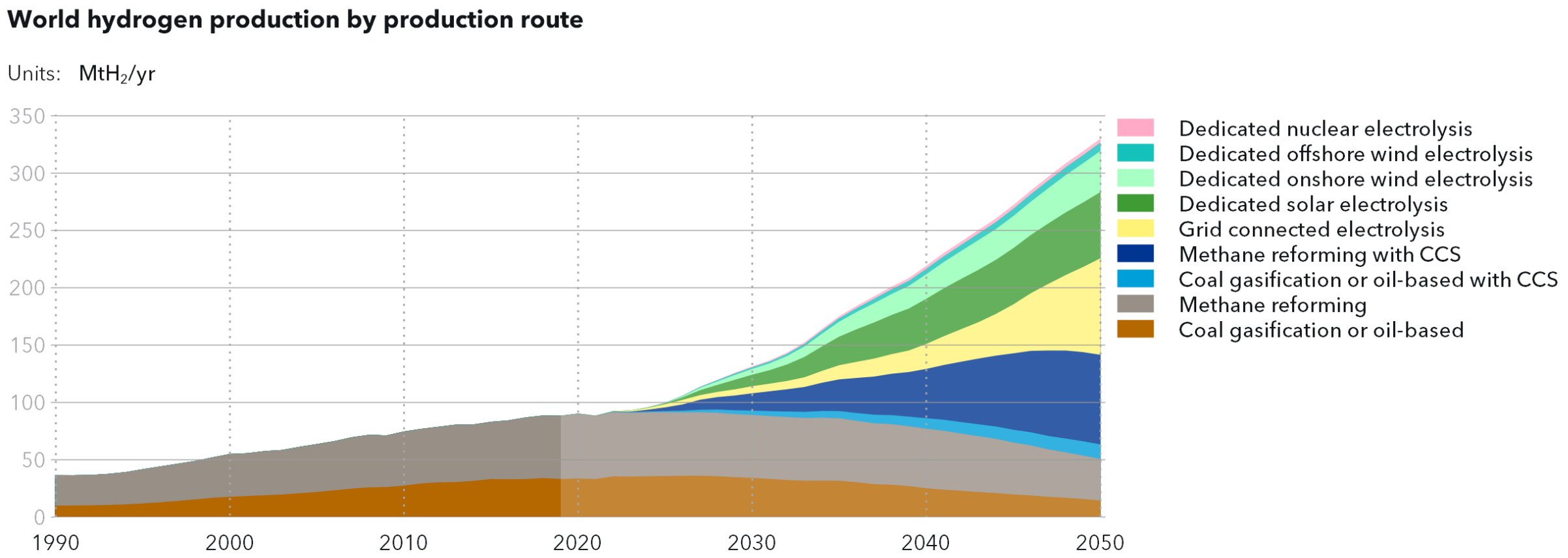


High temperature heating processes will dominate

By 2050, ¾ of hydrogen from electrolysis



