

IR Seminar

Toray Group's Initiatives Toward Realization of a Hydrogen Society

The Group held an IR Seminar titled "Toray Group's Initiatives Toward Realization of a Hydrogen Society" on September 5th, 2023. In this event, these three speakers gave presentations: Satoru Hagiwara, Executive Vice President and Representative Member of the Board, Keisuke Ishii, General Manager, Torayca Division, and Kozo Takahashi, General Manager, HS Division.

Hydrogen Is the Key to Fulfilling Carbon Neutrality

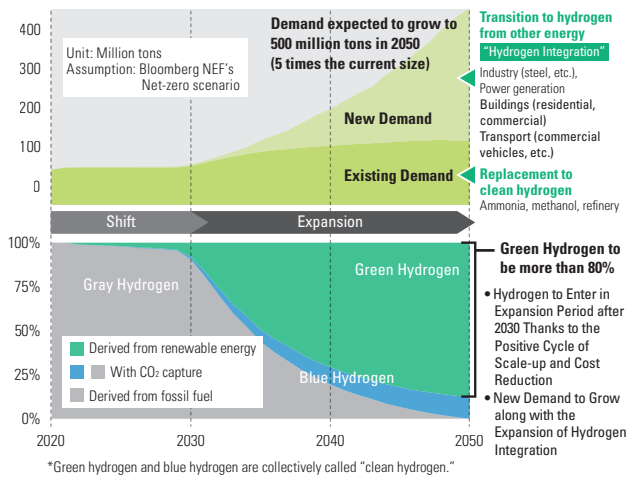
In 2050, in the world that has achieved carbon neutrality, the primary energy source will have completely shifted from fossil fuels to wind, solar, and other forms of renewable energy. Moreover, hydrogen will have come to play an important role as a source of clean power, a carrier of clean power, and as a form of secondary energy.

Satoru Hagiwara

Executive Vice President and Representative Member of the Board, CTO



Hydrogen Long-term Demand Forecast (upper) and Transition to Clean Hydrogen (lower)



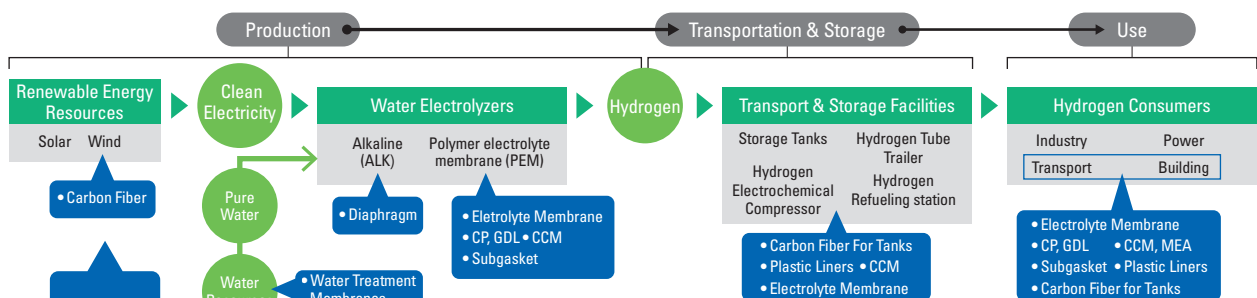
Already, the trend toward real-world implementation of clean hydrogen is spreading among countries across the globe, with the number of related projects exceeding 1,000 and amounting to a total investment of ¥45 trillion. Over the coming decade, real-world usage will progress centered on green hydrogen, which is produced by water electrolysis using renewable energy, where replacement of existing demand for ammonia and other raw materials will begin. Following on this, new demand will emerge as each sector begins to convert to hydrogen use, after which up-scaling and cost reductions are expected to progress. The hydrogen society will then enter a period of rapid expansion, driving the hydrogen market to a scale of 500 million tons per year in 2050, five times of its size today. Green hydrogen is expected to account for 80% of the total.

