Note: this transcript has been produced verbatim and includes all the quirks and idiosyncrasies of the speakers.

Steffan
Connecting for positive change. Hello everyone and welcome to the first episode of the Hydrogenerally podcast series, brought to you by Innovate UK KTN. So I'm Steff Eldred from the Clean Energy and Infrastructure Team at Innovate UK KTN and along with my colleague, Simon Buckley, who leads on zero emission mobility, we will be leading you through today's opening episode. So take a break, grab a tea, grab a coffee, and join us. Hi, Simon.

Simon
Hi Steff, it's exciting to be involved in this foray into the world of podcasting. I'm Simon Buckley. I'm from Innovate UK KTN transport team, I look after zero emission mobility. And obviously hydrogen could be a big play in that field. The Hydrogenerally Podcast Series is giving a voice from the Hydrogen Innovation Network of Innovate UK KTN to explore the applications, opportunities and challenges of the hydrogen economy. So we're really looking at the end use case that's one of our primary aims. The Innovation Network, we're aiming to pull knowledge from existing hydrogen communities to help understand our challenges, to enable that clean hydrogen production at scale, on the uptake of that. If you haven't already, then you can go to the Innovate UK KTN website through the link in the description. You can sign up to receive newsletters, and updates. And as this series develops, you will find the future episodes here. So please go there for more information about Hydrogenerally as well.

Steffan
Thanks, Simon. So, for this first episode, we want to go back to basics. So a huge number of people have joined the hydrogen community over the past probably 12, even 18 months. At Innovate UK KTN, we receive a huge number of enquiries from other people wanting to do so and to see where to go, who the players are. Well, many of the existing players are some of the leading experts in the topic, we felt it'd be useful for newcomers to discuss the basics around how hydrogen is currently produced, how it will be produced in the future and how it will fit in with the energy system going forwards. So to help guide us through this, we are very pleased to welcome our special guest joining us today, Sam French is a Business Development Director at Johnson Matthey. Hi, Sam, would you like to just tell us a bit about yourself and about your role?

Sam
Okay, brilliant. And thanks for the invitation to join you both. So yeah, I've been working at Johnson Matthey, probably for about 17 years now, started in a very technical arena, computational chemistry, actually. But since then I move towards more applied applications of the chemistry background I have, before recently moving into business development. I suppose most of the work I've done in business development has been looking at opportunities to use new feedstocks, new low carbon feedstocks to produce the chemicals. So things like how do we bring renewable electricity into processes using biomass or waste. But more recently, or probably over about last five years, I've been very focused on low carbon hydrogen and we'll get into the different routes of manufacturing hydrogen. Now, I'm focused on green hydrogen, in a business that Johnson Massey launched about a year ago. And again, I know colours of hydrogen come up, we try and avoid them but it's hard to. So

I'm looking forward to the opportunity to go through this and lay out some of the real foundations of what we're trying to do here.

Simon
Thank you very much, Sam. Our first question is going to be about how hydrogen is produced? and maybe links slightly into those colours as well.

