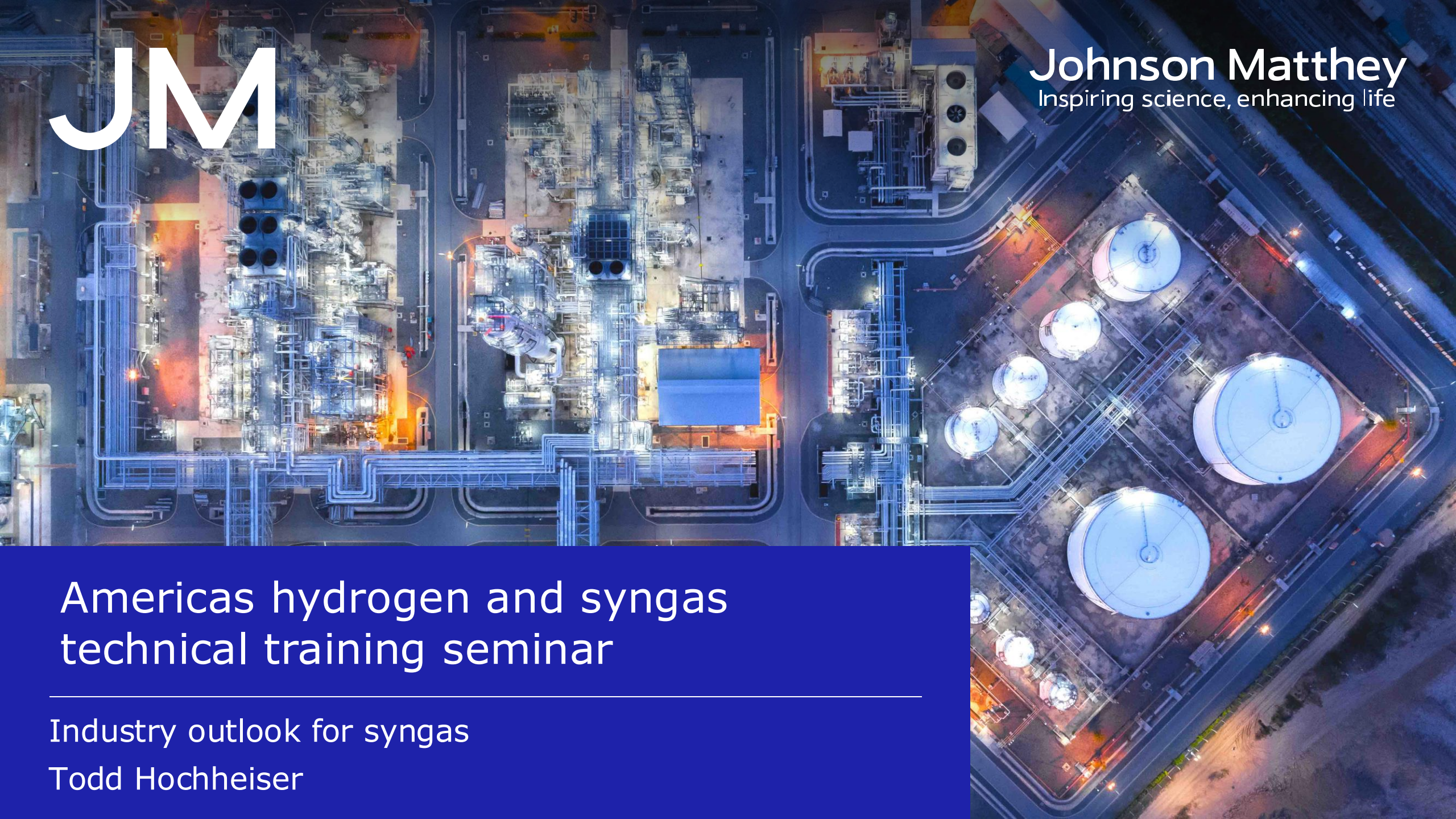

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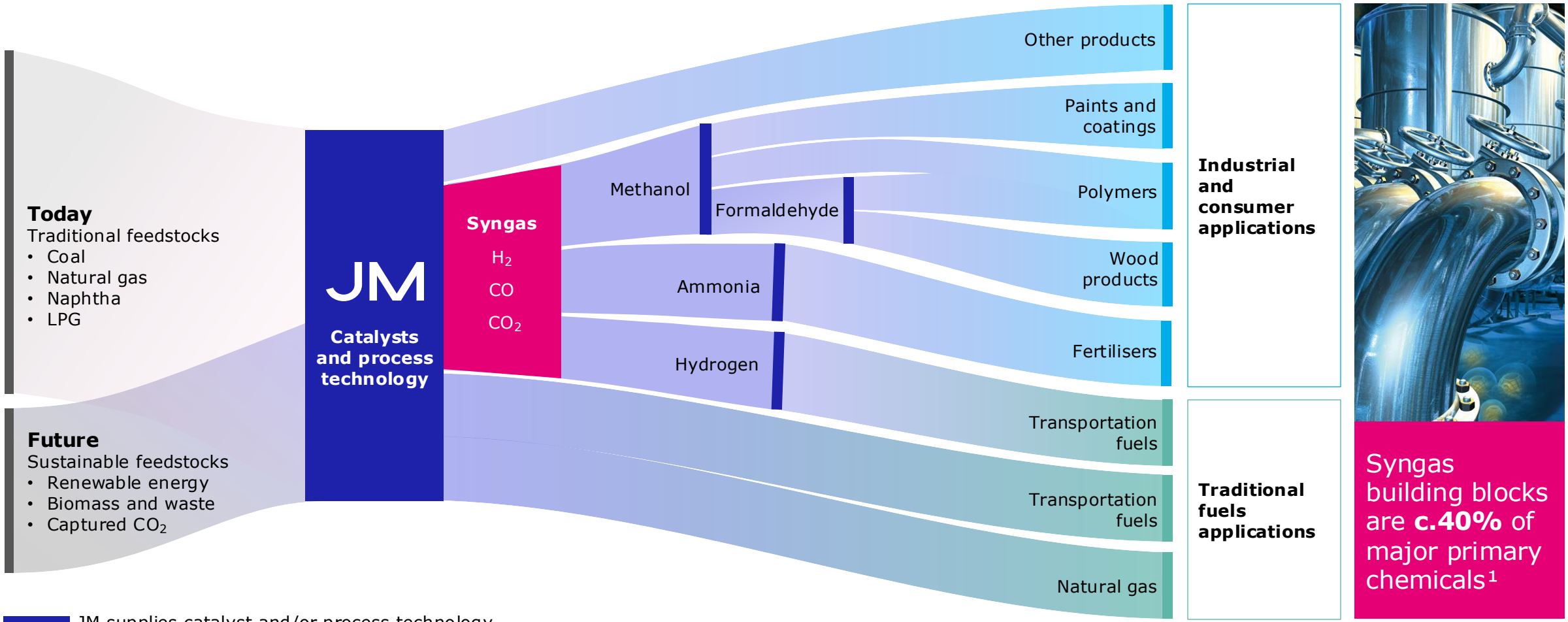
Inspiring science, enhancing life

