

**TORAY**

Innovation by Chemistry

Toray IR Seminar

Toray Group's Initiatives Toward Realization of a Hydrogen Society

# Initiatives of HS Division

September 5, 2023

Kozo Takahashi

General Manager, HS Division

Toray Industries, Inc.

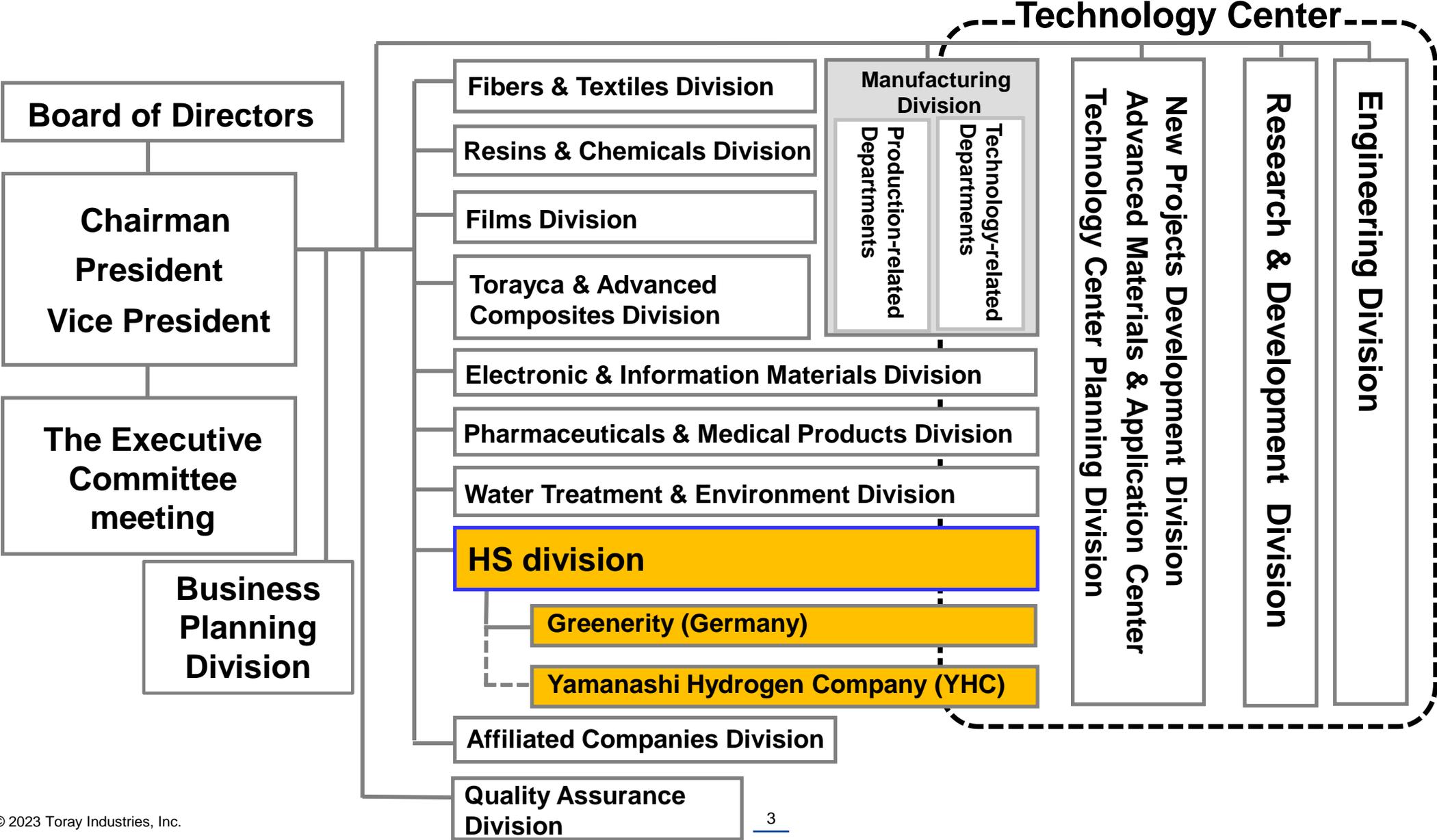


- I. About HS Division**
- II. Toray's Hydrocarbon (HC) Electrolyte Membrane and Initiatives for Water Electrolysis Application**

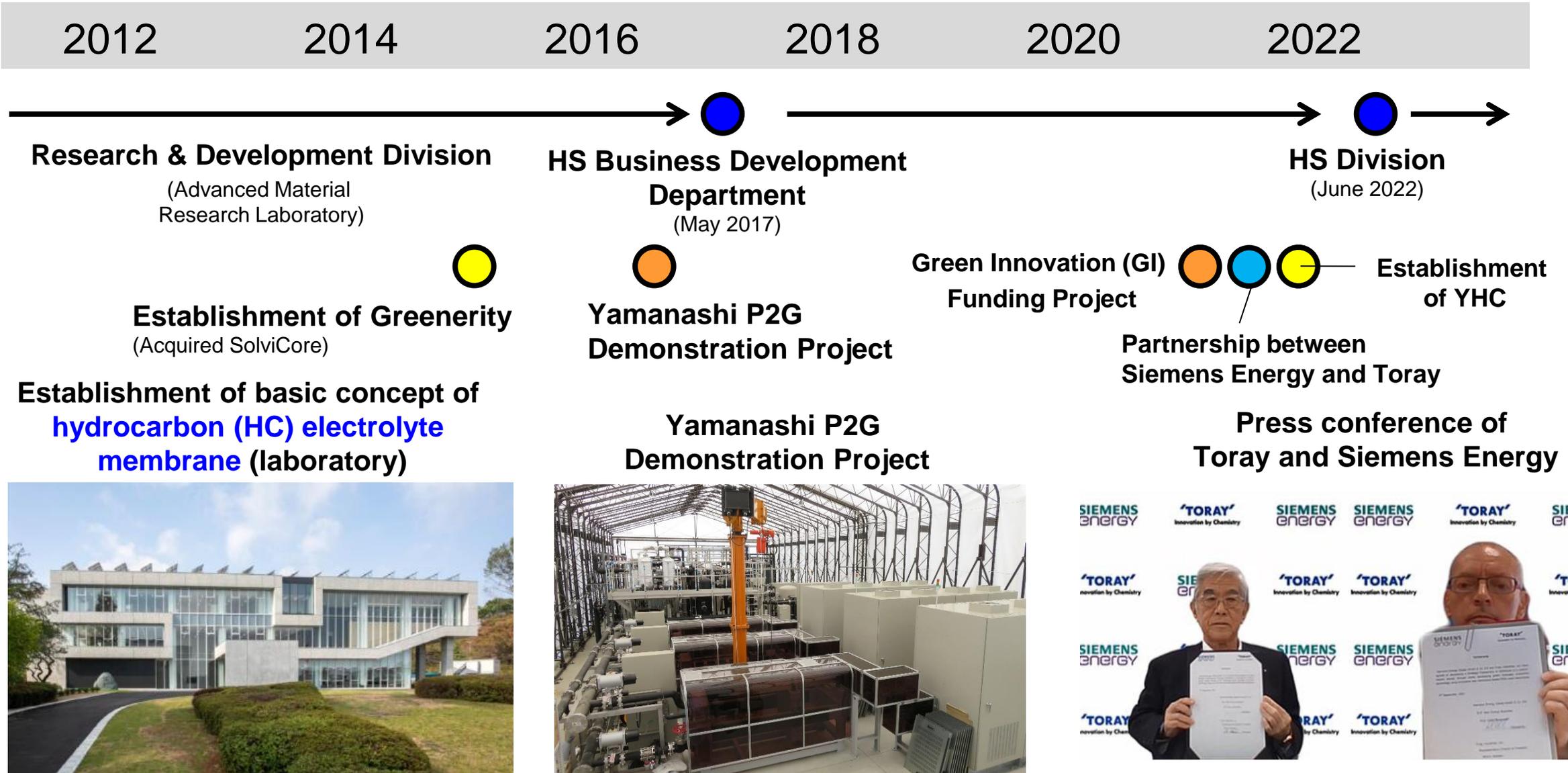
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# About HS Division

