TRANSCRIPT

TRATON GROUP Webcast 2023: Current developments in battery technology for heavy-duty vehicles

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Introduction

Claudia Fuhrmann [02 - 02:33] Hello everyone, and welcome to the TRATON GROUP Webcast on battery technology for heavy commercial vehicles. My name is Claudia Fuhrmann, and I will be guiding you through this session.

The transportation industry is undergoing a major transformation and at the heart of this transformation are battery electric vehicles. Battery technology has improved significantly in recent years, which makes them not only suitable for urban distribution, but also for the long-haul segment.

At the TRATON GROUP, we are preparing every possible aspect for the electric era. Our brands already offer electric trucks and buses. We established the Milence charging joint venture last year, and in September, we opened a new battery factory in Södertälje, Sweden. On our agenda today are the three key areas:

- Heavy duty truck use cases and factors to consider when developing new technologies.
- Battery architecture and integration into the vehicle.
- And, last but not least, elements of a battery lifecycle, including end of life battery recycling.

For our discussion, we welcome four experts from TRATON, MAN and Scania. And following our panel talk, we'll have a Q&A session where you can ask your questions. So, feel free to submit your questions in the chat box. Please note that the webcast will be recorded and published on our website afterwards.

Part 1 - Heavy duty truck use cases and factors to consider when developing new technologies

Now let's kick off our webcast. For a long time, there used to be the prejudice that heavy duty trucks could not be electrified because of the long distances they cover and the high costs of batteries. This assumption has already been debunked, as demonstrated by first use cases from our brands Scania and MAN. Batteries have found their way into the heavy commercial vehicle sector.

Cell chemistries and battery architectures are constantly evolving, and a new generation of batteries is already on the horizon. So now it's a good time to take a look at how far batteries have come. To begin, let's focus on our customers, the typical use cases for electric trucks, and the challenges we face when developing batteries. So, let's welcome Dr. Götz von Esebeck, TRATON's Head of Technology Strategy & Innovation, and Dr. Stefan Tillmann, Product Manager Batteries within the TRATON GROUP.

So, Götz. There are a number of critical factors to consider when developing batteries for heavy duty electric vehicles. Could you tell us a little bit more about the typical applications of these vehicles and why they play such an important role when developing batteries?

Dr. Götz von Esebeck [02:34 - 04:04] First, it's important to understand why batteries, or which requirements or specifications for batteries for commercial vehicles are important and why. So, we have to look in the so-called use cases we have, or we see, in commercial vehicles and there is, you mentioned in your introduction already, the long haul and the distribution as the main areas. The distribution even includes trucks for distribution, but also city buses in the urban area. These are two of the main use cases or main applications, but there are a lot more we identify, so we are working with the more than 500 use cases. All of them have this high annual mileage, as an important topic and the long lifetime, especially compared to passenger cars. And there are a lot of customized specifications. Important is also the uptime. So, the vehicles have to run to bring our customer the benefit. So, they are industrial products and they need to make money for our customers.

But in general, we have to say, the cell chemistry for commercial vehicles is not a totally new chemistry is an adaptation compared to the general or more front runner passenger cars.

Claudia Fuhrmann [04:04 - 04:08] *Can you give us some more details on the two typical use cases?*

Dr. Götz von Esebeck [04:08 - 06:15] Yeah, sure, of course. First, maybe starting with the long haulage, if you look at that application of that use case, we see an average of

130,000 to 160,000 kilometers a year, which is of course a lot. They run an average of 520 kilometers per day and even up to 250 days a year. In the long-haul application, that's also important in Europe due to the European regulation, that the vehicle can run two times 4.5 hours but have a mandatory brake for the driver of 45 minutes. And that's an interesting point, of course, for a battery electric vehicle. That time can be used then for charging the vehicle so that the second four-and-a-half hours can be run then on that battery.

That's of course a very important difference also to, passenger cars. They have high charging cycle numbers due to the daily drive, the charging in between, overnight charging, and a high energy throughput per cell. That has to be taken into consideration when designing and developing the batteries and the battery cells.

A new standard is coming also for the charging for trucks, especially, the long-haul trucks, the so-called megawatt charging. We then charge the vehicle with a higher power. Usually, a high-power charging for a battery means a high stress for the battery, but not in our commercial vehicle case with this megawatt charging, because we have a quite high, well, quite big battery. So, the stress on the batteries, the so-called C-rate in case of charging, is not so big compared even to passenger cars with high power. So that helps of course in the lifetime then of the battery.

