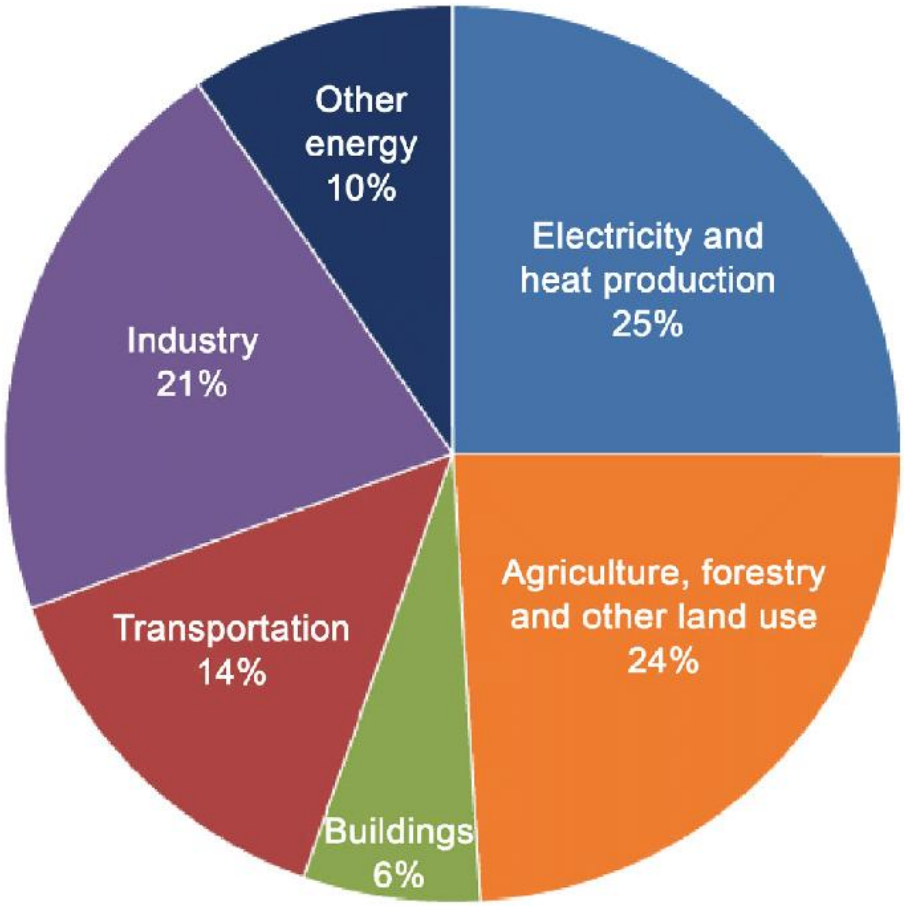
Johnson Matthey
Inspiring science, enhancing life

