Decarbonization

An interview on how today's industry can drive global decarbonization and what role the Hitachi Zosen Group wants to play in this transition

The climate targets confirmed at COP26 in Glasgow in November 2021 require rapid action in politics, business, and society. To drive decarbonization, emissions from the burning of fossil fuels must be avoided and replaced by CO_2-neutral, renewable energy sources such as solar, wind, hydro, geothermal, and biomass energy. Where a shift away from fossil fuels is not possible or not fast enough, emissions must be captured and used or stored. In addition, products and services must be made more energy-efficient.

The Hitachi Zosen (HITZ) Group supports energy transition by building plants to generate alternative energy in the form of wind power, waste-to-X, biogas, electrolysis, and power-to-X plants. It also manufactures process elements for a CO_2-neutral industry, such as nuclear fuel cycling-related equipment for the safe disposal of spent fuel rods, decommissioned reactors from nuclear power plants, or tanks for alternative fuels. The development of liquefied natural gas (LNG) marine engines, which can reduce nitrogen oxide (NOx) emissions and even achieve net zero carbon dioxide (CO_2) emissions, is contributing directly to a shift away from fossil fuels and the decarbonization of the naval transportation sector.

In addition, the group is developing strategies and solutions for capturing and collecting CO_2 for further use as a product gas or for permanent storage.

Under the term "decarbonization technologies," the Hitachi Zosen Group summarizes its in-house technologies that contribute directly to the reduction of CO_2 in the environment. The Group's portfolio includes biogas upgrading with CO_2 capture using membrane technology or amine scrubbing, carbon capture and storage (CCS) and carbon capture and utilization (CCU) strategies, alkaline and polymer electrolyte membrane water electrolysis, proprietary biological and catalytic methanation, and gas liquefaction technologies. The HITZ Group currently employs nearly 400 people worldwide dedicated to this field, ranging from research and development to service activities. Since its entry into these new technology fields 30 years ago, the company has built more than 170 decarbonization plants worldwide.

Hitz

In a group interview with decarbonization experts from the Hitachi Zosen Corporation (Osaka, Japan) and its subsidiary Hitachi Zosen Inova (Zurich, Switzerland), we discussed the milestones in the group's decarbonization portfolio, the potential applications of these technologies in the context of SDGs (sustainable development goals), the global market situation, and the company's goals and visions.

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The Hitachi Zosen Group's decarbonization portfolio has grown considerably in recent years. What application areas does the company cover?

KK: With our CO_2 capture system coupled with CCS, we have a solution for reducing CO_2 by capturing the emitted CO_2 and storing it underground.

The combination of CO_2 capture, electrolysis, and methanation allows us furthermore to produce synthetic methane. To achieve this, we use captured CO_2 and water and subject the two elements to electrolysis with the addition of electricity from a renewable source. The result is green hydrogen. This is then methanized in a biological or catalytic process. Thus, the synthetic methane obtained can be used as a substitute for natural gas.

The green hydrogen produced by electrolysis can also be directly used as a renewable fuel. Currently, it is primarily used in hydrogen fuel cells, fuel-cell vehicles, hydrogen boilers, and hydrogen burners.

BB: By adding CO_2 liquefaction to our gas processing plants, we expanded our focus. Previously, we focused only on methane. However, with the liquefaction of CO_2 we can store it, and with additional purification we can market it as product gas for various industrial processes, even under the food grade label for use in the food industry.

We also offer a method to decarbonize the transport sector using methane liquefaction. We have already undertaken some projects in Germany and Finland.

Do you have reference projects for these technologies?

BB: Of course, both client and research projects.

In June 2023, we inaugurated our latest project on the liquefaction and use of CO_2 (CCU) in Nesselnbach, Switzerland (press release: Nesselnbach (hz-inova.com)), and one carbon capture project is being completed in Zörbig (Germany) (press release: Zoerbig (hz-inova.com)).

The two BOO (Build - Own - Operate) projects in Apensen (press release: Apensen (hz-inova.com)) and Blankenhain (press release: Blankenhain (hz-inova.com)) (both in Germany) are milestone projects in terms of efficiency: here we produce bioLNG, greenhouse gas quotas and liquid CO_2 of food grade quality for further marketing.

We were able to implement a power-to-H_2 project with an alkaline water electrolyzer at the Waste to Energy (WtE) plant in Buchs, Switzerland (press release: Buchs (hz-inova.com)) and biological methanation at the WtE site of Limeco (press release: Limeco (hz-inova.

com)) in Dietikon, Switzerland. Our projects for catalytic methanation for the client Inpex in Osaka,Japan and Energie Steiermark in Gabersdorf, Austria (project description: Gabersdorf (hz-inova.com)) are particularly worth mentioning because they were the first projects with an international collaboration of our group entities.

PS: There are also some noteworthy research projects for scaling up our methanation technology to methane production of 400 Nm^3/h and 1,200 Nm^3/h respectively. And the already mentioned Gabersdorf project, we conducted a research on the direct methanation of biogas without a preceding separation of CO_2.

KK: In Japan, our 1 MW PEM-type water electrolyzers are available on the market. The latest system was supplied earlier this year to Hokkaido Electric Power (news release: Hokkaido (hitachizosen.co.jp)).