Americas hydrogen and syngas technical training seminar

Industry outlook for syngas

Todd Hochheiser

Syngas in the world today



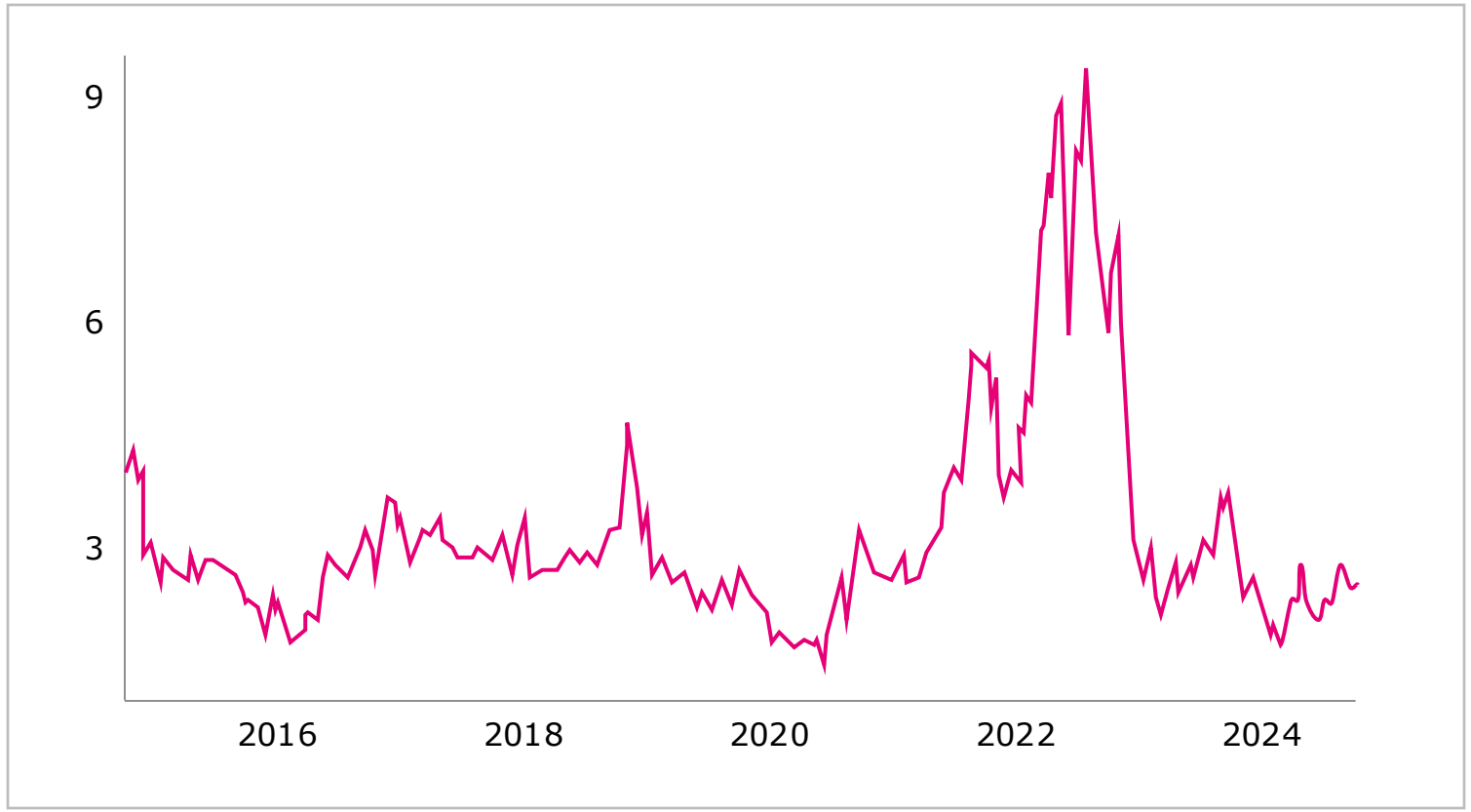
Syngas building blocks are **c.40%** of major primary chemicals[1]

JM supplies catalyst and/or process technology

1. Source IHS Markit. Capacity of methanol and ammonia as a proportion of total capacity for primary chemicals (methanol, ammonia, major olefins and aromatics).
Note: H_2 – hydrogen; CO – carbon monoxide; CO_2 – carbon dioxide

Volatile natural gas prices in the recent few years have impacted operating costs

Henry hub natural gas price (USD/MMBtu)



- Natural gas is the dominant feed for hydrogen and syngas plants
- Record natural gas prices were observed in 2022 due to the Russia/Ukraine conflict, impacting hydrogen and syngas production costs
- Gas price has come down since the peaks in 2022
- Recent unrest in the Middle East has caused an upward movement in price
- North America gas prices are expected to rise in 2025 as LNG exports increase while domestic consumption and production remain relatively flat.

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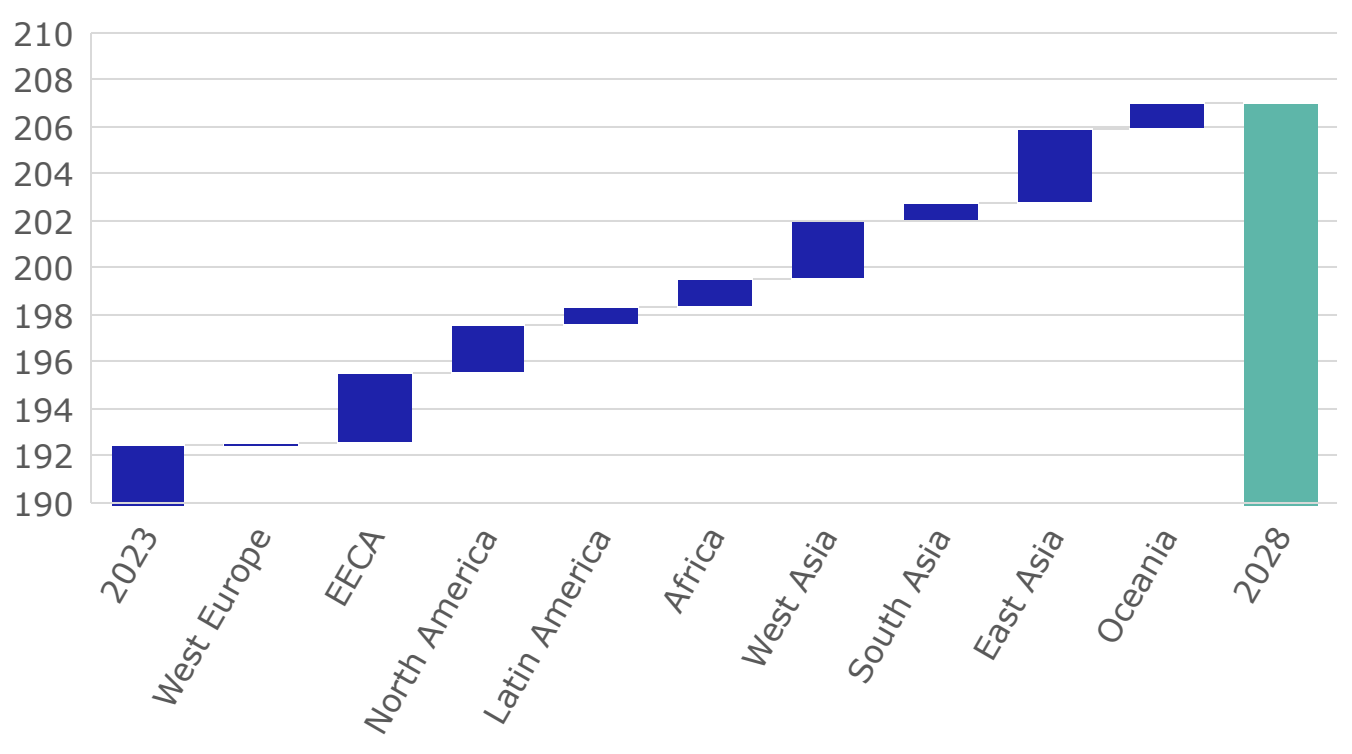
Based EIA 2024 data

