



Johnson Matthey
Inspiring science, enhancing life

Power-to-methanol: maximising efficiency with proven technology

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Hydrogen & P2X 2023 Conference, Copenhagen, 14th-15th June 2023

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

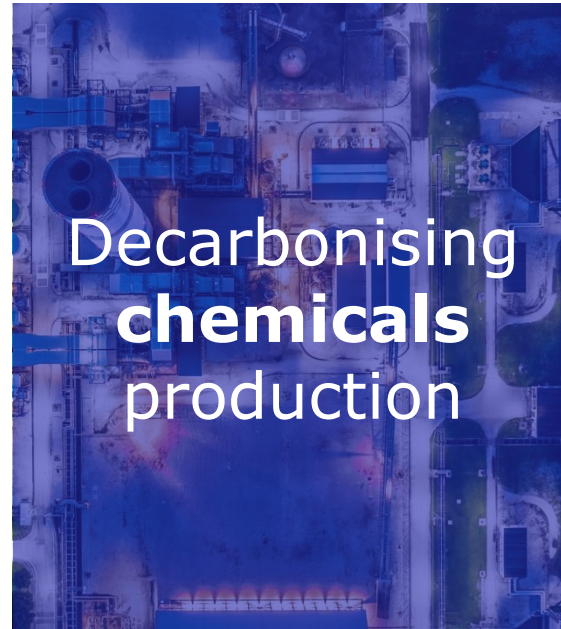