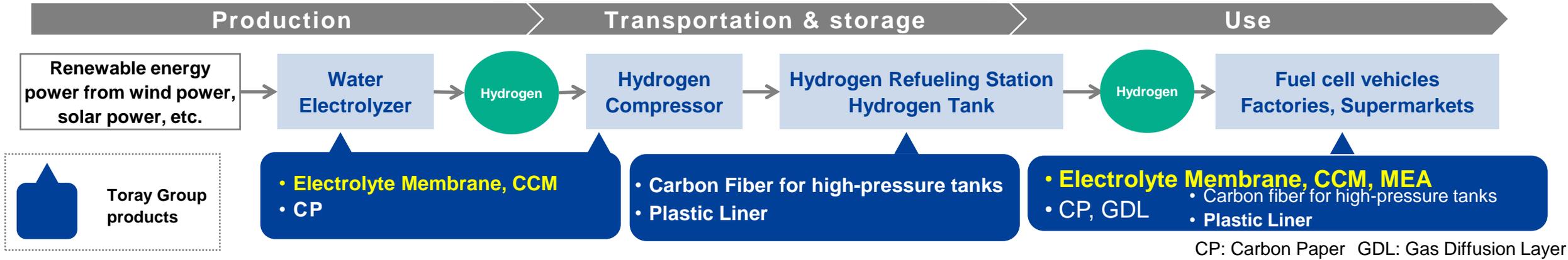
# About HS Division



# History Leading to the Establishment of HS Division



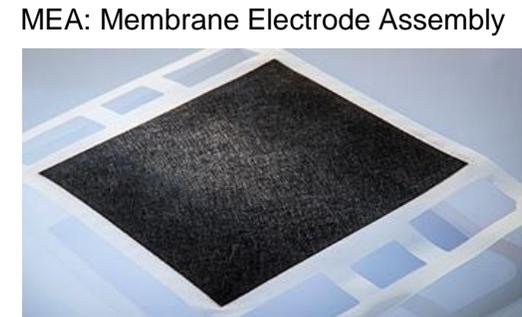
# Products of HS Division



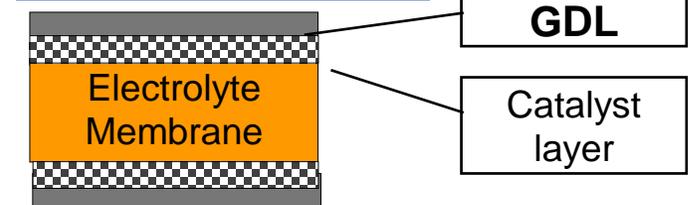
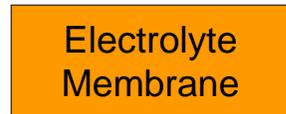
**Electrolyte Membrane**



**CCM**



**MEA**



Production and sales of electrolyte membrane, CCM, and MEA that are key components of water electrolyzer, hydrogen compressor, and fuel cell



# **Toray's Hydrocarbon (HC) Electrolyte Membrane and Initiatives for Water Electrolysis Application**

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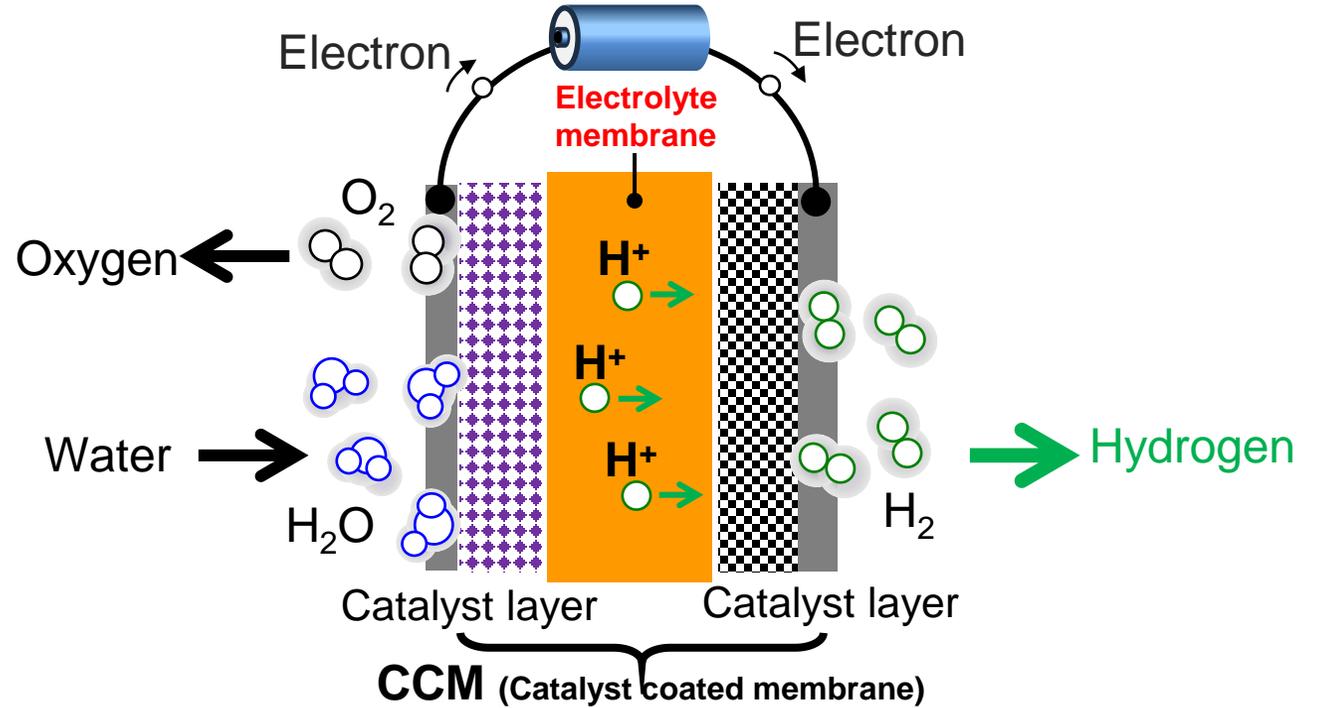
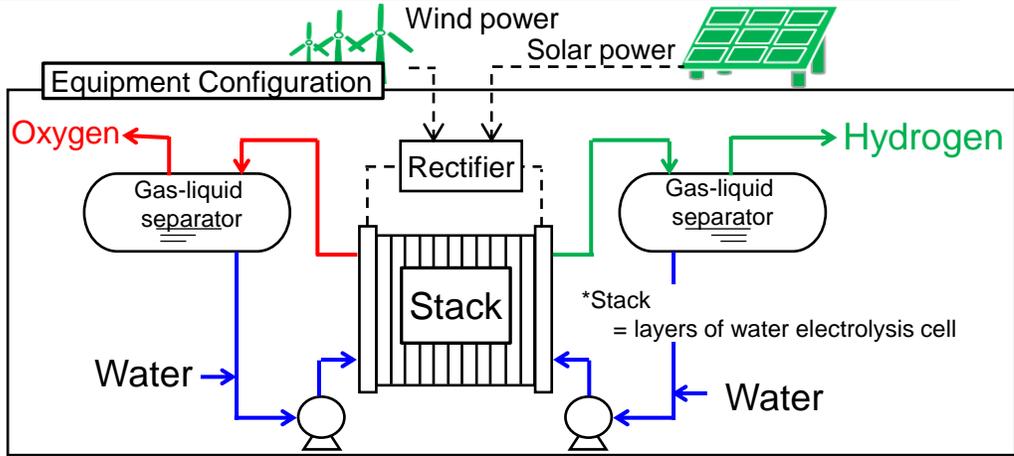
# Applications of Electrolyte Membrane

