NRW-Japan Business Seminar

拡大を続けるドイツ水素エコシステムと日本企業のビジネスチャンス -
ドイツ水素戦略の最前線 “NRW州”

Hydrogen Value Chain

LOHC-MCH for Energy Transition

Chiyoda Corporation
森本 孝和
Takakazu Morimoto

March 16, 2023

Agenda

1. Who we are
2. Hydrogen Transport Technology : LOHC-MCH
3. From Demonstration to Commercialization
4. Use-case and Business Development

1. Who we are

Chiyoda's Philosophy

Chiyoda has been providing pioneering engineering solutions for each generation since 1948, and under our company's philosophy 'Energy and Environment in Harmony', continues our vision of 'serving society through technology'.

From Coal to Oil, Oil to Gas, Gas to Renewables and New Energy

1948–1970 **1971–1990** **1991–2000** **2001–2010** **2011–2020**

1960
Mitsubishi Oil Co., Ltd.
Mizushima grassroots refinery

2004
LNG plants for Qatargas Operating Company Limited

2018
World's largest battery power storage system project in Hokkaido, Japan

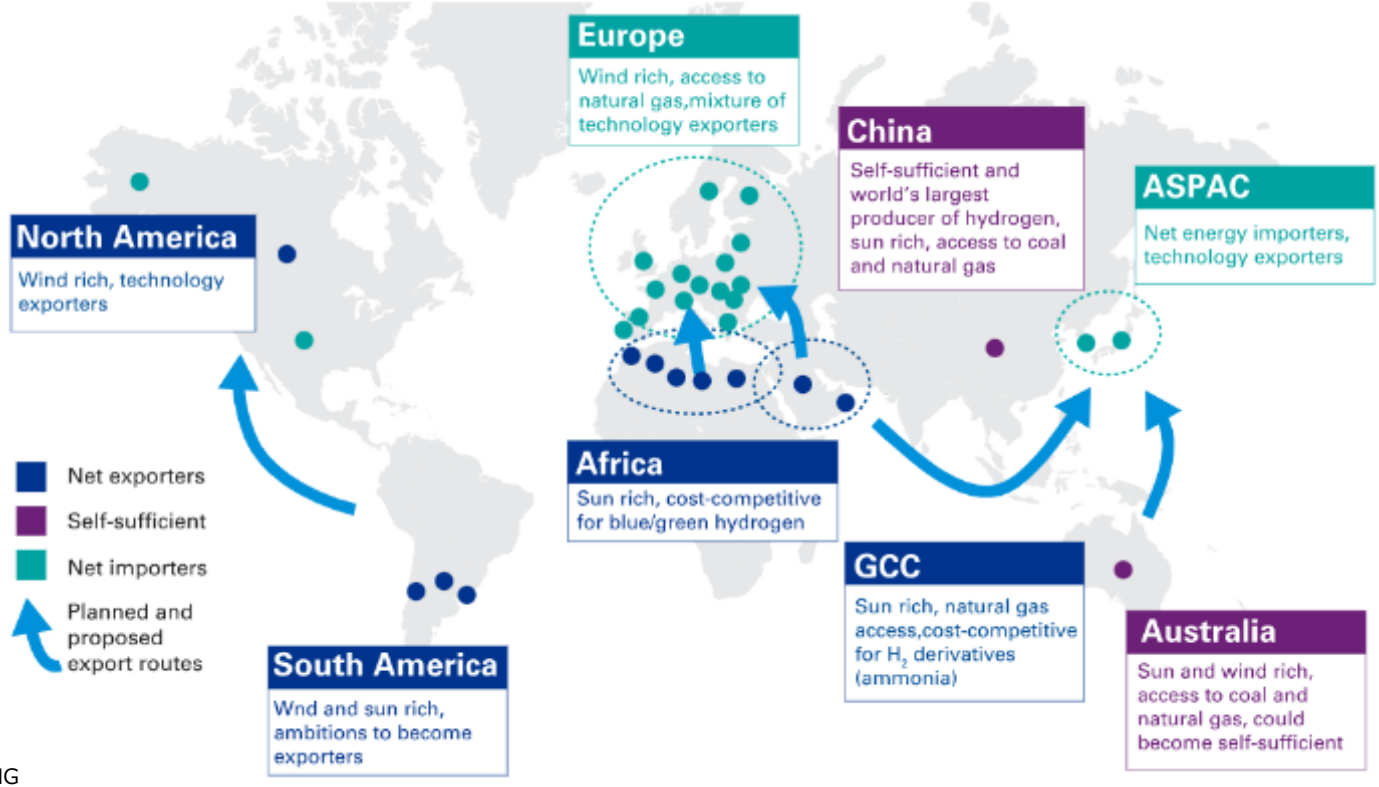
2015-2020
World's first global hydrogen supply chain demonstration project

