

**Media Briefing on Batteries and Carbon Neutrality**

*Notes from TMC's media briefing on batteries and carbon neutrality, which aired on September 7, 2021 at 8:00 PM JST / 7:00 AM EST.*

**Presentation - Masahiko Maeda, Chief Technology Officer: Toyota's Battery Development and Supply**

**Also present for the Q&A panel session:**

**Masamichi Okada, Chief Production Officer**

**Keiji Kaita, President, CN Advanced Engineering Development Center**

**Jun Nagata, Chief Communication Officer**

**Q: Batteries is where most auto companies are competing, but Toyota has always produced them in house. What is the advantage of doing so?**

**For solid state batteries, you have been saying this will be commercialized in the first half of the 2020s, do you have more details on target schedules or a road map?**

- **Maeda:** On the strength of Toyota, maybe it is more a characteristic of Toyota, our emphasis for battery development is the 5 factors shown in slide 8. They are Safety, Long Service Life, High Quality, Affordable and High Performance. But the 5 factors sometimes go against each other; for example, if we are to focus on safety, it can go against high performance. Fast charging time is of course a good thing, but we know overdoing this can jeopardize safety, which can result in instances of heat and fire. It is important that we balance these 5 factors.
- We do this by coordinating the development of vehicle and batteries together. When we are considering the use of the battery, it is about how the vehicle is going to be used. If it is a taxi, it will be charged frequently, and we will have the information on the heat condition of the batteries. We provide this data to the team in charge of battery development, and we feed that back in order to create the best battery design for usage under different situations. We believe taking this integrated approach is faster and more effective. We take multiple data from the usage of the vehicles and use that to analyze the battery condition over and over again to improve the performance and safety of the batteries. We believe being able to do this, not just on a desk top calculation basis, but through trails where we aim to strike the balance between the vehicle and the battery, is an advantage of Toyota. We take this approach for all the batteries.
- For the next question on solid state batteries, our basic development approach is similar. As shown in slide 17, with the characteristic of fast ion movements and higher tolerance to heat, we are currently aiming on high output and a shorter charging time. For this reason, we believe focusing on the application to HEV is the fastest way to deliver the product to our customers. However, there are still challenges remaining. For example, longer use will result in creating spaces in the solid electrolyte which leads to deterioration. We need to continue developing the material for the solid state, leveraging our experience over the years.

**Follow up Q: Just one point to clarity, the target of first half of 2020 is unchanged?**

- **Maeda:** Yes, unchanged.

**Q: In your battery strategy for 2030, you mentioned an investment of ¥1.5 trillion. Toyota has an in-house production strategy but is also collaborating with Panasonic and other partners. How are you going to allocate this investment?**

**Also, on the cost of batteries, it is said the battery is about 30% of the price of the vehicle. How are you going to lower the battery cost?**

- **Okada:** 200 gigawatt/hour by 2030 is a number we have in mind. The ¥1.5 trillion is for supply and development – so on the production and supply side it is about ¥ 1.0 trillion. This is largely for electrified vehicles and by 2025, we will build 10 more new lines. Between 2026 to 2030, we will build 10 lines per year which will be a total of 70 lines for BEVs. Therefore, this investment is mainly for production, including machines and facilities. These will be small base units and the production units will be kept small in order to remain agile. This is based on our experience with HEV production, and investments will be managed as such. On top of our in-house battery production capability, we also will work closely with our partners. We will localize the supply chain to pursue efficiency as well.
- **Maeda:** On lowering the battery cost, integrating the development of both battery and vehicle is very important. If we take the battery alone, we will be looking to lower the cost of the materials, as shown in slide 15. As we develop battery materials in-house, we will be looking for lower cost materials. We will also be thinking about easier assembly, such as integrating the battery with the vehicle.
- Battery control is another area we are looking at. We are exploring the best charge level by looking at the balance between charging closer to 100% and how this will affect deterioration and durability. The vehicle side is also important. Reducing drag and mechanical resistance is important as it will contribute to the re-charging of the battery during deceleration. The target is to accumulate these efforts and bring the overall drag down 50%.

**Q: How does Toyota's long experience in battery development become the competitive advantage, when the requirements for the new BEV batteries are vastly different from the earlier ones?**

**Would the large and diversified investment of 1.5 trillion yen become a risk for the company?**

- **Maeda:** First is our integrated approach of developing the battery and vehicle together, and how we can explore the full capability of the package. The key is to understand how the vehicle is used and the state of the battery under such conditions. The other is the development of the battery materials, which is the world of chemical reactions. This will contribute not only for performance but also for cost and durability. By accumulating this data over the years, we can combine it with the vehicle usage information.

- **Kaita:** On the point about how we use the knowledge through the development of Nickel Hydride Batteries to the large Lithium-Ion Batteries, I would like to explain our thinking behind the development and production. In the first-generation Prius, we used Nickel Hydride Batteries in a sequence, where if one failed, all batteries failed, and the vehicle becomes immobile. We learned that battery quality was extremely important. Measuring the voltage of a battery is like monitoring blood pressure. For Lithium-Ion Batteries, there are a number of factors that can cause fires and we need to focus on the quality.
- In 2009 – 2010 we had quality issues, and soon after that, we launched a strong HEV with Lithium-Ion Batteries as part of our challenge. During this time, the President of Toyota was called in to the US congress. After that hearing, he had told us that although Toyota has always had a priority on the five points of Safety, Long Service Life, High Quality, Affordable and High Performance, this was not enough. Peace of mind is most important.
- As shown in slide 24, we fully utilized 10 thousand channels in our testing equipment, in slide 23 we also visualized all the steps of the battery process by testing it ourselves. In slide 25 and 26, we are using AI, material informatics and data from vehicles for our testing, and we made sure all of this was done in-house. Although the number of patents is not the sign of our technical capability, we would like to believe it is an indication of efforts of our development.
- **Okada:** ¥1.5 trillion is a large investment, but it is important because it will be used to proactively promote our electrification efforts. Based on our lessons learned from our experience during the financial crisis, we will do this through building small units. It quickly made us realize at that time, that being aggressive and making large investments during our growth stage can be our weakness when situations change. We want to make sure we control risk even when we are expanding. Getting what we need when we need it is the core understanding of Toyota production, and we are building production lines in that fashion. It allows us to be agile and nimble when we need to adapt to the changing environment. This is not limited to just batteries, and we have developed all our production lines in the same way. This allows us to minimize risk.

