



JM

Johnson Matthey
Inspiring science, enhancing life

Johnson Matthey

Working together to build the new hydrogen economy

Strong credentials supporting our strategy and vision for a cleaner and healthier world

Strong brand
**205 year
history**

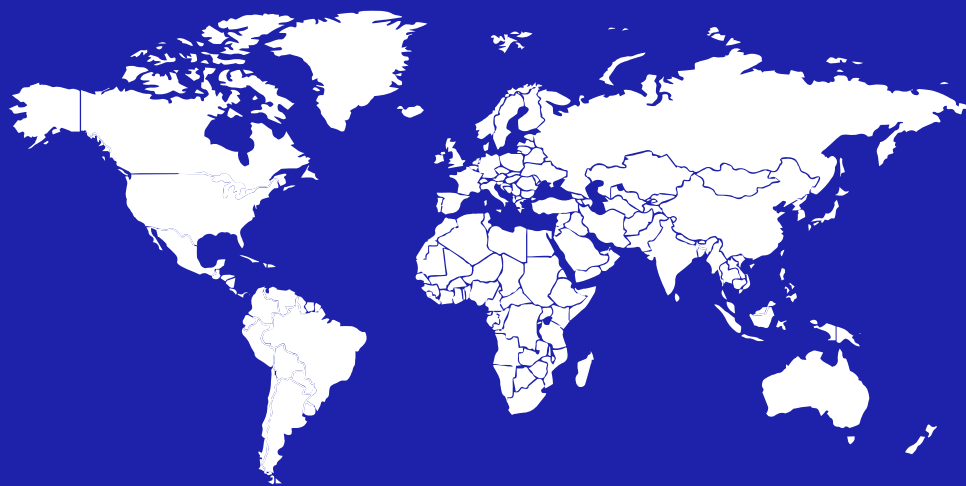
Technology
leadership
#1 or 2
in chosen markets

Sales¹
£3.8 billion
Underlying profit
£553 million

Employees²
13,400
R&D Spend
£201 million



Where we Operate



13,400
employees worldwide

North America

11 major manufacturing facilities
27% of Group sales*
19% of employees

Europe

15 major manufacturing facilities
41% of Group sales*
59% of employees

Rest of World

4 major manufacturing facilities
7% of Group sales*
5% of employees

China

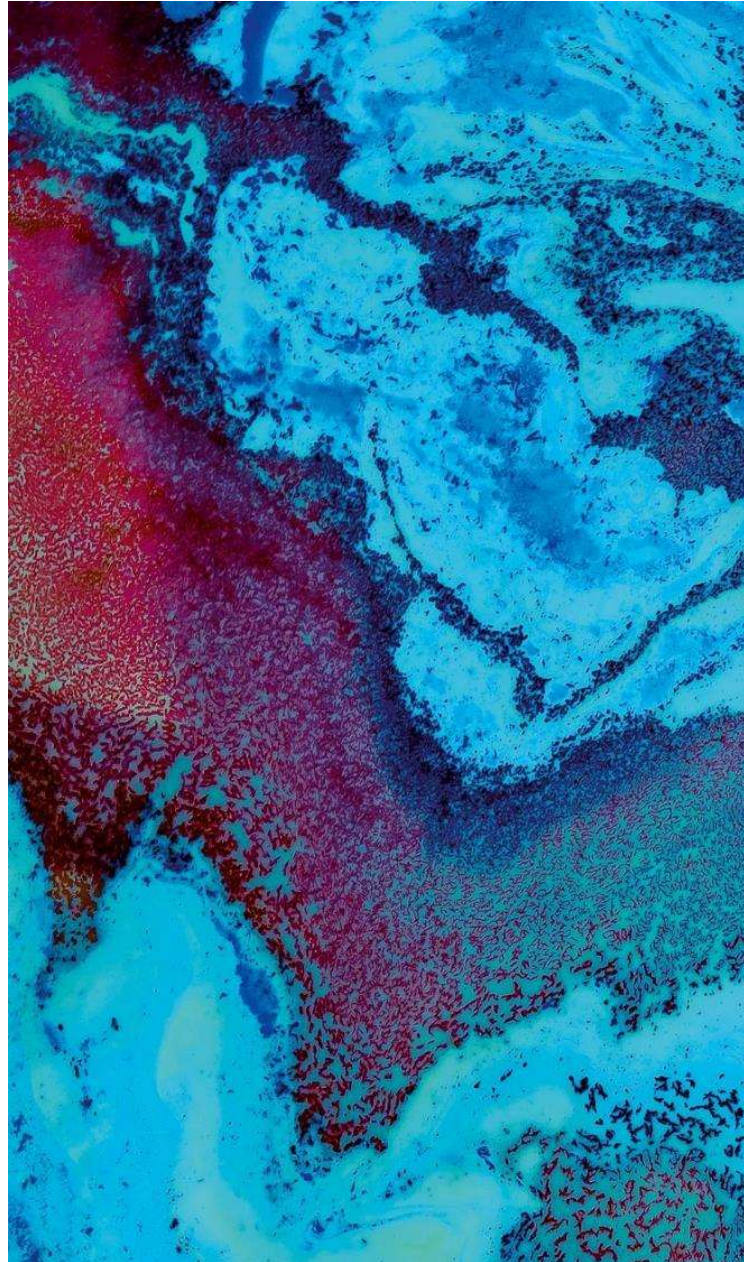
6 major manufacturing facilities
13% of Group sales*
8% of employees