2022/23 sales¹
£4,2 billion

13,400
employees
worldwide²

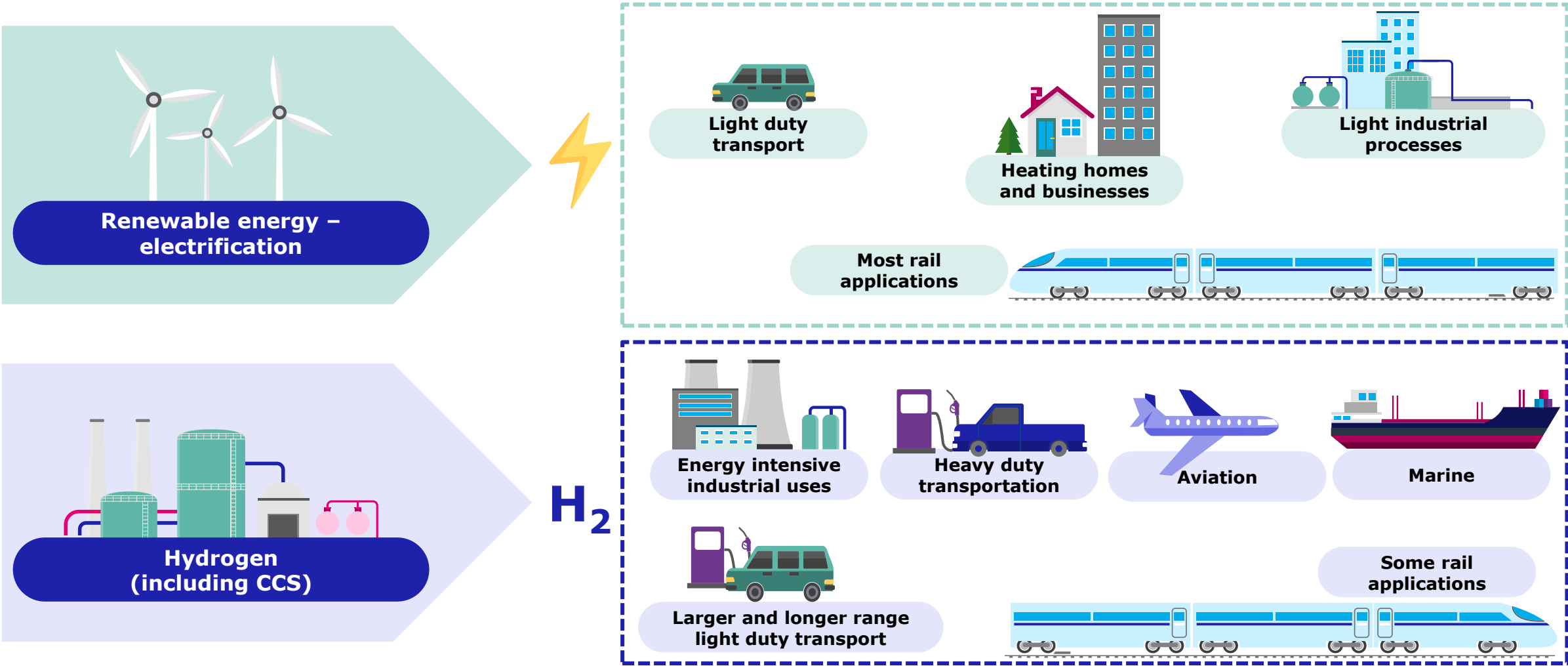


Catalysing the transition to net zero with our customers

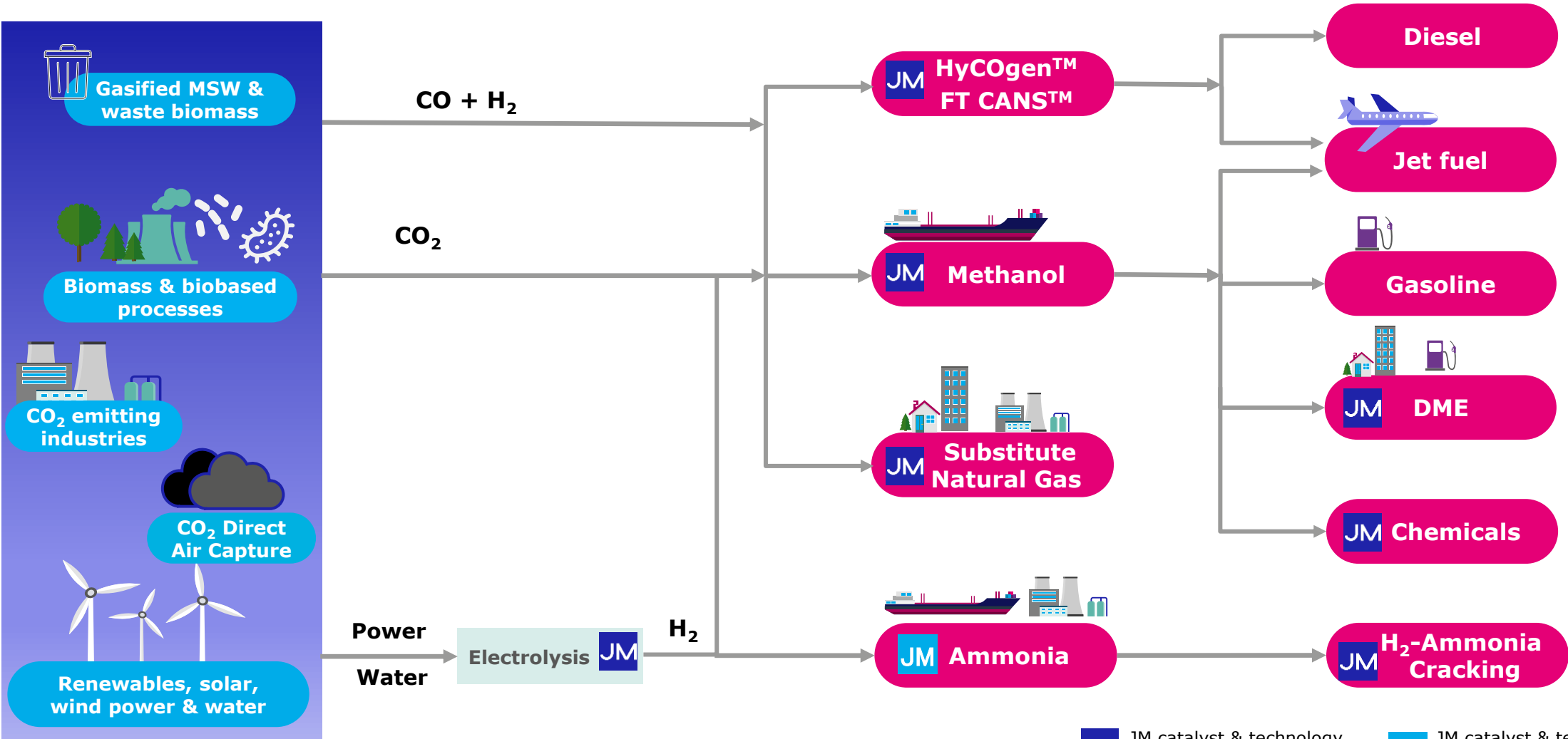
We are making it our business to help address the four essential transitions the world needs for a sustainable future.



