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Johnson Matthey
Inspiring science, enhancing life

Exane BNP Paribas expert call – Hydrogen

25th January 2021

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A world that's cleaner and healthier;

today and for future generations

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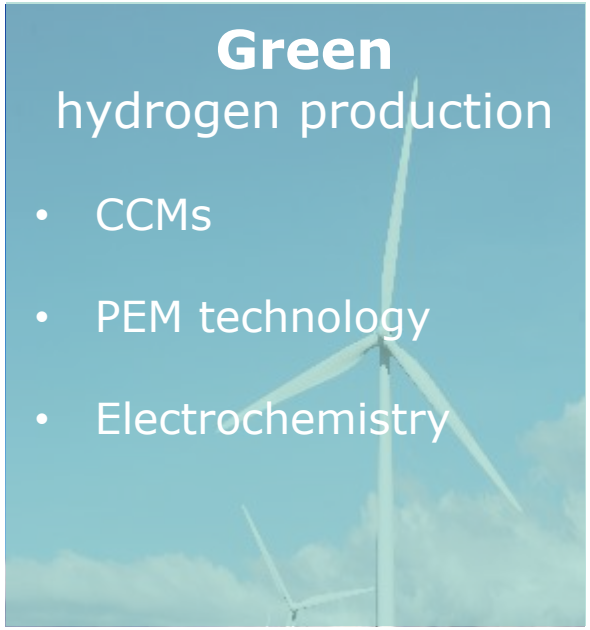
The move to net zero is accelerating: “building back greener”

