Lignode – Making batteries out of trees investor presentation transcript

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Introduction – Ulla Paajanen, Head of Investor Relations

Good afternoon everyone and welcome to the Stora Enso teach in – Lignode – Making batteries out of trees. I am Ulla Paajanen, Stora Enso's Head of Investor Relations, still until the end of Q3 result announcement. This event is being recorded for internal and external purposes. If you do not want to be part of recording, please feel free to leave the teams meeting. Our team presenting and taking the questions today are Markus Mannström, Head of Biomaterials Division, Lauri Lehtonen, Head of Innovations at Biomaterials, and Stephan Walter, Director, Emerging Business Bio-based Carbons. If you want to ask questions, please write them to the chat box. I will then read them to the audience. We will keep the participants lines muted the whole event. The slides will be available on our website after the event, so now I will hand it over to Markus Mannström. Markus, please go ahead.

Lignode – Making batteries out of trees – Markus Mannström, Head of Biomaterials Division

Thank you all and warm welcome also on my behalf. It's truly fascinating that we have come this far on the road. As we all know, Lignode is one of the biggest opportunities that we have at hand. We will today provide you with a teach-in on what Lignode is really about. We will also talk about how we believe we can scale up this business opportunity. But before I hand over to Lauri and to Stephan, let me share a short, very short story about our R&D innovation work in the division.

We have performed Innovation Reviews since 2016 and in the 2018 Innovation Review, just before Christmas, Stephan and the team had prepared a small surprise for us. I have always been pushing to make demonstrations showing something visible. Well, just before Christmas in 2018, Stephan and the team showed the first small Christmas present, it was a tree energized by the first ever battery made with our anode material, and to everybody's surprise, this small Christmas tree had small lights. It was still shining bright until Easter the following year. So, with that, I hand over to Lauri. Please take the floor.

Video introduction – Lauri Lehtonen, Head of Innovations, Biomaterials

Thank you Markus what a nice story, thank you. So, before we want to start and go deep into the teaching presentation, I think we should start with the welcome movie to give you guys a little bit of a flavour on the big picture. So why don't we start the movie?

Lignode video

The future is electrifying, in just a few years, we've seen huge leaps in technology, electric cars, handheld devices, alternative energy sources, and robotics. We rely on electricity in almost all parts of society, which means that batteries are becoming all the more important as well. In fact, in 10 years, battery production is expected to increase tenfold.

So what if you could make that trees more sustainable than today? By making them from trees.
Well, you could at least partly.

Today, lithium-ion batteries consist partially of graphite, which is often obtained or produced under less than satisfactory conditions. So, what we're doing now is replacing fossil-based graphite with renewable hard carbon.

There's a material called Lignin found in trees. It's actually one of the most common materials in all of nature.

In the production of cellulose fibers, lignin is separated and usually just burned for energy. But why not put it to use instead since millions of tonnes of lignin is produced every year. By refining this material, we can turn it into hard carbon and replace graphite in the anode part of the battery. The amorphous and highly opened structure of hard carbon enables the anode to be charged and discharged faster compared to graphite. And to achieve a better performance at lower temperatures.

Unlike graphite, lignin is a by-product that comes from existing renewable, traceable sources available in Europe. This enables companies and products using tomorrow's batteries to become more sustainable, unnecessary development. Bearing in mind how much the battery industry is expected to grow. The technology is already here, and it could be used for thousands of different applications. We are now scaling up production to be able to offer this solution to the market soon.

Join us in the ECO evolution. By making batteries from trees.

The future is electrifying, and sustainable solutions are needed – Lauri Lehtonen, Head of Innovations, Biomaterials

Wonderful and for those who didn't have a good enough connection, this video is available on the website, we will share the information later on where the link can be found. So, as we heard in the movie and then our little video that, the world is electrifying, and a lot of this electrification is driven by the electrification of mobility, so electric vehicles. This electrification of the world is driving a lot of demand of new technologies.

