EBARA IR Day 2022

<Session 2>

EBARA Group-wide Co-Creation Initiatives for Hydrogen Supply Chain

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Looking ahead,
going beyond expectations
Ahead Beyond

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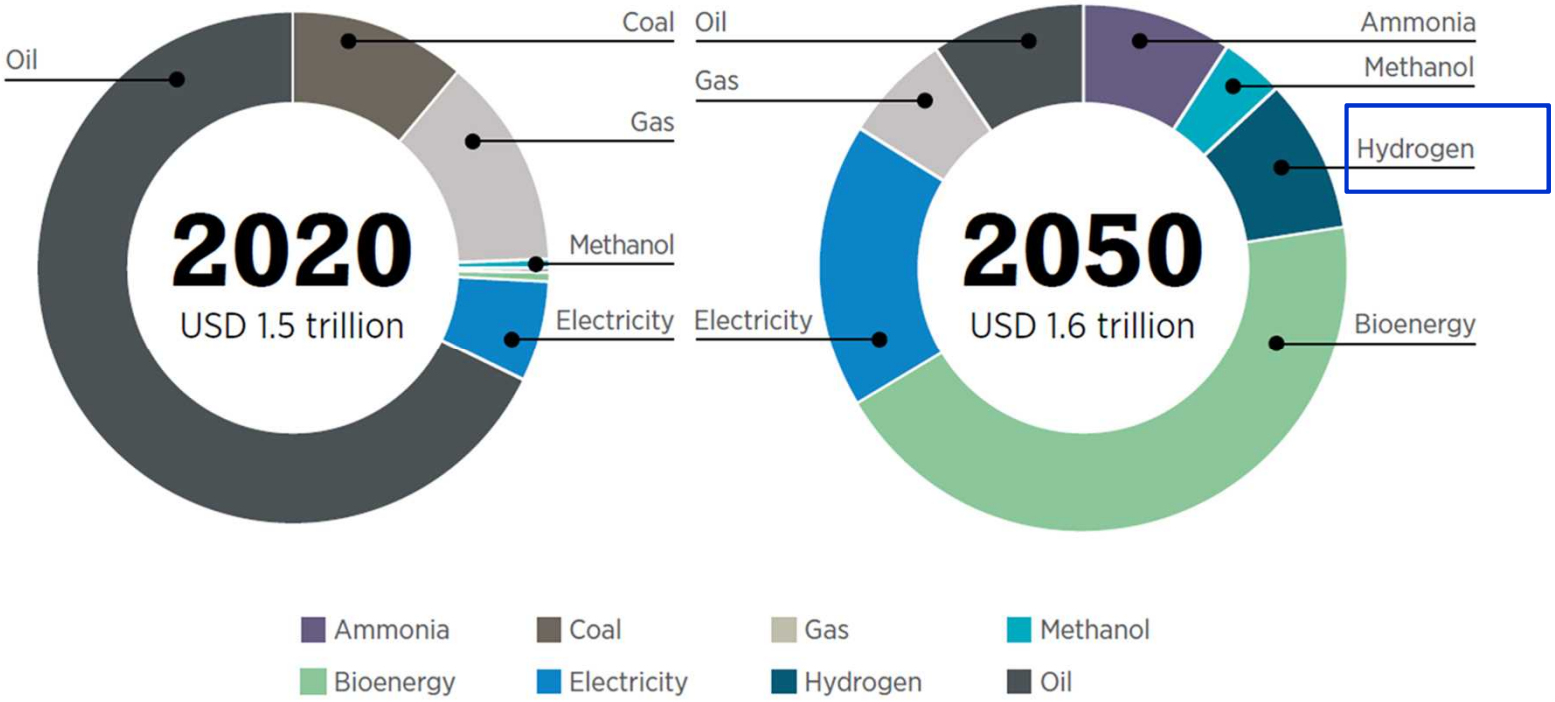
1. Hydrogen Market: Future and Trend

- **10% in 2050: Hydrogen** portion of **global energy trade volumes**
  - IRENA(The International Renewable Energy Agency) forecast
- **200 trillion yen in 2050**: **global hydrogen market size**
- **Europe, the United States and China**: countries accelerating decarbonization and energy security
- Possible significant change in existing energy value chain by hydrogen