Hydrogen is key to reaching “net zero” - Cost effective replacement for fossil fuels, to enable decarbonisation of industry, transport and heat



JM is enabling production of e-fuels for the difficult to decarbonise sectors including aviation, marine and land-based energy systems



Methanol is an attractive low-carbon intensity marine fuel; growing number of renewable methanol projects chases demand for marine markets, SAF and chemicals



High TRL & high safety regulatory maturity

Can be produced from renewable sources

Significantly reduces SO_x, NO_x and PM emissions

Liquid at ambient conditions

Nascent, fast developing market requires partnerships across the value chain to build the wider e-methanol ecosystem and deliver required supply

JM: the world's leading methanol technology and catalyst supplier, spearheading low-carbon methanol technology deployment

- ▶ We are **passionate** about **methanol** and are proud to offer the **most efficient** and **reliable** flowsheets in the market.
- ▶ **1st CO₂ to methanol plant in 2011-**
Leading the transition to **sustainable methanol**
- ▶ We supply the **next-generation** catalysts, with **high activity** and **extended life**
- ▶ We have unique **insights** into the global methanol **market**
- ▶ We maintain strong, **long-standing partnerships** with the world's largest methanol producers

Global commercial licensing & project execution experience



#1

in licensed capacity and installed catalyst

100+

licenses in

35

countries

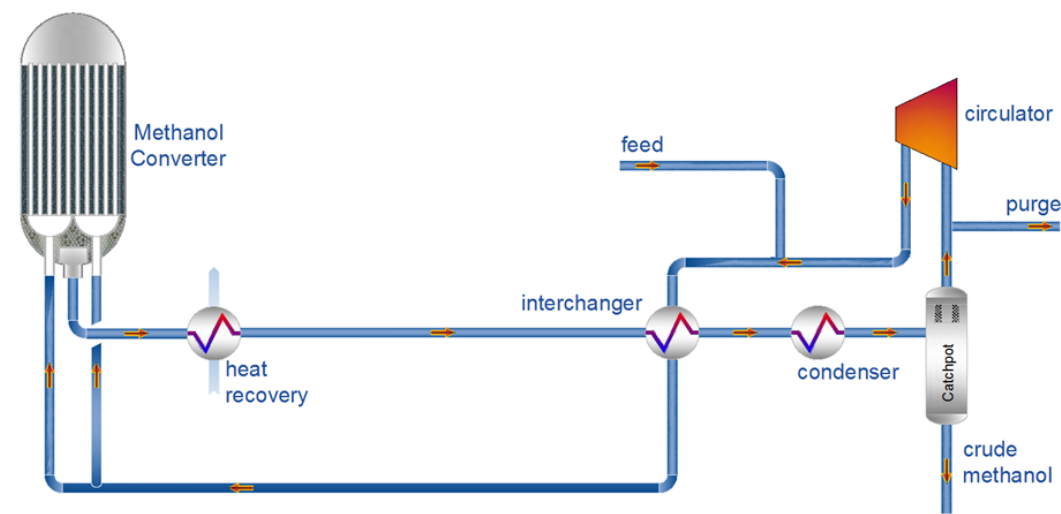
60M

t/y licensed methanol production

JM's CO₂ to methanol: commercially proven, low risk and offering high H₂ efficiency to support a strong business case

