Asia-Pacific Economic Cooperation

4. Highlights of Draft APEC Hydrogen Report

APERC Workshop

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Outline

- Timeline of policies to support zero- and low-carbon hydrogen
- Status of the hydrogen industry in APEC
- Key hydrogen projects in APEC
- Current challenges
- Conclusions

Timeline of policies to support zero- and low-carbon hydrogen

2017

Basic Hydrogen Strategy (Japan)

2019

National Hydrogen Strategy (Australia)
Strategic Roadmap for Hydrogen and Fuel Cells (Japan)
Hydrogen Economy Roadmap 2019 (Korea)
Vision for Hydrogen in New Zealand (New Zealand)

2020

First Low Emission Technology Statement (Australia)
Technology Investment Roadmap(Australia)
Hydrogen Strategy for Canada (Canada)
National Strategy of Green Hydrogen(Chile)
China's Hydrogen Energy and Fuel Cell Industry Development Plan (2020-2030) (China)
Hydrogen Strategy Roadmap (Japan)
Green Growth Strategy (Japan)
Hydrogen Economy Promotion and Hydrogen Safety Management Act (Korea)
Roadmap for Hydrogen Development until 2024 (Russia)
Energy Act of 2020 (United States)

Timeline of policies to support zero- and low-carbon hydrogen

1st Basic Plan for the Implementation of the Hydrogen Economy (Korea)
Hydrogen Shot (United States)

2021

2022

Hydrogen Industry Development Plan (China)
Singapore’s National Hydrogen Strategy (Singapore)
Hydrogen Energy Development Roadmap (Chinese Taipei)
The inflation Reduction Act (United States)

National Hydrogen Infrastructure Assessment (Australia)
The Emission Reduction Plan 2030 (Canada)
Basic Policy for the Realization of Green Transformation (GX) (Japan)
Revised Basic Hydrogen Strategy (Japan)
Hydrogen Economy & Technology Roadmap (Malaysia)
National Hydrogen Strategy and Roadmap (United States)

2023

2024
(under development)

Green Hydrogen Action Plan (Chile)
New Zealand’s Road Map (New Zealand)

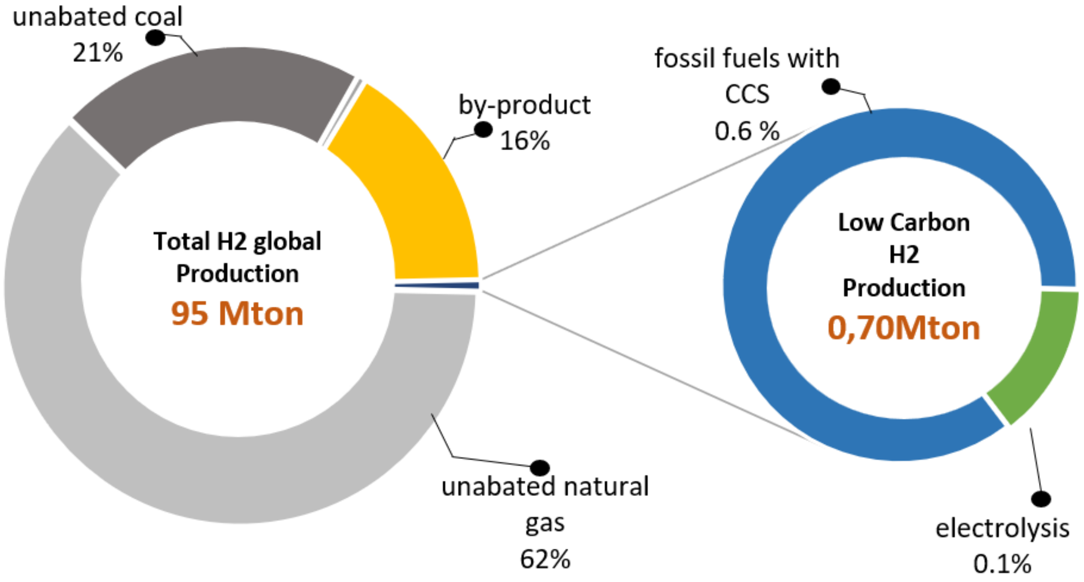
Policies to support zero- and low-carbon hydrogen

