

Unknown Speaker

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Nikoleta

Welcome everyone to the fifth episode of the Battery Caffè, focusing on solutions for off-highway vehicles. I'm Nikoleta Piperidou from the Clean Energy and Infrastructure Team at KTN hosting today's episode alongside my colleague, Sheena Hindocha. Hi Sheena.

Sheena

Hi, Nikoleta, hi, everyone. It's great to be back. Sheena Hindocha from KTN's Chemistry and Industrial Biotechnology Team.

Nikoleta

Thank you. And the Battery Caffè is an initiative of the Cross-Sector Battery Systems Innovation Network, a community funded by KTN and the Faraday Battery Challenge. The Innovation Network aims to open new markets for the battery industry, promote innovation in batteries, and help decarbonize a wide range of end-users. If you haven't already, please go check out our online platform at [ukbatteriesnetwork.org](http://ukbatteriesnetwork.org) you'll find lots of useful material and our first four episodes on investment in batteries, battery recycling, market trends for solid-state batteries, and EV fire safety. Today with us two very special guests, Steve Abbott, Business Development Manager at Hyperdrive. Hi Steve.

Steve

Hello, yeah, I'm, my name is Steve Abbott. I'm Business Development Manager for Hyperdrive, been with the company for around seven years and in that time, we've grown from an engineering consultancy to a volume manufacturer of lithium-ion battery systems. Off-highways is a key area for us. So hopefully I can bring some insight from some of the work we've done.

Nikoleta

Thank you very much. And Jon Regnard, Automotive Trend Strategist at the Advanced Propulsion Centre. Hi, Jon.

Jon

Hi, Nikoleta. Thanks for having me. So my name is Jon Regnard, I'm an Automotive Trend Strategist at the Advanced Propulsion Centre. I've been there for about six years now. And my job really is twofold. One is to look after the automotive capsule roadmaps, so that's looking at different products like cars, buses, but also off-highway vehicles and heavy goods vehicles. And also the technology roadmaps, so batteries, motors, power electronics, and they feed into the product roadmaps. And my second role at the APC really is understanding the supply chain for next-generation technologies. And really, where are attractive places for the UK to

invest in. So, really pleased to be on the show today to talk about some opportunities and trends in the off-highway sector.

Nikoleta

Thank you very much, Jon. So everyone, please make yourselves a coffee and join us. Today we're talking about battery solutions for off-highway vehicles. Jon, can you give us an overview of some of the challenges associated with off-highway and the sectors where this is the biggest issue?

Jon

Yeah, so I'll kick-off. So the first challenge is sort of the term off-highway itself. It's kind of a catch-all term for such a diverse range of products. And all the different niches within such a broad catch-all. So you've got small forklifts and diggers that can run off sort of 48 volt systems right through to massive mining equipment with hundreds of kilowatt-hour batteries and operate over 1000 volts. And I think due to this divergence, most vehicle classes are produced under the off-highway plus they tend to be really low volumes. So a big challenge is being able to source sort of the powertrain components and batteries included that an affordable price. Yes, we see battery prices declining by you know, 90% in 2010. But that's really only available for the large volume passenger car OEMs. For the smaller players in the off-highway sector, they can't get access to that kind of cheaper battery. But there is early evidence, some of the battery types of these off-highway machineries is going down, and probably another big challenge I'd like to talk about is just the total cost of ownership as well, is that when you buy a passenger car, it's always about the sticker price that you're worried about. The economics is different when you look at off-highway vehicles because primarily they're a workhorse. So they do a job, they don't move people from A to B. So, therefore, ensuring that off-highway vehicles are as cost-effective to run as possible and can generate revenue in the same way as the ICE technology, I think is an essential challenge to overcome.

Sheena

That's super interesting, John, that difference between the passenger vehicle market and the off-highway market is really interesting. Thank you. So Steve, as a solution provider working in this space, can you take us through some of the potential solutions that can be applied, and potentially address the challenges that Jon's just mentioned?

Steve

Yeah, I agree with all of those comments really that the diversity, the low volume nature of things and the emphasis on cost ownership, I suppose what we've done is as Hyperdrive, we've always focused on being able to provide something that's better than a traditional engine, rather than just more environmentally friendly. So that kind of focuses on the business case, and total cost of ownership and understanding the costs of ownership, which vary quite significantly, depending on

where the batteries are being used and where and how they're being used in terms of the duty cycle. So what we've done is we've been working with some off-highway machinery and vehicle manufacturers, and most have got relatively low volume, so it's not mainstream automotive volume. But they've also got the challenge that they've got other machines in the same range. So they really are looking for standardisation in a relatively non-standard world. So what we've done is we've developed something in the mid-ground where it's a, it's an off the shelf, it's a universal modular battery system, which comes together, uses the best automotive battery cell technology, and means that customers can adopt that, knowing that it's based on proven technology. This means that we can, and where we've been successful, we can offer economies of scale, we can take away a lot of the engineering development and kind of lower that investment barrier for the customer. Because even though the environmental legislation to a lesser or greater degree, depending on the market is driving demand is driving the change, there does need to be the business case for it. And that's only where, where they will succeed and where we will succeed. We have also for companies, so even very established engineering businesses and manufacturers, this is all very new to them. So they've got teams of mechanical engineers. And really, the electrical and the electronics side of things has been relatively new. So we have put our team into projects working very closely with customers to really prove concepts and to get machines up and running to really show their customers that it is possible to not just equal the performance, but better the performance to sell that machine into the market.

