**When I was learning to drive, about (cough) thirty five years ago, I read an instruction in the British Highway code which struck me as very sensible. It said “Always give way to trains”. It’s advice that I’ve followed carefully ever since, and so far it’s stood me in very good stead.**

**An equally insightful piece of commentary, this time from the aviation industry, comes from this report at the website Flight Global. It says this**

**“power failure in mid- flight is a major risk engineers want to avoid”**

**That breath-taking piece of wisdom was referring specifically to the problem of trying to power a long-haul commercial aircraft with lithium-ion batteries instead of jet fuel, and it’s a challenge that’s becoming a lot more relevant now that the world has started to pick it’s way carefully out of the last fifteen months of chaos. As nations try to rebuild their economies and infrastructure in a greener more sustainable way, the question of low or zero carbon aviation is arguably higher on the agenda of our national governments now than it ever has been.**

**And those long-haul flights to far away destinations that so many folks are so desperate to jump onto are just not suitable candidates for the lithium ion batteries that are used in Electric road vehicles. They’re just too heavy for intercontinental flights.**

**So, for some time now, the aviation industry has been trying to develop hydrogen as an alternative fuel source to replace the fossil fuel derived kerosene used in aircraft today. And now the aviation giant, Airbus, has upped the stakes by confirming that they’re aiming for commercial hydrogen airliners to be in service by 2035.**

**So, is that a realistic ambition?**

**Hello and welcome to Just Have a Think,**

**According to research carried out in May 2020 by consultancy firm McKinsey and Company, on behalf of a European Commission project called Clean Sky, the engines in modern aircraft emit just over three kilograms of carbon dioxide for every kilogram of fuel burnt during a flight. They also emit nitrogen oxides or NOx, water vapour, and soot at high altitudes, all of which contribute to atmospheric warming either by impacting the ozone layer or by creating dirty contrails that radiate heat.**

**The latest scientific evaluations suggest that the non-CO2 emissions from kerosene fuelled aircraft, could have a total effect between two and four times as large as the impact of the CO2 emissions alone. That means aviation accounts for somewhere between three and seven percent of total global CO2 equivalent emissions from human activity, which is between two and four billion tonnes of CO2 every year.**

**Switching to synthetic fuels made either from biofuels or from hydrocarbons derived from direct air carbon capture doesn’t change the NOx emissions of an aircraft engine, but initial studies of hydrogen combustion powered aircraft show that NOx emissions can be reduced by as much as eighty percent without large concessions in efficiency. And when a hydrogen fuel-cell propulsion system is used, there are no NOx emissions at all.**

**The reverse is true with water vapour though. Hydrogen combustion and hydrogen fuels cells emit about two and a half times more water vapour than synthetic fuels or kerosine. Having said that, the McKinsey report points out that, although by dint of sheer volume in the atmosphere, water vapour is the predominant greenhouse gas, 3:46 individual water molecules themselves are actually ten times less potent than CO2 molecules. Initial simulations of hydrogen combustion show that the ice crystals in their contrails are heavier, which means they fall back to earth more easily. Those contrails don’t contain any soot either, so they’re more transparent. The result is a thirty to fifty percent reduction in impacts from contrail and cirrus formation compared to kerosene aircraft. And, in the case of fuel cells, the vapour can actually be contained and managed within the aircraft itself**

**And then there’s take-off and landing. The McKinsey research showed that, compared to kerosine, synthetic hydrocarbon fuels emit a little less particulate matter but don’t reduce the other pollutants at all, whereas hydrogen emits lower or even zero NOx, much lower harmful particulate matter, and far fewer non-methane volatile organic compounds, or NMVOCs.**

**Now, I should just give a little bit of credit to lithium-ion batteries at this stage rather than writing them off completely for powered flight. They don’t cause ANY local pollution or atmospheric warming, and in fact they may well represent a very good solution for short haul flights of less than a thousand miles.**

**But eighty percent of the aviation industry’s pre-Covid emissions came from long haul flights, and according to studies carried out by the European Union, if the Pre-Covid global aviation industry was a country, it would rank among the top ten greenhouse gas emitters.**

**So, hydrogen has become the development fuel of choice for most of the major industry players. Kilogram for kilogram it’s got three times the energy density of kerosine, which sounds great, but it also has a higher volume compared to kerosine, which means larger fuel tanks are needed, and that can fundamentally affect the entire design of an aircraft.**

**Engine makers and aircraft builders, including Rolls Royce, Boeing and Airbus, are all working on the challenge, but until recently the general consensus was that we wouldn’t see hydrogen planes in commercial service until 2050.**

**So, this latest 2035 target from Airbus brings the whole project forward quite a bit.**

**The projection was made by Glenn Llewellyn, Vice President of Zero Emissions Aircraft. He believes Hydrogen is the best pathway for decarbonisation, but he also made the very important point that success would depend heavily on the widespread adoption of hydrogen fuel in many other industries in modern economies, combined with the continuing decline in the cost of wind and solar power to drive the electrolysis needed to produce green, carbon free, hydrogen rather than grey, carbon-heavy, hydrogen derived from steam reforming methane. Nevertheless, Llewellyn does expect the cost of hydrogen to drop significantly in the coming years as production increases around the world.**