In the centrepiece of this transformation is the battery and the battery technologies and development of that value chain is taking huge leaps and in addition have more than 200 giga factory projects announced or in production state globally right now. And these projects and giga factories need a huge amount of raw materials, so the raw material demand is significant. A typical giga factory, let's say 20 giga, needs about 20,000 tonnes of anode raw materials which we will be talking about today. This is a significant amount, especially when multiplied with the amount of giga factories that is currently under planning. The estimate corresponds the potential volume of maybe more than 3,000,000 tonnes in the next 10 years, so the demand of raw materials and demand of batteries is increasing significantly, and this is a transformation that's happening. I think we have a lot to offer in this transformation.

In addition, what's happening is the sustainability demand in this value chain is increasing. It is driven by the fact that 50% of the upfront carbon footprint of an electric vehicle comes from the battery itself, there's a huge demand from the value chain to look at more sustainable solutions to address that challenge.

With this I would like to start telling you how we do this and share how we move forward with this. Stephan, can you take us forward with the basics and what we're trying to do here?

How a lithium-ion battery works – Stephan Walter, Director, Emerging Business Bio-based Carbons

Sure thank you Lauri. Ladies and gentlemen, to understand how we connect to this opportunity of the battery industry, which is really taking off and going into all sectors of industry and then of course having electric mobility as the major driver, we need to take a look at the technology. We will do this in brief and then explain how we do that from trees fulfilling our mission, that everything that is done from oil and fossil-based raw materials today will be made and can be made from trees tomorrow. So, this slide will show us the basic principles of a battery.

Now, in order to store electrical energy, it usually requires two sides, and those are usually labelled anode and cathode, which are separated by a pros film or sheet through which the ions can travel but the electrons cannot travel. So important to say, cathode on one side, that's a material that is a lot talked about and it's about the metals in it. Most batteries today still have a lot of cobalt in it. There are trends to also mitigate those issues and challenges, and on the other side, most batteries still today consist of carbon material, which then forms the anode.

On the next slide, we will see the basic principles in the functionality of a battery where both materials, the anode material on one side and the cathode material on the other side are basically hosting the lithium ions, and during charging, the lithium ions are migrating into the anode. The anode needs to take up these lithium ions and during discharge they're migrating back into the cathode material. The electrical current then flows through the connectors and driving whatever device is powered. Of course, at best, a nice fast electrical car or any other device really. And this process of the moving of the ions is key. What we're going to look into in a second. Why our material makes a lot of sense in this application.

What’s the problem with graphite? – Stephan Walter, Director, Emerging Business Bio-based Carbons

In this slide you see here some aspects on the current material, roughly 90% or even more depending on which statistics you're looking up, use graphite anode today. Graphite is a material that's been used for this application for decades, and it's been developed for a while. There are some problematic aspects, like with every fossil-based material. Graphite is often produced under less than satisfactory conditions. It is made from a fossil fuel. There is a lot of CO_2 generated when it is generated, and also other materials are mined and ripped from the ground. Then they need to be cleaned, and after those processes, they are not as clean as you would like to have.

Then there are technical parameters and performance indicators, which can be looked at in many ways and also in competing concepts. One of them is the ability to accept the lithium ions in slow and fast charge applications. So, in a short time, a lot of ions that need to be taken up. And those factors to improving will be our angle of attack with our materials.

A more sustainable alternative to graphite – Stephan Walter, Director, Emerging Business Bio-based Carbons

So the future concept you see in this slide. Battery using our material is going to look very much the same. So, on the left-hand side you see the concept that has a graphitic carbon as the anode to accept the lithium ions during charging. We will bring in a material that we call Lignode, which can accept the ions, and which can replace either fully or in parts the graphite that you see on the left side and conventional concepts. Lauri, take us into the world of Lignode please. Thank you.

What is renewable hard carbon? – Lauri Lehtonen, Head of Innovations, Biomaterials

So we will be generating a product that's called renewable hard carbon. So, what do we mean by this? What are these renewable hard carbons? So, let’s take a look. Our hard carbon that we manufacture is made out of lignin. A tree consists about 30-40% of lignin, and traditionally this lignin is used in pulping process as a fuel and as a biofuel.

We have established the technology to extract lignin and then take the lignin to value added production. There are millions of tonnes of lignin produced in Europe alone and circulating in the pulping process, so there's an ability to

extract more and more of that. What is a wonderful thing about this is when we do the extraction, we're not increasing the number of trees that we use, but we put more value at it.

