



Innovation by Chemistry

Toray IR Seminar

Toray Group's Initiatives Toward Realization of a Hydrogen Society

Toray Group's Hydrogen-related Businesses

September 5, 2023

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I . Toray Group's Sustainability Initiatives

II . Hydrogen that Contributes to Realizing Carbon Neutrality

III . Toray Group's Hydrogen Strategy

I

Toray Group's Sustainability Initiatives

Achieving Sustainable Growth

- Expansion of **Sustainability Innovation (SI)** and **Digital Innovation (DI)** businesses
- Target: Expanding revenues from businesses related to these areas to about **60% of total** by 2025

SI&DI Projects

Growth Business
Fields under
AP-G 2022



Growth Business Fields under AP-G 2025

SI Business Sustainability Innovation Business (*1)	1 Products that accelerate measures to counter climate change
	2 Products that facilitate sustainable, recycling-based use of resources and production
	3 Products that help provide clean water and air and reduce environmental impact
	4 Products that help deliver better medical care and hygiene for people worldwide
DI Business Digital Innovation Business	Materials, equipment, technologies, and services that help improve convenience and productivity by supporting the widespread adoption of digital technology

[Carbon fibers for aircrafts](#)



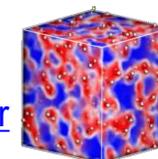
[Electrolyte membranes for production of H2](#)



[Bioprocess using membranes](#)



[Chemical recycling using subcritical water](#)



[RO membranes for seawater desalination](#)



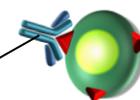
[Environmentally friendly offset plate](#)



[Protective clothing](#)



[Cancer Antibody Drug](#)

TRK-950  Cancer Cell

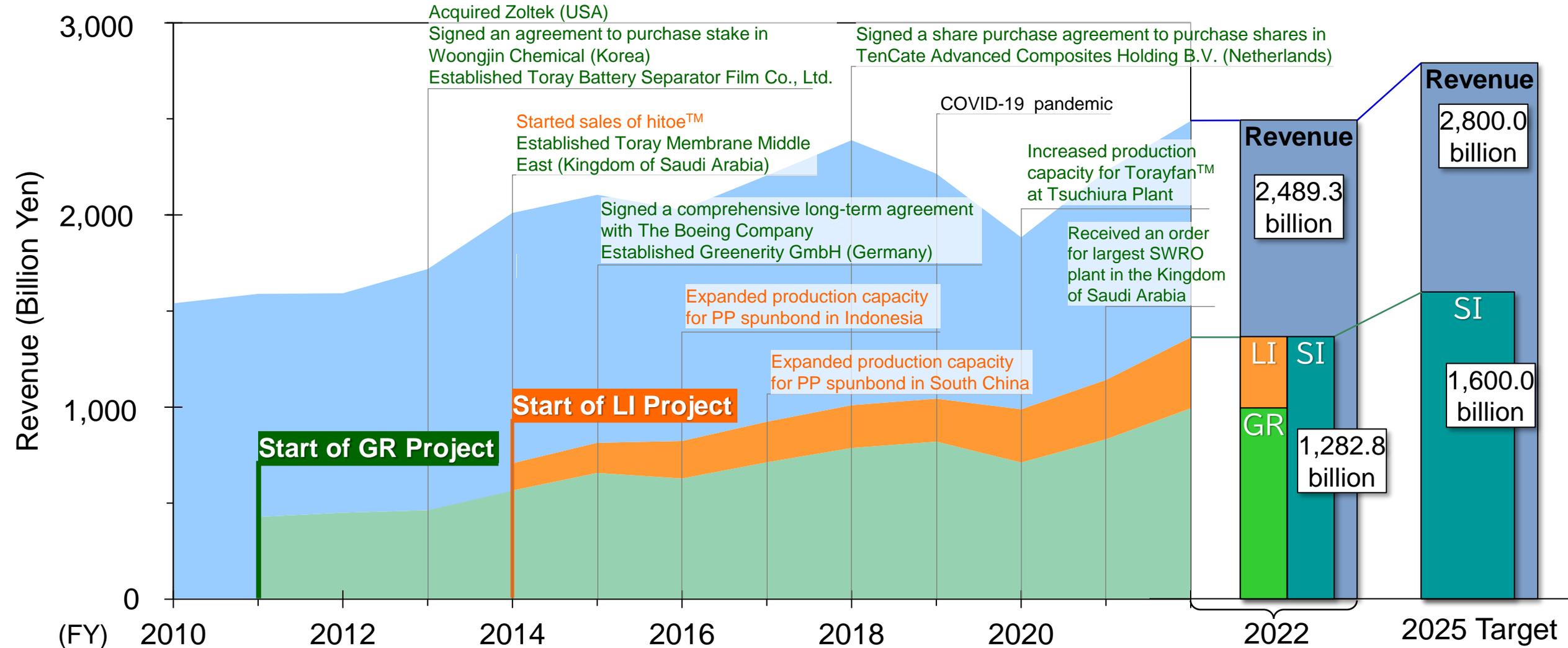
[Polyimides](#)



[Semiconductor manufacturing and inspection equipment](#)



Toray Group's History of Business Expansion



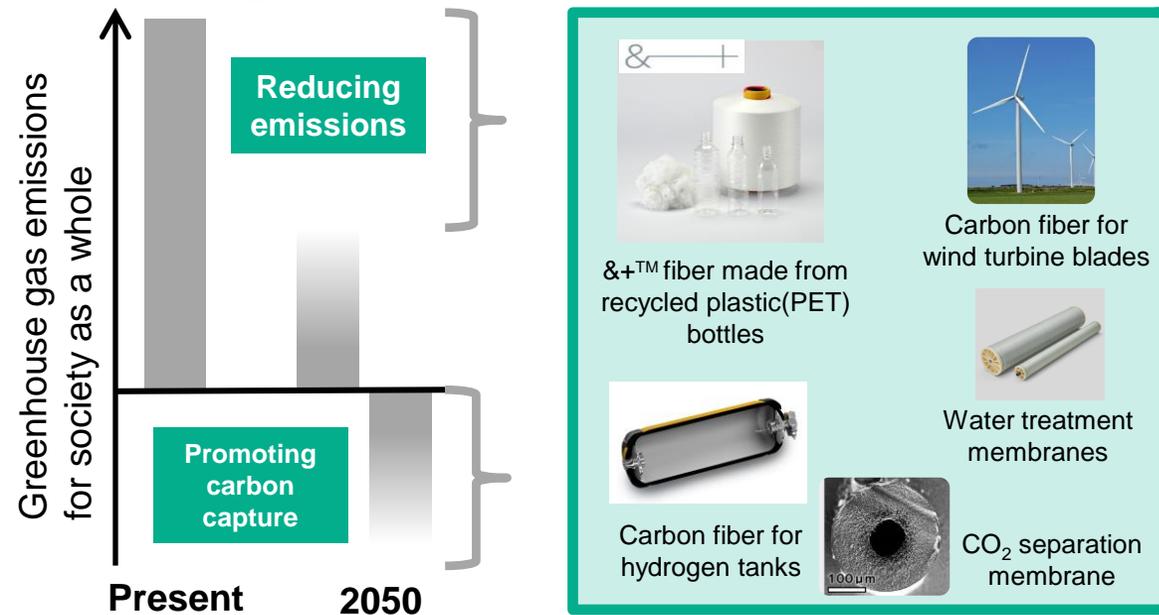
As a Part of Commitment to Growth Fields, Sustainable Innovation (SI) Business has been Expanded