Rest of Asia

4 major manufacturing facilities
9% of employees

Science and metal expertise is at the heart of the group

- Leaders in complex metal chemistry
- Developed over decades; hard to replicate
- Synergies across the group
- Key to many technologies tackling climate change

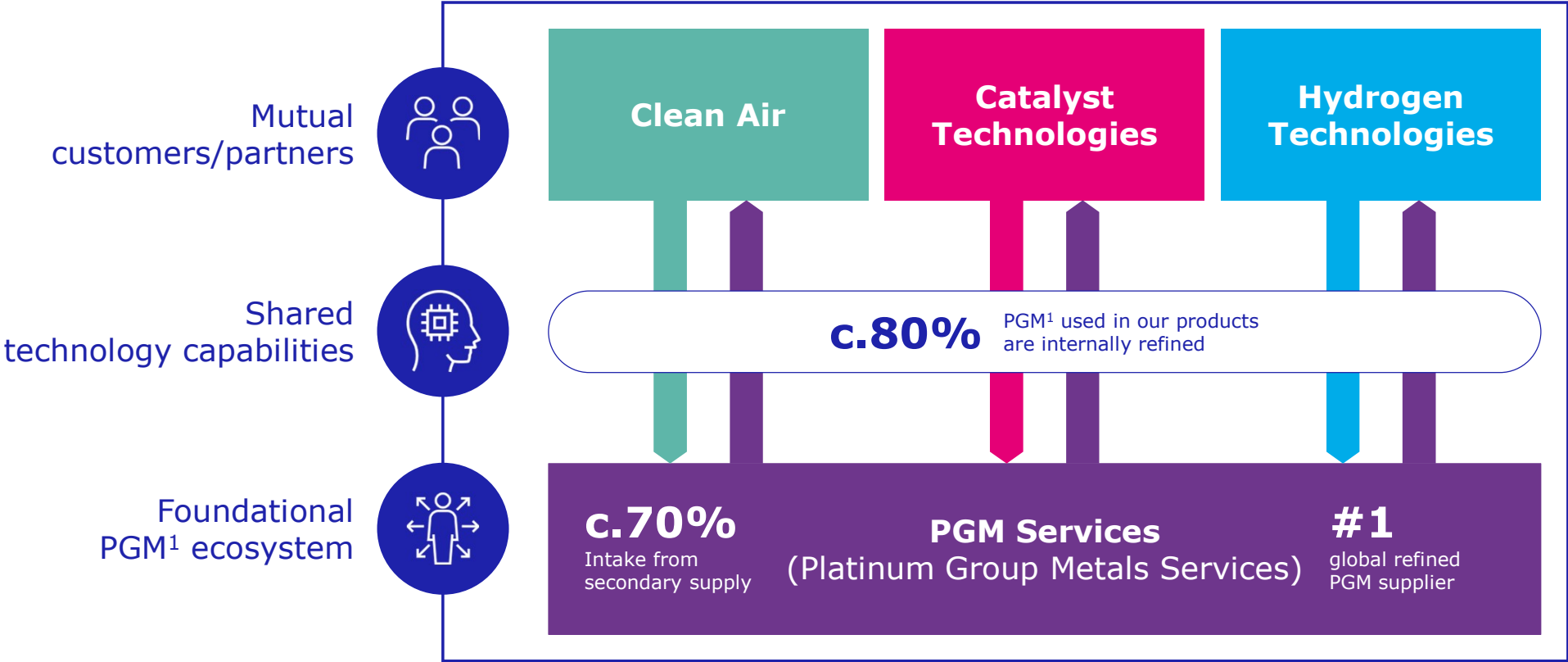
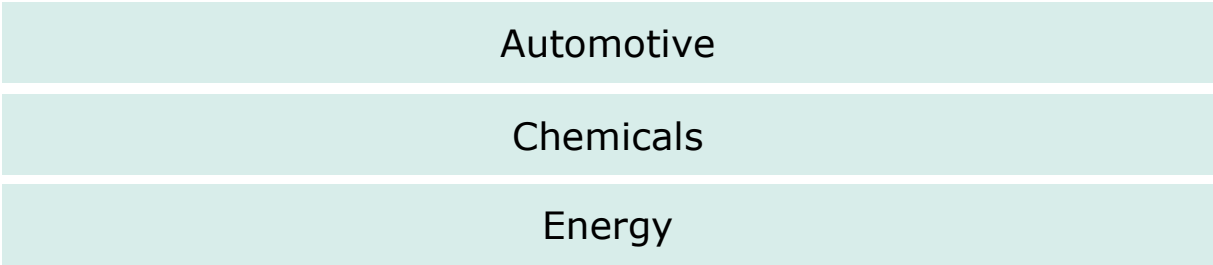


c.£200m
R&D spend (5% sales)