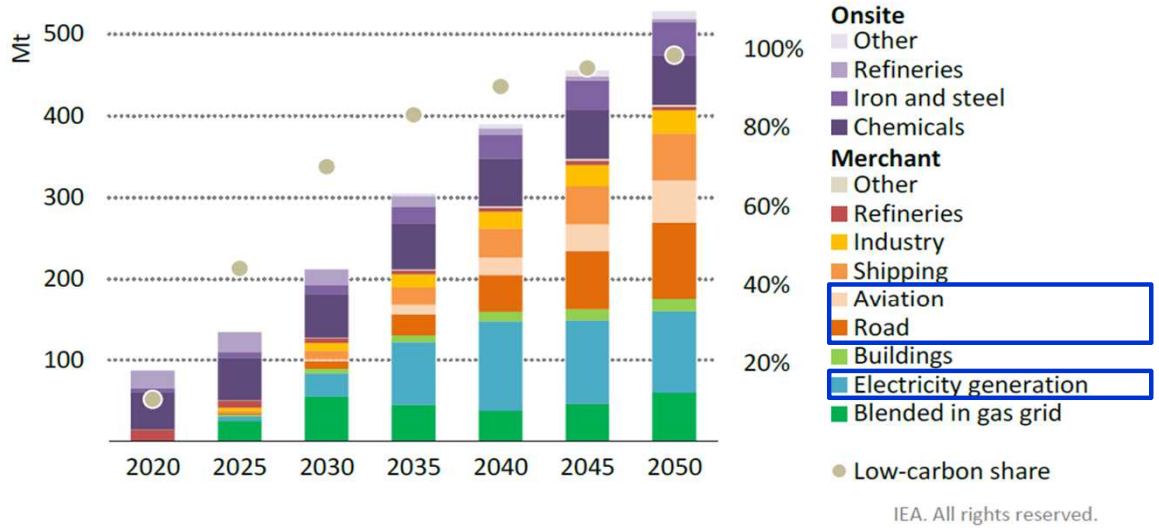
Citation: IRENA (2022), Geopolitics of the Energy Transformation: The Hydrogen Factor, International Renewable Energy Agency, Abu Dhabi. ISBN: 978-92-9260-370-0

1. Hydrogen Market: Future and Trend

- **500 Mt in 2050 (x5 2020 level)**: **global hydrogen consumption**
  - IEA (The International Energy Agency) forecast
- **x10 power generation sector** From 2030 to 2050
- **x40 transportation sector** (large commercial vehicles) From 2030 to 2050
- Diversified utilization; Steel-making, Ships and aircraft
- **60%**: hydrogen derived from renewable energy (green)

  40%: coal or natural gas + CCS (blue)

Figure 2.19 ▷ Global hydrogen and hydrogen-based fuel use in the NZE



The initial focus for hydrogen is to convert existing uses to low-carbon hydrogen; hydrogen and hydrogen-based fuels then expand across all end-uses

Note: Includes hydrogen and hydrogen contained in ammonia and synthetic fuels.

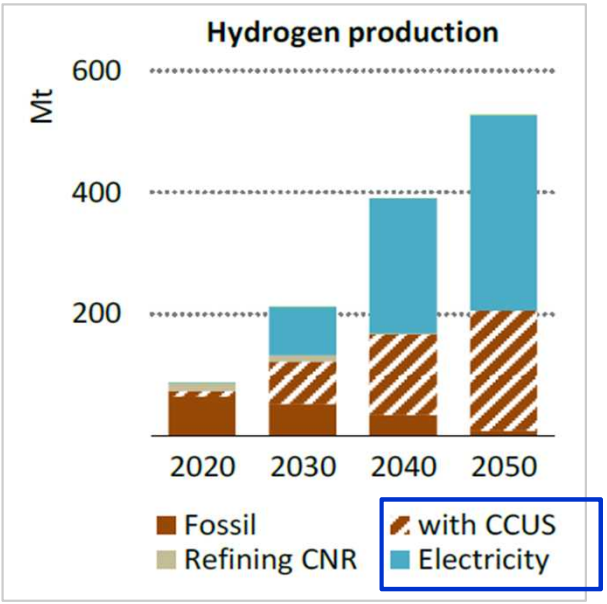


Figure 3.8 ▷ Global production of hydrogen by fuel and hydrogen demand by sector in the NZE

Source: IEA (2021), Net Zero by 2050, IEA, Paris, https://www.iea.org/reports/net-zero-by-2050. All rights reserved.

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2. EBARA's Hydrogen Business: "Production, Transport and Use"

■ August 2021: Launched a corporate project

kicked off a group-wide effort for the creation and co-creation as the fourth pillar

[Production] Licensed out the technology of producing hydrogen by gasification of plastic waste (Ebara Ube Process or EUP)
Developed turquoise hydrogen technology

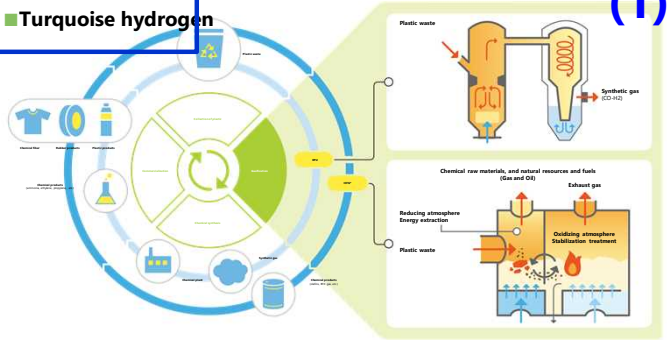
[Transport] Developed pumps handling -253°C liquid hydrogen for liquid transportation
hydrogen compressors for gas transportation
canned motor pumps (leak-free structure) for liquid ammonia transportation

[Use] Developed liquid pumps for hydrogen refueling stations
pumps to supply rocket engine fuel

Production
Attempt to produce carbon-free hydrogen.