Carbon Neutrality Initiatives

Helping the broader society to reduce overall greenhouse gas emissions through the Sustainability Innovation (SI) Business. Also reducing Toray Group greenhouse gas emissions* by maximizing the use of renewable electricity, hydrogen, and low carbon-footprint raw materials, based on expansion of the SI Business. (*Scope 1, 2, 3)

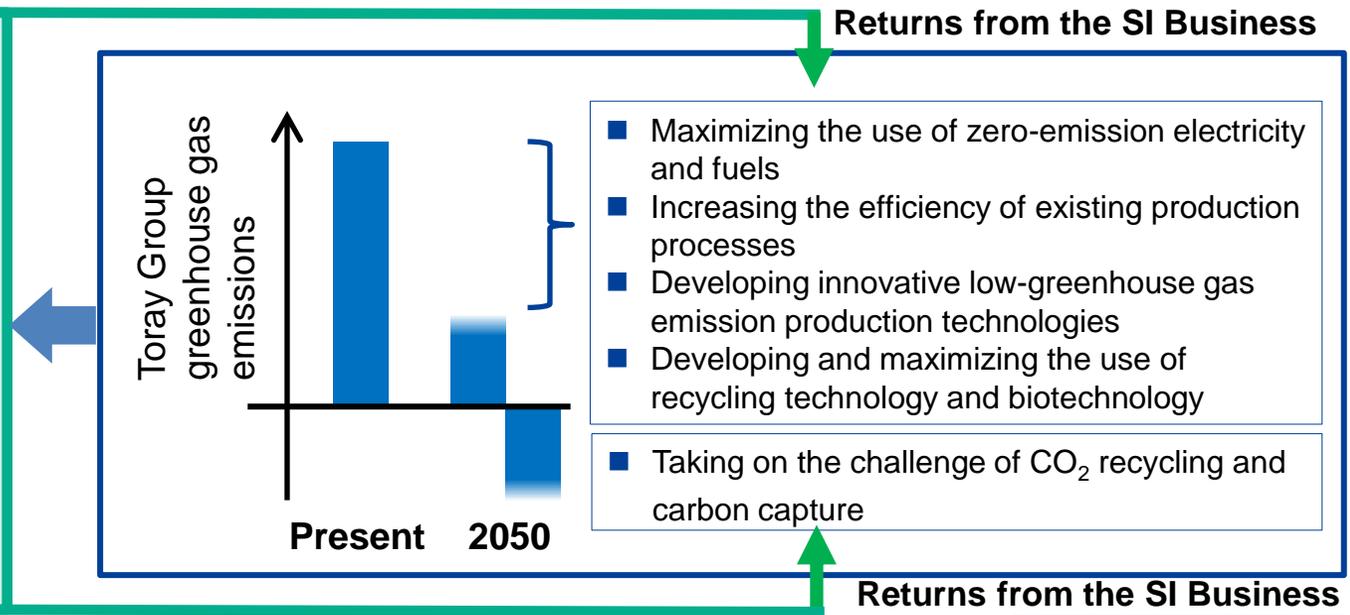
Contributing to building a carbon-neutral world

Increasing the Volume of Greenhouse Gas Emissions Avoided through the Sustainability Innovation(SI) Business



Achieving carbon neutrality for the Toray Group by 2050

Adopting greenhouse gas emissions reduction technology in business activities



(Corresponding KPIs)

	FY2030 Target [Compared to FY2013]
Supply of Sustainability Innovation products	4.5-fold
CO ₂ emissions avoided in value chain	25-fold

(Corresponding KPIs)

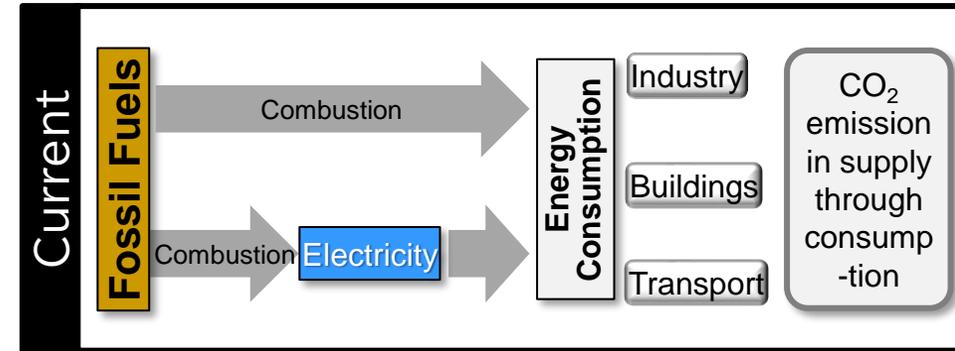
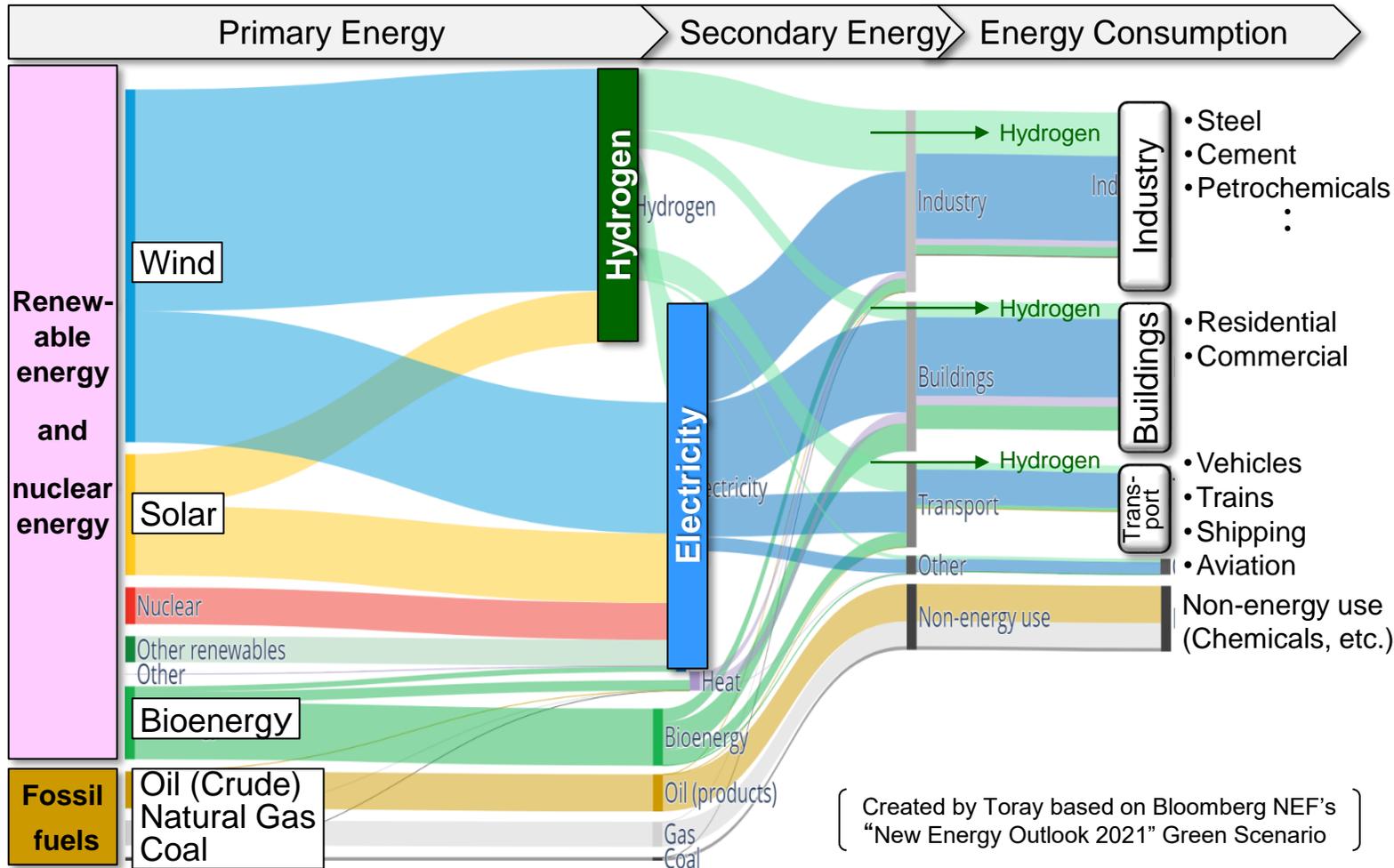
		FY2030 Target [Compared to FY2013]
GHG emissions in production activities	GHG emissions per unit of revenue for the entire Toray Group	Over 50% reduction
	GHG emissions of Toray Group in Japan	Over 40% reduction