Sam
Yes, as I say, you can't avoid them. In reality, let's be clear at the outset, I think what we should be looking at is the carbon intensity of these different processes. And I think we'll unpack that later on, but it is hard to avoid the colours. So, most hydrogen today is made by a process called steam methane reforming, involves the conversion of fossil fuels and primarily natural gas, where you mix natural gas and the main component of natural gas is methane. So methane and steam and you break it into syngas and syngas is a really important thing, something Johnson Matthey has a really strong heritage in. Syngas is a mixture of carbon monoxide, carbon dioxide and hydrogen. Now, you can do a lot of things with syngas, you can make methanol for example, sustainable aviation fuels. It's one of the key processes intermediates in the manufacture of ammonia. And also critically for this discussion, hydrogen. So essentially you feed natural gas and steam into a flow sheet, which is a number of different unit operations that are all connected. First of all, we've got to take out any impurities from the natural gas. So things like sulphur, we then mix in the steam as mentioned, we break it in a steam methane reformer, where we have to put a lot of energy in and we'll come back to that, to drive the the reaction of breaking methane and to its constituent parts, because it's very stable. We then go through some what's called bought gas shift reactions. And here, what we're doing is trying to get more hydrogen into the product. And essentially, at the end of the day, we've then got to split that syngas, which is now predominantly hydrogen and CO2 into a pure hydrogen stream. So today, that's how most hydrogen is manufactured and we would turn that as grey hydrogen because it's been made from natural gas. The CO2 in that process is all emitted to atmosphere. So what we can look at doing is manufacturing hydrogen, where we capture that CO2, we remove it from the stream and actually then sequester it, using processes called carbon capture and storage. That's what people call blue hydrogen. The thing is, though, because we're changing the product that we want, so in grey hydrogen, the product we want is high purity, high pressure, hydrogen, and that's it. Blue hydrogen, we've now changed the product, we want high pressure, high purity hydrogen, but also high pressure and high purity CO2. What this means is actually you need to look at that flow sheet and think about whether all of the unit operations are right to produce that product as efficiently and cost effectively as possible. So what we've done at Johnson Massey has gone back and looked at that flow sheet, and realised that actually, using a steam methane reformer is probably not the right way to go. Because as I mentioned, you need to provide a lot of energy to drive the reaction. And in a steam methane reformer, what you do is you burn natural gas in burners to provide heat which drives the reaction in the steam methane reformer. That burning fuel to drive the reaction contributes about 40% of the CO2 footprint of the process. And that fuel, because you've combusted it in air leads through CO2 stream, which is really dilute an atmospheric pressure. And it's really expensive to capture that CO2. So if we want to get a truly low carbon, blue hydrogen, with a low carbon intensity, it's not a particularly efficient way of doing it. So what we've looked at is the use of what's called an auto-thermal reformer. Whereas rather than burning natural gas to drive the reaction, we use oxygen, which we

inject into the auto-thermal reformer. That means all of the CO2 produced is within the product stream, which means it's at high pressure and high concentration and much easier and more cost effective to capture at the end of the process where we're trying to split the streams of hydrogen and CO2. We also use a gas heated reformer in our flow sheets.

Because this makes the reaction even more efficient. So by looking back at the flow sheet, we can now really drive the efficiency of the process, driving down the overall cost, both the capital and the OPEX costs of the process and make a highly efficient flow sheet. To give you an example, where we're really driving down the carbon intensity and we're targeting over 95% total CO2 removal from the process, in the various projects that we're looking at, so this really can contribute to an overall hydrogen strategy. That blue hydrogen technology has been taken forward as part of the HyNet project, which is up in the Northwest of the UK, which is one of the first projects that's being supported by government. And we're also working with a number of the other clusters who are looking at their hydrogen technologies at the moment. Finally, and quickly. The other one, which we're seeing a lot of movement in is around green hydrogen. Green hydrogen is the electrolytic hydrogen production. Essentially, what we need there is renewable electricity and water. We bring the renewable electricity and water together in an electrolyzer stack, splitting that water into hydrogen and oxygen. So in some ways, a very simple process, and we can unpack some of the chemistry involved in there. But very simple, but equally, you know, highly efficient process that really will be the future of how we produce hydrogen in a low carbon, really sustainable way.

Simon
Thank you. And what about, I've heard of brown and black hydrogen and also pink hydrogen?

Sam
To be honest, Simon, there's a rainbow of colours of hydrogen. And so, okay, I think primarily, people talk about bright brown hydrogen is coming from coal. So essentially, you're gasifying coal, again, to make a syngas, which CO2 CO hydrogen, it will be a different ratio from what we had in natural gas, a highest carbon oxide content. And again, you're looking at various water gas shift processes before then separating the hydrogen and carbon oxides out. You could sequester the CO2 in that process as well. But primarily people aren't looking at doing that, partly because you're forming a lot of CO2. The driver in there is the low cost of coal, but really in a net zero ambition, that's not going to be a good way to be making hydrogen in the future. And pink hydrogen generally, I think that's where, again, people talk about different colours, but that's where you're using an electrolyzer again, but you're getting your electricity from nucular. Okay, so it's just a different provision of electricity up front of your electrolyzer and the electrolyzer can look exactly the same, it's just a different form as I say, of electricity, which will come with a different cost base, potentially a different production cycle, because you probably got more of a lack of baseload electricity, whereas with renewables, one of the elements that we need to work with is the fluctuations in availability of that electricity.