Ammonia is driven by global fertiliser demand, which is forecast to increase at ~2% per year

N capacity additions, Mt N



- Ammonia is the second most produced chemical and around 80% of ammonia is used to produce fertilisers and global ammonia output was 189Mt in 2023.
- Demand for ammonia is driven by the need for food and hence by the size and wealth of the population.
- Fertiliser demand is expected to grow by approximately 2% per year in the short term.
- The largest contribution for the in the increases in demand volume for fertiliser is expected to be Latin America and South Asia.
- Most of the expected capacity investment in the next five years is in low-cost regions with abundant natural gas resources and in countries with strong support for decarbonization activities.

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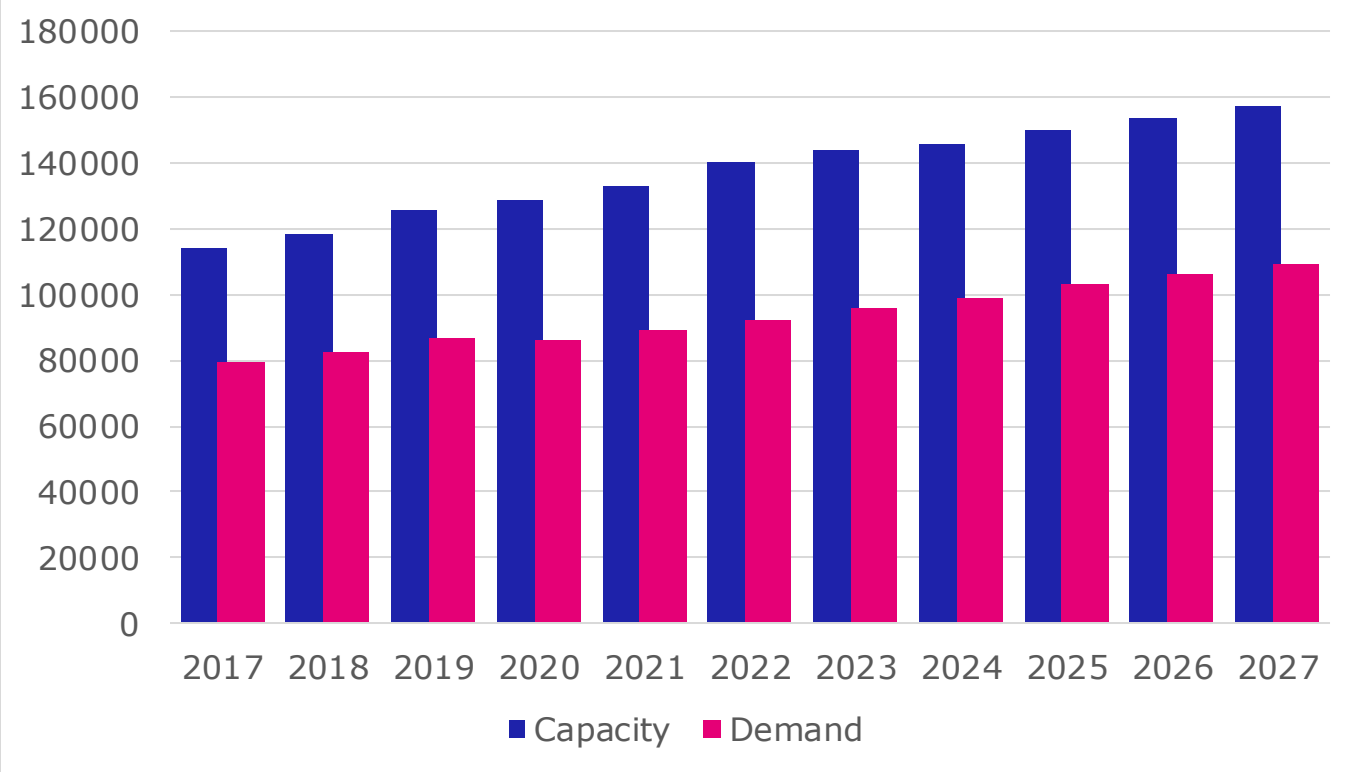
Based on IFA data, July 2024

Methanol demand expected to develop at a rate of 3.5% per year

World supply/demand for methanol (thousands metric tonnes)



- Methanol is used to produce a wide range of chemicals.
- In 2023, global methanol demand amounted to nearly 126 million metric tons. The use of methanol to produce olefins has been the primary growth driver during the past decade.
- Over the next five years, methanol demand is expected to develop at an average rate of 3.5% per year, supported by traditional chemical applications as well as methanol-to-olefins (MTO) and bunker fuels.
- Major shipping companies have starting to order vessels that have the flexibility to run on (renewable) methanol.

