

The Battery Caffè - Batteries for Off-highway

Innovate UK, the UK's Innovation Agency.

Welcome everyone to this episode of the Battery Caffè, focusing on batteries for off-highway applications. I'm Neelam Mughal, from the clean energy and infrastructure team at Innovate UK Business Connect, hosting today's episode alongside my colleague, Debra.

Hi everyone. I'm Debra Jones. I'm the Chemistry Knowledge Transfer Manager in the Chemistry and Industrial Biotechnology team here at Innovate UK Business Connect. I work across a variety of sectors, including critical materials, sustainable fuels and chemicals, hydrogen, and today I've got my batteries hat on, so I'm really happy to be here.

Thanks, Debra. So just as a reminder to our guests, today, the Battery Caffè is an initiative of the cross-sector battery systems, Innovation Network. Community funded by Innovate UK and the Faraday battery challenge. So, the Innovation Network aims to open up new markets for the battery industry, promote innovation in batteries and help decarbonise a wide range of end users. So, if you haven't already, please go check out our online platform at [UK batteries network.org](https://ukbatteriesnetwork.org), where you'll find lots of useful material on both our first series of podcasts on various different thematic areas for batteries, like investment battery recycling and market trends, as well as our second series that are looking at different end user markets for batteries. So, today's guests are Maria Jose Morera from global nano network and Matrishvan Raval of Turntide technologies. Hi, Maria Jose. Would you like to introduce yourself?

Hi everyone. I'm Maria Morera, Operations Director and co-founder at Global Nano Network, or GNN. So, well, I have been in the battery industry for the last five years, leading both development and industrialisation strategy for GNN core technologies. My work is basically focused on turning early stage innovations into a scalable, market ready solutions, especially for challenging applications where performance, cost and sustainability are critical aspects and well, at GNN, we specialise in the development of high-performance technologies for the battery sector, like advanced performance materials and next generation of dry manufacturing techniques for battery electrodes. Well, I think it's really important to also highlight that one of our key areas of focus is the heavy-duty electric vehicle sector, particularly electric mining trucks and well, I'm really excited to be here today and to share some of the insights we have gained through our work with OEMs in this space. And I hope this conversation brings lots of value to everyone.

Thank you so much, Marie Jose. And Matrishvan, would you like to introduce yourself?

Yes, hi. This is Matrishvan Raval. I'm the Head of Product at Turntide Technologies. I'm looking after our product strategy and various product development initiatives across the batteries, electric motors and power electronics range. Turntide Technologies is focused on sort of giving cutting edge high technology products to various market sectors, off highway, automotive, marine and railway as well. So, one of the things that I've been very fortunate to see is the harmonisation of requirements across various sectors and where there are

differences and how we can have product developments that cater to multiple industry sectors while maintaining, you know, quick development time. So, I'll be keen to share some of those insights and learn from the podcast as well.

Thank you so much. So everyone who's listening, please make yourselves a coffee and join us. Today we're talking about battery trends, opportunities and challenges when integrating batteries into the off-highway sector.

Over to you Debra.

Thanks, Neelam. So let's start with a scene setting question and Matrishvan, you kind of touched on this in your introduction. Let's start with you then. So, what are your thoughts on how battery needs for off highway applications differ from on road vehicles like EVs or trucks?

I think the key differentiator there is along two axes. One is a higher need for energy density and power density, and the second axis is along ruggedness. So, in terms of off highway and off-road applications, they need to be much more robust to higher vibration standards, higher NVH (noise, vibration, and harshness) profiles and harshness as well. Some of these are very harsh environment applications like mining. So, they see the harshness of temperature conditions, harshness of vibration conditions, and also because of the compactness of the equipment needed, they need to have much higher energy and power densities, as opposed to what you would get away with in an on-road automotive car. So, these are the key axes of differentiators. There are commonalities as well when it comes to safety, when it comes to security, when it comes to meeting all the regulatory requirements on EU and international safety standards. But there's a few very critical performance parameters on which you need to design specifically for the off-highway sector.

Yeah, that makes a lot of sense. MJ, is there anything you'd like to add to Matrishvan's answer?

Well, I completely agree. Well, in in passenger EVs or well commercial trucks, the focus is usually on range, energy density and charging speed. But in off-highway applications, especially like in sectors like mining, the priorities change a little bit more, like into durability, uptime and thermal efficiency, or thermal management so well, and that's linked obviously, because these vehicles operate in extreme environments, under constant vibration, dust, long operational hours and high temperatures, and well on top of that, a mining truck run several heavy duty swifts back to back, and it needs to be recharged really quick. So yeah, unlike passenger vehicles down timing, mining is incredibly costly, because every minute a vehicle it's out of operation that translates directly into loss of productivity, and that's why batteries for off highway use must be structurally robust, thermally stable and extremely reliable over time, because failure is not just inconvenient, right? It's really expensive.