Steffan
Cool. Cheers Sam. We definitely got the right person on this podcast as we can tell and the 95% reduction in CO2 you talked about sounds like an amazing development on the blue

side. Do you just have it off the top of your head? Do you just happen to have rough percentages of what the current UK production mix looks like?

Sam
Yeah, so in reality, nearly all hydrogen made today in the UK is grey hydrogen, from fossil fuels. We don't actually produce a whole lot of hydrogen today in the UK. So quickly, the largest users of hydrogen globally, are refineries and the key element there you're doing is removing sulphur out of crude. So cleaning up petrol and diesel essentially, so an important process, particularly for air pollution. And then the other ones are ammonia production and methanol production. So we do have a couple of ammonia plants in the UK, again, so you're using hydrogen to then insert into the Haber-Bosch loop. And there are a couple of steam methane reforms on refineries. They're also some hydrogen produced as a byproduct from chlor-alkali processes and some small electrolyzers. So in reality, our hydrogen production today is really small. But what you'll have seen within the Ten Point Plan and the hydrogen strategy that was released by government last year, is a five gigawatt ambition and I'm hoping we're beyond ambition to target by 2030. So we're going to have to get going and we're going to have to be deploying large projects. And quickly, I mentioned earlier, HyNet up in the Northwest of the UK, that's on the Stanlow Refinery. So again, providing hydrogen into refinery complex. But in this case, we're now providing low carbon, very low carbon hydrogen. And that's phase one, the subsequent phases, we'll start looking at how you should switch away from natural gas, for example, in glass manufacturer at the likes of Pilkington and really starting to build low carbon hydrogen out as a fuel source into an industrial environment there. On the Northeast coast the first carbon capture and storage cluster that's going forward is a combination of projects out of the Humber and Teesside. Both of those also have real ambitious plans for low carbon hydrogen, the reserve cluster at the moment is up in Scotland, up near St Fergus where a lot of UK natural gas lands and that will need to come online as well, before, way before the 2030s. If we're going to hit that five gigawatt target. Critically, this shouldn't be all about blue hydrogen though and we're very supportive of the government's twin track approach, where we also need really large projects, green hydrogen projects coming forward. But then also some smaller projects which are more delocalised. For example, some that are really, one area that's gaining traction, which is interesting, is the use of hydrogen in distilleries, particularly whiskey distilleries, where they're shifting away from using natural gases of fuel to using hydrogen. Now, you can understand to some extent that that's a product, a premium product that can probably afford an increased price in their energy bill. So we have to be realistic that that's a bit of a niche application. But it's a really good example of how hydrogen can work in a delocalised environment, as well as the large industrial clusters that I've mentioned.

Simon
Thanks for mentioning the UK hydrogen strategy. So it was a key thing to look at for everyone in the space. Steff, there was a number of consultations within that strategy, don't know if you could just give us a quick overview of those consultations.

Steffan
Well the hydrogen strategy was sort of eagerly anticipated for what felt like most of last year and it sort of landed about August time. They refer a lot to low carbon hydrogen playing a significant role. And as Sam has spoken about comprehensively, that definition of low carbon kind of includes blue and green. We've already mentioned about the twin track approach,

which means that the blue hydrogen can be scaled up significantly to 2030 and help establish the infrastructure and demand. But then at the same time, green production, green hydrogen production can be demonstrated at scale and you can focus on reducing the production cost. I think we'd all like to see more focus on the green side. But understand that blue is key and especially with what Sam's mentioned about that 95% reduction in CO2, blue is obviously key to getting it moving in the short term. There's a lot of activity surrounding that strategy and coming out of the strategy and so there was a big consultation on the low carbon hydrogen standard. So in terms of just standardising what we're referring to when we talk about low carbon, hydrogen and I think the outcome of that is due out any day now. So I think that will be key. And then also, any day now or certainly into this year, were waiting for the net zero hydrogen fund to be launched, which has more of a focus on green and there's 240 million in the pot for that one. So again, I think that'll be key to helping to drive that. I mean, Sam, you've already mentioned about the twin track approach. Do you know much more about the low carbon hydrogen standard coming out shortly?