	Production	Transportation & Storage	Use
	Water electrolysis	Hydrogen compression	Fuel cell
Structure	<p>Oxygen electrode      Hydrogen electrode</p>	<p>Low pressure electrode      High pressure electrode</p>	<p>Hydrogen electrode      Air electrode</p>
Principle	Produce hydrogen from water by electricity $\text{H}_2\text{O} \rightarrow \text{H}_2 + \frac{1}{2} \text{O}_2$	Compress hydrogen by electricity $\text{H}_2 (0.1\text{MPa}) \rightarrow \text{H}_2 (80\text{MPa})$	Power generation using hydrogen and air $\text{H}_2 + \frac{1}{2} \text{O}_2 \rightarrow \text{H}_2\text{O}$
Value of HC electrolyte membrane	Highly efficient hydrogen production, utilizing low gas permeability	High-pressure hydrogen compression, utilizing low gas permeability	High power density by taking advantage of high temperature drivability

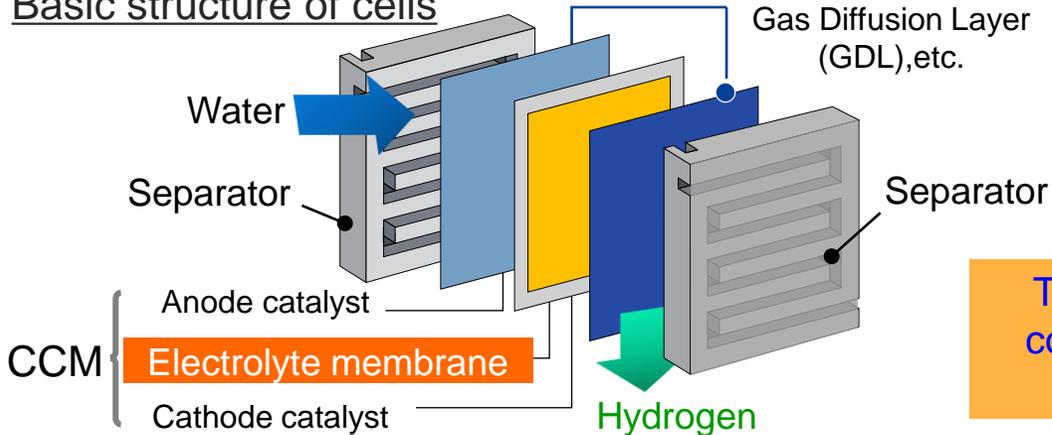
Electrolyte membrane is the key material common for water electrolysis, hydrogen compression, and fuel cell

# Principle of Green Hydrogen Production by Water Electrolysis and Function of Electrolyte Membrane

Polymer electrolyte membrane (PEM) water electrolysis



Basic structure of cells

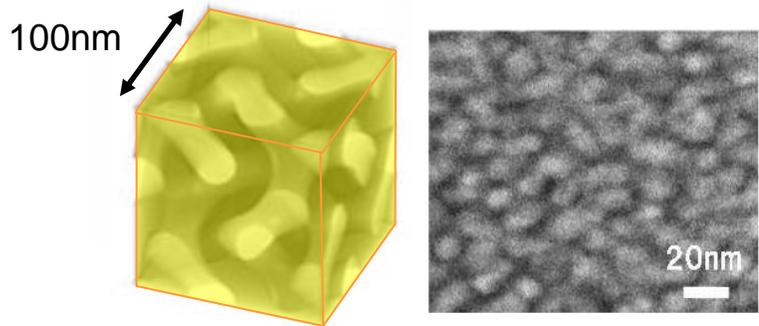


The higher the hydrogen ion (H<sup>+</sup>) conductivity, the more hydrogen is produced per electrode area

The lower the gas permeability, the less backflow of product gas, and the higher efficiency, operating rate, and safety

Electrolyte membranes affect the performance of water electrolyzers

# Toray's Proprietary Hydrocarbon (HC) Electrolyte Membrane



Phase separation size 5-10 nm

## Characteristics of "HC electrolyte membrane"

(In comparison to conventional membranes)

High proton conductivity

(2-fold)

Low gas permeability

(1/3)

High strength

(4-fold)

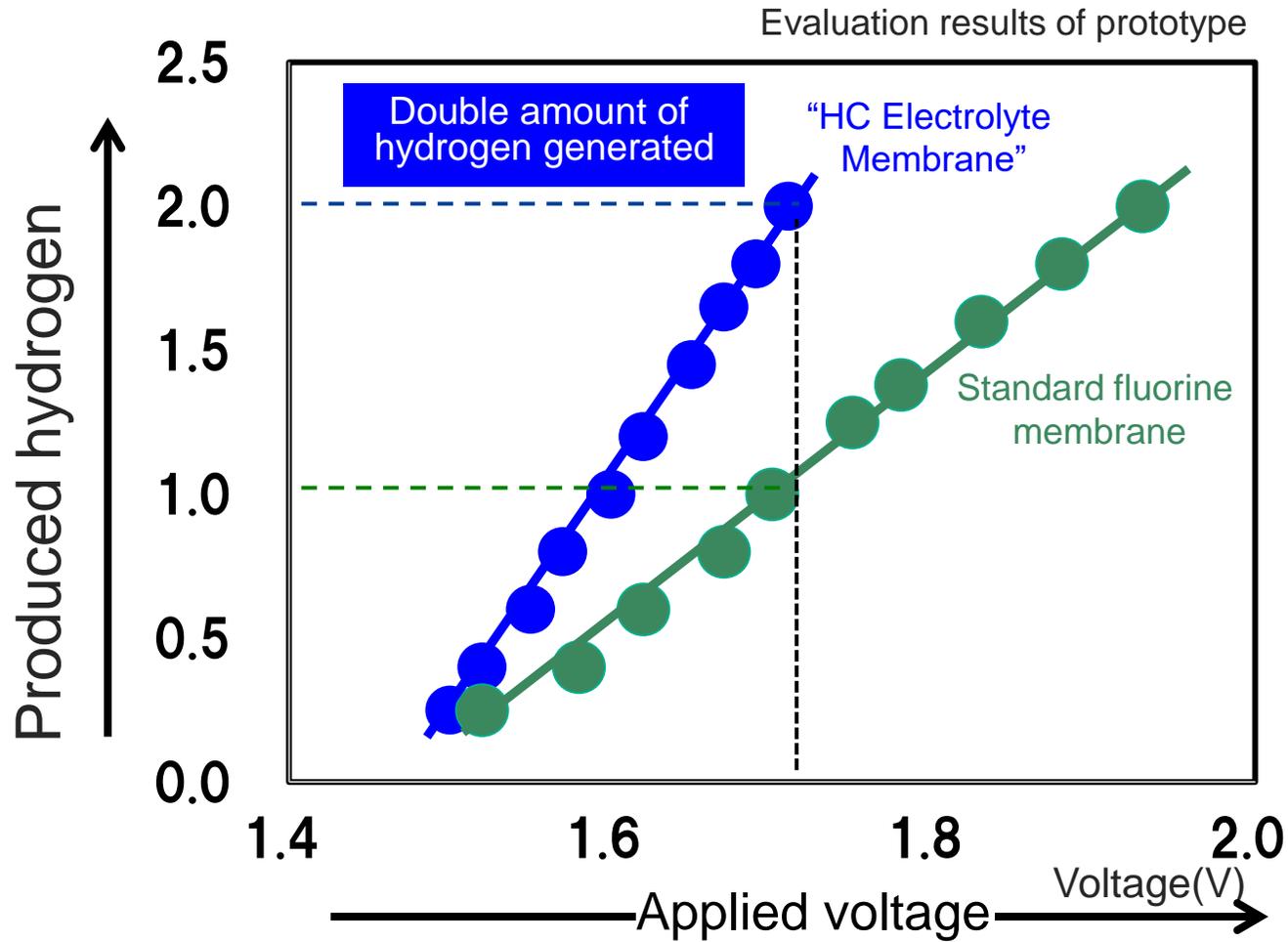
Heat-resisting property  $>150^{\circ}\text{C}$