■ Gasification and hydrogen production from plastic waste, etc.
EUP*1(Ebara Ube Process)
ICEG*2: (Internally Circulating Fluidized Bed Gasification System)

(5)
■**Turquoise hydrogen**



■**Production of hydrogen from surplus electricity of waste incineration plants**
■**Technology of compression and storage of supercritical CO_2**

*1: EUP is a registered trademark of UBE Corporation in Japan.
*2: ICFG ® is a registered trademark of EBARA Environmental Plant Co., Ltd. in Japan.

Transport
Provide technology indispensable to all modes of transport.

(4)
■ **Technology for compressing and transferring hydrogen**
Compressor

(1)
■ **Technology for carrying cryogenic liquid hydrogen**
Pump Participating in NEDO's Development of Technologies for Realizing a Hydrogen Society project with demonstration of technology planned in 2022.

■ **Ammonia transferring technology as a hydrogen carrier**


Conceptual presentation of liquid hydrogen pumps


Conceptual presentation of leak-free ammonia pumps


Conceptual presentation of hydrogen compressors.

Use
Promote every usage of hydrogen ranging from everyday life to industry.

(2)
■ **Technology for large-scale hydrogen power generation**

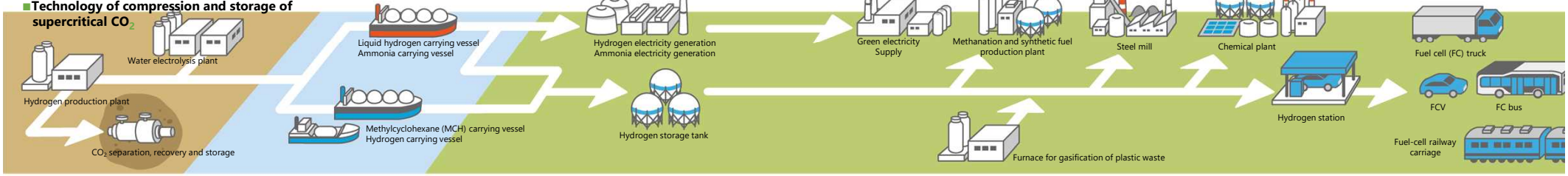
(3)
■ **Technology for hydrogen refueling stations**
■ **Technology of rocket engine fuel supply pumps**
Pumps, etc.

■**Technology of hydrogen-fired absorption chiller-heaters**
■**Technology of hydrogen aircraft fuel pumps**

■**Technology of completely leak-free ammonia transfer**

Since 2019, EBARA has developed liquid hydrogen pumps by deploying LNG cryogenic pump technology as a project sponsored by the New Energy and Industrial Technology Development Organization (NEDO). As for future development, we will continue to develop the system in order to contribute to the demonstration for commercial use, scheduled for around 2025, and commercialization*, scheduled for around 2030, of hydrogen power generation and an international hydrogen supply chain.
* In accordance with the strategic roadmap for hydrogen and fuel cells by the Ministry of Economy, Trade and Industry (announced in March 2019).


