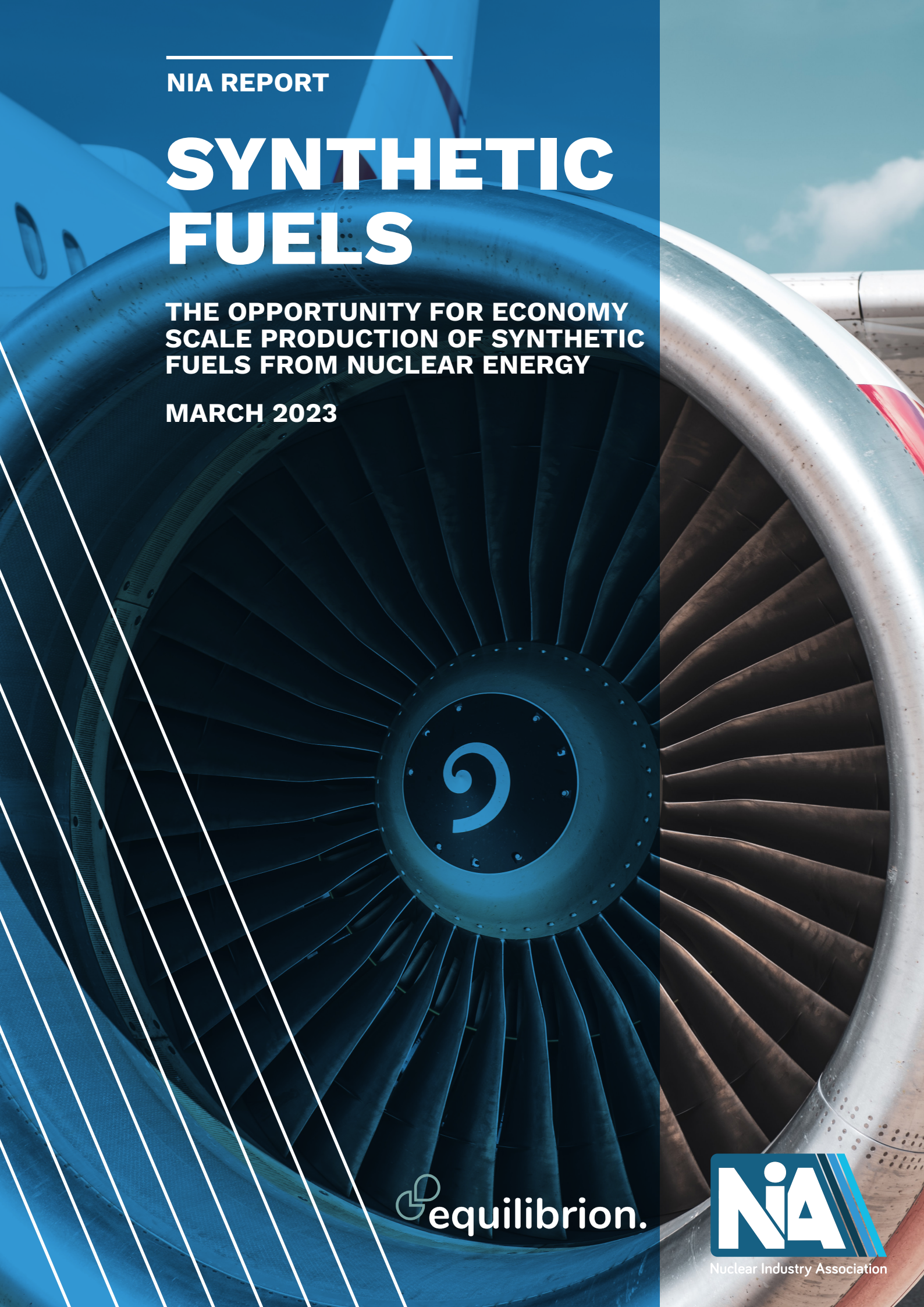
NIA REPORT

SYNTHETIC FUELS

THE OPPORTUNITY FOR ECONOMY SCALE PRODUCTION OF SYNTHETIC FUELS FROM NUCLEAR ENERGY

MARCH 2023



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FOREWORD

Immediate action to decarbonise sectors where emissions are hard to abate is crucial if the UK is to reach its net zero 2050 target. The scale and enormity of the challenge in front of us in this regard is rarely articulated. To have any chance of delivering on climate obligations for all of our energy consumption, including non-electric energy use, we need national-scale, reliable, proven solutions supported by a vast expansion of clean energy sources.

