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Umicore's battery materials innovation roadmap for next-generation EV technologies

Stephane Levasseur
Senior Innovation Director, New Business Incubation

Okay, so good afternoon everybody. I hope you had a relaxing and refreshing break, and that you still have some appetite for tomorrow's menu and next month's menu, because there's still a lot of innovation to come.
And I'm going now to introduce our approach on the longer term innovation and how to better serve the needs from customers when it's about
longer term transport electrification.
So we will take an helicopter view starting from the market perspective
what do customer need, and how we answer that with our technology portfolio. And then we'll bring you into two very exciting development projects that we are ongoing right now. The first one on solid-state batteries - I mean, you have all heard about this technology, I'm sure about it.
And the second one, we will show you how we solve the concerns of OEMs when it's about addressing the long term perspective on the cost-sensitive segment and the opportunity that it represents for Umicore.

So talking about market first, I mean, here are a few quotes from OEMs on their longer term perspective. And you can see that it goes in all directions. And the more OEMs you will quote, the more directions you will get. And at the end, there's a consensus that we have from an industry perspective to go beyond what has been done so far.
We have to differentiate on the technologies in order to be able to sustainably and profitably electrify all the market segment on the long run.
The technologies that we are going to put on the market next have to answer very precisely the very specific need on each and every vehicle segment in order to really do the job. And this is why you see so much diversification in the technology portfolio and the strategies that the OEM want to take on the longer term.
Up to now, they were mainly playing with the chemistries, changing the chemistries to address the market segment. But you will see in the longer term also, them playing with new cell technologies to even better answer customer needs.
And all that translates in this technology road map that my colleagues have shown already, where mainly I want to emphasize on the post 2025 period, where you see new cell technologies popping up.
So on the premium segment, the solid-state battery appearing post 2025 and slowly entering also the high-end of the mass market segment as a technology mature.
And at the opposite of the spectrum when it's about cost and entry segment, the sodium-ion, there has been a lot of hype around sodium-ion due to high lithium price in 2022 and early 2023, mainly driven by Chinese initiative and we really see this technology to take a step into the entry segment and possibly start to eat on the LFP market landscape at the bottom of the mass market segment.
In terms of technologies, I mean, on the solid-state battery, premium segment, high energy density range, G.S. was vocal on that. So it means at first high nickel. But again, as technology mature, people will try to find some more cost optimized solution when it's about cost of energy. And the medium-nickel high-voltage products, we also make a step in this segment later once more mature.
On the sodium-ion segment, well, this is a new segment. So you have to develop cathode chemistries from scratch as well. And today there are three main chemistries

coexisting on the market or trying to penetrate the market, we will discuss that in a few moments.
And at last, I mean, still considering the liquid lithium-ion market segment, which is the main technology to address the wide mass market, we are putting a lot of emphasis on the DRX or standing for disordered rock salt, which is a kind of improvement and continuation in the philosophy of HLM of reducing the metal base in order to bring more value to customers. So it's an HLM V2.0 if you want, where we reduce very significantly the amount of expensive metal in the metal base.

Okay, now let's take a breath and deep dive into the wonderful world of solid-state batteries.
Why solid state? I mean, today we see what the premium segment is able to bring as a technical solution with the advanced liquid lithium-ion system, but it's clear that OEMs want more. They really want to be able to unlock the superior energy density level, but without sacrificing on the safety and also in order to be able to bring fast charge for their customers.
That's why at the end, we see today a market introduction for those technologies in the years to come, 2025 first, very first vehicle platform for demonstration coming in 25, and then for all solid-state as of 2027, 2028, as recently announced by Toyota and some other OEMs.

Again, if need be, some quotes from the OEMs on semi-solid, both from the premium segment, but also from the mass market segment, really confirming that all the OEMs have incorporated solid-state in a way or another in their technology roadmap. And at the end, the value prop is always the same, bringing a decent range for the consumers, but without sacrificing cargo space or weight, and with allowing fast charge at the end to get a wider and faster consumer adoption.

What does it relate to in term of technology? Yeah, I will show you and compare the different technologies. So on the left, you see what is a liquid lithium-ion system on the road today, on the road since 2021. On the positive electrode side, these are the CAM material that Umicore is producing and that G.S. has introduced already. On the negative side, this is mainly graphite with a few percent of silicon at best, and all that is swimming into a liquid, flammable organic solvent.

Let's move to semi-solid and solid-state technology, but first let's ask ourselves, why we want a solid-state battery?
At the end, this is in order to be able to accommodate very high energy density and to raise the bar in term of energy density. So the semi-solid incorporates indeed a high energy density energy. You increase the silicon content from a few percent to 30, 40, 50% of silicon.
This is what most of the developers are now pursuing as an avenue, or you can even be more disruptive thinking of integrating lithium metal. This is what, for example, a few startups are promoting.
So you have a boost in term of energy density, but that at the end can be done safely, only if you replace this volatile solvent by something a bit more robust, a solid. And here we talk about a semi-solid, which is actually a polymeric sponge, in which you inject a few percent of liquid electrolyte.
And that indeed ensures some mechanical stability to the system, take on the swelling of the system, the contraction and the expansion of the anode during cycling, so that you can ensure durability.

In term of process technology, at the end this is very close to that of liquid lithium-ion battery for battery makers. And in term of CAM material, so the very high nickel and high voltage medium nickel solutions which are driving the high energy density in the liquid lithium-ion segment will also be the very first technologies to be implemented in the semi-solid system.

Now let's move to the grail of the industry and where all the efforts are focusing on right now, which is the all solid system. In term of anode energy density, we talk really about maximizing, very, very high silicon content, lithium metal or even more disruptive, the anode free technology that some technology developers like for example Quantum Scape are trying to push on the market and develop.
In term of energy density, we really take a step compared to the liquid system. We talk about doubling the range at the end. And it means that in term of robustness of a structure, the semi-solid will not make the case anymore. You need a very strong and robust, all solid electrolyte system.
And this is why people are now developing inorganic solid electrolyte like the sulfides or dry polymers like the solutions that companies like Blue Solutions are now trying to put on the market.