II

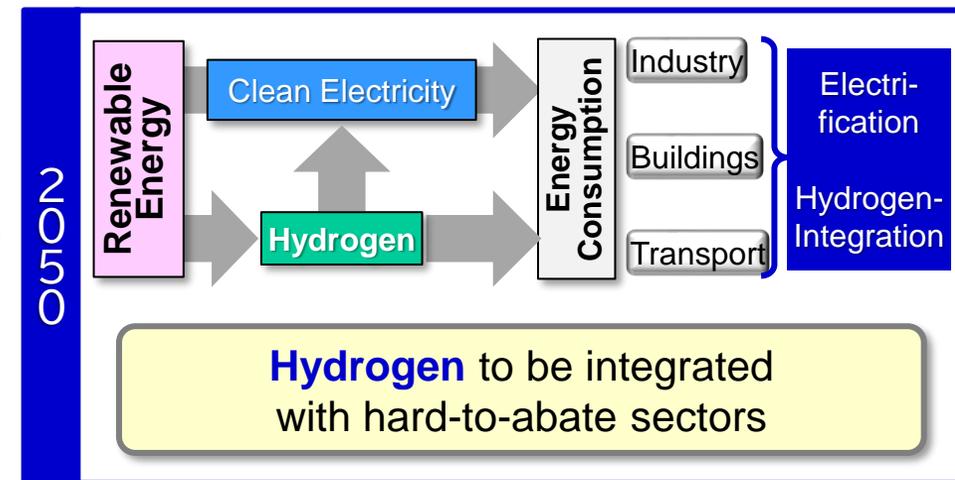
Hydrogen that Contributes to Realizing Carbon Neutrality

Hydrogen's Contribution to Realizing Carbon Neutrality

Energy Transition toward Carbon Neutrality in 2050



Energy Transition



Hydrogen is the Key to Fulfilling Carbon Neutrality

Global Movement toward Hydrogen

Created by Toray based on Hydrogen Council's "Hydrogen Insights 2023"

○Europe

- Green hydrogen in/ outside the region: 10 million ton/ year for each in 2030
- Water electrolysis system installed in the region: ~ 100 GW

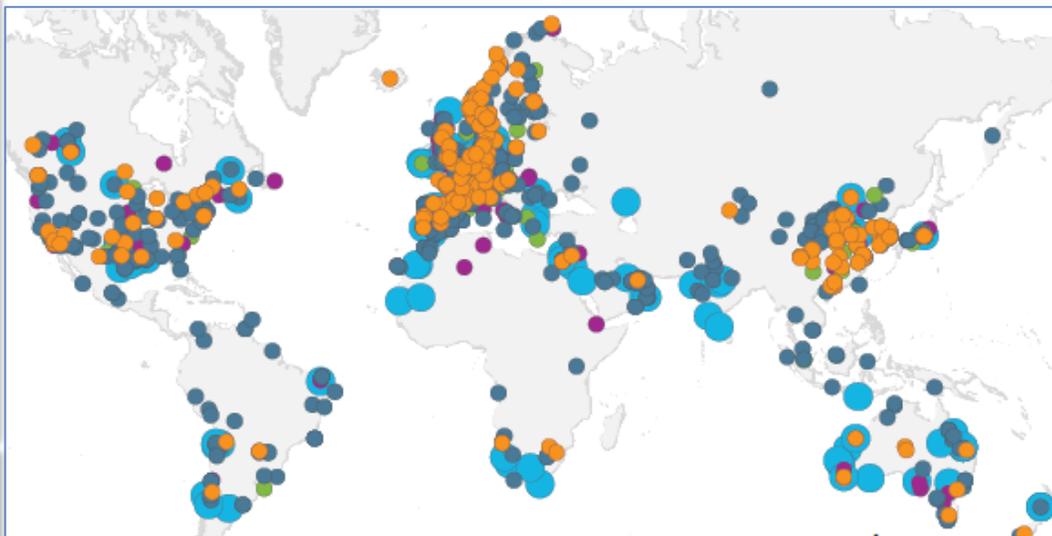
16.4 Trillion Yen

○USA

- Clean hydrogen production in 2030: ~ 10 million ton/ year
- Target hydrogen cost in 2031: 1 USD/ kg
- Legislated tax incentives and Clean Hydrogen Hubs

6.4 Trillion Yen (North America)

■ Global Hydrogen-related Projects (until 2030)



1,046 Projects Announced
Investment Amount: Around 44.8 Billion Yen

[As of Jan 2023; Currency Assumption: 140 JPY/USD]

Investment Amount

- **112**
Giga-scale production
- **553**
Large-scale industrial use
- **191**
Mobility
- **94**
Integrated H₂ economy
- **96**
Infrastructure projects

○Other Countries and Regions

- Countries and regions of abundant renewable energy such as Chile, Australia, India, Middle East, and Africa will transition to export of hydrogen after fulfilling the demand within its own country/region.