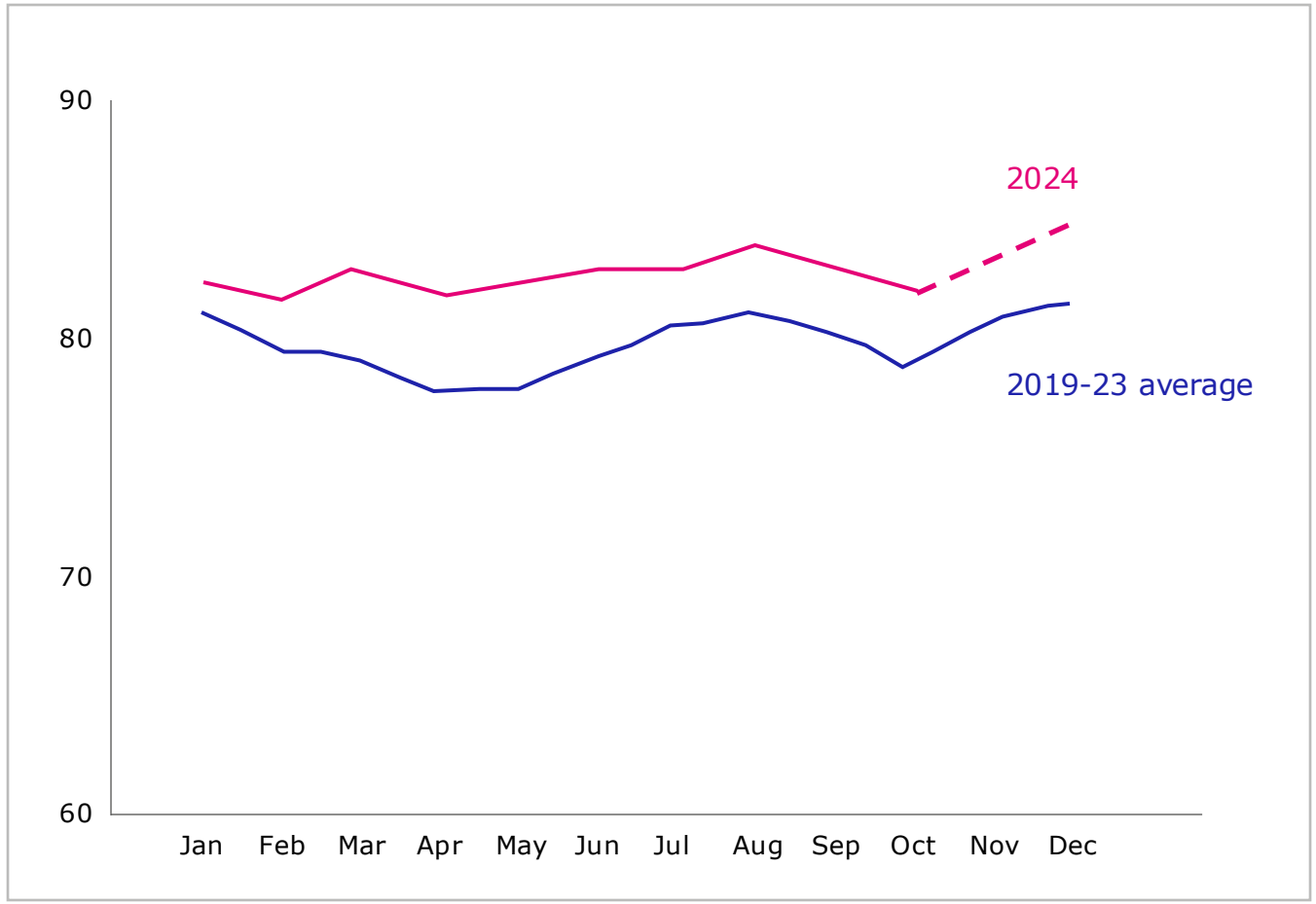
Based on S&P data, May 2023

Hydrogen for desulphurizing fuels in refineries

Refineries observed record margins in 2022, and now continue to trend downwards

Gasoline and diesel demand in Europe and North America are showing a decline, but this is offset by growth in other regions, particularly India and China

Indicative global refinery crude runs (million b/d)



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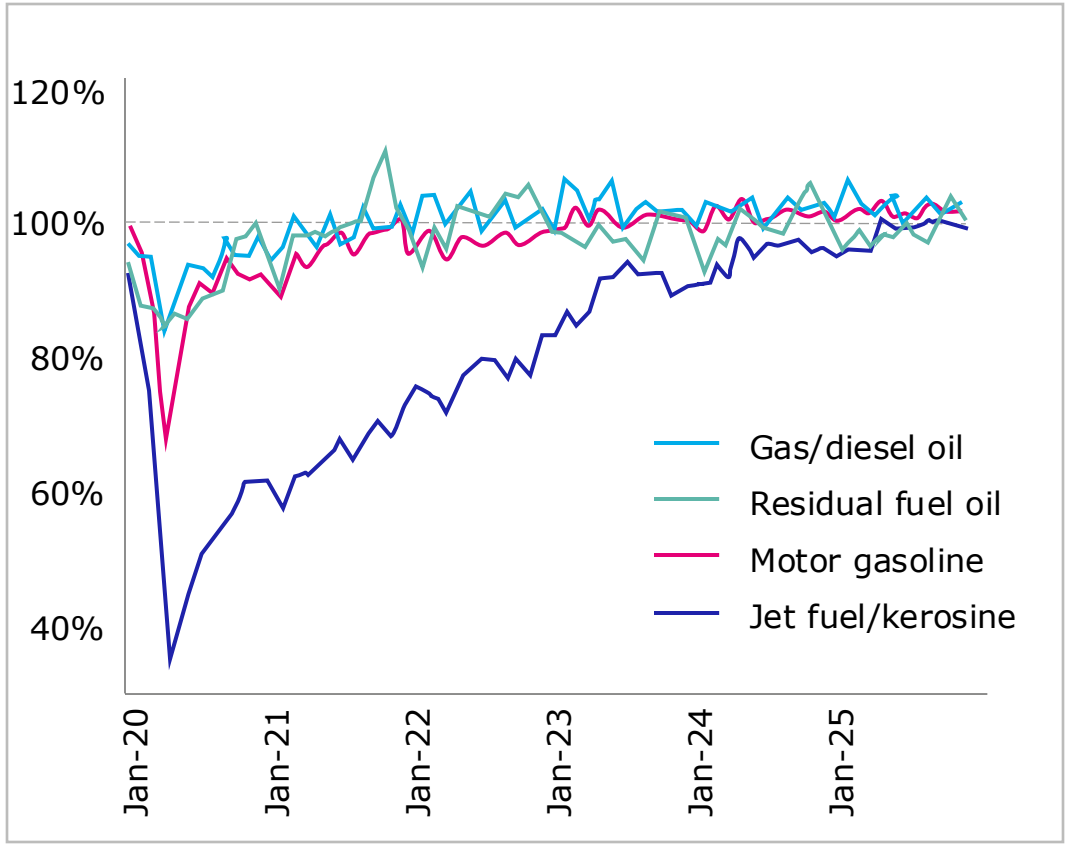
Based on S&P Global 2024 data

Reliance on fossil fuels maintains grey hydrogen production in the mid-term

Global major products demand vs 2019 levels



Volatile effects on the market from COVID have mainly passed and market aligning to long term trends