It has implication for battery makers because you also have to adapt your battery manufacturing process and it has implication for us. Because due to the fact that you don't have any liquid in the system anymore to basically buffer and pamper the imperfection of the electro manufacturing process, you really need to have a step forward in term of manufacturing and integration of the solid component to the other.
You need a very good contact and intimate contact between the solid electrolyte and the cathode material in order to be able to do the job. And this has implication at the end on the way we will develop product. We really need to make tailor-made cathode material solutions that we co-develop together with the integration partners in order to answer the very specific need of their technology system.

So it looks very complex. And is it worth the game at the end? It's a very valid question. Here I will try to give a bit more substance and some numbers. And I will compare basically the gravimetric and the volumetric performance of some state-of-the-art cell-to-pack technologies with, I would say, mature all-solid state battery technology, but still keeping some realistic assumption on the energy density you can reach with all-solid state.
So you will see on the left is the state-of-the-art advanced LFP cell-to-pack simulated into a 100 kilowatt-hour pack. The same for the high-nickel NMC, which is again a CTP commercial system. And on the right is a solid-state battery.
So for a 100 kilowatt-hour pack, this is how we translate in term of weight. Basically, you cut your weight by two while going from the best LFP you can find so far to solid state. And in term of volumes, that's exactly the same. You go from above 300 liter for LFP pack to something below 150 for a solid-state battery.
And at the end, this high energy density is what is driving the hysteria around solid-state battery. I mean, all the OEMs see it as a very big opportunity for them to get much more freedom in their design parameters. Because on one side, you can indeed double the range of your car by keeping the pack size. But more importantly, and this is what is the main driver for OEMs, you can clearly make a 700 kilometer smaller vehicles with a very good cargo space, low weight, fast charging capabilities, and then increase the customer pool that you can target with such a product.

Also worth noting, and very important in the equation is the fact that with solid-state battery, you get access to really fast charge and better safety. And why? Remember that in the case of liquid lithium-ion system, the electrolyte is a flammable solvent with a low boiling point.
When you try to charge a battery, and even more fast charge a battery, you will generate high current drains. These high current drains will generate heat. And if you are in a liquid system, you will have to control this heat generation. You will need a thermal management system around in order to be able to cool down the battery, in order to be able to also control the charging speed not to go above the limit where the thermal runaway could happen. I mean, without any flammable liquid in, and with materials which are much more tolerant to temperature change, you can really get the full speed in terms of fast charging.

So all that parameters combined together at the end will bring very significant efficiency gain at vehicle level that at the end will lower the overall cost for energy below that of advanced lithium ion system after 2030. This is basically the bet of all the OEMs today.

So where is Umicore in the landscape? Actually, we have started already in 2017 a very ambitious innovation program on solid-state battery with multiple objectives. The first one was to validate the market. What will come and when? The second was really to take an offensive step on the cathode landscape, taking advantage of our 20-year experience on the liquid lithium-ion system development to really be, well, the leader and the front runner in the game.
And at the end, I mean, who talks about new technologies being implemented and also about new opportunities for value creation. So we also looked at the other components in the system, electrolytes, anodes, … to see if there was some room to play for Umicore there.

Where do we stand now? Seven years after. And if we look at market, I think we have a very good understanding of what the technology could bring and how fast it could come. If we look at our projections on the left, this is basically the penetration rate of solid-state battery in the global lithium-ion battery market, and one can expect around 14% of market share by 2035.
If you dig a bit deeper into the technology platform and their introduction, as I mentioned earlier, the semi-solid platform that you see on the right with a green bar will come first and faster. But then from 2027 on, you will see the all solid-state battery technologies coming in first with the sulfide and then with other chemistries like the polymers. At the end, the all solid-state battery taking over on market share, versus semi solid after 2030.

From an R&D perspective, what have we achieved? I'm really proud to say that our teams have done a great job. I mean, our business developers and the innovation team have been able to chase the technology developers to make sure that we would be their preferred partners. And in the end, it seems really delivered on the promise and managed to really develop great products out of the lab. So we have today, I would say, a very strong foothold in the solid-state battery landscape with a full set of technologies, fully IP protected and dedicated to semi-solid and full solid-state batteries.
Also very important to note and very surprising, our competition, our peers, the juniors in the field, have taken a very academic approach on process technology when it was about finetuning product for solid-state application.

On the contrary, from the beginning, we have put a lot of efforts in process innovation to make sure that the solution we would bring to the market would be fully compatible with the production process that we have for liquid lithium-ion CAM product.
And I mean, with that, I can just say that, I mean, if we have to upscale tomorrow, we can upscale tomorrow. And I'm sure that when the hockeystick will start, there will be some damage somewhere else.

And at the end, as a result of that, I'm really also happy to share that our products will be indeed on demo cars on the road from 2024 on at the end to reach mass production SOP in the second part of the decade.

So how do you deal with solid state and what are the implications in terms of product development? Let me give a bit more substance there. As I mentioned earlier, I mean, the contact and intimacy between the solid electrolyte and the CAM material are very important, much more than they are actually in liquid-based system. And this is why taking advantage of what G.S. presented on our technology development and competencies, we have been able to really produce product dedicated to this new technology. We had to restart from scratch on core material optimization, playing with the microstructure, starting from the CAM, playing on the morphology. We talked about the polycrystalline, the monolithic, the same recipe apply, but also playing on the surface engineering to make sure that we avoid parasitic reaction between the solid electrolyte and the cathode active material during the use phase.
And that, as I mentioned, has to be tailor-made and was done in a very extensive open innovation effort with battery makers, car makers, start-ups, academia, where we really, for each and every technology development, worked very closely with a partner in order to adapt the recipe to the exact need of their cell design and solid electrolyte recipe.
So we use what we call our building block approach, I mean, varying the nickel composition everywhere from 60 to 90-plus percent, playing on the morphology, polycrystalline, monolithic, the mix of the two, playing on the particle size, playing on the coating recipe, the composition of the coatings in order really to have the perfect fit and the perfect match with the system of the customer.
And in this perspective, also, I want to emphasize the fact that the monolithic high nickel that have been also developed for liquid lithium-ion batteries get a lot of traction on the solid-state landscape.
I mean, there was a question earlier on dry-electrode manufacturing. A lot of companies are thinking about dry-electrode manufacturing for solid-state battery. And in this perspective, the monolithic product have very strong advantage thanks to their very good mechanical properties.