17.1 Trillion Yen (Total of South America, Australia, Middle East, and Africa)

○China

- Hydrogen from renewable energy resources in 2025: ~ 250 thousand ton/ year

2.5 Trillion Yen

○Japan

- Clean hydrogen supply in 2030: ~ 3 million ton/ year
- Water electrolysis system deployed in/ outside Japan in 2030: ~ 15 GW
- Target hydrogen price in 2030: 30 JPY/ Nm³ (2.4 USD/ kg)[†]

[†]: Currency Assumption: 140 JPY/USD

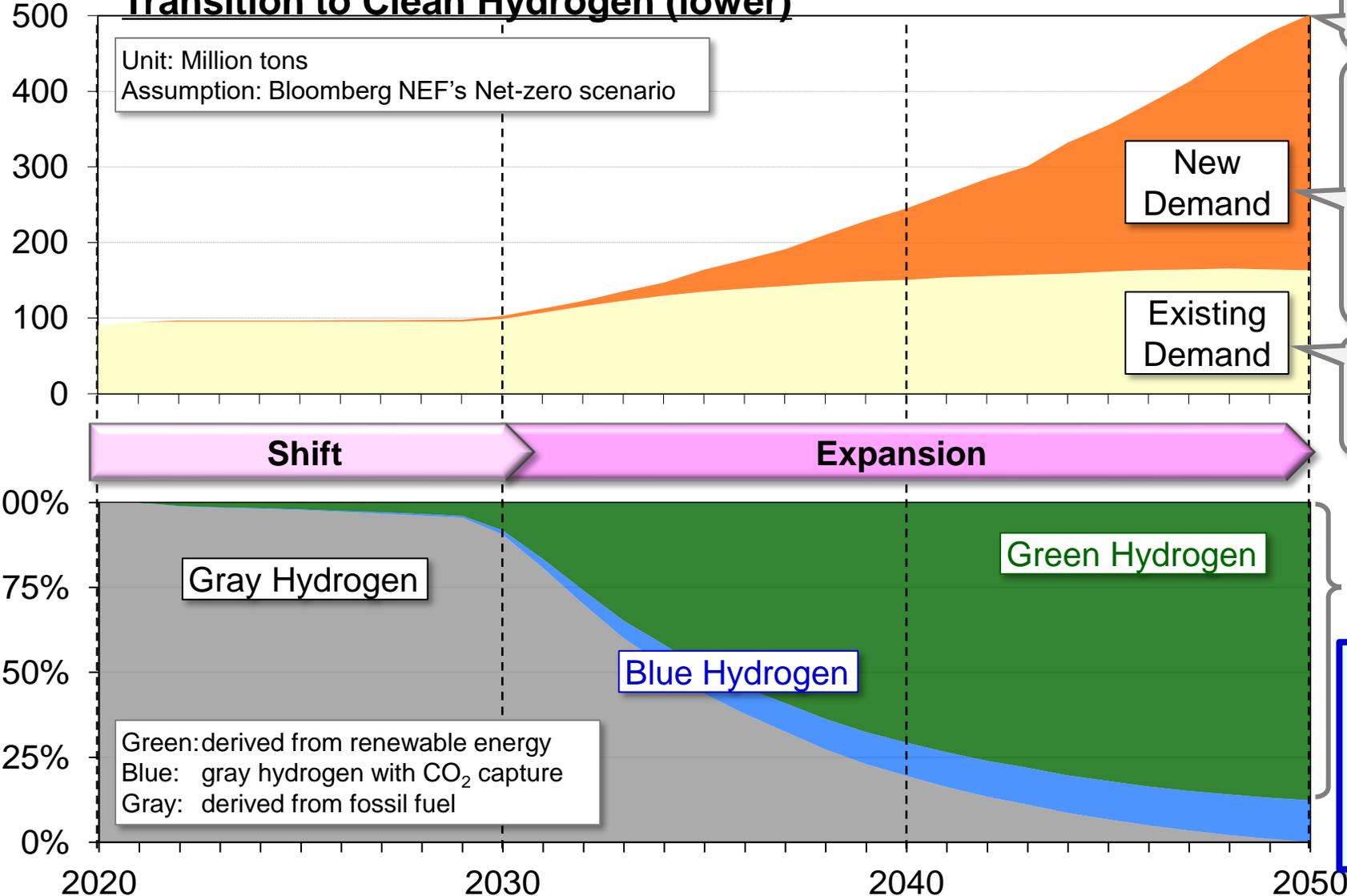
2.4 Trillion Yen
(Total of "Asia-others")

Hydrogen to be Integrated Concurrently into Global Systems Led by National Policy, Further Driving Rapid growth. The Key to Future Success is Demand Creation.

Emerging Hydrogen Markets

[Created by Toray based on Bloomberg NEF's "New Energy Outlook 2022"]

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



Demand expected to grow to **500 million tons in 2050 (5 times the current size)**

Transition to hydrogen from other energy
"Hydrogen Integration"

Industry (steel, etc.), Power generation
Buildings (residential, commercial)
Transport (commercial vehicles, etc.)

Replacement to clean hydrogen
Ammonia, methanol, refinery

Green Hydrogen to be more than 80%

Hydrogen to Enter in Expansion Period after 2030 thanks to the Positive Cycle of Scale-up and Cost Reduction
New Demand to Grow along with the Expansion of Hydrogen Integration