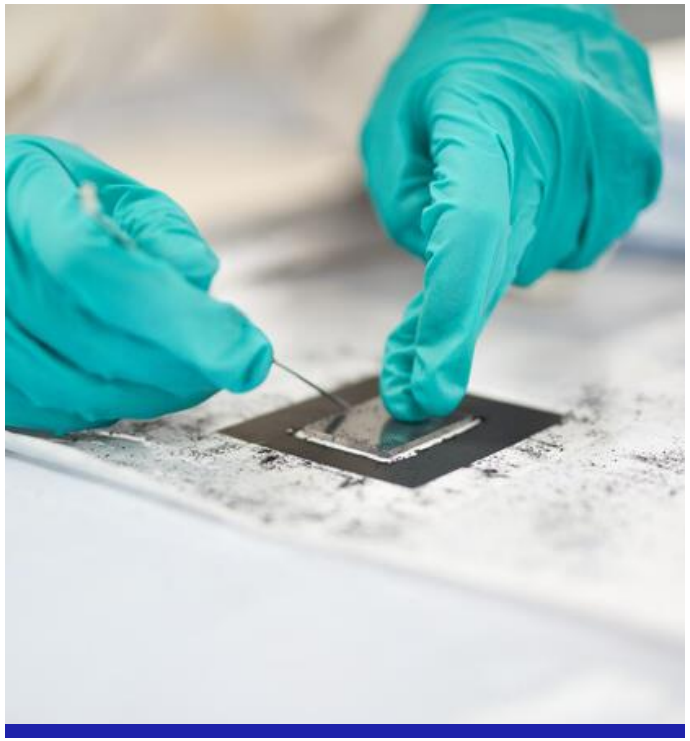
Major refined products continue to show a slow increase in the short-term

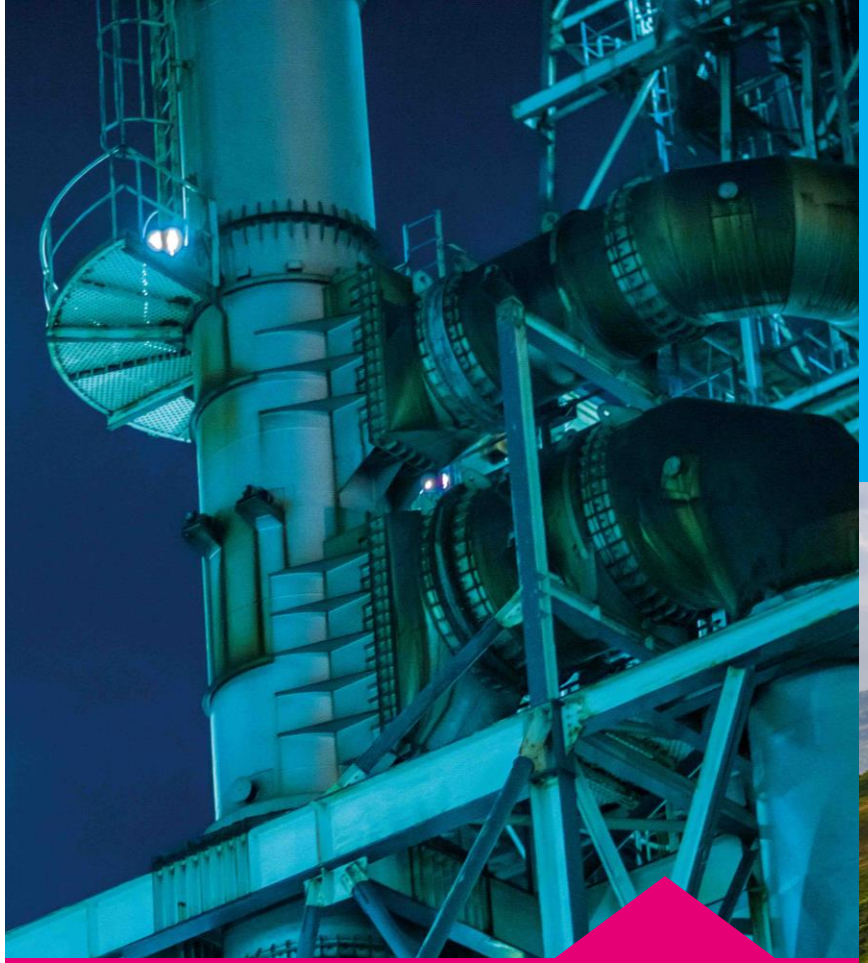
Whilst net zero targets aim to reduce reliance on fossil fuels, stronger incentives for decarbonization is required

70% grey hydrogen will be maintained through 2030

Based on S&P Global 2024 data

The changing role of hydrogen and syngas





Today

Hydrogen and syngas is mainly used in oil refining, fertiliser production and manufacturing of chemicals.

Tomorrow

Hydrogen is increasingly seen as the clean fuel of the future for applications such as heating, refining metals, synthetic fuels, upgrading biomass, generating electricity and other uses. Ammonia and methanol will play important roles as hydrogen carriers.

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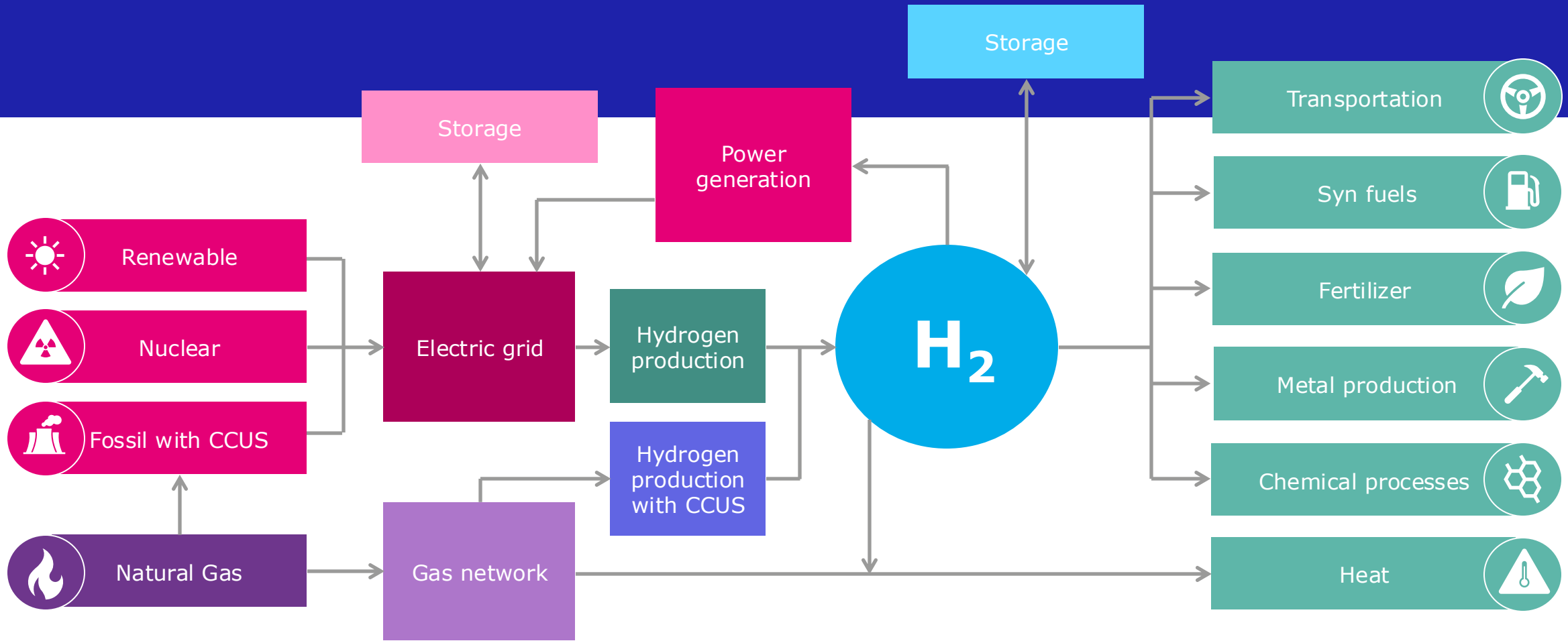
An expanding network for hydrogen