Nuclear energy can play a crucial role in providing the primary energy to support the decarbonisation of sectors which are currently almost entirely reliant on fossil fuels. Nuclear is completely unique in providing low carbon electricity and heat 24 hours a day, 7 days a week, whatever the weather. We believe this is exactly the type of energy that the low carbon fuels market needs in positioning the UK as a world leader in synthetic fuel production.

The Department for Transport has recognised the role that nuclear energy can play within the proposed Sustainable Aviation Fuels Mandate and I am delighted that through this paper the NIA outlines the nuclear industry's ambition, approach and asks from stakeholders to take this vision from recognition to reality.

The almost universal use of fossil fuels in transport presents very different challenges to achieving net zero than simply decarbonizing electricity alone. The nuclear sector is primed to support decarbonisation of both electricity and fossil fuel use, through cross-sector partnerships with industry and government we stand ready to provide the energy that the market needs.

TOM GREATREX, CHIEF EXECUTIVE
NUCLEAR INDUSTRY ASSOCIATION

NIA would like to thank Equilibrion Limited for their valued technical and policy knowledge that has contributed to this paper. Equilibrion is a new company and NIA member focused on the application of nuclear energy for decarbonisation in a range of energy end use sectors, particularly those which are hard to abate.

www.equilibrion.co.uk

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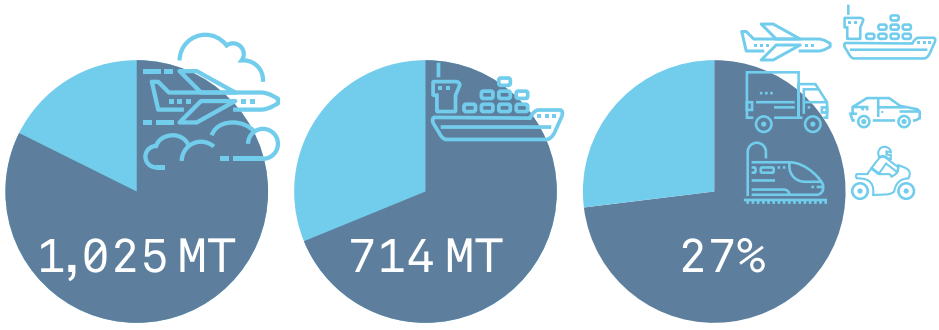
National-scale production of British synthetic fuels from nuclear energy provides the opportunity for high reductions in emissions in the transportation sector and could create thousands of high value jobs delivering on both our industrial strategy and levelling up ambitions. Importantly, a home-grown source of synthetic fuels could reduce or eliminate reliance on foreign imports, in line with the British Energy Security Strategy.

DECARBONISING TRANSPORT: THE FACTS

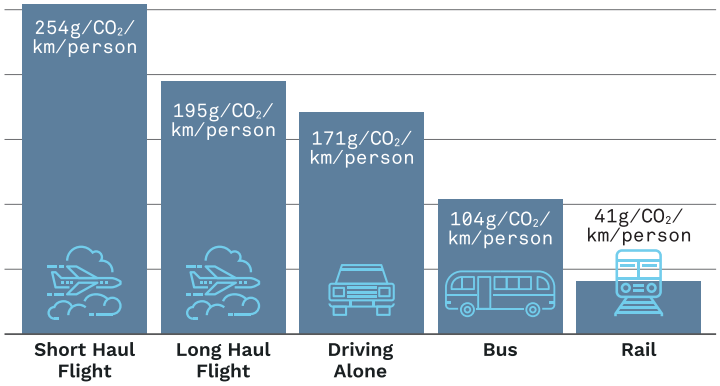
The transport sector, including aviation, shipping and heavy road transport, is responsible for 27% of our total greenhouse gas emissions. The sector faces competing demands to continue supporting economic growth from international travel and the absolute necessity to decarbonise. Some demand can be met with electrification, but for sectors where this is not a practical option, synthetic fuels become a highly credible and, in many cases, essential alternative to fossil fuel use today.