III

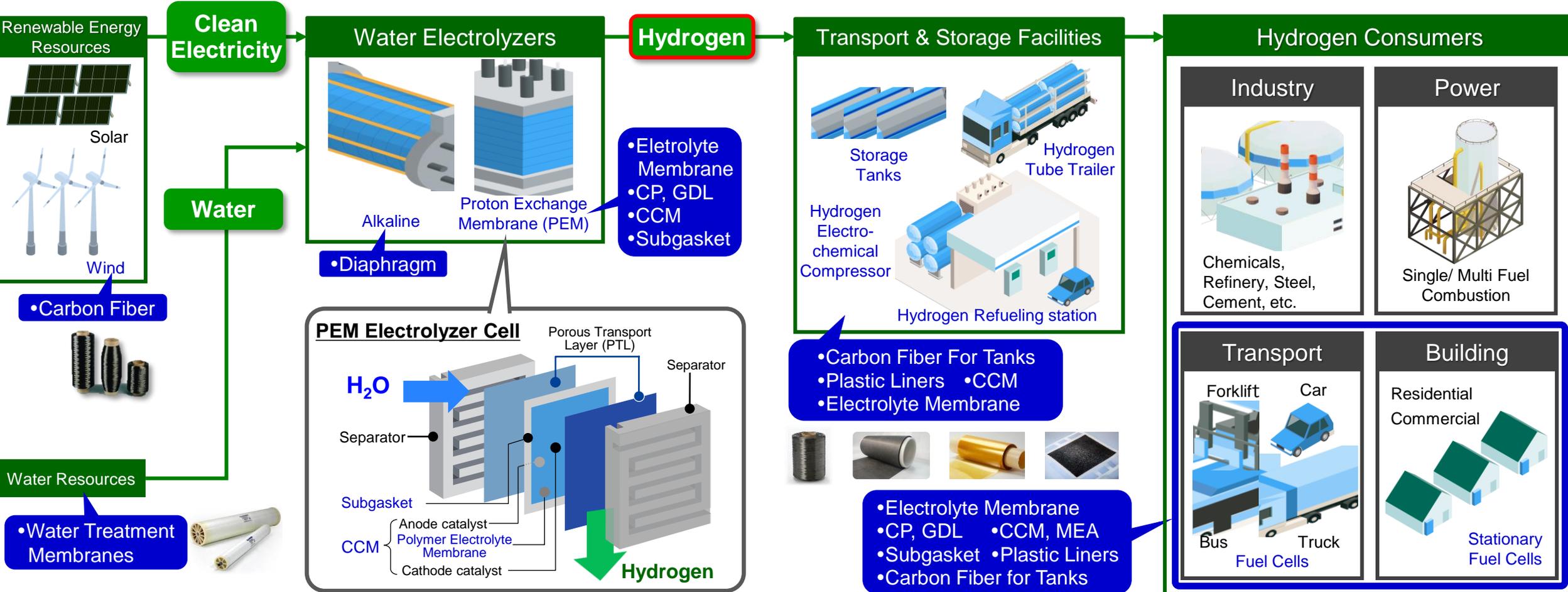
Toray Group's Hydrogen Strategy

Toray Group's Strategies for the Expansion of Hydrogen Business

Production

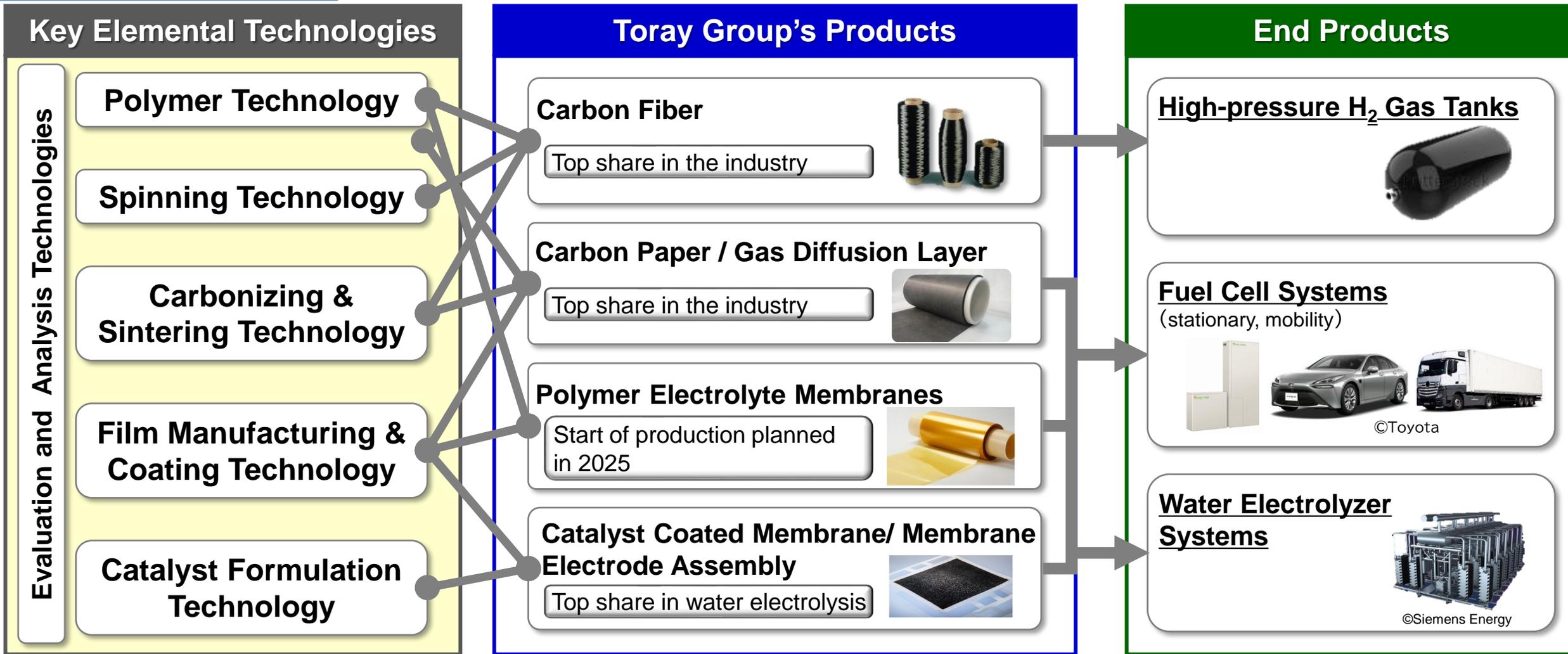
Transportation & Storage

Use



Providing Toray Group's Proprietary Advanced materials throughout the Hydrogen Supply Chain as Solutions to Realize Hydrogen Society

Overview of Hydrogen-related Materials and Technologies



Leveraging on Toray Group's Proprietary Technologies to Develop and Propose Core Materials that Support Hydrogen Society

Toray Group's History of Hydrogen-related Materials Development

Products	1990-	2000-	2010-	2020-
Carbon Fiber for High-pressure H ₂ Gas Tanks	1961- Began R&D	Development and mass production of T700S • Application to natural gas tanks	Started sales and expanded varieties of T720S • Application to hydrogen tanks	Full-scale mass production
Carbon Paper (CP) & Gas Diffusion Layer (GDL) for Electrode	1982- Began development of CP	Development of rolled-type CP / GDL	• Application to fuel cell vehicles, expansion of models	Enhance business expansion in automobiles • Introduction of mass production facilities at Ehime Plant (CP, GDL)
Hydrocarbon (HC) Electrolyte Membranes		Development for fuel cells	• Began full-scale R&D	Start of sales planned in 2025 Development for water electrolysis Start of production planned in 2025 • Partnership with Siemens Energy • Began large-scale water electrolysis project funded by the GI fund
Catalyst Coated Membranes (CCM) & Membrane Electrode Assembly (MEA)		Early 90s- Began development at each former company (Degussa, Umicore, etc.)	Development in Toray Group • Acquisition by Toray, establishment of Greenerity	Expansion of business • Began mass production • Established 3 rd plant

Promoting Development and Commercialization of Unique Advanced Materials from a Long-term Perspective