We can add more features and benefits to it, so it is a wonderful raw material to have. It is coming from traceable and certified resources, so we have sustainable forestry practices that yields eventually lignin that we can transfer into higher value-added products and this is what we've created here. So, for the past I would say seven years, there has been significant Research and Development (R&D) into this concept. And we have eventually developed a technically advanced hard carbon, which is replacing existing graphites in the anode side of the batteries. There are significant performance benefits. They enable a faster charging and discharging, higher cycling stability and perform better at low temperatures, and they can be mixed, or they can be used alone.

So with this Stephan, can you tell me a little bit of why? Why does it do this?

An amorphous, highly open structure – enabling faster charging and discharging – Stephan Walter, Director, Emerging Business Bio-based Carbons

Yes, of course. So, if we look into the mechanisms on how energy is stored in the lithium ions. It basically all depends on the structure. This slide will actually show you this. In a simplified illustration and on the left side you see the graphitic carbons, which consist of these very parallel layers. That's the very definition of a graphite. And the lithium ions migrate from the sides into the layers and sit in between those stacks. The process of intercalation is basically the secret of why we can store energy, particularly in these graphite carbon.
These have shortcomings. Lauri has named them in the introduction here that the migration in and out goes via two sides - left and right basically and the intercalation also has its challenges at low temperatures. Lignin based hard carbon, which is resembling hard carbons that the industry has known for years and years, just not bio-based, lignin, has a different structure.

So the graphite layers are different. The crystalline structure is different, which will lead to a different performance, and incidentally it brings a lot of this. Faster movements of ions and a higher degree of freedom to move in low temperatures. That translates into the fact that our materials will allow a battery to charge faster and also to discharge faster. So you have more power in a short while that you need out of the battery without any problems. So the limitations are smaller.

Everybody who has driven an electrical vehicle here in the Nordics know that during winter you have a smaller range compared to in the summer, and particularly when you start up, the range and the battery will actually decrease quite much faster. Our materials bring a solution to improve that performance, and that's where we see a major attack angle for us into this market entry point.

Hard carbon to complement or replace graphite as anode material in Lithium-ion cells Stephan Walter, Director, Emerging Business Bio-based Carbons

Here we see a short summary of the secrets of why this material shall and will have a place in the market and as a matter of fact it is existing in the market. Cell makers that we are communicating with know this material and they know how to use it. They appreciate a lot of these beneficial properties.
Looking at this chart, which itself can take very long to go into every detail, shows again some main benefits. The fast charge and fast discharge capabilities, often referred to as so-called see rates. Then you see the low temperature performance where we bring benefits related to electrolyte versatility. So, basically, the choice of the electrolyte that hosts, and that carries the ions back and forth inside the battery is wider. And allows to build different chemistry compositions for our customers.

The cycling stability means allowing more cycles with the same battery before it degrades, and then there are some other factors like cell voltage and the energy densities. Both were low metric as far and as a gravimetric, where we do have challenges. Our material is not as dense, it is more open. It allows more movement, but with this comes of course some downsides which we don't want to hide. It's very well described in the literature and the cell makers know this.

And here we see that even for applications where the energy density is a key factor, like the battery in a car, you can mix the material of regular standard graphite with our material and you get benefits from both sides. So you're adding 1 + 1 and you're getting more than two. So, this is where we really see great potential going forward.
So, where's all this happening?

Large scale production underway - Stephan Walter, Director, Emerging Business Bio-based Carbons

If we look at the this slide, you can see our well known picture of our Sunila mill in Southern Finland, near Kotka city, which is one of our pulp mills in the Biomaterials division where we have invested in building a commercial lignin extraction unit many years ago, and we are currently, and we announced in the Q2/2021 report that the pilot production for Lignode is going online there.

And we call it a pilot operation because the amounts we can produce there are good for R&D and customer sampling. However, what we want to stress here, it is basically a miniature factory. So we will be producing the Lignode there and we are producing samples in the very same set that we are currently projecting to be used in a commercial setup. It is serving as the blueprint for the next commercial plan to be supplied with the commercial lignin extraction volumes.