- The APEC region has been a leader in developing and implementing policies to promote the nascent hydrogen industry. Each economy's hydrogen strategy reflects the economy-specific characteristics and priorities.
- Some economies emphasize their ability to produce low-carbon hydrogen, while others emphasize the role of hydrogen for decarbonization of energy end-use and power sectors.
- For example, the Inflation Reduction Act in USA and the proposed Clean Technology Investment Tax Credit in Canada aim to support investment on clean hydrogen production.
- Japan's Green Innovation Funds supports projects to establish large-scale hydrogen and ammonia fuel consumption. Additionally, Japan's Green Transformation (GX) promotes investments in key sectors including the use of hydrogen and ammonia cofiring in power sector, expanding hydrogen stations, and the introduction of ammonia/hydrogen-fuelled ships.

Today, low-carbon hydrogen represents less than 1% of total production

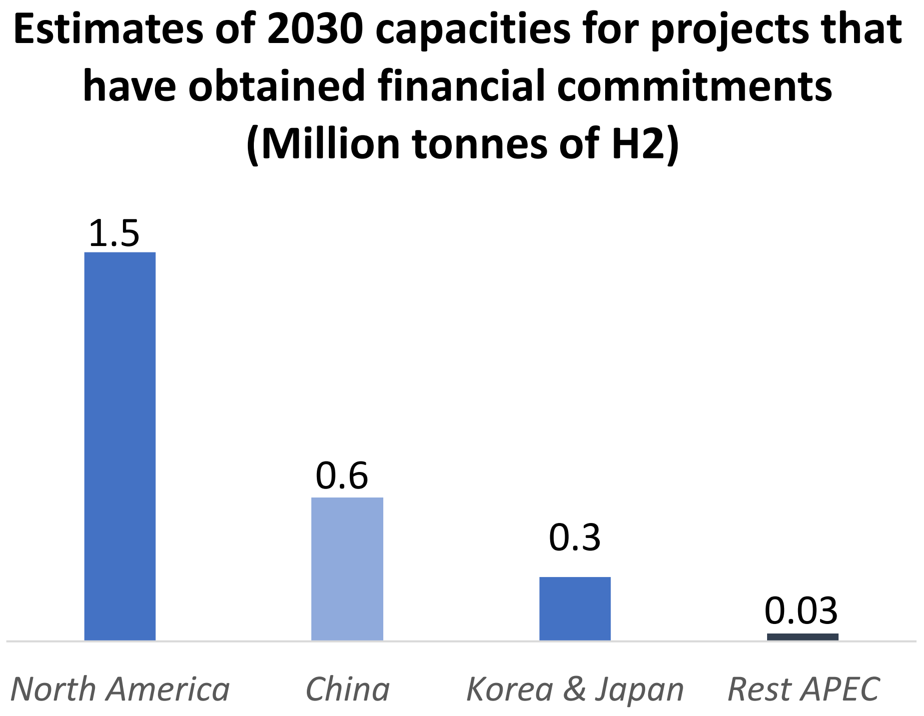
- Hydrogen production reached 95 million tonnes in 2022. Nearly all the hydrogen was produced from unabated fossil fuels. The energy content in this hydrogen is approximately equivalent to 2% of global energy consumption and is responsible for around 2.5% of global CO_2 emissions.
- Most low carbon hydrogen production is fossil fuel-based with CCS.
- **Almost all hydrogen is currently used as feedstock in industry**.

Global H2 production in 2022



Data Source: Global Hydrogen Review 2023 (IEA)

Status of low-carbon hydrogen industry in APEC



Source: Estimation based on the Hydrogen Insights 2023 update report (Hydrogen Council & McKinsey & Company, 2023) and the draft of APERC H2 report

- Only 7% of globally announced low-carbon hydrogen projects have reached final investment decision. Most of this committed capacity is in APEC.
- China and USA are the main global hydrogen consumers and are leading on committed investments in renewable and low-carbon hydrogen.
- Committed investment in North America, mainly Canada and USA, is primarily in natural gas-based hydrogen with CCS, while committed investment in China is in renewable energy-based hydrogen projects.
- Most of the recently announced hydrogen projects globally are renewable energy-based projects.

