Q&A at the Hydrogen business briefing 12, December, 2022

Question	Answer
Q1: What is the current scale of your hydrogen power business in Europe and what are our company's medium- to long-term goals?	A1: According to the Hydrogen Scaling Up announced by the Hydrogen Council and McKinsey in 2017, global demand for electricity generation in 2030 will be 200 TW/h. Japan and Europe, which lead the way, are expected to account for half of that. Our company is aiming to capture around 20% of the 30 MW class market in Europe. In addition, the EU taxonomy requires co-firing with low-carbon fuels and single-firing after 2035, so we aim to capture a share of about 20% here as well. On the other hand, the REPowerEU projects a hydrogen power demand of 100,000 tons per year. This will be generated by 1 large 500 MW GTCC, but this option is unlikely due to the adjustment of renewable energy fluctuations, and in fact small and medium-sized gas turbines will be used in distributed generation in various regions.
Q2: What is the competitive environment for hydrogen gas turbines? Where are the potential competitors in the future? What are your views on barriers to entry for Chinese and Korean players?	A2: Hydrogen gas turbines are being developed by various companies, but for small- to medium-sized turbines with a generating capacity of up to 30 MW, only our company has achieved fuel switching in a short period of time (from 100% hydrogen combustion to mixed combustion), and no other city demonstration. Although it is possible that existing gas turbine manufacturers will catch up in technological development, the manufacture of gas turbines requires advanced technology in material development and precision casting. In addition to Japan's progress in material development, only a few companies in the world are capable of precision casting gas turbine blades using heat-resistant materials. Catching up requires not only time but also huge capital investment. Our company has been developing jet engines and gas turbines since the 1950s, and has continued to invest in equipment to do so, and will maintain this lead with its own homegrown gas turbines. Our company also has the advantages of long-running reliability and NOx suppression technologies that have established it as a leading manufacturer of hydrogen gas turbines.
Q3: Tell me about the trend of inquiries. Are power producers like RWE the main players, or are there inquiries from companies that produce by-product hydrogen?	A3: Small and medium gas turbines are in great demand not only for power generation but also for cogeneration, which uses steam and heat, and there are many inquiries from paper, food and chemical companies. Many customers are looking to switch to hydrogen fuel in the future by monitoring fuel price trends, and we believe that the flexibility of co-firing is required, especially during the transition period when hydrogen and natural gas are used together for the time being.

	In addition, although the EU taxonomy mandates hydrogen combustion after 2035, the gas turbines provided by our company are technically ready to meet legal requirements.
Q4: How do you see the relationship between hydrogen and ammonia?	A4: The transportation of liquefied hydrogen requires the development of mass transportation technology, and it takes several years to commercialize it. When ammonia is used as a hydrogen carrier, it is possible to transport large quantities of it immediately without any technical development, but on the other hand, it requires a process of dehydrogenation to extract hydrogen from ammonia after transport. It is also necessary to increase the purity of hydrogen when filling fuel cells with hydrogen. Such a process is no longer necessary for our company's liquefied hydrogen transportation. A paper published by the Institute of Energy and Integrated Engineering Research (IAE) shows that liquefied hydrogen has the lowest cost when large-scale manufacturing and transportation are possible. Liquefied hydrogen has a higher ratio of CAPEX, while ammonia has a higher ratio of OPEX. Liquified hydrogen also has the advantage of being rounded up early in compensating for the difference in value from existing fuels (a system similar to CfD in the United Kingdom), and liquefied hydrogen is expected to become the mainstream in the future. On the other hand, ammonia has attracted attention in coal-fired power generation because it can reduce CO2 by being put directly into a coal boiler, and it is suitable for a boiler that can burn existing fuel over time in a large combustion chamber. However, because jet engines, gas turbines, and reciprocating engines have small combustion chambers, combustion of unflammable ammonia poses a high technical hurdle, and it is not an effective measure against global warming unless measures to control nitrous oxide (N2O: global warming potential of 265) are fully implemented. Liquefied hydrogen fuel is expected to be used in the future for the mobility of long-distance buses and trucks, railcars, ships, aircraft, etc. Therefore, liquefied hydrogen, which can be filled as is without a dehydrogenation process, has an advantage in cost and convenience.
Q5: Is it possible that the lack of capacity of water electrolyser manufacturers will hinder the implementation of large-scale hydrogen power projects?	A5: It remains to be seen whether the supply capacity of hydroelectrolyser manufacturers will catch up with the market needs. However, in addition to the method using water electrolysis, there is also a method our company is working on in Australia to produce hydrogen from fossil fuels and capture and store the CO2 generated, so we expect customers to find a way to procure it within their energy portfolios.

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Q6: Will Kawasaki expand its capacity to build liquefied hydrogen carriers in the future? And how many liquefied hydrogen carriers are expected to be completed by 2030?	A6: One of the commercialization demonstration vessels has been confirmed and is currently beginning design, as well as consideration of follow-on vessels with customers for full-scale commercialization. We are reorganizing our plants and making capital investments in order to establish a construction system.
Q7: How much of the 400 billion yen hydrogen business sales plan for 2030 is Europe expected to account for?	A7: As of 2030, the focus is on the commercialization demonstration of the domestic market and the 1st and 2nd chains. Gas turbines for Europe are also included, but we will not provide an answer on the amount.
Q8: Which do you think is more advantageous in mobility, hydrogen internal combustion engines or fuel cell vehicles?	A8: Fuel cells increase capacity by increasing the number of stacks, so the cost increases in proportion to the increase in output. Although internal combustion engines are low in cost to begin with, their output and capacity are determined by the volume of the combustion chamber, and they have cost advantages over fuel cells, in part because the cost increase associated with larger engines is reduced. In addition, some large internal combustion engines can run for nearly 100,000 hours and are more durable than the replacement life of the stack. Some large marine internal-combustion engines have a thermal efficiency of over 55%, which is nothing compared to fuel cells. Ultimately, we recognize that the internal combustion engine is reasonable in terms of owner cost. In addition, for aviation engines, the internal combustion engine has an advantage in terms of weight reduction, and for more hobby forms of mobility such as motorcycles, you can enjoy exhaust sounds that you can't get from a motor. As described above, we expect that a certain degree of smoothness will occur in small mobility, while internal combustion engines will be applied to large vehicles. Specifically, we believe that the size of buses and trucks will be the boundary between fuel cells and internal combustion engines.
Q9: Are you developing a hydrogen internal combustion engine? If so, when is the best time to market?	Q10: HyEnge Corporation, established by three marine engine manufacturers including our company, is sharing the development of high-speed small internal combustion engines for marine use, medium-speed internal combustion engines for medium use, and low-speed 2-stroke internal combustion engines for large use, and is scheduled to launch in 2030. In addition, Kawasaki Motors, a subsidiary of our company, is planning to release vehicles with hydrogen engines in 2030.
Q10: Are there measures against hydrogen embrittlement?	A10: We know which materials will not become brittle due to progress in material development, and we have measures against hydrogen embrittlement in place.

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Q11: What does the introduction of IRA tax breaks mean in the United States? While gray hydrogen/CCS and blue hydrogen are becoming more competitive, I suspect that the United States will see more investment in hydrogen power before Europe.	A11: American power producers tend to focus on small and medium-sized facilities, and there is interest in our company. It is fully expected that the United States will be a large market for hydrogen gas turbines as well as Europe. However, we are keeping a close eye on how long it will take for IRAs to be able to do this because they do not have the full set of criteria (Environmental Justice) and mechanisms in place to make grants.