So our pilot plant in Sunila will provide us: 1) ability to build more batteries 2) to test more to develop the product with the customers and 3) make us actionable in creating market opportunity.

So Lauri, I think this is a good point to sum up. Thank you, we move into the summary slides.

Sustainable – Lauri Lehtonen, Head of Innovations, Biomaterials

We have really a sustainable, competitive and scalable opportunity here, and I'd like to recap some of the things that you just heard.

Sustainable - we have an active anode material in a battery value chain that is based on lignin and lignin is a renewable biorefinery product from trees, so providing a very sustainable starting point. In fact, our target is to create the most sustainable and lowest impact anode material available in the market in this value chain.
And we are using trees. Taking something that has been there a long time and adding value to it and putting it into a value chain that needs these benefits. And when we bring in the value chain this superior, traceable raw material, it offers a good sustainable footprint.
Stephan, it's also competitive. Yes, the next slide please.

Competitive – Stephan Walter, Director, Emerging Business Bio-based Carbons

It's not only sustainable, but it is bringing advantages that the market wants to have and is asking for.
Our hard carbon can replace the graphite fully or it can replace the graphite partially and our customers are then able to dial in exactly the properties that they wish for their systems. And it could be that they are looking for the fast charge rates or/and it could be that they're looking for the cycling stability. Could be that they're looking for the

low temperature performance that they want to offer their customers, and at the end application they want to use this. Our material comes with tuneable properties as far as that goes and is hence a very competitive solution in combination or in replacement of the fossil-based materials.

Scalable – Lauri Lehtonen, Head of Innovations, Biomaterials

Good and then that next slide. It's also highly scalable, so there is a lot of lignin in our existing systems. So, it can be extracted. In fact, in Sunila, we are already extracting lignin significantly and we've already invested into a pilot plant that is taking us into a pathway of a scalable process. In fact, this can be scaled to a lot more because there's quite a bit of lignin and we're faced with a market that is growing significantly and demanding millions of tonnes of anode materials eventually in the next 10 years.

It is addressing the needs of a very important future application, and it is already happening today in Europe, where we want to drive self-sufficiency in the battery supply. Anode and hard carbon based on Lignode will be part of that solution. So how will we move forward?

Partnering in the value chain is key to get speed – Lauri Lehtonen, Head of Innovations, Biomaterials

Partnering is a key, and partnering is key to get speed, and partnering is key to become a credible player in the value chain. We are looking at the value chain players that can come and help us to speed up and we're looking at the active players, like giga factory players and OEMs to see what kind of potential partnership we could create in this field.

Speeding up is important due to three reasons: 1) to get market acceptance and 2) speed up the qualification processes and also 3) to scale up the manufacturing process.

And with this next slide, we present how we will with smart partnering enable a fast scale up to reach our ambition.

Enabling a faster scale-up to reach our ambition – Lauri Lehtonen, Head of Innovations, Biomaterials

We are planning to establish potentially five anode mills in the next five years, which corresponds to the range of 80 000 tonnes to 100 000 tonnes of annual production. This equals roughly 15% market share in Europe. And Lignode has potential of EUR 1 billion in sales, with very healthy EBITDA margin. And estimated investment at this stage is in the range of EUR 1.0 - 1.5 billion for the partnership.

I need to stress that these are current estimates and based on assumptions today. We are moving in this journey forward with operating a pilot plan and we are working with the customers and learning day by day with very rapid speed. And with partnership we will speed up things.

In the picture on the right-hand side, you can see our Nordic pulp mills. The pulp mills serve as basis for the initial locations. Mills outside of Stora Enso are also viable candidates for supply of lignin.

So, what's the pathway to this ambition? So how we will do this?

Pathway to the ambition – Lauri Lehtonen, Head of Innovations, Biomaterials

Single production unit timelines from design to production traditionally take four years. We feel that with partnerships we can speed this up quite a bit, and in fact, design work has already started. And in 2021 we are on the pathway and now with smart partnering with the right partners, we feel that we can significantly look at shortening those timelines. Then qualification processes with battery manufacturers and OEMs can take up to three years or even more. Partnering again here, as partners are very viable in the role of shortening those timelines and getting through the qualification processes. So our current plan includes construction of several production sites in a partnership setting with a different value chain partners. And the scale is built on with a plan to have standardised 20 000 anode material units. And the timeline. We're looking at building 1-2 plants/yr after piloting phase, which is estimated to take 1-2 years.