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

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

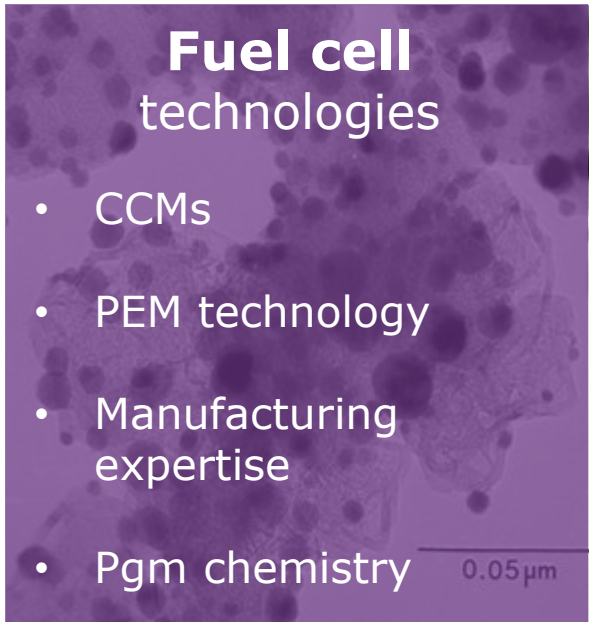
Blue
hydrogen production

- 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

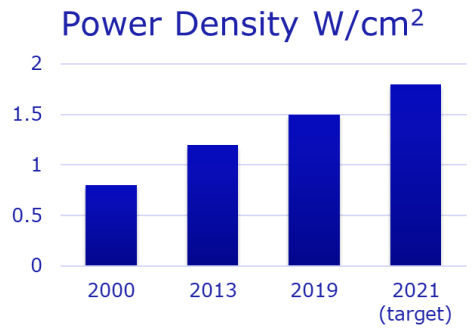
Hydrogen production technologies

Use of hydrogen

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

Fuel Cells: JM has a strong competitive advantage…

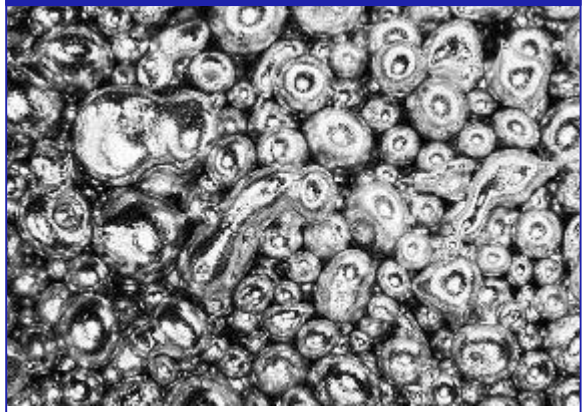
Science



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

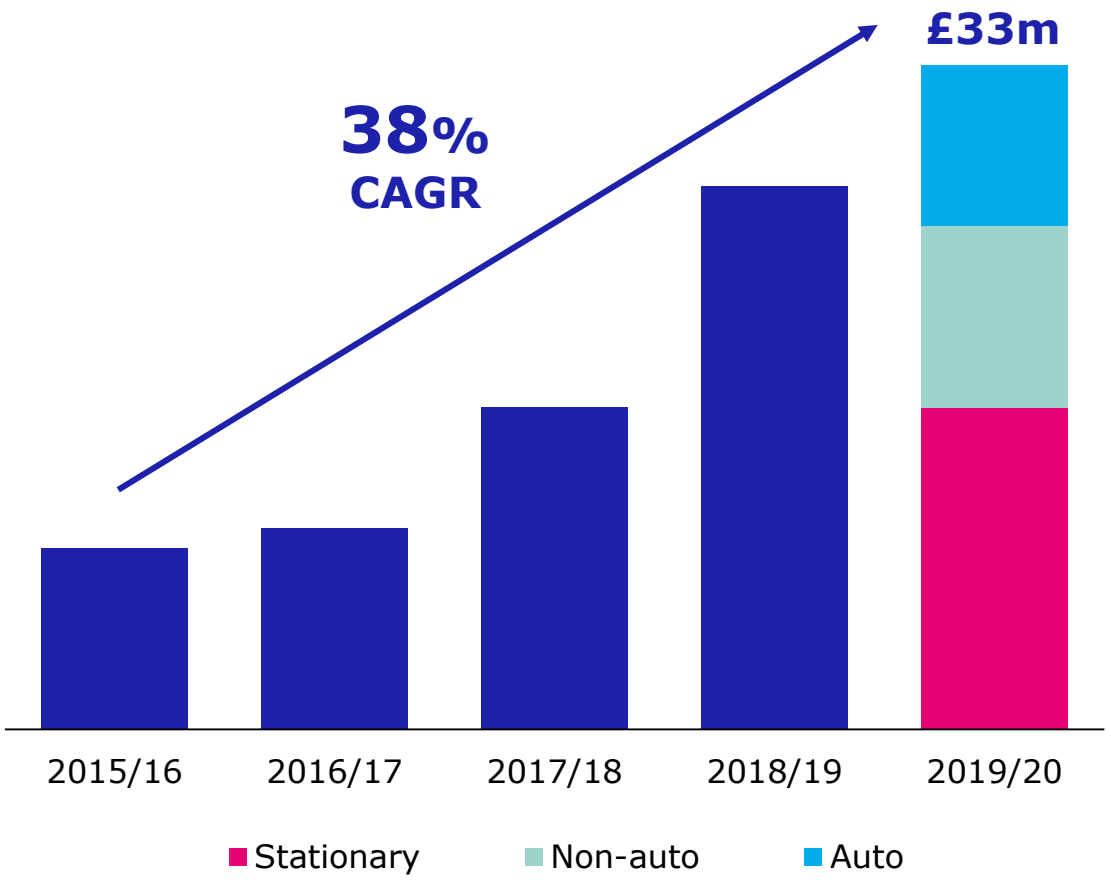
Well along experience curve

Doubling capacity 2020/2021

Further expansion

…JM has an established, profitable and growing business

Fuel cell sales (£m)



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]

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.