Developing and Manufacturing a Wide Range of Core Materials Used throughout the Hydrogen Supply Chain

The feature of Toray's hydrogen-related businesses is the range of products it offers across the entire supply chain, from production to transportation, storage, and use. For example, Toray's carbon fibers are required for the wind power used to generate green electricity employed to produce hydrogen, while its water treatment membranes are used to produce water that serves as the raw material. The water electrolyzers, which are expected to expand in the future, include alkaline (ALK) and polymer electrolyte membrane (PEM) types. Toray is working to apply its core materials such as diaphragms, polymer electrolyte membranes, catalyst coated membranes (CCM), electrodes, subgasket films for these electrolyzers. In

regard to hydrogen transportation and storage, Toray provides carbon fibers and plastic liners of which high-pressure tanks are made, while in terms of use it delivers the core materials that are similar to those used in fuel cells.

The primary driver for expansion of green hydrogen is realization of parity pricing (pricing that can compete with existing fuels). As part of its efforts to realize a hydrogen society, Toray therefore provides advanced materials as solutions that facilitate the answers to the challenge of increasing the availability of lower cost clean hydrogen to a wide range of customers throughout the supply chain.



CCM : Catalyst Coated Membrane, CP : Carbon Paper, GDL : Gas Diffusion Layer, MEA : Membrane Electrode Assembly

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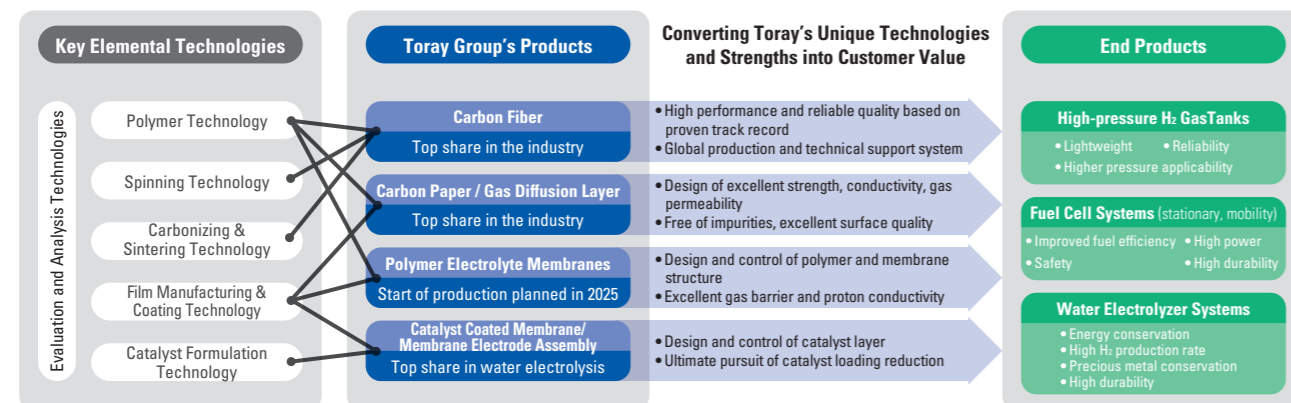
Converting Toray's Proprietary Technologies and Strengths into Customer Value

Toray develops the core materials that will support a hydrogen society by leveraging its key polymer and processing technologies, thereby providing these materials with an advantage in terms of its high quality compared with its competitors. Moreover, Toray holds a leading industry share for carbon fibers used in gas tanks; carbon paper (CP), gas diffusion layer (GDL), and other electrode materials used in fuel cell and water electrolysis systems; and catalyst coated membranes (CCM) / membrane electrode assembly (MEA). In addition, in 2025 the Group plans to begin mass-production of hydrocarbon (HC) electrolyte membranes, which are positioned to become a major new product.