With this, I want thank you for participating in this teach-in and would like to hand over back to you Ulla.

Q&A – Ulla Paajanen, Head of Investor Relations

Thank you Markus, Lauri and Stephan! We have here a number of questions already coming in. So why don't we start from the last one because that was asked when the presentation was completed, which might be more relevant than the first ones.

Q: So who is the main competitor in this technology? Given you mentioned a 50% market share in your presentation.

A: So first, our target market share is 15% not 50%, so that is market share from the total anode market. So there are different manufacturers who are producing anodes, synthetic and natural graphite manufacturers, and that's the competition field. (Lauri Lehtonen)

Q: OK, good thank you. Do you have ongoing qualification processing with battery manufacturers now?

A: Maybe I can comment that so from the early days of this project, we've been interacting with big greencell manufacturing companies as we are basically stopping with our area when the active material is created. But related to the actual validation testing and the feedback on how these materials run, we've since 2018-2019 been creating with entities in the market that actually manufacture the cells and test the cells and today we are in touch with a number of big players around the globe. Of course, we're not revealing, or we cannot talk about which partnership or which company we're really working with in detail. But yes, we are working with the relevant players in the market. (Stephan Walter)

Yeah, and maybe build on that. The pilot plant that is now in operation is a key part of this collaboration with the customer base. Customers are anxiously waiting for our samples. (Lauri Lehtonen)

Q: OK thanks Stephan and Lauri, so next one – would you start constructing the plants on your own without partners?

A: I can take that. I mean, as we have communicated and you just heard from the presentation, we see a huge opportunity in partnering. Given the interest that we see around us, we will explore this partnering avenue fully now. In case we might have to change direction, that kind of decision would be taken later. But for the time being, we believe that partnering is key to scale this up fast. (Markus Mannström)

Q: OK thank you Markus. Who's next? What could be the optimal mix of Lignode and graphite?

A: I'm happy to take that. So that question really can only be answered by the cell maker and by the OEM that wants to use that product. So there are currently concepts that are ranging between 50/50 to levels that actually can go as low as 10%. We also see concepts where customers want to go for 100% Lignode replacement, so it really is case dependent and it actually drills down to levels of what type of car, what size of car? Is it a last mile delivery vehicle or is it a passenger car that is driven in a completely different manner so that could be ranging in the combination concept in the mixing between 10%-50%. (Stephan Walter)

Q: Thanks and next one to Markus. How large share in the partnership model would you anticipate for Stora Enso?

A: Well, I think in a good partnership, you work with very like-minded partners that have equal interest in the consortium or the setup that you are developing. So you could easily think that if we would be in a three partners model, we would share the pie in three pieces. However, it is always subject to what each partner really contributes. So if we find ourselves with major contributors of course then we are ready to share the cake in equal pieces. If you have partners that that bring something less to table then of course it's a different story. From the experiences that we have from other partnerships, we have learned that there is also a roof, especially at the early stages of scale up. To sum up, I would say that partnering with two or three like-minded partners but not more than four is an ideal setup for Stora Enso (Markus Mannström)

Q: Good thanks! But do you have any initial partners already or will this require the pilot phase to take place first?

A: I can take that, Yep, so. I'll leave that open. I can't talk about the initial thinking that we have but we are moving towards that. Answering to question is pilot and piloting phase needed to do before partnerships are created? That's also to be seen, and it's dependent on the dialogues that we will have. So I'll leave that open and don't take a judgment on that yet. (Lauri Lehtonen)

Q: OK, good thanks. Is the mentioned 50% EBITDA margin corresponding to your earlier announced 35% EBIT margin target? So how do these two EBITDA and EBIT margins link to each other?