Claudia Fuhrmann [06:15 - 06:21] *That was the long-haul segment. What about urban distribution what are the requirements there?*

Dr. Götz von Esebeck [06:21 - 07:22] Now, urban distribution, the use case looks a lot different than the long haulage. There, we have shorter distances. We have more frequent stops. If we think about city buses or distribution in the cities, of course, with all the stops there. We see an average of 65,000 kilometers a year and they run 300 to 350 days a year.

So, the battery can be optimized for lower weight, for lower cost. Not such ultra long range is needed as we see it in the long haulage applications, then we can optimize the battery for that use case. But in general, again, our products are for our customers an investment good. They need to pay off, so the batteries have to meet their demands, the vehicles have to run and fulfil their demands.

Claudia Fuhrmann [07:23 - 07:38] *But it's not only the different use cases that need to be considered when developing batteries. I think the next question, Stefan, is for you. The intended region of use also plays an important role. Can you tell us a little bit more about that?*

Dr. Stefan Tillmann [07:39 – 09:40] Yes, TRATON is developing a modular kit for those batteries that we will use across all brands within the TRATON GROUP. And for this development, there is for sure the specification based on our extended use case analyses that Götz has presented. And that's also the basis how we will come up with a solution that fits all brands within TRATON. The major forces that we need to look on is, for sure, the environment and the mechanical forces coming in the vehicle, but also local regulations and also the supply chain considerations that will help us to make a good choice how to do this modular kit.

For example, to cope with climate, constraints, and conditions, we will have a system where we have an advanced kit to heat and cool the batteries. For example, in cold countries like Scandinavia, we need to heat the batteries in wintertime to optimize towards performance, but also charge and discharge power. And in hot climates like Spain, we need to cool the batteries to have a good fit to aging, which is prominent in higher temperatures, but also to keep the battery in the limit of the specification.

So that's what we are doing here. And, for sure, customer demands are the central drive force to optimize the batteries so that we have a good fit for what the customers are asking for. And yes, major considerations, beside what I just described, are the environmental regulations that we have to work with, safety standards which work right across the markets, and also recycling laws that can alter what we do. We need to find a good fit all together. The strategic approach of TRATON is to develop a common modular setup that we can use across all brands.

Part 2 - Battery architecture and integration into the vehicle

Claudia Fuhrmann [09:41 - 10:09] *Thank you Götz and Stefan for this comprehensive overview. Now let's take a look at the individual components and at TRATON. The TRATON GROUP has a very diverse product portfolio, so modularity is key. It not only enables synergies and scale, but it also allows us to be prepared for local supply issues and market disruptions. Stefan, you already mentioned the TRATON modular set-up. What does this mean for batteries?*

Dr. Stefan Tillmann [09:41 – 11:33] Yeah, basically you need to understand that commercial vehicles are based on a frame structure where every big component is being attached to. Like cabins, axles, drive lines, but also our batteries. So, we mount them on this frame. For the near future we'll see that we will not have the space in between the frame available, because there are still parts of the drive line, so most batteries are mounted outside the frame hanging on the sides. In the future, we are looking on to a more optimized setup where we have maybe electrified axels, where we gain the space in between the frame also for batteries so that we can have a better fit for the customer. How to place the batteries, to optimize for his specific application. So that's from our perspective, one of the major things in the TRATON GROUP to do.

And what we are also doing with the TRATON management, we are looking on to optimizing towards the application into a set up where we say what is the driving range, what is the charging time, but also payload penalties. If you have a full set of batteries, then this is heavy. But maybe, as Götz described, it's not necessary not for every application, so we can balance this to the right application.

Claudia Fuhrmann [11:34 - 11:49] *So you just mentioned the battery... When we talk about batteries, we usually mean the whole unit, so the battery pack. But the battery pack itself is made up of modules. Can you explain how exactly a battery is built?*

Dr. Stefan Tillmann [11:49 – 12:45] Yes, we get supplied with cells from our suppliers with specifications according to our set-up. There, we have conducted what is the requirement of the cell to cope with our loads, so to say. And then we are building in our factory, from the cells, the modules and those modules might be something like 15 to 20 cells in a pack and those we will then fit into a battery package which has different forms to fit into the specific space on the frame.

