



Capital Markets Day 2022

Wednesday, 22nd June 2022

Mobility Transformation: Capture Profitable Growth in Circular Battery Value Chain with Battery Recycling Solutions

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Thank you, Bart. Thanks a lot. Good afternoon. I have to start by really thanking you here, thanking everybody online. This has been a long and, I think – a long and very informative day. But nevertheless, I know after two years of being eight to ten hours after a PC screen at home how hard it is. So thank you for being online. Thank you, colleagues, following us here on this exciting day.

Indeed, I have the honour to accept a small gem. I like raising teenagers at home and I like to raise teenage businesses in Umicore. I like to bring them to life, to grow them, and then hand over when the time is right. I'm here today to close the loop, in good tradition of the company, and that's also what I'm very passionate about. I'm going to really guide you through the journey of Battery Recycling Solutions in the next half hour.

Agenda

I will start by explaining why battery recycling matters. And I will explain how we will do that. And then, last but not least, try to wrap up and print some key messages in your head before you first enjoy a drink and then you go home.

1. Mobility transformation driving growing battery recycling needs

End-of-life EV Batteries Surging in the Second Half of the Decade

I'm kicking in an open door when I'm saying that the market of end-of-life batteries ready to be recycled is growing dramatically in the next decade. That is true.

However, how the business models will develop on how these end-of-life batteries will come to our plant or come to the company, there is still some debate, some discussion and really some different business models are being discussed. I would like to stress that there is also a market pull because from a regulatory perspective, new batteries will have to contain a recycled content in the future. And that will actually also create clearly demand for battery recycling and a need for that.

Production Scrap Primary Source of Supply Towards 2030

Now, end-of-life batteries is an interesting market but underlying in the next decade, there's also production scrap. There is a huge battery industry emerging in the world. And many people challenged me often on how is it possible that so much scrap is being generated. Now, frankly speaking, if you look at it proportionately, the amount of scrap to be recycled for me as a recycler, is huge compared to the end-of-life batteries. But in the end, battery industry is preparing now for future electro-mobility and I'm getting the batteries at end of life that were put on the market ten years ago. So there is a huge baseline difference.

What does this mean for me? Or for Umicore? Well, we have to, first of all, prepare for a very flexible and mixed feed. Secondly, we have to be capable to manage flexibility. Today, I'm getting maybe a much higher fraction of production scrap, and tomorrow, I'm getting modules, or packs, and I have to be ready for that. The technology that I will apply will be – will have to be robust, to cope with that flexibility. And it has to be fast scalable.

Global Recycling Need Accelerating Significantly Post 2030

You saw the numbers until 2030 but look at what happens beyond 2030. The recyclable volumes are going to triple in the five years beyond that. So, in other words, I'm preparing a mass scale – or the company is preparing now a mass scale technology that is going to be scalable to accept these huge volumes beyond 2030.

The graph is also showing the geographical split of the volumes. No surprise here as well. The biggest volumes you see in China. China is the region with the highest battery manufacturing today and in absolute terms, also the highest electric vehicles in the market. So, by consequence, this is a very important market. Look, however, at Europe and the US. These markets will develop very fast and will form 45% of global volumes.

As mentioned, the next decade, we need to be ready to accept quite a bit of production scrap. But around 2030, 2031, we really see a flip, a turnover and end-of-life volumes take the majority of the volume.

Recycling is Crucial for the Mobility Transformation...

Recycling is absolutely crucial in the mobility transformation for very, very different reasons. I would like to stress, first of all, that recycling will help to reduce the need for virgin raw materials. Every atom that we can recycle, that we can get back to recycling is an atom that we don't have to mine. That's, of course, the first and foremost reason.

On the other hand, every atom that is being recycled, is an atom of known source, is 100% traceable, so we can really confirm what the origin is. In that context, you heard a lot about a battery passport being developed. Umicore is a very strong supporter of that and it's introducing this concept in the industry.

And last but not least, recycling will really help to develop the regional supply chains. Because natural resources are not equally spread all over the world so certain regions will definitely focus on recycling for geopolitical reasons.

Recycling is also important from ESG perspective. Through recycling – like Géraldine mentioned, through recycling, we can reduce the environmental impact of the battery supply chain. I'm often explaining to people who really ask, why is this now, this energy; what is happening? Well, very fundamentally, what is happening is that we are – on the world, we are changing single-use fossil energy resources by multiple-use mineral resources. On the largest scale, this is what's going on. But of course, multiple use of metal means you have to recycle.