JM has a strong presence across hydrogen production technologies

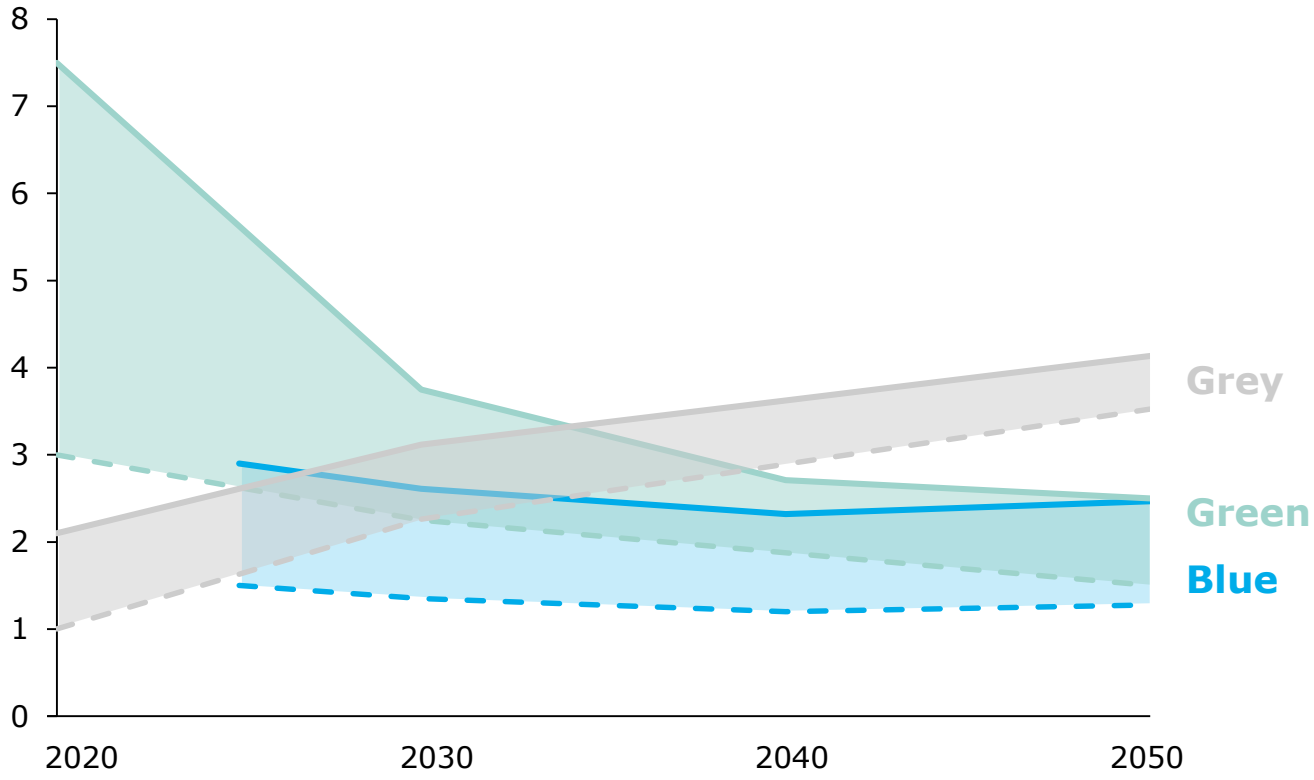
JM's technologies

Grey	Blue	Green
Natural gas	Natural gas	Renewable electricity
Leading catalyst supplier 40% segment share[1]	Differentiated technology and catalyst supplier	Expect to supply catalyst coated membrane
Steam methane reforming No CCS	Advanced gas reforming CCS	Electrolysis
High GHG emissions (11 tCO_2/tH_2)	Low GHG emissions (0.2 tCO_2/tH_2)	Potential for zero GHG emissions
\$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)



