Q&A Summary

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Questioner 1

Q: I would like to ask two questions. The first is about gas turbines. I understand that the initiatives you have just described are behind the very strong growth in both orders and sales in this business. How do you compare with other companies in terms of competitiveness? I understand the efficiency of the J-Series gas turbines, but I believe GE and Siemens are also working on hydrogen. I would like to ask you about how what you have explained today affects your competitiveness in gas turbines. Second, I understand that new technology development is progressing well. However, I think that you may face difficulties in developing new plant projects as you move toward commercialization between 2025 and 2030. Please explain the profitability and risk management of projects with a view to commercialization.

Hashi: I would like to answer about the comparison with other companies as regards the growth of Gas Turbine Combined Cycle (GTCC) orders and sales. I believe that reliability is the most important reason why our gas turbines have recently been highly evaluated by customers and orders have been steadily increasing.

As I explained during my presentation, we develop, design, manufacture, and then launch state-of-the-art machines to market after thoroughly verifying them at our demonstration power generation facility, which we call T-Point 2. In the case of the state-of-the-art J-Series gas turbine, the reliability is 99.5%, which is overwhelmingly more reliable than other companies' products, and orders are increasing. Also, I think one of the major factors is the high efficiency of the JAC-Series gas turbine. Regarding the status of development related to hydrogen, GE, for example, announced that it has achieved 5% hydrogen mixed firing on commercial equipment. In our case, last year, we achieved 20% by volume mixed firing in a project in the US. In this way, we believe that we are one step ahead of our competitors.

As introduced today, we will advance hydrogen mixed firing to 30% this year on a commercial-grade JAC-Series gas turbine at Takasago Hydrogen Park. In the Takasago area, we will realize 100% hydrogen firing by the end of FY2023 on commercial-grade

40 MW small- to mid-size gas turbines. We believe that this is probably why the customers evaluate us so highly.

Second, you asked if we might have trouble when we launch the hydrogen-fired gas turbines we are developing. As I mentioned earlier, we have commercial-grade gas turbines in Takasago. We will run hydrogen firing on that commercial system, identify any problems, and then launch commercial units. Therefore, we believe that the probability of having issues is lower than in the case of proceeding without this kind of validation. Naturally, for new projects, we will continue to manage risks preventatively as we have in the past. We will monitor the progress of projects while construction is underway, and we will continue to follow our routine of identifying and immediately addressing risks. We will deliver quality power generation equipment on time while preventing risk and avoiding inconveniencing our customers.

Kaguchi: MHI has both gas turbine and CO2 Capture and Storage (CCS) technologies, and we can offer a combination of the two in-house. I understand that GE and Siemens do not offer CO2 capture, so they need to partner with other manufacturers. In that way, I believe our company has an advantage. Actual modifications needed to convert existing gas turbine plants to hydrogen firing will be very minor. This will not be a major investment, as it only involves replacing the combustors, slightly modifying the piping, and installing a hydrogen storage system. So, we consider it less risky in that sense as well. Other than that, it will depend on if a value chain can be properly created on the supply side.

Questioner 2

Q: Earlier, you mentioned that the JAC-Series gas turbine is competitive and that its ability to be converted to hydrogen firing is highly regarded. Is it difficult for other companies to obtain that capability, and can this superiority last for a long time? How long will the advantage of being able to convert by simply replacing the combustors last?

Hashi: We think that other companies will probably only need to replace the combustors, too. The question is when they will actually be able to do validation using commercial equipment. We have a commercial-grade gas turbine at Takasago Hydrogen Park, so we will be able to move ahead of other companies in mixed firing. I believe that it will be a race to develop 100% hydrogen firing. Also, our company both develops hydrogen-fired gas turbines and designs boilers. Therefore, we believe that we will have an advantage in the combination of exhaust gas and CCUS. Integrating a thermal power plant with CCUS cannot simply be achieved by connecting the CCS system to the flue from the power plant. There must also be other considerations during systems integration, such as exchanging steam with the power generation systems. We believe that our strength lies in our ability to consider these items as a single company.

