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Steffan

Connecting for positive change. Hi, everyone, we've made it to episode three. So thanks for joining us again and welcome to the Hydrogenerally podcast series brought to you by Innovate UK KTN. I'm Steff Eldred from the Clean Energy and Infrastructure Team. We had great conversations in episode one with Sam French on how hydrogen is produced. Episode two was with Joanna Richart, on where it can be used. Before we get into today's episode, just a reminder about the podcast and the network. So the Hydrogenerally Podcast Series is the voice of the Hydrogen Innovation Network of Innovate UK KTN. We look at applications, opportunities and challenges of the hydrogen economy. We've got a goal to enable local clean hydrogen uptake at scale. So the uptake side and comparable costs and to help find novel solutions to that. So if you haven't already, then please go to our website, through the link in the description and sign up to receive newsletters and updates. You'll also find previous and future episodes of this podcast there too. So following on from the chat with Joanna, we are today going to delve deeper into one of those key opportunities and that's the world of aviation. So to help me with this, we've got someone far more knowledgeable on aviation than myself, my colleague, Hannah. Hi Hannah, do you want to introduce yourself and your role, and most importantly, introduce our guest today.

Hannah

Hi, everyone. My name is Hannah Abson and I cover aviation within KTN. So that's anything that's up in the sky. So yeah, today we're really grateful to have Katie on the line, on the podcast to help us understand the opportunity for hydrogen in aviation. Katie is the Head of Industrial Strategy at FlyZero, which is a project led by the Aerospace Technology Institute and backed by the UK Government, with the aim to realise zero carbon emission, air travel by the end of the decade. Which is no mean feat considering at present, the aviation industry contributes around 3% of all carbon emissions annually. So Hi, Katie, it's great to have you on the line. Would you like to introduce yourself, your role, and maybe a bit more about the work that's underway within FlyZero?

Katie

Hi, Hannah. Thanks for such a lovely introduction. Yes, so I'm Katie Milne. I run a team within FlyZero. FlyZero's got 100 engineers, market specialists and sustainability specialists that came together for one year from early 2021 to really try and understand what the challenges are with taking a hydrogen, well, in fact, let me take a step back. So what we did first was try and understand what the routes were to zero carbon aviation, full stop. So we looked across all the different energy sources. And we did that by assessing lots of different options. So we looked at, battery electric, at solid fuel sources, even, so we were trying to be unbounded, we looked at ammonia, we looked at hydrogen. So all of these options, but they're all options which would have zero carbon dioxide out of the back of the aircraft, as opposed to some alternative options, which would produce carbon dioxide out of the back of the aircraft, but which have been produced by taking carbon dioxide in the aircraft in the first place. So we differentiate between those two different options by saying one is like zero carbon, true zero carbon aviation, and the other is a net zero carbon solution. So we've been asked by Government, by the Jet Zero Council, so we could talk about them a little bit

maybe later by the Jet Zero Council to look at this zero carbon solutions. And very quickly, we came down to hydrogen as the technology that has the most potential to scale to larger aircraft. And so to address the vast majority of emissions, and the team within FlyZero, those 100 people that was talking about, we came together for a year, since kind of about June last year, when we downselected to hydrogen, we've been looking at kind of all aspects of how you take a hydrogen aircraft to market, technology market. My team's particularly concerned about manufacturing materials, but also looking at what intervention strategy would be needed from the government. So what's the industrial strategy for for intervention? And also, working on industrial engagements, so we're quite a multi-function team really, but it's been a it's been a really challenging, interesting, exciting year and amazing to be part of such an incredible revolution in aerospace technology.

Steffan

Great, thanks. Thanks for that Katie, thanks so much for joining us and thanks for the intro Hannah. If we may, we'll just jump straight in with a with a question really. So, as someone myself, from outside of the aviation world, Katie perhaps you could just start by giving us a quick overview of where you see the key opportunities for hydrogen in aviation?

Katie

Okay, so in terms of aviation, we just talked about the aeroplane first of all, there's there's two propulsion system architectures that have potential. The first one is hydrogen fuel cell electric. So that's the hydrogen fuel cell, probably a proton exchange membrane fuel cell driving an electric motor. And that technology has potential we believe to scale, possibly up to regional aircraft, so something that goes to kind of 80 seaters, 800 nautical miles, that kind of range. That's already under development. Like there's a lot of companies out there around the world who developing hydrogen fuel cell electric aircraft and they're mainly targeted at very small aircraft at the moment. So 20 seaters sub-regional. What we've also been looking at though is a second propulsion system architecture, which is a hydrogen burning gas turbine. So gas turbines are the solution jet engines for most aeroplanes at the moment. And they could be modified, you can modify the combustor and the fuel system so that they run on hydrogen instead of on kerosene on Jet A1, which they do at the moment. So those are the two options. And we think that that second option, hydrogen gas turbines, they couldn't fully replace all jet engine aircraft. So they potentially couldn't replace an A380 or a 787 the really long range ones, but we think they could scale up to a midsize aircraft. So something that could fly you maybe from London to Los Angeles, five and a half thousand nautical miles. And we're carrying hundreds of passengers, we reckon about 280 passengers. Yeah, so that's where we're at on aircraft.