Chiyoda's Vision for the Future

Engineering that shapes the future of energy and the global environment

1. Hydrogen Transport Technology : LOHC-MCH

Global Hydrogen Trade - Hot Spots and Corridors

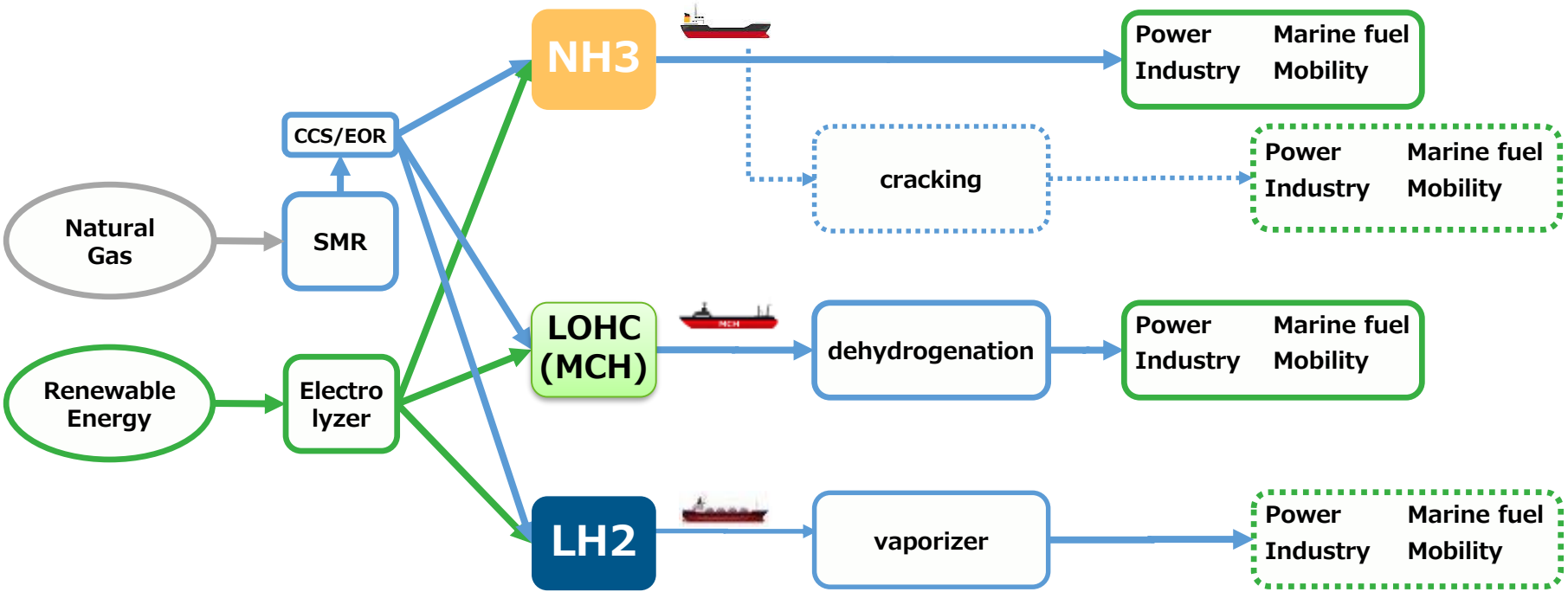


Source: KPMG

(https://home.kpmg/xx/en/home/insights/2021/01/geographic-hydrogen-hotspots.html)

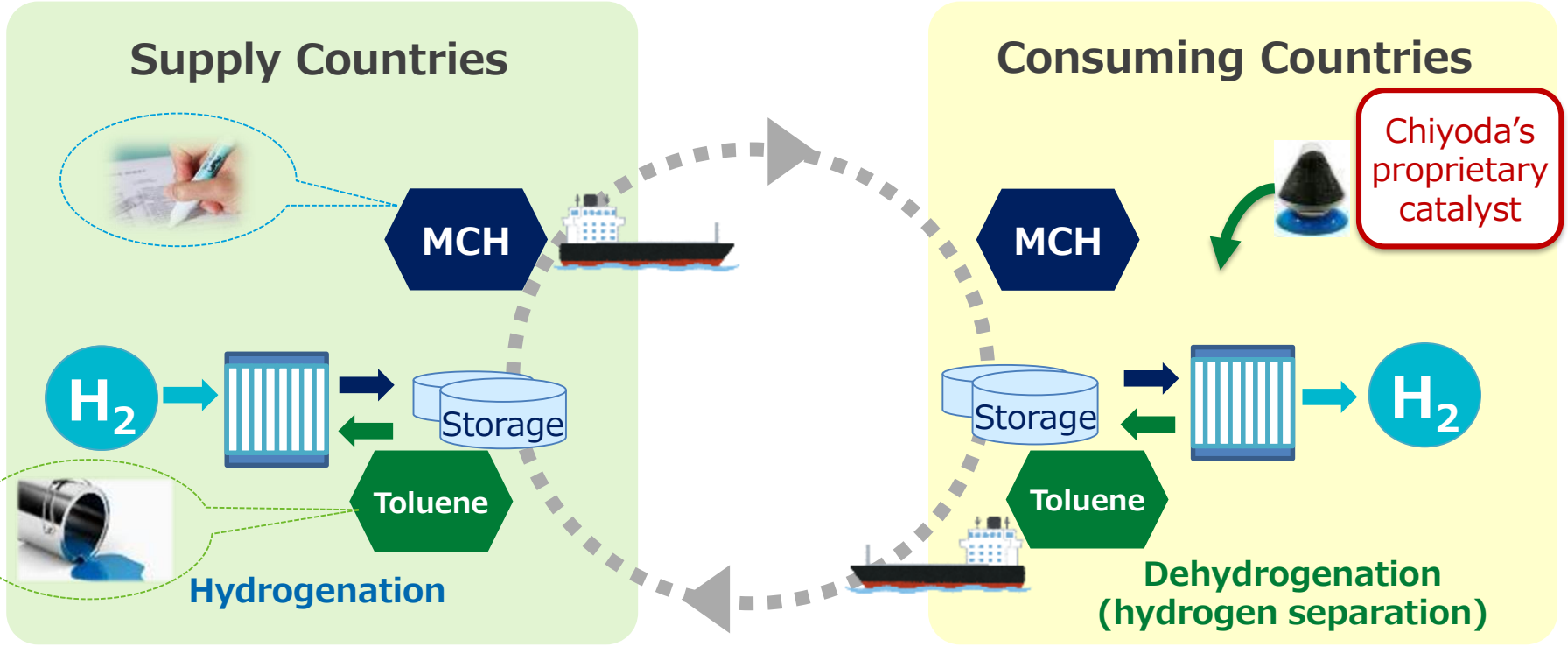
Hydrogen Carriers Landscape for Ocean Transportation