>1,600
R&D employees

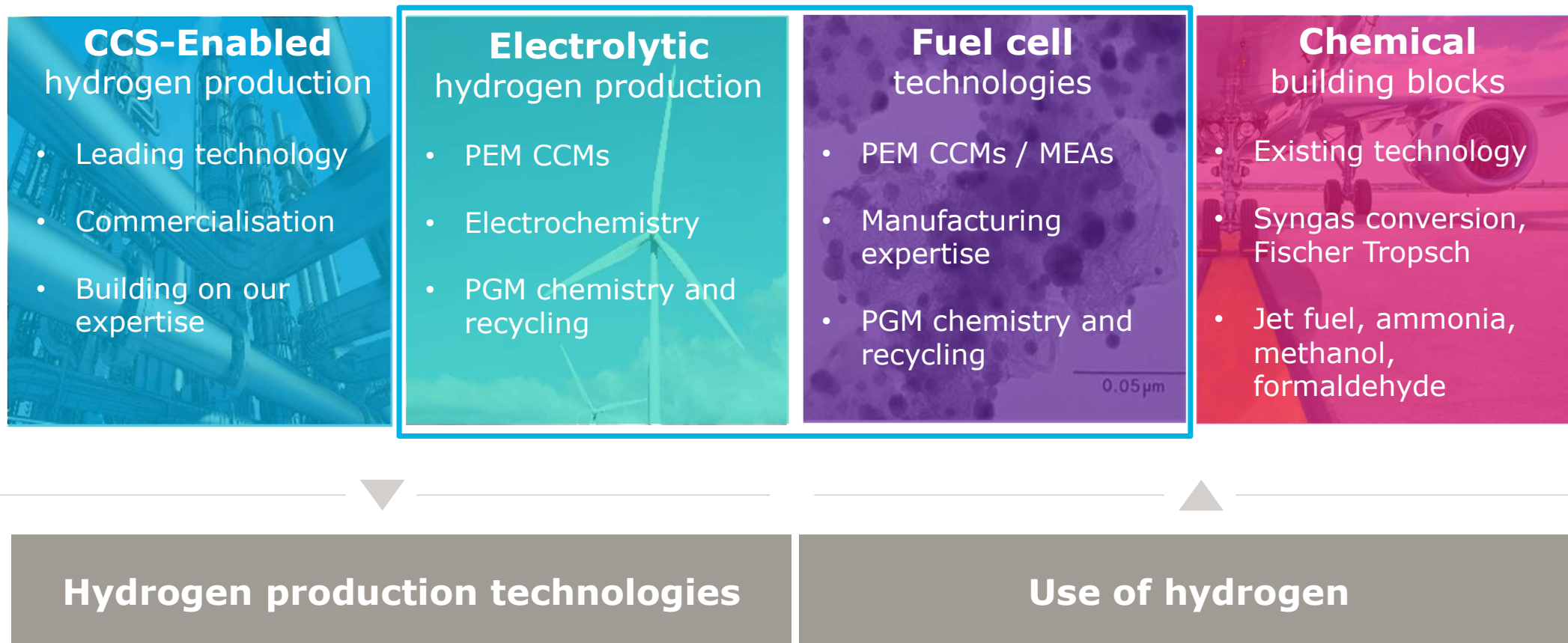
87%
Gross R&D spend
contributing to 4 UN SDGs

Key markets

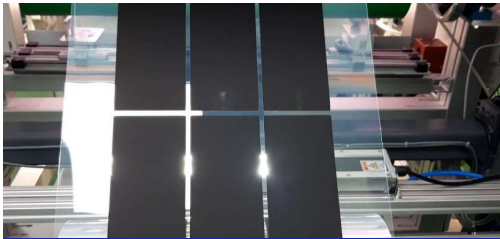


1. Iridium, Palladium, Platinum, Rhodium and Ruthenium.

JM delivers value across all areas of the hydrogen value chain



Enabling the hydrogen transition with cutting-edge science and sustainable technologies



Performance components for fuel cells & electrolysers

- **High-performance catalyst coated membranes (CCM)** and membrane electrode assemblies (MEA)
- Only **backward integrated** supplier
- **R&D programme and roadmap** to deliver next generation performance



Industrialised and secure supply chain

- Existing **2GW production capacity** on the ground delivering product today
- **Investments in future capacity planned** globally in-line with customer demands
- **Integrated supply chain** helping secure key raw materials



Embedding circularity principles

- Significant **sources of secondary PGMs**, reducing the carbon impact of CCMs
- Refining Ir and Pt today and developing **closed loop recycling** systems and technology
- Advanced manufacturing processes that **minimise waste materials**