METHANOL SYNTHESIS LOOP

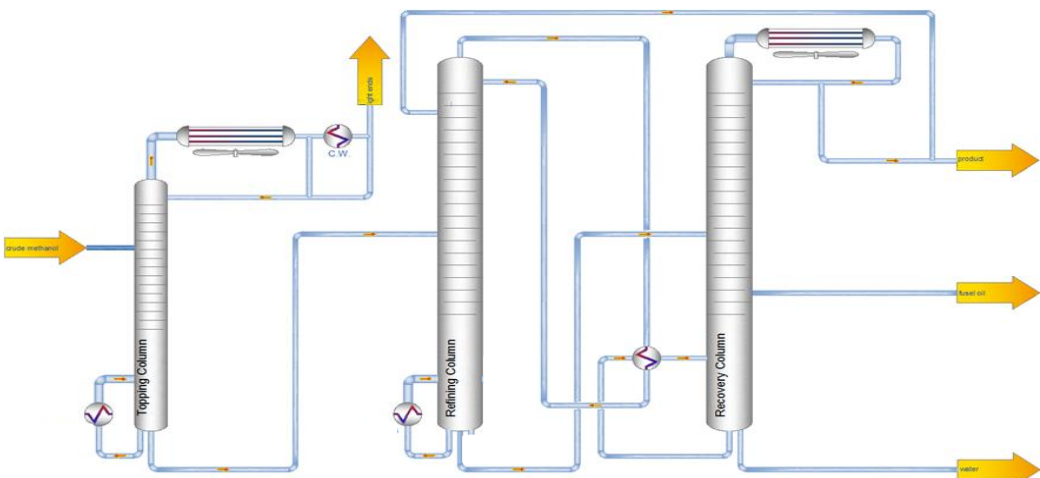
- Converter and loop design tailored for CO₂ to methanol plants, ensuring high feedstock efficiency



INDICATIVE PERFORMANCE ¹	Value
Hydrogen loop efficiency	~99%
Carbon loop efficiency	~99%
Electric Power	~450 kWh/te
Cooling water	~140 te/te

METHANOL DISTILLATION

- Adapted to suit end-product and customer requirements
- Optimising capex and opex of the process

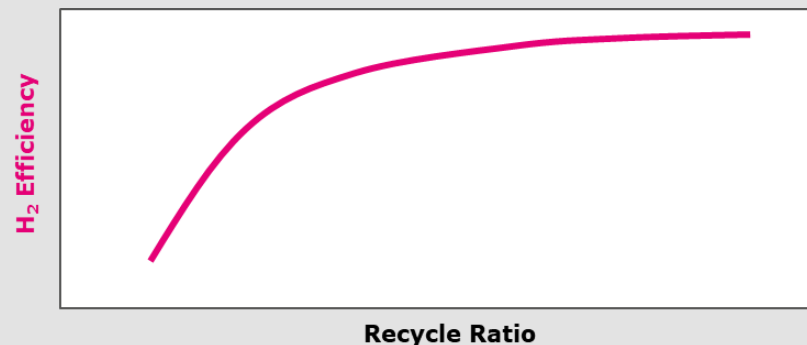


	US Federal AA	"MTG-grade"	
	3 Columns	1 Column	3 Columns
Heat import	1	1.4	0.02
Equipment Cost	1	0.4	0.9

Converter and loop design tailored for CO₂ to methanol plants, ensuring high feedstock efficiency

DESIGN CONSIDERATIONS

- ▶ Lower heat of reaction:
- ▶ Optimisation focus for e-methanol plants critically lies on maximising H₂ (and CO₂) conversion into product methanol
- ▶ Larger catalyst volumes
- ▶ Circulation ratio is the most important control parameter for high feedstock efficiency



High recycle ratios

Low pressure drop

Heat removal

Flow

Catalyst Position

Methanol capacity

Comments

Tube Cooled Converter

Most suited



Gas cooled converter

Axial

Shell-side

3 up to ~2500TPD
(single converter)