- Each carrier has pros and cons depending on situations
- All carriers should co-exist



LOHC-MCH : Hydrogen Transportation Mechanism

SPERA Hydrogen™* System



*SPERA Hydrogen: Chiyoda's hydrogen storage and transportation technology. 'SPERA' is Latin for 'HOPE'

Key Features of LOHC-MCH

Stable Liquid	under **ambient temperature and pressure,** containing H2 of **500 times of the volume of MCH.**
Safe and Easy	for transportation and storage that is **equivalent level to petroleum products**
Proven technology	with the combination of conventional **simple chemical reaction** and **new dehydrogenation catalyst**
Existing infrastructures	**code & standards, regulations, can be applied** which can minimize social investment for H2 introduction




CHIYODA CORPORATION

3. From Demonstration to Commercialization

The Euro-Québec Hydro-Hydrogen Pilot Project (EQHHPP)

- The project was started in 1989.
- The project examined the feasibility of transporting hydrogen across the Atalantic.
- MCH has also been studied in addition to the LH2 and NH3.

The study was finally terminated because the dehydrogenation catalyst for MCH could not be implemented

Source： Historisches Projekt: Euro-Québec Hydro-Hydrogen Pilot Project
https://ludwig-boelkow-stiftung.org/eqhhpp

LOHC-MCH, Record of development

2002~2010	2013~2014	2015~2020	2025	2030
Cat Development	***Demonstration***		***Semi Commercial***	***Full Commercial***
Lab/Bench scale	Pilot Scale (50 Nm3/h)	International Supply Chain *1 (300Nm3/h)		

*2

*2

Further improvement of SPERA system (LOHC-MCH)

*1 Supported by NEDO
*2 Permission obtained by AHEAD

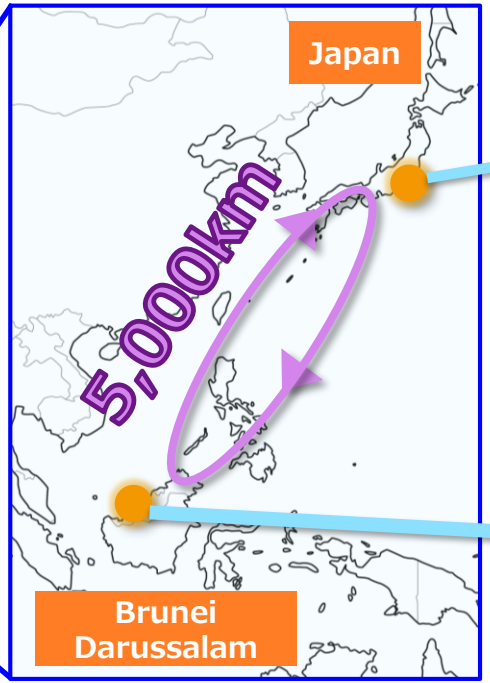
CHIYODA CORPORATION

Global Hydrogen Supply Chain Demonstration Project 2020

AHEAD: Chiyoda Corporation, Mitsubishi Corporation Mitsui &Co Ltd and Nippon Yusen Kabushiki Kaisha as members.

NEDO: Supported the project.