Projects operating or under development

- Japan's Fukushima Hydrogen Energy Research Field (FH2R) was known in 2020 as the largest green hydrogen plant, featuring a 10MW electrolyser and a 20MW solar generation plant. It had the ability to produce enough hydrogen to power roughly 150 households or 560 fuel cell vehicles each day
- Air Products is developing a large blue hydrogen project in Louisiana, USA, which is expected to produce 21 million m^3 of hydrogen per day when completed by 2026. The goal of the project is to supply low-carbon hydrogen to refineries along the US Gulf Coast, with a CO_2 capture rate of 95%
- The Net-Zero Hydrogen Energy Complex in Canada consists of an Auto-Thermal Reformer hydrogen production facility, with carbon capture technology with CO_2 capture rate of 95%. Hydrogen-fueled gas turbines will provide electricity to the project and the grid.

Projects operating or under development

- Several green hydrogen projects are under development in China. The Kuqa Hydrogen project began commercial operations in June 2023. Once it is fully operational, the Kuqa Hydrogen project is expected to produce 20 000 tonnes of hydrogen per year. Additionally, the Ordos Project in Inner Mongolia, with a nominal capacity of 30 000 tonnes of hydrogen per year, will replace coal-based hydrogen in nearby chemical plants.
- Korea is building hydrogen pilot cities. The first selected cities were Ulsan, Ansan, and Jeonju/Wanju. The first phase installed 20 km of hydrogen pipelines, operated 72 hydrogen buses, among other actions that can reduced almost 1 kton CO2-eq annually in these three cities. In 2023, the government announced a similar project in six additional cities: Pyeongtaek, Namyangju, Dangjin, Boryeong, Gwangyang, and Pohang. A hydrogen city must use hydrogen in major urban functions in buildings, transport, and industry.
- Advanced Clean Energy Storage, located in USA, will use a 200 MW electrolyser to produce 100 tonnes of hydrogen per day. The hydrogen will be stored in two salt caverns with a capacity of 5500 tonnes.

Future projects in APEC

Several other important projects have been announced that are under study:

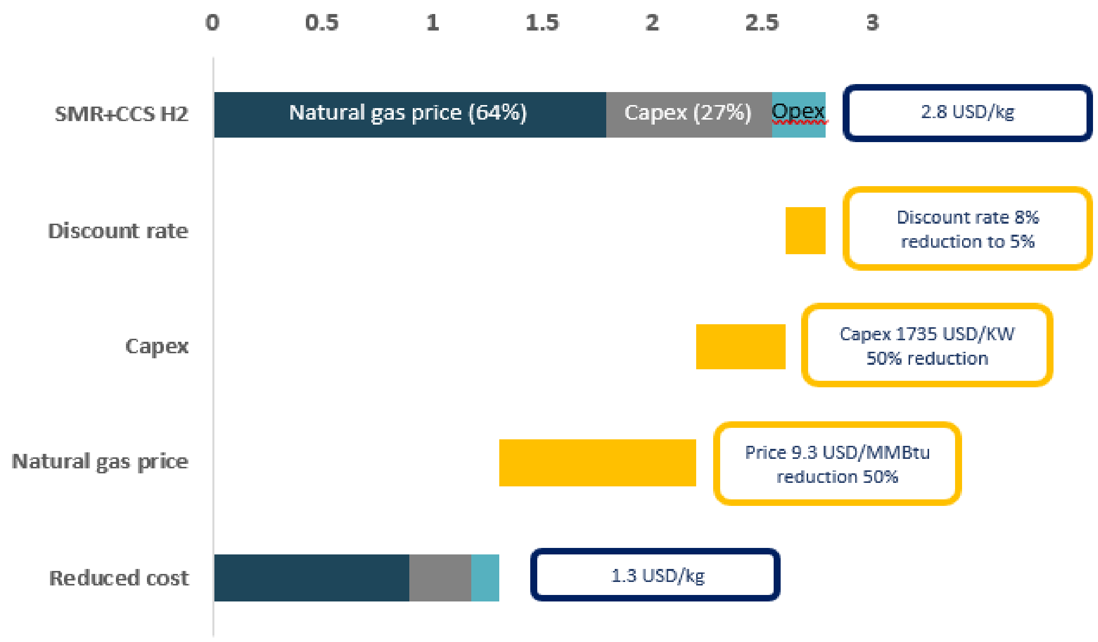
- The Australian Renewable Energy Hub and the Eastern Green Energy Hub, both located in Australia, with a combined capacity of 5 million tonnes of hydrogen per year.
- In its pilot phase, the HyEx Green Ammonia project in Chile aims to yield 3,200 tonnes of green hydrogen for ammonia production. The upscale would increase capacity to 130 000 tonnes per year and use 2000 MW of electrolysers.
- Verano Energy has recently announced the submission of the environmental impact study for a green hydrogen project in Arequipa, Peru. The nominal capacity of this project is 1.6 million tonnes of hydrogen per year.

