Innovation objectives for decarbonising UK transport: near term targets for sustainable fuels and key projects

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What is Sustainable Fuel?

Avoid Land Use Change

Does Not Displace or Compete with Food Production

Use Greener Sources of Energy

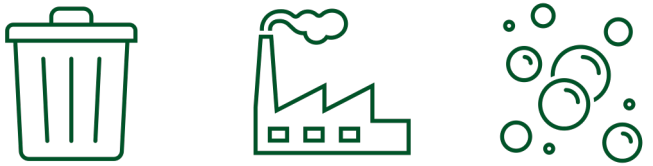
Conservative Water Use

Minimal impact on biodiversity

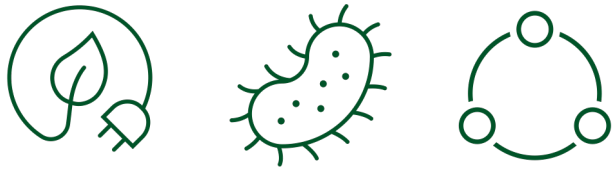
Avoid Pollution

A sustainable fuel is made…

…from waste



…from clean processes



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Which Sectors are most suitable for sustainable fuels?

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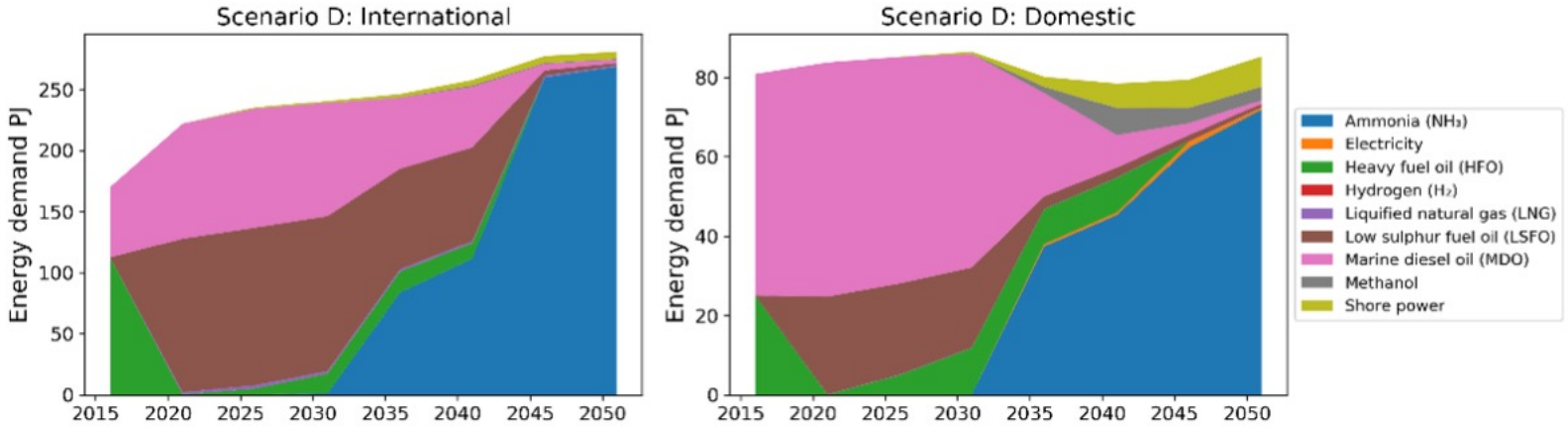
Liquid fuel options for maritime

Fuel	Pros	Cons	Outlook
Liquified Natural Gas (LNG)	• Energy density 18% higher than HFO • Infrastructure available and growing • Low Sulphur emissions • “Cleanest” fossil fuel • Mature technology • Regulatory route established	• Volumetric density only 43% of HFO • Slippage (unburnt fuel) • Natural gas prices unstable • Requires carbon capture to be considered low/zero carbon	*Limited CO_2 reduction but maturity of technology higher than other alternative fuel options*
Biofuels	• Mature technology • Drop in technology (HVO) • Could be blended	• Questions over feedstock origin and environmental impact • Scalability • Competition for feedstock	*Little to no modification is needed to adopt HVO (100% FAME unlikely).* *Concerns over feedstock and scalability*
Hydrogen	• Can be combusted directly or in fuel cells • Energy density 3 times higher than HFO • Carbon free combustion	• Volumetric density only 7% of HFO • Leakage • Current production mainly via fossil fuels • Storage requires cryogenics or very high pressure	*Requires huge increase in production which must be ”Green”. Hydrogen essential for other fuel pathways*
Ammonia	• Can potentially use existing infrastructure • Haber-Bosch process well established • Scalable production	• Highly toxic and corrosive • Current production from fossil fuels • Production of green ammonia limited by hydrogen availability	*Ammonia production and distribution is an established worldwide. Availability of hydrogen is key to further scale up*
Methanol	• Can be stored as a liquid • Existing supply chain and storage in ports • Storage under standard conditions • Maersk ordered 13 methanol vessels to date	• Current production from fossil fuels • Lower energy density • Worldwide production would need significant ramping up • Regulation still under development • Requires carbon capture to be Net Zero	*Industry giants backing methanol as a fuel however, it still requires carbon capture*