Description	
Scale	210 tons/year at facility scale (Maximum) Toyota MIRAI x 40,000



Business Scheme	・Conducted by AHEAD ・Funded project by NEDO

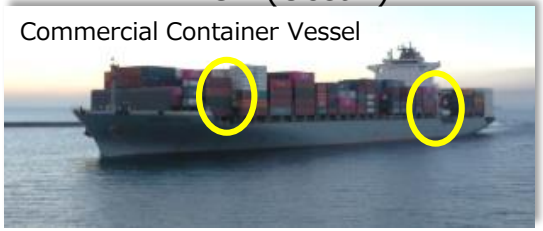
Global Hydrogen Supply Chain Demonstration Project

Use of hydrogen extracted by dehydrogenation as gas turbine fuel (first in Japan)

Hydrogenation Plant (Brunei)

MCH (Land)

MCH (Ocean)



Dehydrogenation Plant (Kawasaki)

Dehydrogenation Reactor

Dehydrogenation Catalyst (Chiyoda Proprietary)

Hydrogen to thermal power generation

World’s 1st Successful H2 Transportation by Chemical Tanker

AHEAD has achieved a world’s first milestone of transporting hydrogen, in the form of MCH, and this achievement demonstrates the viable long-term storage and transportation of hydrogen in the form of MCH by tanker on a global scale.

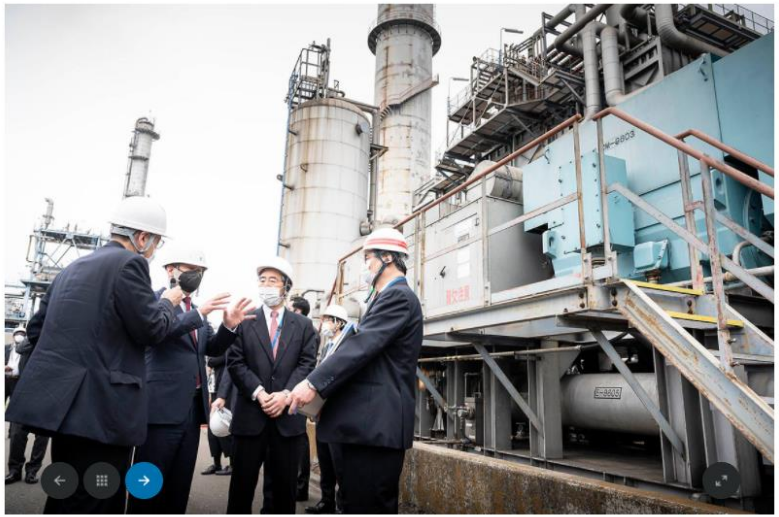
- AHEAD manufactured MCH in Brunei Darussalam, for transportation to an ENEOS petroleum refinery in Japan.
- For supplying MCH to the ENEOS refinery, this global demonstration project supported by CROS*1 has been conducting.
- The first chemical tanker arrived at the refineries receiving facility on 4 February 2022, and the MCH was fed into the refinery.

*1 CROS : Consortium for Resilient Oil Supply System

Visit by the German Federal Chancellor

April 29 2022

German Federal Chancellor Olaf Scholz visits the Dehydrogenation Plant



10 / 11

Kawasaki, 29 April 2022: On the second day of his trip, Federal Chancellor Scholz still had time to visit the Toa Keihin refinery, a short distance outside Tokyo, before flying back to Germany. A hydrogen generation plant belonging to the Chiyoda Corporation is located at the facility.

Photo: Federal Government/Bergmann

11 / 11

The business uses a process that combines hydrogen with a solvent. This allows it to be transported in conventional containers and cargo ships. Later the hydrogen can be separated from the solvent and used by industry.

Photo: Federal Government/Bergmann

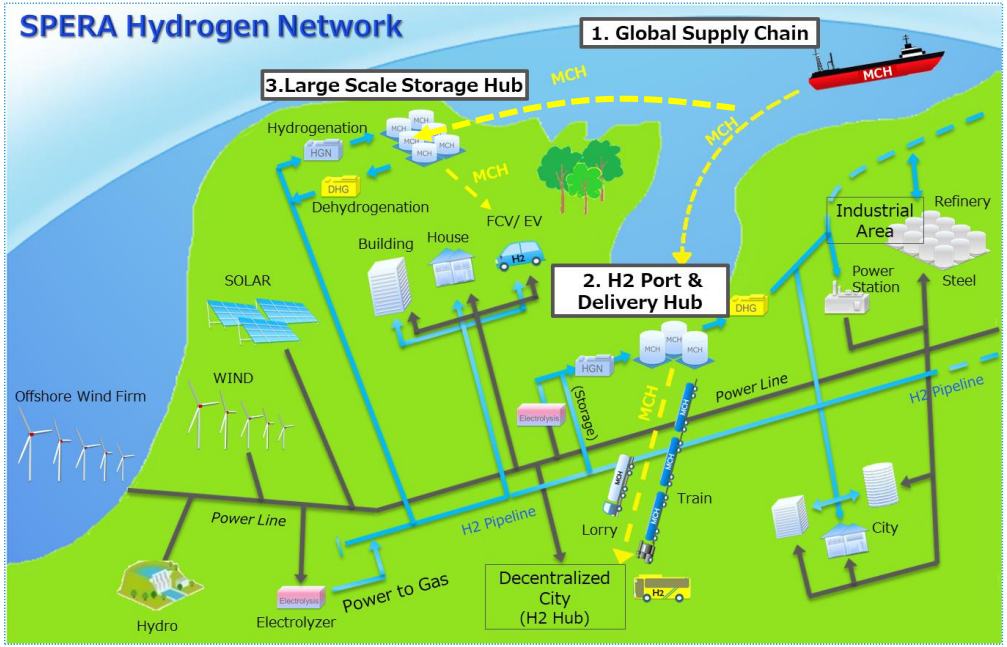
Source: Press and Information Office of the Federal Government
https://www.bundesregierung.de/breg-en/news/federal-chancellor-japan-visit-2029280

