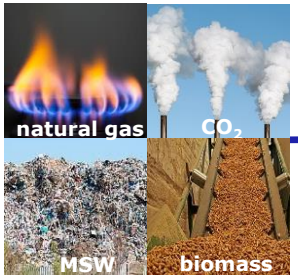
Johnson Matthey
Inspiring science, enhancing life

Johnson Matthey and bp:
FT **CANS™** Technology – Enabling Waste to Jet Fuels

Global Syngas Technologies Council 2020 Conference 27Oct20

Overall XTL Flowsheet



tails gas recycle

syngas generation (reforming/rWGS/ gasification)

purified syngas

Fischer-Tropsch synthesis

crude FT products

wax LHC

product upgrading (hydro-processing/fractionation)

naphtha diesel kerosene

n-Paraffins

CO

H_2

H_2O

Cobalt

Support

hydrogen

offsites and utilities (including ASU)

BP/JM licence

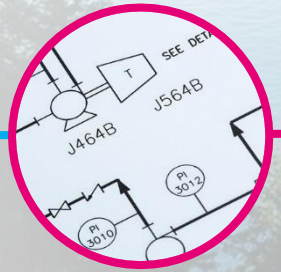
- For natural gas / CO2 feedstocks JM also provides the syngas generation technology and catalysts
- For MSW, biomass and coal feedstocks, JM can provide the secondary gas clean-up

JM

History of JM / bp development in FT

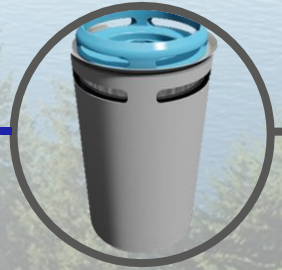
1980 | 1990 | 2000 | 2010 | 2020

BP initiated FT R&D programme



Established technology co-operation with JM

Nikiski demonstration plant operation



Development & launch of FT CANS technology

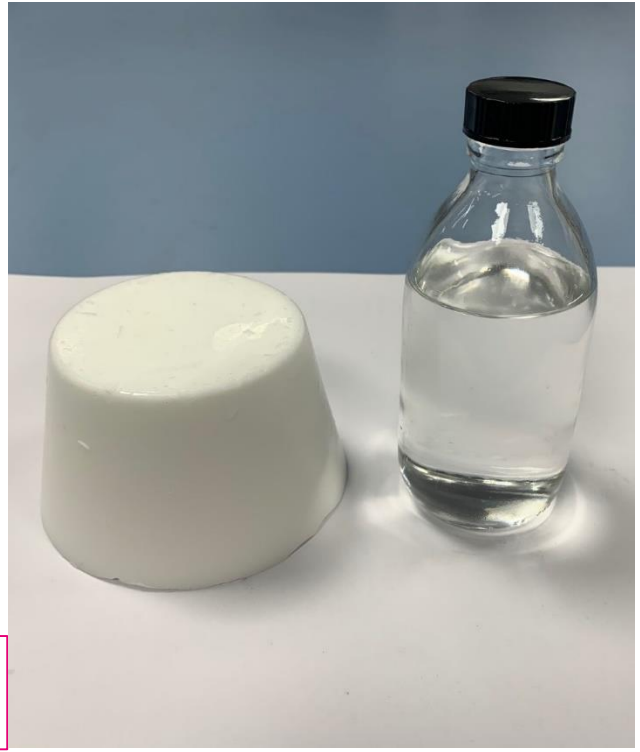
First commercial licence signed with Fulcrum

JM

Benefits of Fixed-Bed FT Technology

Benefits confirmed by JM/bp at Nikiski Demonstration Unit

No Catalyst Movement	• No catalyst loss in product • Benign environment
Simple Design	• Easy to operate • Minimal scale up risk
Developments easy to incorporate	• Demonstrate on single tube
Modular	• Increase capacity by adding tubes
Well proven technology	• Many manufacturers of equipment • Not proprietary supply
Attractive product slate	• High S-F alpha • Maximise middle distillate production after product upgrading (hydroprocessing /fractionation)



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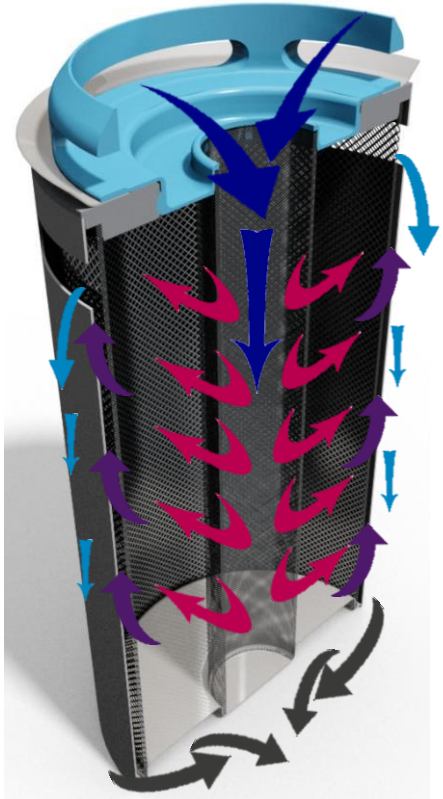
Benefits of FT **CANS** technology compared to conventional Fixed-Bed FT Technology