**Q: Is the new structure Lithium-Ion Batteries targeted for BEVs?**

**Is Toyota going to sell these batteries to other companies? If so, who do you plan to sell them to?**

- **Maeda:** As shown in slide 31, Bi-Polar Batteries send a large current directly through the structure and we are using this for high output. It also has a very simple structure and can be designed to have a larger capacity. This can be adapted for BEV and PHEV, which is something we already have in mind, but it is not at the point where we can definitively say we will use it solely for BEVs.
- For the sale of our Bi-Polar batteries to outside parties, if there is a request, there is a possibility that we will have a discussion with the interested parties, as it might be a way for us to promote EVs and become closer to carbon neutral.

**Q: What are your thoughts on the life of Lithium-Ion Batteries?**

**Would a longer wheelbase and lower center of gravity of BEVs be an advantage for an attractive car?**

- **Maeda:** Fatal elements for a battery are heat and fire. We are conducting considerable research and monitoring to achieve a longer service life. As you see on slide 24, we need to monitor and understand what is happening inside the battery. It will depend on the usage of the vehicle, and we need to evaluate this affect. The results of this evaluation work are accumulated as digital data and analyzed, including the usage of artificial intelligence. We have not found anything fatal at this point, but even when batteries are used under various and changing environments, we want to make sure there is peace of mind for our customers.
- We also need to think about how we can use the battery for its full life span. Batteries do not come back to us, but we can do a better job at re-cycling them. Toyota cannot do it alone, but we would like to address the challenge as the Toyota group.
- For the second question, a low center of gravity is a good thing, but weight is a disadvantage. Development is always a challenge from that perspective. High response motors, however, can be used to control the car and this is an advantage compared to the internal combustion engines. With an electric motor there is no need for a propeller shaft and that is also an advantage for four-wheel drive cars. For off-road vehicles, BEV can adapt to slower movements and can be used for better performance.

**Q: What is the breakdown of 2 million units of ZEVs, between BEV and FCV?**

**For the new Lithium-Ion Batteries, what is the improvement compared to the existing batteries and how long are you going to use nickel batteries?**

- **Maeda:** For the breakdown of the 2 million units, we cannot be clear at this point. This number was mentioned in our financial reporting as guidance number. Please understand we do not have the details for the breakdown.
- For the next generation batteries and how they will evolve, we understand current customer demand is on lower cost. With lower cost as a key theme, we will balance development with the 5 factors mentioned earlier. If we are to focus on durability, there can be a trade-off with performance. We do not have targets for any specific performance item, but we will be balancing the capability of the batteries with the requirement of the cars that are being developed.
- For the Bi-Polar Nickel Batteries, we would like to use these as long as we can. The potential of these batteries is based on their simplicity and, as they are a new battery, there are possibilities to further lower its cost.

**Q: Follow up question**

**Looking at targets for sales unit targets, is it possible to indicate which is larger BEVs or FCVs?**

- **Maeda:** Based on our read of customer demand, BEVs are expected to be higher, but we all know there are discussions around the commercial usage of FCV. If this kind of movement accelerates, composition may be different. So, for now it is BEV, but not at the point that we can foresee what will happen in the coming years.

**Q: 200g watt/hour battery by 2030 is a very ambitious target, and as BEVs will require the most battery capacity, I am assuming there will be more production of Lithium-Ion Batteries than Nickle Hydride. Lithium in its pure form is a very harmful material and nickel and cobalt are used as stabilizers, but Toyota is saying it will reduce the use of these materials. Question is what will be used instead, I am assuming iron phosphate, but there was no mention of that in the presentation today.? Are you going to use iron phosphate, or do you have in mind other materials that are better?**  
**If you are producing large volumes of lithium-ion, what are your plans to secure lithium, nickel and other materials for production?**

- **Maeda**: Iron phosphate is not ignored, and it is one of the options, but at this point we can only say we are not just focused on iron-phosphate. We are putting a priority on using less lithium and making better cars. We have researched iron-phosphate, and we have that in the back of our minds, but we are looking into the true demand for the range. As a mean of competitiveness, we know there is demand and there is benefit in providing a longer range, but this is also dependent on the usage in each market. We will look further into the true demand of each market to determine which market and customer best suits the type of batteries, including lithium-ion or iron-phosphate.
- On how we are securing the materials, our basic understanding is to use the minimum amount of material to produce a battery. By improving the characteristic of a battery, we can control the use of the materials and, if the usage rate of a battery is reduced, that will also reduce emission and can address the issue of supply.
- **Okada**: Supply of the materials is a big challenge in our battery strategy. We are positioning this as part of the broader strategy along with building smaller facilities and how we work with our partners like Panasonic. This is an agenda that Toyota will not address on its own. Toyota Tsusho is also part of the collaboration, and we are looking to work as a team to secure the necessary volume.

**Q: Follow up question**

**On a global basis, there are companies that are developing mines, but is Toyota thinking about a similar strategy?**

- **Okada**: Toyota is not thinking of developing mines, but as the group, I am not denying the possibility.