4. Use-case and Business Development

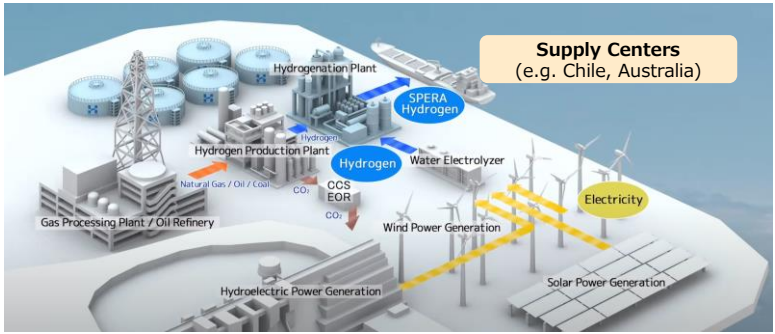
SPERA Hydrogen™ Use Case

There are 3 major use cases (global supply chain / hydrogen port and delivery hub / large scale storage hub) by using SPERA Hydrogen technology, to well-link between domestic and global hydrogen supply chain network.

SPERA Hydrogen Use Case

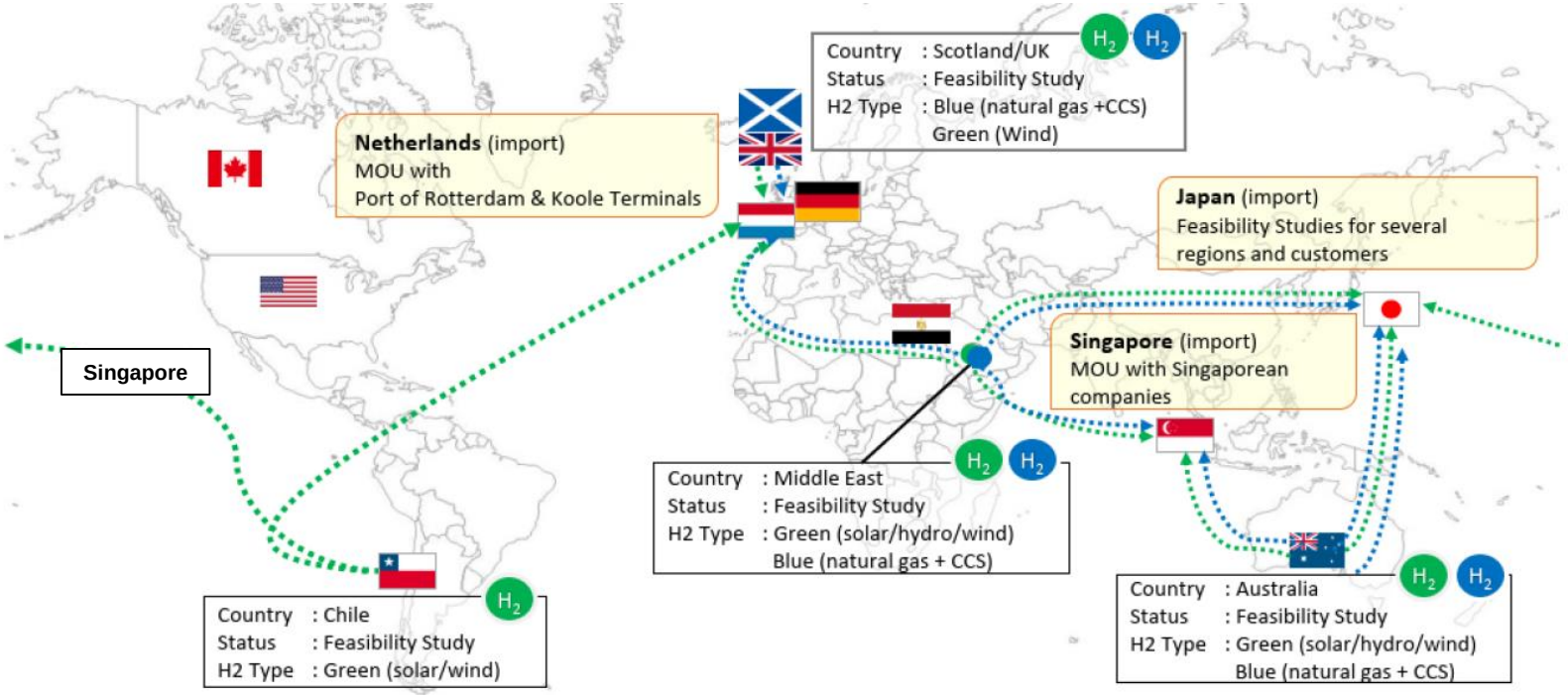


Global Hydrogen Supply Chain Concept

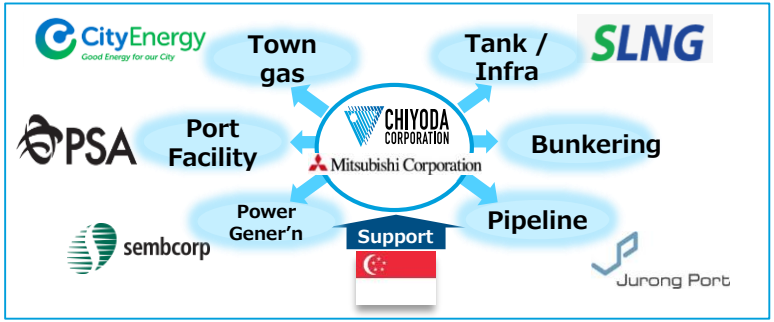


Global Hydrogen Supply Chain Projects

Global supply chains are fundamental for SPERA Hydrogen. Studies/discussions are ongoing to identify cost-competitive and feasible hydrogen supply/logistics to H2 demand countries (i.e., Europe, Singapore, Japan)



LOHC-MCH Project in Singapore



Mar. 2020 **MOU with 5 Singaporean companies**

Mar. 2022 **Award for LCER Fund**
University and industry research collaboration

