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Inspiring science, enhancing life

UBS Mobility Conference

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A world that's cleaner and healthier;

today and for future generations

The move to net zero is accelerating: “building back greener”

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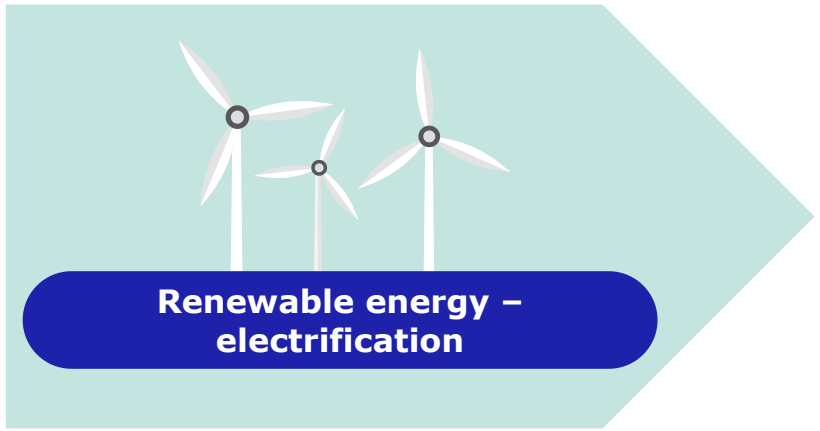
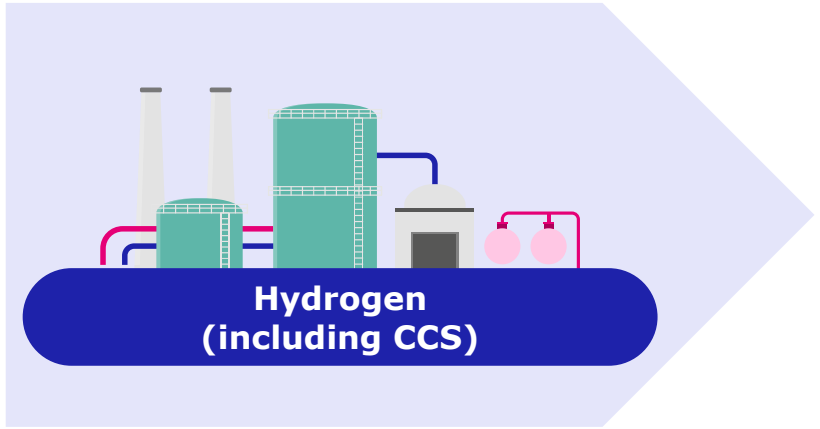
Source: Committee on Climate Change, Net Zero Report, May 2019; Energy and Climate Intelligence Unit, August 2020.

Hydrogen is key to reaching “net zero”





H_2

Light duty transport

Heating homes and businesses

Light industrial processes

Most rail applications

Energy intensive industrial uses

Heavy duty transportation

Marine

Larger and longer range light duty transport

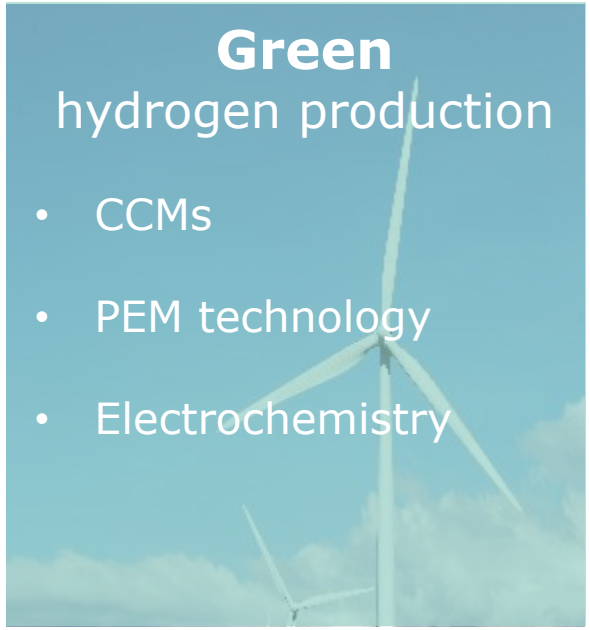
Some rail applications

Note: CCS – carbon capture and storage.