**His team has developed three different aircraft models, each designed to cater for a specific sector of the aviation industry. All three concepts are hybrid-hydrogen aircraft, powered by hydrogen combustion through modified gas turbine engines. Liquid hydrogen is used as the combustion fuel, while hydrogen fuel cells create electrical power that complements the gas turbine, resulting in a highly efficient hybrid-electric propulsion system.**

**For flights up to about a thousand miles carrying a hundred or so passengers, a propeller system known as a turboprop has been shown to be the most efficient, least polluting and most climate friendly option. Two hybrid engines drive eight bladed propellers to provide the thrust, with the liquid hydrogen storage and distribution system housed behind the pressurised cabin bulkhead.**

**For long haul, intercontinental flights of more than two thousand miles, Airbus are developing a couple of options. The first is a fairly traditional looking “turbofan” design, carrying about two hundred passengers. It’ll have an elongated fuselage to hold the higher volume of hydrogen fuel, with their hybrid hydrogen system powering a jet engine on each wing.**

**The second option is this futuristic design known as a blended-wing body where the wings merge with the main body of the aircraft, allowing fuel to be stored across the entire underside of the fuselage. It will also have a range of about two thousand miles, and there’ll be a very wide-open cabin space with enough seating capacity for about two hundred passengers.**

**Airbus will stop making their A380 superjumbo this year, and it looks very much like the days of five or six hundred people on a massive aircraft flying many thousands of miles directly from one major hub airport to another are set to be a thing of the past, with so-called point to point flights winning out as the most economical option for airlines.**

**Airbus plans to invest hundreds of millions of euros in hydrogen up to twenty twenty-five, to determine which aircraft to bring to the market first. After that according to Llewellyn, the investment will scale up to multiple billions through to twenty thirty-five**

**Demand for Liquid hydrogen is projected to be about two hundred million tonnes a year by twenty forty, by which time there’ll be a global infrastructure in place to support distribution. Aviation would account for about five percent of that demand, which means the majority of airports could easily draw on local hydrogen supply chains that also serve other industries.**

**Llewellyn argues that airports shouldn’t wait though. He reckons they should start using hydrogen to decarbonise their ground transportation ecosystem immediately. He says that’ll enable airports to scale up their hydrogen infrastructure in preparation for the hydrogen aircraft that will be arriving by the mid twenty thirties. And he suggests if they are smart about how they install that infrastructure then they could become very profitable hydrogen hubs servicing adjoining cities.**

**No doubt some of you will be shouting the word ‘safety’ at the screen right now. Quite right too.**

**Although hydrogen is non-toxic, and no more or less dangerous than jet fuel or methane gas, safety will still, unsurprisingly, be the overwhelmingly most important consideration in the development of hydrogen powered aircraft. No commercial aircraft has any chance of getting off the ground until it’s been through the rigorous testing required by aviation industry regulations.**

**If all those hurdles can be overcome though, then Hydrogen powered aircraft could make up a very significant proportion of the global fleet in the coming decades. And If older existing jet engines are converted to synthetic fuels instead of kerosine for the remainder of their serviceable lifetime, then according to the McKinsey study, even with the expected uplift in passenger flights over the coming decades, aviation’s climate impact would drop to the equivalent of about 2.7 gigatons per year of CO2 equivalent versus 5.7 gigatons in their baseline scenario without hydrogen and just with efficiency improvements to existing fossil fuel powered engines. And if the entire aviation industry steps up to match the ambition and urgency shown by Glenn Llewellyn and his team at Airbus, instead of kicking the can further down the road, like Boeing seem to be doing, then those CO2 emissions could be almost completely eliminated by mid-century.**

**Now, I know there are a lot of folks out there who have a forensic level of detailed knowledge about the aviation industry, and I’m sure you’re chomping at the bit to point out any variables or challenges that I’ve missed here. If that’s you, or if you work in the aviation industry and you have views to share, then jump down to the comments section below and leave your thoughts there.**

**That’s it for this week though.**

**Thanks as always to the amazing folks who support this channel via Patreon and help me keep the video content independent and ad free. And I must just give a quick shout out the folks who’ve joined since last time with pledges of ten dollars or more a month.**

**They are**

**Michael McKinzy Snr**

**Brian Scanlan**

**Thomas Kish**

**Augeur Flaneur**

**Matt Cartlidge**

**Bryan Dollery**

**Thomas Furst**

**J. Herman**

**Daniel Katz**

**Clive Price**

**Eric West**

**Pedro Gonclaves**

**Vince Gabor**

**and**

**Glen Cox**

**And of course, a big thank you to everyone else who’s joined since last time too.**

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**As always, thanks very much for watching, have a great week, and remember to Just Have a Think.
See you next week.**