...Requiring Critical Competences and Skills for Battery Recyclers to Succeed

What are the requirements to be successful in battery recycling? I tried to split in three blocks.

Process

The first block is everything about the process: production process. We need a process that is capable to reduce the sheer volume, the sheer size of what is coming to us. And we have to reduce that mass and volume as soon as we can. The process needs to be able to extract the metals, the critical metals, with a very high yield. Of course, from an ESG environmental impact view, this is important. But it's also important from an economical point of view; the more you extract, the more value you can recover.

The process has to be flexible, because you need to treat a wide diversity of mix – of feed mix – and it has to be sustainable. I will get to that in much more detail later in my talk.

Product

A recycling process yields also a product, and for battery recycling, we are in a very strange situation. Today, for cobalt, for nickel, and various – for lithium, and very soon for nickel, the volume coming out of recycling will be too big to be accepted in any other application for these metals.

What does this mean? You have to produce a product that has a battery grade. The quality requirements are very high. That's what we have to produce. This is really the contract that I have with Ralph and his team. For less, we don't go.

The way we do that is actually focusing on efficiency. I need to come up with a product that is capable to kick into the virgin raw material flow of our colleagues of cathode active material production as soon as possible. Because let's not forget, let's see things in perspective, the next 15 years, the virgin raw material flow is going to be bigger than what comes out of recycling. If I want to enjoy cost efficiency scale effects, I have to be capable of bringing these atoms as soon as possible in that virgin flow.

Services

Thirdly, recycling, it's about services. We offer a service to our customers. Are we going to present ourselves in the market as a total service provider? We are there for the different raw materials in a different business model, as is required by the different type of customers. We haven't in the meantime, an Umicore closed-loop operating system – reminds me even a bit of Microsoft. So basically what we are doing is we are offering an administrative system for our customers that allows them to demonstrate that they comply with regulations, which is quite important in this recycling industry.

And last but not least, when you recycle, when you receive packs at end of life, you will learn a lot about mistakes that have been taken in design. I invite all of you, if you're ever around, in our Battery Dismantling Competence Centre in Germany and have a look what is needed to open a pack. This is not designed for recycling. And what is the consequence? It takes time, it takes cost and the TCO of the battery usage is higher. And that's the feedback loop that we want to establish with our partner OEMs. And they appreciate that. We have ongoing running R&D programmes where we help them to give input and make easier to dismantle battery packs.

2. Frontrunner Gearing for Profitable Growth

How are we going to take this on in the next decade?

Capture Profitable Growth in Circular Battery Value Chain

Where to play

Umicore is an absolute frontrunner in this industry. We can start from a model that works. We are recycling today. It's a matter of scaling up now. We are going to do this first in Europe, and we were going to roll this out further in North America. We have a plan to build a 150,000 tonne treatment plant in 2026. This will be the biggest battery recycling plant in the world. We are going to use a technology, a combination of high temperature pyrometallurgy and hydrometallurgy.

I'm going to explain you later on why we take this equilibrium and why we combine these two technologies. This is a proprietary technology that we worked on for more than 15 years, it is applied today, and now we are going to scale. And we are going to do this for different input materials. End-of-life batteries are obviously the focus, but we have also a service to deliver now to people that need to recycle their battery scrap, or their production scrap.

How to win

How are you going to do that? You already know by now, RISE is going to help us. RISE is going to be the hand trail of how we do things.

Capture Profitable Growth in Circular Battery Value Chain: Supporting Our Customers with a Circular Offering from the Start, Ready to Accelerate Together

Industrial-scale operation since 2011

We are already a reliable partner for car OEMs. When we initiated our battery recycling operations more than a decade ago, one of the targets and one of the objectives was to certify the battery packs that the car OEMs were bringing to the market at that moment in time already. Battery recycling is not new for us; I still recall in 2006, I went to a battery show and my colleague for battery recycling was joining me. That was the first appearance for battery recycling. So this is more than 15 years ago.

We learned a lot. We made mistakes but we learned from mistakes. And in the last couple of years, we've really worked hard, tirelessly hard, on the technology to improve it; to improve efficiencies, to improve also the practicability and to improve the scalability. With this experience, with this experience, our presence is currently demonstrated with more than 15 running commercial partnerships, both for car OEMs and cell makers.

