Battery Caffè - Batteries in Rail

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Welcome everyone to this episode of the Battery Caffè, focusing on batteries for rail. I'm Nikoleta Piperidou from the clean energy and infrastructure team at Innovate UK Business Connect, hosting today's episode alongside my colleague, Debra Jones. Debra, over to you.

Hi everyone, my name is Debra. I'm part of the Chemistry and Industrial Biotechnology team here at Innovate UK Business Connect. I work across a variety of sectors where they need a chemistry input, including critical material supply chains, sustainable fuels and chemicals, hydrogen and also batteries. I'm really happy to be here.

Thank you very much, Debra. And just a little bit of an introduction to today's episode. So the Battery Caffè is an initiative of the Cross-sector Battery Systems Innovation Network, a community funded by Innovate UK and the Faraday Battery Challenge. The Innovation Network aims to open new markets for the battery industry, promote innovation of batteries and help decarbonise a wide range of end users, so if you haven't already, please go check out our online platform at ukbatteriesnetwork.org, you'll find lots of useful material and both our first series with episodes on investment of batteries, battery recycling, market trends for solid state batteries, as well as our second series, which is primarily looking at different end use markets. So today's episode, we have two fantastic guests, Matthew Prosser, Asset Management Director at Angel Trains, and Robert Hay, Technical Advisor at the Railway Industry Association. So I'll start with you Matt, would you like to introduce yourself?

Yeah, thanks very much Nikoleta, very pleased to be here this afternoon.. I'm the Asset Management Director at Angel Trains, and we're a rolling stock leasing company, which means that we own trains, in our case, more than 4000 passenger carriages, and we lease those to train operators in Great Britain. Now, my role in the organisation is to lead the team that manage those assets throughout their life cycle. And we do that in a variety of different ways, depending on the type of leasing arrangements those trains are under. But the life cycle of a train is quite long - it's typically 35 to 40 years, so we have a very long-term view over the life of those assets.

Thank you very much Matt. And Rob, would you like to also introduce yourself?

Thanks. Yeah. My name is Robert Hay. I'm Technical Advisor for the Railway Industry Association, RIA, which is a membership association for the supply chain in the UK to the railway industry, both infrastructure and rolling stock. And we've got about 400 to 450 members currently. We say that our membership can build a train and build a railway. So we've got members through the whole supply chain. Personally, I'm a Chartered Mechanical Engineer. My previous role before RIA, I was Technical Manager at a train operating company, so lived with

the day to day challenges of running a railway. And I've also worked for an engine manufacturer, a train manufacturer and automotive manufacturer.

Thank you very much, Rob. And yes, at this point I will say, please make yourselves a coffee, everyone and join us today. We're talking about battery trends and opportunities and solutions when integrating batteries in the rail sector.

So Rob, let's start with you please, if I might. Would you be able to give us an overview of where you think things are going with the electrification of the rail industry, and how you see the role of batteries evolving.

I've done quite a bit of thinking in this field. Last year, we published a paper on, can we have a decarbonised railway by 2050? And our view was that currently, about a third of the railway is electrified. To have a decent decarbonised railway, we need to electrify another 30% and the final 30% we expect to be able to run with battery traction. Even at higher rates of electrification that we're seeing now, the additional third of electrification won't happen for 25-30 years and beyond. Full electrification for the railway is probably the right solution for high-speed rail and areas where there's significant freight usage. One of the benefits of knowing what is going to be electrified is actually it opens up what we know is not going to be electrified. And if you know what's not going to be electrified, then you can start implementing the solution just now. So that's one of the things that we are pushing for. We know that the final solution for the non-electrified is very likely to be battery traction, either battery on its own, or battery with diesel and electric multi-mode. And this is already happening. It's happening in the core Valley lines in Wales. It's happening in Merseyside, where we have multiple trains with batteries. So that's what we see, a nice spread of electrification and batteries between now and 2050 we hope when we have a final decarbonised railway.

Thanks, Rob. I guess it's really exciting to hear that there is no sort of one size fits all solution. And I guess that's one thing we have to think about all the time. And it's also great to hear that things have already started. We've already started putting batteries in trains, and that's already in motion. Thanks, Rob.

Yes, this was a great introduction to the topic. And Matt from an Angel Trains perspective, would you like to tell us about your latest trials. We also read in the news a couple of months ago about the recent investment in a new battery hybrid train fleet. And where do you see things heading? Over to you Matt.