Hydrogen-driven aircraft



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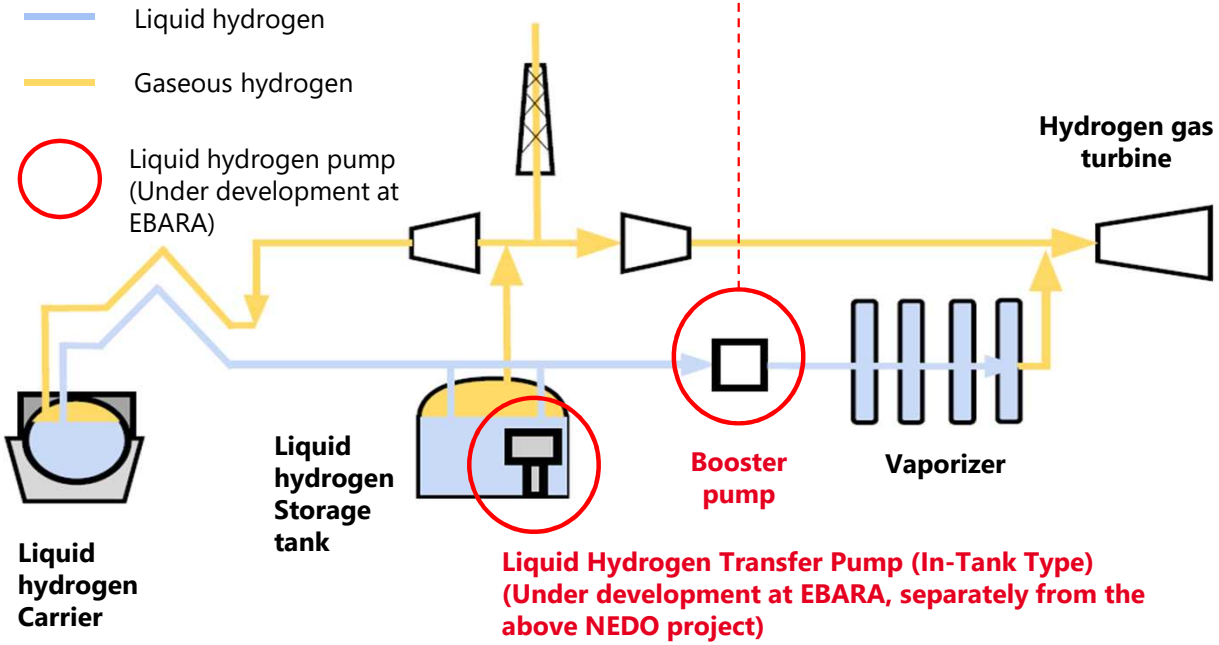
3. EBARA's Technologies and Competitive Advantages "Transport and Use" (Liquid Hydrogen Pumps)

(1) The world's first "Liquid Hydrogen Fuel Supply Pump" indispensable for hydrogen-powered gas turbines

- Under development as a project sponsored by the New Energy and Industrial Technology Development Organization (NEDO) (since 2019).
- Conducted an LNG test (-162℃) at Elliott facility in the United States (in February)
  *The measured performance well matched the designed one.
- An actual liquid hydrogen test(-253℃) is scheduled at the JAXA Noshiro Rocket Testing Center.

Flow chart of the process from receiving liquid hydrogen to supplying fuel hydrogen for power generation



Liquid hydrogen fuel supply pump

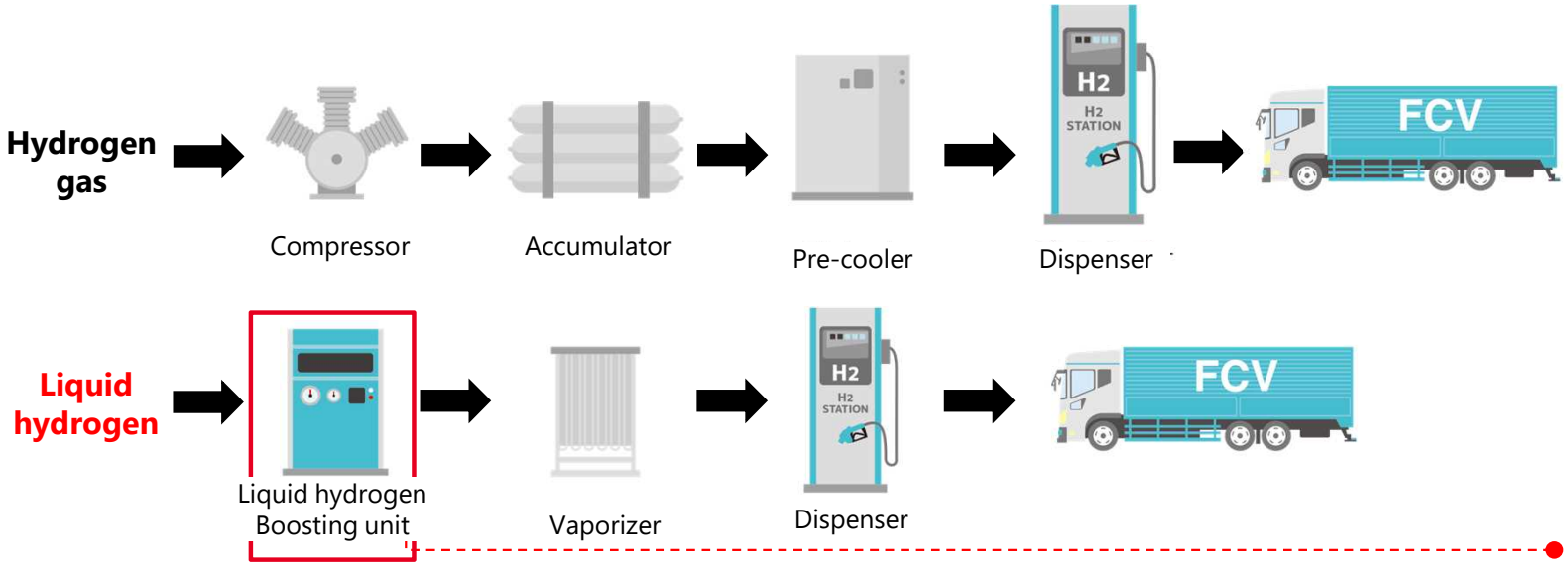
3. EBARA's Technologies and Competitive Advantages "Transport and Use" (Liquid Hydrogen Pumps)

(2) "Highly Efficient Liquid Hydrogen Plunger Pump" expected to be used in hydrogen refueling stations for large and commercial vehicles

- Developed liquid Hydrogen plunger pumps (reciprocating) and tested components (in November 2021).
- From 2022 to 2023: A test scheduled by using actual liquid hydrogen.