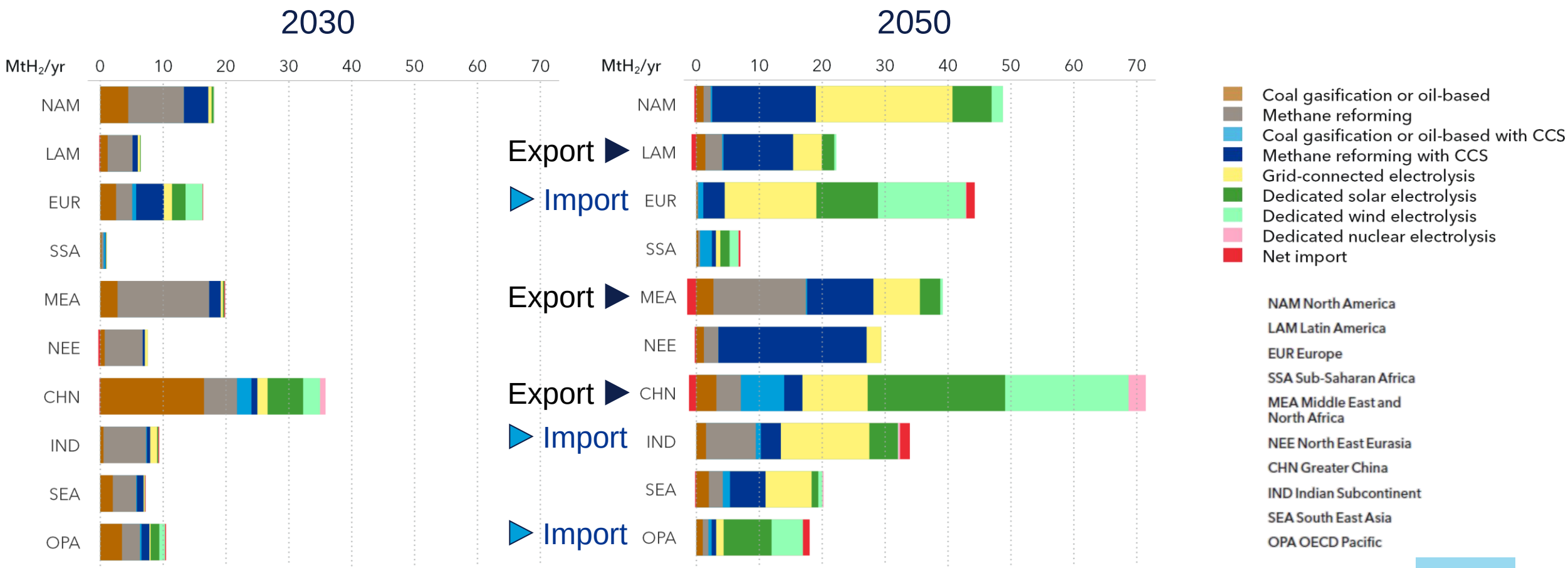
In 2050, 85% renewable and low-carbon hydrogen



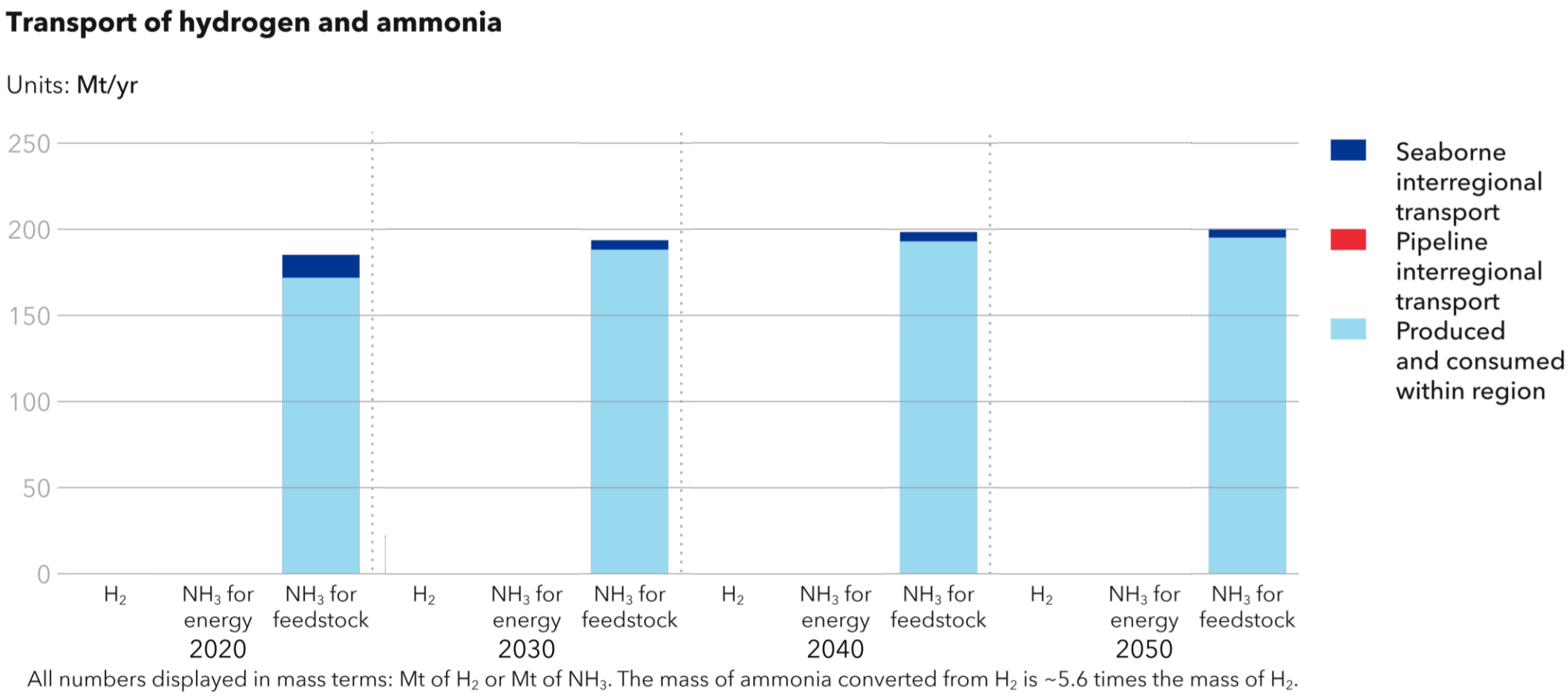
Historical data source: IEA Future of Hydrogen (2019), IEA Global Hydrogen Review (2021). Does not include hydrogen use in residual form from industrial processes.

