Tokyo Zero-emission Innovation Bay
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＜Hub introduction ④　Battery Development under NIMS-ABC COI-NEXT Project＞

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Thank you very much for giving me this opportunity. To be honest, it is the first time to talk about the project in public.

We launched Center for Advanced Battery Collaboration in NIMS as a center of innovation, which was funded by JST program called Program on Open Innovation Platform for Industry-Academia Co-Creation (COI-NEXT) about two years ago. This program is identified as a priority area of the environment and energy domains and categorized as full-fledged research.

Next please.
First, the background. The slide shows various projects on batteries. However, we had no projects on the advanced lithium battery in Japan. In fact, we could find them abroad, but not in Japan, and we needed to establish the project because what we needed very soon was the advanced lithium battery. We were driven to get down to advance lithium battery such as lithium ion and lithium metal battery. Co-creation cannot be achieved by a single entity, and hence we proposed building an innovation platform through industry-academia collaboration, which is essential during battery development in NIMS. We share the opportunities in the platform with companies to create innovations.

The biggest challenge is to reduce the research and development time to a tenth. I may be exaggerating, but if we reduce the time to a tenth, the development costs could also be saved. What I would like to emphasize is that the time saving could consequently result in reducing CO2 emissions to a tenth, which will be a good lesson to create new platforms for other fields as a consortium. This was the background for the submission of the proposal for the accepted project.

Next please.
The official title of the project is Program on Open Innovation Platform for Industry-Academia Co-Creation (COI-NEXT), Program in the field of Environment technology. What we try to achieve is to realize a clean energy society where battery puts together people, goods, environment, and data. I think what we are trying to do is the same as what other presenters are trying to do. Center for Advanced Battery Collaboration (ABC) was established in NIMS.

Next please.
We are aiming for the implementation of an innovative battery platform. We must think about how we collaborate with companies, which is a hard task, and I will explain it later. We need to support the acceleration of battery research and development in Japan to reduce the cost, which is our fundamental concept. The shape of the platform will depend on how we create it, as it is the very first battery platform. As already explained, in the platform, we are trying to initiate protocols for lithium-ion batteries that show how they can be developed efficiently, which requires high performance from the battery.

The batteries are required to support a variety of applications in line with SDGs. The figure on the right shows batteries of all kinds that can deal with each SDGs. Our plan includes various batteries that meet the SDGs, which is the requirement of the project. We pursue the development of other batteries than lithium battery including post-lithium batteries and advanced batteries. On top of it, it is always important to follow or to contribute to SDGs.

Next please.
Now moving on to how we proceed with the development. We are frequently asked how to proceed with the project. Fundamentally, we are expected to apply a backcasting approach on COI-NEXT project. In battery development, a backcasting approach means backcasting from the battery pack. Battery pack can mean anything from cell to various other things that are not generally final products. What we are targeting are batteries of electric vehicles of this size. Our goal is to create a platform where we search for the best battery development process through a backcasting approach. First, we need to understand the needs of society and then look back from the final products stage to material state. This will speed up research and development by ten times. That is what we say in a somewhat superior manner.

The slide shows the needs of society on blue including characteristic requests for battery pack, cell, electrode, component, and materials. Process technology is also one of the needs necessary in factories, which is not on the slide. The right part of the figure shows the objectives of the final product as a battery including pack design, battery life and safety evaluation, and cell design. From a scientific point of view, we have two objectives regarding materials, such as an interface control and a structure control. We will use the co-creation platform to bridge them.

In the platform, we plan to create protocols of simulation technology, measuring technique, computer science, and data practical use technology. It is quite reasonable that the protocols are more than one and that they should be ten or twenty. So far, they amount to more than ten from our understanding. The story is when member organizations share and use the protocols in the platform, it accelerates battery development. We are continuing our research in NIMS in the hope that we can apply the story to society. I would like to emphasize that the COI-NEXT project always supports SDGs in the context of research. We

will also apply Life Cycle Assessment (LCA) to the project.