Yeah, thank you. Look as Rob just set out there, there's a number of different ways of doing this, and some of the solutions are electric, battery electric, or tri mode, as we call it. So battery electric diesel. So a trial that we co-funded last year with Hitachi was to run a trial on a train that we own, a relatively modern train - it's a Hitachi class 802 unit that's operated by TransPennine Express. And that train is a bi-mode train, which means it's an electric train with diesel engines on it as well. And in this case, it's got three diesel engines or generator units under the five-

coach train. So the purpose of the trial was to say,well, can we take one of those diesel engines or generator units off, replace it with a battery system, and run the train in a number of different modes, and understand how it performs in real world conditions. And that sounds quite simple but, but it was actually quite a complicated modification. It's not just as simple as putting a battery in the space where the diesel engine was. You've got to think about the enclosure system for the batteries, how to protect it, how to protect those batteries from damage, and to protect the train in the event that those batteries may catch fire. And as part of that, also a fairly complicated, or complex cooling and heating system to manage the thermal management of the of the battery system. So Hitachi did this work at their factory in Newton Aycliffe in the Northeast of England, and it was tested last autumn, and it ran over 11,000 miles during its testing programme, mainly at night, when we could get space on the railway to do it. And the results we got from it, in many ways, exceeded the expectations. First of all, it proved that the technology could be retrofitted to a train like that. The train performed extremely reliably during those 11,000 miles. It was able to achieve nearly 90 miles an hour on battery power only, and the range of the train was around 44 miles on battery mode, or when it ran in hybrid. So that's the battery and the remaining two generator units together, the range of the battery was up to nearly 90 miles. But actually, the really important thing here is what that trial proved is that a significant reduction in the amount of diesel fuel that the train burned and in hybrid mode, so when the battery is operating in conjunction with the two diesel engines, there was a 35% reduction in the amount of fuel that it used, and we were able to demonstrate that the train could also recharge its battery from the overhead line when it was operating under the overhead line. So that trial was really successful, and the beauty of that system is that it's entirely scalable. So the trial was replacing one generator unit with a battery you could replace two or even three. And of course, the other benefits of doing this is it allowed the train to run into stations with the engines off, so that provided quieter operation. Quite significant other environmental impact of running diesel trains, and also those local emissions from the diesel engine weren't there when the train was operating in battery mode, in and out of stations. So, we see definitely a future for this type of technology. And actually, as a direct result of doing this trial, it gave both us as the owner and also Grand Central as the operator, the confidence to order a fleet of these trains to replace their existing diesel trains for their operation up the East Coast Main Line. So, in many ways, although it was a trial where the train has now been reverted to standard and returned to TransPennine, it gave the industry, gave us and gave the operator, confidence that this technology is a very, very viable solution for some real world problems that Rob set out in the industry.

Thank you very much, Matt, that was a great overview of where things are going with an Angel Trains. And we understand, of course, that introducing new technologies doesn't come without challenges. And you kind of alluded to a few just right now. But where do you see the main challenges when introducing batteries in the rail industry, would you say? Is it mainly technical, regulatory, a mix of both, something completely different? Robert this time, let's start with you.

I don't want to make the task seem simple that Matt's just discussed, but technically, we've had a couple of successful battery trials that say that whilst it might be difficult, it's not impossible. So the technical challenges, I think, with good engineering, can be overcome, regulatory challenges

the whole industry, I think, is behind bringing batteries in. The Office of Road and Rail, the RSSB (the Rail Safety Standards Board), the owners, the operators and Network Rail, they're all behind and there's a lot of forums and there's a lot of work to overcome the regulatory challenges. And I really don't think that will be a significant challenge bringing battery trains in. One of the challenges that I do see bringing batteries to the trains in is just the supply of electricity. We currently run diesel trains and diesel brings an awful lot of energy into the railway and to transportation in general, and replacing that energy with electricity is going to be a challenge, whether that's to power more electric trains, or whether that's to charge batteries either static or underneath the OLE (Overhead Line Equipment). Currently, there's places with the overhead line that we're at capacity anyway for electricity supply to trains, and we can't run any more services, and then our diesel engines running in that area. So to replace those diesel engines with electric is going to be very, very difficult. So that's one of the, one of the big challenges that I can see. And I really, I really do like talking about this, because some people seem to miss it. Trains are hugely energy efficient, though, when it comes to moving people and goods around. And if we do have an energy constrained future, then trains really need to be a part of it. So even though it's a problem, I think, or a challenge, I think it's a challenge that the country needs to think about overcoming.

Thank you very much, Rob. And Matt, obviously you have different perspective from where you sit within the rail industry, what are your thoughts? Would you agree on those challenges? Is there anything else you've noticed from your experience?