A: I think it's very important to understand the roles of these two measures. EBITDA is a key to anybody entering a new market, especially when you come in with something that substitutes something existing. We have now a track record in our innovation community to incorporate the logic of understanding and simulating, with tools, the assumed future production costs from a very early stage. And that is a real benefit for us. You have to understand what are the costs of the raw materials, what you are processing? What are the actual costs in the different areas? When we talk about carbon related products, it is important to understand what the cost of electricity is and what is the type of electricity that you are using to process this. You need to understand your cost competitiveness against existing materials. (Markus Mannström)

If we look at the other lever. And you think about this from an EBIT perspective. In a fast scale up business, I find EBITDA much more relevant than EBIT. We can always steer, at the end we end up with a certain portion of amortisation annually, depending on where we end, or how far we want to go, or how fast we want to go. So we have a strong focus on making ourselves cost competitive by using the same analogy we have in our pulp business - cash costs is king. (Markus Mannström)

Q: Good thanks, so the next one is what kind of partnership structure do you plan to set up? A 50/50 JV or several JVs or what? I think you have certainly been touching upon this, but maybe you can sort of clarify this even further?

A: Well, with all simplicity, I think that the shareholding structure leading to a joint venture where we have a couple of partners sharing the cake is the way forward using the example of sharing the cake in three. For the moment, we also quite a lot focusing on setting up one structure to commercialise this. Not several different structures. (Markus Mannström)

Q: OK, the next two questions are relatively related, so I read them one after another. So what are the benefits in renewable hard carbon compared to silicon based anodes? Silicon is also used as an anode material. How would Lignode fit in here?

A: I will gladly take that. Yeah, this goes now into details. It really depends on how much time we have to go into the details right now. Yes, it is very true that silicon is a material that can also host the lithium ions and it is going into anodes today. Large car makers of electric vehicles are using batteries with a certain additional level of silicon today. Which then, I would say replaces the graphite in order to boost the capacities and to change the properties of the entire cell. And that's a trend that we also would expect to continue. We don't claim that will turn around the entire market. The energy storage market exploding will also lead in our perception and what we hear from the market, into a diversification of concepts. And we see this all over the place. In the discussions with the customers but also in media. Now coming back to the silicon. And how does that work together with Lignode? Currently, we have indications and our own hypothesis of going forward is that it works just as fine as graphite with a silicon. So if you look at lower additional levels, that would be a concept. And then if you go into a silicon heavy concepts those would be dominant or completely silicon. Of course, they are replacing also the graphite completely, then the Lignode would be either only a minor component or may not even be needed. However, when we look at the forecast for the next 10-15 years, we are confident that the carbon dominated and that means graphite and Lignode in the future, will be a very large share of the energy storage market. There can be more than one two or three solutions in the future, going forward. (Stephan Walter)

Q: You told that you aim to gain credibility in the battery raw material market. What do you mean by becoming credible? What does it take?

A: Good, that's a very good question. It takes many things actually and setting up a new business is always going in the value chain that you have not participated in before, so you need credibility related to product performance, securing supply and making sure that you're serving your customers as needed. So the basic aspects of business and I think partnering will bring dimensions into that equation that we can speed up, and not build everything ourselves. So combination of many things, right? (Lauri Lehtonen)

Q: Good thanks. Can you quantify the charging speed benefits?

A: That's a that's a really good question and I cannot say a straightforward answer that would satisfy you. You know, by a number. It really depends on the entire set up and design of the battery cell. The cell consists so many components and balancing acts of different ways of building that cell, so that would have a much larger influence than the performance of a material that would replace one thing. We are targeting for relevant changes, so if it is only you know, cutting your charging time by 10% or anything like that, then it may be not satisfactory. But at the end of the day, that value parameter, that performance parameter would have to be discussed with the cell makers. What we do know is that they want to have Lignode for exactly that application. (Stephan Walter)

Q: OK, so thank you! So the next one is: what are the production costs for renewable hard carbon anode and graphite and silicon? Which has the highest margins?

A: That is something that we are not in a position of disclosing right now. As I said, this is a product that we are

working on and one day the costs are known reality but not yet. (Markus Mannström)

Yes, and if I may add one thought, which I think is very important to say is that Stora Enso has been a pioneer in commercial extraction of lignin, and raw materials are a great part of that cost structure, and why we're not ready to discuss the cost structure against the competitors' products. We see that we have our costs well under control because it is lignin that we are extracting from trees. That's the integrated part. And adding to what Marcus said this is something that's unfolding. And we are quite confident in being competitive here. (Stephan Walter)

Q: Good thanks Steven. How much does the carbon footprint of a regular car go down with this solution?