And that is at the end of the optimization that we drive, so that we have a good fit of the batteries to the frame and to the application. For example, some customers may need to have free space along the frame to fit in some pillars, or hydraulic pumps or something like

that. So, you cannot populate everything everywhere. That's also part of what we do in our business to find solutions for the customer.

Claudia Fuhrmann [12:46 - 12:48] *So how many cells would go into a vehicle usually?*

Dr. Stefan Tillmann [12:49 – 14:37] Something between 180 and 200 cells, but we will have, when we have the decision clear, we will have all packs on the same level so that we can have the form factors being mixed up, but not the chemistries. That's impossible.

So, when we look at what's the composition of a pack that's not only the cells, the modules, and the mechanics, but also the battery management system (that means hardware and software) to control this stuff and also the battery system.

So, and what are the chemistries we are looking at? That's nickel manganese cobalt (NMC) chemistries, which is a very common chemistry. And then we are looking on low-cost chemistry, which is called LCC, where we have the main focus on the LFP, the lithium iron phosphate cells. Basically, the cells are very similar, except the cathode side, where we have the different compositions of those materials which is giving the names to the cell.

The NMC or nickel manganese cobalt cells have a higher performance with a higher price tag. While the LFP cells or LCC cells, low-cost chemistries, have a lower performance due to lower voltage per cell, but with a higher lifetime, and with a more affordable price for cost-sensitive applications.

And, as you said, we are starting up a factory in Södertälje for the production of Scania. And we will in future do the same thing in Nuremberg for MAN and that's the situation right now.

Claudia Fuhrmann [14:40 - 14:53] *So one factor which is always important for our customers is the price. Götz, another question for you. Do you think that new cell technologies will make battery electric vehicles cheaper in the long run?*

Dr. Götz von Esebeck [14:54 - 16:17] This in general, is very difficult to predict, the battery costs. But the issue we see here is that we are very much depending on the raw material. And there we have seen just recently, some high fluctuation on the raw material prices, due to the geopolitical topics. That's why it's also very important really to look at different aspects. How you can get rid of some of the most valuable and most costly materials like nickel and cobalt, for example. On the other hand, of course it's also important, and we come later to that, to the recycling. To ramp up the recycling that you can get the material back.

But in general, on the long run, we see a decrease on the costs of batteries. But again, very volatile on the raw material. But there are other developments really to decrease these costs, to get the best TCO (Total Cost of Ownership) for our customers.

Claudia Fuhrmann [16:18 - 16:21] *So what developments can we expect for truck batteries?*

Dr. Götz von Esebeck [16:23 - 17:12] In general, there's a continuous discussion on batteries, on different materials. If you make an outlook on the electric truck batteries, we will see quite fast changing technologies there. So, every three years we have, we see a different adoption, a different content of that material. So, on the adaption of the products, an updated of mix of chemistry in a different way, but that's not only on the cells but also on the whole battery pack, of course, optimization of the pack and the software as well.

Claudia Fuhrmann [17:13 - 17:24] *You already mentioned there is more than just the chemistry which improves. Which other trends for batteries are there?*

Dr. Götz von Esebeck [17:25 - 19:23] Yeah, there are a lot of different topics to consider. First, for example, maybe I can jump back also on the chemistry. One is the continuous development, but we see also some revolutionary steps in the battery chemistry, which we currently see in the research area, like all solid-state use, sulfur, and lithium air.

One example is, all solid-state which uses solid electrolytes instead liquid. That has a potential for huge improvements, like higher energy density, it will be safe, it will allow faster charging. But there's always a trade off the different properties and cost, of course, but that's on the chemistry.

Other issues or other developments are also on the manufacturing of the cells, which is improved by dry coating, water-based coating, items like that to be even more sustainable. But also, on the pack itself, like the topic of immersion cooling, so optimizing the cooling for a longer lifetime and topics like that.

But also working on cell topics, cell to vehicle developments, improving the charging process, and optimizing the battery management as well, to have a better prediction of aging. So, all that will improve the battery and be helping us to get to better properties for our customers. But in general (so battery development is continuous and quite fast) we will see, say for less costly and better performance of cells as well as the packs.