(+60 $^{\circ}\text{C}$ )

HC electrolyte membrane is the outcome of Toray's proprietary polymer design, precise polymerization technology, and nano-level structure control technology.

# Value of “HC Electrolyte Membrane”

Current density(A/cm<sup>2</sup>)



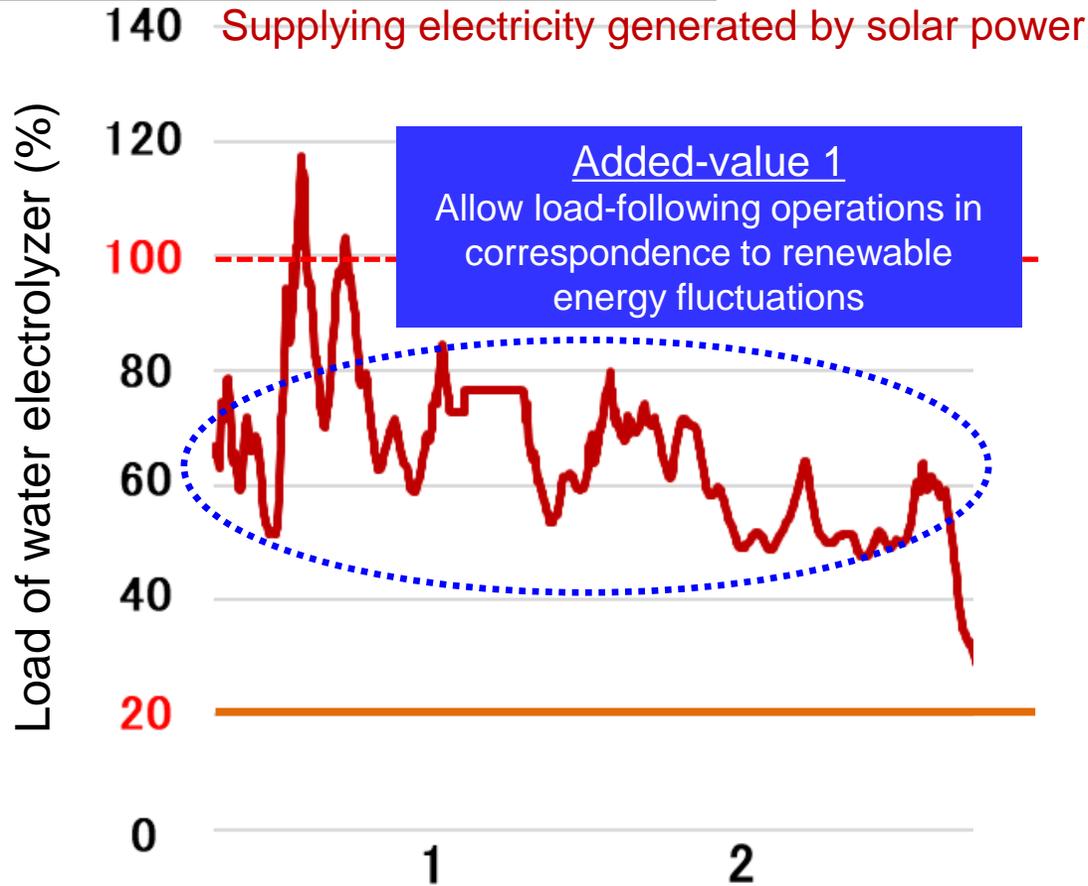
Toray’s “HC electrolyte membrane”

Requirements		Standard fluorine membrane	Toray’s HC Electrolyte Membrane	
Efficiency	%	76	→ 87	High efficiency
High current density	A/cm <sup>2</sup>	1	→ 2	Reduction of stack cost
Low gas permeability	a.u.	1	→ 1/3	High safety, high operating rate

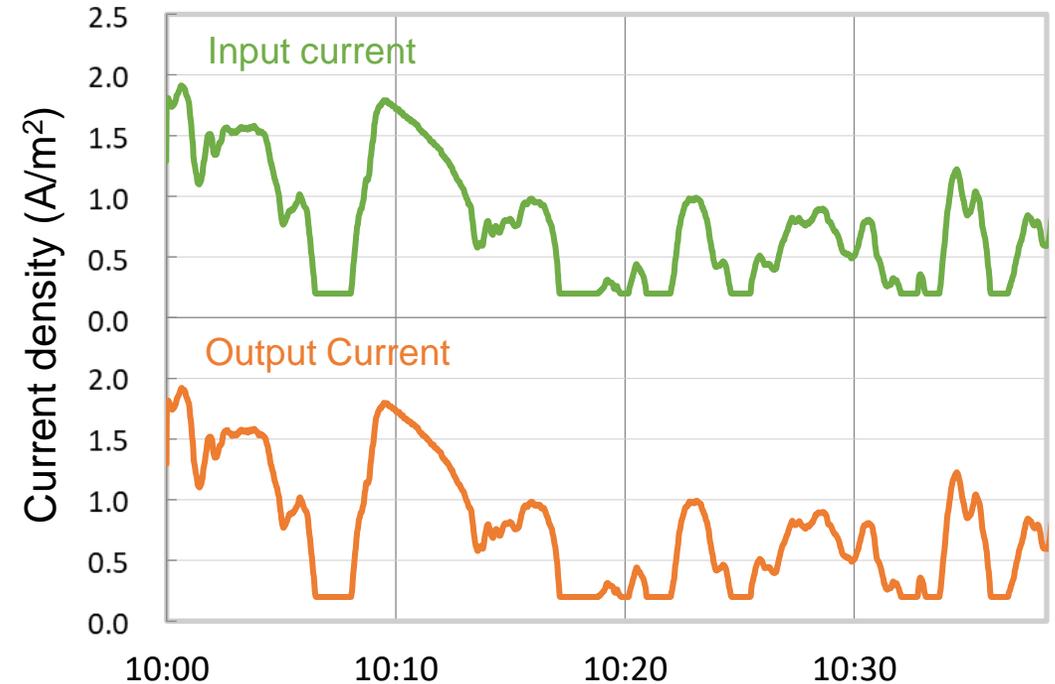
Expected to contribute to significant reduction of green hydrogen costs by dramatically increasing the efficiency of water electrolysis