Hannah

It's really great to hear those kinds of options laid out and I assume there's been kind of a strategy, as you've worked through the different options for hydrogen and zero emission aircraft opportunities. So what challenges specifically have you found for hydrogen within aviation?

Katie

So, I think there's two groups, there's getting it onto the aeroplane and then there's the at the airport, really, so if I just talk about the the aeroplane challenges briefly. One is materials. So in order for hydrogen to go into an aeroplane, it would have to be liquid, and liquid. Hydrogen

only becomes liquid at minus 250 degrees Celsius, so it's cold, so it has to be cryogenically cooled in order to put it onto the aeroplane. So that means that we need materials that can cope down at those low temperatures but they can also cope with long exposure to hydrogen. Now, the space sector, people who make space launch vehicles that run on liquid hydrogen, and there aren't many, so then the NASA SLS launch vehicle or the Ariane rocket, then they use already these liquid hydrogen and fuel tanks and fuel systems. So I mean, that's been great, because it's a stepping stone up for the aerospace industry. But those launch vehicles only are used once. You know, they're not used over and over and over again, as we would have in aerospace. So like getting the materials data really that shows that it's durable and will last is a big issue. We're also concerned about mass, you know, so we'll be flying a tank and insulation and more systems for managing the hydrogen fuel down from the very low temperatures, to potentially quite high temperatures in the gas turbine. So lightweighting is always a thing with aerospace, it'll be even more of a consideration with hydrogen aircraft. And then the last thing obviously is ensuring safety. So it'd be things like if you had an uncontained engine failure, which is very, very rare in aerospace but does occur. If that happened, making sure that none of the hydrogen systems were you know, were affected. So those are the three big areas for the aeroplane. The the other issues are more at the airport. So what we're expecting is that for very small, short range aircraft battery electric will be a solution and it's particularly a solution as a kind of replacement for helicopters, so two seater, six seater you see amazingly innovative companies like vertical aerospace in that space taking battery electric to market but batteries will find it very difficult to scale to bigger aeroplanes, much bigger aeroplanes. So you could have an airport that needs electric charging points for these tiny aeroplanes that needs hydrogen supply for middle sized aeroplanes. And then for very long range aeroplanes needs kerosene, that's quite challenging managing that energy mix. Over time, it's possible that one solution will win through, you know, like, Betamax and VHS everybody will then have a certain certain refuelling system. So it's like, how do you how do you manage that transition, I suppose from from one place to another. And of course, you can't fly from one airport and not land somewhere. So like, there's one of my favourite stats is that 93% of UK flights are international, we've got one of the highest amount of aviation emissions per capita in the UK globally with fourth in the world, in terms of number of flights. And the vast majority of those are international, because we're an island, you know, so like, the hydrogen airport that we have in London has to connect to another hydrogen airport somewhere else in the world and so you've got to coordinate across country boundaries. It's a really, it's a really big and interesting challenge. And then the last thing supply, you know, in order to have these hydrogen aircrafts, we need hydrogen supply that hydrogen has to come from green sources, or else it's not, zero carbon. So you need very large amounts of renewable electricity. You need, you know, plants that are doing electrolysis from water, to produce the hydrogen and then you need conveyance from those production plants to the airport. And there's options, you could you could produce the hydrogen at the airport, potentially. So, you know, it's just lots of innovation to go at. It's exciting.

Hannah

Definitely exciting. And I think what we hear a lot within the aviation industry is that there's this kind of approach required that almost has a basket of measures. So there's not one solution that will ultimately be able to tackle the various kind of I suppose distances that we travel within aviation and aerospace. So within KTN, we're quite keen to promote the right tech for the right solution or opportunity. And so I wondered where you see hydrogen,

working and complementing these other technologies like sustainable aviation fuels or batteries? Do you see them as complementary? Where do you see the splits and I know the Jet Zero Council are kind of tackling both the FlyZero side and also the sustainable aviation fuel side. So it'd be interesting to hear a bit more about that.