Market needs

- Hydrogen refueling stations market: North America, the EU, China and Japan.
  (Example) Several thousands of units each in North America and China in 2030
- Since Liquid Hydrogen type has the following advantages against gas compressors, it is more suitable for large mobility
  - space-saving, continuous filling, short filling time, and energy-saving.



Liquid hydrogen plunger pump

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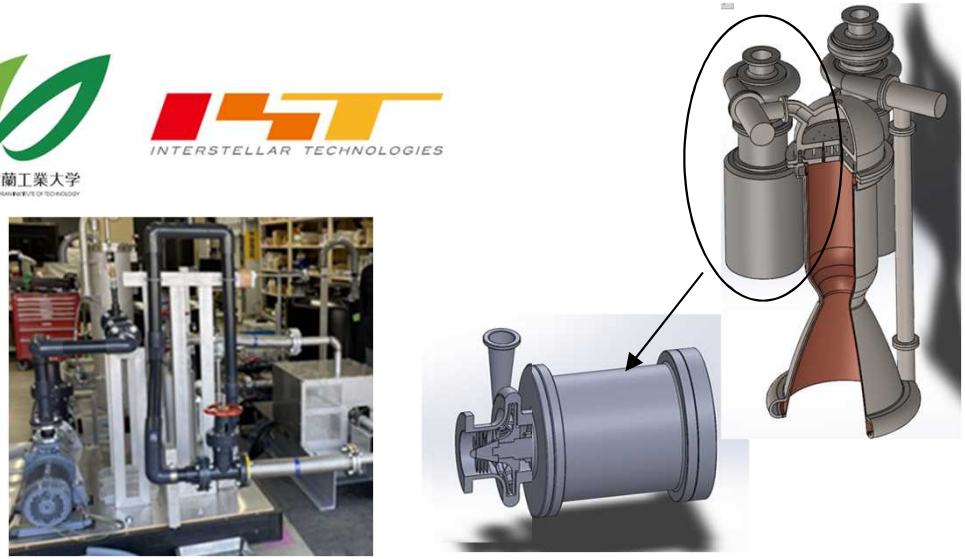
3. EBARA's Technologies and Competitive Advantages "Transport and Use" (Rocket Pumps and Compressors)

(3) "Cryogenic Rocket Fuel Supply Pump" supporting the commercial satellite rocket market growth

- Collaborated with Muroran Institute of Technology and Interstellar Technologies in the development of turbo pumps for rockets (in September 2021).
- Conducted a components test for turbo pumps (in April 2022).
- Accumulated fuel supply technology and started the development of electric pumps as well.

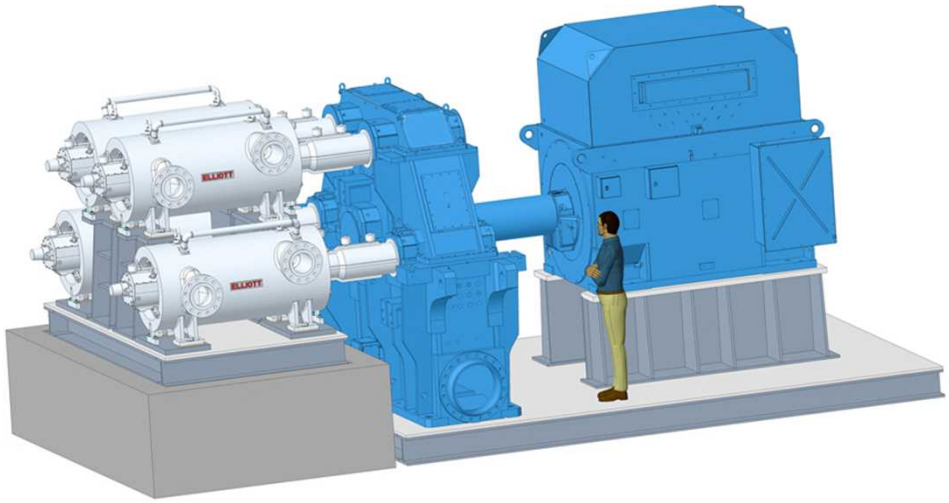


Testing equipment for components for turbo pumps (water-flow test)
The photo provided by: Interstellar Technologies, Inc.