Challenges and opportunities for hydrogen in industrial applications

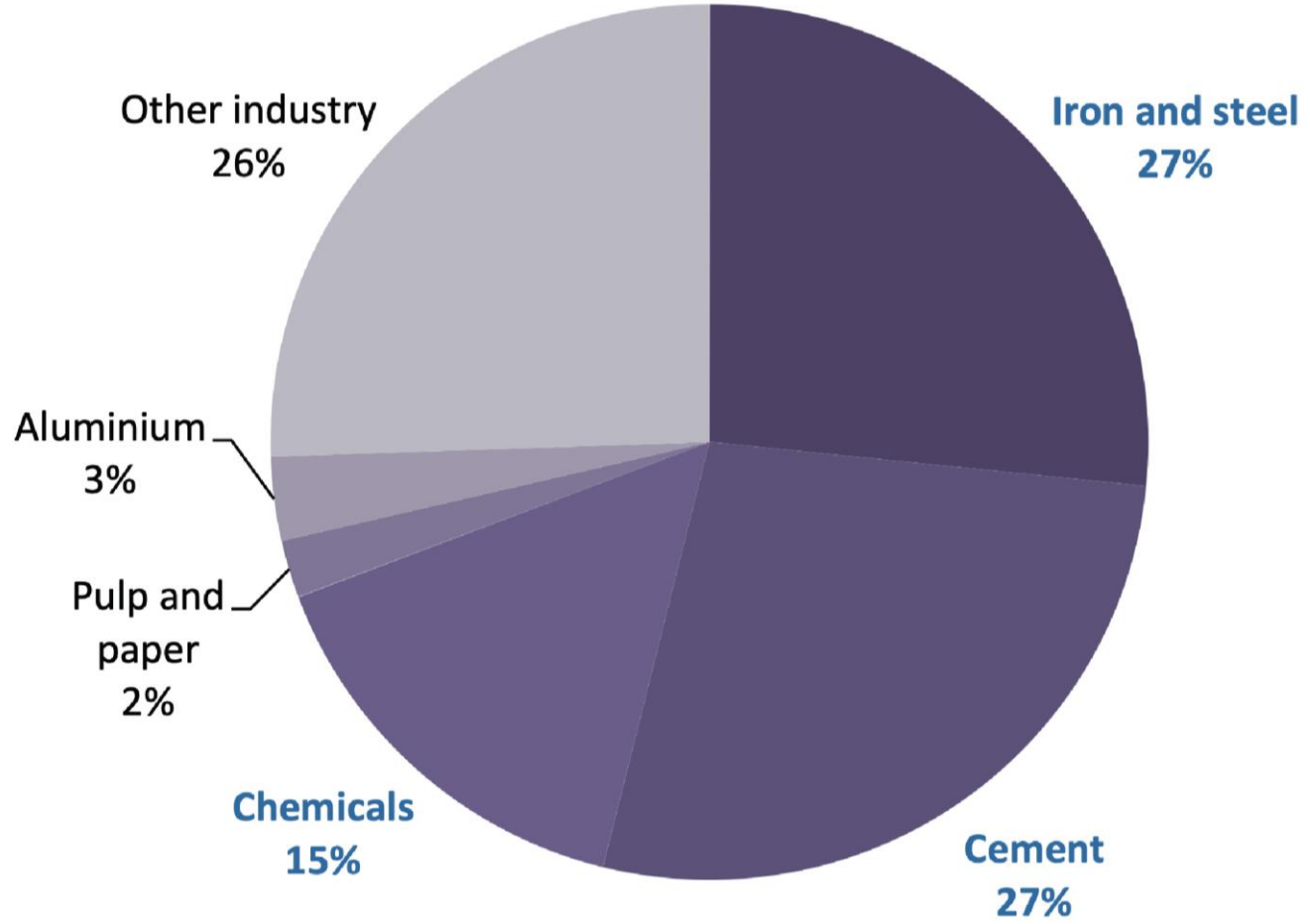
March 2023

Andy Walker, Technology Market Insights Director

How important is it to decarbonise industrial emissions?



Global GHG emissions by economic sector



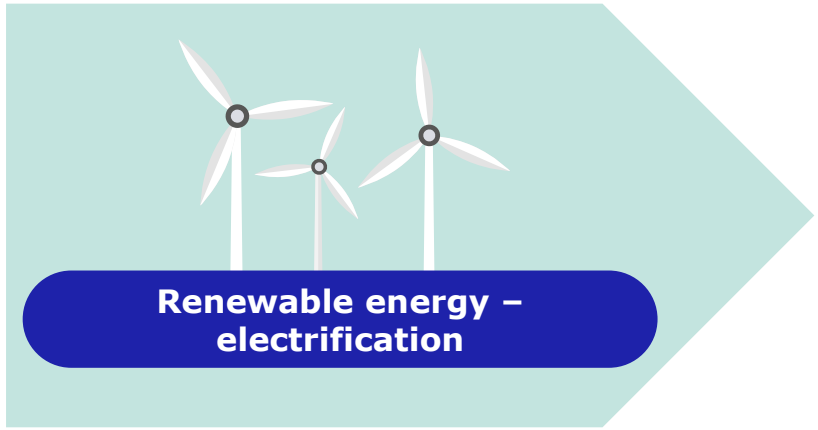
Share of global direct CO_2 emissions by industry sub-sector