Yeah, the answer is yes. I agree with everything that Rob has said. And the challenge is, and we can perhaps talk about some of the technical challenges, because there are a few, but certainly the biggest challenge is introducing this technology onto rolling stock means that effectively, you are delivering much more of a system solution than you do with a diesel train on its own. A diesel train, because it carries its own power and energy source around with it in vast quantity, can pretty much operate anywhere that its gauge is cleared to do so. Introducing battery trains really does have a strong dependence on the infrastructure that's available, and that's both in terms of, as Rob just said, the overhead lines or third rail system, which is already there, the capability of that to both run additional trains, which were diesel trains, but will operate under electricity of some form. And remember that the electricity that goes into a battery has to come from the system somewhere. So the system has to be able to provide that energy, not only to drive the train, but also to recharge the battery for when it's operating away from the OLE. But also in terms of the amount of OLE that's available. And this is one of the points I made before about the scalable approach of the trial that we did, because the choice of whether you replace one, two or three diesel engines with batteries is largely a function of how far that train needs to go away from the overhead wires. So what I think you will see in the future, and the paper that Rob described, sort of does set this out, is in order for those decisions to be made about what type of train you need to operate on the infrastructure, there needs to be a choice about what infrastructure upgrades will be needed to support the train, both in terms of existing OLE but also whether you have some discontinuous electrification or charging stations at stations to recharge the battery. And that way, in that way, it becomes much more of a system type approach that that certainly a diesel only train really ever had to worry about. And

then, of course, there's some other considerations about the challenges - operational challenges. So battery trains will need to be managed in a different way to certainly electric trains and diesel trains. And one of the things you really need to think about is what happens during disruption, when there's service perturbation? That means a train that has a certain amount of range under with its battery. How will you manage a situation where your ability to recharge may not be there if the train is diverted, or if there are problems with the overhead power supply, and I think where the focus therefore needs to be, is about energy conservation and energy efficiency in new trains. And we're certainly seeing this type of technology already in automotive - so if you buy an electric EV, many EVs now have heat pumps, for example, to heat the trains, because they are much more efficient in their use of electrical energy. So I think that whole energy management system on a train also needs to be thought about in conjunction with how big and what type of chemistry the battery will have on the train.

Thank you both. It's really nice to hear that there seems to be more of a sort of systems thinking, holistic approach to the rail sector generally, rather than just, how do you get a battery on a train. Really, really nice to hear that. So we recently held a Cross-sector Battery Showcase event where we discussed about embedding safety in battery innovation. Is that something you see as a big concern Matt?

Yes, it's a concern, but it's a concern which can be managed. I mean, clearly the biggest risk with batteries are thermal events or fires, and it's how you manage those on a train which has a much, much bigger battery than you would find in many other applications, but I think the answer is yes, you can do it. And I think the trial that we undertook and some of those other battery trains that we're seeing introduced in Great Britain and across Europe show that these risks can be managed effectively using technologies which prevent the batteries from overheating in the first place, before they start thermal runaway. And then if they did start to thermally run away, that the batteries are contained and modularised in effective containers that can contain that battery for the amount of time that's needed until, until that that fire can be dealt with, as well as the battery management systems to manage the heating and cooling the battery. So, I think the answer is yes. The industry is in the process of drafting a standard which will provide the framework around which the safety decisions can be made, and it looks at things like gas detection, fire detection, off-gassing, containment, storage and handling of batteries. So they're all pretty well-known risks, which I don't think will hold back the deployment of batteries on rolling stock.

Thank you very much, Matt. And it's great to hear that whilst it is, let's say, a slight concern, it is actually all manageable and the right actions are being taken care of. So that's all great to hear. And just the closing question for Rob, so if you were to predict, how would you see the rail industry being shaped in terms of different technologies and innovation in general in the next 10 to 15 years?

So I'm representing the Railway Industry Association. We've got over 400 members, and 70% of them are SMEs, and a significant portion of them have got ideas and new technology and things

they want to bring into the railway to take it forward. It's a very exciting place to be. It's perfectly placed to be a leader in decarbonizing transport recently, since recently, since the mid 1990s due to, competition, how rolling stock has been funded, we've seen huge progress and performance and passenger satisfaction in the railway. And I hope that that continues with the introduction of the new governance under GBR. I hope it still allows that place where innovation can happen. Due to the size of the network and the varied geography across the UK, there's not going to be one solution. There's going to be many, many solutions. Difference in service profiles, whether it's a high-speed train or a local metro or a low frequency, rural line in the north of Scotland. Variations in power supply, whether you can get rechargeable power to charge lineside batteries. There's so many options for how we can set up services, set up lines and set up fleets, that it's going to be a really, really interesting and exciting place to work, place to be involved in, and I'm looking forward to seeing what happens.

Thank you very much to our brilliant guests, and to Nikoleta and thank you all for listening. We hope you enjoyed this discussion as much as we did, and don't forget to visit our online hub on UK batteries network.org and register to receive our news and updates and participate in the networking area of the hub. Bye for now.

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