Meanwhile, we have completed and are working on several R&D projects: this year, we completed the construction of Japan's largest methanation facility in Odawara, Kanagawa Prefecture (news release: Odawara (hitachizosen.co.jp)). The plant produced 125 Nm^3/h of methane, which covers the gas consumption of approximately 3,000 Japanese households. It was the first methanation plant in the world to use carbon dioxide emitted from a waste incineration plant. After its successful demonstration operation, the plant is now being dismantled.

A demonstration project of a 6 MW electrolyzer to test possibilities for upscaling and cost reduction is planned for 2026. Several installations of 1–5 MW electrolyzers to decarbonize Japan's industry are also projected, alongside the demonstration of a high-pressure water electrolyzer, which will be built in Laos with funding from the Japanese New Energy and Industrial Technology Development Organization (NEDO) (news release: NEDO International Demonstration Project of Japanese Technology (hitachizosen.co.jp)). Furthermore, we conducted a pre-feasibility study for a large-scale methanation plant project in China with NEDO funding.

It seems that more customer projects are being created in Europe, while research projects take precedence in Japan. Why is that?

BB: Since 2018, the Renewable Energy Directive (RED) II has obliged all EU countries to increase their share of renewable energy to 32% by 2030. Some countries went a step further and have taken additional regulatory measures that encourage businesses to actively address their CO_2 reduction. For example, Finland is committed to decarbonizing the transport sector and is putting pressure on energy suppliers to replace traditional coal power with alternative fuels such as LNG or renewable biomethane by imposing heavy penalties.

Furthermore, Russia's invasion of Ukraine led to increased electricity prices and strengthened Europe's intention to become independent of Russian gas. The European Commission's "REPowerEU Plan" creates the necessary incentives for energy suppliers to provide new offers. These conditions make our technologies real business cases that are interesting to customers not only ideologically, but also economically.

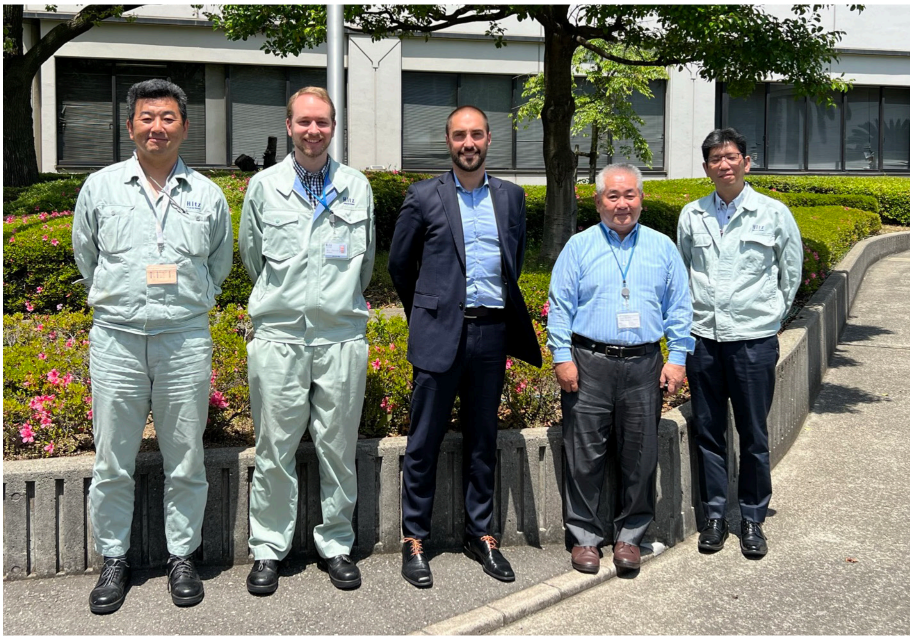
KK: In Japan, the government is introducing a system of subsidies and penalties to accelerate decarbonization. This will provide the necessary incentives for industry and the economy to implement these technologies. Until this is implemented, we are trying to position ourselves by participating in various research projects so that we can start from a pole position when the time arrives.

So, we have regionally differing regulatory bases, which influence sales opportunities. How do you assess the market situation in general?

KK: That varies a lot, of course.

In Japan, the demand for synthetic methane is expected to increase owing to existing gas grid infrastructure.

The demand for hydrogen will also increase, as the government has set an ambitious target of multiply-



ing the plant base from 160 plants today to 900 by 2030.

In terms of target segments, the Japanese energy, industry, and transport sectors and, segmented by industry, the steel, chemical, machinery, and ceramic industries are responsible for over 70% of total domestic CO_2 emissions. So, there's a lot of potential for decarbonization strategies and technologies.

BB: The European Green Deal outlines the political framework for decarbonizing the continent by 2050. Energy suppliers in all EU countries are thus forced to raise the share of renewable and decarbonized energy in their portfolios, which increases the demand for downstream products of biogas (biomethane, RNG, and biofuel from renewable gases), green hydrogen, and e-fuels for transport and aviation.

In addition, most countries have their own targets, leading to a fragmented market.