Next please.
We are frequently asked what is exits to this project? The slide shows the exits to the projects. Creating exits is harder than it seems. We need to think about that from now on and, in any case, the exits need to be something through which both NIMS and companies can share benefits, such as research commission or joint research. It would turn to be a consortium, if it expands to the certain level. As We, NIMS, are a kind of academia, one of exits would be something like collaboration with government institutes including AIST.

We would hold seminars on protocols to be created to contribute to the development of the battery industry as a whole and transfer technology of protocols for free to encourage companies' research and development. We proceed with the project considering these exits.

Next please.
The slide shows the structure. Members on orange are from NIMS and those on green are from outside. I am the project leader, and we have Dr. Iba from TOYOTA as a sub. Dr. Iba gives us valuable advice from his professional point of view. Numerous members are involved in this project, and due to the academia nature of NIMS, young research leaders in particular have been assigned to research topics five and seven. Woman leader was also appointed as written in red. As you can see, we keep up with the times when it comes to personnel selection. So far, I have explained the personnel in NIMS as the representative organization.

Members from outside NIMS are shown in the right. Professor YAMADA from University of Tokyo and Professor UCHIMOTO from Kyoto University joined the project, but apart from these two, there are no other universities on the team. However, many university professors, at least five universities, are involved in the project, as NIMS researchers.

Please look at the right on the slide. Members outlined in blue are companies that are directly involved in the project. We have Toyota, Murata Manufacturing, Asahi Kasei, Softbank, and Mitsubishi Chemical and we need to keep increasing the number, but many obstacles have been encountered along the way. The obstacles must be sorted out one by one to level up.

Next please.
So far, I have talked about protocols and the project as a whole. This slide summarizes the project. This slide illustrates the list of each research challenge. Challenges one and six to nine are set for initiating protocols using measurement technology, simulation program, smart lab, computer science, and data base. AI and Machine Learning are not listed but have been understandably applied, and every single possibility

would be used for this platform of battery development. As for challenges two through five, excuse me for the scattered numbers, they are presented by each battery type.

Each objective is listed correspondently to each battery type. The objective of lithium-air battery is to produce one with ultra-high energy density. Currently, we are collaborating with Softbank to work on High Altitude Platform Station (HAPS). HAPS asked us to develop previously unproduced batteries, which, from a scientific point of view, requires extensive technical knowledge of gas-active materials.

Next challenge is the production of Mg and Na batteries. We need to develop these batteries while anticipating lithium depletion. When we develop batteries, we must always keep element strategy in mind. The objective of Mg and Na batteries is to produce batteries with versatility at the lowest cost.

The fourth challenge is Solid-state battery, which you may be familiar with as it often appears in the news. We try to make batteries with high energy density that guarantee safety and long life. We must deploy solid-state electrochemistry scientifically and break new ground where we hardly find any schoolbook. The challenge presented on the bottom is to produce advanced lithium battery which includes lithium-ion battery. Lithium metal secondary battery is categorized in this field as well. The Lithium metal secondary battery has a long history of 40 years but remains unknown. As we explained, we develop each battery, looking at it from an academic point of view as well. This is how we work on the project.

Next please.
The slide describes the detailed internal structure of NIMS. Please take a look at the blue outlined Center for Advanced Battery Collaboration in NIMS, which represents how much NIMS is devoting its efforts to COI-NEXT projects. I am the responsible person for the organization. Dr. Iba helps us in various aspects, and many others from NIMS support us organizationally.

The structure itself looks like what I have already shown in this talk. Now. I would like to show you what exactly we are doing with the slide. The upper left shows a pack battery followed by battery evaluation technology or module. Likewise, a cell follows a module. We go from a battery pack to a cell through the module to clarify what is necessary for battery production at each level. It is not difficult to assume what is the best module and cell for a battery pack. Along with this assumption, actual data of materials and electrode, are collected in the computer to run simulations.