And as I mentioned, I mean, we really built and work closely in the ecosystem on solid-state battery, very strong collaboration with academia, with start-ups, with peers in order at the end to really develop a full set of competences and technologies, allowing us also today to have a pretty strong foothold in terms of patent landscape with a fast-growing patent portfolio of dedicated solutions for solid-state battery.

So product development is one thing, but at the end, it's also important to be able to speak customer language. And this is why, in parallel to the product development, we have, like we have done, actually, for lithium-ion and like we are still doing for lithium-ion, developed very strong integration capabilities to be able to test our product in relevant environment.

And over the last years, I mean, we have developed extensive know-how in electrode manufacturing, electrode formulation, so we have developed a wet process, dry process, in order to really be able at the end not to become a cell-maker, but to provide our customers with optimum recipes for them to get the maximum out of the product we would bring to their system.

And now, let me share with you a short video on our solid-state battery prototyping center, which will give you a bit more of a taste of what we actually do, and which will also allow to introduce some of the great team members that we have in our solid-state battery team in Olen in Belgium, where we do a part of our research.

SSB video playing

Stephane Levasseur, Senior Innovation Director, New Business Incubation
I hope you enjoyed the video.

So research is good, but now let's talk about market acceptance of the technology. And here I will give you a snapshot of where we stand today after this development.
So we have obviously a lot of collaboration going with car makers, battery makers, start-ups, a different stage of maturity. Some of them are still in the early experimentation phase, but I'm really also happy to share that some of them moved into the pilot testing. And actually we are talking about ton level sampling today.
At four battery OEMs, two Japanese car makers, two start-ups, famous, that are backed by big OEMs, which at the end translate into attraction a bit everywhere around the planet with Asia and North America leading. And indeed, as we mentioned already, after demo cars being introduced with our technology from 2024, on mass production from 2027 for semi-solid and 2028 for all solid state battery system.

That was it for CAM. Now let's talk very rapidly on some very exciting adjacent value creation opportunities that have been emerging the last year with this new technology. The first one is on an advanced product associated to electrolyte, an advanced product that we call the "catholyte", which is actually a functionalized CAM material aiming at solving the last technical hurdles that the all solid-state battery face. And I will come back on that later.

And the other one may be more surprising and linked to an adjacent project that we have on silicon carbon compounds for liquid lithium-ion system. We have been confirming that these products are also fully suitable for semi-solid and all solid-state battery creating extra opportunity.

On the "catholyte", a bit more detail. So why do we want to work on that? If you looked really at the details and maybe you have read that in the press, they are still a few orders to solve for all solid-state batteries. Especially when it's about power and temperature performance. And the contact between the solid electrolyte and the cathode material is not yet optimum and you need to keep that contact with high pressure engineering to be able to have decent cycle life and durability.
So the battery makers are looking at that on their side with more advanced manufacturing process. The car makers and battery integrators are looking at that by trying to propose more advanced packaging around the cell. But at the end, I mean, it's again about materials intimacy.

And we scratched our head and looked at what could be our contribution from a materials producer perspective. And to achieve our goal, basically we partnered with Idemitsu, a leading Japanese solid electrolyte provider to develop this advanced product that we call "catholyte", a functionalized CAM with a very thin layer of solid electrolyte ensuring a perfect match between the components. And at the end, we have the goal to answer this performance limitation I just mentioned before.

So where do we stand today? I mean, we are validating various manufacturing routes as we speak. We have already proof of concept product that have been sampled to our partners OEMs and results to come soon, but very exciting project.

Now allow me to present Nakamoto San to you. He's the CEO of Idemitsu Advanced Material and he will talk a bit more in detail about Idemitsu and the project we have in collaboration with him.

Video playing

Stephane Levasseur, Senior Innovation Director, New Business Incubation
So that was it for solid state battery. Now let's switch gears and move to the other side of the technology spectrum and focus on more consistent solutions for longer term entry and low-end mass market segment electrification. And I am going to talk now about sodium-ion technology.

Why sodium-ion? Well, it has been very much in the press the last two years. Some demo cars now on the street in China. It has clearly the potential we believe to further drive the cost down in the entry segment. And that with still proposing the same energy density level as LFP, but with a significant cost advantage.

So it's very clear that it's technology is in its infancy. It's not yet mature and it's basically, if you take a step back, very similar to where LFP was six to seven years ago. You may remember that LFP went through a very strong improvement path thanks to cell integration strategies moving from small cylindrical to very large hard case prismatic blade batteries cell to pack, cell to chassis. And that allowed basically LFP to break in in the transportation segment.
The same will happen definitely with sodium-ion and a lot of players are already betting on that.

Why sodium? Well, actually we target entry segment, for the goal again is to improve the metal base in the bill of material at the cell level. Sodium is abundant, low cost and from a chemistry point of view it has very similar properties to lithium.

If we talk about bill of material, sodium is one element, but one also key aspect to take into account is that sodium ion technology does not require the copper current collector, which is currently in the negative electrode of lithium-ions. And copper current collector is also one of the biggest components in the bill of material for lithium-ions.
Basically you can get two birds with one stone with sodium-ion and that associated to the fact that the technology has very high power performances. It represents - we believe – a very promising technology if one think about globalization of entry segment in the light of the expansion of zero emission zones post 2025 all around the globe.

If we look today, what is the status of the technology? There are mainly three technologies coexisting on the market, differentiated by their cathode material.
The first one on the right and it's the historical one, the first one on the market, the Gen 1, which is based on Prussian Blue. It has a very good total cost of ownership but a very low energy density. And this one is definitely the technology of choice for stationary storage but it cannot play a role in transportation as such.
The other one on the left is a vanadium fluor based polyanion; so in term of material philosophy and manufacturing processes is very close to LFP. Very good power, very good cycle life but again very low energy density.
So this is today the technology of choice for example for power tools, and it has started to be introduced in power tool application. Remember like LFP was in 2009.