Part 3 - Elements of a battery lifecycle, including end of life battery recycling

Claudia Fuhrmann [19:24 – 20:23] *Okay. Thank you, Götz and Stefan. I think these are very valuable insights, and you already answered a lot of the common questions we receive about battery technology. Now, however, to all of those who are watching, if you still have questions, please remember to send them in via the chat box in your browser and we will try to answer as many questions as possible in our Q&A session after the next part of our webcast.*

And for this third part of today's webcast, I am happy to welcome our experts for high voltage battery recycling and battery lifecycle management: Nicole Rostock from MAN and Christer Killgren from Scania.

Nicole, with the rapid transformation of the transport sector towards battery electric vehicles, batteries are used on a large scale. This makes it crucial to set up an advanced recycling strategy. Can you tell us which aspects have to be considered when setting up such a strategy?

Nicole Rostock [20:24 - 22:40] Yeah, actually there are some aspects that have to be considered when setting up a strategy for recycling. So, first of all, what has a major impact are the different regulations in terms of batteries and waste management in the different countries. So those regulations are focusing strongly more and more on sustainability aspects in terms of preserving resources and protecting the environment.

One example is the new battery regulation of the European Union. So, this is now focusing strongly on recycling efficiencies. Like you have to fulfill recycling efficiency not only on the whole pack, but you also have to fulfill recovery material rates, and even to have recycled content in new batteries starting from 2031. So, when we have a look at the slide here, we see what the status within TRATON is today.

So, for the whole pack, we have an average recycling efficiency recovery rate of over 70 %. When it comes to the material recovery rates for cobalt, nickel and copper, we have over 95 % and for lithium we have around about 70 %. So, within TRATON, we use the same recycling network as the Volkswagen Group and, with the partners that we have today, we are fit for the future, I would say, because we already fulfill the targets of the new regulation even today.

So, this is one aspect that has to be considered. Another aspect is, actually the development in the recycling industry itself. So, because of all these regulations, we see that in the future, the demand of recycled content will increase. So, a lot of companies see business opportunities there. So, more and more companies are entering into this industry. We see a

lot of startups claiming to have better recycling technologies with increased recycling efficiencies. So, our target that we have is to really keep track, get a transparency of who is really capable of doing what along the value chain, and then decide who should be our partner in the future.

Claudia Fuhrmann [22:41 - 22:52] *So, the partner network is one thing. Another thing is, as Götz already said, there are different cell chemistries being developed and discussed. Does this also impact the recycling strategy?*

Nicole Rostock [22:53 - 24:04] Yeah, definitely! It has an impact because today the recycling industry is strongly focusing on the recovery of nickel and cobalt. So, there you have established processes and partners that can handle big volumes and you also have the demand for these recycled materials. Because they can even today be used in different products in different industries, for example, in products in the chemical industry, not only in the batteries.

For LFP, actually this is a different story. So, to be frank, LFP batteries are not very popular in the recycling industry today, because the only valuable material you have is the lithium. So, when you only extract the lithium back, you will not be able to reach the target of the European Union for the whole pack, as we just saw on the slide. And if you are a recycler and you cannot fulfill this target, then you are not a good partner for an OEM like us anymore.

So yeah, at the moment it's very challenging and there has to be some development in order to, yeah, increase the efficiency rates for LFP.

Claudia Fuhrmann [24:06 - 24:24] *So, TRATON's approach for life cycle management is a circular economy. Christer, you are our expert for life cycle management when it comes to batteries. Can you explain to us how the closed loop, which is also named for the circular economy, works?*

Christer Killgren [24:25 – 25:22] Yeah, of course. So to understand the context, let's have a look at this illustration then. It starts in the upper left corner with the raw material coming in. And, as already discussed, we produce cells and then modules and packs and we put it in a truck. And then we try to repair those batteries in the truck and keep them in the truck and re-use the batteries as long as possible.

And when they cannot be reused anymore, we repurpose them and then sell them to battery energy storage producers who can build the basis, which is a power bank that you can use for energy storage or grid balancing and so on. And then it comes back to recycling.