Underpinned by unique capabilities

- **State of the art in-house testing** capabilities and capacity for single cells and stacks
- Dedicated **technical and programme support** from design and sample, to scale up
- **PGM management, financing** options and global insights

Hydrogen Technologies manufacturing capability

Well positioned with production capacity on the ground and plans to invest



- Opened in 2002 as first ever dedicated CCM and MEA manufacturing facility
- 2GW of CCM production capacity
- Also serves as a competence centre for scaling production capability globally



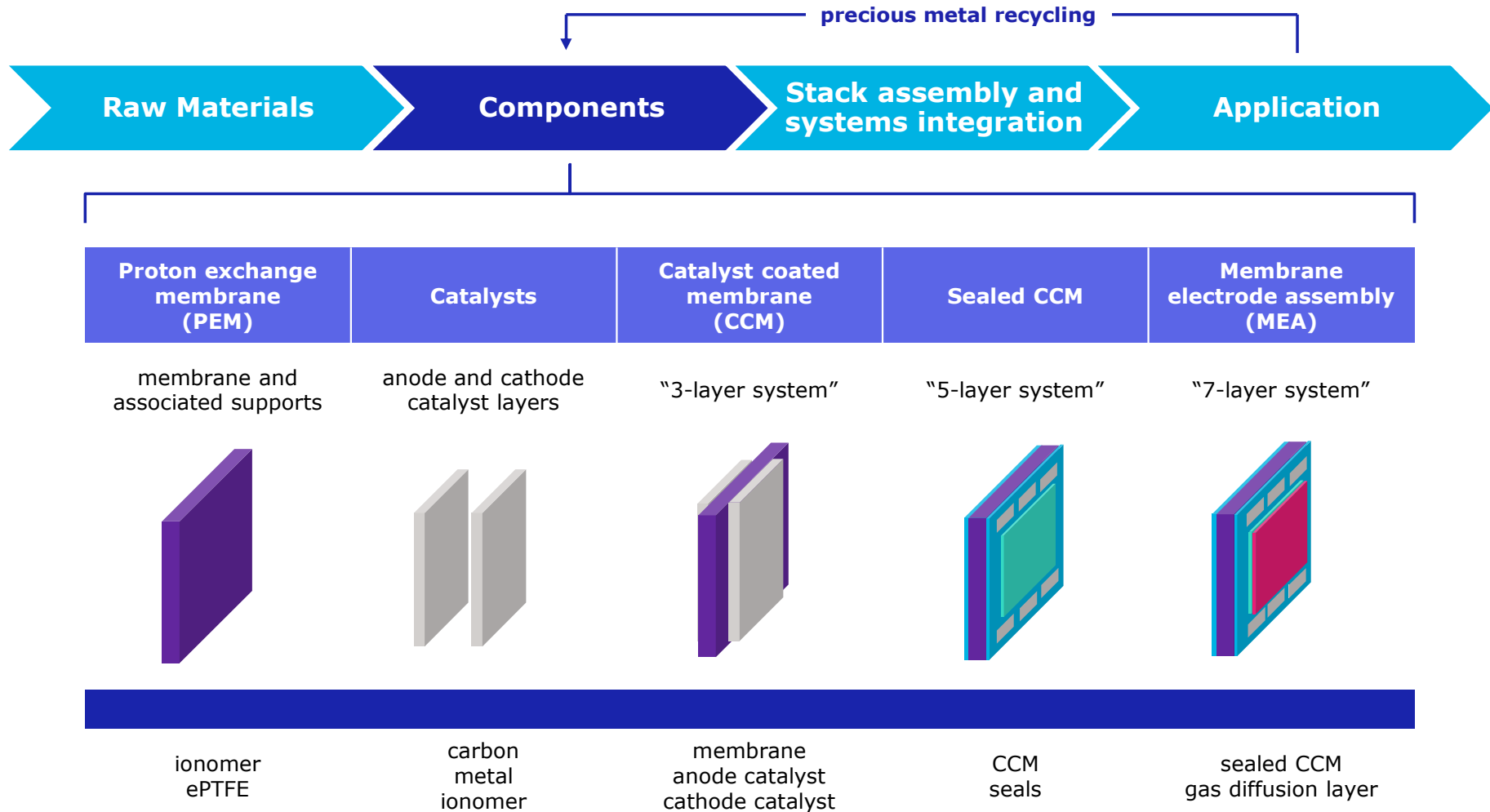
- Opened in January 2021
- Capacity to make 4 million MEA components per year
- Plans to invest in development, testing and production capability in China



- Due to open in H1 2024 at existing JM site
- Capacity to produce 3GW of CCMs annually
- Possibility to triple capacity in future with flexible, modular layout

JM
2GW today
increasing to **5GW**
by 2024

Proton exchange membrane (PEM) fuel cell offer JM experience in electrochemical value chain is comprehensive