# Value of “HC Electrolyte Membrane”

Image of the demonstration site in Komekurayama, Yamanashi prefecture



Results of load response and followability test at NEDO P2G demonstration project (25kW stack)



Confirmed high followability performance for considerably fluctuating power loads (response and followability)

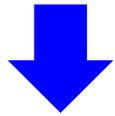
Expected to contribute to cost reduction, improvement of operation rate, and improvement of adaptability to renewable energy sources of water electrolyzer

# Value of “HC Electrolysis Membrane”

At low load, generated gas flows back and mixes  
⇒ Operation stops

Characteristics of PEM type

Electrolyte membrane prevents backflow of gas, minimum load line is low and restart is quick



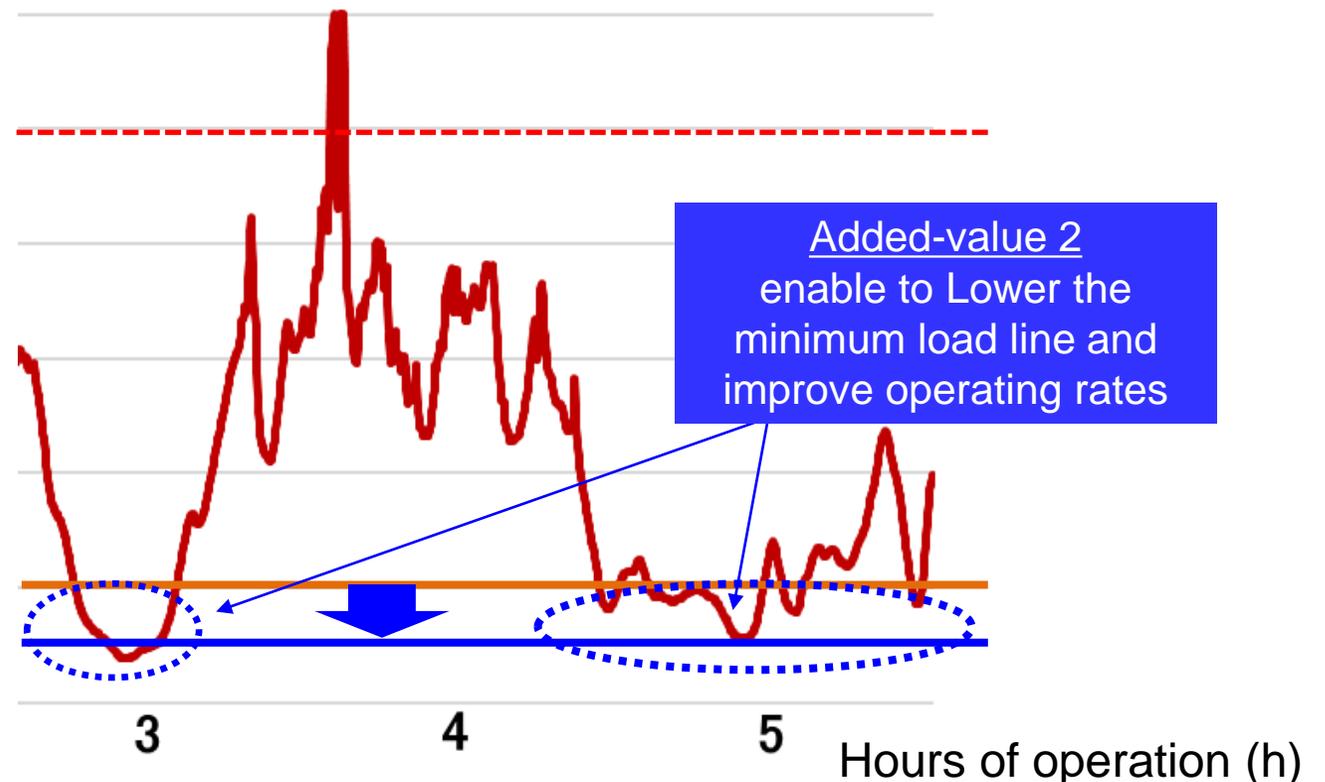
Characteristics of HC Electrolysis Membrane

With low gas permeability, there is little gas backflow, leading to lower minimum load line and higher operating rate

Image of the demonstration site in Yonekurayama, Yamanashi prefecture

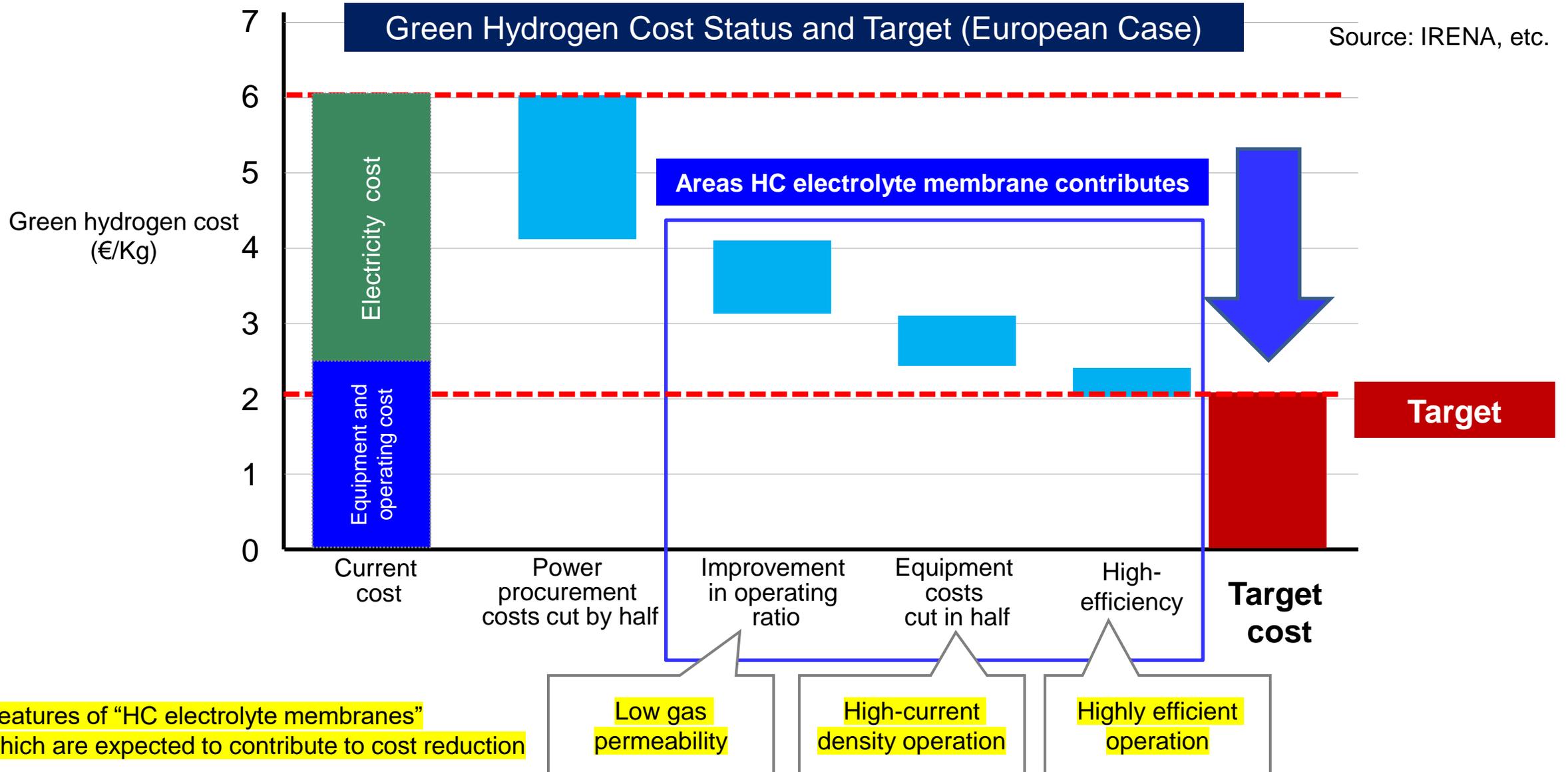
This graph is created by Toray, in reference to materials from IRENA, etc.