Singapore Government

"Low-carbon hydrogen has the potential to be a major decarbonisation pathway towards net zero by 2050, which could supply up to 50% of our power needs, by then."

2020 — 2021 — 2022 — 2026 — 2050

Oct. 2021
Strategic Partnership
with Sembcorp & Mitsubishi

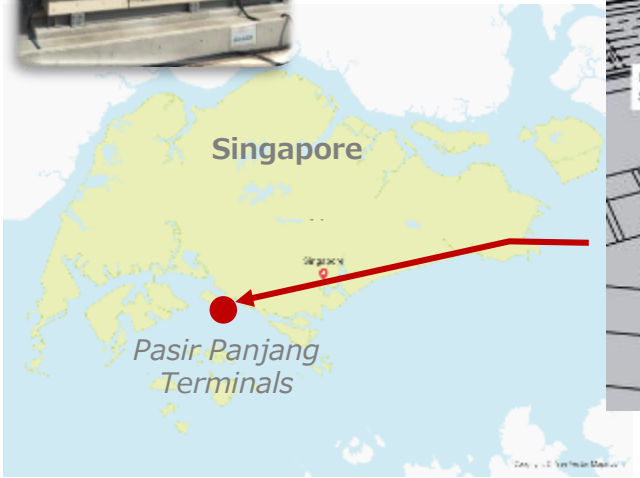
sembcorp
CHIYODA CORPORATION
Mitsubishi Corporation

Oct. 2022
MOU advancing to Pre-FEED study
with Sembcorp & Mitsubishi

2026
Dehydrogenation Commercial Plant
to commence operation

Global Hydrogen Supply Chain Projects : Singapore Hydrogen Project - 2

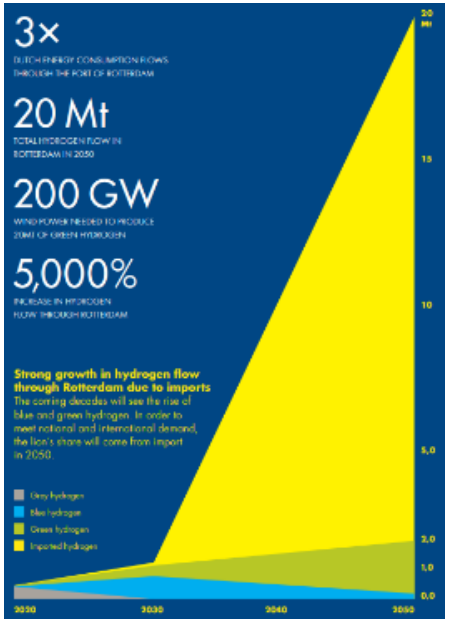
In addition to the global H2 supply chain, Chiyoda and its partners are executing the engineering work for MCH Hydrogen Refueling Station demonstration project at PSA Pasir Panjang Terminals, aiming to start operation in 2024.