For transportation clearly the focus from the ecosystem is around the chemistry in the center which is manganese based oxide. This is a technology out of the three which is providing an energy density round which is compatible with transportation. So this is a technology of choice for transportation, and this is the one that all the cell-makers and all OEMs are now focusing on in order to be able to address the entry segment market needs in the longer term.

What's the actual value prop of this technology if you compare that to LFP? It has a much better performance under extreme temperature and especially under low temperature it stands still very good properties. So we were discussing earlier today about some Twitter's, tweets on people getting stuck with a car powered by LFP when going to a Christmas party because of the cold weather and they could have made it through with sodium-ion probably.
It has also some better fast charge properties thanks to the fact that you don't use graphite but hard carbon as an anode technology and that also implies that you get into a better safety behavior. And at the end, I mean, we talked about the lower cost in the bill of material, but more importantly the fact that with sodium you shield the OEMs from the lithium price volatility in a segment where when you make a few hundred bucks per car it's very important.

Some technical hurdles to overcome obviously, as I mentioned, it's still embryonic technology, so the industry has to go the full pass in term of material optimization and in term of cell technology improvement in order to get it where it can actually go.

The role of Umicore like it is for lithium-ion based product, we can take advantage of our strong competence in term of product development, pCAM and CAM, to bring really the maximum out of our product in close collaboration with customers, to get the durability, to get the energy density at a level where it's acceptable for transportation.

And last but not least, I mean, all those products can be produced in our existing NMC production lines globally, meaning that this technology can really be a technology of choice for entry segments in regions where the value proposition of LFP is far from being obvious.

Okay, last technology point - coming back after solid-state battery, after sodium-ion, coming back to the liquid lithium-ion system - the world does not stop after HLM. There's still some improvement to be expected in the metal base for the cost sensitive segment with the disordered rock salt product, and we can really expect to drive the

cost even down for the mass market segment while still keeping the energy density at par with the HLM level.
Today we are still very early stage validating the performance claim in the lab, but so far all books checked and we are progressing.

What's the value prop of the technology, as Mathias explained in his introduction - basically it's a lithium-rich, cobalt and nickel-free or expensive metal free product, and you can put whatever you want almost and make it work. So today the first designs are manganese-based, with a few other elements, salt and pepper to get to the required level of performances: very low metal base, very high capacity, very good rate and safety.

You may have never heard about this technology, and it's possibly due to the fact that it's a very unique development path that we have followed for this technology. Actually this product came out of a computer. There has been a very long understanding in the industry the last 30 years that in order to have a good cathode metal you need a very well ordered layered structure, in order to have good transfer properties.
And actually what the computers of Gerbrand Ceder, professor in MIT and now at Berkeley University, have shown is that by very specific disordered structure you can get a lot of excellent properties to make a very good CAM.
So it's a long standing open innovation collaboration that we had with Ceder on that topic which allowed us basically to secure a very strong base at peak portfolio on this wide family of product at the end to bring a longer term competitive advantage for Umicore.

We are today exploring different process route again in order to be able to be compatible with our production assets and also working on integration strategies in order to validate, from next year, on with partners the value proposition of such a product. So a lot of excitement there as well.

Okay, time to wrap up. A few takeaways and so many missions. So, well, like for short term you see that Umicore also for longer term is aiming at serving all vehicle segment and for that has developed very specific materials development strategies.
We are able on the short medium and long term to answer the needs of OEMs and we don't impose technologies.
We propose a portfolio of product that at the end they are free to choose depending of the exact set design and exact market segment they want to serve for the different regions.

I hope also I was able to convince you that it's all about process and product innovation, and that there are still a lot of work to be done under the hood to be able to get the product on the market.

At the end, I mean, Umicore is clearly uniquely positioned to play around today, to play around the medium term and to play around on the long term, since we are clearly in a leadership position also on this next generation technology to come.

And with that I would like to thank you and open the floor for Q&A. Together with my colleagues.

Mathias Miedreich, CEO
Yes, we are coming. I hope I don't have the chair that Ralph had before.

Very good, let's start.

Charlie Bentley, Jefferies
Could I ask two quick questions? So one is just on HLM: can I confirm basically to any of the agreements you've signed with ACC or with VW, the AESC, have any kind of, you talk about introduction in 2026, are there any kind of agreed volumes that you have to have in the future? Any kind of agreed volumes for HLM as part of those?

Mathias Miedreich, CEO
Let me put it this way, so as I said to the previous question, all of our contracts are based on certain technology. And when we talk about this order book, we have shown the composition of that, mostly high, very high-nickel and a smaller portion of mid-nickel.
So at the same time, I would say we are in very advanced discussion with many OEMs and what I said before is still true. It's possible to change, and that's the beauty, and that's maybe also a summary of everything what we have said. You see, the nice circle that we are always showing is the flexibility of our manufacturing system, is a strong asset for us and that's something that we can react to that.
But if you ask the very clear question, do we have already contracted today HLM delivery volumes to an OEM, is that part of our order book? I have to say no, it's not. You can be sure that we will also clearly announce that once that happens.

Charlie Bentley, Jefferies
And just to be clear, like on that kind of timeline around 2026, when would we need to hear something from you in terms of that kind of evolution? But it was probably by the end of next year at some point.

Mathias Miedreich, CEO
Yeah, that's about right. So when we say it's roughly one and a half, two years of introduction, the qualification and verification processes are already ongoing multiply. We have prepared our plants already for that, but that's about right. So something like end of the next year would be the critical path.

Charlie Bentley, Jefferies
Okay, great, and then, sorry, the second one was just on like next generation, mid-nickel. I guess that seemed to be something that your predecessor focused on a lot and it seemed like a direction that Umicore was driving in and it seemed like that was something that maybe didn't, maybe the timing wasn't right in the market, maybe the technology wasn't right. I guess, what's the difference between that direction then and this direction now, what's changed?

Mathias Miedreich, CEO
I will give this question to G.S., but so much already about it. What we talk about is now the next generation mid-nickel high -voltage and that's an important, very important part because there is a learning that we took from the high-nickel, coating, et cetera, that was also helping us on the mid-nickel side.