Regional differences in renewable hydrogen shares and export/import

Production of hydrogen by production route and region

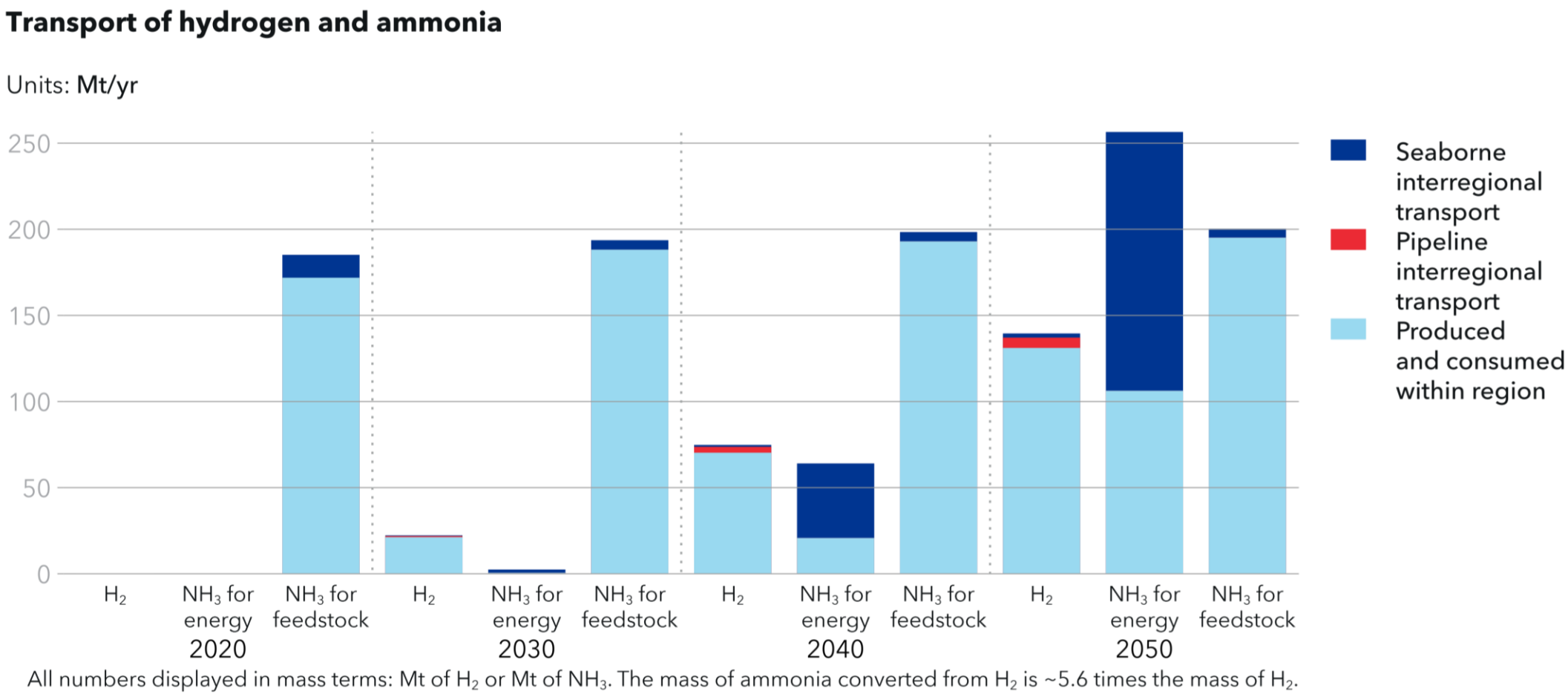


Ammonia scaling as a global hydrogen carrier

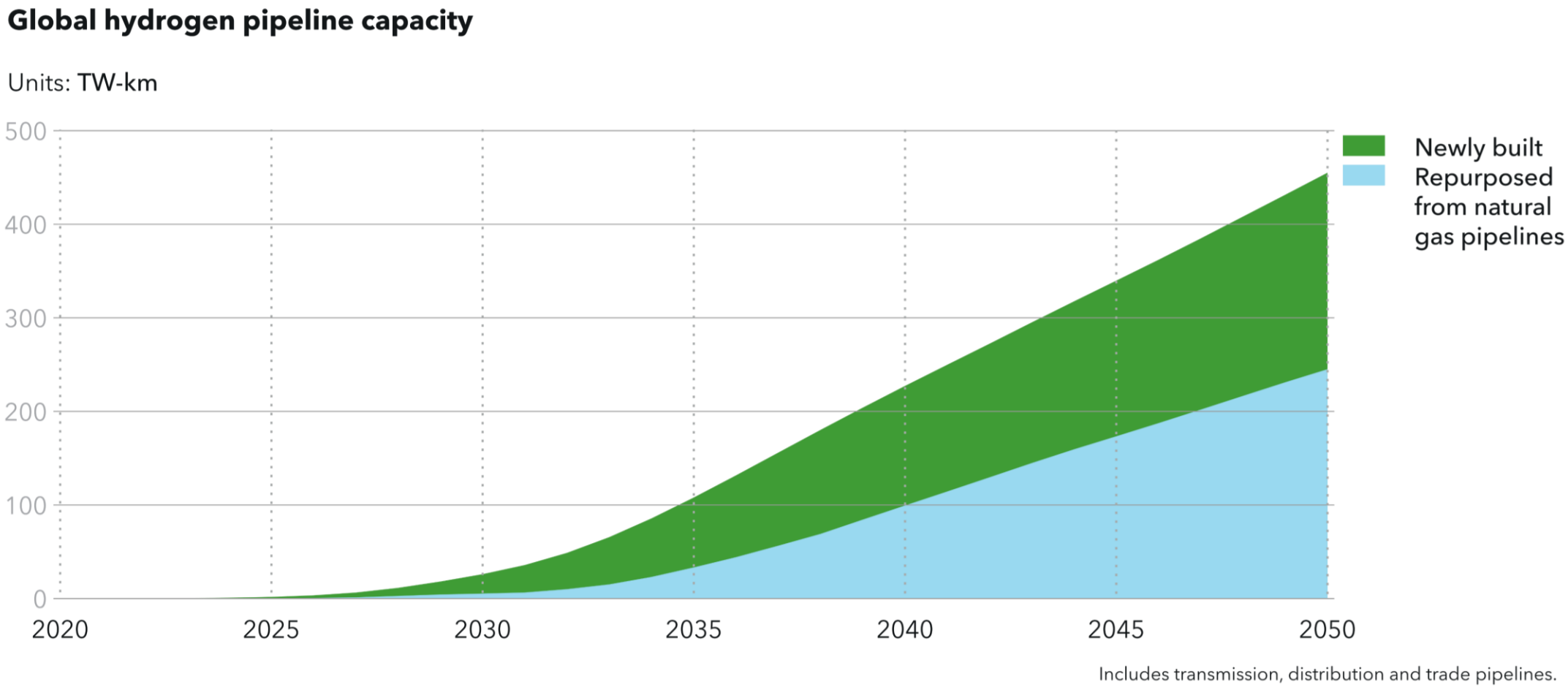


All numbers displayed in mass terms: Mt of H_2 or Mt of NH_3. The mass of ammonia converted from H_2 is ~5.6 times the mass of H_2.

Ammonia scaling as a global hydrogen carrier



More than 50% of global hydrogen pipelines will be repurposed from natural gas pipelines