Carbon intensity: Mapping the transition

Legislation is increasingly focussed on **carbon intensity** not **color**

Global Clean Hydrogen Standards

US Clean Hydrogen Production Standard
≤ 4 kg CO_2e per kg H_2
Four levels in the IRA

China Hydrogen Alliance
≤ 4.9 kg CO_2e per kg H_2

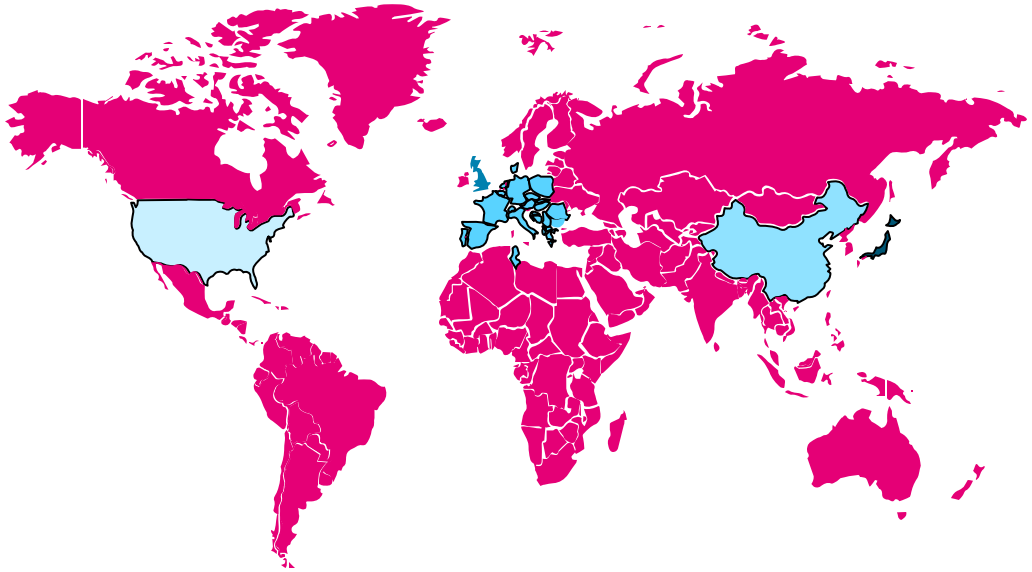
Expected EU regulations
≤ 3.3 kg CO_2e per kg H_2

UK Low Carbon Hydrogen Standard
≤ 2.4 kg CO_2e per kg H_2

Japan Clean Hydrogen Standard
≤ 3.4 kg CO_2e per kg H_2 and 0.84 kg CO_2e per kg NH_3*

S. Korea Clean Hydrogen Certification
Four grades – < 4.0 kg CO_2e per kg H_2

CertifHy
Voluntary international standard
≤4.4 kg CO_2e per kg H_2



Note: some values are for well to gate emissions, others are well to port

1,418
Clean hydrogen projects announced as of Oct 2023 [1]

51
Hydrogen strategies in action around the world[2]

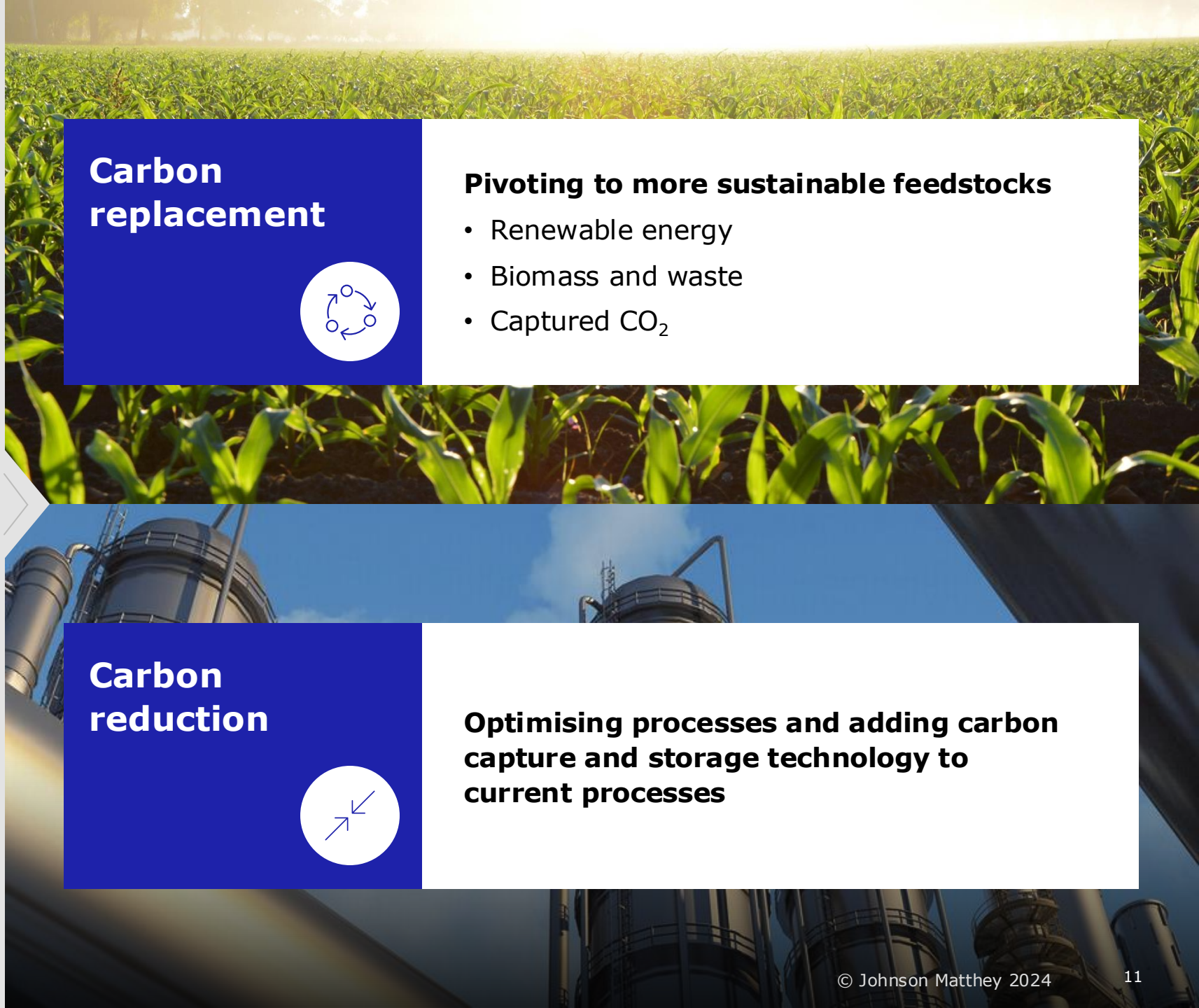
+30%
Investment growth from Jan 2023 to Oct 2023