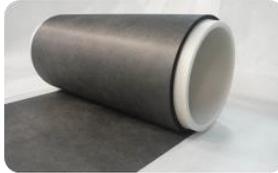
Toray Group's Strengths

Products

Carbon Fiber



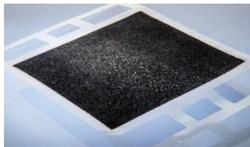
Carbon Paper/
Gas Diffusion
Layer



Hydrocarbon
Electrolyte
Membrane



Catalyst Coated Membrane/
Membrane
Electrode
Assembly



Converting Toray's Unique Technologies and Strengths into Customer Value

- High performance and reliable quality based on proven track record
- Global production and technical support system

- Design of excellent strength, conductivity, gas permeability
- Free of impurities, excellent surface quality

- Design and control of polymer and membrane structure
- Excellent gas barrier and proton conductivity

- Design and control of catalyst layer
- Ultimate pursuit of catalyst loading reduction

Value to the Customer

High-pressure Hydrogen Gas Tanks

- Lightweight
- Reliability
- Higher pressure applicability



Fuel Cell Systems

(Stationary, mobility)

- Improved fuel efficiency
- High power
- Safety
- High durability



©Toyota

Water Electrolyzer Systems

- Energy conservation
- High H₂ production rate
- Precious metal conservation
- High durability



©Siemens Energy

Aim for Sustainable Growth by Creating and Sharing Value from Customers' Perspective

Toray Group's Hydrogen-related Products (1): Film Products

Toray Group's Business Areas

PPS Films for Subgaskets

Polymerization

No.1

- World's largest capacity with plants in Japan and Korea
- Integrated to resins, films and fibers

Biaxial Orientation

Only One

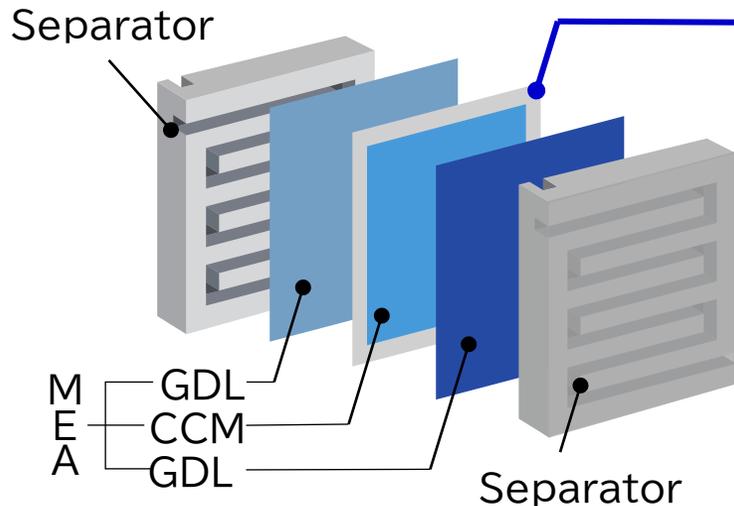
- Structural control by orientation and crystallization
- A wide variety of thickness

Converting & Final Use

Promoting collaboration

- Attachment of seal layer and cut out
- Used for water electrolysis and fuel cells

Fuel Cell



Subgasket

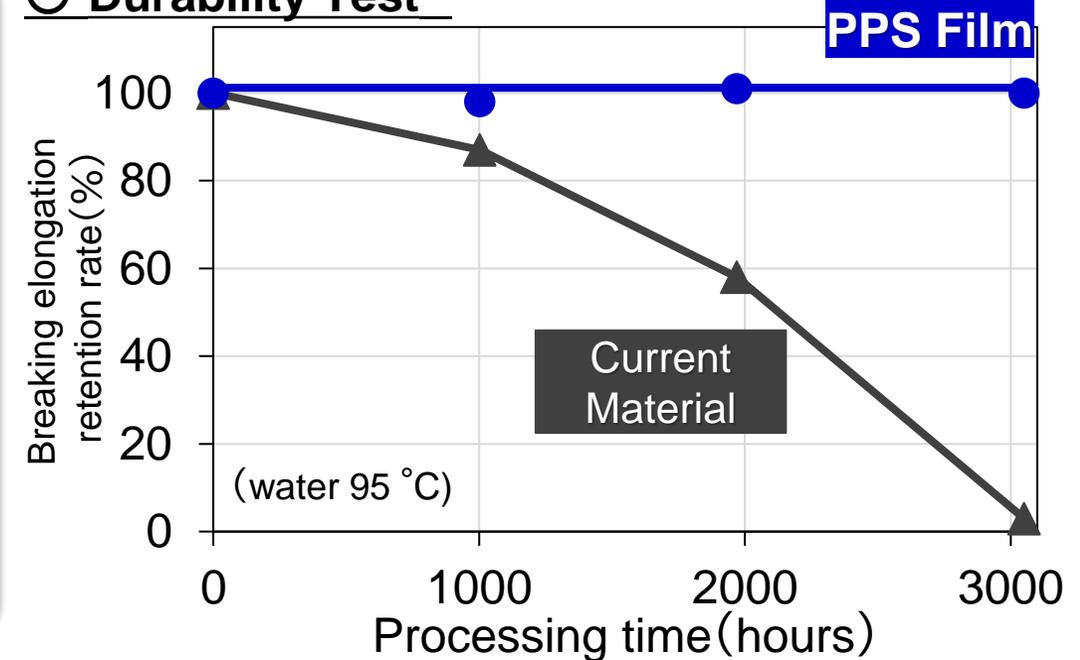


PPS Film
Torelina™



Heat resistance, Electrical Insulation
Flame retardancy, Low ionic elution
Chemical stability

Durability Test



Toray's Unique Value Chain and Characteristics such as Durability and Low Ionic Elution are Highly Evaluated and Adopted for Water Electrolysis and Fuel Cell Applications

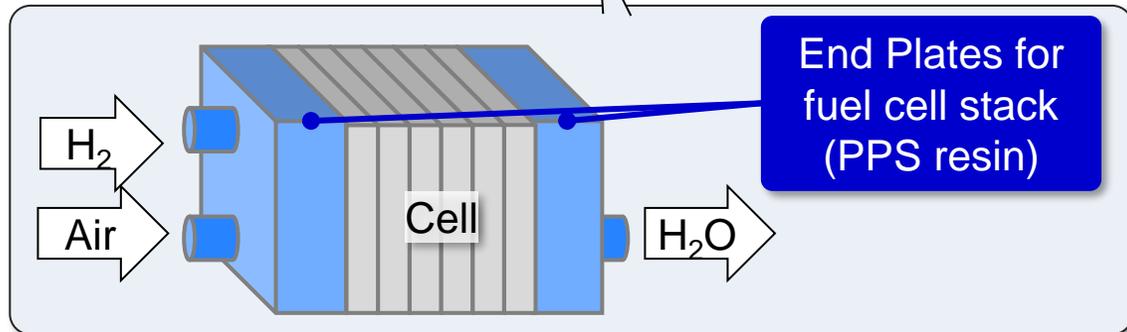
Toray Group's Hydrogen-related Products (2): Resin and Fiber & Textile Products