Katie

The Jet Zero Council is covering both SAF sustainable aviation fuels, which would be a drop in alternative to kerosene and also hydrogen through the work initially by FlyZero, but then I expect that's going to be taken forward by their their zero emissions, the Jet Zero Council zero emissions delivery group. I think at this stage, they are right to be pursuing multiple pathways to zero carbon, definitely, because there's uncertainty in all of those pathways. And if you think about it, like one of the things we've we've really paid attention to is timing. So battery electric is going to come to market imminently, really, but it's for very small aircraft. Hydrogen fuel cell electric for sub-regional aircraft will likely come to market in the 2020s hydrogen gas turbine in the 2030s. Sustainable aviation fuel's interesting. In theory, it is nearly ready now. That's the theory. But like all these things, it's not quite that simple. There's a couple of things that will constrain it, firstly, blending. So it will need to be mixed in a way that it's kind of reliable, and people know what they're getting at airports around the world. And then the second thing is scale. So sustainable aviation fuels either comes from biomasses, lipids, fatty acids, greases, or it comes from hydrogen. And the sustainable aviation fuels that come from biomass is are ultimately constrained in terms of capacity, because they're either waste and so it depends upon us consuming and hopefully we're going to cut down consumption on lots of things, or they are from biomass, which you grow on purpose and that things like sugars or algae but they use up land and water, that we might want to not use. You know, we might not want to turn the entire world into a massive farm for us, or that might compete with our food supply, you know, so, biomass and algae, there's a lot of potential in countries with a lot of landmass like the United States, but for the world on the whole, they are capacity limited. The European Union did a really good study on this, where they kind of showed biomass ramping up early, but then topping out in the in the kind of 20, late 2020s, 2030s and having a maximum use of about 25% of European demand. So then, in order to get all the way up to 100% of European flights being through sustainable aviation fuel, you need to turn to another type of sustainable aviation fuel, which is called power to liquids, or E fuel or synfuel. Now that power to liquid fuel is produced by taking hydrogen as a feedstock and also taking carbon dioxide, which you have to basically suck out of the atmosphere and that technology is not mature either. So then you've got two technologies that have potential to scale liquid hydrogen on aircraft or power to liquid SAF. And both of them need a lot of investment to scale, but in different places, one is on the aircraft, one is in developing, like direct air capture solutions. And both of the technology levels are immature. So what you really need to do is be pursuing both of those quite aggressively, and at certain points, it will become clear which one is going to pull through. But companies around the world are doing that. So you're seeing increasingly a number of aerospace companies pursuing both pathways in parallel, different emphasis, depending on which company you're talking about. But definitely looking at hydrogen as a route. Do we use hydrogen on aircraft? Or do we use the hydrogen to turn into E fuel or synfuel power to liquid? We really need to converge on just one name for that fuel, I think, and then you use that to fly around the world.

Steffan

Yeah, thanks. Now that's really comprehensive. And it sparks a couple of thoughts really, I think, your past couple of answers. But I suppose that the SAF and the fact that it kind of relies on us consuming and kind of waste products from that, is very similar to challenges in sort of heavier industry, perhaps 15 years ago, kind of waste derived fuels where it was always, just as you'd got the plant or the process set up for that fuel, then it changes and actually, as soon as you start consuming that, it becomes a different kind of commodity, it's no longer a waste. So yeah, it's very, very tricky, really, to get that. Right. There's also your comment about us being an island really, I know that's, unsurprisingly, real key issue with maritime as well. So it's not just about the vessel or the technology to you know, the transport element, if you like, it's knowing that when you get to your destination, you can use whatever fuel or technology they've got there. So yeah, hopefully, we're going to discuss that a little bit going forwards. We're running out of time, actually. But just something that keeps springing to my mind, you mentioned about safety and NASA and things like that is the public perception element, so I'm guessing this is a really key issue in this industry, I just wondered how the industry is tackling that really, or any considerations here?

Katie

Yeah, so people must be safe and it is a number one priority for Aviation that people are safe. Aviation has one of the strongest track records of any mobility sector and they want that to continue. So, ultimately, it's through testing, testing, testing. You know, that's, that's got to be the route and so before any passengers came anywhere close to those aircraft, they will be tested within an inch of their lives. One of the things that we've been looking at in the FlyZero project is what would that testing strategy be? We need to fly hydrogen aeroplanes, you know, we need to have them on flying test spades, we need demonstrator aircraft and all this stuff is time consuming. So the balance is trying to develop and test as aggressively as we can, so that we can begin to take these aircraft to market as fast as possible, so that we can begin to have some of the positive environmental impacts and fundamentally allow people to continue to fly on their holidays to, you know, to the Costa del Sol, because the the flip is, that if we don't decarbonize the the sector as in by 2050, it could be 25% of global emissions.

Steffan

Yeah, no, totally understand. The technology is one side but the kind of perception and people being comfortable with it, I suppose, be comfortable with the solution is probably as key as anything else. As I said, we are sort of running out of time to be quite honest. So thank you. Thank you so much. Yeah, we feel really fortunate that we've had you along with us today and hear about the scale of the opportunity that hydrogen and aviation present. Also recognising like Hannah said really that you know, we at KTN, very much appreciate you've got complementary technologies and we want, you know, the right solution, for the right fit. So, yeah, thank you everyone for listening. Any links mentioned today and a direct link to the Innovate UK KTN website will have been added to the description for this episode. Don't forget to sign up to receive the newsletters and updates. In the next episode. We're going to continue this theme of delving into a bit of detail but we're going to go onto maritime hopefully. So thanks again for following us. Please join us again and goodbye. Connecting for positive change