In the course of the second half of this year, we will start to implement the improvements that we've prepared for our scaling up. Improvements focus a lot on recycling efficiency. And I'm actually extremely proud to say that for lithium, we have now received the highest recycling efficiencies with our technology. And this will prove to be market leading if you compare that with other options in the market.

Reliable transformation partner in emerging market

I would like to stress how important it is that we close the loop for battery recycling in the transformation exercise that is going on with our strategic partners. There is a huge uncertainty about supply of critical raw materials and with our recycling – battery recycling offer, we can reduce that anxiety and that uncertainty on the raw materials. So in that sense, we form actually a strategic partner, both on the upstream – they know us, in the meantime, from cathode active material production, and that we can refine these metals. But in the meantime, they know that we are a trusted and reliable partner for battery recycling.

Capture Profitable Growth in Circular Battery Value Chain: Science Meets Business – Long-Standing Materials and Process Technology Know-How

Leveraging historical competence

Innovation. Innovation goes literally to my heart, as some of you probably will know, but I like really when science meets business. And that's where we actually excel. We have chosen for the right arguments, for fundamentally good arguments, for a combination between high temperature and hydrometallurgy for our process. Being a chemist, I see no

way how you can ever treat an end-of-life battery, which is a hazardous chemical factory, and how you would make out of that waste a high-quality cathode material, unless you use a high temperature step and a chemical purification step. Without that combination, we will never get there as an industry.

Let me spend two minutes on what we do, and what we see that others are doing, and where we maybe have the same approach or where we differ. On the left side, this is the process that Umicore is going to apply; and on the right side, I try to generically explain what others are doing.

We both have to start by making an assessment of what we get in our plant. A pack is not necessarily very safe, you do not necessarily know the health, and you sometimes have to discharge that. So there are a number of manipulations, pre-treatment steps, that are equal for all of us. The Umicore process starts with a high temperature process, which means that we don't have to dismantle or crush or make powder out of that. It goes right away in a high temperature process. Remember, you have to reduce the weight and the volume as soon as you can.

Other companies start to have different processes, either or not with an intermediate temperature treatment, shredding, mixing, powders, separation. And after all this being happened, you end up with a black mass. And in the end, from my point of view, battery recycling still has to start.

At the left side, you see, less stuff happens there. So you have a pyro step, complemented with a straightforward but shorter hydrometallurgy. We do things fast and good with the pyro. And then we basically clean up and do the very last steps to make battery grade with hydrometallurgy.

I would like to give a couple of very talking numbers. If one truck of end-of-life batteries enters our plant, I need one truck of reagents to clean up, all the way, the critical metals to battery grade. If one truck enters the other process, people need four trucks of reagents to enter their plant to get to battery grade. This, of course, translates into an environmental impact as we will see later on.

Umicore's battery recycling technology

Umicore's technology is really looking at an optimal balance between high temperature and the selectivity of hydrometallurgy. The technology is proprietary. It's protected in the meantime by over 20 patents, of which 15 have been granted worldwide.

Why have we now chosen for this technology? There is a lot of discussion in the market about that and I want to set the record straight with this slide. The technology gives us input with flexibility; I think it covered this already a lot. The reason why we have to do it, and how we manage that. It's thanks to the robustness of pyrometallurgy.

Secondly, the process needs to be effective; it has to be reliable, robust, scalable, and very efficient. And like I mentioned already, I'm extremely proud that for lithium recovery, we are reaching industry-leading recoveries. And for the chemistry round, you, in the meantime, know what kind of strange element this is of the table of the elements.

The investments and the cost of the technology are striking. A detailed benchmark has revealed that we can invest for a same amount of input material at roughly 20-30% cheaper

than alternative treatment ways. And like I mentioned, every truck that needs to come to your plant needs to be paid. We can do this at probably around 1/3 lower OPEX. Combining high yields with lower investment costs and lower operational costs, this is an audience that I don't have to explain that this creates the highest value potential.

Last but not least, the environmental impact of this process is better than any other alternative we see in the market. I'll get to that in even more details.

Benchmarking recovery and valorisation rates closing the loop

Regulation is ambitious. Battery regulation in Europe is setting pace and other regions are copying the targets. The table on the right gives you an overview what's currently under debate and will be decided and signed off, voted, towards the end of this year. The number of batteries that will need to be recycled has to increase, so there is clearly a market for battery recycling. But then if you look at the regulatory details that are being specified, the metal recovery efficiency of recycling process is going to be specified; you will have to meet that hurdle. The governments, the regulatory bodies really force people to use best available technology, and this is what we do.