What we are doing is the digital transformation of battery development. In other words, everything you need about battery is in the computer, that is what we are working on. Along with the development, we need some protocols to build up the platform, which is so simple as everything is in the computer. In short, development will go forward only if you combine all the data, seeds, and needs in the computer. Development is immediately accelerated because we can focus just on what we need without unnecessary

work. We build the platform keeping that in mind. This work may take some time.

Let me jump to page 26 as we are running out of time. The story of the project interests people but we found some obstacles along the way, which you can see on the slide. This is the relationship between NIMS and each company. NIMS launched Materials Open Platform (MOP) with ten or so companies. However, as shown above on the right, the development is still difficult to advance. Of course, every organization has both open and closed information. Each company pursues its own profit, and the difficulty that has now arisen is the coordination of each company's profit.

This is the important subject for us as well. In other words, COI-NEXT can be a good opportunity to think about it carefully. Furthermore, we can create the research result defining the model of research collaboration in Japan as shown on the slide.

The slide shows our recommended collaboration model, which we call Combining Horizontal and Vertical Collaboration. It combines vertical collaboration such as bilateral collaboration and horizontal collaboration open to multiple companies. In fact, some companies do not accept the recommendation, especially people from a legal section are reluctant to go ahead with it. This is partly because of common sense in Japanese society and, I think, we need to make sure that changes as well.

Next please.
As I explained earlier, we expect many exits and I describe them in detail on the slide. For chemical manufactures, it is data-driven materials and material structure optimization all contained within protocols. For battery manufacturers, it is the optimization of battery structure through computational technology, all contained in protocols. A battery specification has to be decided for the user companies,
which also fulfills all the requirements contained in the protocols. We would welcome companies for battery analysis and design development protocol in the platform. We advance while promoting society's battery development by activating activities within the platform.

Next please.
Next, I would like to show you the relationship with other projects, which is frequently asked by JST and MEXT. We are on a co-creation platform, and thus, we do not believe that we are working independently. We are striving to advance the project and also involve other national projects. From our point of view, we hope to absorb more and more insights from other projects to improve the platform. Please excuse the way I explained it beforehand if you hear it odd. There are many ongoing projects including ALCA SPRING, SOLiD-EV, and RISING II as national projects, and Materialize and MOP as NIMS. We are considering adding more insights to the platform for our self-improvement.

Next please.

Now, I will flesh it out a bit more for you. The SOLID-EV in the middle is a METI project that produce solid state batteries that can provide us with their standard battery for analysis in the computer on our end. Since we get the data from the battery, we can simulate the battery development in the computer without any experiment. As for the project called Materialize, the project is about manufacturing and we get insights into materials technology from it.

ALCA-SPRING is a project that conducts research in the fields of materials science and fundamental and applied sciences. From RISING II, we learn analytic technology. From the project of Grant-in-Aid for Scientific Research on Innovative Areas, we learn basic scientific theory. Every project has its strengths and weaknesses, and we use each one's strengths to improve. The goal of this platform is to become as effective as possible. Now, let me go on to the last part.

The project has two natures. One is the cooperative character, and the other the competitive character. The important thing is how we ultimately organize these two natures for the project's success, which I feel, will be sought until the end. In terms of the cooperative character, the significance is to create protocols available for anyone to collaborate on research and provide development platform for introduction. Social implementation requires the competitive character that we eventually achieve through the platform. In fact, if we always conduct collaboration with all companies openly, we cannot facilitate social implementation. We must consider cooperation nature in different light from competitive nature in the platform. The end goal is social implementation, and for that goal, we need to think about the way we collaborate with companies including contracts. I have no idea how many JST projects under MEXT thus far have thought about it seriously, which NEDO project would have quite naturally. Perhaps, reflecting the current of the trend, university faculty members must create something practical, which we hope to demonstrate through this project. That brings me to the end of the presentation.

Thank you so much for your attention.