Let’s look at some of JM’s technologies for the hydrogen transition

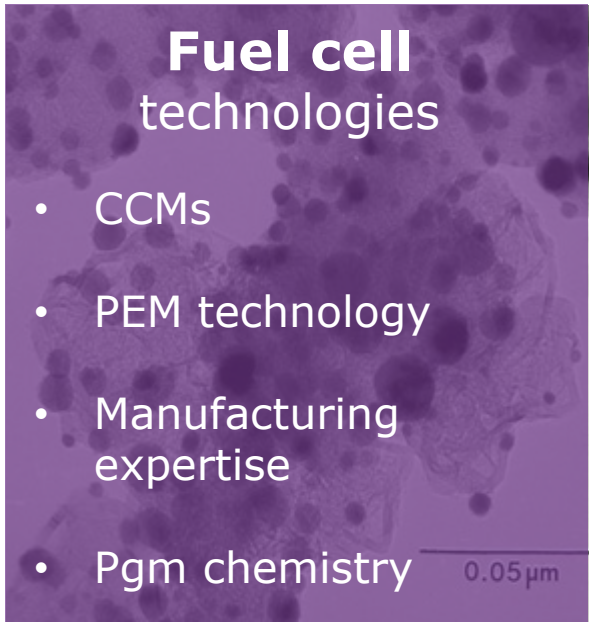
Blue
hydrogen production

- Leading technology
- Commercialisation
- Building on our expertise



Green
hydrogen production

- CCMs
- PEM technology
- Electrochemistry



Fuel cell
technologies

- CCMs
- PEM technology
- Manufacturing expertise
- Pgm chemistry

Chemical
building blocks

- Existing technology
- Syngas conversion, Fischer Tropsch
- Jet fuel, ammonia, methanol, formaldehyde

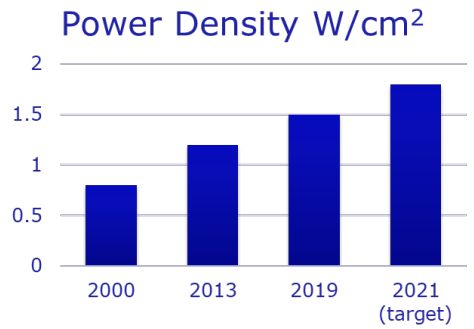
Hydrogen production technologies

Use of hydrogen

Note: CCM – catalyst coated membrane, PEM - proton exchange membrane.