Geon Seog Son, Senior Vice President R&D, Umicore Battery Materials
Will you make one more time to your key point of the question?

Charlie Bentley, Jefferies
I guess what has changed in terms of that mid-nickel development program in the last six years? What's been the kind of incremental change that, and I guess also on the customer side, how has that changed? How has that discussion changed?

Geon Seog Son, Senior Vice President R&D, Umicore Battery Materials
Ah, okay, so we have a very good mid-nickel product in the past, and still we have. At the time, also, we promote high-voltage mid-nickel, as you know. But at the time, electrolyte was not in the level to survive at the high-voltage, because electrolyte can be decomposed at high-voltage that we are talking about.
But now with the improvement and the progress in the electrolyte side with a lot of new additive materials, we found the good electrolyte. And then in our battery testing, we can show proof. We can prove the conformity within our material and electrolyte. And now customer is also moving this medium, high-nickel, medium-nickel with high-voltage. So that is the reason we have a lot of traction under the joint development agreement.

Mathias Miedreich, CEO
Would you say that medium-nickel high voltage is the capacity or the energy density of high-nickel at the price of mid-nickel?
That's the idea actually.

Geon Seog Son, Senior Vice President R&D, Umicore Battery Materials
Correct. That is like, we cannot reach it to the very high-nickel like 90 plus, but up to 80 or 83, we can achieve that same energy density with the medium-nickel. And then as I presented to you with the higher safety, that is a benefit of this product and technology. And it is changing the concept and then the thinking of the cell designers.

Charlie Bentley, Jefferies
Thanks.

Mazahir Mammadli, Redburn Atlantic
So I guess you are now in advanced enough stages of development of HLM that you have a pretty good idea of its cycle life. Any number you can give there or perhaps you can compare it to current mid or high-nickel technologies? Is it on par? Is it better? Is it slightly worse maybe?

Geon Seog Son, Senior Vice President R&D, Umicore Battery Materials
Thanks for the good question. Actually, I'd like to say that one in my presentation, but it was too much of a thing.
We can survive 1,500. That is a very remarkable, right? So if we can survive, for the passenger vehicle, 1,000 cycles, that'd be good, but more than 50% higher. So we are now achieving this technology and with the customers, we can go into mass production, I hope.
And as I mentioned, it's not in the early stage of development, we are in the industrialization stage.

Mazahir Mammadli, Redburn Atlantic
Thank you, that's very useful.
And another question on sodium-ion. So I think inherently it looks like sodium is sort of inferior to lithium in terms of milliamp power per gram basis. So does that mean you're going to have to, again with HLM, sort of rely on higher voltages to bring it on par with lithium-ion gravimetric density?

Stephane Levasseur, Senior Innovation Director, New Business Incubation
The fact that on sodium, if you look at the manganese based compound, the very first generation indeed have a lower capacity in term of milliamp per gram.
But again, like for NMC, you have a very wide landscape of composition that you can target. And there is a lot of development work ongoing in order to improve this capacity. Also like for high-voltage medium-nickel, we can play with the voltage to get more capacity out of the system. And that combined with the integration strategy that I mentioned earlier, you end up in a system which is on par, potentially on par with LFP. Yeah.

Mazahir Mammadli, Redburn Atlantic
Thank you.
And my last question to Mathias on the previous slides actually. So how important is the CO2 intensity to OEMs? I mean, you mentioned that CAM is like 60% of battery CO2 footprint and OEMs care about the Scope 3 emissions, but does it come up in actual negotiations? Are there like firm thresholds brought up by OEMs that we don't want our batteries to have CO2 footprint per kilowatt hour above a certain number?

Mathias Miedreich, CEO
Yes, that's an absolute increasing importance of that fact. And we see with the latest contracts that we have made it was even a USP to win the business in a certain way.
There are, especially in Europe, but also more and more in North America, there are requirements that give a minimum threshold that we need to guarantee in terms of Scope 3. So to say from the perspective of the OEM or the cell maker, the Scope 3 of the battery materials through the use of the technologies we have through our manufacturing process, but also through the sourcing of the raw materials and things like the global battery passport will then track that also into the future.
So it has become from something that is nice to have, a clear requirement, but I have to say, not at all in China. So China does not have that. In the other parts of Asia, also not so much, very clearly in Europe and upcoming in North America.

Mazahir Mammadli, Redburn Atlantic
Thank you, very helpful.

Tristan Lamotte, Deutsche Bank
I was wondering if you could please try to put into context on these technologies where you are versus competitors in the development program of these products. So where you're market leader and why specifically you and with your set-up, you have an edge versus competitors.
Are you spending more on R&D? Are you focused more on competitors and the development of these products? And are these technologies actively helping to win

business? Or is it really just a case that all competitors aim to be across all of these technologies as well? Thanks.

Mathias Miedreich, CEO
Yeah, I would like to give this question to G.S. and to Stephane for, I think we cannot declinate all of the technologies, but especially for the high-nickel and for the solid-state battery.
Let me give you a first general answer. One of our differentiation points that is really different to most of our competitors, for sure our Korean competitors, is that we have an integrated approach for R&D. So we're not developing only cathode material, we are developing from the precursor, and you saw that there are very important functions inside to the cathode material and then even on battery level testing.
But then the result of that, let's make two examples. Why are we better in high-nickel and why are we better in solid-state from our perception? So maybe you can start, G.S.

Geon Seog Son, Senior Vice President R&D, Umicore Battery Materials
But I think, what Mathias already mentioned, because it's one integrated R&D in the precursor and cathode material, because in the low nickel or medium nickel, precursor is not playing so much an important role as in the high-nickel.
But if we, when it's moving into high-nickel, precursor design is so crucial to make right cathode active material. And then how we design this one, that is also the battery level testing is very crucial. Our testing is synchronized with our key customers in the testing protocol. And then when we provide the material with the test result, customer, they can easily accept and then adapt our material into their cell design.
This is not the end of the answer. As I mentioned, we have a very special team, global applied technology team. They have a good connection and they have all taken care, the technical discussions and the meetings, they bring the right direction, what we have to develop, what we have to adjust in our development with the customer discussions.