Challenges to the development of zero- and low-carbon hydrogen trade

- Hydrogen can be an effective tool to decarbonize hard-to-abate sectors.
- However, challenges remain:
  - High cost of zero- and low-carbon hydrogen
  - Increasing complexity of announced projects
  - Lack of adequate transportation and distribution systems
  - Lack of recognized international standards for zero and low-carbon hydrogen
  - Uncertain future demand

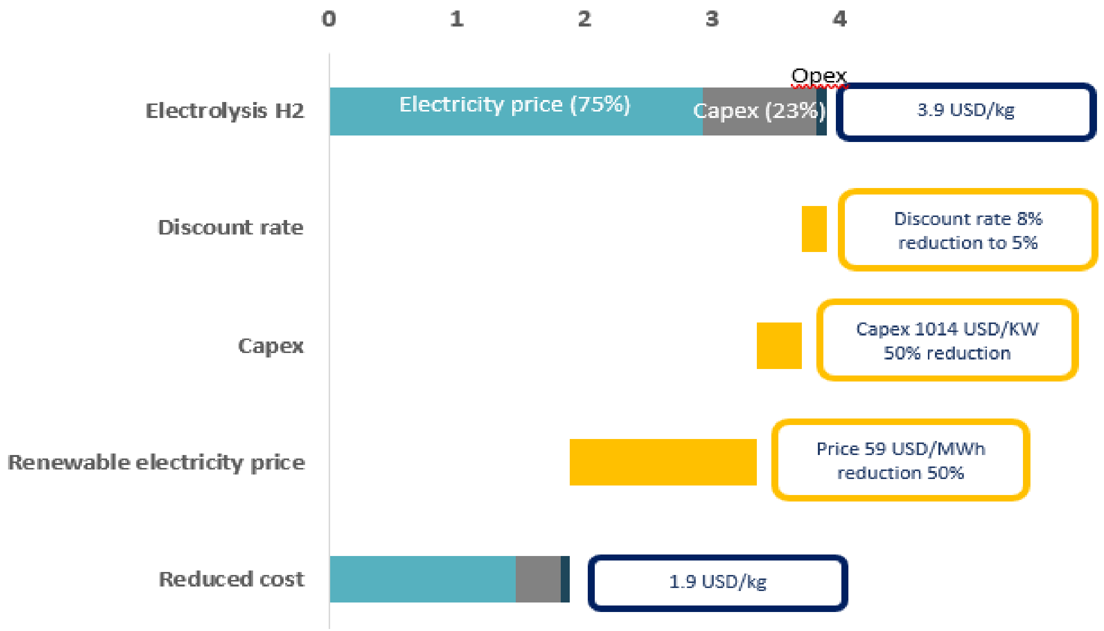
Cost of zero- and low-carbon hydrogen is vulnerable to energy prices hikes

Cost of low-carbon hydrogen (USD/KgH_2)



Note. The price of natural gas was estimated using Henry Hub prices from August 2022. Capex cost for US Gulf Hydrogen with CCS (Platts, 2023)