Fuel Cells: JM has a strong competitive advantage…

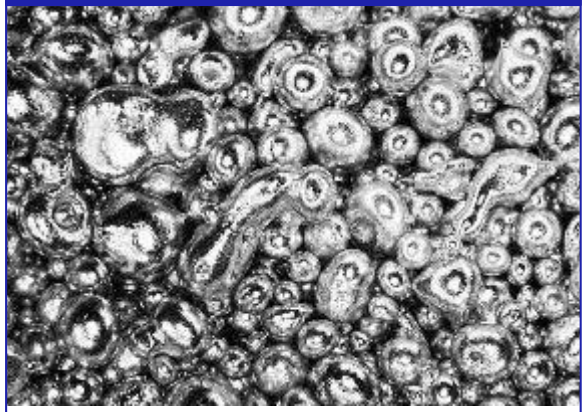
Science



Catalyst and membrane expertise

Optimisation for high performance

Pgm expertise



Potential closed loop offering

Lower carbon intensity

Ability to reduce cost

Trusted partner

Stationary, auto and non-auto markets

Existing customers

Over 20 years' experience

Established manufacturing

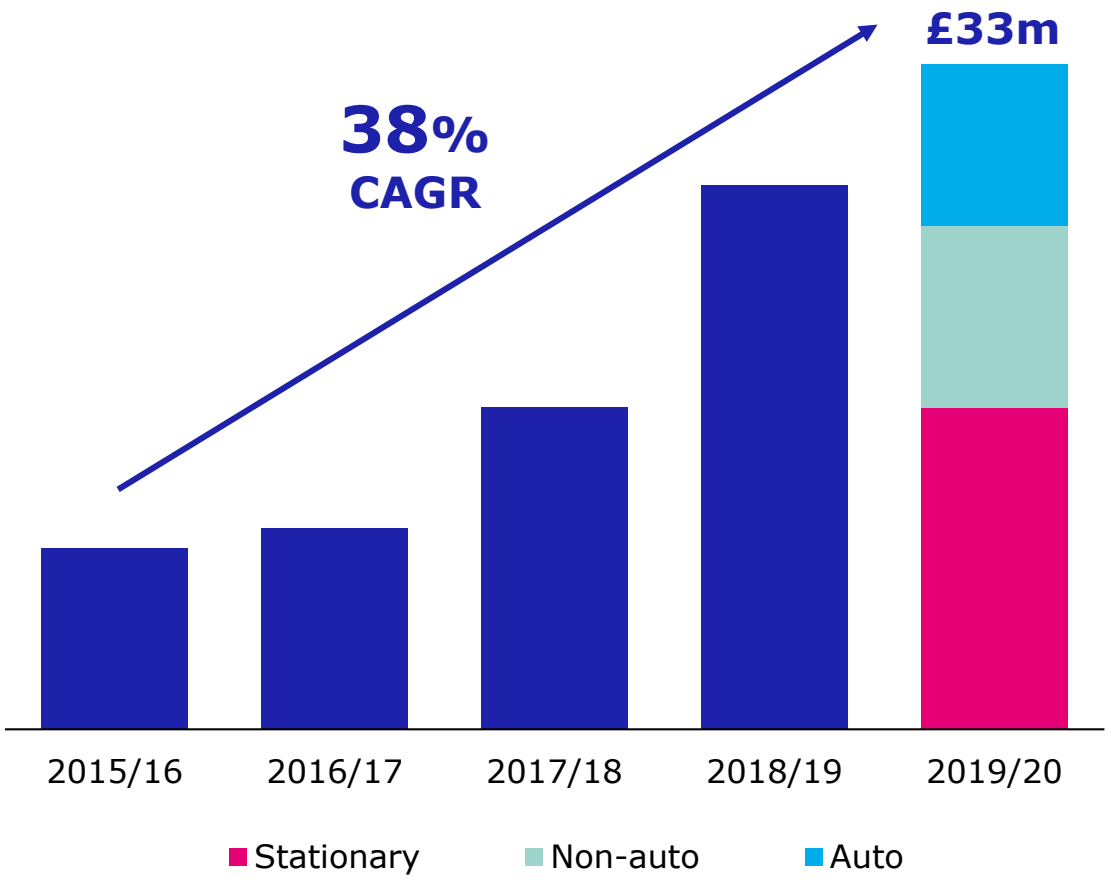
Well along experience curve

Doubling capacity 2020/2021

Further expansion

…JM has an established, profitable and growing business

Fuel cell sales (£m)



Note: Sales excluding precious metals.
1. Based on LMC, KGP and JM assumptions which equate to i) c.0.4 million trucks.
2. Source: McKinsey cost estimations and OEM targets.
3. Based on LMC, KGP and JM assumptions which equate to i) c.3 million trucks and ii) c.14.5 million autos, of which c.60% is assumed to be non-captive in 2040. Estimated CCM value per auto vehicle is c.£800.