How has and will the HITZ Group establish itself in these markets? How do your products differentiate themselves from competing products?

BB: Our broad positioning is our biggest USP. No other company has as much experience, proprietary technologies, or such a broad installed base in the areas of wind power, nuclear power, waste to energy, renewable gas, and power to gas as Hitachi Zosen. We can offer combined and fully integrated solutions from one single source for all these technologies. Benefitting from our enormous EPC expertise in WtE projects, we can now transfer this expertise to our decarbonization projects. For the customer, this means lower risk and easier project execution.

TK: In the hydrogen sector, we are the only large-scale PEM water electrolyzer manufacturer in Japan. We built Japan's largest PEM water electrolyzer (1.5 MW). Fueled by hydrogen from one hour's production of such a facility, a Toyota Mirai can travel more than 3,300 km.

KI: We pioneered methanation 30 years ago, when we took up this topic in R&D, and have continued to pursue it ever since. Today, we can boast one of the largest track records of demonstration projects in the market.

Our catalysts must also be mentioned. These are characterized by higher activity and faster reactions (in short, higher efficiency) than other competing products. In addition, they have longer runtimes, and lower Operation & Maintenance costs. One drawback of these catalysts is that they incur high investment costs. However, we believe that it is worth the investment, as it will benefit the customer later owing to better performance, longer service lives, and lower maintenance costs. Furthermore, we are currently working towards lowering prices through commercial production.

Since entering into these new technology fields 30 years ago, we have built more than 170 decarbonization plants worldwide.

And what are your biggest challenges and how do you approach them?

KK: From our side, cost reduction is the greatest challenge. To establish hydrogen and methanation systems as an alternative to conventional fossil fuels, we must reduce the cost to an acceptable level.

How can you do that?

KK: : Through economies of scale. Increased module size and stack manufacturing significantly impact costs. Additionally, automated stack production in a GW-scale manufacturing facility can achieve a step change in cost reduction, and the standardization of system components and plant design.

What is your company's vision in the decarbonization sector? What are your goals for the next few years?

KK: In alignment with HITZ's brand statement "Technology for the people and planet" we will do our utmost to achieve the global SDGs. These are integral components of our group's business plan. In 2019, we were able to reduce global CO_2 emissions by 15.8 million tons in one year. By 2030, we aim to reduce global CO_2 emissions by 40 million tons per year.

BB: On HZI's side, the word "decarbonization" is part of the vision statement. A major part of the R&D budget is directly or indirectly linked to technological developments in waste treatment or the energy sector to integrate carbon offsets or carbon capture into present and future businesses. With the first large RG and WtE projects based on a decarbonization business model breaking ground in Europe, the trend is quite clear, and the organization of the group has already made some significant adjustments to keep HZI in a position to deliver this type of new project in a new business environment.

Technology Glossary

Methanation

Biological Methanation:
The biological methanation converts hydrogen and carbon dioxide through a biological process at moderate temperatures around 65 °C and a pressure of about 8 - 10 bar. The required biomass can be obtained from an AD plant or sewage sludge and is continuously stirred in the reactor. The conversion rate is very high, leading to a methane concentration close to 100%.

Catalytic Methanation
Catalytic methanation converts hydrogen and carbon oxides into methane and water. The reaction requires a catalyst, typically nickel-based, and occurs at temperatures around 200 – 240 °C. An elevated pressure of 8 – 10 bar is beneficial to the final methane concentration. The reaction is highly exothermic; therefore, the reactor is cooled using a natural draft water-steam system. Consequently, the system also provides high-pressure steam.

Carbon Separation & Capture

CCS
Carbon Capture and Storage (CCS) is the process of separating, capturing, and compressing carbon dioxide from various sources and transporting it to a long-term storage location.

CCU
CCU stands for Carbon Capture and Utilization and focuses on the recycling of CO_2 for further usage.

Membrane Technology:
The pre-treated gas is fed into membrane modules, where carbon dioxide is separated from methane by selective gas permeation. As CO_2 permeates the membranes more quickly than methane, the latter is retained in the membranes and removed from the modules as product gas. The CO_2 can also be collected and utilized as product gas.

Amine Scrubbing:
In the chemical process, the pre-treated raw gas flows through a packed column, where an amine solution that absorbs carbon dioxide is trickling from top to bottom in the direction opposite to the gas. Subsequently, methane with a purity of up to 99.9 % is obtained at the top of the tower. After desorption from the solvent the CO_2 can also be utilized as product gas.

Electrolysis (Hydrogen Generation)

Electrolyzers consist of an anode and a cathode separated by an electrolyte.

Alkaline Water Electrolysis:
The electrolyte consists of a liquid alkaline solution of sodium or potassium hydroxide. Hydroxide ions (OH) are transported through this electrolyte, from the cathode to the anode, generating hydrogen at the cathode.

Polymer Electrolyte Membrane Water Electrolysis:
The electrolyte is a solid plastic material, the PEM. Water is oxidized at the anode to form oxygen, positively charged hydrogen ions (protons), and electrons. Hydrogen ions are conducted through the PEM and are then reduced at the cathode, reacting with electrons to produce hydrogen gas.