Chapter 4

Main Findings of Interviews and Site Visits

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Chapter 4

Main Findings of Interviews and Site Visits

To further substantiate the desktop research, we conducted interviews and visited sites to investigate the demonstration projects that apply hydrogen energy storage, to identify lessons, experience, and key barriers given the current levels of technologies and costs of supply chains.

Lessons from China

Sites visited in China were the Sichuan Energy Internet Research Institute, Tsinghua University in Chengdu, and Chengdu Lyuzhou Renewable Energy in Chengdu (Sichuan Province); and Energy China in Guangzhou, R&D Centre of Hydrogen Energy Standardization in Foshan, and Hydrogen Industrial Park and related infrastructure in Nanhai county, Foshan (Guangdong Province).

China could soon be one of the biggest producers and consumers of hydrogen energy. As of 2019, the central government had issued over 10 policy documents, and of 34 provincial administrative regions, 17, in addition to 22 municipalities, had issued policies to develop hydrogen energy-related industries and infrastructure.[2] Guangdong Province issued the most numbers of policies.

Guangdong Province provides the most generous subsidies for FCEVs and HRSs, in addition to central government subsidies. Table 13 summarises central and local subsidy policies as of 2019.

Table 13. Central and Local Subsidies for Fuel Cell Electric Vehicles in China, as of 2019

	Central Government	Guangdong Province
FC passenger vehicle	CNY6000/kW (up to CNY200,000 per vehicle)	CNY200,000 per vehicle
FC light truck or bus	CNY300,000 per vehicle	CNY300,000 per vehicle
FC heavy truck or bus	CNY500,000 per vehicle	CNY500,000 per vehicle
HRS		Up to CNY 8 million per station

CNY = yuan, FC = fuel cell, kW = kilowatt, HRS = hydrogen refuelling station.
Source: Authors, based on published reports.

[2] Source: Sohu.com news titled "Stock taking of policies on hydrogen fuel cell vehicles and hydrogen energy industries in the first half of 2019" (in Chinese) http://www.sohu.com/a/327206089_618917 (accessed 30 Dec 2019)

Over 2,000 FCEVs operate in China, mostly supported by demonstration projects, together with 26 HRSs.[3] The number of HRSs is expected to increase to 1,000 by 2030 (Author, Year).[4]

It was surprising, however, to find that most demonstration projects source hydrogen from conventional petroleum by-product hydrogen. All HRSs use compressed-hydrogen trucks to transport hydrogen at 35 MPa (350 bar). For these reasons, hydrogen energy is neither competitive in price (about CNY85/kg for refuelling at the HRS) nor green.

We understood from local experts that, besides the lack of economic competitiveness of the hydrogen supply chain, two main barriers stand in the way of developing green or clean hydrogen energy. First, comprehensive and valid feasibility studies are lacking on potential renewable or clean energy-to-hydrogen projects and their associated energy infrastructure network for transport and distribution.

Second, stakeholders have no consensus on who should do what to dismantle the institutional and regulatory barriers. For example, the power grid company has no redundant capacity to transmit the curtailed renewables or nuclear energy to a hydrogen production facility near the demand market. To build new transmission lines, decisions have to be approved by central regulation bodies. The power grid company, however, has no incentive to build dedicated new lines for such purpose, partly because of lack of understanding and partly because downstream market demand for hydrogen is not guaranteed. It is a ‘chicken-and-egg’ situation. Power regulations do not allow onsite production of hydrogen at renewable power stations, either, even if they were to use curtailed electricity.

An implementation plan study could collect information and ideas from experts in industry, government, and academia to identify economic and non-economic barriers, and determine who should do what by when. China needs a framework of policies that support clean and green hydrogen energy.

Like solar and wind power in the past 2 decades, hydrogen power technology will experience accelerated improvement and decline in cost because of the learning effect, economies of scale, and the network effect of hydrogen infrastructure, which are typical in the rise of new back-stop technologies. Policy support to get the industry through the typical ‘Death Valley’ of new technologies is critical.

Lessons from Japan

Because of the outbreak of the coronavirus disease (COVID-19), physical site visits were impossible within the project’s time scope. Instead, we interviewed hydrogen energy experts from Chiyoda Corporation online. The feedback helped us verify whether or not several key data inputs, such as the cost and performance parameters of fuel cells, hydrogen liquefaction plants, hydrogenation plants, LOHC trucks, and HRSs were in reasonable range. We conducted desktop studies on a few cases of renewable energy-to-hydrogen projects (Table 14).