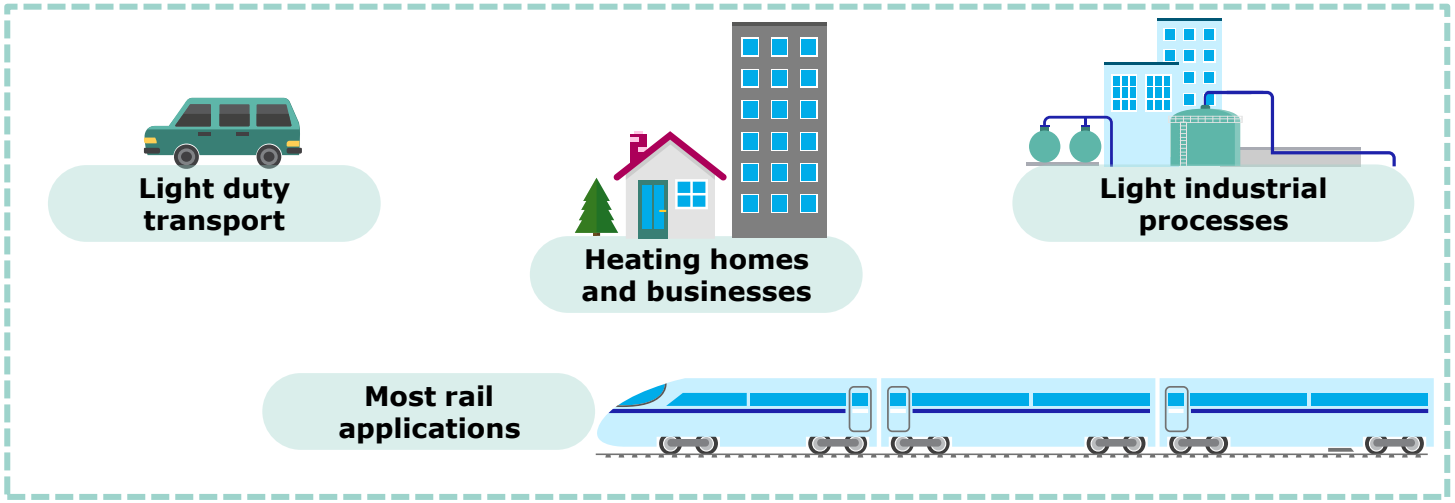
JM

Source: Researchgate.net; IEA: www.iea.org/report/transforming-industry-through-ccus

Clean electricity will play a critical role in decarbonisation

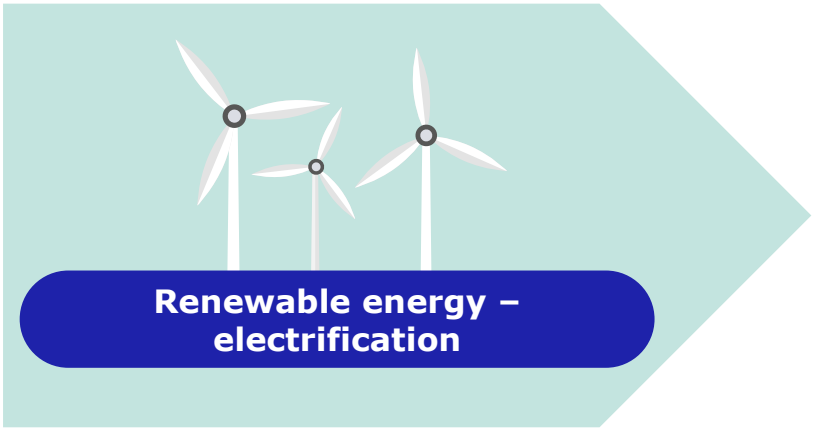
We should electrify what we can – it's often the most energy efficient route