Competition on costs, *and* emissions

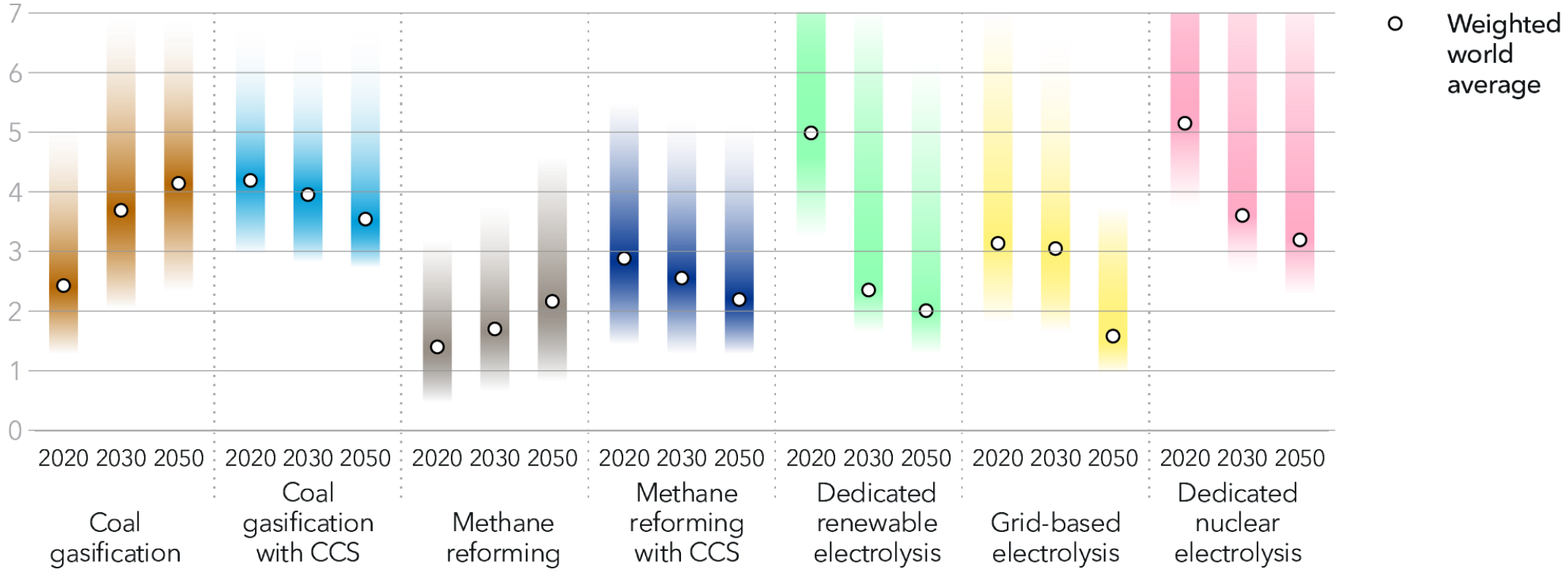
< 3 < 6 < 4.9

EU USA China

$kgCO_2/kgH_2$

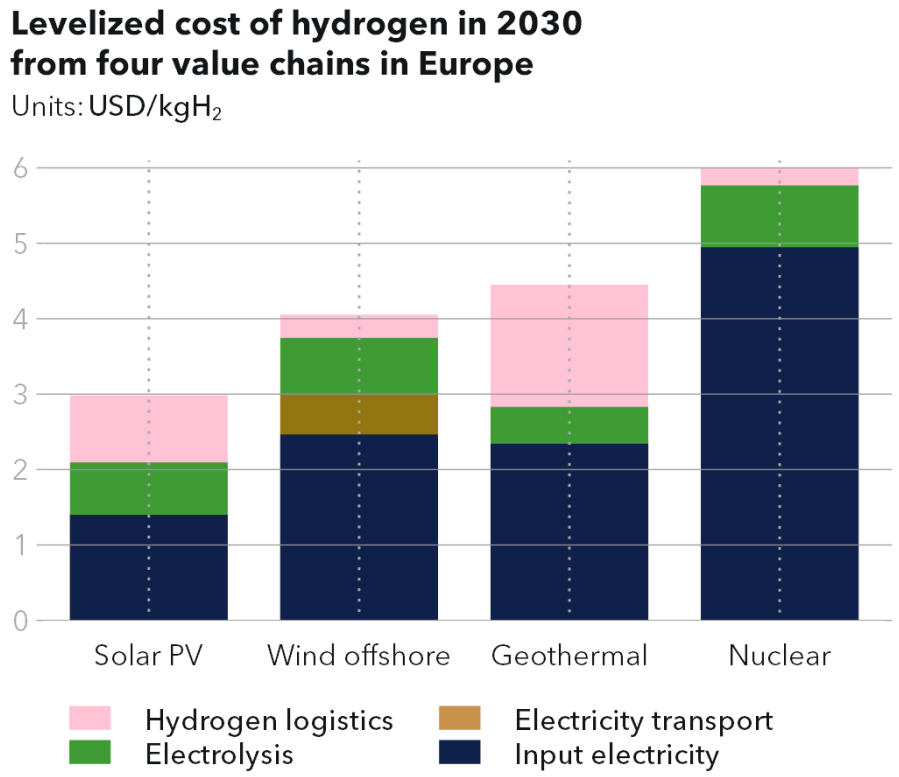
Levelized cost of hydrogen after support by production route