Conceptual presentation of Electric Pump for Rocket Engines

(4) Compact "Hydrogen Compressor" promoted by Elliott and EBARA Group co-creation

- Developed a new Flex-Op hydrogen compression solution (in March 2022).
- Launched in the first quarter of FY2022.



Conceptual presentation of Flex-Op Hydrogen Compressor

3. EBARA's Technologies and Competitive Advantages "Production"

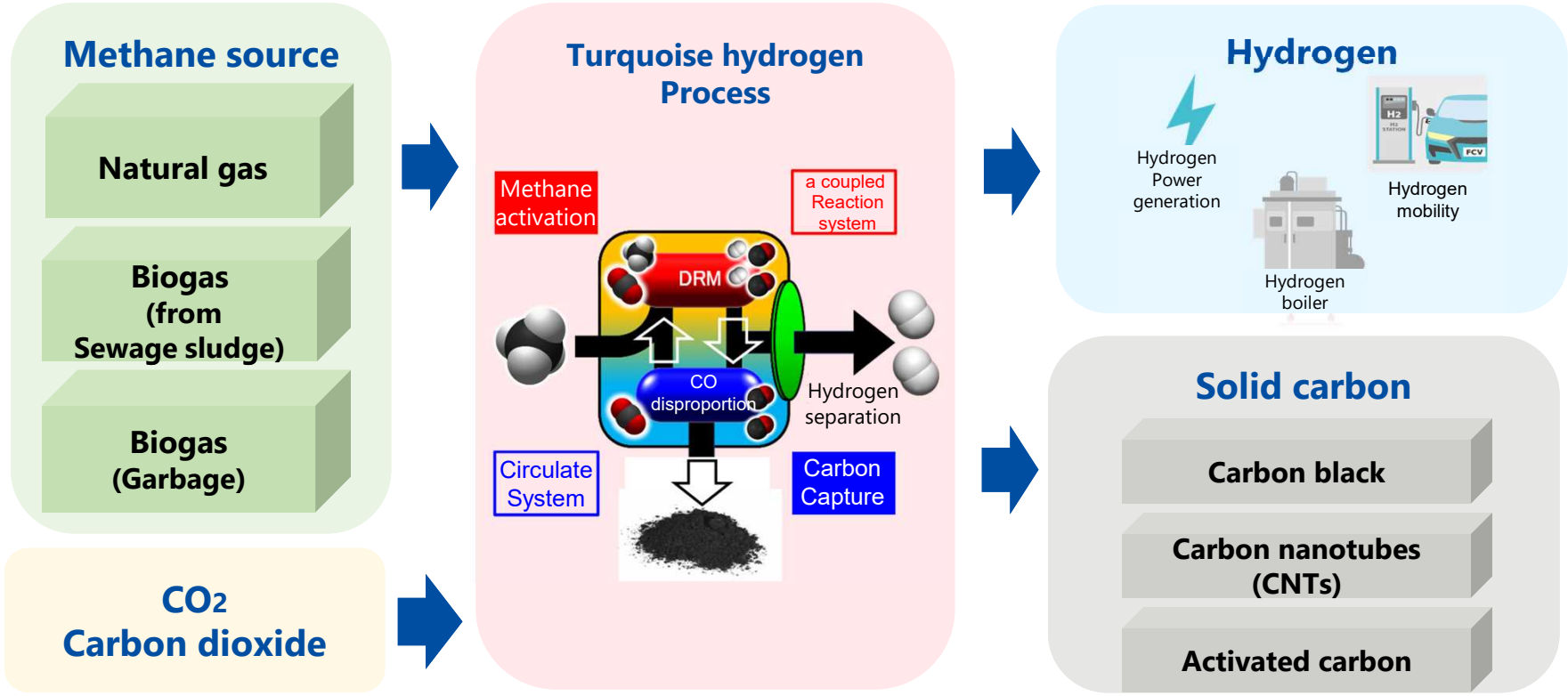
- The classification of hydrogen depends Production technology (the classification differs slightly in regions).
- CO2-free hydrogen is an essential for an energy system with net zero emissions, EBARA will build a secure position in this area.
- For future hydrogen demand and supply(Scaling up and distribute application), Ebara makes an approach in this area

Classification of hydrogen	Production technology	Carbon emission
Green hydrogen	Produced via the electrolysis of water: the used electricity must derive from renewable sources	CO_2-free hydrogen (clean hydrogen) *Turquoise hydrogen has a carbon fixation characteristic.
Blue hydrogen	Produced using a carbon capture and storage (CCS)	
Turquoise hydrogen	Produced via the thermal splitting of methane (methane pyrolysis)	
Pink hydrogen	Produced via the electrolysis of water: the used electricity from a nuclear power plant	—
Gray hydrogen	Production via the steam reforming of natural gas and fossil fuels (CO_2 is emitted)	Emission of CO_2

3. EBARA's Technologies and Competitive Advantages "Production" (Development of Turquoise Hydrogen and Solid Carbon)

(5) Methane with high Global Warming Potential is separated into hydrogen and solid carbon

- Aim at a commercialization in 2026
  Conducting feasibility study, a medium-scale and a large-scale demonstration.
- NEDO's "Advancement of Hydrogen Technologies and Utilization Project*1"
  Under development and demonstration with NIMS*2, TAIYO KOKO CO., LTD etc
- Recruiting business partners to start cooperation with
  Methane sources (gas and electricity companies, etc.) and hydrogen and carbon suppliers.