With over 60 years of history, Toray carbon fibers were first used for natural gas as applications spread to the high-pressure

tank field, and will continue deploying into new areas with the expansion of the hydrogen market. In the field of fuel cells, the Group developed CP electrode materials for passenger vehicles, and is now working with a focus on expanding the business for heavy duty vehicles that will depend on fuel cells for decarbonization. HC electrolyte membranes have a history of 20 years, while the CCM/MEA offered by Greenerity, Toray's subsidiary in Germany, have a history of 30 years.

Leveraging these proprietary technologies and strengths accumulated over the years, Toray Group will enable lighter weights, higher pressure, greater reliability, better efficiency, improved performance, superior durability, and other forms of value for the hydrogen supply chain, which are ultimately delivered to its customers.



Promoting R&D of Innovative Technologies that Contribute to Carbon Recycling

A carbon neutral world will also need to realize carbon recycling, whereby carbon is recovered and converted into valuables (ammonia, methane, methanol, synthetic fuel, polymers, etc.) for use in combination with clean hydrogen. This will require separating various mixed gases into their individual components, for which Toray proposes innovative separation membranes. One of these is hydrogen separation membranes. The Group has demonstrated the highest level

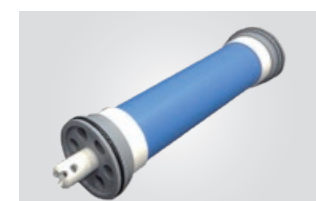
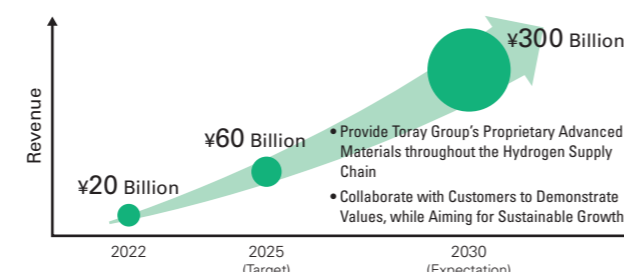
of hydrogen purity in the world by leveraging its water treatment RO membrane technology for use in this area. Another is CO₂ separation membranes, for which the Group has demonstrated basic performance in terms of heat resistance and efficiency, for example, and for which it is advancing to the field demonstration stage. Moreover, the Group is investigating a hydrogen-oxidizing bacterium-based bioprocess as a technology to convert the series of raw gases into valuables.

Aiming to Achieve Sales of ¥300 Billion in FY 2030

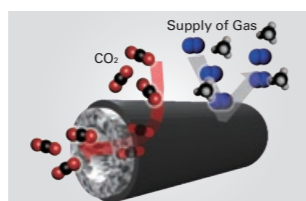
Sales for Toray Group's hydrogen-related businesses in FY 2022 amounted to around ¥20 billion. During FY 2025, the final year of Medium-Term Management Program, Project AP-G 2025, the Group is targeting sales of up to ¥60 billion, with carbon fibers for hydrogen tanks, electrode materials, and CCM/MEA as the primary growth drivers. Together with HC

electrolyte membranes, further growth in these businesses will serve as a driver in the Group's efforts to steadily capture the growth of the hydrogen society with the aim of achieving ¥300 billion sales in FY 2030.

Challenge for Expansion of Hydrogen-related Businesses



High-Efficient Hydrogen Separation Membrane



All-Carbon CO₂ Separation Membrane

Initiatives of Torayca & Advanced Composites Division

Anticipating Dramatic Growth in Demand for High-pressure Gas Tanks and Gas Diffusion Layer (GDL) for Fuel Cells

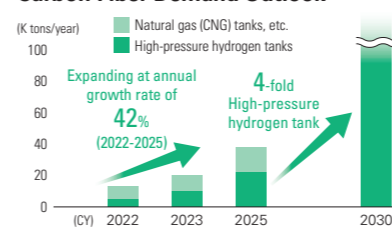
Toray's carbon paper (CP) is used as porous transport layers (PTLs) for the water electrolyzers that produce hydrogen, while high-pressure gas tanks reinforced with carbon fiber are used for hydrogen refueling stations, hydrogen transport trailers, and fuel cell vehicles. Moreover, CP and the gas diffusion layer (GDL) made from CP play an important role as electrode substrate for fuel cells.