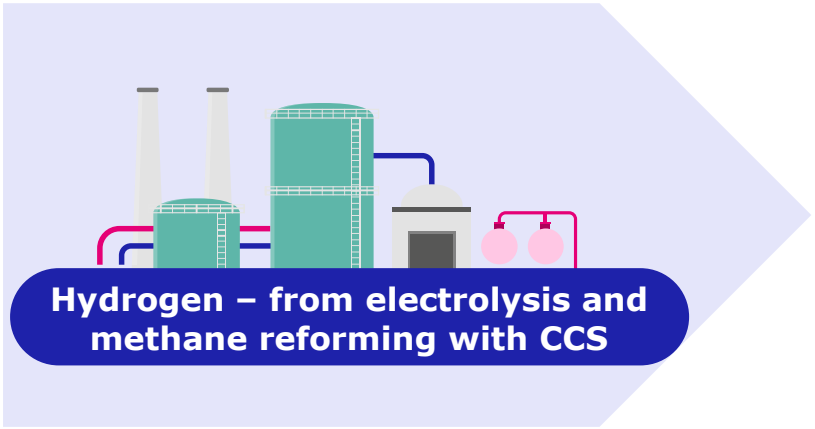


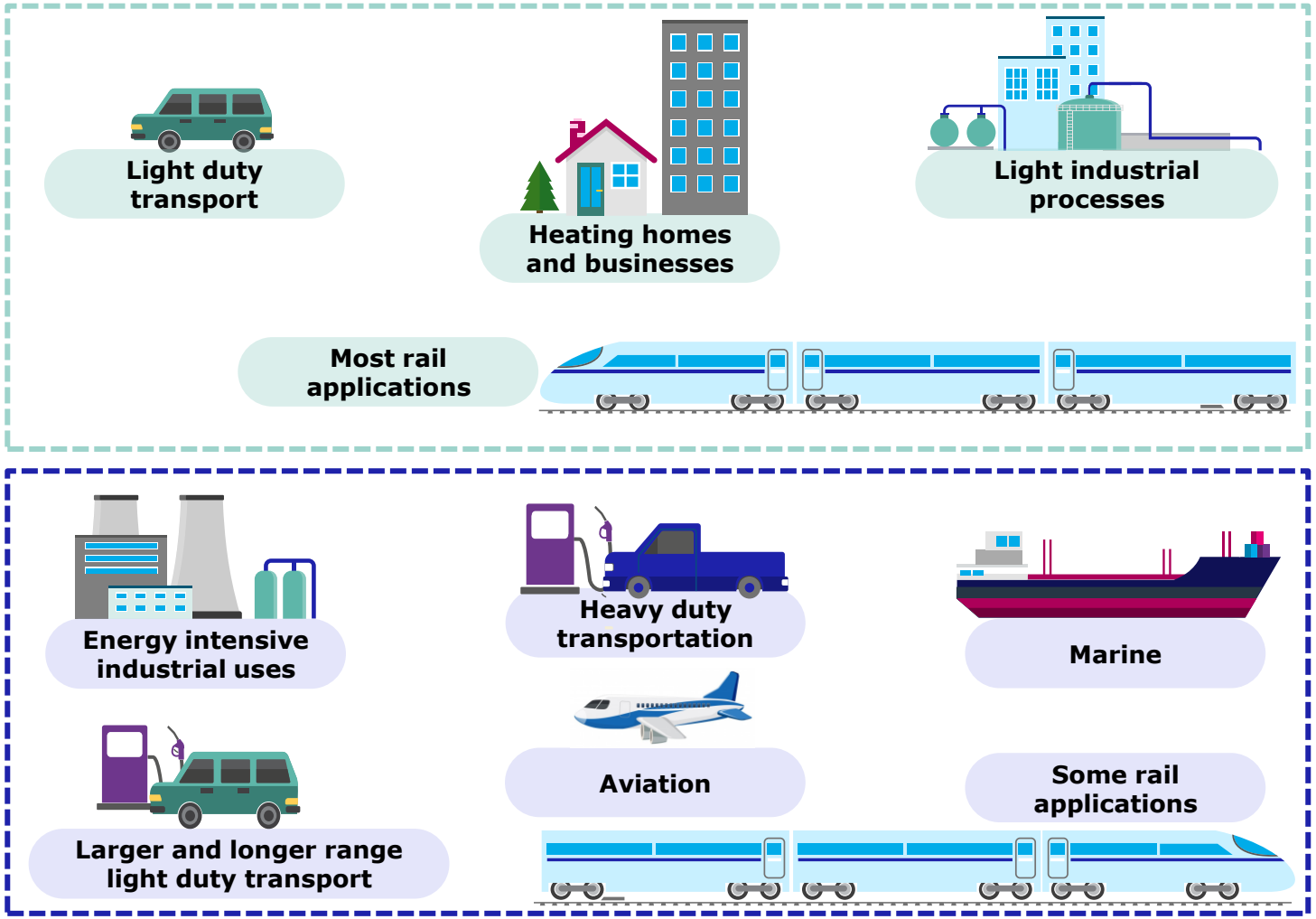


Clean hydrogen will play a critical role in decarbonisation

Particularly in hard-to-abate sectors – both directly (eg fuel cells) and indirectly (via sustainable fuels)