Molded Resin Products (PPS)



Examples of Use

Manifold	Gas-liquid separator
Piping	Stack end plates

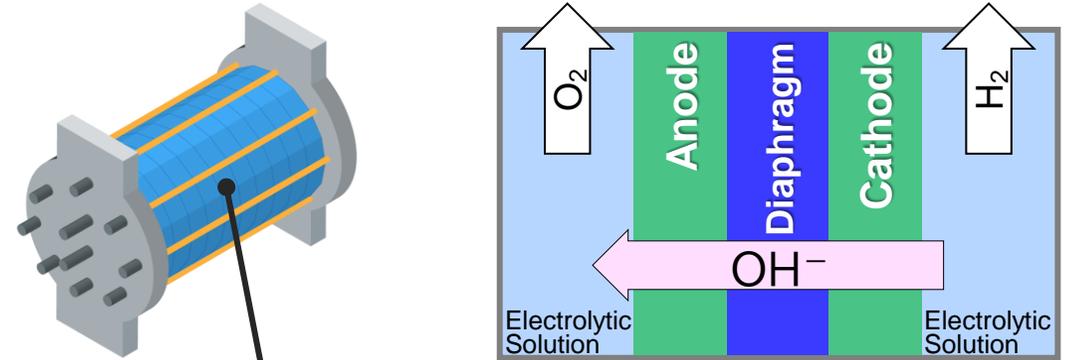


Low Ionic Elution Features Allow for Application in Balance-of-plant Components

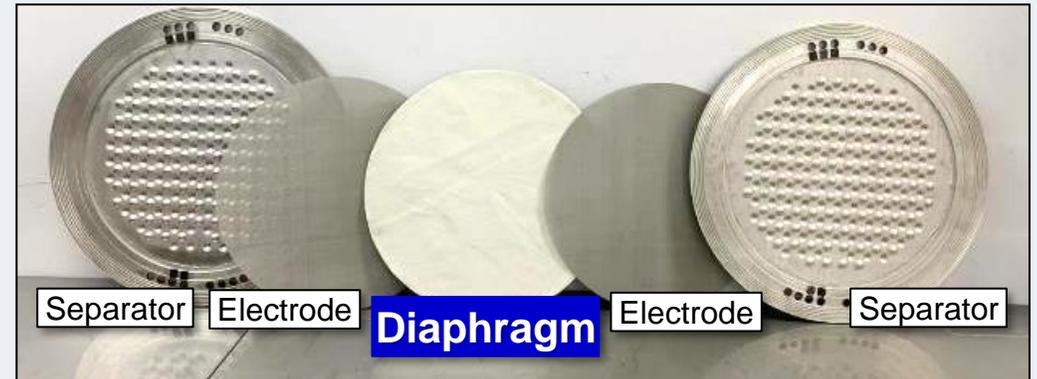
Diaphragm for Alkaline Electrolyzer

Alkaline Water Electrolyzer

Top Share in China

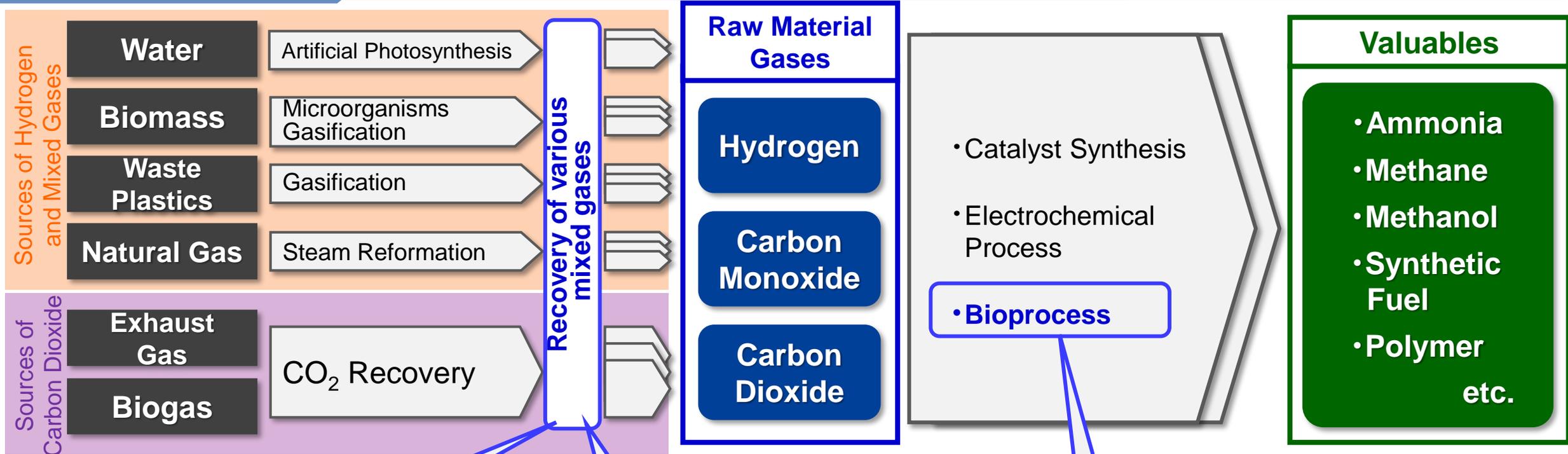


Cell Structure

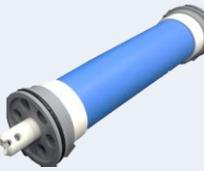


Fine Fiber Structure Allows for both Low Resistance and High Gas Barrier

Toray Group's Hydrogen-related Products (3): Carbon Recycling-related Products (R&D stage)

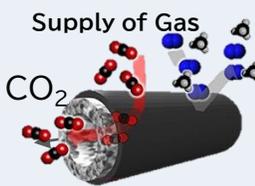


High-Efficient Hydrogen Separation Membrane



Utilize Toray's RO membrane technologies to demonstrate world's highest level of high-purity hydrogen

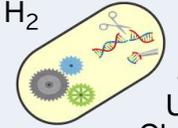
All-Carbon CO₂ Separation Membrane



Supply of Gas
CO₂

Hollow, porous carbon fiber with proprietary dual all-carbon structure demonstrates excellent heat resistance, separation efficiency, high durability, and miniaturization

Hydrogen-oxidizing bacterium to create raw materials for polymers



CO₂ & H₂ → Useful Chemicals

Selected for NEDO's Green Innovation Fund Project (joint project of six organizations)

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

Examples of Adoption and Value Demonstration

1. Carbon Fiber and Electrode Materials used for Fuel Cell Vehicles

MIRAI

CLARITY
FUEL CELL



- Adopted in over 30 million cars (cumulative) including Toyota's MIRAI, Honda's CLARITY and other FCEVs

2. CCM, MEA used for Fuel Cells and Water Electrolysis Systems

Greenerity®

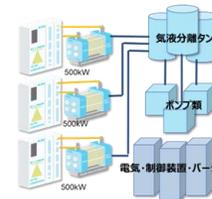
- Have participated in many demonstration projects mainly in Europe
- Leading company in fuel cell battery and water electrolysis markets