In particular, fuel cell vehicles are considered to be advantageous for large trucks and other

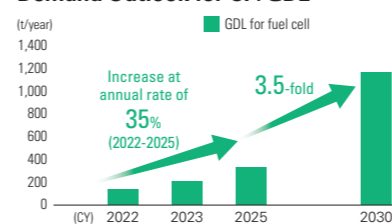


Keisuke Ishii
General Manager,
Torayca Division

Carbon Fiber Demand Outlook



Demand Outlook for CP/GDL



commercial vehicles that travel long distances because they offer better payloads and range than battery EVs. Likewise, the Group anticipates significant growth in demand for carbon fibers used in high-pressure hydrogen gas tanks starting in 2026. Specifically, the demand for carbon fibers for high-pressure gas tank applications, including those used for natural gas, is expected to expand at an annual growth rate of 42% until 2025, whereas the demand for these in 2030, when hydrogen gas tank applications will fully take-off, is expected to quadruple that of 2025.

Moreover, the demand for CP and GDL used in polymer electrolyte membrane (PEM) type water electrolyzers and fuel cells is also growing. This area is expected to expand rapidly, with demand in 2030 increasing 3.5-fold compared with 2025. Boasting a leading share of the industry, Toray's GDL has superior features compared with those of competing manufacturers, in terms of gas permeability, water transportation characteristics, high conductivity, high strength, and high surface quality. Thereby it contributes to the higher output, longer life, and improved safety of fuel cell vehicles.

Initiatives of HS Division

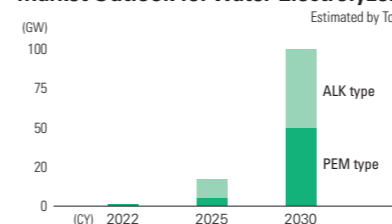
Working to Capture the Growth of the Hydrogen Society through Hydrocarbon (HC) Electrolyte Membranes

The HS Division offers the core components that are shared by water electrolyzers, hydrogen compressors, and fuel cells, namely electrolyte membranes, catalyst coated membranes (CCMs), and membrane electrode assemblies (MEAs) made by laminating a gas diffusion layer onto a CCM. Moreover, it is responsible for Greenerity (Germany) and Yamanashi Hydrogen Company (YHC). Along with establishing the basic concept of hydrocarbon (HC) electrolyte membranes

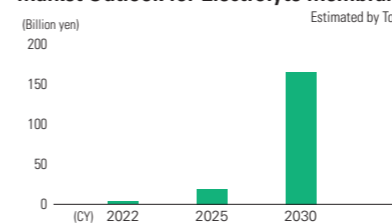


Koza Takahashi
General Manager,
HS Division

Market Outlook for Water Electrolyzer



Market Outlook for Electrolyte Membrane



at its laboratories, Toray acquired Greenerity and has since incorporated its CCM/MEA production technologies. Later on, it demonstrated this technology as part of a national project, entered a partnership with Siemens Energy, and established the HS Division as a new profit center in June 2022.

Leveraging proprietary polymer design, precision polymerization, and nano-level structure control technologies, Toray conceived of HC electrolyte membranes, which contribute to significant performance improvements for PEM-type water electrolyzers with superior adaptability to renewable energy power sources. As the use of renewable energy progresses in the future, the ratio of PEM-type electrolyzers using HC electrolyte membranes will rise compared to existing alkaline-type water electrolyzers, and are therefore expected to account for 50% of the market by around 2030. The electrolyte membrane market will also grow significantly along with the increase, and is expected to reach a market scale of around ¥160 billion annually in 2030, of which the Group intends to capture a major portion using Toray's proprietary HC electrolyte membranes.