Aviation and shipping are two of the most challenging sectors to decarbonise as they both require a high power output and large on-board energy stores to ensure long distances between refuelling. In these sectors, low carbon fuels of the future must provide the same or similar performance to fossil fuels. For all but the lightest duty applications, electrification is not an option.

Multiple analyses seek to predict the low carbon transition pathway for these sectors with the majority showing a continued use of fossil fuels in 2050, with these subsequently balanced by atmospheric carbon removal approaches to balance emissions through a complex accounting system. Few-to-none of the predictions fully consider the role that nuclear energy could play resulting in a significant gap and the impression of an intractable challenge.



Sources: IEA Aviation, Shipping and Transportation Analysis[1; 2; 3]



Source: BEIS, Greenhouse gas reporting: conversion factors 2019

1] Aviation Tracking Report, International Energy Agency, September 2022 https://www.iea.org/reports/aviation

2] CO_2 emissions from international shipping, 2010-2019, and in the Sustainable Development Scenario, 2030, International Energy Agency, 26 October 2022 https://www.iea.org/data-and-statistics/charts/co2-emissions-from-international-shipping-2010-2019-and-in-the-sustainable-development-scenario-2030

3] Transport: Improving the sustainability of passenger and freight transport, International Energy Agency https://www.iea.org/topics/transport

WHAT ARE SYNTHETIC FUELS?

Fossil fuels have enabled a near unimaginable pace of economic and social development; faster than at any other time in history. They have also contributed to the path we are now on towards the catastrophic effects of climate change. If we are to decarbonise transport, we must find a way of ending the use of fossil fuels in the manufacture of our transport fuels forever. Synthetic fuels could be the answer.

The term 'Synthetic Fuel' is not new, and in its broadest sense means a fuel which is not derived from extracted fossil fuels. By avoiding the greenhouse gas emissions associated with the burning of traditional fuels such as petrol, kerosine and diesel, synthetic fuels provide a carbon-neutral alternative, with the same energy density while being compliant with international fuels standards.

They are distinct from bio-fuels as they are not reliant on organic waste feedstocks to provide the carbon and hydrogen inputs for fuel production, and overall they have a greater potential to reduce emissions and scale to larger volumes as they are not constrained by limited supply.

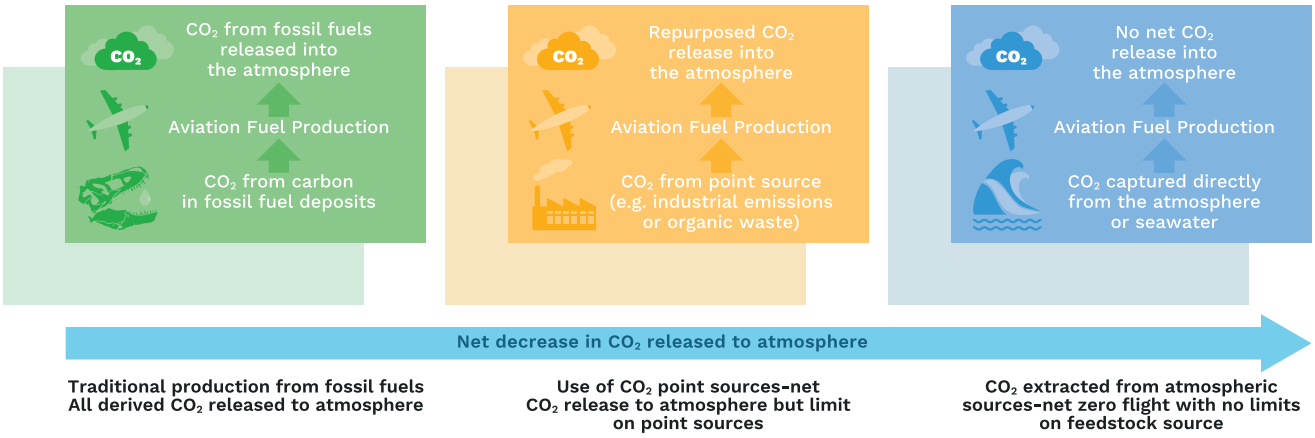
Instead, synthetic fuels rely on carbon dioxide obtained from the environment and low carbon hydrogen feedstock to synthesise hydrogen-based fuels that perform like fossil fuels, but with no net release of carbon dioxide to the atmosphere. Even though they look, smell and burn just like fossil fuels their carbon neutrality and the unlimited availability of feedstock makes them highly attractive, if sufficient clean energy sources, such as nuclear energy, can be deployed.