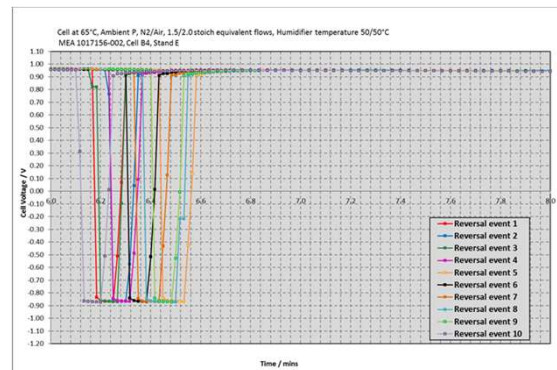
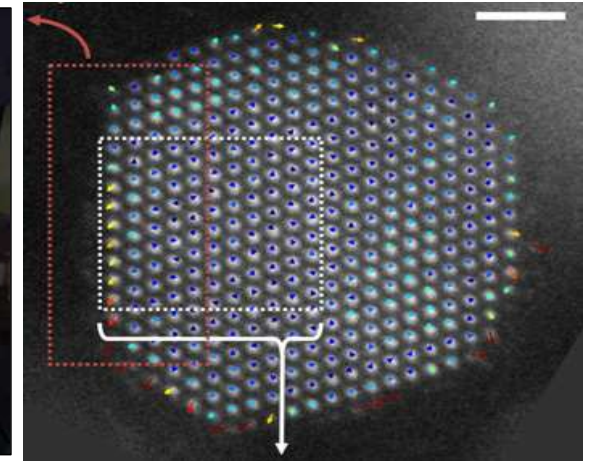
Technology

Improved membranes and interfaces

Improved cathode electrodes

Improved anode electrodes

Advanced manufacturing



Building strong collaborative partnerships for success

Fuel Cell Funded Programmes

**Since
2005**

Participated in **46** programmes

Invested **>£35 million**





Secured **~£17 million** in funding




Supported by **>20 academic institutions**



Collaborated with **>100 partners**

Best **innovation & success stories** 2019, '20 & '22

Recent Partners

Recent Success Stories

VOLUMETRIQ¹


Stack volumetric power density² of 5.4 kW/L


GAIA¹


20% increase in power density to 1.8W/cm² at 0.6V


Announced Customer Partnerships

Fuel Cells













Electrolytic hydrogen







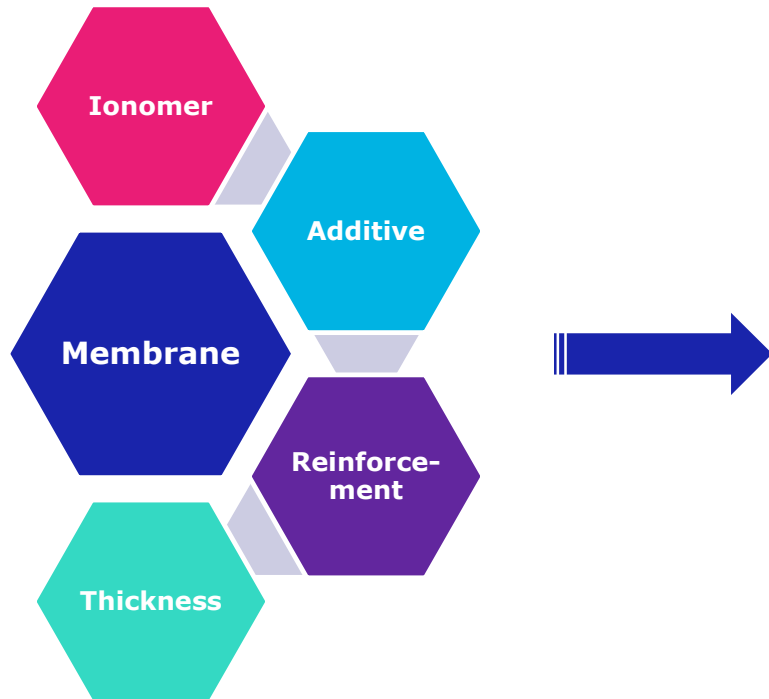


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¹ Passenger car focused fuel cell programmes. ² Stack volumetric power density including end plate. 6.6 kW/L was achieved on the cell block.

Ionomer, reinforcement, and membrane

Manufacture of membranes in-house allows **JM** to tailor membrane by altering **ionomer selection**, **additive levels**, **reinforcement type** and **thickness** to suit certain application use cases