A: I can take that just to change, please. Yeah, it's one of those things. It depends on the system quite a bit and depends on the replacement rates and so forth, ranges etc. It's such a specific benefit for a cell manufacturer or an OEM that we don't want to disclose that right now. But 50% of the carbon footprint of a car is in the batteries and raw materials are a significant part of that footprint. (Lauri Lehtonen)

Q: Then the next question is a bit detailed one, so be careful listening in. So just to clarify, is the EUR 1 billion opportunity for Stora Enso sales with 50% EBITDA margin for Stora Enso or is it split into two or three ways?

A: The opportunity that we target here and the opportunity that we calculate is the total opportunity, which is then to be shared with the partners that are participating in this opportunity. And just to clarify, when the opportunity was presented, we said 15% market share, not 50% market share. But of course, we have to remember that the world doesn't end in five years, and we can assume that speed in this raw material opportunity in the following five years is going to be faster and bigger than this coming five years. That is very much supported also by legislation that we hear about within Europe for the time being on the role of electrified vehicles versus vehicles that would still run on combustion engines. (Markus Mannström)

Q: Good thanks, then the next one is about the energy angle. Over time do you intend to remove lignin from the pulping process to the level of energy self-sufficiency, or potentially even more than that?

A: Well I can take this. So thank you. This is also always a business case specific calculation. The role of lignin extraction and the fundamentals from pulp mill perspective will vary. This becomes a little bit of an engineering stuff and explanation. But depending on the dimensioning of the existing pulp mill you can either extract lignin with a better or less good business case. Whenever we have limitations from a scale up in the energy block with the recovery boiler – lignin extraction is a very positive contributor and a very cheap way to get more pulp out of the mill. (Markus Mannström)

It can be also another way round. There can be capacity in the boiler part and the debottlenecking should happen on the digesting part or wood handing part. So there is no one answer. As we in our division, we actually run quite a number of different lignin applications, and this might also then lead the whole discussion to another direction. We see more applications in the future that are building on lignin. We do biobinders (NeoLigno) and now we are quite far with our carbon fiber and then we have Lignode and we see more applications around us based on lignin as a raw material. Eventually one day lignin is going to be commodity traded by itself on its own merits. And of course then the investment case again might look different. So not really one answer here. We of course strongly believe that lignin is going to become a very important raw material, contributing to the renewability story of Stora Enso and give us attractive new business in the future. (Markus Mannström)

Q: Good, thanks for very good answer Markus! So next one is about the three year of qualification after production start. Can we see it in the EVs storage applications by 2028? Or can some part of the three-year qualification process run simultaneously with the four-year ramp-up production? Which would be the earliest possible year?

A: I think our pilot plant serves a very important role here and maybe Stephen explains a little bit more on how we're going to work going forward with that. (Markus Mannström)

Sure, sure, thank you Markus. So the qualification of a material into battery sales is done very thoroughly and rightfully so. When you see those new EV cars, you know having problems with the batteries or even with the smartphones that we've all may have been affected by or at least heard it when we entered the airplane a couple of years ago. And then that is the background to this topic. Now the qualification cycles are three to four years before commercial volumes of batteries would be going into the OEM product. But this is overlaid with a construction of a factory. The pilot factory or the miniature factory that we have in operation in Sunila Mill in near Kotka city is going to be our stepstone to speeding that up. We'll have the customers testing materials, designing their systems and then there will only be the final qualification phase which will be coming from the actual facility that will then supply those cell factories. So the answer is no, it's not 2028, but we see this in very close timely vicinity to the commercialisation of the first factory that we will have online. (Stephan Walter)

Q: OK, so has the Lignode been tested by the EV producers already?

A: What we said earlier is that we've been interacting with cell manufacturers globally with different materials, and with our concepts for years. That indicates the level of interaction and to this date or until a few weeks ago, our pilot factory was not operational yet and in order to make batteries that actually can be tested by an EV or OEM, we would need to be able to supply hundreds of kilograms and tonnes of materials for their test cells in order to have enough. In short, the answer is there. There is no prototype car driving around with our Lignode batteries, yet.
But of course, we are pushing and hoping for, you know, having that really close in the future. (Stephan Walter)

Q: Can the lignin be extracted from both softwood and hardwood?