Q: My next question is about page eight of the presentation materials. There are two ways to reduce CO2 emissions, one is to combine a high-efficiency gas turbine with CCUS to reduce CO2 emissions by 90% or more, and the other is to use 100% hydrogen firing to avoid emitting CO2 in the first place. When customers consider initial and running costs, which of the two methods is more advantageous, and which could grow in the future? I know it is very difficult to compare them, because of the various conditions involved, but could you please tell me what the key points are?

Kaguchi: To be honest, I think everyone is still considering this issue. Looking at IEA and gas turbine industry reports, CCS is likely to remain in the future, although the ratio may be larger for hydrogen-fired plants. I believe CCS will depend on proximity to locations where CO2 can be stored and other considerations. If CO2 has to be transported to a distant storage location, it will be cheaper to supply hydrogen to a plant. However, I think it will be up to the customer. Overall, my understanding is that hydrogen will be slightly more widely used by around 2050.

Questioner 3

Q: My first question is about page 13 of the presentation materials. There are three types of combustors, Types 1, 2, and 3, which will be used to replace existing combustors, but I think the approach is different for each. I understand that Type 3, which is for 100% hydrogen firing, is being verified aiming for commercialization in 2025, but is there a high degree of certainty that you will be able to achieve this? As you know, the ratio of hydrogen mixed firing has been a target for Inflation Reduction Act (IRA) incentives up until now. Although things have only been at the incentive phase up until now, the Environmental Protection Agency (EPA) in the US is now looking to tighten regulations. If MHI launches 100% firing, could you comment on whether you would be the only company that could do that?

Hashi: There are three types of combustors, Type 1, Type 2, and Type 3. Type 1 uses diffusion combustion, which means that when the fuel is fired, a considerable amount of NOx is also created. Although this type has good combustion performance, it produces high NOx emissions, so water or steam is usually injected to reduce this. When we started firing hydrogen around 1970, we used Type 1 combustors. We have used this technology to fire nearly 100% hydrogen fuel in small-size gas turbines.

Type 2 is a premixing, or dry low NOx combustor, and is mainly used in natural gas-fired combustors. This type can achieve low NOx emissions without injecting water or steam. With this combustor, it is possible to burn a mixture of 30% to 50% hydrogen. By the end of 2023, the JAC-Series gas turbine at Takasago Hydrogen Park will be used for validation of 30% mixed firing on a commercial-grade system.

When the amount of hydrogen is increased to 100%, the rate of combustion of hydrogen is considerably faster, and flashback in the combustor is a concern. The type of combustor which allows for 100% hydrogen combustion is the Type 3 multi-cluster combustor. As we explained earlier, we completed 100% hydrogen firing in 2022 with multi-cluster combustors for small- and mid-size gas turbines. These were tests using combustors on their own, but we always verify on commercial equipment. During FY2023 or early FY2024, we plan to conduct a 100% hydrogen firing test on commercial-grade 40 MW gas turbines in Takasago. After testing 100% hydrogen firing in small- to mid-size gas turbines in early 2024, we believe that we will be able to commercialize this technology in 2025 or thereafter. As for large frame gas turbines, although this depends on our infrastructure, we will continue to develop 100% hydrogen firing aiming for commercialization by 2030.

Kaguchi: You also asked about the EPA. I am sure that there will be debate about the details, but this is certainly a tailwind. The proposal says that you will need to install CCS or fire hydrogen not only as an incentive but also as a regulation, which I think is very important. We are not the only company active in this area; there are competitors out there as well, so we will do our best not to lose out.

Q: It is my understanding that the EPA is proposing a guideline requiring 30% hydrogen mixed firing by 2032 and 100% by 2038. MHI says it hopes to finish development for large frame gas turbines by around 2030. Am I correct in understanding that if you can do that, you will be able to comply with the regulations?