Government policies to unlock the opportunity for synthetic fuel production are currently in development in many countries, so this is a crucial time to ensure that future market and regulatory frameworks are available and can stimulate demand pull for solutions, including nuclear energy.

Synthetic fuel production can use carbon dioxide from several different sources including point sources, such as industrial emissions, or from carbon removals by direct air or seawater capture. Point sources may provide a useful opportunity to repurpose unavoidable emissions in the near term, however this route still results in a net release of carbon dioxide and as industry becomes decarbonised and there will be fewer and fewer suitable sources of carbon dioxide available. Direct air or sea capture presents a more scalable and sustainable long-term solution.

The drawback is that synthetic fuel production routes are perceived as energy intensive and restricted in availability due to assessments which solely consider the use of renewable energy. This is where nuclear can deliver the solution needed, with its unique ability to provide low carbon electricity and heat 24 hours a day, 7 days a week from a very small land area. Applying nuclear energy in this way could unlock the path to far greater supply of synthetic fuels to the sectors which need it most, reducing emissions beyond what can be achieved with bio-fuel alternatives and even becoming carbon negative in the future.

The vision therefore is for integrated industrial solutions that incorporate nuclear energy from their inception using technology already available to drive both deeper decarbonisation and wider adoption in markets where there are very few or no alternative options.

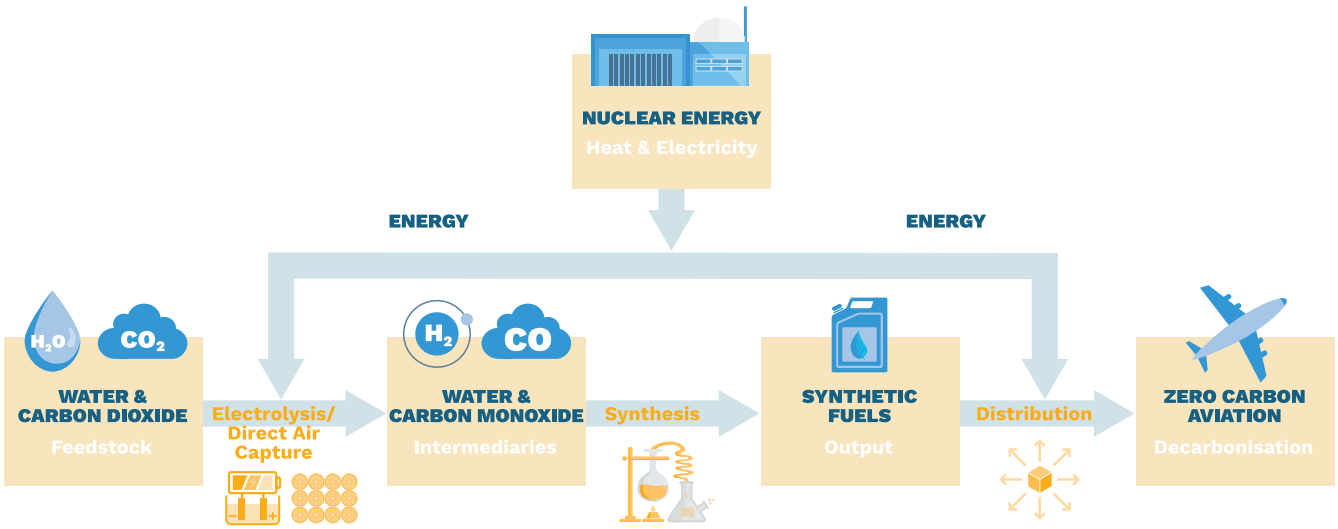


THE ROLE OF NUCLEAR ENERGY IN SYNTHETIC FUEL PRODUCTION

There are over 400 operating reactors in the world producing nearly 10% of the world's electricity from nuclear heat. As a proven, reliable and safe energy source, nuclear energy could provide for the needs of the future synthetic fuels markets turning our plentiful supply of uranium into synthetic fuels for transportation using the technology we have today.