Mathias Miedreich, CEO
And one example of that, if you allow, one example, and maybe you can comment once more on that. It was in your presentation, but maybe to make it even more clear in the high-nickel case - we have the poly and the mono type of chemistries. We, you have developed with your team, a clear leadership as we think, especially on the poly, on the mono side, which is again helping for issues that come along with the high nickel case.

Geon Seog Son, Senior Vice President R&D, Umicore Battery Materials
And that's the reason, when we listen to the customer, what's happening with the poly, when we, what they have also our competitors sample, but when they recognize what's the problem of poly and they're asking, do we have another solution and then we can provide and then it's going the right way.

Mathias Miedreich, CEO
Right.
Maybe another example, more on the next generation.

Stephane Levasseur, Senior Innovation Director, New Business Incubation
Yes, so on solid-state, for example, you may want to differentiate on the solid state technologies.

I would say that in the semi-solid field where the capacity for differentiation is somewhat lower, as I mentioned earlier, we are definitely among the front runners because we take early move and as such we managed to keep the pack behind.
Also, it stayed on the contrary. I mean, since we have really defined very early stage an innovation project, not only an R&D project, but innovation project, we have been able to develop product, develop process, develop the business and all that combined together basically, I think nobody has the same status today.
So the pack is looking at our back, I would say.

Mathias Miedreich, CEO
At the end of the day, our proof of concept where we measure our success is always the customer and we can either measure that in business success in our order book for some of the chemistries we have clearly proven that.
For the ones that are more far out, we are measuring ourself on the amount of customer interactive projects, on the amount of prototyping, on the amount of sampling that we do and here for the, I can only say for the solid state, since I'm with Umicore that's now a little bit more than two years, it has been dramatically increased over the last two years and as you said, we went from gram to ton level now in terms of sampling and that means something for itself.

Riya Kotecha, Bank of America
Thanks for the presentations, they were really interesting. I've got three questions please.
My first one is on single crystal cathode material. What proportion of Umicore's high-nickel mix is this today? Some peers have mentioned that the move from single crystal or two single crystal form polycrystal has impacted their yield rate. Has Umicore seen the same and how has it managed this transition?
My second question is on HLM commercialization. I understand that it's not just the pCAM or the CAM that needs to be coated or doped, but also the battery needs a more sophisticated management system. So that 3% cost advantage that you mentioned compared to LMFP - is that at the pack level or the cell level? I'm interested in learning about the pack level economics.
And then my third question related to HLM is that being the first mover in this chemistry means that Umicore also has to develop the value chain upstream. From what I understand, about 80% of battery grade manganese is produced in China and so can you talk about how you solve this problem
or address raw materials here? Thanks.

Mathias Miedreich, CEO
Maybe, G.S., I would ask you to cover the middle question which was about the cost advantage on pack level. And I will elaborate on the other two.

Geon Seog Son, Senior Vice President R&D, Umicore Battery Materials
So if I answer first the second question.
Currently, the LFP, they are now using in China cell to pack because they would like to increase the polymetric efficiency. But this cell to pack is not only applicable to LFP, no. NMC and HLM can be applicable also into cell to pack for the cell to chassis, C2C, right? And these things can be applicable for NMC, like a medium-nickel high-voltage, and HLM.
So I'd like to say the current cell model would not be so different even if it is moving into cell to pack or cell to chassis design.

Mathias Miedreich, CEO
Yes, maybe on the first question. So, yes, it's true that when you look to our order book, let's say the, I would say the majority, so more than 50% is actually on the mono side. And that was also one of the key competitive advantages - besides others - why Umicore was selected and why we have been able to secure the business.
Now in terms of yield, in terms of manufacturing, like G.S. said, there's always a drawback, you know, that you have benefits and doubts, but our team has found also solutions for that to be able to keep pretty similar yield also on the mono crystalline side. So from our own cost structure, we don't have an issue here.
Now, the raw materials supply, of course, the manganese needs for the current cell chemistries is far below than would be needed for HLM. And indeed, like for many other battery materials, the processing of manganese is concentrated in China today while the sources of manganese are abundantly everywhere.
Now, the technological complexity to create battery-grade manganese is not comparable with the one of lithium. So it's just a matter of time that this can also be transferred into the other regions of the world. And our teams are already working on it.
Maybe during the dinner, I would recommend a discussion with Stephan Jannis from our supply team**,** who can give you the latest update also on this one.

Ranulf Orr, Citigroup
Thank you – I have three as well. We'll start with the first.
Just curious how reliant you are on technological developments in other parts of the supply chains with the cell or the battery pack to actually deliver on your own technology roadmap. The move to high-nickel, I think, caught you offside already once. Could that happen again?

Mathias Miedreich, CEO
Maybe Geert**,** if you want to answer to our--

Geert Olbrechts, Chief Technology Officer and Executive Vice President
Your question is how involved we are in those developments, correct?

Yes.

Mathias Miedreich, CEO
How can we make sure that what we talked about, the mid-nickel, high nickel, and so on, doesn't happen again?

Geert Olbrechts, Chief Technology Officer and Executive Vice President
So I think what I mentioned also, I alluded to in my presentation, I think what we have now established, to a lesser extent in the past, is that we have very close, very intimate contacts with the battery makers and with the OEMs.
So by that and having that partnership, we really co-develop and we really get first-hand feedback on what works and what doesn't work. So in those discussions, we get really a good measure of the temperature and we can really feed that back and also adjust our development parts to make sure that in the end we develop one solution and we keep on track.

Mathias Miedreich, CEO
And maybe I add to that as well, as you have seen, that one part of our process is involving battery-level testing and battery-level validation, which means we speak the same language like our customers. And that means that also any kind of developments that they have on the pack side, that they have on the battery management system side and on other thermal management strategies that they have can be very much translated into requirements that we test on our battery.
So I would say we are very closely linked with the hips to the engineering teams of the customers. And rightfully said, that wasn't always the case, but in the last three years or so, that has been our daily bread.

Geon Seog Son, Senior Vice President R&D, Umicore Battery Materials
On top, we are listening to more customer voices.

Mathias Miedreich
Yeah, it's a broader base of customers that we have.