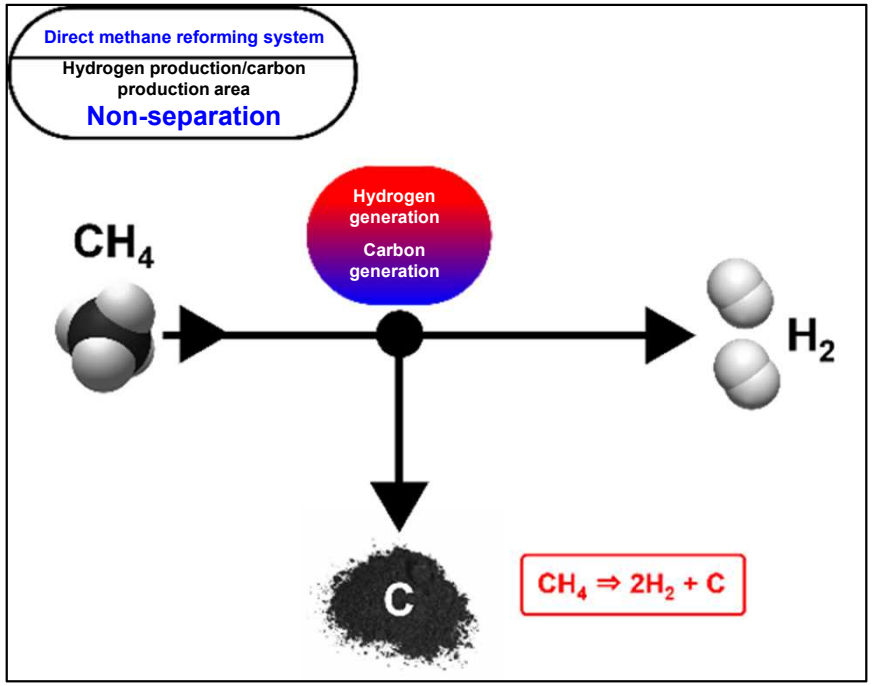
*1: Advancement of Hydrogen Technologies and Utilization Project/Development of technology for producing hydrogen without CO_2 emissions by use of hydrocarbon, etc./Hydrogen production through reaction field separation of methane activation and carbon deposition

*2: National Institute for Materials Science

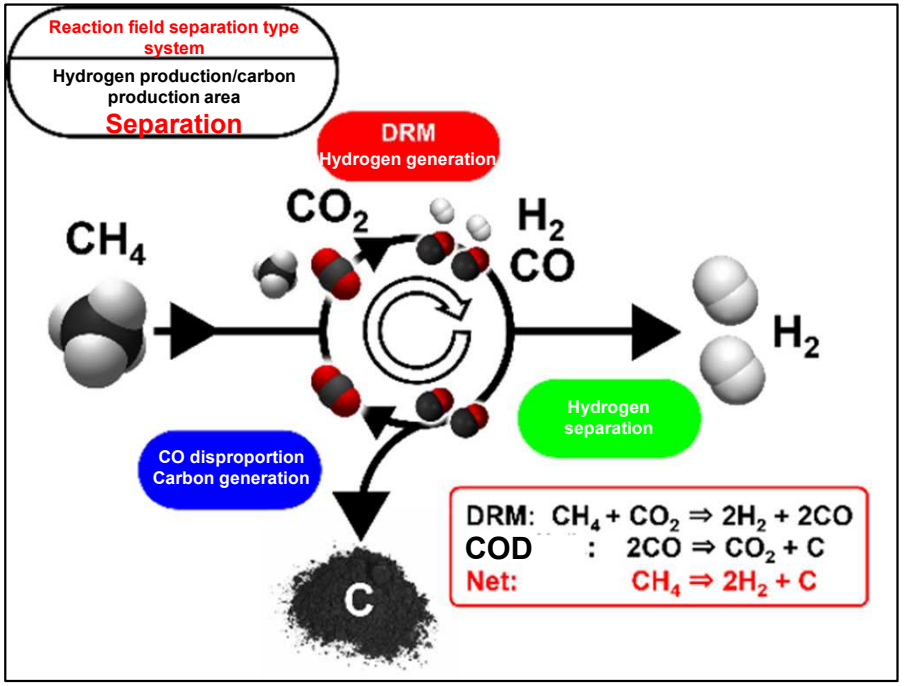
3. EBARA's Technologies and Competitive Advantages "Production" (Development of Turquoise Hydrogen and Solid Carbon)

- **Production high value-added carbon**
  Capable of producing high value-add carbon by separating the reactors of methane decomposition and carbon capture and optimizing temperature, pressure and others. In addition, contribute to long-life catalyst by preventing from the carbon coking of the methane pyrolysis.
- **High efficient process with low temperatures**
  Achieve low temperature process by developing catalysts with long-life and low temperature activity.