Sheena

That's great. And it's really key, I guess, to show and demonstrate that those technologies work in those different challenging environments. Nikoleta, so we recently delivered a webinar or workshop on the top of this topic within the Innovation Network. Can you tell us some of the key findings from that activity?

Nikoleta

Yes, thank you, Sheena. That was a great activity. So a few weeks ago, we held a webinar and a workshop jointly with the Hydrogen Economy Innovation Network. And we brought together challenge holders from the construction, agriculture and defence sectors, as well as solution providers, both from the batteries and the hydrogen sectors. And it was really nice to work all together on this. So for anyone who's listening in and missed the webinar, you can find the recording on KTN's website. During the workshop, lots of interesting points were raised similar to the points that Jon and Steve raised. So we looked at the technical challenges, infrastructure requirements, the need for more energy-dense batteries, next-generation batteries etc. We also looked at non-technical challenges such as business models and the role of behavioural chains. And we tried to map the innovation activity and gaps where further support is needed. So such as portable charging capability outside of automotive, modular systems for heavy equipment, hydrogen or battery, and the need for retrofit and conversion demonstrators. We will

be circulating the outputs through our newsletter. So please do sign up to see all the outputs from that work. And, Jon, a question for you. APC recently launched an off-highway and heavy-duty roadmap. Can you tell us a little bit more about the key highlights from that?

Jon

Yeah, sure. So the off-highway and heavy-duty roadmap are basically heavy-duty vehicles over three and a half tonnes and off-highway vehicles across a broad weight spectrum. And really, this roadmap puts the energy versus power demand central to how it's constructed. So there are three distinct clusters of off-highway vehicles that we've defined. So the first is urban services and lower-powered off-highway vehicles. These vehicles have a smaller power requirement. Maybe a forklift or a small electric digger like the one JCB produced a few years ago. They may also operate under restricted access. So either in an air quality zone or indoors where it's a bit more hazardous to run an ICE engine. So in terms of battery technology, we feel that this cluster is where battery technology is likely going to be adopted first through technology transfer over from high volume automotive, so expect things like lithium-ion phosphate or some NMC to start replacing the ICE or lead-acid batteries. But I've read recently that some technology companies like Nitride Energy who looking at using sodium ions, which is high powered sodium ions for material handling equipment, so that's an interesting thing to watch out for. And then the second category of vehicles is long-range, high powered off-highway vehicles. So these vehicles need to traverse long distances or work for very long periods of time. So the types of vehicles here are like backhoe loaders, large excavators, perhaps mining equipment that isn't tethered and is away from energy infrastructure. So we think BEVs and fuel cells for these will be likely dedicated platforms that are custom-built for kind of that application. And for batteries to provide the sole propulsion for that will have to be advanced lithium-ion chemistry or even next-generation cell chemistry will be needed. And even for those applications that could transition to fuel cells, you're still going to need a high power battery, or an ultracapacitor to manage the peak demands of power for a few seconds or minutes as well. And then the third category of vehicle is something that we call external energy source. And these can be across many power levels. But the unique thing about this category is that the vehicle has a dedicated energy source on-site that's required for them. So to give an example, these solutions could be quite a niche. So it can be farmed using excess farm waste to create biomethane to fuel tractors, so it's closed-loop fuelling. And there's an APC project actually looking at biomethane tractors with CNH. But also tethered mining vehicles as well that uses the electricity grid from a local mining operation. And it's sort of got an umbilical cord that attaches to the vehicle, it has a high powered power train as well. So what distinguishes this category from long-range high power is the fact that it's the onboard energy storage of these is significantly lower because it relies more on energy infrastructure around it. Another highlight of the roadmap, which was interesting to me, especially in the context of off-highway, is also powertrain system efficiency from the perspective of

the hydraulic systems as well. So you can replace, you know, an engine system with a BEV system, or a battery or a fuel cell, but the hydraulic systems that you know, do the lifting and the work, the way they're currently manufactured, is quite inefficient, and you lose all the efficiency you gain from electric motors, batteries, so new novel, sort of hydraulic systems. And there's another APC project called V to displace, it's looking at novel hydraulics systems to improve efficiency radically, with Danfoss and Artemis. So, again, these are some of the things that, you know, come out of the roadmaps.