Sam
We were in conversation with Bayes yesterday and I think we will, as you've mentioned, see that low carbon hydrogen standard come forward fairly soon. I think at the moment, they're looking at a single threshold. And essentially, that will be the threshold that gives you access to the business models and also to some extent some of the funding through the net zero hydrogen fund. When we replied to the consultation, we were pushing for a high barrier to that standard, because we really think that, particularly I suppose for blue hygiene, it's got to be squeaky clean, if it's going to be viewed as being part of a net zero strategy. I've mentioned 95%. In reality, we're pushing higher than that with some of the particularly for example HyNet. I think, though, that is important. And some my colleagues would be telling me off for talking about percentages, because we really should be talking about carbon intensities. Because whilst, yes, it sounds great to have a threshold of 95%, if you've got a really low efficiency process, and you're producing lots of CO2, that 5% still could be quite a lot. So let's remember, there's a combination of what the efficiency of the process is, as well as what the efficiency of the capture plant on the back is. And what we're really trying to do is push those both as high as possible. What we think at the moment, is that it is likely that initially, there'll be a lower threshold to get more projects in. I worry a little bit, though, that for particularly for something like a blue hydrogen project it's likely to have, you know, at least a 20 year life to get the kind of the asset value and the payback for that project. And so if we're putting those on the ground, we really need to have a think of what the targets, you know that that's heading out to 2045, you know, we're five years off our need to be at net zero. So we should really make sure the projects going down today are future proofed. I think the other bit that sort of struggling with is where you draw the boundary, which is understandable. And how you deal with things like electrolyzers, when they're running on the grid, how do you count the carbon intensity of that hydrogen, when the grid clearly is fluctuating? It's becoming, you know, the direction of travels to a lower carbon intensity grid. But today, still, we rely on fossil fuels natural gas, primarily, probably for 50% of our electricity requirement. So I can see, it's not an easy thing to do but I think they're going about it in a good way by really having an open consultation. I think the comment when we spoke yesterday, that was there really wasn't that much of a consensus in actually what the absolute figures should be. But, you know, so they've got work to do.

Steffan

Thanks, Sam. Yeah, really, really comprehensive again. I think we're coming to the end of our time, it's been great to discuss this. Just Simon, very quickly, I know you're passionate about the need for green. In our next episode, we're going to be talking about how and where hydrogen should be used. So appreciating that this is a whole podcast in itself. But I just wondered, in a nutshell, if you had any thoughts on how the transport community feel about the green hydrogen space?

Simon
Yeah, I think it very much depends on what type of transport you're talking about. Because obviously, that is covering everything from micromobility, where hydrogen almost definitely is not suitable to aviation or maritime where it may be much more suitable. Generally, obviously, in transport applications, as with all business, money, and cost of operation is really important. There's also net zero into the mix, with net zero, there are various targets for passenger cars, HGVs. There's also maritime 2050 plan and our move to Jet Zero as well. And to achieve those roles, particularly in the heavier sectors, hydrogen is clear, is going to play a key part. So there's particular keenness I think, in the aviation sector, maritime sector, and also the HGV sector to explore hydrogen and how it can work. Also, there's quite a few hydrogen buses out there and they're being trialled up and down the country or more than trialled, in service up and down the country. And we've got a really Innovate UK and DFT have got hydrogen freight trial. So we've been doing feasibility projects over the last six months. And in the spending review, you can see that there's a large amount of money to aviation maritime and HGVs and I think hydrogen could play a key part in some of those.

Steffan
Cool. That's great cheers Simon. It's exciting times, isn't it? I think in the interest of keeping our first episode short and snappy, I think we're going to wrap up there. So thank you so much, Sam. It's always tricky to ask some of the more basic questions in a community that feels like it's absolutely filled with experts. So, I'm sure our listeners have welcomed that. Thank you all for listening. We've added the useful links and a direct link to the Innovate UK KTN website in the description. Don't forget to sign up and receive newsletters and updates. And in the next episode, as we just said we'll explore sort of where hydrogen should be used. So thanks again for following us. We hope you've enjoyed the first episode and until next time, goodbye. Connecting for positive change