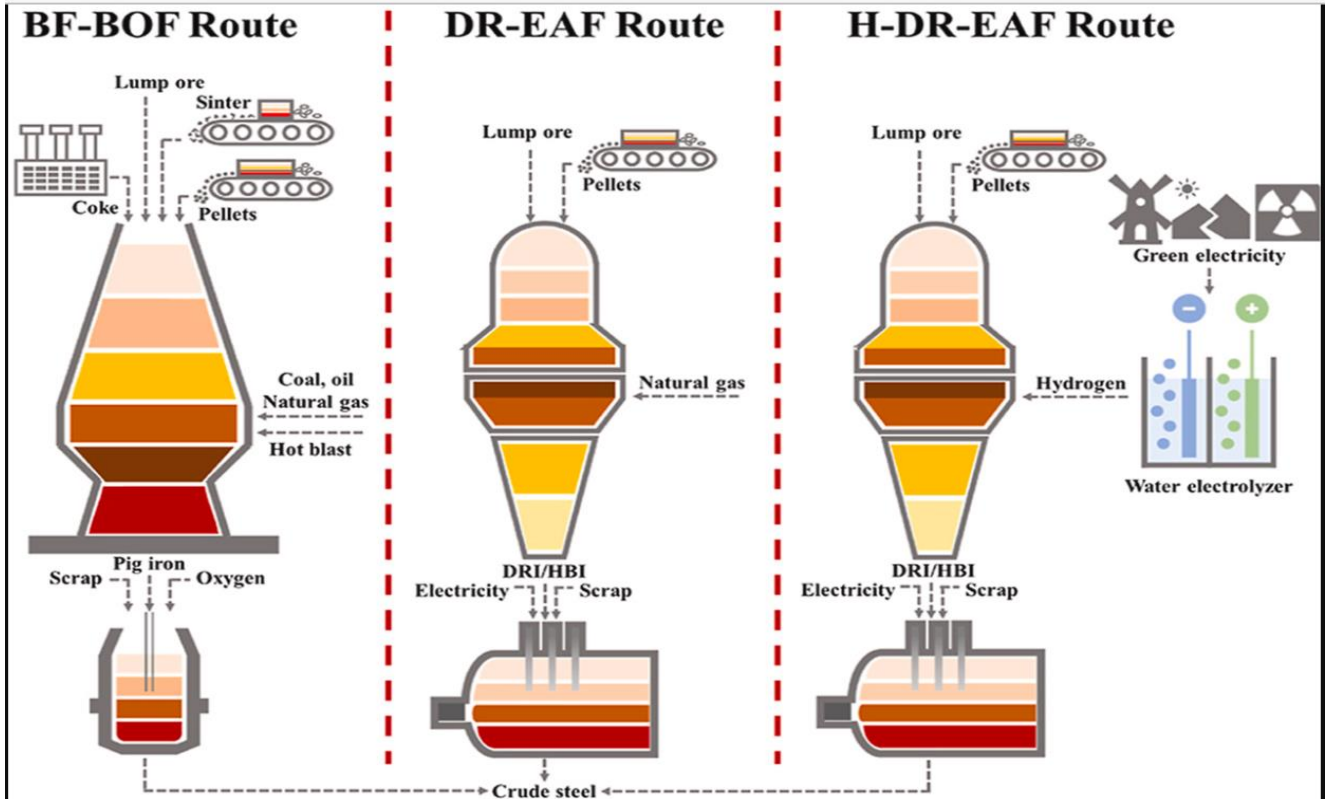






Note: CCS – carbon capture and storage.

Commitments and options to decarbonise steel



Blast Furnace
Basic O_2 Furnace
3.1 $GtCO_2$ pa

Direct Reduction
Electric Arc Furnace
0.5 $GtCO_2$ pa

H_2 Direct Reduction
Electric Arc Furnace
Concept

CLIMATE GROUP
STEELZERO
In partnership with Responsible Steel

Committed to buy or specify 100% net zero steel by 2050 with interim target of:

- 50% responsibly sourced steel by 2030

Moving to H_2 promising, but with challenges

Global Prodn (MT)	H_2 needed (MT)	Electrolyser Capacity (GW)	Renewable capacity (GW)	% of today's RE capacity
1,951	97	1,100	1,371	44%

JM

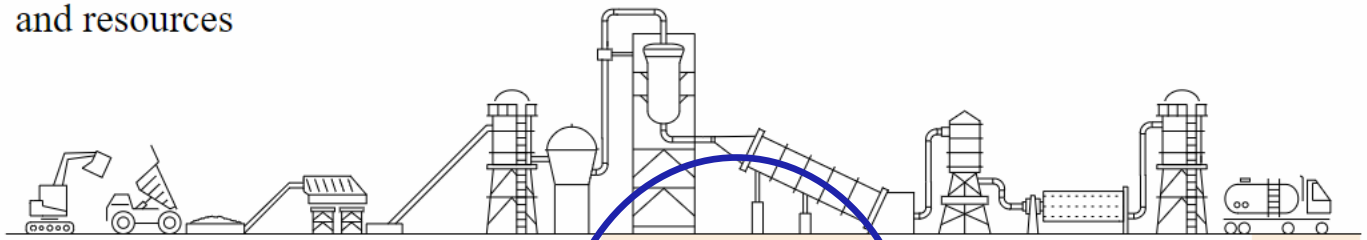
Source: https://doi.org/10.1016/j.jclepro.2021.129797; theclimategroup.org; IRENA, AFRY

Commitments and options to decarbonise cement

Most of the CO_2 emitted comes from the release of CO_2 during calcination and the combustion of fossil fuels to generate heat