Claudia Fuhrmann [25:23 - 24:30] *So the recycling is the last step of the closed loop, but how does it actually work? Nicole, can you explain this?*

Nicole Rostock [24:31 - 27:14] Yes, of course. Maybe we have a look at the next slide to better understand the process. So, when it comes to recycling, first of all, the battery has to be deeply discharged first, and then it will be disassembled. So, then it will be divided into different fractions and sorted. For example, you have the housing made out of aluminum. Then you have two different cables made out of plastics and copper and the electrical components. And then the main part are the modules with the valuable raw material inside. So those modules will be put into a shredder and crushed.

So, in a next step, all the solvent will be extracted, so it will be dried and then in a few more steps further, purified, so that all elements like plastics and impurities will be deleted and in the end the output module will be black mass. And this is how it looks like. I have an example here…

So, this black mass will be at the same time then the input material for the next step, the so-called hydrometallurgy process. So, in this process, this is the input material and via chemical processes you extract valuable materials out again. And as an end product you will have the so-called sulfates.

So, and as an example, we have, for example, the nickel, cobalt, and copper sulfate. And those sulfates will be then treated in further steps, so that it can be used in batteries again as cathode active material.

Claudia Fuhrmann [27:15 - 28:21] *That's great, very informative! Thank you, Nicole. So, I think we learned a lot about the lifecycle and the recycling of batteries, and now it's that time already, we are coming to the end of our webcast.*

But before we finish up, we want to give you the chance to ask our four experts some questions. So, if you haven't done so already, now is your chance to send in your questions via the chat function in your web browser.

What is it you always wanted to know? And, by the way, we are also welcoming back Christer and Götz and Stefan – Christer is still here and Nicole, of course, as well. So, let's have a look if we received some questions… And I can see we have some questions…

Part 4 – Q&A Session

Claudia Fuhrmann [27:15 - 28:21 *One question we received – and that's probably a question for you, Götz – is the battery strategy the same for Navistar?*

Dr. Götz von Esebeck [28:22 - 28:39] Yeah, basically it's the same strategy. Of course, there are different boundary conditions depending on the market, but in general – maybe it's even more in Stefan's direction – but our modular system is of course valid for everyone. For every brand in our Group.

Claudia Fuhrmann [28:43 - 28:51] *Okay, another question we received in your direction… are most of your trucks using LFP or NMC technology?*

Dr. Stefan Tillmann [28:52 – 29:02] Yes, that's what we're heading for, to have those two chemistries for the next years to come to be our major cell chemistries, yes.

Claudia Fuhrmann [29:03 - 29:05] *And do we have a preference which ones?*

Dr. Stefan Tillmann [29:05 – 29:21] It depends on the application. That's very clear. You have applications that require large range, high power – you tend to use NMC. And if you have, let's say short range or price sensitive application, then you would tend to use LFP.

Claudia Fuhrmann [29:24 - 29:34] *Thank you. And Nicole, Christer, maybe one question for you. Why is the TRATON recycling rate for lithium much lower than the other raw materials?*

Nicole Rostock [29:35 - 30:16] As I said before, the recycling industry was strongly focusing on the recovery of nickel and cobalt. So, there you have established processes where you can treat high volumes. And lithium has never been in focus before, because there was simply no demand for recycled lithium, so nobody needed it. So, they didn't recycle it. But now this will change with the regulation coming up.

So, there will be more investments and technologies to get the lithium back. That's valuable material. So this is why the scale up is missing the point.

Claudia Fuhrmann [30:17 - 30:29] *Okay, let's see if we have some more questions. That's maybe another question for you, Götz. What do you see as the key barrier to broader adoption today?*

Dr. Götz von Esebeck [30:30 - 31:11] In general, I would say the biggest barrier is the missing infrastructure, especially for commercial vehicles. So, as I mentioned, this mega-watt charging, which the standard is set soon. So that needs, of course, the ramp up in Europe, for example. That's why and that you mentioned also in your introduction, we have set up this joint venture with Milence to run that. So, I would say the vehicles are ready, but now we need the infrastructure and then the ramp up will come.

Claudia Fuhrmann [31:14 - 31:22] *Another one, which probably is one for Stefan about the platform. Do we already have a dedicated platform for battery electric trucks?*

Dr. Stefan Tillmann [31:22 – 31:49] That's what I talked about, when I talk about the modular kit. The modular kit is our future platform where we have common batteries, common installation spaces, common electronics and software across all brands for the battery electric vehicles. They share also some of the conventional one of those interfaces. But that's actually what we are heading for. Today, we have a little bit separated specification, so we are very keen to get this done.