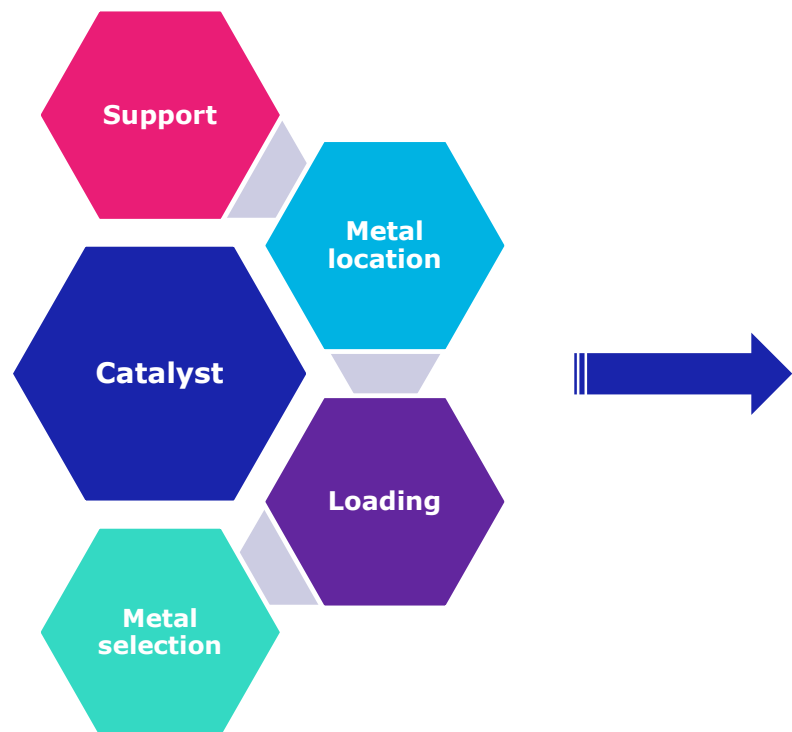


Example from membrane programmes:

	Thickness (μm)	Reinforcement	Chemical Stabilisation
V5+	15	ePTFE	Y
V10i	15	ePTFE	Y
V11	15	ePTFE	Y
V12	15	ePTFE	Y
Alternative Mem	15	Alternative	Y

Catalyst support and catalyst design

JM influences catalyst properties by altering **carbon support**, **location of Pt** and **metal loading** to suit certain application use cases



Example from catalyst programmes:

JM selected a support material with strong ionomer-support interaction, improved corrosion resistance and sufficient pore structure for improved mass transfer.

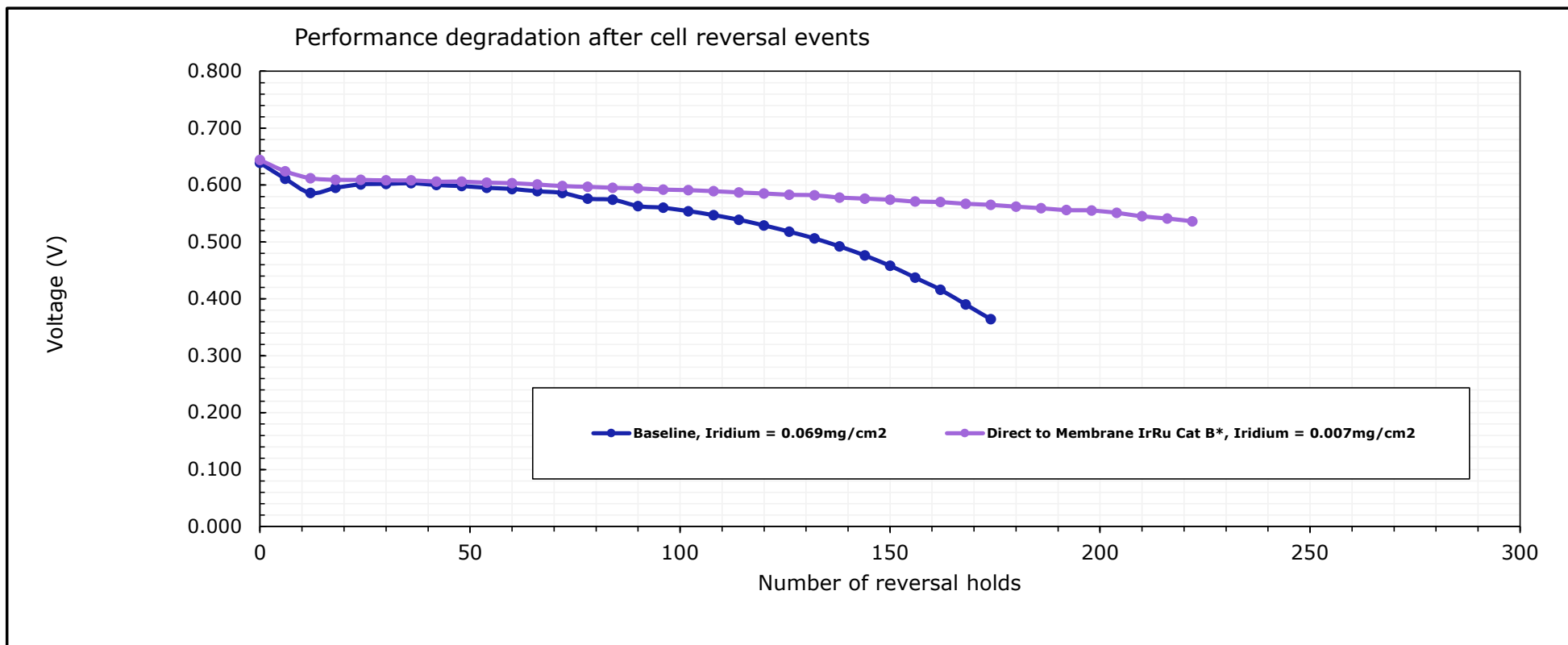
Cathode:

- Automotive Pt/C
- Catalyst support for higher current densities
- Low loaded Pt/Co alloy
- High loaded Pt/Co alloy

Anode:

- CRT (Cell Reversal Tolerant)
- Non-CRT
- CO tolerant

Iridium 90% reduction for FC Cell Reversal Tolerance

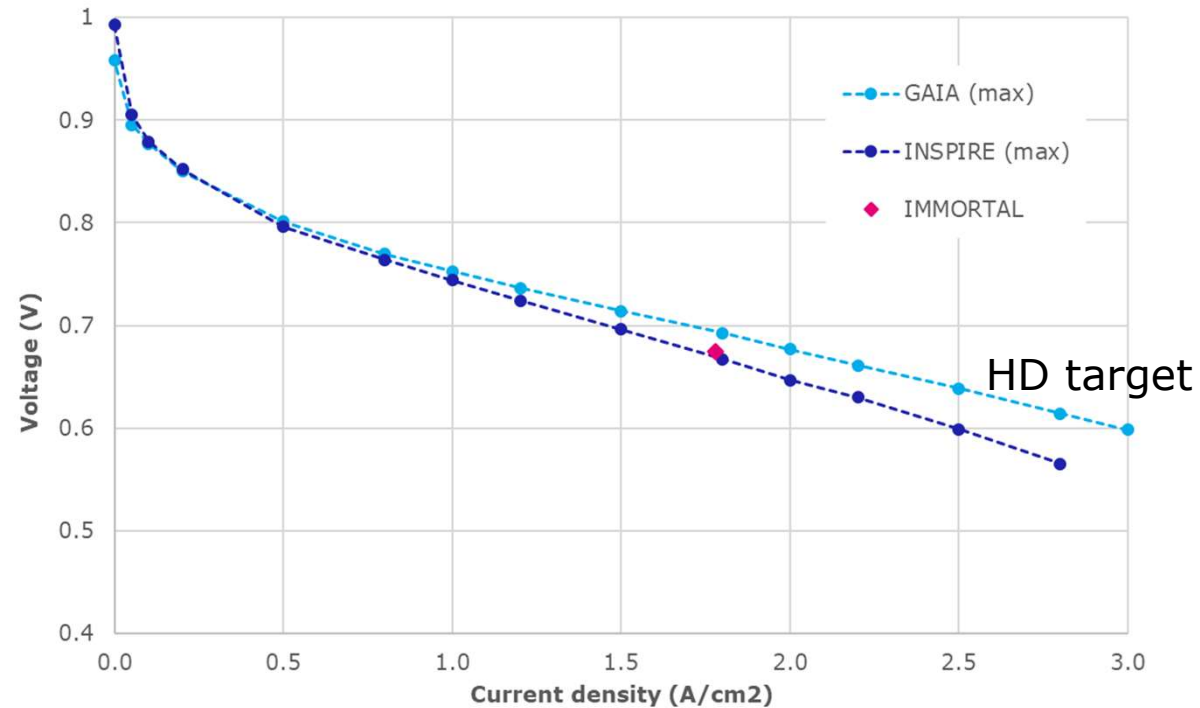


Performance Data



JM components deliver world-leading performance and power density

	Power Density Achieved	Proof Point	Consortium Includes
2019	1.5 W/cm ² @ 0.6 V	INSPIRE	JM, BMW, sgl carbon, DANA
2021	1.8 W/cm ² @ 0.6 V	GAIA	JM, BMW, FREUDENBERG, 3M
Future	> 2.0 W/cm ²	JM will continue to push performance limits to deliver next generation MEAs now and into the future	