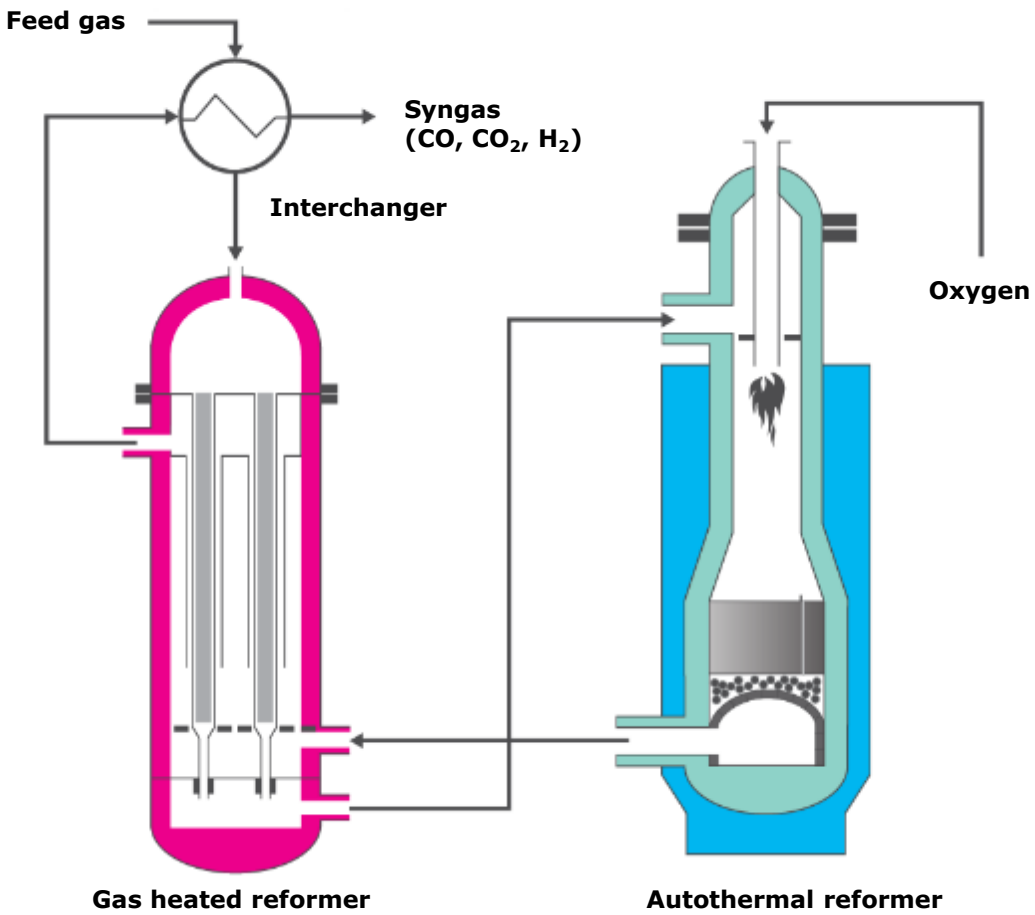
Blue hydrogen advantaged in certain regions and likely to be a long term solution in places with the right geology and infrastructure e.g. US and UK

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]

98% 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).

World's most progressed low carbon hydrogen projects have JM's LCH™ technology at their heart

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

Engaged with a growing global pipeline of over 15 projects

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).

JM is a trusted partner in the rapid scale up of 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 and on UK Govt Hydrogen Advisory Council

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…and our stakeholders are recognising it

Market is accelerating and we are delivering for our customers

JM and SFC Energy AG sign multi-million pound deal and joint development agreement for supply of fuel cell components

11th January 2021

HyNet:
A step closer to the UK's first hydrogen hub which will use JM's low carbon hydrogen technology

15th January 2021

JM announces manufacturing capacity for products enabling 10s of MWs of green hydrogen; ability to scale up to multi-GW