Raw materials, energy and resources

Clinker and cement manufacturing



	Quarry	Crusher	Trans - port *	Raw mill	Kiln and preheater/ precalcinator §		Cooler †	Cement mill	Logistics ‡	Total
Energy (MJ/ton)	40	5	40	100	3,150		160	285	115	3,895
CO2 (KG/ton)	3	1	7	17	479 calcination process	319 fossil fuels	28	49	22	925

* Assumed 1kWh/tonne/100m.
§ Assumed global average, data from Global Cement and Concrete Association (2017).
† Assumed reciprocating grate cooler with 5kWh/tonne clinker.
‡ Assumed average truck transportation of 200 km.
Source: Mckinsey data.

CLIMATE GROUP CONCRETE ZERO

Concrete industry commits to the use of 100% net zero low-emissions concrete by 2050 with interim targets of:

- 30% low-emission concrete by 2025
- 50% low-emission concrete by 2030

Potential decarbonisation approaches

- CCUS – capture released CO_2 and store or re-use in eg e-fuels (combine with renewable H_2) – eg Holcim/TotalEnergies project to decarbonise fully a Holcim cement plant[1]
- Move away from fossil fuel use – to eg H_2, bioenergy, renewable waste

JM

[1] https://sgvoice.energyvoice.com/strategy/11947/totalenergies-fully-decarbonise-cement-plant-belgium/

Options to decarbonise chemicals/fuels

Embodied carbon in chemicals/fuels

Carbon replacement

Pivoting to more sustainable feedstocks

- Biomass
- Waste/recycled material
- Captured CO_2

React this carbon with clean H_2 to generate products

Clean hydrogen used both as a feedstock and energy source through combustion

Process CO_2 emissions

Reduce CO_2 from energy to drive process

(85% of CO_2 emissions[1])

- Add CCS to fossil fuelled plants
- Switch to renewable electricity or clean H_2
- Optimise process/catalyst

Reduce CO_2 emitted during the process

(15% of CO_2 emissions[1])