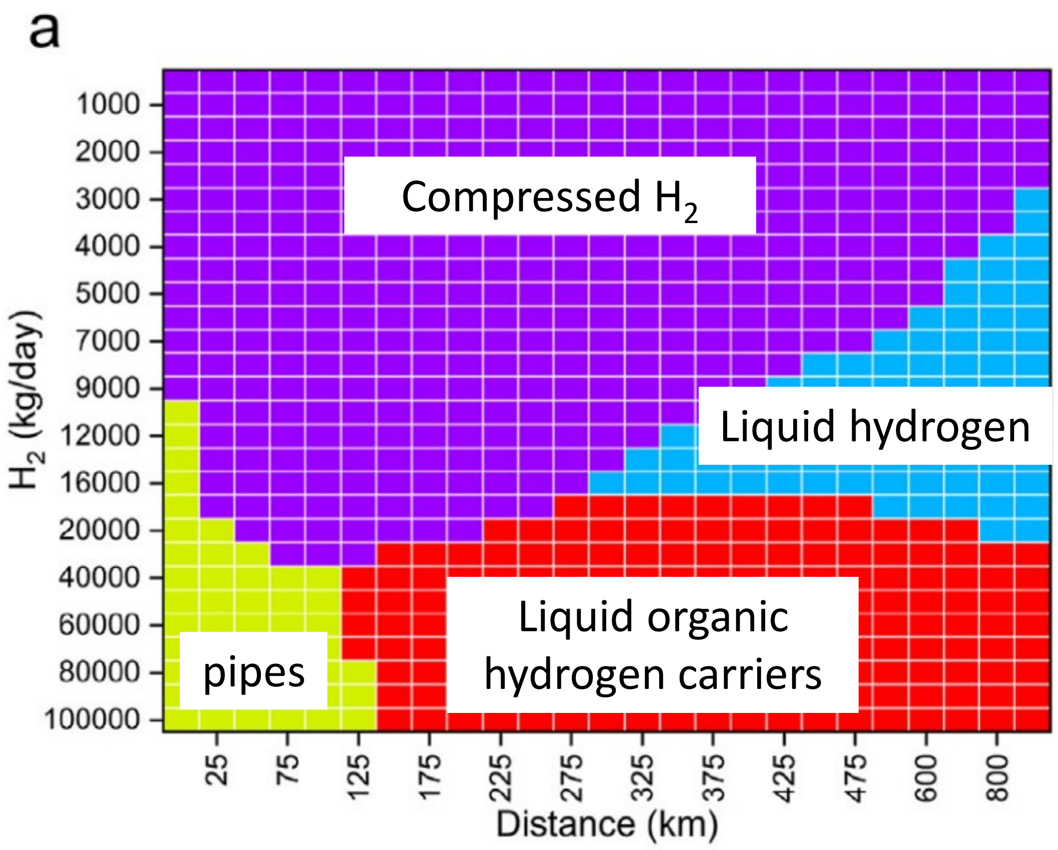
Cost of renewable energy-based hydrogen (USD/KgH_2)



Note: The electricity price was assumed to be equal to the levelized cost of energy from wind power in the US. The electrolyser capacity factor was assumed to be 50%. The assumed electrolyser capex cost is based on a US Gulf Coast Hydrogen Alkaline Electrolysis Capital cost (Platts, 2023)

Transport and distribution to end-users could be a bottleneck

- A large gap in investment exists in transport and distribution.
- Different conditions require different solutions:
  - Short distance (<350km) and less that 0.4 PJ demand (approx. 10 tonnes of hydrogen/day) , transport through trucks is more competitive.
  - Pipelines are expensive in economies that do not have existing natural gas pipelines.
  - Blending hydrogen with natural gas has a limit of 20% (V/V) due to technical constraints. This option reduces the amount of energy per unit of volume (14%) and reduces emission by 6.7% per unit of energy.

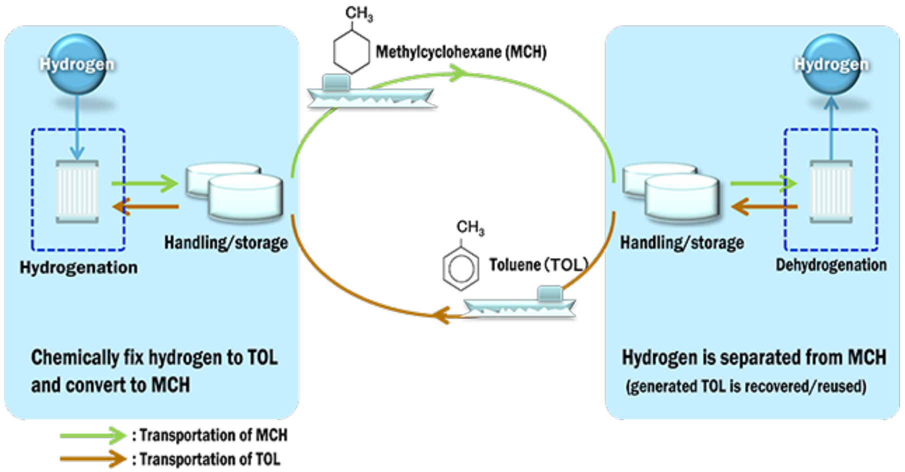


Source: Techno-economic analysis of hydrogen storage and transportation from hydrogen plant to terminal refueling station (Rong et al., 2024)

Long distance transportation projects in APEC

APEC has experience with long distance transport: AHEAD ,that uses methylcyclohexane (MCH), and HESC, that uses liquefied hydrogen.