Customers include major global truck and auto OEMs

Estimated addressable truck market of

c.£1bn p.a. in 2030[1,2]

>£10bn p.a. in 2040[2,3]

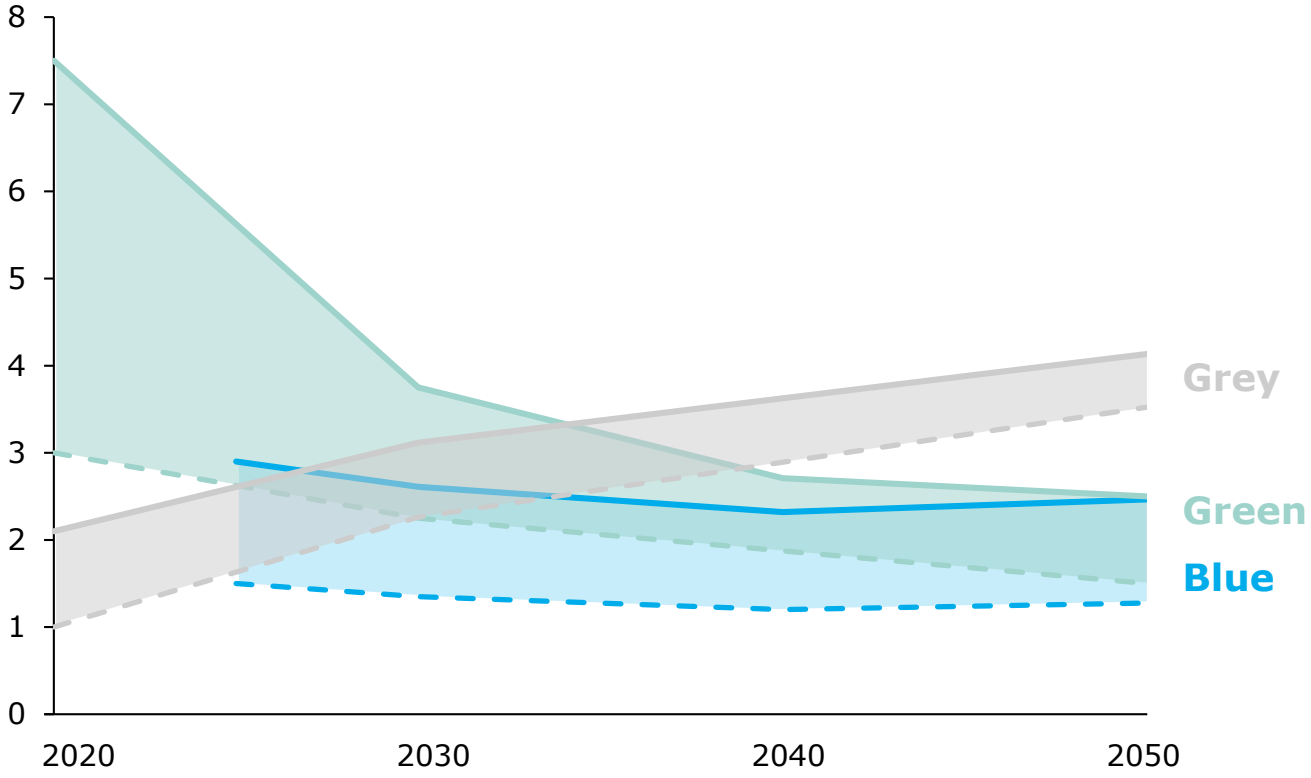
JM has a strong presence across hydrogen production technologies

Brown	Grey	Blue	Green
	JM's technologies		
Coal	Natural gas	Natural gas	Renewable electricity
-	Leading catalyst supplier 40% segment share[1]	Differentiated technology and catalyst supplier	Expect to supply catalyst coated membrane
Gasification No CCS	Steam methane reforming No CCS	Advanced gas reforming CCS	Electrolysis
Highest GHG emissions (19 tCO_2/tH_2)	High GHG emissions (11 tCO_2/tH_2)	Low GHG emissions (0.2 tCO_2/tH_2)	Potential for zero GHG emissions
$1.2 to $2.1 per kg H_2	$1 – $2.1 per kg H_2	$1.5 – $2.9 per kg H_2	$3 – $7.5 per kg H_2

Note: GHG – greenhouse gas; CCS – carbon capture and storage; tCO_2/tH_2 – tonne of carbon dioxide per tonne of hydrogen.
Source: IEA, The Future of Hydrogen, Karuizawa, Japan, June 2019.
1. Based on Johnson Matthey data.