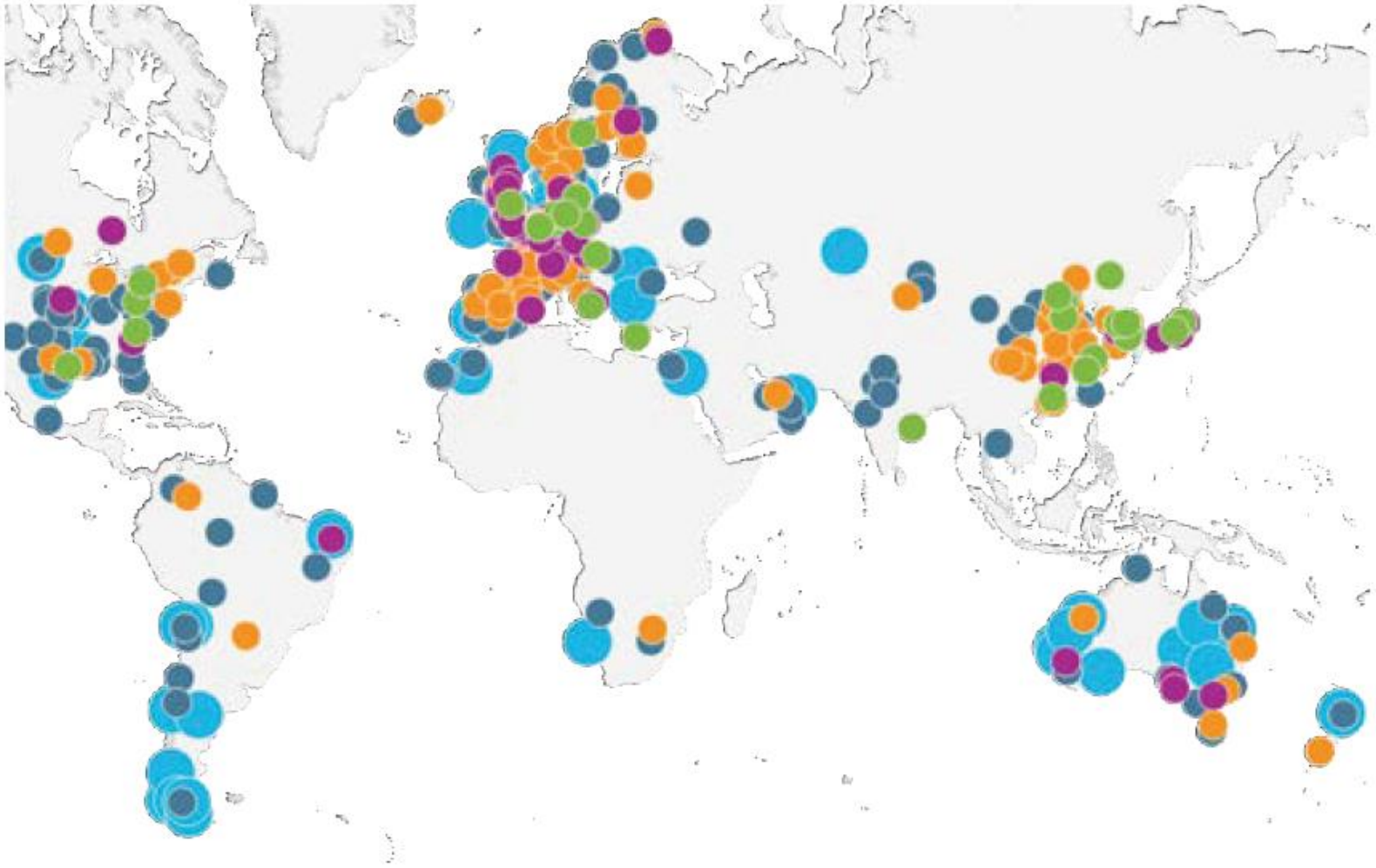
- Add CCS
- Optimise process/catalyst

JM

Source: [1] IEA

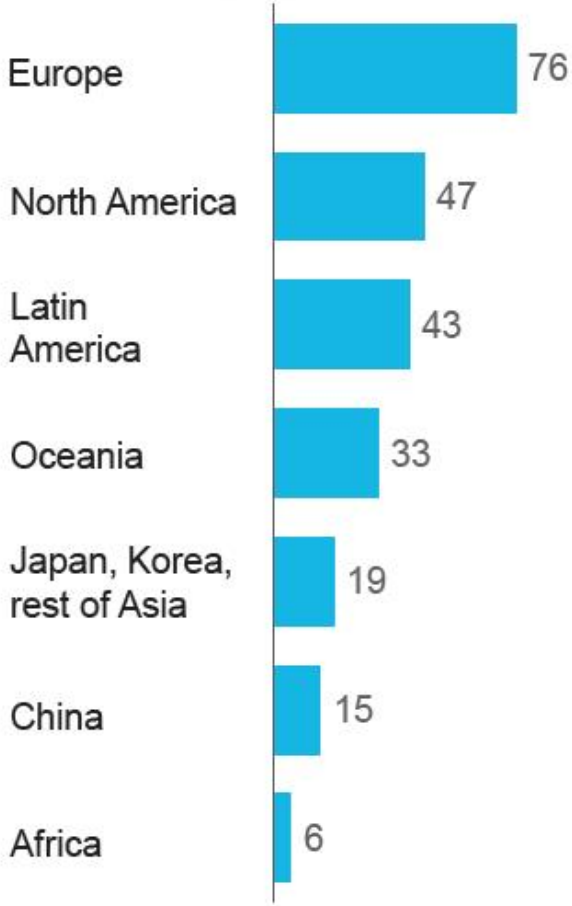
Lots of focus on clean H_2 for industrial use globally

Out of 534 large-scale clean hydrogen projects announced globally, 262 target large-scale industrial use



USD 240bn

investments required for announced projects until 2030



# of projects

51 Giga-scale production

262 Large-scale industrial use

128 Transport

53 Integrated H_2 economy

40 Infrastructure projects

JM

Source: Hydrogen Council

Clean H_2 projects are targeting industrial and chemicals decarbonisation – HyNet example

Trialling decarbonised hydrogen as a fuel and feedstock

Phase 1: 80kt (350MW) of hydrogen p.a. Equivalent to world scale hydrogen plant

Used in industry, homes and transport

UK targeting 10GW of clean H_2 by 2030

- HyNet capable of providing 40% of this by 2030
- Front-End Engineering Design completed