Increased Productivity	• 3 fold increase in production for same size reactor
Easier to Manufacture Reactor	• Larger tubes, low weight • Tube numbers reduced by 95%
Large Cost Savings	• FT Unit cost reduced by ~50%
Improved Catalyst Performance	• Volumes reduced by >50% • 3 years life without regen. expected
No catalyst handling in life cycle	• Prefilled in factory • Spent catalyst returned in **CANS** carriers for metals recovery
Improved Efficiency	• >90% overall CO conversion in single stage recycle loop which can operate with >50% inerts



JM

bp 2030 aims – low carbon electricity and energy

Low carbon electricity

- **50**GW developed renewables
- **Position** across generation and customers
- **500**TWh traded[1]

Integrated gas

- **25**Mtpa customer sales
- **>30**Mtpa LNG portfolio

Hydrogen and CCUS

- **10**% hydrogen share in core markets
- Net Zero Teesside

Bioenergy

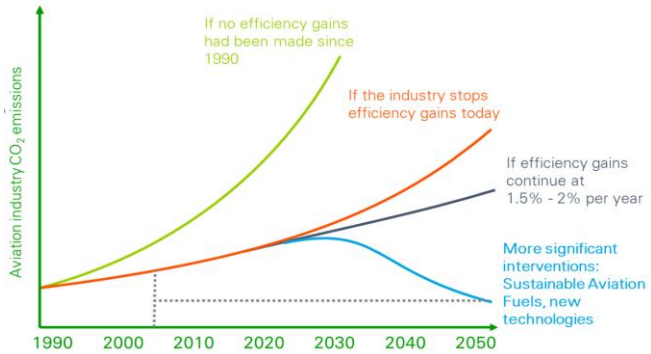
- **>100**Kbd produced and integrated across value chain
- **20**% biojet market share
- **Cost advantaged** platforms across Brazil

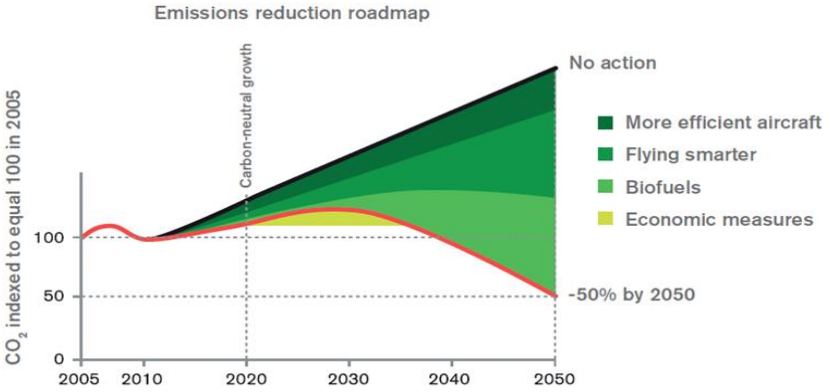
Integrated low carbon portfolio

(1) *Traded electricity may include electricity sourced from the grid*

Long-term aviation industry goals

50% reduction in CO2 by 2050





Source: International Energy Agency (IEA)