Green hydrogen becomes more competitive over the medium term

Estimated hydrogen cost
($ per kg H_2)



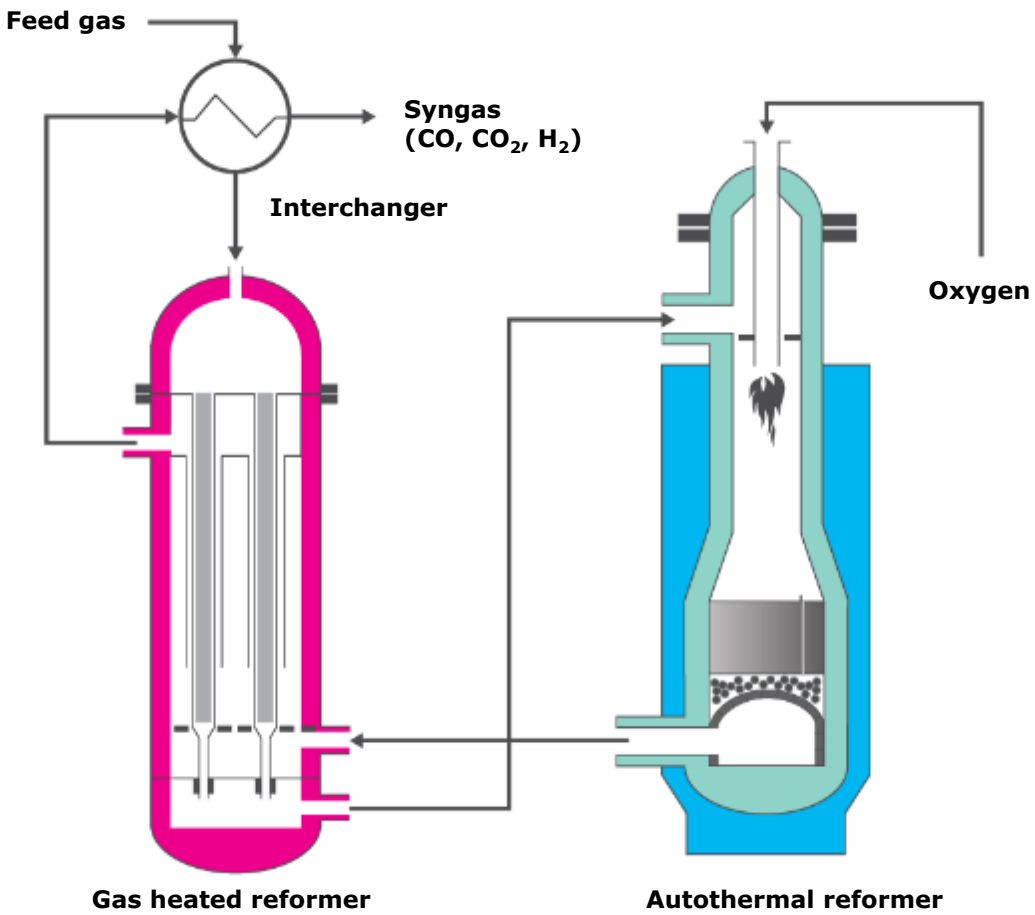
Blue hydrogen advantaged in certain regions and likely to be a long term solution in places with the right geology and infrastructure e.g. US and UK

Green hydrogen will be a solution in some regions as both renewable energy and capital costs decline

Source: IEA, The Future of Hydrogen, Karuizawa, Japan, June 2019; McKinsey; Johnson Matthey.

JM's award winning blue hydrogen technology builds on our expertise in grey hydrogen and methanol

Johnson Matthey's blue hydrogen technology



Methane (CH_4) from natural gas is reacted with steam to produce **hydrogen** (H_2) and **carbon dioxide** (CO_2)

Most efficient process – 9% less natural gas usage[1]

Lowest capex – 40% lower capital cost[1]

>95% of produced CO_2 **captured**: **single stream** at **high pressure** and **purity** enabling easier transport or storage

1. Compared to conventional steam methane reforming technology with carbon capture and storage. *Johnson Matthey Technol. Rev.*, 2020, **64**, (3), 357–37.
9% efficiency saving based on a project equivalent to the size of HyNet Phase 1 (80kt p.a.) would give a saving of c.£6 million to 7 million p.a.
Note: Feed gas is methane from natural gas; syngas is predominantly carbon monoxide (CO), carbon dioxide (CO_2) and hydrogen (H_2).