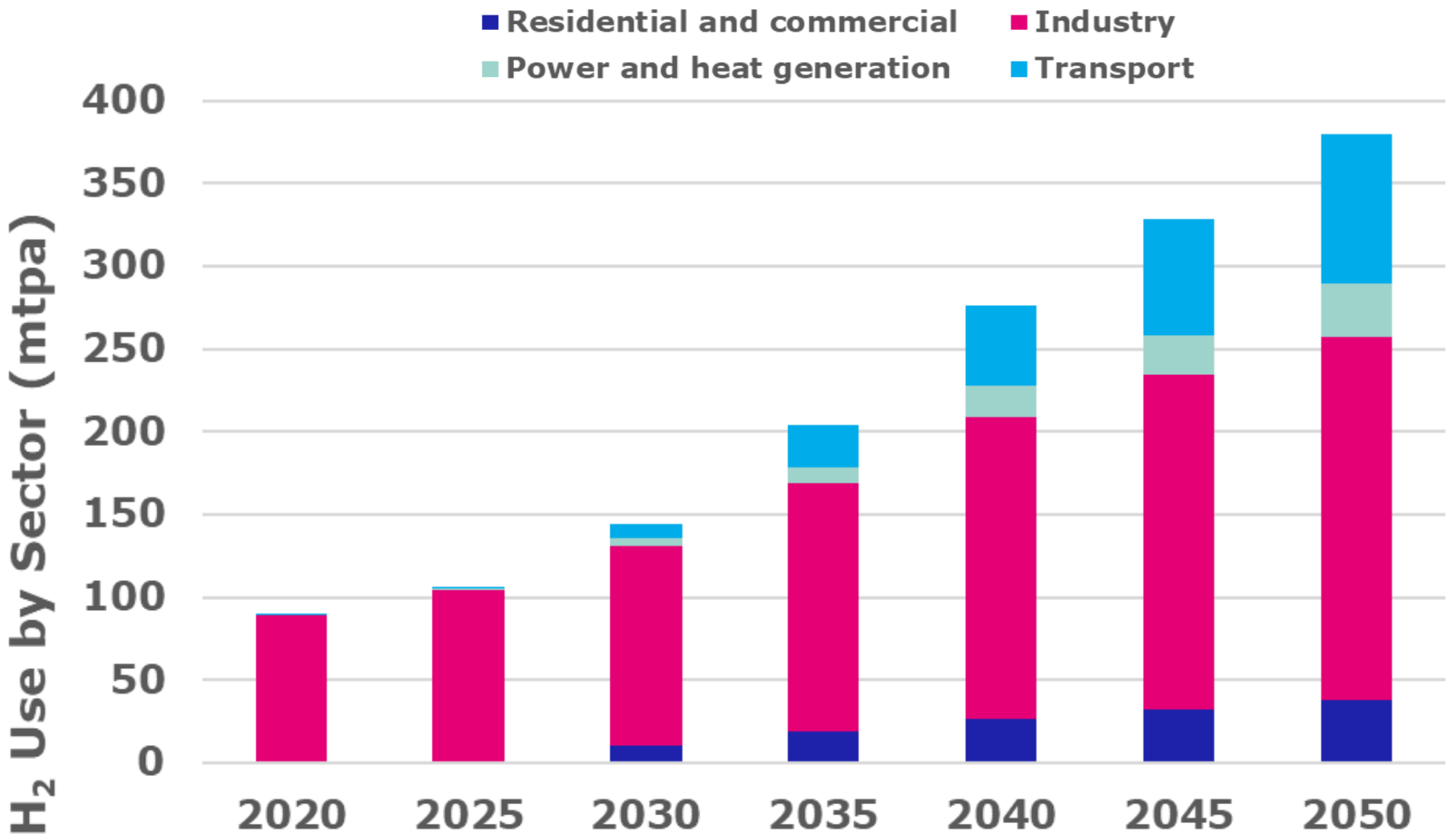
Over 25 **industrials** and flexible power generators engaged with HyNet to decarbonise via hydrogen

Pilkington's glass furnaces and Unilever's manufacturing processes to be fuelled by hydrogen

Hydrogen also to be used in refinery decarbonisation, and in heating and transport applications

JM

IHS analysis projects that the main role of hydrogen in the clean energy transition is within the decarbonization of industry



JM

Challenges and Opportunities for clean H_2 in industrial decarbonisation

- As outlined, there are plenty of opportunities for hydrogen to play a key role in the decarbonisation of heavy industry, but there are also challenges to be overcome:
- Cost – using clean hydrogen will be more expensive than current approaches, so we need business models to enable the transition, potentially using carbon pricing
- Need to create a market for near zero-emission industrial products – eg through carbon contract for difference or direct public procurement
- Need to de-risk these technologies for conservative industries through at-scale demonstrations
- Supporting infrastructure needs investment – eg for CO_2 transport and storage; low emission hydrogen production and distribution
- Need to protect industries against lower cost, high carbon imports – eg via Carbon Border Adjustment Mechanisms

JM


JM
Johnson Matthey
Inspiring science, enhancing life