LOHC-MCH（SPERA Hydrogen™）Project in The Netherlands

July 2021 : Signed an MOU

Port of Rotterdam　koole TERMINALS　CHIYODA CORPORATION　Mitsubishi Corporation



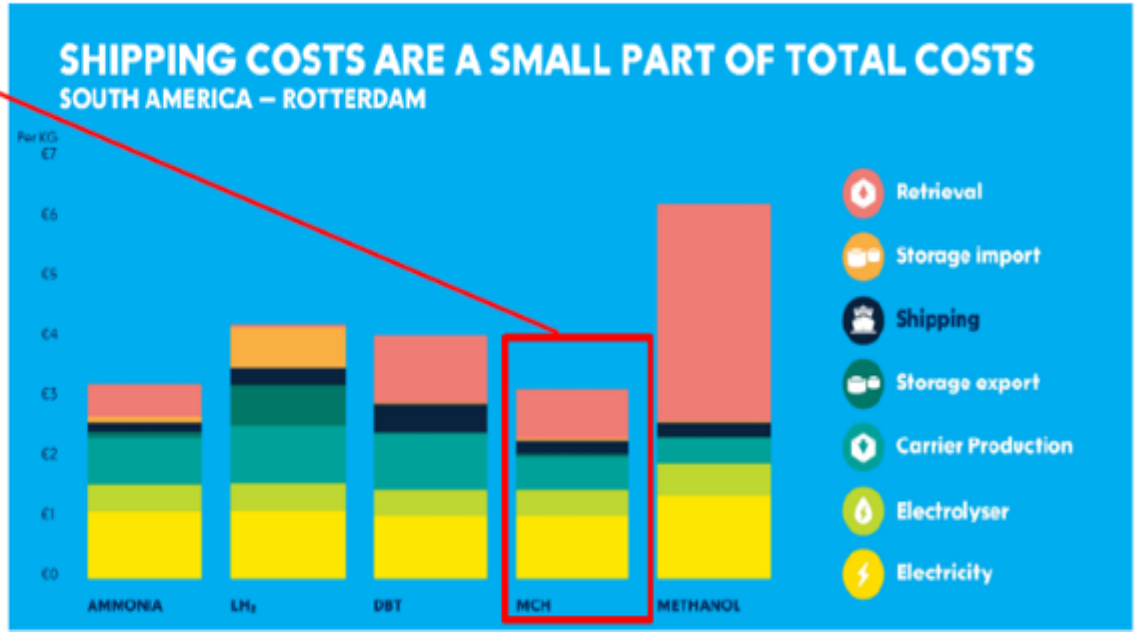
Source : https://www.portofrotterdam.com/sites/default/files/2021-06/hydrogen-economy-in-rotterdam-handout.pdf

CHIYODA CORPORATION

Hydrogen Carriers: Characteristic/ Supply Chain Cost Comparison

MCH is the most competitive result in total hydrogen cost.

Port of Rotterdam showed the **overall costs of producing green hydrogen** in South America and shipping it to Rotterdam in different forms.

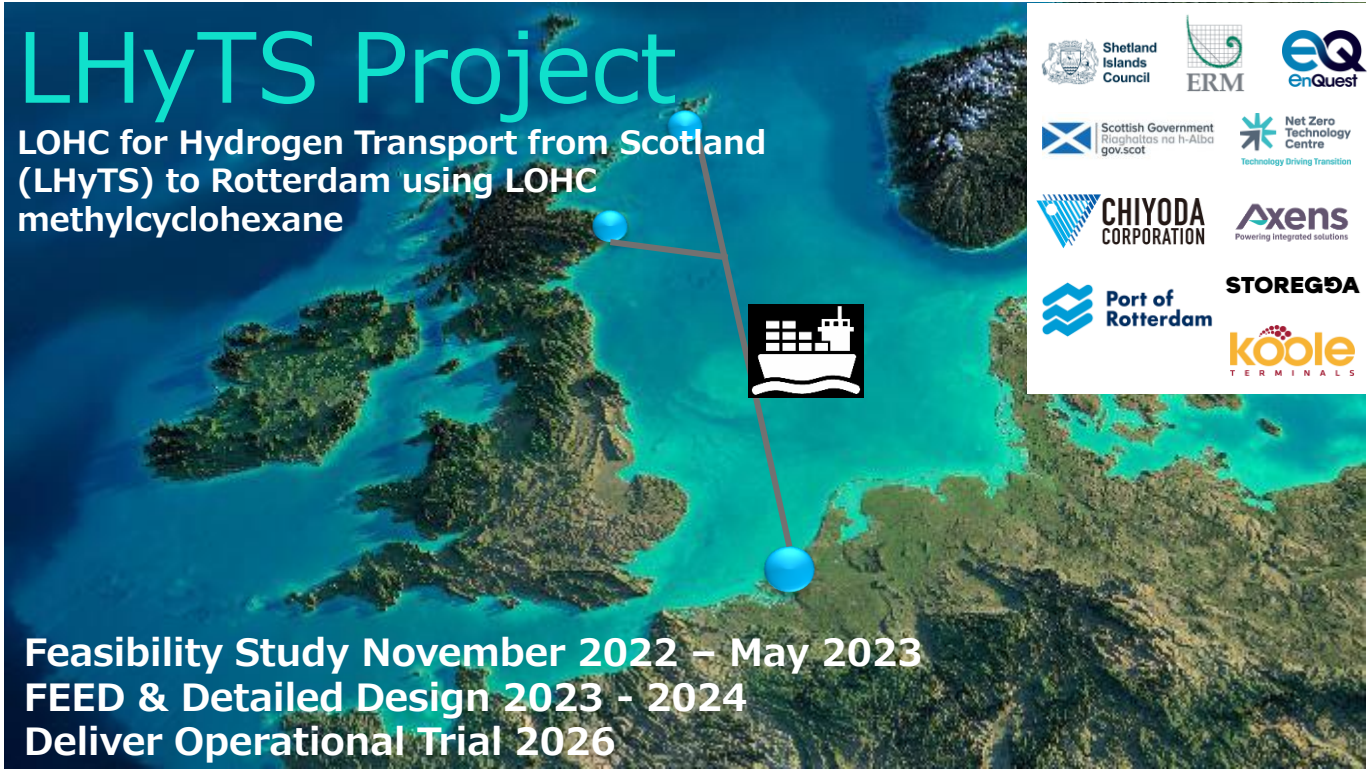


(Source) Keynote speech Allard Castelein, CEO Port of Rotterdam Authority, at the 2nd World Hydrogen Summit