Like I mentioned this is for cobalt, this is for nickel, this is for lithium; not a coincidence that these elements are specified because these are the value drivers in battery recycling. The targets that are currently under discussion for 2030 are ambitious: 95% for nickel, and cobalt; and 70% for lithium. The technology we have chosen is future proof. We have today demonstrated, we are demonstrating in our plant that we can meet these targets.

Capture Profitable Growth in Circular Battery Value Chain: Key Enabler for the Circular Economy

Embedded sustainability value

Sustainability, really a very important differentiator for Umicore. The most important element in the overall lifecycle analysis for battery recycling is the CO₂ emissions. Allow me to take a couple of minutes to explain this because here, as well, there is a completely wrong perception in the market. We have studied in depth with external partners, and using the ISO 140040 guideline – and I'm giving this detail because it is really important. This ISO guideline dictates you to let the studies validate by a third party, which we did. We used the German Eco Institute to do that.

The results of our study of our lifecycle analysis for CO₂ emissions is the following: we compared three different processing technologies, Umicore technology, an intermediate temperature, hydromet treatment, and a full mechanical hydrometallurgy treatment of batteries. What is the result? CO₂ emission per kilogramme module input – apples to apples comparison – our technology shows the lowest CO₂ impact of the three different methods.

But look at the details between Scope 1, Scope 2 and Scope 3. First conclusion, the energy requirements, so Scope 2, is almost the same; we do a little bit better than the others, but is almost the same. Completely wrong perception in the market because people say, you do high temperature, you're using a lot of energy. Wrong. We use the energy that is already in the battery. That's what we do.

But look at Scope 1. Our Scope 1 is biggest of all the technologies. But we take a commitment, a responsibility to go to zero and it's in our control. So in ten years from now, this will be about zero.

The light blue is a different story. The light blue is of course, the CO₂ that is in those trucks that arrive in your plant. And this is something that is far more difficult to decarbonise. So this is where the wrong perception lies. People see – when they come to us, they see a stack but they have forgotten that there are four stacks at the chemical plants that indirectly arrive when you use reagents.

Responsible and circular sourcing

Battery recycling is actually the best way of responsible and circular sourcing. It's under your control, it's a secondary source, and we can reduce the CO₂ burden for the products of Ralph to the highest extent. This is a huge lever to decarbonise the battery value chain. And last but not least, it's fully traceable. There is a lot of debate about where things are coming. I always like things that I control really myself, then there is no question about that.

Capture Profitable Growth in Circular Battery Value Chain: Scalable Technology Delivering On Market Requirements

Frontrunner ready to accelerate

Excellence and execution, we still have a long way to go. We do this – we do battery recycling for close to 15 years. But if you look at the volumes, we have a challenge in front of us. Thanks to the experience of our operations right now, we are confident that we can scale to a 150,000 tonne unit. This is roughly a scale factor of 15. The engineering teams feel comfortable about that. They feel comfortable, because we have experience in those pyro technologies at that scale.

Oops, sorry, that was first.

We start from our existing presence in Europe. And we are going to roll out a similar model in North America. We will follow there the market as it will grow. And during that growth phase, we clearly see a synergy between our activities in Europe and North America. The engineering track for the 150,000 tonne unit is on an accelerated path and I really like this kind of engineering CAT/CAM designs rather than the artist renderings that I often see in a lot of announcements.

Linking variability with product consistency

Talking about excellence, we have to combine water and fire here in this closing the loop exercise. What we get is usually variable in composition, in chemistry, in shape, and format. And in the end, what we need to produce as a cathode material has to be, quality wise, [inaudible] flat.

How do we merge these things? We merge these things through experience, competence and skills. That's what we excel at. And we're going to apply this to create a reliable industrialisation path for our customers. This is what we commit to with the team.

3. RISE 2030

Battery Recycling Solutions – RISE

Let me come to the conclusion slide. With battery recycling solutions, we are going to really capture profitable growth in the next decade. The market is going to grow fast. We are

going to scale up from Europe by building a first 150,000 tonne unit. Like I mentioned, I hope I could convince or I hope I could explain why we opt for high temperature hydrometallurgy combination. And the most important thing, battery recycling, in the end, it's a service that we need to provide to our customers, and service means you have to be service minded. You have to be able to accept what is available, what comes to you, and you take the burden out of the hands of your customers. And that's really what we're going to focus at with the team, scale with them and offer them the service they need.

And with that, I think we get to the Q&A session.