Thanks so much Matrishvan and MJ. So Matrishvan, I wanted to focus in a little bit on what you kind of mentioned. So, you said, Turntide, provide batteries for agricultural, mining, construction vehicles, you know, those kinds of sectors. Would you mind giving us a bit of a

high-level overview of some of the electrification trends that are happening in these sectors, some of the innovation and batteries that might be taking place.

Sure. So, there's been a few go to chemistries. One is NMC, and the other is LTO for high power throughput, whilst maintaining the advantage of those of those chemistries, we're seeing an increasing demand for safety. So how do we take the relatively unsafe perception of NMC, for example, and turn it to be a safe solution for use in these end sectors, for example, if I, if I stay on the mining front, then you know, the fire hazard is particularly heightened in mining environments. And it's about proving, not just through simulation, but also test that an NMC chemistry battery is just as safe, if not safer, when designed with the right thermal cooling conditions, when designed with the right circuit and BMS (battery management system) protections. So, one trend that I'm seeing is an increasing uptake of safety requirements in the off-highway sector. The other trend, of course, which will, which will take longer to go, is automotive tends to be the first adopter. So when it comes to cutting edge technology in terms of connectivity, so be it fleet management or gateway connectivity of the batteries, or even, you know, functional safety of cyber security, those sorts of requirements, you see automotive as the first mover and the off-highway sector taking it up three to five years down the line, we are seeing those cycles shorten a lot quicker now. So, the off-highway risk sector is becoming a fast follower, rather than a three to five year laggard. In terms of taking up these trends, similarly in in terms of solid state that, because the automotive industry itself is at a nascent stage in terms of taking up solid-state batteries, I'm not seeing a horizon where the off-highway sector will take it up. But that would be a new trend that I would like to see. I would like to see an explore over the next five to 10 years.

Thank you, Matrishvan for that overview.

MJ, would you like to share Global Nano Network's experience in this space? So I understand that you've been developing current collectors for high performance applications. Are you able to share the key insights from working in this area?

Yeah, sure. Well, as you mentioned before, yeah, we have been deeply involved in the development of high performance battery components and dry manufacturing technologies as well, where, well, one of our key areas of experience has been working with OEMs that design and build electric mining trucks, which, well, that has given us an incredible first hand exposure to some of the technical and operational challenges that these vehicles face. And with that level of insight, I think it has allowed us to design our technologies with almost surgical precision, targeting critical issues like, for example, fast degradation, that is something really frequent under extreme duty cycles. Well, something we believe in GNN that when you that is really important is that when you're developing high performance components for batteries, like, for example, current collectors or electrode structures, for example, you are essentially like re-writing the battery's DNA, right? So you're basically engineering how the entire system behaves under different conditions like cell stress, which is something critical in this industry, and that's why, well, having this direct relationship with OEMs is so valuable to us, and it has helped us to build efficient battery technologies like our incredible technology Hyperfoil, which is our proprietary current collector technology, which we are currently validating and implementing in battery cell designs for electric mining trucks to optimise cells durability.

A question for both of you is, if we could focus in on those sorts of challenges, a little bit for batteries and off-highway. Do you feel that it's durability or thermal management, or maybe around, sort of the AI side of things and the battery management systems? I'd be keen to hear from, from both of you. And if, if you have the power to solve one challenge in the next year, which one might it be?

Sure. I think the foremost challenge that I would like to solve is around cost. So, in terms of the uptake of electrification in the off-highway sector or in wider electrification initiatives, the primary challenge has been cost, unless the industry as a whole is able to show parity or improvement against your internal combustion options, that's always going to be the hampering factor. You can only have so much regulatory or policy support when it comes to electrification. The sector, and all the players in the sector will have to come off their own accord and show economic benefits of the technology for there to be a mass adoption. And there's a few contributing factors that that will lead to, or that will help in terms of achieving those price efficiencies, mass manufacturing capabilities, we need sort of sovereign investments like China has done in other sectors, in other geographies as well, to try and combat the price challenges. As far as technical challenges go, I think on the software control, battery management side of things, there are many innovations happening, the self-learning or the AI predictive nature of various systems help us with predictive maintenance. In that area, we are also seeing much more high-fidelity models when it comes to state-of-charge and state-of-health monitoring. There's been a constant improvement, and I would say, a step change in terms of the predictive performance on SSE (Sum of Squared Errors) and SOH (State-of-Health), through the use of various neural network and convolutional and other neural network technologies within the BMS and control space. As far as mechanical durability and thermal management solutions go, we are seeing more innovative, you know, oil cooling, immersion cooling technologies come up which can withstand those harsh environments, I think, for niche and special applications where that is the highest requirement, we will see more of those solutions come through. And I don't want to miss out my electronics friends, there's a lot of electronic hardware improvements as well that are going on at the same time, be it in terms of intelligent sensors, sort of self-balancing batteries as well. So, I'll leave the chemistry side of things to the chemistry experts, but when it comes to everything else that goes in terms of building the battery, we're seeing constant improvements on all these axes. Yes, there are challenges in terms of getting all these improvements to the right price point. But if we solve that, that'll be the single biggest challenge that we if we can solve, we'll see a massive change in terms of adoption rates of batteries in the off-highway sector.