Simplicity,
robustness,
operational flexibility

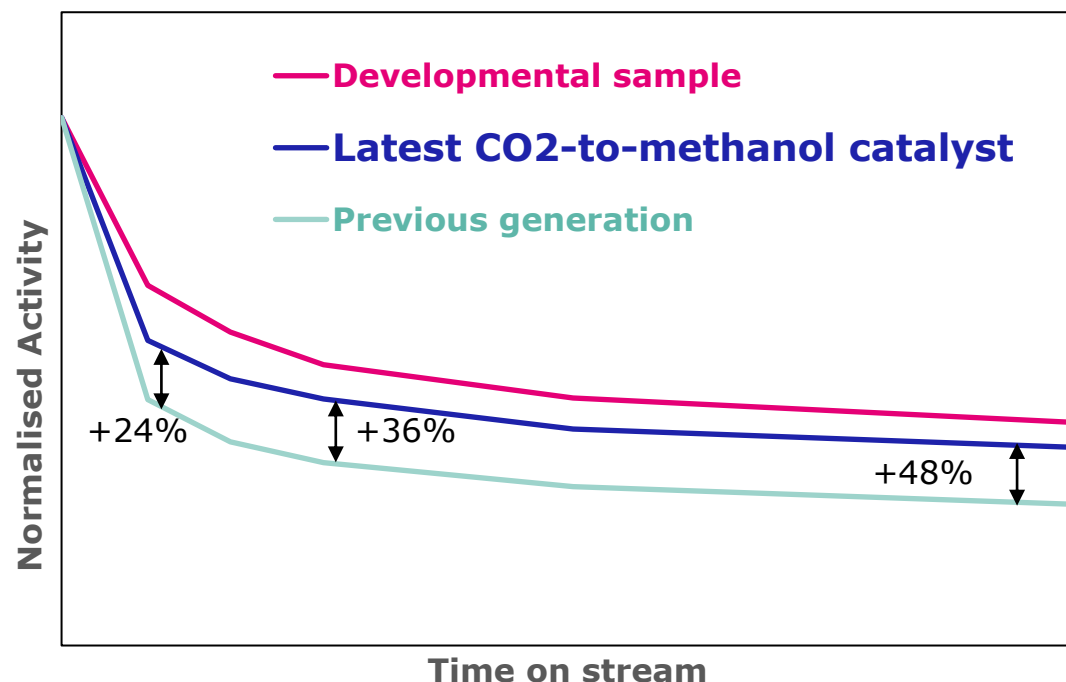
Proven technology- low risk, supporting project bankability

- Developed in the 1980s
- TCC converters have been selected for **multiple plants**
- **Proven scalability** with references at a wide range of scales
- Largest TCC-based loop in operation: 3600 TPD

Capacity	Start-Up
5,000 MTPD	Est 2023
3 MTPD	2022
2,030 MTPD	2014
2,030 MTPD	2013
3,600 MTPD	2011
10 MTPD	2010
1,650 MTPD	1998
1,650 MTPD	1996
165 MTPD	1994
1,500 MTPD	1993
200 STPD	1992

Highly stable JM catalyst achieves high methanol productivity over a significantly longer lifetime

JM's latest commercially available catalyst offers sustained methanol production



- **Unique composition offering enhanced hydrothermal stability**
- **4 years typical catalyst lifetimes**
- **Continuous investment in R&D targets even longer life times and sustained high MeOH make**
- **Existing manufacturing assets and proven supply chain**

Haru Oni e-fuels demonstration project

Project details		Purpose	JM role
Pilot Phase:	2022	Demonstrate technology for world's first large-scale commercial plant producing climate neutral methanol and gasoline from green hydrogen and CO ₂ recovered by direct air capture	The project is being developed by Siemens Energy in partnership with JM and other major corporations including Porsche and MAN JM has licensed methanol technology and supplied the engineering, catalyst and equipment for the project
Technology:	JM licensed methanol technology		
Product:	Sustainable fuels (methanol and gasoline)		
Uses:	Transportation fuel		

900,000 litres of sustainable methanol produced per year as early as 2022, growing by 2024 to 55 million litres of sustainable fuels and by 2026 to... **c.550 million litres**

HIF Global initiates engineering for U.S. Sustainable Aviation Fuel facility, selects Johnson Matthey technology

Project details

Engineering Phase: 2023

Technology: JM CO₂-to-methanol technology;
Honeywell UOP eFinishing™ technology

Product: eSAF-Sustainable Aviation Fuel

Purpose

Preliminary engineering for HIF's first Sustainable Aviation Fuel (SAF) facility in the United States.

eSAF is made by combining recycled carbon dioxide (CO₂) with hydrogen produced using renewable electricity.

eSAF can be dropped-in to existing jet engines without any modifications required.

JM role

Johnson Matthey's technology will use renewable (green) hydrogen and recycled CO₂ to produce eMethanol which can be used in the shipping and chemical industries or upgraded into other eFuels including eSAF.

HIF intends to produce ~11,000 barrels per day of eSAF by 2030, decarbonizing ~12 billion air passenger miles per year in its second U.S. facility

Key takeaways

01

JM: the world's leading methanol technology and catalyst supplier

02

Tailored solution for e-methanol feedstock efficiency, low technology risk,

03

Proven, scalable technology deployed in pioneering projects

04

Highly stable JM catalyst for high methanol productivity over a longer lifetime

JM is a recognised leader in the syngas value chain and a key partner for successful Power-to-methanol project development



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