Kaguchi: According to the current schedule, I believe that on a technology level, we will be able to commercialize 100% hydrogen firing by 2030. However, we understand that the question of whether hydrogen infrastructure can actually be developed to that level is more significant.

Q: For my second question, I would like to ask you to share your thoughts on how widespread the use of turquoise hydrogen will be. There are certainly several advantages to producing hydrogen with this method. On the other hand, my understanding is that securing a heat source and methane is an issue. This gives me the impression that although turquoise hydrogen appears likely to become widespread, the places where it can be produced will actually be limited by geographical factors. What is MHI's view on this?

Kaguchi: To be honest, we are doing a lot of studies on this, and we think it will depend on the location. For example, we have done calculations to determine which kind of hydrogen value chain would be most advantageous, comparing various cases, such as transporting liquefied hydrogen or methylcyclohexane (MCH) from far away, with transporting natural gas using current infrastructure, making turquoise hydrogen in Japan, and burying only the carbon somewhere. Frankly, I believe turquoise hydrogen will be competitive in Japan. In other places, such as those where hydrogen can be transported through pipelines, green hydrogen will likely be more promising. It will really depend on the location.

Questioner 4

Q: First, I would like to ask two questions about technology. Please tell me about the positioning of Integrated coal Gasification Combined Cycle (IGCC)? Could you tell me if you expect any new developments in IGCC, such as applications of the technology? Also, if hydrogen combustion can be achieved normally in automotive engines, why can it not be done in power plants?

Kaguchi: Regarding your second question on why hydrogen engines are being made for cars, but hydrogen combustion is not easily achieved in gas turbines, even for stationary gas engines, hydrogen engines are not readily available and have not been commercialized. When I asked our engineers about the major reason for this, they said that the operation time of car engines is actually very short. We understand that the durability requirements are different for power generation systems and mobility.

The gasification furnace used in an IGCC system also enables the production of hydrogen from coal, so I believe it could also be an effective method to be utilized in the Energy Transition. Gasification technology has a high degree of difficulty, but it is also difficult for other companies to develop, so I believe it can become a competitive edge for us. As such, we are eager to commercialize this technology.

Q: I believe that various players are now experimenting with hydrogen and ammonia. Are you trying to move toward a single consortium with MHI taking the lead in Japan? You spoke earlier about how MHI can do everything, but from a global perspective, excessive domestic competition in Japan and the dispersal of subsidies seem to be a huge waste of money. Is MHI doing anything to try to eliminate this?

Kaguchi: We are not making any particular moves like that right now. We will also use government money to develop projects, so we will do our best to take your recommendations under advisement and avoid waste.

Questioner 5

Q: You spoke about the acceleration of the Energy Transition on a global scale. Originally, MHI’s goal for 2030 was ¥300 billion in sales from hydrogen, CCUS, and other products. If the Energy Transition is accelerating on a macro level, please let me know how much you are likely to exceed the target. Also, while there are various positive stories here, I would like to ask about risk factors. For example, what happens if the war in Ukraine ends? The IRA is a tailwind in the United States, but what happens in the unlikely case Trump comes in and things go in the opposite direction again? Please tell us what you consider to be risk factors.

Kaguchi: Regarding your question about whether we will be able to exceed the ¥300 billion target for 2030 because of global acceleration of the Energy Transition, we believe that we will be able to achieve this figure and maybe even exceed it. We are at the stage where we have received orders for Front-End Engineering Design (FEED), but actual projects are not in view yet. I think there will be ups and downs, but I expect that we will reach a value close to that figure rather quickly as we reach final investment decisions (FIDs) on larger projects. I cannot tell you what the exact amount will be in 2030, but we hope to achieve the goal a little earlier than that.

You asked about the situation in Ukraine and risk factors due to the changing political situation in the United States. I do not think the impact of Ukraine will be that great in the future, except in the scenario where multiple conflicts erupt around the world, and the Energy Transition falls by the wayside. As regards American politics, the IRA was created by Senator Manchin under the Biden administration. I believe you are asking about the risk of the IRA’s being overturned in the event a Republican administration is elected. Many people have various concerns about this. We have asked people in the US about this, and our understanding is that the IRA is not something that can be changed very easily just because the president changed. So, we consider the IRA’s incentive commitments through around 2032 as somewhat probable.