Our blue hydrogen technology is already being commercialised

HyNet Phase 1

North West England

- Trialling decarbonised hydrogen as a fuel and feedstock
- Phase 1: 80kt of hydrogen p.a. Equivalent to world scale hydrogen plant
- Used in industry, homes and transport

Acorn Phase 1

North East Scotland

- North Sea natural gas reformed into clean hydrogen and CCS
- Phase 1: 55kt of hydrogen p.a.
- Used in transport and the gas grid to decarbonise heating

…and a pipeline of blue hydrogen projects globally

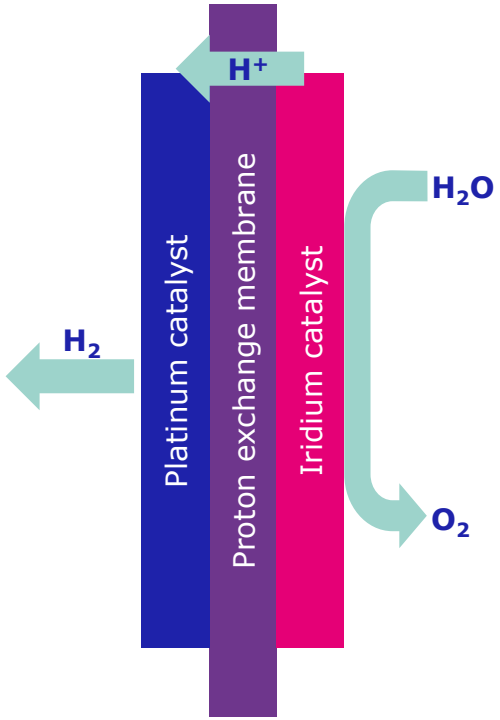
Estimated addressable market of c.£1.5bn to c.£2bn p.a. in 2030[1,2]

Note: CCS – carbon capture and storage.

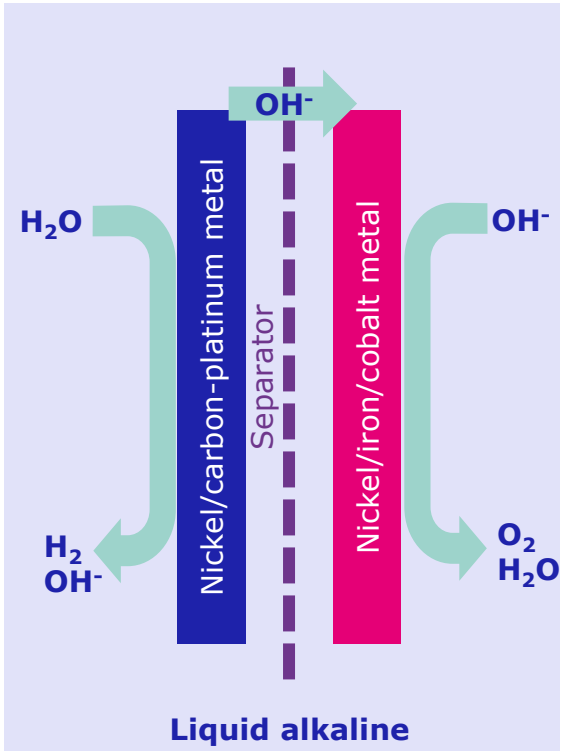
1. Based on total hydrogen demand (Hydrogen Council, "Hydrogen, Scaling up" report, 2017); average plant size of 160kt p.a. (equivalent to twice the size of HyNet project Phase 1).
2. Assumes c.30% of the market is blue hydrogen (Johnson Matthey, IEA, BP).