As part of a synthetic fuel production facility, the heat and electricity from nuclear can be used for all stages of the process with the potential to improve overall energy efficiency, economics and scale. Unlike other energy sources, nuclear can be built in a range of locations and is not limited in its scale of deployment by the local availability of renewable energy resource, making it ideal for densely populated regions.

High Level Schematic of Nuclear Energy Synthetic Fuels Production



On a number of measures, nuclear is also more sustainable than other energy sources which are frequently associated with synthetic fuel production, due to very low carbon lifecycle emissions and minimal requirement for materials, rare and various metals.

For synthetic aviation fuel production nuclear electricity and heat can provide:

Desalination: providing the clean water required for hydrogen production

Hydrogen production: delivering electricity and steam to electrolysers for high efficiency hydrogen production

Carbon capture technology: extracting carbon dioxide directly from the environment creating a closed carbon loop in the production and use of synthetic fuels

Carbon monoxide: reduction of carbon dioxide to carbon monoxide as required for the fuel synthesis either through electrolysis or the water gas shift reaction

Fuel synthesis: electricity to drive traditional and innovative batch processes on a large scale

Hydrocracking: hydrogen for the cracking of long chain hydro-carbons to produce fuels

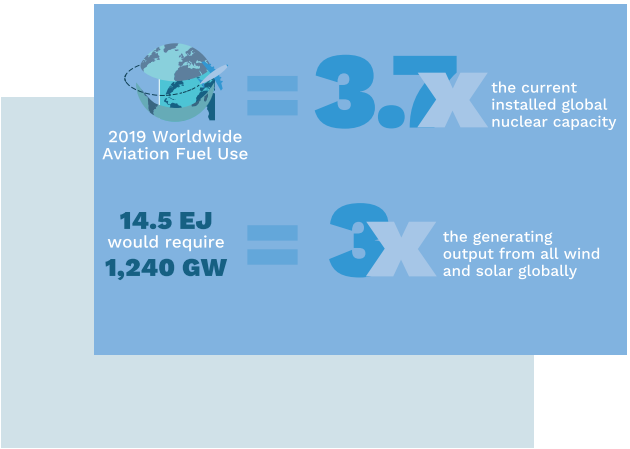
The UK Government recognises the role that nuclear energy could play with its likely inclusion upcoming Sustainable Aviation Fuel Mandate.[4] It is essential that this follows through to the final legislation. Once in place, this mandate means synthetic fuels produced from nuclear energy will have access to the aviation fuel market on a level playing field with other technologies, such as renewable produced synthetic fuels and bio-fuels.

The potential for nuclear energy to produce synthetic fuels does not stop at aviation fuel production. There are further opportunities for the integration of nuclear energy sources to provide a low carbon energy source for the production of ammonia, gasoline and methane production processes. The committee on climate change predicts that 87% of shipping fuel use in 2050 will be synthetic ammonia.[5] In the UK, low carbon fuel use in these sectors is covered by the Renewable Transport Fuel Obligations, which excludes the use of nuclear energy. Amending this is an obvious opportunity for the UK to support market development and ensure consistency in policy on low carbon fuels production.

A SENSE OF SCALE: WHAT COULD BE ACHIEVED THROUGH NUCLEAR ENERGY?

The introduction to this paper highlighted that the sense of scale of challenge for decarbonising the hard to abate sectors is rarely appreciated. In 2019, The energy requirement for the global aviation sector was over 14.5 EJ[6] and emissions accounted for 2% of the global amount.

To decarbonise all of this fuel use with synthetic fuels would require over 1,200 GW of nuclear electric production capacity[7] based on stated production efficiencies,[8] which is equivalent to over three times the currently installed global nuclear capacity output, and around three times the total global installed solar and wind generation output in 2021.[9]



For the UK, the aviation sector accounts for approximately 10% of energy use,[10] which would require approximately 55 GW of installed electricity generating capacity. These figures do not account for the potential direct use of heat, which stands to improve production efficiencies providing economic and integration advantages.

Key to success will be demonstrating that nuclear energy can be commercially competitive against other technologies and recognising its true system value as part of a diverse energy mix that is increasingly reliant on renewable energy. This includes the potential for integrated synthetic fuel plants to also provide flexible electricity to the national grid to compensate for the variability of renewables.