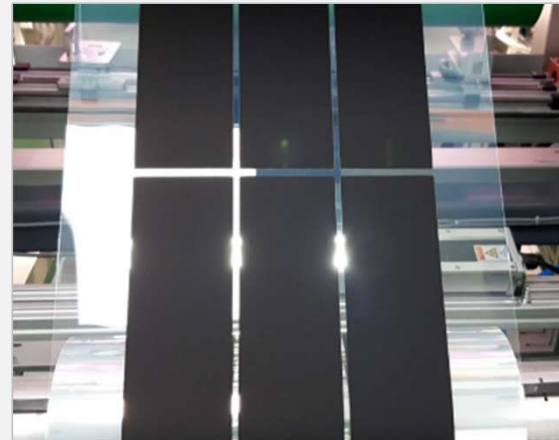
Next generation manufacturing

Increasing green manufacturing capacity and performance of part

Direct-to-membrane

Direct to Membrane coating (DTM) is the next leap forward from decal-transfer

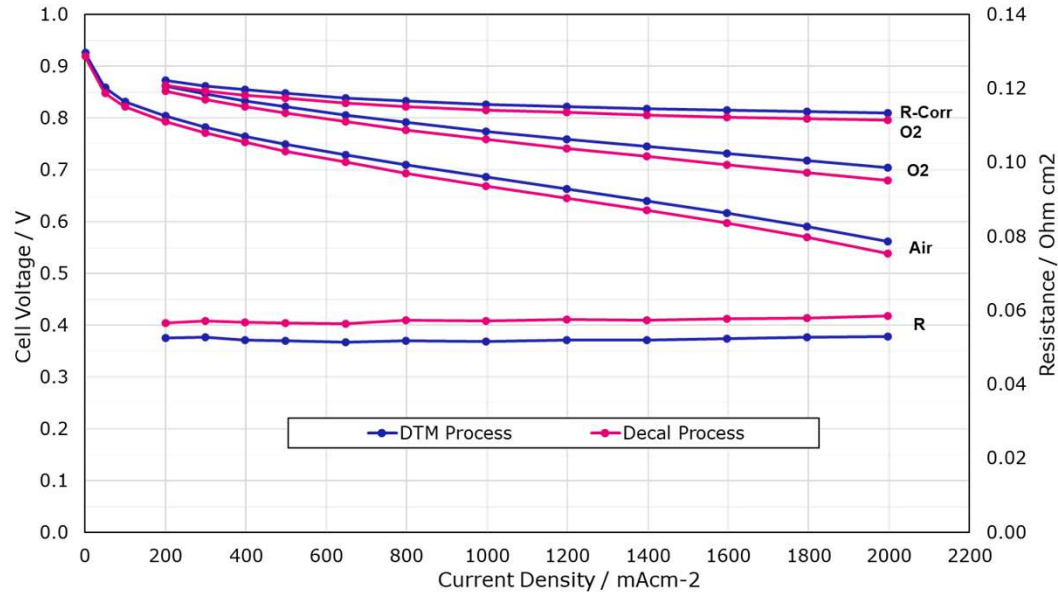
- Improved quality CCM with better interactions between the layers
- More efficient, greener production process



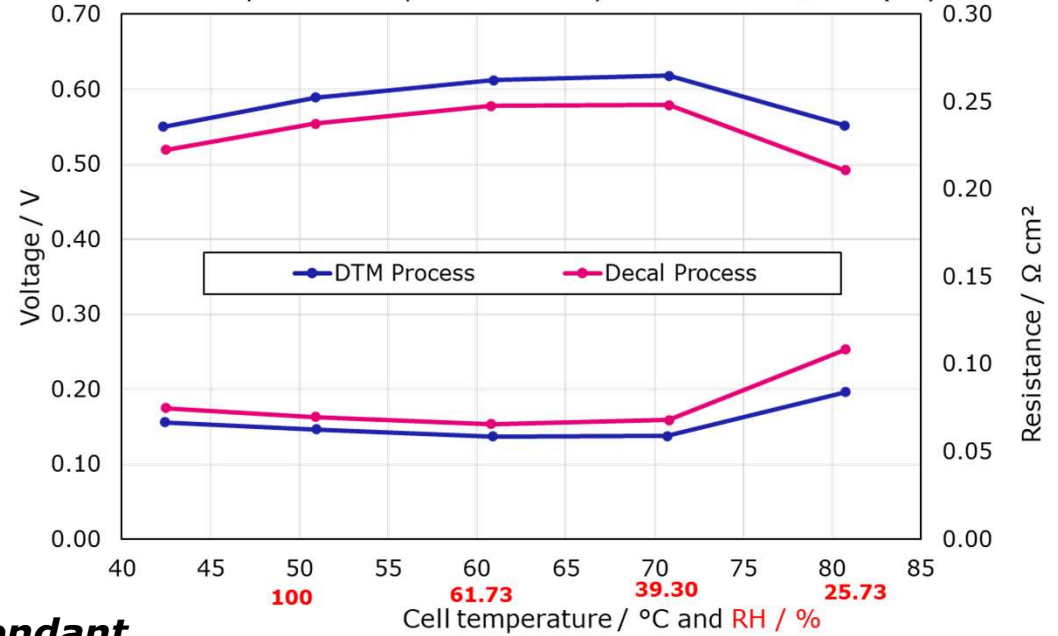
BOL Performance comparison

100kPa, 100%RH, 80C, 2WayOx

Cell at 80°C, Pressure 100/100 kPag, Hydrogen/Air / O2, 1.5/2.0/10 stoich, - membrane, Humidifier temperature 80/80°C



Fixed Dewpoint - Temperature Sweep Chart at 1.2 A/cm² (Air)



***Results are stack and operating conditions dependant**

- Improved performance seen across the polar curve for DTM material with increased kinetics and reduced resistance.
- Humidity sweep shows performance benefits from cold-wet through to hot-dry conditions.

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