Nikoleta

Thank you very much. Excellent highlights. And, Steve, are you able to tell us about some of the off-highway projects you and Hyperdrive have been involved in?

Steve

Yes, definitely. What's been quite nice, just thinking about this question is that hyperdrive, we've actually been quite flexible. So we've been in the production of battery systems for probably the last five years or so. And we've had to be quite flexible, because we noticed that larger companies, whilst the end, kind of, the reward may be quite big, they do tend to move quite slowly. So we needed to build a manufacturing facility which to get the economies of scale which served a wide range of markets. So we've got a really nice mix of what you might call kind of new technology district disruptors, big, bigger multinationals who are a bit more staged in their process development and then smaller companies who might be moving over to electrification or even an aftermarket company looking to be quite agile and get a product to market before OEMs. So we've got a really nice mix. So in terms of sectors, construction is very much leading the way, work with JCB has been widely publicised with this small electric excavator but then a whole host of other machines and, kind of, supporting infrastructure. We've worked well with another British brand, Dennis Mowers, who've moved very quickly to selling their electric fully electric mowers, worldwide, and are also now developing new models. We've got some bigger multinational customers in Europe, looking at going into production of electric alternatives to engines for a host of applications from truck-mounted forklifts, transportable refrigeration systems, air compressors, aerial lifts. And we're also working with a company in the Netherlands called Lemac. And what's interesting about what they're doing is that they're actually electrifying some quite big excavators with sole batteries. They're going up to nine tonnes. And they're even developing some quite novel battery swap solutions. And there's a particular need in the Netherlands in a very incentivized market to get all of their construction sites moved over to cleaner technology. So yeah, we've been quite flexible in the kind of customers we're working with. And it's, it's been very interesting.

Sheena

Sounds like you've been kept really busy. Steve, which is great to hear, to be honest. So, Jon, you've mentioned the APC roadmap. And already Steve touched a little bit

on the adoption of some of the technology. Could you sort of, what do you think are the biggest challenges for the adoption of off-highway solutions?

Jon

Yeah, good question. So I think the one that, the thing that gets cited the most is, especially for larger off-highway machines, is the high CAPEX cost of the battery, the big barrier. So with the battery off-highway equipment, that's larger can be around two to three times more expensive. But without the battery, it's only you know, 20%, say more expensive. So some companies are moving to this sort of battery as a service business model, or the user pays per kilowatt-hour or megawatt-hour of energy it uses. And so the power train providers are kind of helping the mining operators or the construction operators by shifting the expense from an upfront CAPEX cost to operational costs throughout the year. And I think that can help reduce the burden of having to shell out for the battery upfront. So that's one way. Another challenge that is probably more pertinent in off-highway and some construction is reliability and safety. And it's key to maintaining profitability as well. So downtime is lost revenue. So ensuring any BEV platform minimises unscheduled downtime, and is safe, because the last thing you want is a massive fire, especially in an enclosed environment is critical. So I think, end customers and OEMs are kind of willing to sacrifice a little bit of energy density and some costs to ensure reliability and safety. On the energy density point, you can kind of see the Sandvig, for example, have adopted a sodium nickel chloride battery, so not as energy-dense as who I am. But it's been adopted in some of their mining equipment because it's inherently safer. And then another challenge is, I think, also did say, they're willing to sacrifice urgency to safety. There is a need for more energy density for those larger vehicle types. I think when you go above, you know, Steve said that nine tonnes, I really think you need a completely different battery that can both do higher power densities and energy densities. And actually, in the APC, electrical energy storage roadmap and the Cross-Sector Battery report that was done by KTN, and I think we identified this cluster of applications that require high energy and high power density. And I think the larger off-highway vehicles sort of fit in that cluster. And it needs kind of next-gen chemistry so either solid-state or lithium metal anodes, or silicon dominant anodes, to be able to have that step change in energy density, and I still think that's five or seven years off. And my final challenge is, I think, to try and get over some of the cynicism or the sort of reticence to adopt these, I think, probably providing robust in-use data, as well to mine operators or construction people who operate construction sites, about, the operational costs, advantages of running BEV diggers, and I'll bet Steve has probably more info on this. But so because there's not many around I suppose there's not many miles or hours that are done with these machines. So I think making that more available or having more data there to sort of ensuring confidence similar to what happened with buses, I think there's loads of data to show to save money and then it takes time to go off now. So there's, I think, some of the challenges.

Nikoleta

Thank you very much, Jon. That was excellent. And thank you again to our brilliant guests, and thank you all for listening. We hope you enjoyed the discussion as much as we did. And don't forget to visit our online hub on [ukbatteriesnetwork.org](http://ukbatteriesnetwork.org) and register to receive our news and updates and participate in the networking area of the hub. You will also find the Cross-Sector target report that Jon just referenced on the hub so please do go check it out. This is the last episode of the series. But we were really pleased to see so much interest in this series so we will be back. Bye for now, bye.

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