Claudia Fuhrmann [31:52 - 32:11] *Thank you. And I have a lot of questions coming in, actually! That's good! Good to see! Okay, that's a cost question: how quickly do you think the TCO for BEV will match ICE vehicles. Maybe one which is hard to answer or maybe can't be answered at all? I don't know…*

Dr. Götz von Esebeck [30:30 - 32:50] That's not so easy to answer and it's depending really on the boundary conditions. We expect it will not take too much longer anymore until the TCO is reached. But of course, items like "Maut" (german for toll) can support that shift to battery vehicles from the TCO standpoint. And I don't want to name here really an exact year, it's so much depending on the boundary conditions – diesel prices and so on – so it cannot be so easily predicted. But there will be soon the year that the TCO is reached.

Claudia Fuhrmann [32:55 - 33:05] *Then there was another question if you could please repeat the truck space kilometers per year and days in use, Stefan. I think it was Götz…*

Dr. Götz von Esebeck [33:06 - 33:38] Again, it's only an average which I mentioned that for a long-haul and for distribution. With our 500 use cases it cannot be precise. But the average again for long haulage is 130,000 to 160,000 kilometers a year, up to 250 days a year, and distribution 65,000 kilometers a year and around 300 to 350 days a year.

Claudia Fuhrmann [33:39 - 34:07] *Alright, thank you. We will have a look if there are more questions.*

There is one question… are batteries expected to be core to TRATON in the long-run, or do you expect larger scale players to enter the market and work as tier one suppliers? To you…

Dr. Götz von Esebeck [33:08 - 34:33] I don't want you to disclose here our strategies, of course, but battery is one of the most important parts in general, of course. What in the battery is then core or not, that we will not open yet. But of course there will be a mixture of everything seen and then, used by suppliers depending on region and so on and so on.

Claudia Fuhrmann [34:36 - 35:00] *So, let's see if there are more questions. I think there is someone… The question is a little bit unclear, but someone wants to hear a little bit more about big megawatt charging, maybe when it will be available or some expectations on that, I don't know.*

Dr. Götz von Esebeck [35:01 - 35:52] Yeah, first, the standardization is currently running, so we expect it will be set 2024 and this megawatt charging aims up to one megawatt, roughly. So 1,000 Volt. And then as a maximum. That, at least in Europe and US, will be a standard then, the same standard. In Asia, there's some discussion ongoing, there are the tendency in a different direction. But it's a special connector, also a special plug, which is designed to withstand this 1,000 Volt and so on. It's maybe too much to go in the details and maybe even a different webcast, maybe for that!

Claudia Fuhrmann [35:54 - 35:59] *But one question which I like is what has been the most exciting recent breakthrough in battery technology?*

Dr. Götz von Esebeck [36:05 - 36:06] Oh, good question!

Dr. Stefan Tillmann [36:06 – 36:54] Maybe, then, that we see that we are constantly evolving, even better performance with existing technology… this was not expected in the sense so why it's always many people so keen to have a new battery, new battery technology. But we are still discovering corners where we can extend the capabilities of the cell, and let's say the base technology that we have today, with small tweaks and the optimization on space usage and other stuff. So that's what we see and that's partly the cell, and partly in the battery packs that we have even better higher packaging rate and all that stuff. So it's really on this, on this when I'm really glad to see that we discover this more and more. There's is still a way to go. It's not finished yet.

Claudia Fuhrmann [36:54 - 36:59] *You know it's a great thing to see that it's now also possible to do long haul.*

Dr. Stefan Tillmann [36:59 – 37:01] Absolutely. Yes. Absolutely.

Claudia Fuhrmann [37:02 - 37:18] *Yeah. Let's have a look if there is more to come.*

So that's maybe more a strategy question about our low emission strategy. Is it electric-only or electric-first?

Dr. Götz von Esebeck [37:19 - 38:03] Now, in the long run, we will see the battery electric vehicle as the main technology. There will be use cases where maybe the battery electric vehicle is not the favorite. There could be others like fuel cells, like e-fuels, maybe even some specialties, but that are really niche applications. The main direction is battery electric vehicles. But also, again, depending on the market which market, we are a global company in Europe, it's battery electric vehicles. But there might be other markets where it's not so evolved yet with infrastructure and so on.