Taken from: Innovate UK Transport Vision 2050, 2021

Liquid fuel options for maritime



Taken from: DfT Commissioned research on scenario analysis for emission reduction technology 2019

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Liquid fuel options for maritime

Transport modes	Elements	2021 position	By 2025	By 2030	By 2040	By 2050
Maritime	International	Marine diesel & heavy fuel oil (HFO) [11]	BEV for short journeys only	All new ships to be ZE capable		
			TRL3-7 hydrogen & ammonia projects [4]	Wind, biofuel, electro-fuel and H2 demonstrators [6]	Large shift in take up of ZE energy sources from 2030s [5] [15]	All zero emission [3]
	Domestic			40% marine diesel [34]	18% marine diesel [34]	1% marine diesel [34]
	Fuel mix [15]	52% marine diesel [15]	52% Marine diesel [15]	47% low sulphur and heavy fuel oil [15]	33% low sulphur and heavy fuel oil [34]	0% low sulphur and heavy fuel oil [34]
		48% heavy & low sulphur fuel oil [15]	48% low sulphur and heavy fuel oil [15]	4% methanol [34]	10% methanol [34]	26% methanol [34]
				3% shore power [34]	5% shore power [34]	6% shore power [34]
				4% ammonia [34]	30% ammonia [34]	62% ammonia [34]
				2% hydrogen [34]	4% hydrogen [34]	4% hydrogen [34]

Taken from: Innovate UK Transport Vision 2050, 2021

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Aviation - Sustainable Aviation fuels

Table 9: Potential fuel supply pathways for production from 2020-2050

Timeframe	Technology pathway	Feedstock	UK production potential
To 2020	Biomass to liquid	Mixed MSW	High
To 2020	HEFA	Waste oils*	Low
To 2020	Alcohol To Jet	Waste gases	High
To 2020	Green diesel	Waste oils*	Low
2020 - 2030	Alcohol To Jet	Lignocellulosic	Med
2020 - 2030	Pyrolysis oils	Mixed MSW	High
2020 - 2030	Farnesene	Sugar cane/LC residue	Low
2020 - 2030	Co-processing	Wastes oils*/ pyrolysis	Med
2020 - 2030	SIP	Sugars/LC materials	Med
2030 - 2040	Novel Hydro routes	Waste oils*	Low/Med
2030 - 2050	HEFA	Algae	Unknown
2030 - 2050	Biotech conversion	Waste gases	Unknown

Sustainable Aviation Carbon Road-Map: A path to Net Zero: https://www.sustainableaviation.co.uk/goals/climate-change/

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Aviation - Sustainable Aviation fuels

	2020	2025	2030	2035	2040	2045	2050
Commuter » 9-50 seats » < 60 minute flights » <1% of industry CO_2	SAF	Electric and/or SAF	Electric and/or SAF	Electric and/or SAF	Electric and/or SAF	Electric and/or SAF	Electric and/or SAF
Regional » 50-100 seats » 30-90 minute flights » ~3% of industry CO_2	SAF	SAF	Electric or Hydrogen fuel cell and/or SAF	Electric or Hydrogen fuel cell and/or SAF	Electric or Hydrogen fuel cell and/or SAF	Electric or Hydrogen fuel cell and/or SAF	Electric or Hydrogen fuel cell and/or SAF
Short haul » 100-150 seats » 45-120 minute flights » ~24% of industry CO_2	SAF	SAF	SAF	SAF	Electric or Hydrogen combustion and/or SAF	Electric or Hydrogen combustion and/or SAF	Electric or Hydrogen combustion and/or SAF
Medium haul » 100-250 seats » 60-150 minute flights » ~43% of industry CO_2	SAF	SAF	SAF	SAF	SAF	SAF	SAF potentially some Hydrogen
Long haul » 250+ seats » 150 minute + flights » ~30% of industry CO_2	SAF	SAF	SAF	SAF	SAF	SAF	SAF