4] Sustainable aviation fuels mandate, Department for Transport, 2021 https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/1005382/sustainable-aviation-fuels-mandate-consultation-on-reducing-the-greenhouse-gas-emissions-of-aviation-fuels-in-the-uk.pdf

5] The Sixth Carbon Budget The UK's path to Net Zero, Climate Change Committee, December 2020 https://www.theccc.org.uk/wp-content/uploads/2020/12/The-Sixth-Carbon-Budget-The-UKs-path-to-Net-Zero.pdf

6] p136—Net Zero by 2050, International Energy Agency, May 2021 https://www.iea.org/reports/net-zero-by-2050

7] Facilities operating at 92.7% capacity factor—Nuclear explained, US Energy Information Administration https://www.eia.gov/energyexplained/nuclear/us-nuclear-industry.php

8] Figure I and mathematical conversion—E-Fuels: A technoeconomic assessment of European domestic production and imports towards 2050, Concawe, November 2022 https://www.concawe.eu/wp-content/uploads/Rpt_22-17.pdf

9] Global Energy Review 2021: Renewables, International Energy Agency https://www.iea.org/reports/global-energy-review-2021/renewables

10] Energy use: fossil fuels by fuel type, Office for National Statistics, 9 June 2022 https://www.ons.gov.uk/economy/environmentalaccounts/datasets/ukenvironmentalaccountsfuelusebytype

ECONOMIC AND SOCIAL OPPORTUNITY

The global market for aviation fuel alone is currently predicted to be $240 billion by 2026[11] and the global synthetic fuels market valued at $15.3 billion by 2030[12] and $600 billion[13] by 2050.

Furthermore, based on a survey of eight leading analyst organisations, the average prediction of the market share that synthetic fuels could achieve is over 42% of the total 2050 aviation fuel market.

42%

market share of synthetic fuels in 2050 aviation sector

This presents an immense opportunity for countries and technology companies which recognise the opportunity and move early.

Nuclear energy is already a significant job creator and analysis funded by the UK Government has shown nuclear to add the most value to the domestic economy than any other energy source.[14] Combining the predicted market and jobs creation is perhaps one of the greatest economic opportunities available to us as part of the energy transition. The UK's existing strong capability makes it ideally placed to exploit the opportunity deploying integrated nuclear and synthetic fuels programmes to reduce reliance on international fuel markets, improve energy security, support jobs at home across all of the UK and position for the export of sovereign synthetic fuels to trade partners across the world.

RECOMMENDATIONS

Delivery of this vision requires concerted effort from a range of stakeholders, including government. Our recommendations are:

- Include synthetic fuels from nuclear sources in DfT's SAF mandate when it is passed into legislation;
- Include nuclear-enabled synthetic fuel production in the necessary UK national infrastructure planning activities;
- Consider including nuclear-enabled synthetic fuel production as part of the terms of reference for Great British Nuclear;
- Add nuclear energy representation to the Hydrogen Advisory Council. As a key part of the synthetic fuels process, recognising the role of nuclear is a clear enabler;
- All relevant UK bodies including Government departments and teams to recognise the opportunity presented and consider actions they can take in collaboration with industry to deliver benefits to aviation sector, nuclear sector and UK overall;
- Government and non-government net zero modelling and assessment should include nuclear-derived synthetic fuels.
- Government should consider amendments to the Renewable Transport Fuels Obligation to enable nuclear to be exploited for the production fuels in the wider low carbon fuels market (land transport and shipping).

11] Aviation Fuel Market, Allied Market Research https://www.alliedmarketresearch.com/aviation-fuel-market

12] Global Sustainable Aviation Fuel Market (2020 to 2030), Businesswire, 22 October 2020 https://www.businesswire.com/news/home/20201022005788/en/Global-Sustainable-Aviation-Fuel-Market-2020-to-2030---Rising-Demand-for-SAF-by-Airlines-Presents-Opportunities---ResearchAndMarkets.com

13] Fuelling sustainable aviation for the long haul, World Economic Forum https://www.weforum.org/impact/fuelling-sustainable-aviation/

14] Page 26—Energy Innovation Needs Assessment, Department for Business, Energy & Industrial Strategy, 15 November 2019 https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/845652/energy-innovation-needs-assessment-overview-report.pdf

The NIA is the trade association for the civil nuclear industry in the UK. The NIA represents more than 250 companies across the supply chain. The diversity of NIA membership enables effective and constructive industry-wide interaction.

#NetZeroNeedsNuclear

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