Claudia Fuhrmann [38:04 - 38:15] *And I see there are still questions coming in… Are our e-trucks built on the same production lines like the ICE trucks.*

Dr. Stefan Tillmann [38:16 – 38:52] That's exactly the beauty with the modular kit that we are developing that we are able to produce on one line all the different trucks and to optimize this, also the usage and the factory. And we can, in this sense also control a little bit what the market is requesting. So, we have a little bit of space to squeeze up and down depending how the ups and downturns in the markets are. That's also why we are so eager to get this modular kit because, as I said already, we share some interfaces with a conventional powertrain and the frames and so on, so that we can use a lot of stuff across those vehicles.

Claudia Fuhrmann [39:02 - 39:13] *Then there is one question: is there still a big trade-off between battery weight and how much payload the trucks can carry? And is government regulation helping with this?*

Dr. Stefan Tillmann [39:14 – 40:11] Actually, yes and no. And yes and no and yes. The point is, yes, there is a trade-off. We are, from a truck, we are deleting the heavy diesel engines and some other axles and stuff. But on the other hand, the batteries are heavy. That's not the question about that. And there are regulations being on the path that allow electric vehicles to be a little bit higher weight at the end, so the growth rate is higher, the battery is a little bit higher also than the conventional powertrain. So there's a delta. But I cannot say today what the delta is because this may depend really on the application and the setup. And some applications, when you have a low number of batteries on the vehicle, it can even be a little bit lighter, depending, really depending on whether there are opportunities. Let's say we have a penalty, but it's not that you have tons to lose, it's less than that.

Dr. Götz von Esebeck [40:12 - 40:22] And, in addition, we have to add that a big portion of our portfolio is volume-limited and not weight-limited. That also has to be taken into consideration.

Dr. Stefan Tillmann [40:22 – 40:23] Absolutely, yes.

Claudia Fuhrmann [40:25 - 40:45] *Yeah, thank you. So, let's see if we have more questions… What role is Volkswagen's PowerCo expected to play in our battery strategy?*

Dr. Götz von Esebeck [40:46 - 41:17] Interesting question. First, it's important to understand PowerCo is a kind of independent supplier, so they can offer us, of course, the battery cells. If that is fitting then our commercial vehicles and if they are competitive, then it's okay then. But that's a prerequisite. And then again, PowerCo as an independent, Volkswagen is a different topic than just their competence, but there are two pair of shoes.

Claudia Fuhrmann [41:19 - 41:29] *Okay, that's a tricky question. Would it be possible to combine BEV technology with fuel cell technology and have sort of a hybrid truck?*

Dr. Götz von Esebeck [41:30 - 41:31] Oh, you want to answer?

Dr. Stefan Tillmann [41:32 – 42:00] Actually, that that's how we plan to use batteries in the fuel cells as well. So there will be – the setup of the battery is smaller than what we usually see on electrified vehicles, but fuel cells need to have support by a battery and so in this sense it's a hybrid system. That's, I would say it's the answer on that. And we plan to use also parts from our modular kit. So it's not a separate development one, no.

Claudia Fuhrmann [42:02 - 42:20] *Okay. So yes, we are coming closer to the end. So, if you still have questions, send them in. Now we have 2 minutes left or so. And maybe there's one more question here at the moment. By how much do you expect the cost of a battery to fall annually?*

Dr. Götz von Esebeck [42:21 - 42:57] No, that I will not answer in numbers. It's even unclear, if we see really a cost decrease annually or if there's one or the other year even a jump up, as I explained, due to the raw material situation. On average, it will fall. But how much, how fast also new technologies are coming in, maybe faster than we expect now, like all solid-state, and so we cannot give a percentage there.

But in the past, we all were always surprised how much it was falling. More than everyone expected. But let's see.

Claudia Fuhrmann [42:58 - 43:54] *Okay, so we are really close to the end and I have no further questions here. Do you still have questions? So be quick and send them in. I'll keep watching if there's stuff coming in…*

Okay, I think there are no further questions coming in. We will close this session. Thank you very much for attending today. Of course, if you have questions, you can contact us and send an email. We will try to answer your questions. But meanwhile, thank you very much. Have a good day!