IATA SAF Symposium, Jonathon Counsell IAG, 2021

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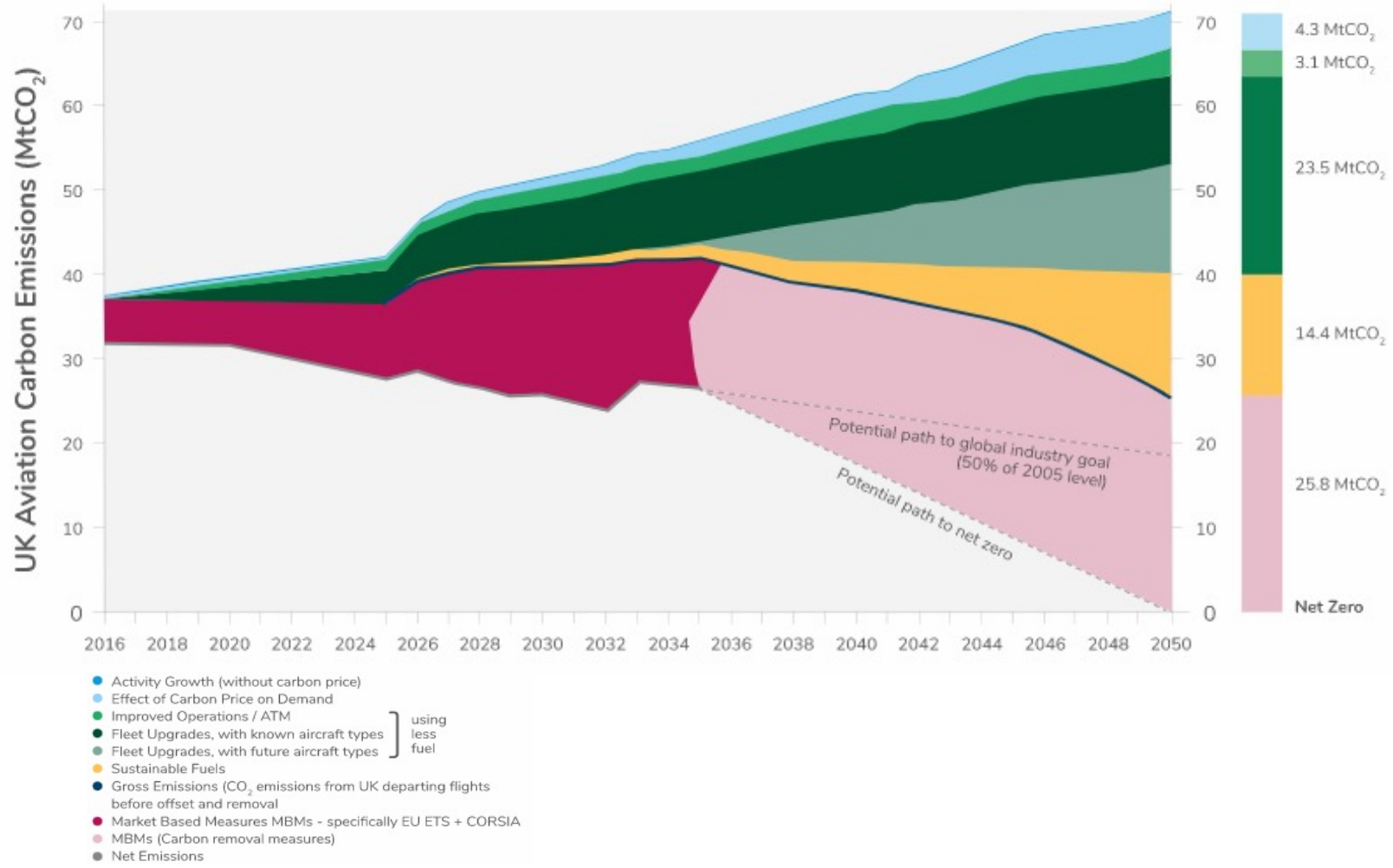
Aviation - Sustainable Aviation fuels



Sustainable Aviation Carbon Road-Map: A path to Net Zero: https://www.sustainableaviation.co.uk/goals/climate-change/

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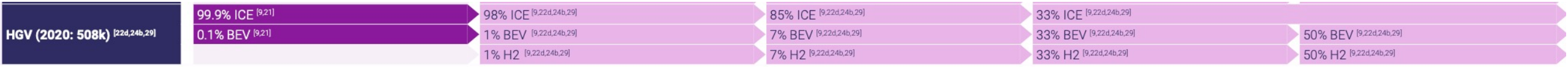
Sustainable fuel for HGVs

- Can reduce carbon emissions by up to 90 percent
- It is a drop in fuel for a number of OEM vehicles
- Requires on site fuel storage
- XPO logistics recently announced that 53 vehicles will be powered by HVO
- Concern over competition for feedstock



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Production Case Study: Altalto – Velocys & British Airways

Velocys, in collaboration with British Airways are developing a commercial plant in Immingham, U.K. to make sustainable jet fuel.

It is expected to be Europe's first commercial scale waste-to-jet-fuel facility.

The plant will **process 500,000 tonnes of household and commercial waste** destined for landfill or incineration each year.

The plant is expected to **produce 60 million litres of sustainable jet and road fuel annually.**

The project has been a recipient of both F4C (£934,00) and GSGF funding (£2,381,000.)

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Combined demand across Aviation, HGV and Maritime in UK

Aviation

149 Billion Litres per annum

Maritime

234 Billion Litres per annum

Heavy Goods Vehicles

8 Billion Litres per annum

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Full System Thinking