[Conventional Process]

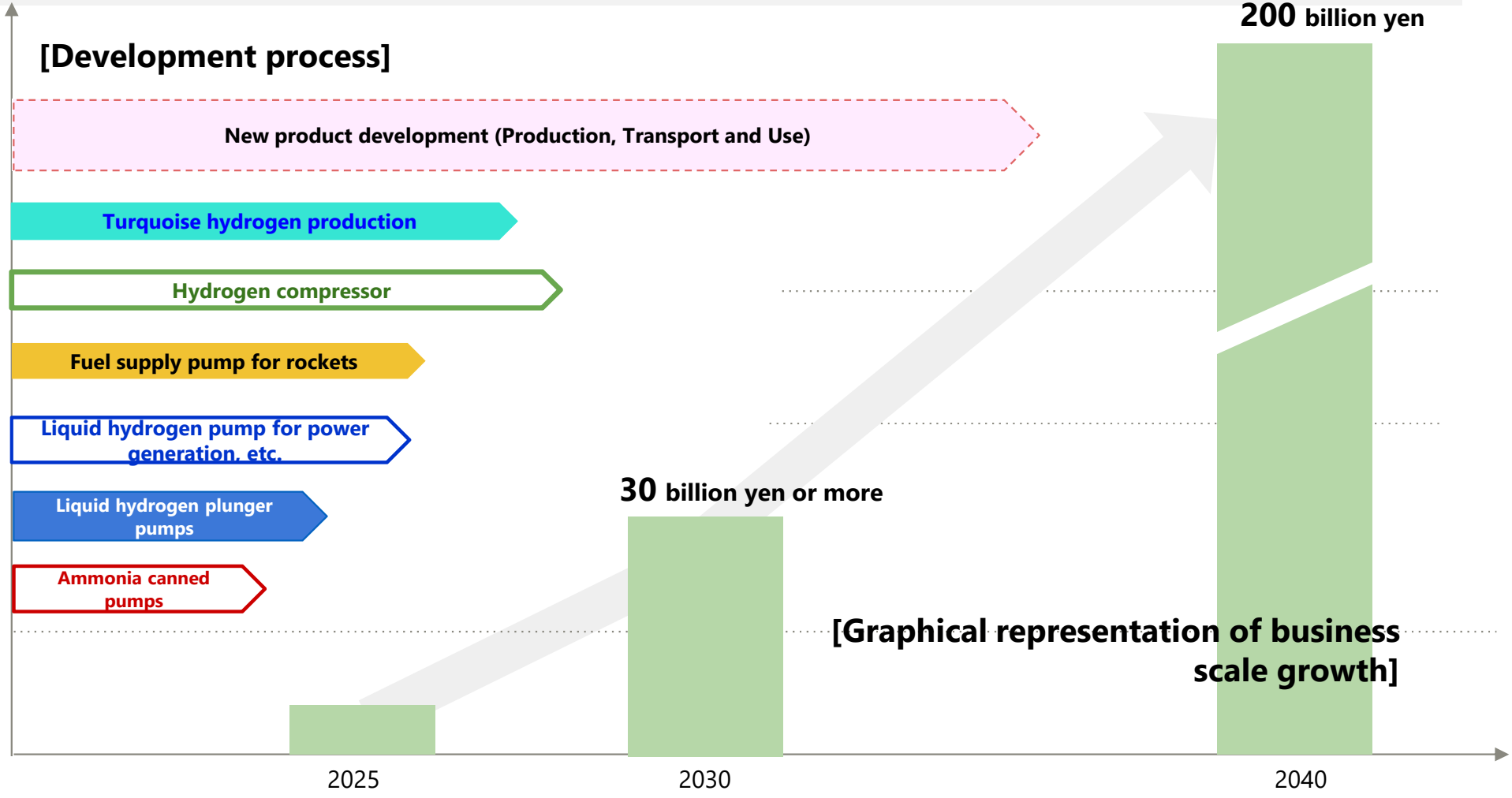


[Process adopted by Ebara]



4. Future of EBARA's Hydrogen-related Business

- Complete product development, launch to the market and accelerate the business growth.
- **Contribute to a hydrogen society through CO2-free hydrogen** by developing new products and new business models in all three fields of "Production, Transport and Use".
- Aim to business development with **a revenue of over 200 billion yen in 2040**.



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