Questioner 6

Q: I think that the technologies you have introduced today will enter their main battleground or period of utilization after 2030. However, in the current Energy Transition's objective to combat climate change, there is also a trend toward increasingly accelerated decarbonization targets such as for 2030 or 2035. It therefore seems inevitable that we will need to do something with the technology that is currently available. Do you have any concerns about the impact of these developments on your technology, the market, or profitability?

Kaguchi: We have no particular concerns. A variety of technologies will nearly all be ready in 2025 or thereafter. When it comes to implementation, these technologies will cost more money than conventional energy, so I think the most important thing is public policy design, such as deciding who will pay for this difference.

Q: So, would it be correct to say that governments as flag bearers for the implementation of technologies and their policies will have a large impact?

Kaguchi: Yes, that is right. The IRA has been passed, and now there are forecasts of a 10- or 12-year payback on investments. Investors are currently investing more and more, and projects are starting to get off the ground. If just one of these projects goes well, the number will continue to increase. I think that is the situation in the US today. Such projects are being considered now in various ways. I envision a timeline where investment decisions are made around 2024 or 2025, actual projects are launched in the late 2020s, and these projects become examples, which will be rapidly copied.

Q: What about countries other than the US?

Kaguchi: Canada is close to the US. Asia has quite a lot of coal-fired power, so I think first there will be a transition from coal to natural gas-fired gas turbines. I believe ammonia is also possible as one option. Japan will likely put public policies in place and proceed in accordance with them.

Questioner 7

Q: I believe there are two schools of thought on decarbonizing GTCC. One is to attach CCS to an existing GTCC, and another is to convert GTCC to hydrogen firing. Both of these were proposed during today's briefing as promising approaches. I am sure each customer will have their own ideas depending on the state of infrastructure, including fuel procurement issues in the case of hydrogen, or storage and utilization issues in the case of CCUS. Comparing these two approaches, could you speak about their advantages, difficulties related to technology or market environment, and regional characteristics?

Hashi: I think regional characteristics will have the biggest impact. For example, in the state of Utah in the US, green hydrogen will be produced by water electrolysis using renewable energy. The hydrogen will then be stored in salt domes, which will be used to generate electricity when there is no renewable energy available. It is very beneficial that hydrogen can be stored and then fired in a gas turbine. However, this kind of storage is not available everywhere in the world, nor is there a surplus of renewable energy everywhere. Depending on the circumstances in each country, there will be many different approaches, whether it be starting with hydrogen mixed firing, or installing CCUS, or eventually moving to 100% hydrogen firing. This is why I believe that the characteristics of each country will have the greatest impact. As I mentioned earlier, technologically speaking, our goal is to commercialize 100% hydrogen firing in large frame gas turbines during or after 2030. I believe it is our responsibility to be prepared to meet the needs of our customers in a variety of regions.

Kaguchi: The places where we are now talking about GTCC + CCS projects are generally close to CO_2 storage sites. In areas such as the US Gulf Coast and other places where there is oil drilling and empty oil fields, many parties will want to utilize GTCC + CCS. We think that these are likely the most economically viable places to do so.

Q: You explained the status of hydrogen-fired gas turbine development during your presentation. The validation of hydrogen firing in small and mid-size gas turbines at Takasago is scheduled for around FY2023, and I believe that commercialization is in sight. What is the current level of inquiries and customer interest?

Kaguchi: It is easier to achieve 100% hydrogen firing in small-size gas turbines, because they operate at a lower temperature. We have received inquiries for this technology, and there are specific proposals. For example, in South Australia, we are proposing 100% hydrogen gas turbines. We are in the phase where we will start to launch these kinds of projects.

Questioner 8

Q: First, I would like to know a ballpark figure for MHI's research and development investments in the Energy Transition area. Can you tell us around how much you are planning to spend on gas turbines, the hydrogen value chain, and CCS in the lead up to 2030?