Green hydrogen: electrolysis of water to produce hydrogen using renewable energy

PEM



Alkaline



Proton exchange membrane (PEM): polymer electrolyte and pgm electrodes

- Compact or large systems
- Robust in non-continuous use applications
- Higher hydrogen purity
- Lowest cost option as technology develops

Alkaline: liquid alkaline electrolyte and base metal electrodes

- Large systems only
- Less suitable for non-continuous applications, e.g. some renewable energy
- More commoditised technology

PEM technology expected to play a major role

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Why JM will be successful in green hydrogen

Comparable technology to fuel cells

- CCM is heart of system and key for performance and cost reduction
- Competitive advantage in pgm catalysis and thrifting
- Ability to scale quickly

Potential closed loop offering

- End of life options designed in from R&D stage
- Pgm recycling expertise

Experience in enabling new technologies

- Fuel cells
- Fischer Tropsch
- Technology for waste to aviation fuel

Estimated addressable PEM market of c.£2bn to £4bn p.a. in 2030[1]

Testing with leading electrolyser players

Note: PEM – proton exchange membrane.
1. Assumes c.30% of the market is green hydrogen, of which the PEM share is 30-60% (Johnson Matthey, IEA, BP).

JM continues to support an integrated hydrogen economy…
-from hydrogen to base chemical building blocks to specialty chemicals and fuels

Research

- R&D investment
- Sample and small series production
- Partnering for pilot scale demonstration

Commercialisation

- Accelerated growth
- Blue Hydrogen, commercial launch
- Appointment of MD in Green Hydrogen
- JM Hydrogen Council

Strategy

- Hydrogen and fuel cells sales already c.£100 million
- Fit with portfolio of small chemical building blocks
- JM is a Global Hydrogen Council Board member & on UK Govt Hydrogen Advisory Council