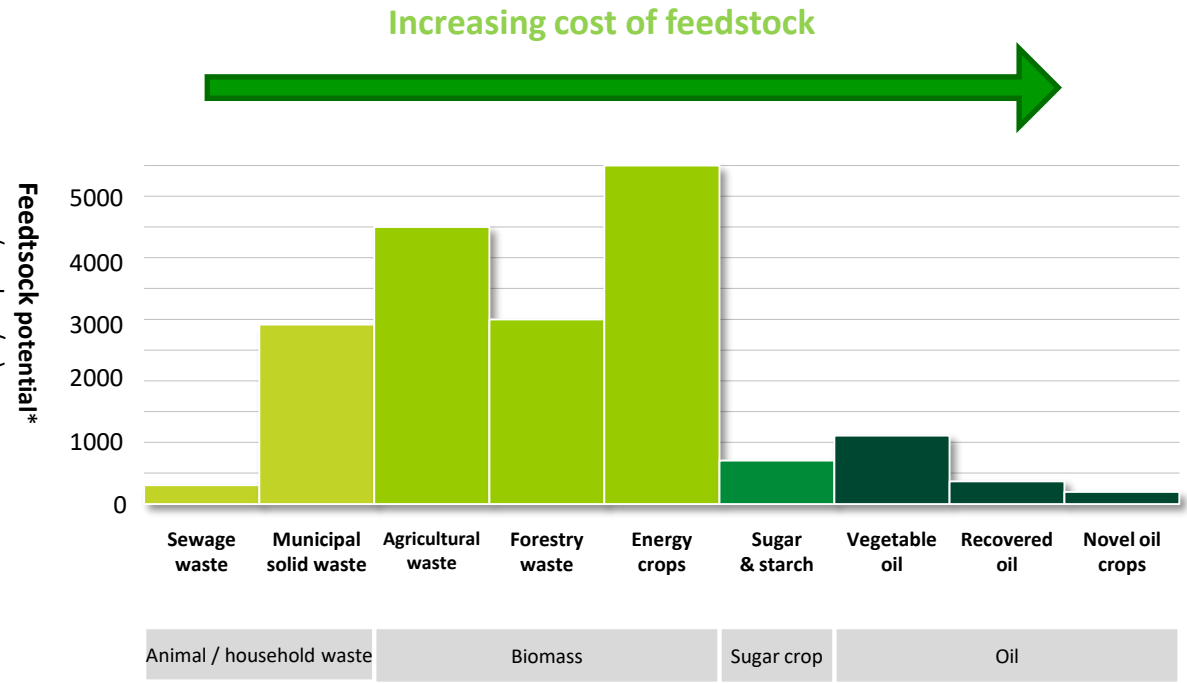
- The aviation industry and IATA have committed to halving aviation emissions by 2050 compared to 2005 levels and carbon neutral growth from 2020
- Achieving this requires a concerted effort across all aspects of the industry
- Biofuels are a critical component of aviation decarbonization strategy and the industry is expecting them to deliver 30-40% of the 2050 emissions reduction target

What is sustainable aviation fuel?

- A jet fuel produced from sustainable, renewable feedstocks
- It must be blended with regular jet fuel before use in aircraft
- Once blended, it is identical to regular jet fuel, and fully approved for use
- Using sustainable aviation fuel results in a reduction of CO_2 emissions compared to fossil jet fuel over the lifecycle of the fuel
- Some typical feedstocks used are
  - Used cooking oil and other waste oils
  - Solid waste from home and businesses that would otherwise go to landfill or incineration

Why municipal solid waste to biojet?

- Feedstock volume match with product demand
- Municipal solid waste, MSW, is the lowest cost feedstock available at suitable scale
- Feedstock is not suitable for re-use/recycling
- MSW is gasified to syngas
- Purified syngas is converted to wax using FT technology
- Wax product is upgraded by hydrocracking/isomerization to sustainable fuels



* IRENA estimates of potential biomass supply

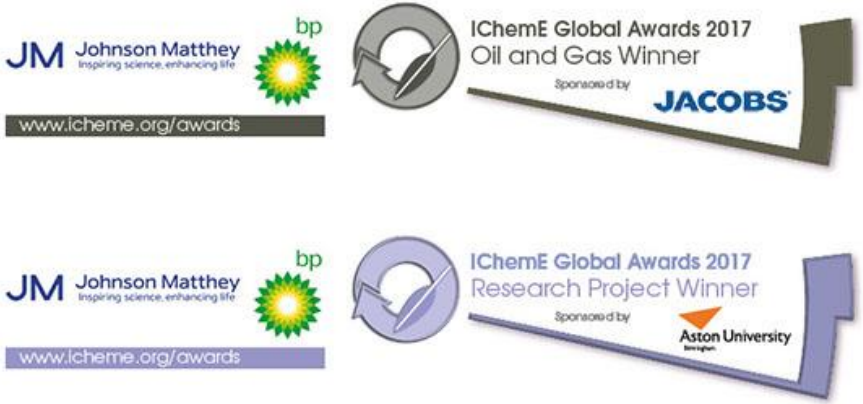
Waste to biojet commercial production

- BP Ventures investment in Fulcrum Bioenergy
- First commercial-scale plant in Sierra, Nevada, US under construction
- It will convert ca. 175,000 tons of municipal solid waste feedstock that would otherwise be landfilled, into a low-carbon, renewable transportation fuel
- First plant designed to produce ca. 11 million gallons of sustainable fuel each year
- BP/JM FT CANS™ technology was selected by Fulcrum Bioenergy for its first commercial-scale waste to sustainable fuels facility

Fulcrum Sierra feedstock processing facility [courtesy Fulcrum Bioenergy]

Fulcrum Sierra Biofuels Biorefinery [courtesy Fulcrum Bioenergy]

Awards and Acknowledgements



Rushlight Awards Winner 2019/20

Winner – Bioenergy Award

Rushlight Awards Winner 2019/20

Winner – Clean Energy Award

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Contact details:
Paul Ticehurst
Senior Business Development Manager
paul.ticehurst@matthey.com