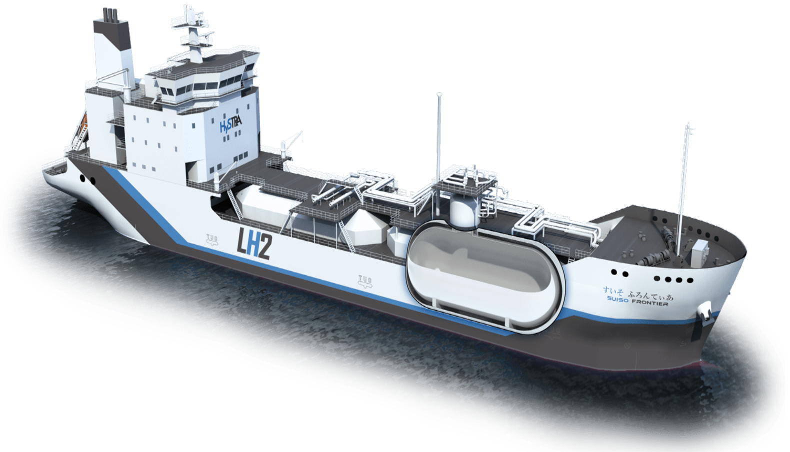
Advanced Hydrogen Energy Chain Association for Technology Development (Brunei Darussalam-Japan)



Source: https://www.ahead.or.jp/en/research.html

In December 2020, the AHEAD project announced the successful transport of 100 tonnes of hydrogen over 10 months, using MCH as hydrogen carrier. The hydrogen was used in a gas turbine in Keihin refinery in Japan.

Hydrogen Energy Supply Chain (Australia-Japan)



Source: https://www.hydrogenenergysupplychain.com/about-the-pilot/supply-chain/the-suiso-frontier/

The pilot was successfully completed in February 2022 with the arrival of the Suiso Frontier, the World's first liquified hydrogen carrier, in Kobe, Japan with liquefied hydrogen from Australia. Suiso Frontier has a capacity of 1250 m^3 of liquid hydrogen (-253 °C)

The need for international low carbon hydrogen standards

- Widely-accepted standards are required to establish an international market for low-carbon hydrogen. The standards must define clean hydrogen, the boundaries where emissions are accounted, and the appropriate certifications.
- Standards that are too stringent could delay investment.

US

Tax credits for clean H2 production according to IRA

Emission Intensity ($KgCO_{2e}/kgH_2$)	Tax credit (USD/kg H_2)
0-0.45	3.00
0.45-1.5	1.00
1.5-2.5	0.75
2.5-4	0.60

Japan

Definition of clean H2 and NH3 established in Revised Basic H2 Strategy

Clean product	Emission Intensity ($KgCO_{2e}/kg$)	System Boundary
Clean Hydrogen	3.4	Well to gate
Clean Ammonia	0.84	Gate to gate

China

Standard and evaluation of low-carbon H2, clean H2 and renewable H2

Clean product	Emission Intensity ($KgCO_{2e}/kg$)
Clean Hydrogen	4.9
Low Carbon Hydrogen	14.51

APERC Asia Pacific Energy Research Centre

Conclusions

- Most APEC economies are implementing policies designed to increase the production, transportation, and consumption of zero- and low-carbon hydrogen as a fuel.
- As a result of these new policies and expected future policies designed to encourage zero- and low-carbon hydrogen fuel use, many projects are being proposed in a number of APEC economies.
- Very few of these projects have achieved final investment decision (FID). The primary reasons are the current high costs of producing zero- and low-carbon hydrogen, the lack of infrastructure and high cost of transporting zero- and low-carbon hydrogen, and the uncertainty about future demand for zero- and low-carbon hydrogen.
- Reducing the cost of zero-and low-carbon hydrogen poses challenges because a significant portion of the production costs are tied to the cost of the energy used.
- Another uncertainty relates to future international standards for zero- and low-carbon hydrogen. The development and widespread adoption of international standards could remove a key uncertainty that slows the financing of zero- and low-carbon hydrogen projects.

Thank you.

https://aperc.or.jp