3. Large-scale Hydrogen Production Demonstrations (Hydrocarbon electrolyte membranes)

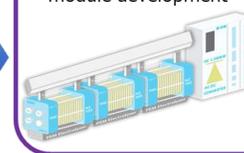
(1) Green Innovation (GI) Fund (Sep. 2021)

- Adopted by the green hydrogen project "Development of a Large-Scale Polymer Electrolyte Membrane (PEM) Water Electrolyzer, and Demonstration of Decarbonization of Heat Demand" under the GI funding program (5 years, up to 14 billion yen, 2/3 funding)

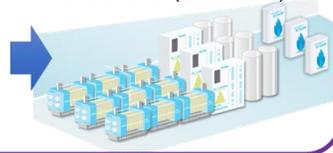
Current 1.5MW electrolyzer



Several MW standard module development



Modularized prototype demonstration (16MW class)



100MW Modularized system



(2) Partnership with Siemens Energy (same as above)

- The two companies will cooperate to promote industrial scale PEM water electrolyzers equipped with Toray's hydrocarbon electrolyte membranes

SIEMENS
energy

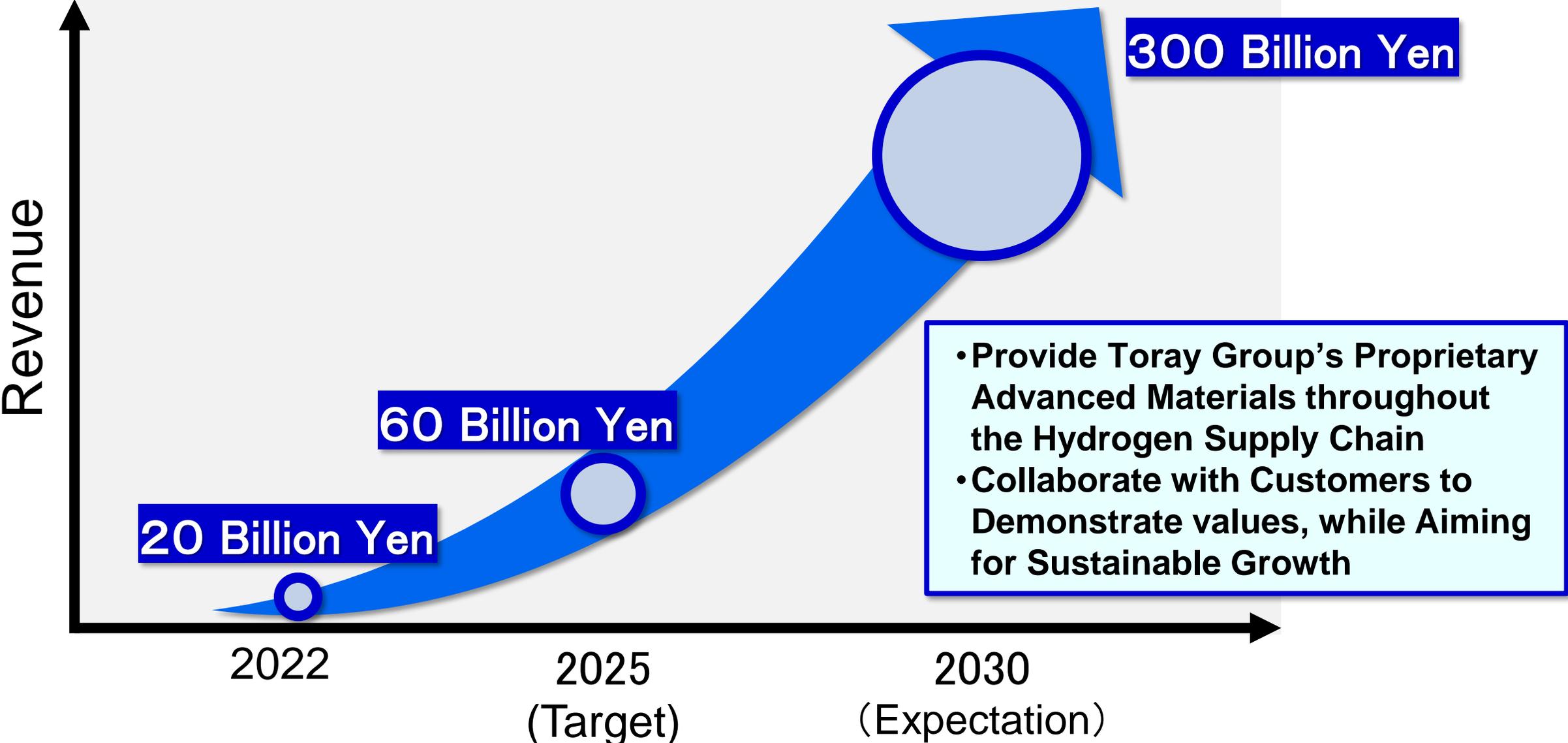
(3) Yamanashi Hydrogen Company (YHC) (Feb. 2022)

- Establishment of YHC, the first company to specialize solely in Power-to-Gas (P2G) in Japan
- Started the Yamanashi Model P2G System, utilizing hydrogen as heat source
- Started feasibility study in India (Apr. 2022) and Scotland (Nov. 2022)

YHC

Yamanashi Hydrogen Company, Inc.
(Yamanashi Pref. 50%,
Toray 25%, TEPCO 25%)

Challenge for Expansion of Hydrogen-related Businesses



Materials Change Our Lives.

Production

- Alkaline Water Electrolyzer
- PEM Water Electrolyzer
- Clean Fuel (Ammonia, Synthetic Methane, etc)

Use

- Material Handling
- Passenger Car
- Bus
- Truck
- Train
- Ship
- Aviation
- Special Purpose Vehicle
- Stationary Fuel Cell

**Toray Group's Advanced Materials
Contribute to Bringing about
Hydrogen Society**

- Carbon Fiber for Tanks
- Carbon Paper (CP)
- Gas Diffusion Layer (GDL)
- Diaphragms
- Hydrocarbon (HC) Electrolyte Membranes
- Catalyst Coated Membrane (CCM)
- Membrane Electrode Assembly (MEA)
- Plastic Liner
- Subgasket
- Engineering Plastic & Molded Products
- Powder for 3D Printing & Modelling Service
- Hydrogen Separation Membrane
- CO₂ Separation Membranes
- Hydrogen-oxidizing Bacteria
- Equipment Engineering
- Analytical Service

Transportation & Storage

- High Pressure Hydrogen Tank
- Electrochemical Compressor
- Hydrogen Tube Trailer
- Hydrogen Refueling Station

Descriptions of predicted business results, projections, and business contained in this material are based on predictive forecasts of the future business environment made at the present time.

The material in this presentation is not a guarantee of the Company's future business performance.

'TORAY'

Innovation by Chemistry