Supplying electricity generated by solar power



Expected to contribute to cost reduction, improvement of operation rate, and improvement of adaptability to renewable energy sources of water electrolyzer

# Potential for Contribution to Reduction of Cost for Green Hydrogen



# Japan's First P2G Company, Yamanashi Hydrogen Company (YHC)

Full view



Water electrolysis plant



Transport trailer

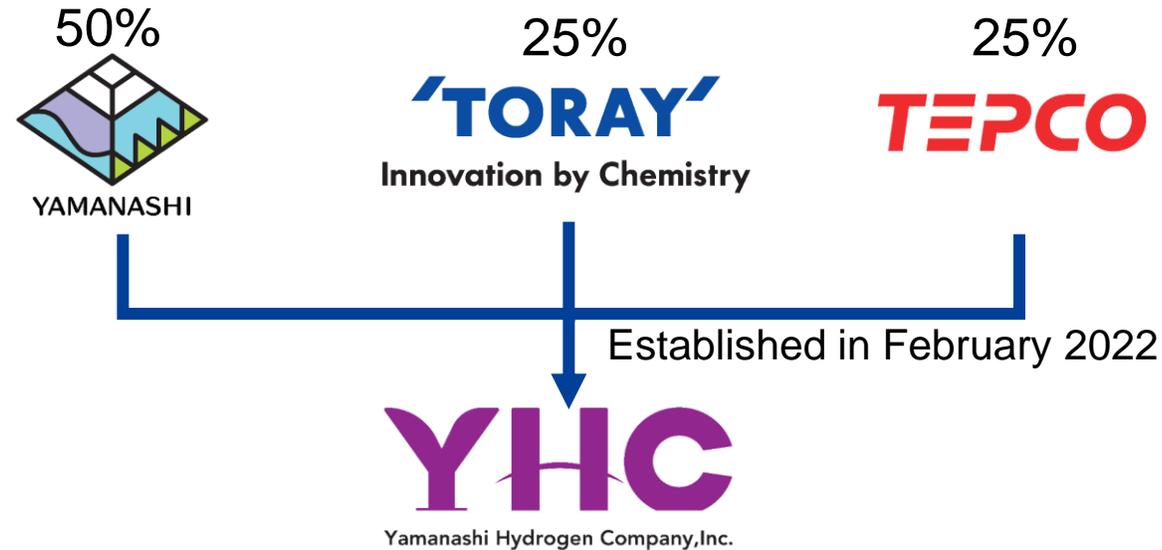


Hydrogen boilers



## < Aim of Establishment >

- Propose solution for “hydrogen production by water electrolysis” to customers
- Develop a framework for hydrogen energy service business in the future
- Keep up-to-date on technologies and trends by implementing up to final stage of the operation



YHC will work on the following;

- Business on hydrogen production, supply, sales and energy services
- Technology development and demonstration on hydrogen production, storage, and transportation
- Business on spreading and expanding hydrogen utilization

# Examples Of Development and Demonstrations through National Projects and Partnerships

1.5MW



**Commissioned Project by NEDO**

“Technology Development for the Realization of the Hydrogen society Technology Development of Systems using Renewable Energy-derived Hydrogen P2G system technology development aiming at building a CO2-free hydrogen society”

**Yamanashi Pref. Public Government Enterprise Bureau  
Tokyo Electric Power Company Holdings, Inc.  
(Cooperating with Hitachi Zosen Corporation)**

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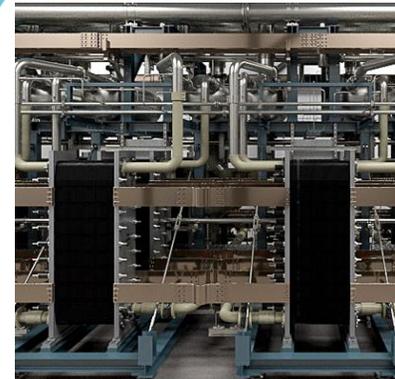
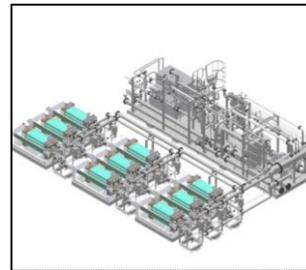
Over 10MW (currently implementing or planning)



Suntory Minami Alps Hakushu Water Plant  
Suntory Hakushu Distillery



**SUNTORY**



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**Green Innovation Funding Program**

“Energy transition and off-taker application development using Industrial scale P2G system towards carbon neutrality”

**Yamanashi Pref. Public Government Enterprise Bureau, Hitachi Zosen Corporation, Siemens Energy  
(Cooperating with Suntory)**



Maruti Suzuki's Manesar Plant



**NEDO's**

**International Demonstration Project**

“Hydrogen Technology Demonstration Requirements Conformity Study for Efficient Thermal Operation at Indian Factories”

**YHC, Suzuki Motor Corporation**

**TORAY**

# Strategic Alliance and Collaborative Development

シーメンス・エナジーと東レ パートナーシップを締結

PEM型水電解を用いたグリーン水素製造により、カーボンニュートラル社会実現に貢献

SIEMENS  
energy

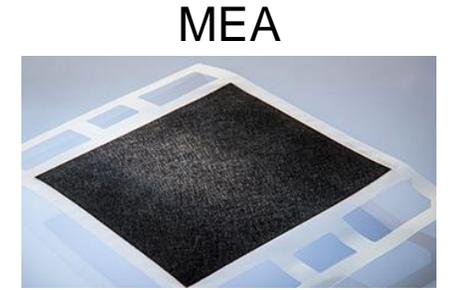
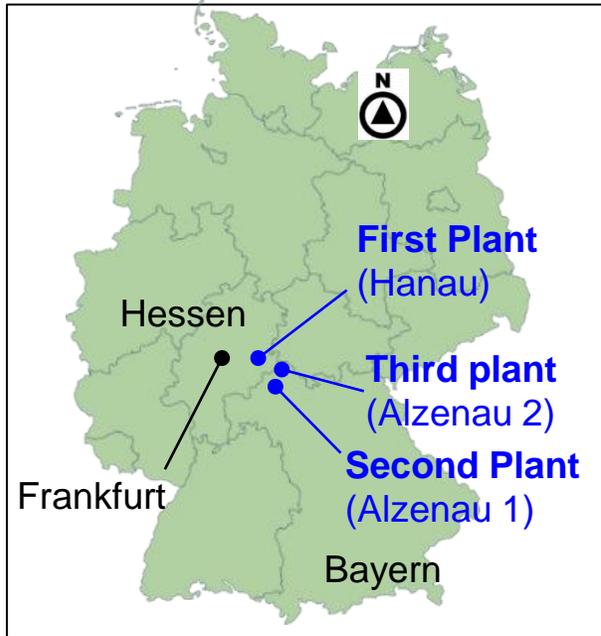


