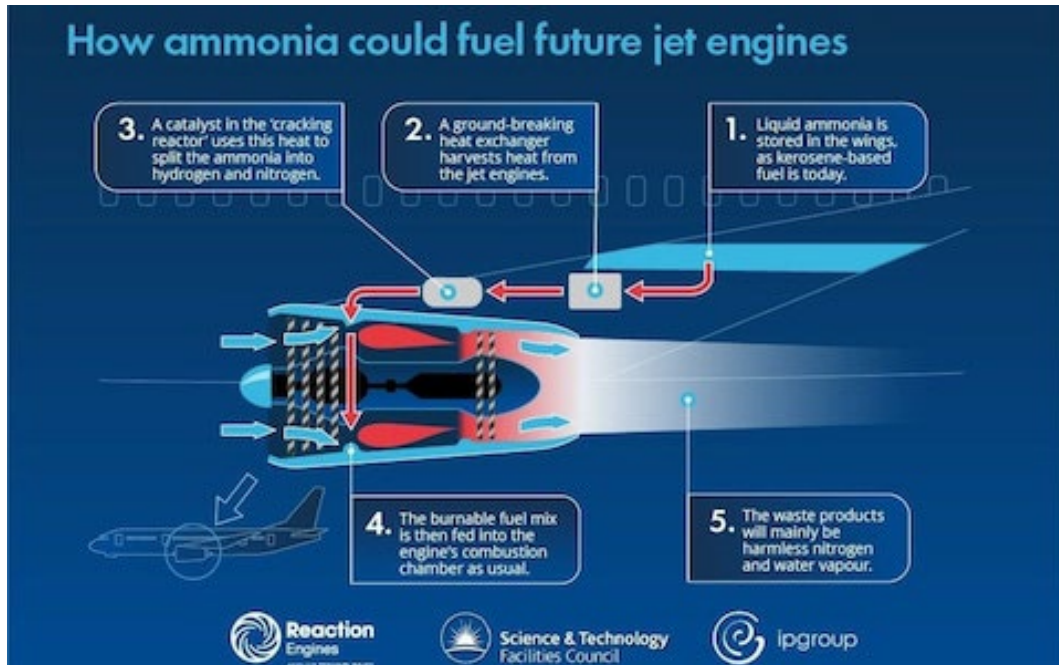


AEROSPACE & THE ENVIRONMENT

TWO ALTERNATIVE FUELS: AMMONIA



With sustainability being very topical the following are another pair of loosely related articles from our Chairman's recent archives. Combined together, the first concerns ammonia as a substitute for fossil fuel; the second, hydrogen. Underpinning them both we conclude with an article entitled 'Aviation's impact on the environment' published by the Air Transport Action Group.

Jet engines for passenger planes that can run on environmentally friendly ammonia rather than fossil fuels are being developed in a new venture involving an Oxford-based company and a government agency. Ammonia produces harmless water vapour, hydrogen and nitrogen as by-products rather than carbon dioxide and could help Britain reach its clean air travel aims years ahead of schedule.

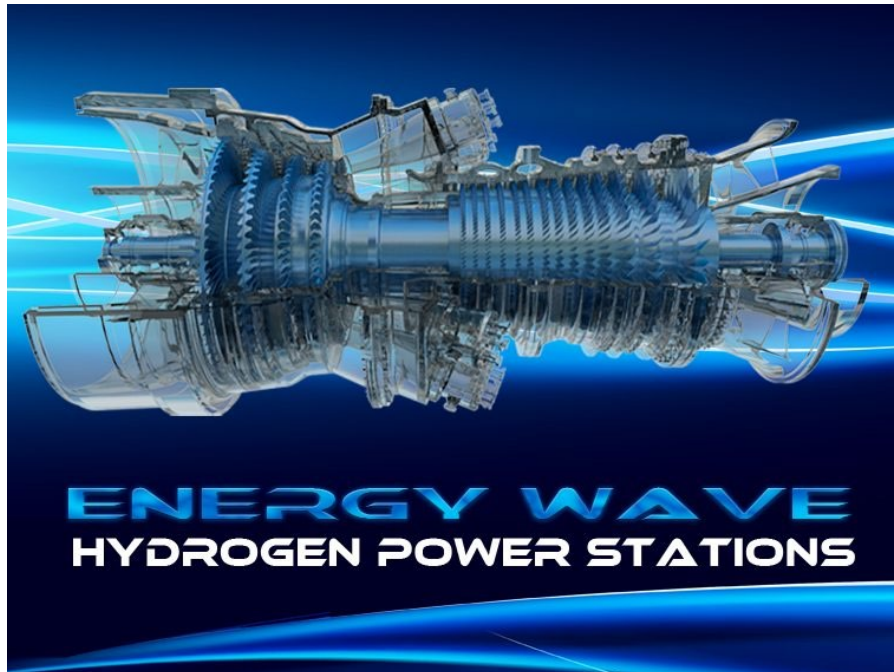
The joint venture is being set up by Reaction Engines with FTSE 250 investor IP Group and the state-backed Science and Technology Facilities Council. It aims to have the technology ready for use by aircraft makers and ship builders as part of the transition away from fossil fuels, such as jet fuel kerosene. Aviation and maritime account for 5pc of the world's carbon emissions.