A: Yes, it can be done. I mean because of the chemistry of wood. There can be always some small differences depending on what kind of lignin you extract. There are a lot of opportunities for example in eucalyptus-based lignin.
In the Nordics, we are mixing birch and softwood species, which means that you would get a mixed type of lignin and that this is a potential solution going forward. (Markus Mannström)

Q: Good thanks, Marcus. Could you please elaborate about your thinking around price benchmarks? Would natural or synthetic graphite be a relevant proxy?

A: I can take this. We learn from the markets and we look at the benefits that we can bring to the value chain. We are looking to be competitive in pricing compared to synthetic. And we believe that the performance benefits that we can bring compared to synthetic graphite is what works in our favour. (Lauri Lehtonen)

Q: Could you describe the production process? What do you do with the Lignin? Could you describe the production cost structure? What are the main cost elements?

A: Hold on, let me rephrase this so I'm turning any biomass into a carbon material is something that has been known for decades, centuries, maybe even longer. The basics are that you need to take that lignin, which we know as a powder material, and then you carbonise this into a carbon material of very high elemental carbon content that is a thermal treatment. And then you need to have the right particle size distribution of very few microns and that depends on the wishes from the customers and their requirements and also their testing schemes or saying which works best in their setup. So we have been able to create a process that consists of multiple steps. There is thermal conversion and mechanical treatments, milling and upgrading of the materials to

the final step. And I think we have created quite a bit of knowhow inside the company that also will allow us to deal with what Markus was saying. Just saying that in some other mills unlike the Sunila mill where we have only softwood lignin, we would be able to adapt our processing technology and steps to other lignin types. Because if we have learned one thing in the past years, lignin is not only lignin. You really need to know your game and Stora Enso is in that position. (Stephan Walter)

Q: Are you counting on selling Lignode at a meaningful green premium to fossil graphite? Is this a part of your profitability expectations?

A: It's a combination. Value-based pricing is a big component of this. There are many dimensions in this as you saw in the Stephan's presentation. There are other benefits as well and it will be a balance of all of those together. There's not one single that's more important than the other. (Lauri Lehtonen)

Q: What amount of extracted lignin will be required for your EUR 1bn sales assumption?

A: Yes, I can take this. So, we were looking at the target yield of somewhere from one to three in that range or more and it will develop over time. This corresponds to 250 000 to 300 000 tonnes of lignin. (Lauri Lehtonen)

Q: What additional lignin extraction capex will be needed to supply you hard carbon production?

A: Well, that range that we gave (EUR 1.0 – 1.5 billion) would correspond to a range of everything that would be included in the total lignin investment. (Lauri Lehtonen)

Q: What percentage of your total lignin production capacity would you use for the EUR 1 billion sales opportunity?

A: Like I said, there is a lot of lignin. There is an optimal way to take out the lignin and there is a potential supply that's relatively high. This is based on the estimation that we feel comfortable when extracting out of our systems. We are still optimising the systems in our mill set ups. (Lauri Lehtonen)

From a scale up and business case perspective one should never exclude our peer mills in other companies that could be equally interested in providing lignin in a new value chain. From a holistic business case perspective, I don't think we can limit ourselves to the lignin that we have in Stora Enso. So, if we go 10 or 15 years into the future. (Markus Mannström)

We have to have lignin so much in our own hands that we really feel comfortable in scaling up to reach this meaningful position that was discussed earlier. Because if we try to enter a big market and a fast-developing market as a very small marginal player, we don't believe it's going to work. So, again you have to see it this in two ways.

One is that there should not be limitations in ultimate scale up. On the other hand, when you go out, you really start to doing it. You have to know what you have in your own hands and what you can really supply and commit to. (Markus Mannström)

Thank you Markus and we need to end with those words because we are running out of time here. So, I want to thank you everyone for participating in this teach-in. It was a great attendance and I hope you were able to get answers to your questions that we have been getting since our Q2/2021 result announcement. So, I thank you for participating and thanks also to the Biomaterials team for your contribution and goodbye to all.