Ranulf Orr, Citigroup
Thanks.
Secondly, just on solid state and your ambitions there, through the period of the 26 to 2030, what do you think is a reasonable market share ambition for you, Umicore, to have of the cathode market?

Mathias Miedreich, CEO
I think that's too early to talk about the market share of solid-state right now, because the ramp up of solid-state, all solid-state, where Stephane said we have the biggest differentiation, technological one. So I wouldn't be comfortable to talk about the market share, but as an order of magnitude, as we have said, end of the decade, the whole solid-state market would be around 8 to 10 and then 2035, 15 or something like that. So that you see what is the...
And you would assume that somebody who is first to market or has this distinct technological advantage, as we think we have, and that is also proven by the customer. You could have a good entry in that, but I think it's too early to talk already about market share ambition in solid-state.

Geert Olbrechts, Chief Technology Officer and Executive Vice President
Maybe one additional comment. I think if we see which players are active on the OEM side and we see with which players we are interacting, I think we cover a very broad range. So that gives a good outlook. It's not a guarantee, but at least it gives us security that we're on the right track and that we will definitely be strong players in the market.

Ranulf Orr, Citigroup
Thanks. And sorry, just my last question is, can you give an outlook or an indication of how you see the kind of cost per kilowatt hour in the sort of high nickel, the high voltage mid-nickel versus high nickel and solid state going forward as well? Thank you.

Mathias Miedreich, CEO
Stephane, who wants to take a look?

Stephane Levasseur, Senior Innovation Director, New Business Incubation
It may be early to give actual numbers, because you have part of the supply chain that are developed and technology is still emerging. But at the end, as I mentioned earlier, in terms of cost of energy, really the goal is to go beyond that or below that of the high-end liquid material system of today after 2030.
So that gives you an order of magnitude ballpark here where the industry aims at landing. But yeah, real numbers to digit figures today is a bit too premature.

Mathias Miedreich, CEO
And now we have to check on the mic, because he's already trying.

Chetan Udeshi, JP Morgan
Mathias, you started the presentation by saying that Umicore is convinced that you guys are great and wonderful in this business and we can see all the information you have provided. But when is the proof of the pudding going to come for us to see that in the numbers?
I think the related question is also we've heard about slowdown in the EV orders in Europe in the recent weeks and months. How does that change, if at all, the ramp up that you guys are expecting for the Nysa plant in 2024?

Mathias Miedreich, CEO
Right. So it's a little bit of a different context and technology, but nevertheless very relevant. And as we have said before, we understand that we have to be measured on results.
Right. One result that you can measure ourself on is how much we how much business for the future we can lock down. I think we have made some quite some good progress here.
The next stepping stone will be the actual profitability and growth rate of that business. And that's what we will provide from next year. And what, independent of the current debate about the speed of electrification, we can confirm that we are looking into a very significant growth of our volumes next year in in the business group of that we will, from next year, have singled out battery materials.
And we also are confident that the profitability that we have, you know, forecasted for 26 and beyond, we are already on a good track into that profitability and we let ourself be judged on the numbers that we will then share next year.

And as we've said before, we will also try to see how we can provide a certain more, you know, clearer guidance also for next year already in the next time to come. But that's, I think, the clear proof point is in the numbers.

Chetan Udeshi, JP Morgan
Thank you.

Mathias Miedreich, CEO
Over there is a question.

James Hooper, Bernstein
I think I've got three.
First question is about the sodium-ion battery, about the cost advantage, the 20% that you referred to, Stephane. What is the kind of supply chain maturation? that's in the present? Can you just talk a little bit about the kind of LFP cost advantage?

Stephane Levasseur, Senior Innovation Director, New Business Incubation
If I understand well, you ask about the maturity of the supply chain for sodium-ion, right?

Jamer Hooper, Bernstein
Yes. Yeah. What needs to happen for the kind of 20% you reference to be true?

Stephane Levasseur, Senior Innovation Director, New Business Incubation
Yeah. Well, I mean, the, let's say, the less mature part of the supply chain today is clearly on the add carbon negative electrode, which is used. But yeah, as all new technologies coming in, the supply chain is being put in place. And we'll follow.
We have already some indication of where what could be the ballpark figures for the different cell components. And this is what brought us basically to this 20% cost advantage once there is more maturity of the supply chain.

Jamer Hooper, Bernstein
Okay.
Second question is going back to the kind of solid-state growth rates and penetration rates that you assumed in your market forecast. Can you just go through some of the kind of more detailed assumptions driving that? And what kind of, what hurdles need to be achieved in terms of – there's clearly a demand for the technology - in terms of theory, but kind of practically what part needs to be tested or how many kind of OEMs need to be releasing models, solid-state models?

Stephane Levasseur, Senior Innovation Director, New Business Incubation
Yeah. Well, in terms of market assumptions, basically, it's a lot related to the announcement around capacity being put in place, programs being started, OEMs' announcement on where they want to be. That's what time with what type of platform. So all that backed by a lot of information and confirmed by the information we have from our different OEM and cell maker partners.

Mathias Miedreich, CEO
Yeah. I would say that we clearly see that this technology is really accelerating in Japanese OEMs because they are, have been, laggards in the liquid solid state and they have been focusing on hybrid and hydrogen as a propulsion system. And now they're trying to kind of leapfrog that and go full speed into solid-state. You have seen some announcements.
Of course, the most prominent one was of Toyota, but you can be sure all of the Japanese OEM are working on similar paths in that direction.

James Hooper, Bernstein
I guess the last one's sort of building on the question from the previous question from Chetan. If we think about the kind of the mix that we've seen in kind of 25, 26, where we'll have high-nickel, kind of some of the voltage, they're kind of high-lithium-manganese, which would be the best products in terms of for you, Umicore, the business?
Which one would you like to be filling your plans with in terms of that?