Kaguchi: I cannot tell you the exact amount, but we have been investing in gas turbines and Takasago Hydrogen Park for some time. At Takasago Hydrogen Park, we are working to prepare a variety of equipment and facilities, so the amount of investment directed toward Carbon Neutrality is increasing. In the future, we are planning to invest in CCS and other growth areas.

Q: In the Key Takeaways, there was mention about legislation aimed at realizing solutions ecosystems. In February, for example, a bill was passed in Japan to promote Green Transformation (GX), which has become a tailwind domestically. Can you tell us what kind of legislation your company would like to see?

Kaguchi: I understand that the total quota for domestic GX funds and government bonds has been decided and roughly allocated. Going forward, there will be discussions on what exactly the funds will be used for. In that process, we are participating in committees, providing our opinions, and making proposals.

Questioner 9

Q: Regarding the alliance with ExxonMobil, you mentioned in your presentation that it is important to work with major oil companies to find suitable locations for storage. Since it seems that some time has passed since the alliance was formed, I would like to ask about the specific cases in which you are discussing storage and in what direction you are aiming. I wanted to know more about the goal of your partnership with Saipem on CO2 capture. I think that both companies have good track records with plant construction on your own, but I would like to know why you are partnering now.

Kaguchi: Regarding the first question on the alliance with ExxonMobil, we signed the contract at the end of last year, and it has only been about 6 months, so we do not have anything concrete to report to you. We are proceeding through regular discussions with them. Regarding the license agreement with Saipem, it is regarding building CCS plants or establishing a standardized method and selling that. Large-scale CCS systems attached to thermal power plants require quite complex engineering. We cannot accomplish this with our resources alone. We would like our process and absorbent to be widely used in CCS, and we understand that partnering needs to be done on a global basis.

Q: ExxonMobil has storage sites. Will you be using their large assets in the US? I wanted to know what direction you are taking with storage.

Kaguchi: Regarding storage, the major oil companies can make a variety of proposals. In Europe, Equinor has storage sites, for example. In Asia, there are sites in Indonesia and elsewhere. There are many ideas for storage, and we are now thinking about partnering with these companies, but our approach will differ according to location and region.

Questioner 10

Q: Regarding your efforts to realize a hydrogen solutions ecosystem, I would like to ask you for your long-term perspective on the outlook for change, including in the operating environment. As for the uses of hydrogen before 2030, I would assume that it will first be used in manufacturing, in hydrogen reduction ironmaking, transportation including by ship and aircraft, and in other parts of large supply chains. Recently, the use of synthetic fuels, known as e-fuels, has begun to be considered for automobiles around 2035, and I believe that this will be allowed. As for hydrogen, supply may not keep up with demand, so will it only be used for the applications I just mentioned? Or do you anticipate economies of scale including the automotive applications I mentioned? Do you think that the competitive environment will become intense and rivals will increase in the long run?

Kaguchi: There is not necessarily a right answer to that question, but just to share what I am thinking now, hydrogen will likely be used first in hard-to-abate areas or those which cannot be covered by green electricity. One example is aviation fuel, which we have to use, even if it is expensive. Other examples include raw materials for chemicals, e-chemicals, and e-methane. However, I believe that in areas where electric vehicles can be utilized, hydrogen will not necessarily have to be used. We are thinking about the order in which hydrogen will be required. If large volumes of hydrogen are used for industrial applications, green hydrogen is made from green electricity, and conversely green electricity is made from green hydrogen, there will be a lot of excess electricity available, and the price of hydrogen will go down rapidly. In the case of California, there are already megawatts of excess electricity that is not being stored. If we used that electricity, then an area where almost all electricity included in operating expenses is free would be possible. In the Advanced Clean Energy Storage Project, in addition to seasonal leveling of power generation, we are talking about supplying hydrogen for long-haul trucks as well, so I believe that these are ways that hydrogen will be used.

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