$570bn
Total announced investment [1]

1 Hydrogen Insights December 2023, Hydrogen Council & McKinsey Company
2 BNEF, Hydrogen Strategies, Dec 2023
* Only Japan has announced a threshold for ammonia carbon intensity for gate-to-gate

The two pillars of decarbonisation for the chemical and energy industries

The chemical industry is the third largest industrial source of GHG emissions



Carbon replacement

Pivoting to more sustainable feedstocks

- Renewable energy
- Biomass and waste
- Captured CO_2

Carbon reduction

Optimising processes and adding carbon capture and storage technology to current processes

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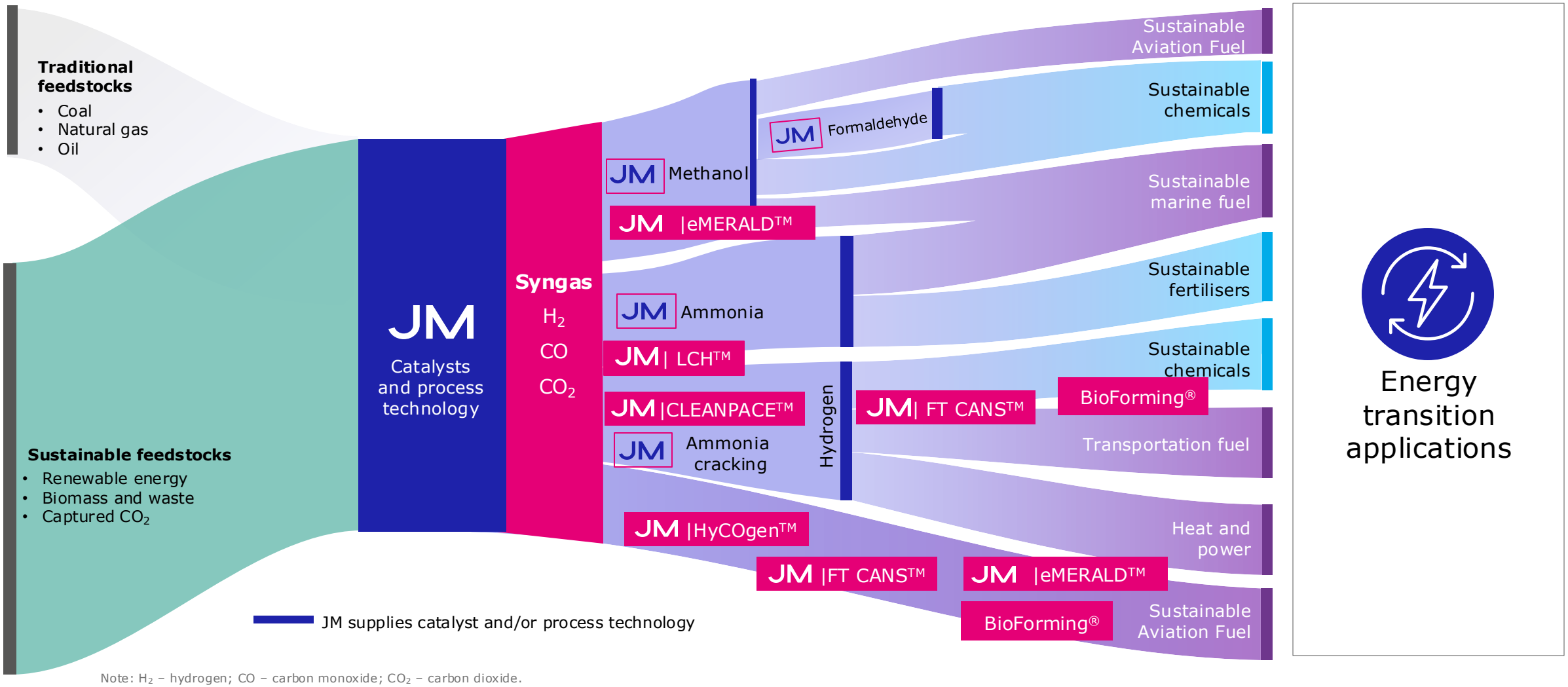
Hydrogen and syngas are at the heart of the energy transition