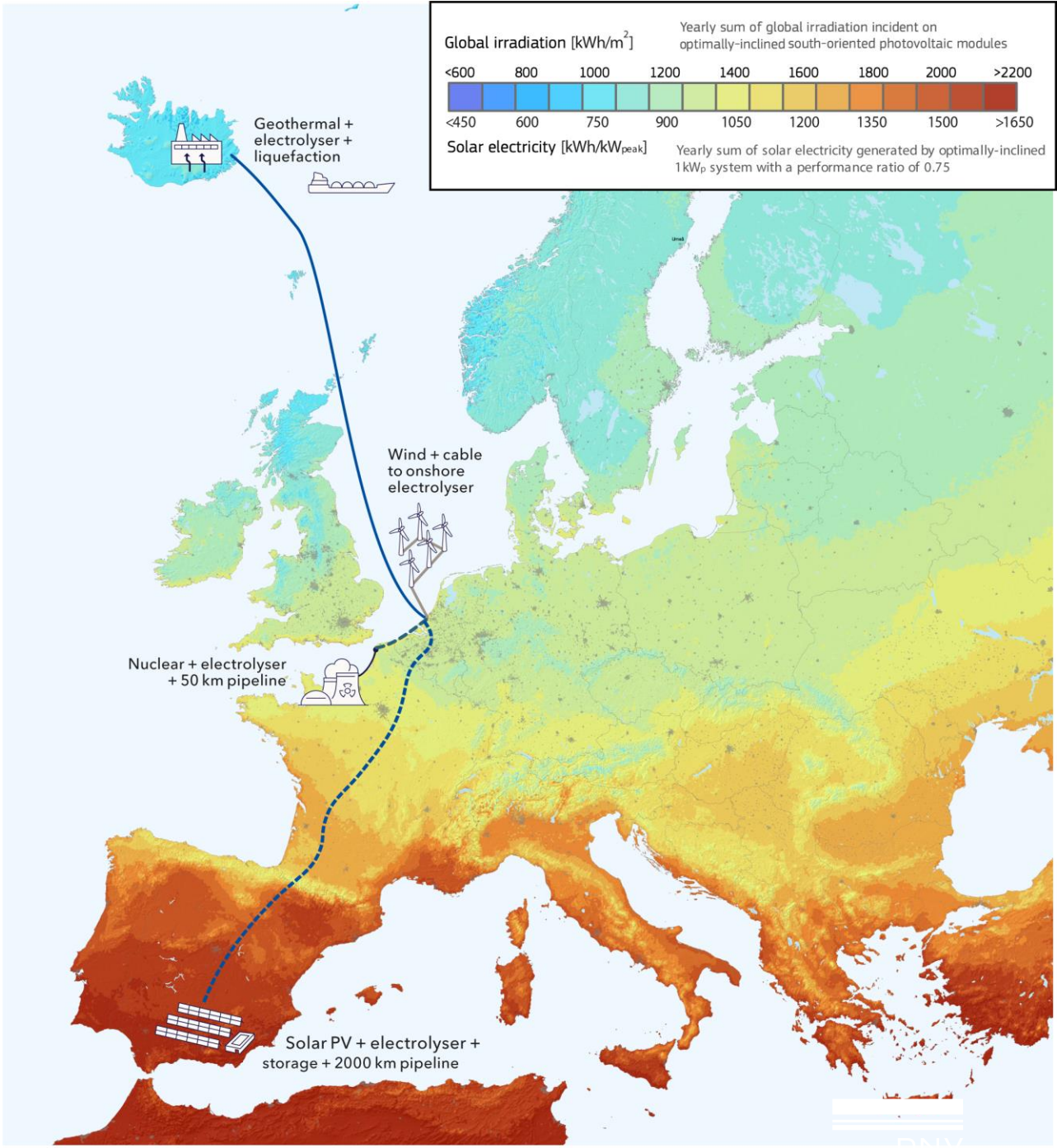
Units: USD/kgH_2



Low cost hydrogen?

- Solar PV from Southern Spain will be the cheapest source of hydrogen for North-West Europe





Irradiation map courtesy of Photovoltaic Geographical Information System (EU)

Hydrogen future highlights

1 Meeting the Paris Agreement

Hydrogen is essential to reach the Paris Agreement,

…but global hydrogen uptake is low and late, at 5% in 2050, it is only a third of what it should be