CHIYODA CORPORATION

Hydrogen Supply Chain in Europe Utilizing MCH

Participating in a Scotland to Rotterdam MCH Hydrogen Highway Project



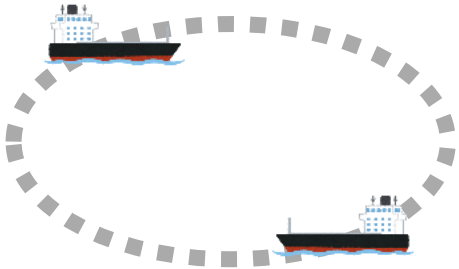
Collaboration between Axens and Chiyoda

Strategic commercial cooperation agreement with Axens enables one-stop service to customers and supports hydrogen transport technology by MCH

AX-CYD License Commercial Package

Axens
Powering integrated solutions

- Hydrogenation (HGN)
- Licensor's expertise

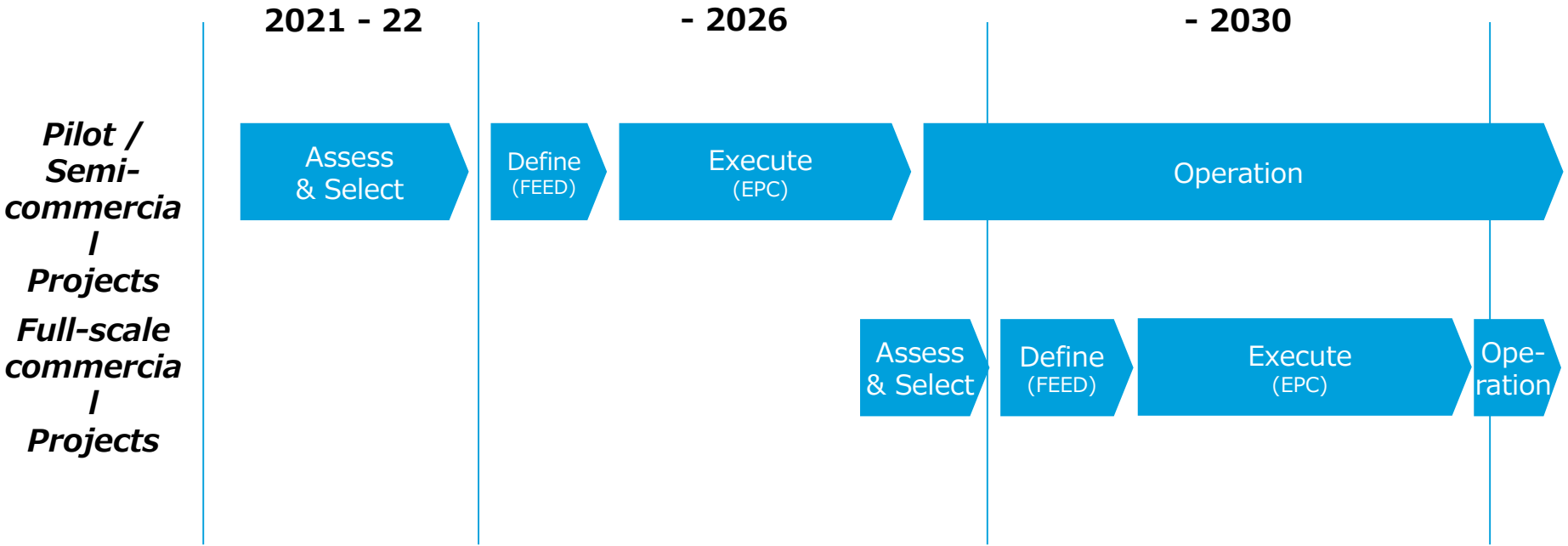


CHIYODA CORPORATION

- Dehydrogenation (DHG)
- Engineering expertise

Target Schedule for Commercialization

Our target schedule for commercializing a global hydrogen supply chain is to commence operation of pilot/semi-commercial projects by 2026 and full-scale commercial projects for the European and Asian markets by 2030.



Summary

1. Each Hydrogen Carrier has its own Advantages and Disadvantages. No specific one carrier is the best all the time, but all carriers will co-exist.
2. Chiyoda's LOHC system uses MCH as a H2 carrier. Chiyoda's proprietary dehydrogenation catalyst enabled the use of MCH as a H2 carrier.
3. LOHC-MCH is the safe carrier and it's chemically stable. Existing facilities /infrastructures can be used.
4. An international demonstration project completed in 2020 successfully. The tanker transportation of MCH has also been demonstrated in 2022.
5. We are aiming at a semi-commercial project operation in 2026, and a large scale commercial project operation in 2030.

SPERA Hydrogen Demonstration Video－YouTube

↑ 日本語

↑ English

Energy and Environment in harmony