The consortium said the technology would make it possible to achieve net zero in short-haul air travel by 2030 - two decades ahead of the Government's target. Ammonia is commonly manufactured for use in fertilisers. The process is not environmentally friendly because it normally uses methane, but ammonia can be made using carbon-free processes such as the use of electrical currents.

The new venture will work on developing engines based on "cracker reactors". These split ammonia into nitrogen and hydrogen, with the hydrogen then fed into a combustion engine to generate thrust.

Ammonia engines could offer an alternative to electric planes, which could suffer from limited range. Reaction Engines said ammonia-powered aircraft could be initially capable of ranges of 1,250 miles.

..... AND HYDROGEN



On 25 September 2020 Cranfield University launched the world's first hydrogen powered plane. ZeroAvia, which is headquartered at Cranfield having relocated from the USA last year, flew a Piper Malibu powered by a hydrogen fuel cell on an 8-minute flight to demonstrate the viability of the company's 800-volt emission free powertrain. The company has received \$37.7M backing from Jeff Bezos and Bill Gates, and a further \$16.3M from the UK Government to help ZeroAvia develop a 19-seat hydrogen-electric powered aircraft by 2023.

And with Cranfield University in mind we recommend readers go to [Aviation and the environment \(cranfield.ac.uk\)](http://cranfield.ac.uk) and download two new publications: 'Aviation and the environment' and 'Aircraft electrification'.

Also, we can advise that Rolls-Royce has completed ground testing of a powertrain for what could become the world's first electric aeroplane earlier this year. It is hoped that the 500 horsepower aircraft could fly at 300mph.

Finally, as background to the subject of aerospace and the environment, the following is an article entitled 'Aviation's impact on the environment' published by the Air Transport Action Group:

"Air transport generated 895 million tonnes of carbon dioxide (CO₂) in 2018. This may sound like a lot, but it is only around 2% of the 42 billion tonnes of CO₂ generated by human activities every year. Despite passenger numbers increasing at an average of 5% each year, aviation has managed to limit its emissions growth to around half of that. This is through massive investment in new