Yeah, I think cost is a really important one for all of the end-users. And you touched on a few points there that we will circle back to after we've heard from MJ on her thoughts on the challenge that she wants to solve.

Yeah, well, for me personally, one of the of the biggest challenges for the battery off-highway applications, especially in electric mining trucks, it's definitely durability, because these vehicles operate under extreme mechanical and thermal conditions and requiring ultra-fast charging. And that's because in mining, every hour a truck is not operating, means loss of productivity and increasing operational cost and well, just to give you an idea, well, these

trucks use a massive battery pack of something around 1.4 megawatt hour, and they often rely on ultra-fast chargers to get back up and running in just 30 minutes. And well, that sounds great, really great, actually, in terms of uptime. But the reality is that charging at that speed with a C rate of over 2C or even more, generates a huge thermal, electrochemical and while mechanical stress on the battery cell, which, over time, accelerates degradation, shortens the battery lifespan and leads to higher replacement cost. And while it's not just about cost, actually, it also increases the carbon footprint, because the more often you have to replace a battery pack, the more resources and energy are consumed across the entire value chain. And well, actually, that's the kind of issue we are trying to address at GNN by designing components like Hyperfoil that directly address the cell level of stress caused by fast charging, by improving the thermal stability and current distribution inside the cell. So from my side, I think that's the biggest challenge.

Thank you, both of you, you've identified some really key challenges and provided a bit more information about how we're getting to solutions for them. So, MJ, I'd like to ask you a slightly different type of question now. So GNN participated in our battery investment readiness programme last year, and do you think that investors are starting to understand a bit more about the opportunity that the sector provides for them?

Yeah, well, of course, I think well off-highway applications are super important and super critical. So yeah, we have seen that. They understand that this is a critical area in where we have to focus. So yeah, my answer is completely, yes.

It's good to hear.

Yeah. On that note, my question, you kind of touched on it a little bit there. The whole value chain sort of needs to get involved with these kinds of innovations to be able to get them at the cost and support that mass adoption. So, I just wanted to get some sort of final thoughts on you, on the kind of cross-industry collaboration that you would like to see, is it really the OEMs, the startups and material scientists who are critical to make this work?

So, I'll start right at the source, all the way from mining itself in terms of getting the raw material. I've been fortunate enough to attend various events which focus on various aspects of the entire value chain. There needs to be greater investment and greater venture capital support to the mining community itself. So people who are actually extracting lithium through various means, in terms of getting the raw materials through, all the way to, you know, the tier one of the OEMs developing the electronic components and the BMS and the batteries in terms of the end-customer. I think there's been enough of an encouragement from the end customers to want these products in their in their platforms, so the OEMs of the world are keen enough to have them. They are only wanting to make the economics of this work so that down pressure has actually been helpful in terms of making our technologies better. We've actually taken on the cost challenge whilst improving the performance of the underlying batteries and other things as well. And it's the entire value chain ecosystem, right? So in order to do the fast-charging challenge that Maria was just mentioning, we need to have the right power electronics as well, the DC converters and the chargers that are able to support those high rates or those high power ratings, and there just aren't enough components available on that

side of things, or in a variety available, or enough competition in that space where you can have price benefits or economies of scale benefit. So, the electronic industry, the charging industry has to take it up as well. And finally, when it comes to, you know, the end-of-life, the material recycling side of things, there's encouraging movements in terms of companies hoarding end-of-life, battery recycling. But that's another sector that needs, you know, again, masses of investment. So as long as the investor community as a whole is willing to wait for a slightly longer than usual period of return, I'm sure we would see many interesting developments and encouraging developments in terms of battery adoption.

Yeah, no, absolutely. So that brings us towards the end of our episode today, and I think from what we've learned today, that the road ahead for off-highway electrification really relies on more ruggedised batteries, smarter systems, cross-disciplinary collaboration to really get that stakeholder buy-in and get these innovations working, and some of the harshest conditions for really important factors. So, thank you so much to our brilliant guests and thank you all for listening. We really hope you enjoyed this discussion as much as we did. Don't forget to visit our online hub on ukbatteriesnetwork.org and register to receive our news and updates and participate in the networking area. Bye for now.

Innovate UK, the UK's Innovation Agency.