20th January 2021

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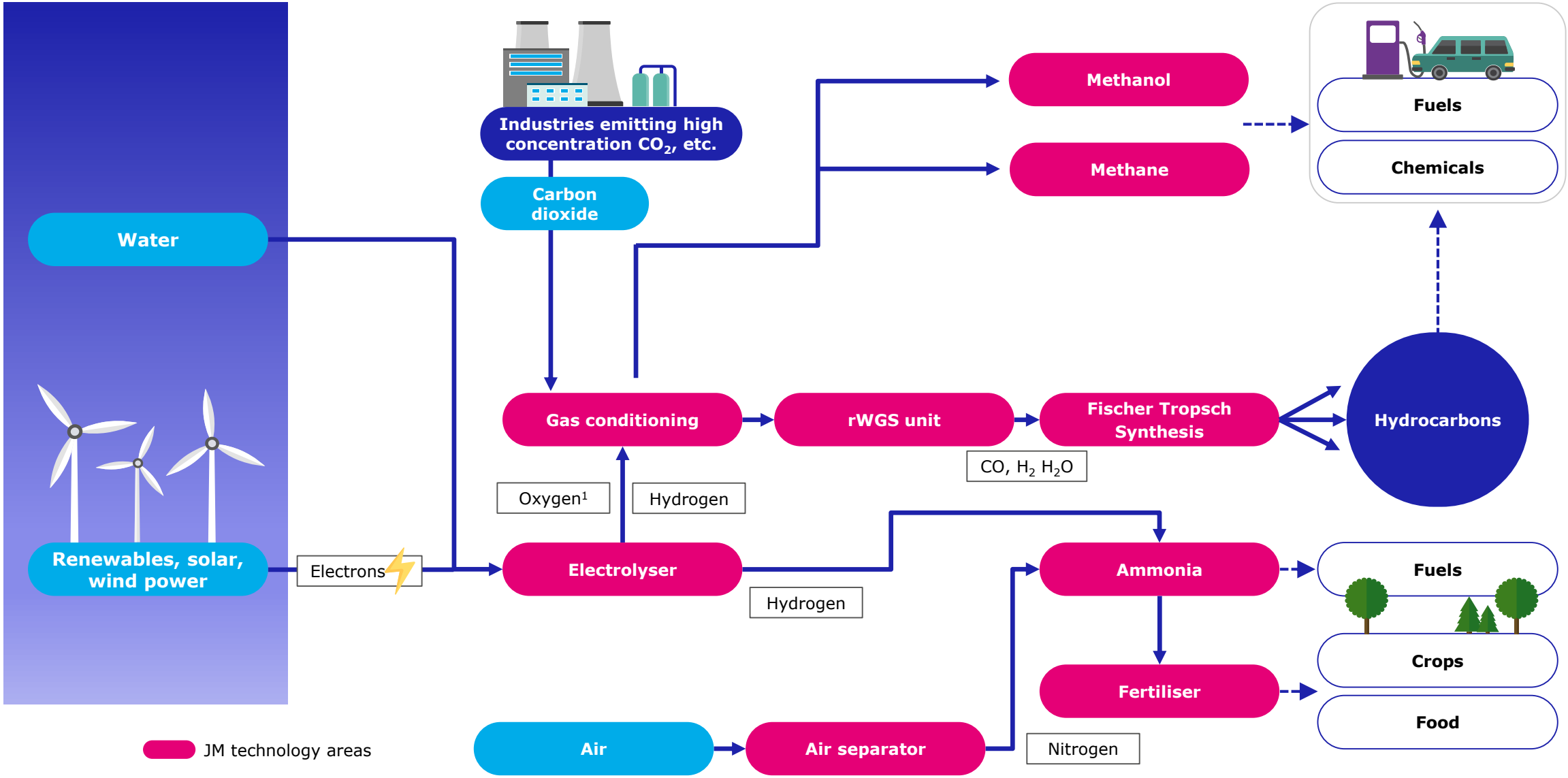
Note: picture courtesy of HyNet.

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

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