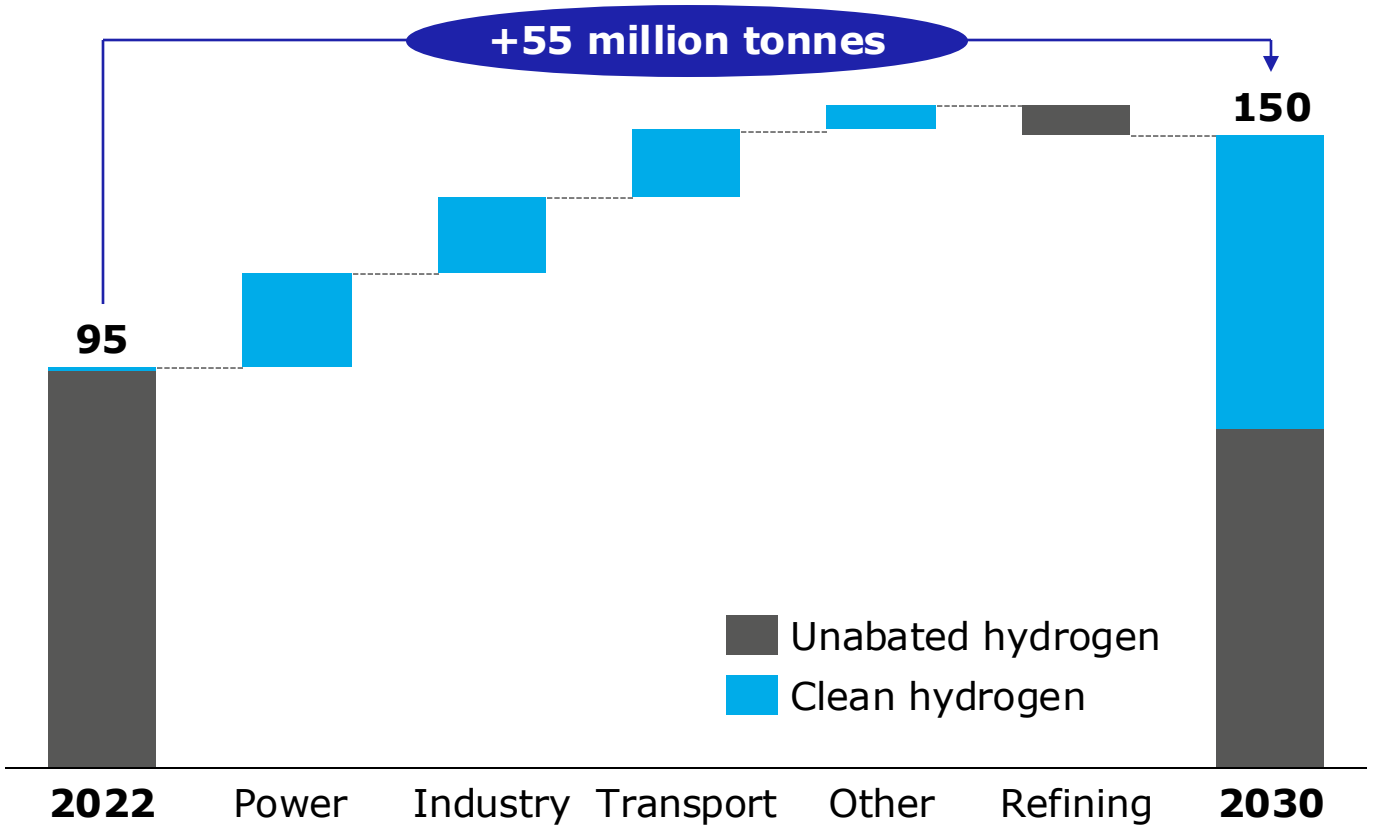


Note: H_2 – hydrogen; CO – carbon monoxide; CO_2 – carbon dioxide.
LCS – Low carbon solutions; FT CANS™ – Fischer-Tropsch CANS.
FT CANS™ in collaboration with bp.
BioForming® is a trademark of Virent Inc.

Only blue hydrogen delivers the scale needed today to keep us on track for net-zero

Total Hydrogen Demand by Sector

Million tonnes per year of Hydrogen Equivalent



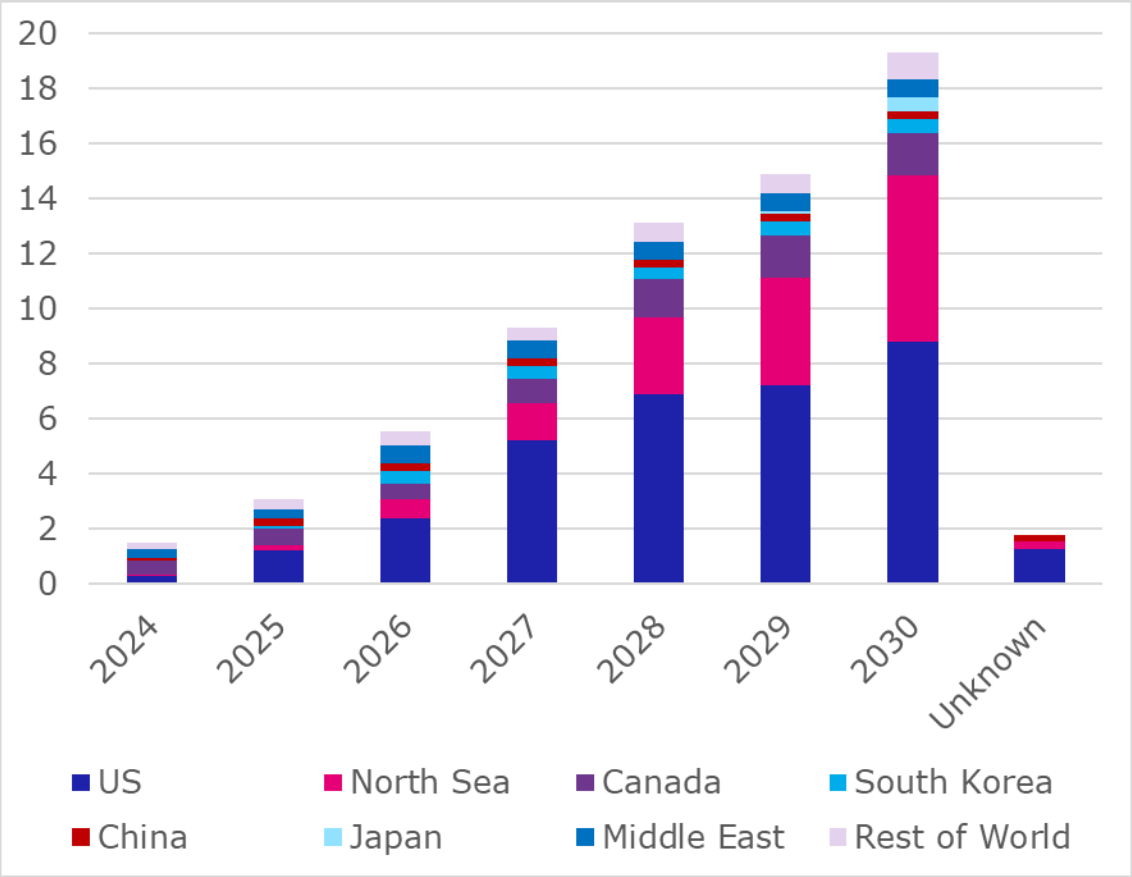
Hydrogen is crucial to reducing CO_2 emissions:

- Clean energy source; releases no CO_2 when combusted
- Versatile molecule which can be stored and transported
- Decarbonises high heat industry applications and transport
- Delivers 4% of global cumulative CO_2 reductions

Source: IEA, Roadmap to Net-Zero, 2023

Progression to a cleaner and healthier world

Cumulative hydrogen with CCS capacity through 2030 (MMt/y)



21.4 MMt/y of hydrogen with CCS capacity has been announced globally through to 2030

US Gulf Coast, Canada and North Sea account for 85% of the announced capacity

Most projects are only announced or in planning phases:

- Operation 1.1 MMt/y hydrogen
- In construction 0.7 MMt/y hydrogen
- Advanced planning 7.5 MMt/y hydrogen
- Early planning 4.1 MMt/y hydrogen
- Announced 8.0 MMt/y hydrogen

Based on S&P July 2024 data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