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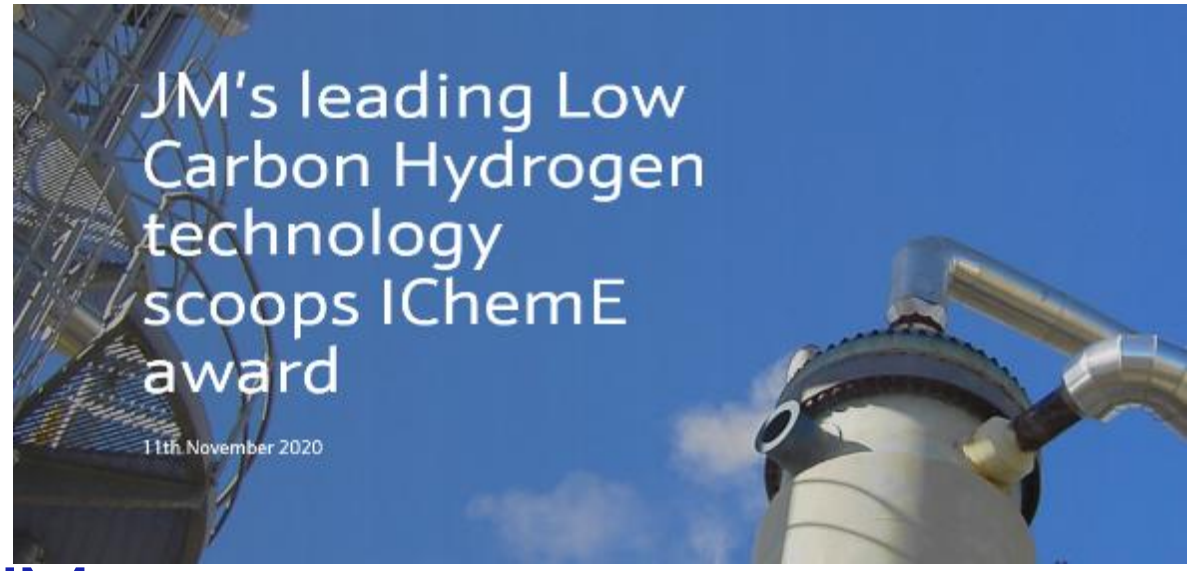
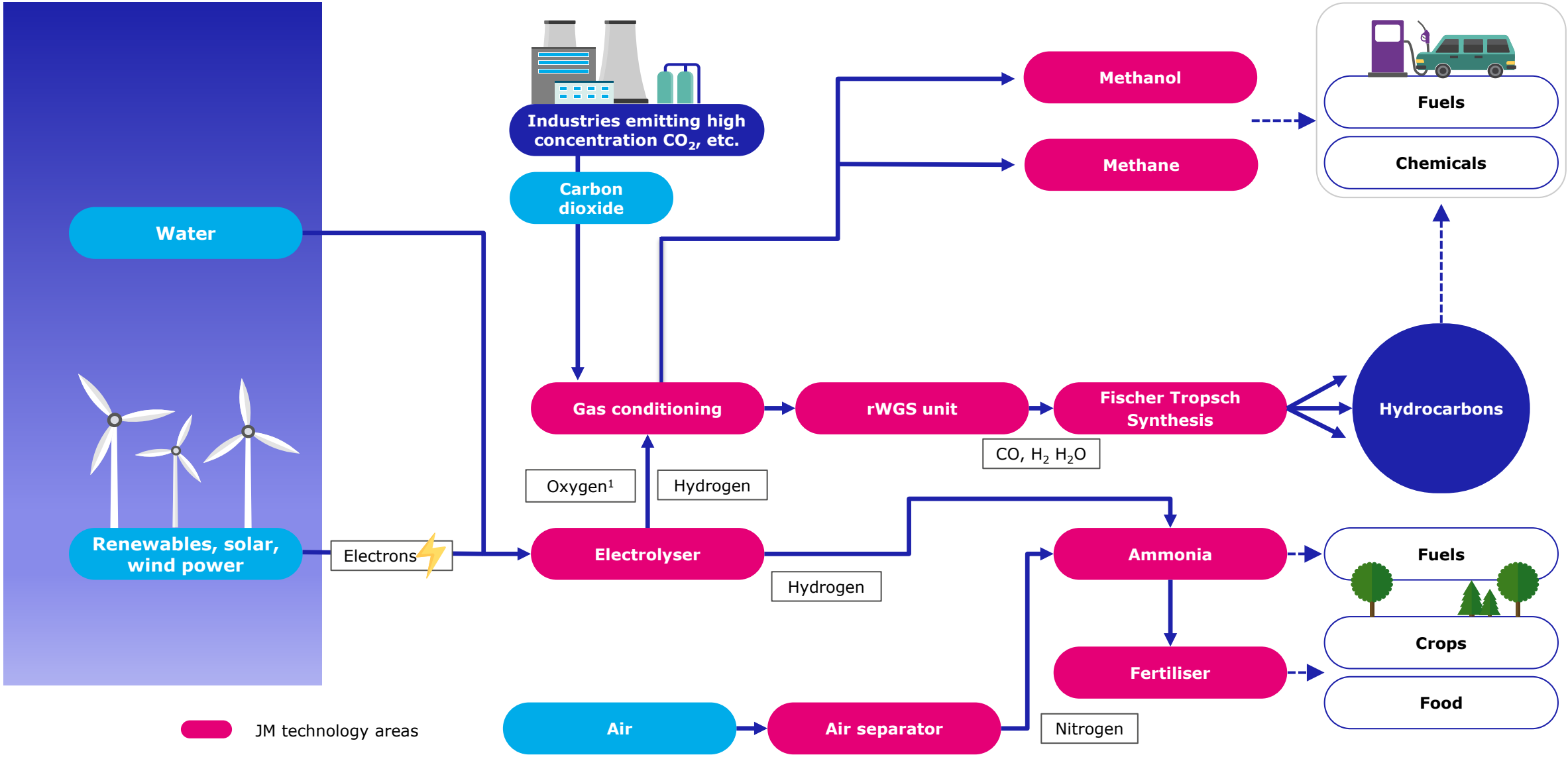
…and our stakeholders are recognising it



Turning green hydrogen into chemical building blocks: a vision



Note: rWGS – reverse water-gas shift reaction

1. Oxygen produced opens up new value streams for electrolyser operators as oxygen is another important chemical widely used by industry. This is not covered in this presentation.

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Q&A

www.matthey.com/investors