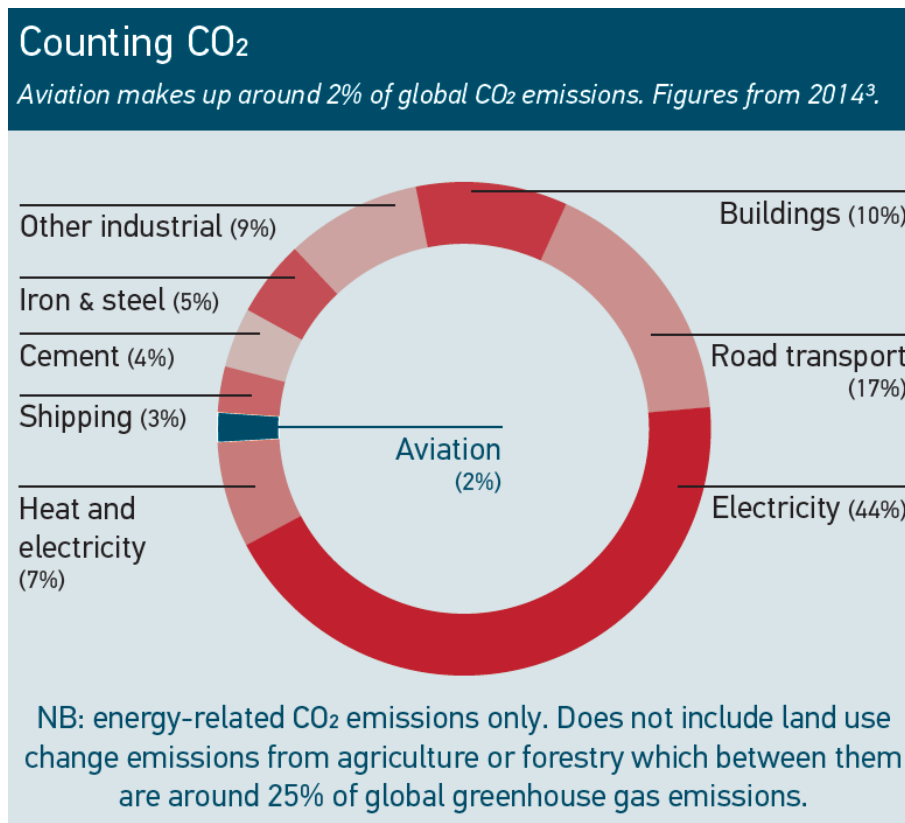
technology and coordinated action to implement new operating procedures and infrastructural measures.

As aviation grows to meet increasing demand - particularly in fast-growing emerging markets - and as other sectors of the economy reduce emissions, aviation's share of overall emissions is likely to increase.

A growing carbon footprint is unacceptable for any industry, which is why aviation, from manufacturers to airports to airlines to air traffic management, is working hard to limit greenhouse gas emissions.

If we consider energy-related CO₂ emissions – without emissions from agriculture or forestry which account for around a quarter of global greenhouse gases – the largest contributor to CO₂ emissions is electricity (44%). Second is road transport at 17%, followed by buildings at 10%.

Aviation, producing 2% of all human-induced CO₂, emits less than the iron and steel industry (5%), cement production (4%) and the shipping sector (3%) and around the same as the servers and transmission cables of the internet.



CO₂ is not the only greenhouse gas emitted by aircraft. Exhaust fumes from aircraft engines are made up of 7% to 8% CO₂ and water vapour; around 0.03% nitrogen oxides; unburned hydrocarbons; carbon monoxide and sulphur oxides; traces of the hydroxyl family and nitrogen compounds; and small amounts of soot particles (although the industry has almost eliminated soot emissions over the past few decades). Between 91.5% and 92.5% of aircraft engine exhaust is normal atmospheric oxygen and nitrogen.

The water vapour trails (contrails) created by aircraft also have an impact, but research is inconclusive about whether these have a net warming or cooling effect on the earth. Under some meteorological conditions they can remain in the atmosphere and form 'cirrus' clouds, which may have an effect on climate change. For example, some research suggests these clouds may have different cooling and warming effects, depending on whether flights are during the day or night. This type of research can identify whether there are any potential benefits in altering operational behaviour. More work is being done in this area, and the aviation industry is assisting with research into the effects of contrails on climate change, including putting high-altitude atmospheric testing equipment on some passenger aircraft.

There are many references to aviation having a greater effect than other industries because of the height at which the emissions are released. The most significant greenhouse gas, CO₂, does not have any additional impact due to difference in altitude, the impact is the same. However, other emissions such as nitrogen oxide and water vapour can have greater effect at higher altitudes. Scientists refer to this as a 'multiplier'.

Recent research suggests that aviation CO₂ emissions should be multiplied by 1.9 times to take account of the added impact of these other gasses at altitude. However, it is important to realise that most other emitters also release non-CO₂ gasses and require a multiplier to determine their overall climate change impact (also known as radiative forcing). The rate for road transport, for example, is 1.5 times its CO₂ emissions.

When these non-CO₂ emissions and the multiplier are taken into account, the Intergovernmental Panel on Climate Change (IPCC) estimates aviation accounts for about 3% of total man-made climate impact. However, some experts say using a multiplier when calculating the emissions of individual flights is inappropriate as it is a tool to describe longer-term impacts. Other sectors do not tend to have non-CO₂ impacts added when calculating their carbon emissions."



Rolls-Royce all-electric 'Spirit of Innovation'