東レ「炭化水素系電解質膜」を実装した、  
革新的なシーメンス・エナジー水電解装置「Elyzer」を実現し、  
グローバルなグリーン水素サプライチェーンの構築を目指します。

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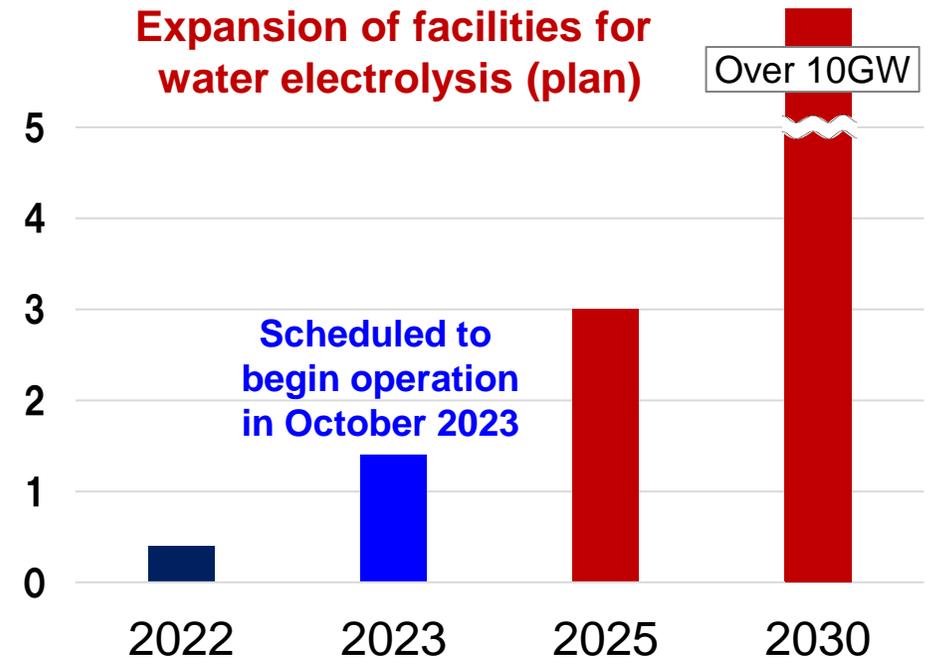
# Greenerity



Leading company of water electrolysis and fuel cell applications

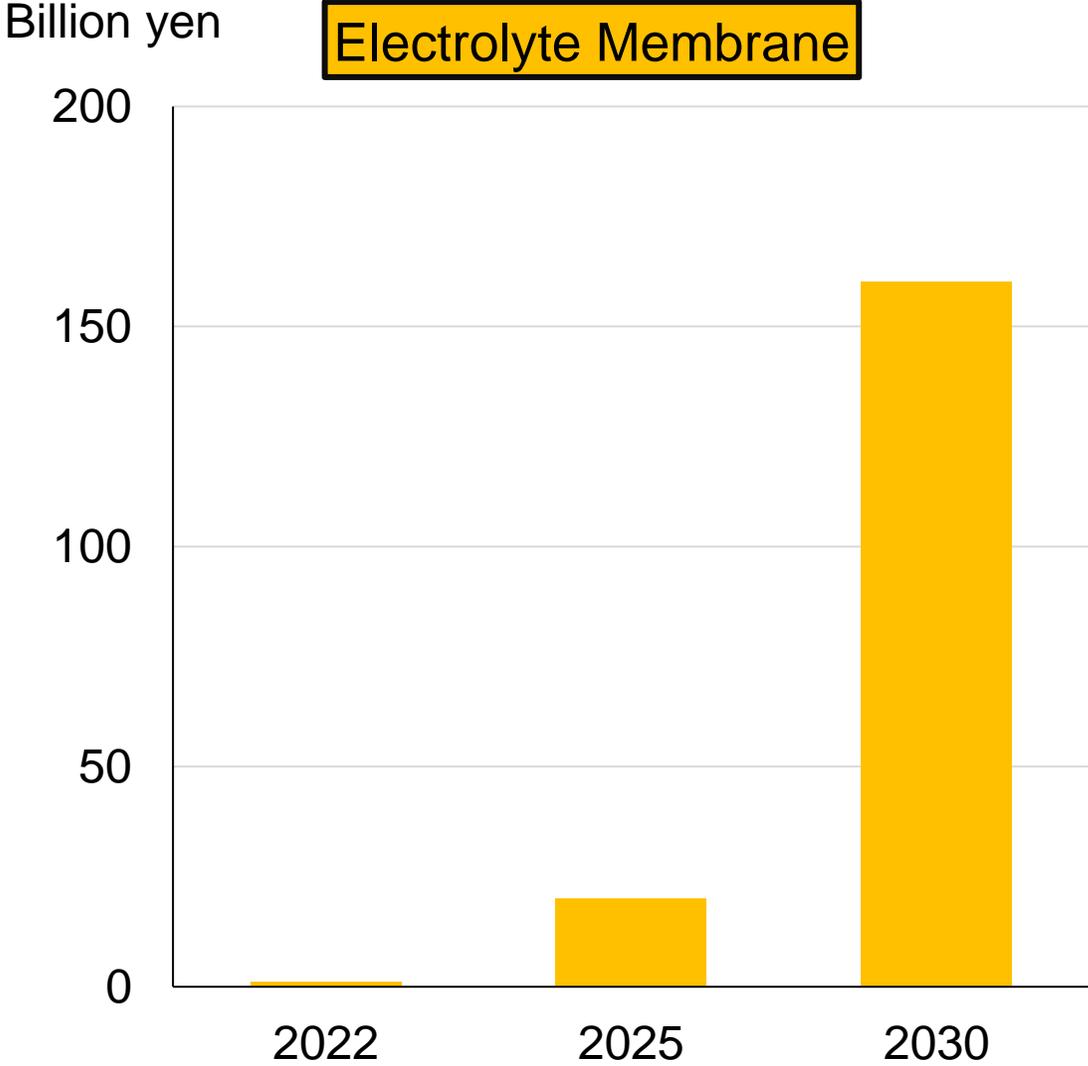
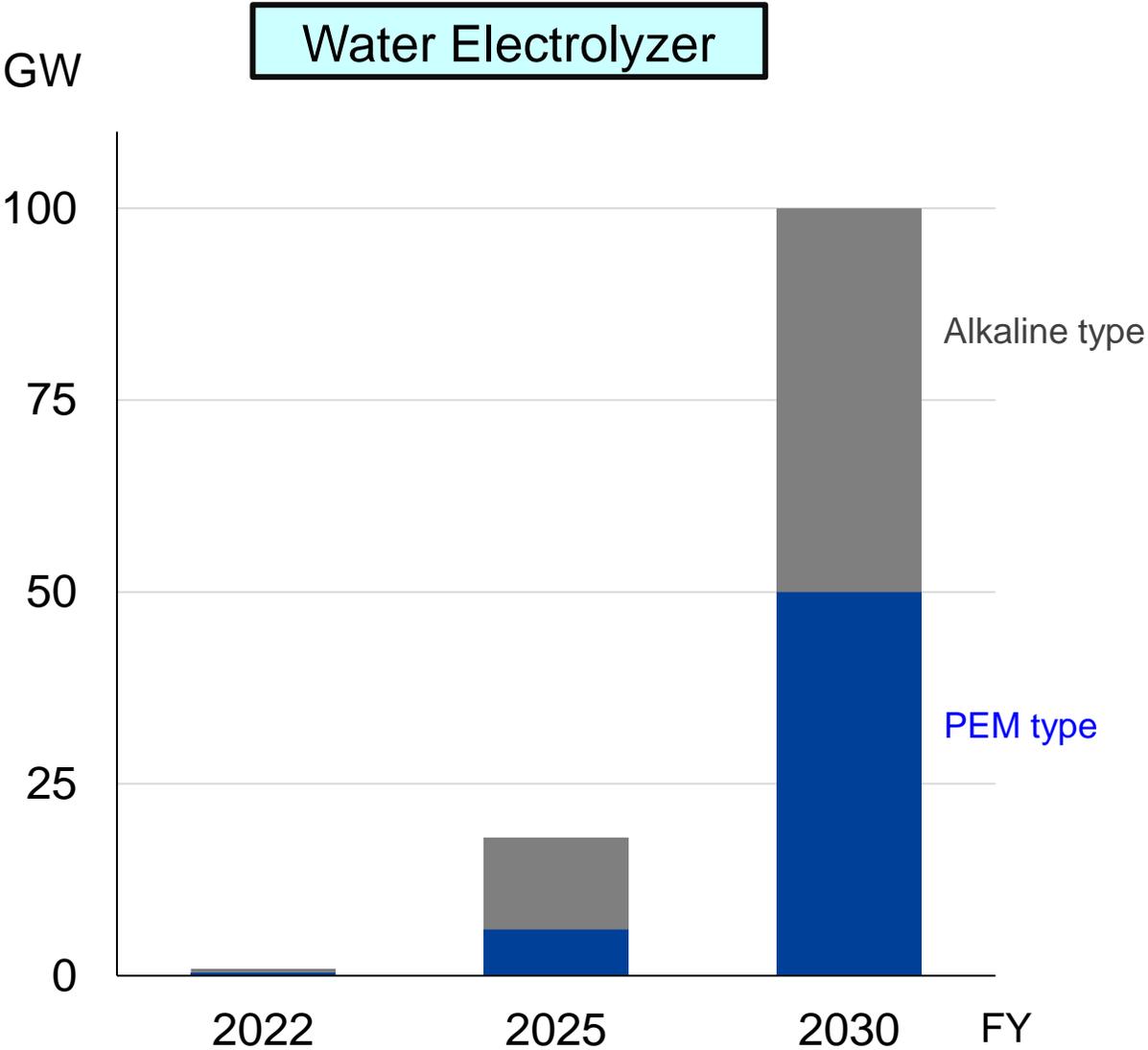
1. Company name: Greenerity GmbH
2. Established: July 2015
3. Headquarters: Bayern, Germany
4. Production sites: 3 plants in Hanau and Alzenau
5. Number of employees: 190 (as of the end of August 2023)