Mathias Miedreich, CEO
Yeah. So first of all, we are already very happy with the business that we have on high-nickel. That's our main order book and the profitability that we have announced is not set in stone, but we have very high, how we call it, planability because we have contracts that have a lot of securities into the future and we have talked about that. That's the one thing.
Now, what is the technology that we think that we would wish, what I would personally wish for to next enter our portfolio is HLM. And it's HLM because it will, you know, we have a lot of discussion about LFP and I fully understand that and we acknowledge that there is only one technology today on the market that can cater that low end segment. So alone the fact that we will be able to announce a customer for HLM, will give a lot more traction.
And I hope also at the same time, I also hope that it's not only Umicore that will give that message because HLM is also a technology where our peers are working on.
We think we have a time to market advantage, but we actually want also more of our peers to come because it's not a good idea in the automotive industry to be the only one who has a certain technology. So that's for sure the wish list in a certain way.
And then we work, we see a lot of traction on this, you know, mid-nickel high-voltage, even though in the past it was not good to mention that with Umicore together, right, because there was some negative connotation, but it's really a customer demand. And I think our main point that we wanted to show today is we are not going to bet on one horse again.
So we have now all of the options, wherever the market would be moving, we can react and we can make it happen in our manufacturing. And that's, I think, the most important thing.

Caroline Kerremans, Head of Investor Relations
Are the questions in the room covered? Yes.
Then we have one question from the audience online.
So can you explain why the BYD ATTO 3 (LFP based), sold in Europe with a 62kWh, offers comparable range to Western EVs with 80kWh NMC batteries? Why is it not evident that high or mid-nickel NMC offers better range?

Mathias Miedreich, CEO
Yeah. Okay. I mean, whatever the technology, if you have that energy storage and that energy storage, you can drive a certain range. Only explanation, and I'm not an expert on that vehicle, but the only explanation is that that vehicle is especially small and light, and the other one is bigger and heavy, and has a less efficient drive train overall, because it doesn't matter at the end of the day what chemistry you use if you store that energy and that energy.
So the answer to the question is, it cannot be dependent on the cell chemistry. That's, I think, the short version.

Geon Seog Son, Senior Vice President R&D, Umicore Battery Materials
If I make a question, to the question, is that comparison coming from China and Europe? If both are in Europe or both in China, then the comparison is totally different, because we are now comparing apples with pears. Why? In China, the testing mode for the driving range is different compared to Europe. Europe is more severe with the high acceleration and deceleration.

That's the reason the driving range is getting shorter compared to Chinese mode. So we should look at where the comparison is coming from.

Mathias Miedreich, CEO
But it's not related to the cell chemistry. I think that's the answer. It's a vehicle level topic or test cycle topic.

Caroline Kerremans, Head of Investor Relations
We can take a last question from the room.

Fabian Smeets, PGGM
Yes, thank you.
I have a question on, I mean, you showed us a lot of different technologies and there's also other technologies in the market which you are not offering, like LFP. So I'm wondering like, how does a customer RFP look like? What are the parameters they are asking for? And how many competitors usually go in to search an RFP? How many competitors do you see when you bid for an RFP? Where can you distinguish yourself?

Mathias Miedreich, CEO
Maybe I would like to answer a question to Ralph actually, because that's his daily bread. So maybe, can you give a microphone to Ralph?

Ralph Kiessling, Executive Vice-President, Energy & Surface Technologies Umicore Group, and upcoming Executive Vice-President Umicore Battery Materials
I think we have to distinguish between different stages. We have a very early sampling stage where it gets broader.
So we have, let's say, in an RFP or competing with a couple, let's say, of competitors here. But it's not because the market is not the big that you have 20 competitors, because they don't have 20 competitors in the market. So let's say it's a single digit number of competitors. And then it's in the next stage really narrowing down.
In the end, you have often you have maybe two competitors in the next stage. Before at a so-called B stage, usually the decision is made. And in this B stage, before piloting, the decision is made. And then you have the commercial negotiation with the customers. So it's narrowing down, as I said, in the very first stage.
You have a couple of competitors. I think they are all well known. You have, for instance, Korean competitors and others as well. But in the end, you have maybe one or two competitors, and then it's really getting to a decision.

Mathias Miedreich, CEO
But to come to your point to the technologies, it's also a bidirectional approach. It's not that the OEM is coming and saying, "I want this exactly battery and this chemistry." They have a specification of what the electric vehicle should do and what the battery should do.
And then our engineers, and that's the team that you have been talking about, are engaging in a dialogue to say, "Look, you had this in mind, but if you use this or the chemistry you said, but in another composition, etc., you might have even better results."
And then you go into a kind of a technical pre-development process where if you have good arguments, you can convince the customer also to change the specification. So it's not like a catalogue that will be sent to several players.

And that's also, it's already a good sign if you receive an RFQ, how we call it, Request For Quotation, because it means the customer thinks that in interacting with you, they will find, because they cannot do it with 20 people, that's not possible in the time they have.

Ralph Kiessling, Executive Vice-President, Energy & Surface Technologies Umicore Group, and upcoming Executive Vice-President Umicore Battery Materials
So I think that it's a parallel process. That on the one hand, you do with your customer, you meet like you address like Mathias says, all the customer requirements, the specification requirements, and then you go and more and more in details in the selection, what the right application and the right technology can be.
And then it's also in parallel, it's let's say commercial, you start with an RFI - Request For Information - for first, and then you go more in detail in an RFQ.
When you're in an RFQ, you more or less know mostly already in which direction the technology goes, because that is of course then also going in, let's say in the commercial exchange negotiations.

Fabian Smeets, PGGM
Thank you.
If you could add one more deeper layer on that, what would you think is the main difference between this process, which you just described, and the process you have on your catalytic converter side with the OEMs? What's the main difference?

Mathias Miedreich, CEO
As Ralph was heading the catalytic business before, he can also answer this question.

Ralph Kiessling, Executive Vice-President, Energy & Surface Technologies Umicore Group, and upcoming Executive Vice-President Umicore Battery Materials
I think in the end, you have a lot of similarities, because also you have, let's say you have a stage process where you have in parallel, you have the applied technology teams, but G.S. was referring to having a close interaction on the technical side, and you have the purchasing teams also on this side, and you're, let's say, you're narrowing down the funnel step by step.
So we have a lot of similarities here. This is by the way also the reason that we, let's say, bring the knowledge from the automotive catalyst teams over to our battery teams, because they know exactly how the OEMs function when it comes to the technology side, and the application side, but also on the commercial side.