2 Leading sectors and regions

Direct use of hydrogen will initially be dominated by the manufacturing sector,

…while hydrogen carriers will be important in shipping

3 Greener than blue

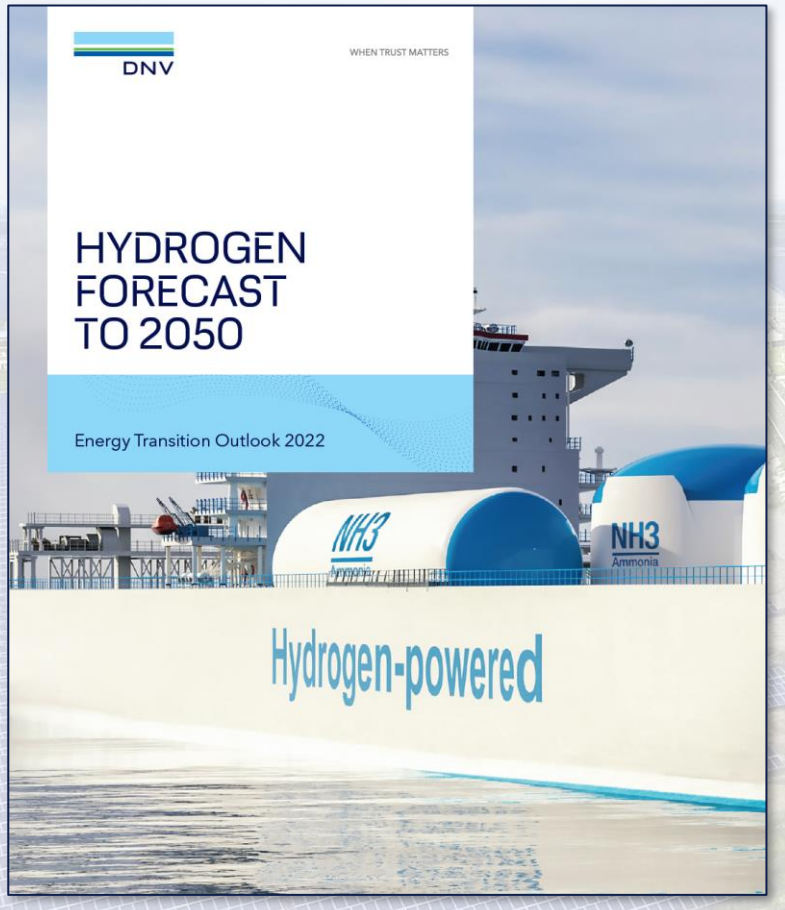
Green hydrogen from dedicated renewables and grid will dominate production for high emission reductions,

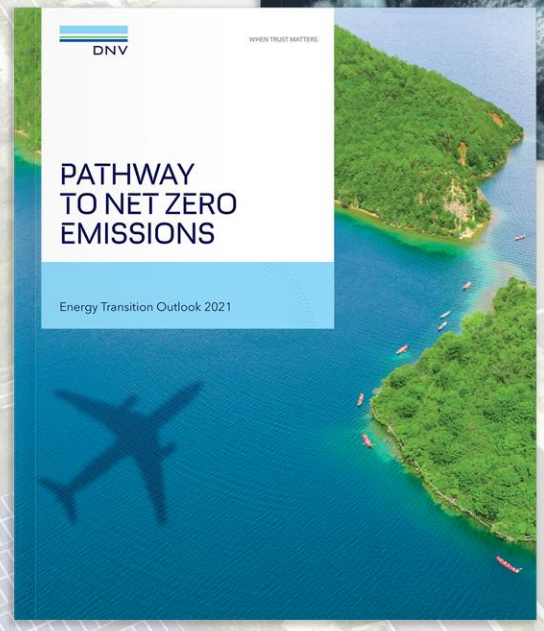
…but blue hydrogen will contribute to low carbon hydrogen

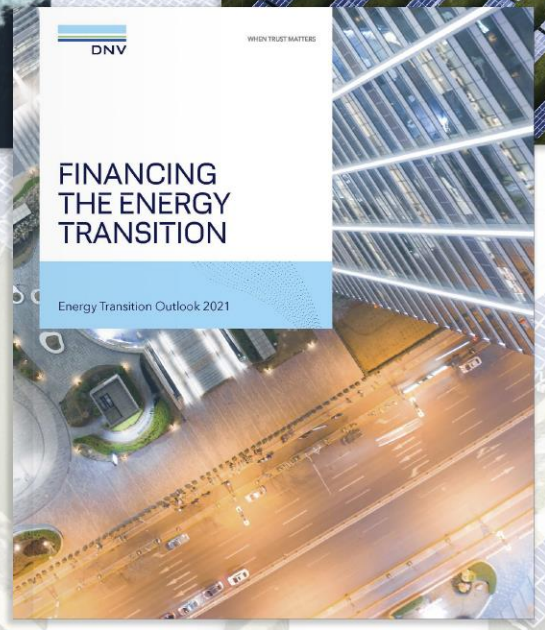
4 Local or global

Hydrogen will be transported between countries within regions, and not between continents,

…while ammonia as a hydrogen carrier will be transported globally







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Thank you for your attention!

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