Capacity of CCM (GW)  
Water electrolyzer equivalent

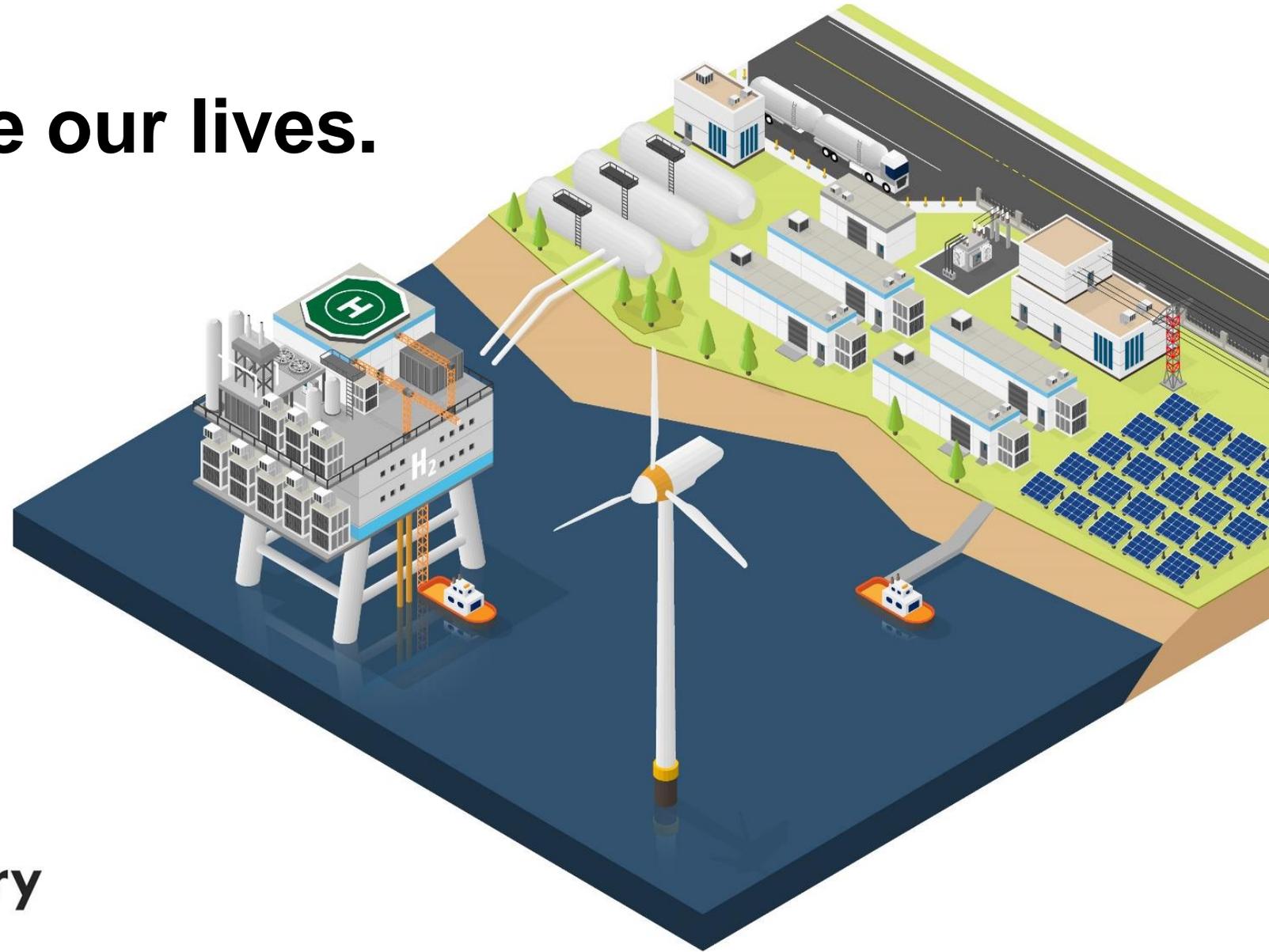


# Market Outlook for Water Electrolyzer and Electrolyte Membrane

Estimated by Toray



# Materials change our lives.



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Descriptions of predicted business results, projections and business plans contained in this material are based on assumptions and forecasts regarding the future business environment, made at the time of publication.

Information provided in this material does not constitute any guarantee concerning the Toray Group's future performance.

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