[3] Source: CBEA.com news titled “First in the world! 6,547 us fuel cell vehicles sold in the U.S. How about China?” (in Chinese) http://www.cbea.com/yldc/201905/876628.html (accessed 30 Dec 2019)

[4] Source: nbd.com.cn news report titled “Spring in the hydrogen industry? Hydrogen station construction subsidies may be substantially increased” (in Chinese) http://www.nbd.com.cn/articles/2019-03-27/1314957.html (accessed 30 Dec 2019)

Table 14: Hydrogen Energy Demonstration Projects in Japan

Project Name	Project Period	Leading Company or Organisation	Technologies Demonstrated	Hydrogen Energy Supply Capacity
Regional Cooperation and Low-Carbon Hydrogen Technology Demonstration Project	2017–2018	A partnership of the Kanagawa prefectural government and others	Wind energy-to-hydrogen supply system	2 MW of wind power to produce hydrogen at 10 Nm^3/hour, fuelling 12 fuel cell forklifts
Low-Carbon Hydrogen Supply Chain Demonstration Project	2018–present	Toshiba Energy Systems & Solutions, Iwatani	Hydropower to produce hydrogen	200 kW small hydropower generation to produce hydrogen at 35 Nm^3/hour
SPERA Hydrogen	2020–present	AHEAD	Hydrogen supply chain using MCH	210 tons
Hydrogen Energy Supply Chain Pilot Project	2020–2021	HySTRA	Liquefied hydrogen supply chain	3 tonnes (expected to expand after the initial demonstration, as the shipping vessel from KHI has a capacity of 87 tonnes of liquefied hydrogen)
Fukushima Hydrogen Energy Research Field (FH2R)	2020–present	New Energy and Industrial Technology Development Organization		20 MWe of solar PV generation to produce hydrogen at 900 tonnes per year

kW = kilowatt, MW = megawatt, MWe = megawatt-electric, Nm^3 = normal cubic metre.
Source: Authors, based on published reports.

The **Regional Cooperation and Low-Carbon Hydrogen Technology Demonstration Project**, commissioned by the Ministry of the Environment in FY2015, was a partnership of the Kanagawa prefectural government, Yokohama and Kawasaki city governments, Iwatani, Toshiba, Toyota Motor, Toyota Industries, Toyota Turbine and Systems, and Japan Environment Systems. The project announced that a low-carbon hydrogen supply chain that would utilise hydrogen produced from renewable energy in facilities along Tokyo Bay (Yokohama and Kawasaki) to power forklifts had been completed and commenced operation in July 2017.

The project involved a 2 MW wind power generation facility to support electrolysis and deliver hydrogen at 10 Nm^3/hour. The hydrogen was subsequently compressed and transported by a hydrogen refuelling truck to supply 12 fuel cell forklifts.

The project examined future courses of action required to reduce hydrogen costs, verified savings from economies of scale, identified the steps needed towards deregulation, and developed a promotional and deployment model to accelerate technological innovation and advance full-scale supply chains.

The demonstration operation in 2017–2018 showed that fuel cell forklifts had shorter recharging times than electric forklifts, were used flexibly without issues, and were generally well reviewed. However, users requested more frequent hydrogen deliveries to improve fuel cell forklift uptime.

In May 2018, Toshiba Energy Systems & Solutions (Toshiba ESS) announced that they had started a demonstration project in partnership with Iwatani in Kushiro City, Hokkaido Prefecture at a hydrogen production facility using hydrogen produced from a small hydropower plant to establish a hydrogen utilisation model suitable for Hokkaido. The project is proceeding under the Ministry of the Environment's **Low-Carbon Hydrogen Supply Chain Demonstration Project**.[5]

The project uses a 200 kW small hydropower generator and produces hydrogen at 35 Nm^3/hour through electrolysis. The hydrogen is transported by compressed-hydrogen trucks to support several facilities that consume electricity and heat, including a dairy farm, a swimming pool, a welfare and health centre, as well as several FCEVs. Although the specifics of the system's performance are not known, evidence from ENE-FARM applications in Japan implies that the system is highly energy-efficient because it combines electricity and heat. The project's purpose is to verify that the hydrogen energy supply chain is operational.

For long-distance transport of hydrogen, Japan is demonstrating two technical pathways. Chiyoda is leading an alliance to demonstrate large-scale liquid methylcyclohexane (MCH) transport technology, a type of LOHC. The technology produces liquid MCH from toluene and hydrogen, which are maintained in a liquid state at ambient temperatures and pressures, and thus are suitable for transport as a typical liquid chemical product. According to Chiyoda, MCH is as easy to handle as petroleum or natural gas; the technology is branded as **SPERA Hydrogen** by the company.[6]

Chiyoda and its partners, including Mitsubishi, Mitsui, and NYK Line, established the Advanced Hydrogen Energy Chain Association for Technology Development (AHEAD) and started the world's first global hydrogen supply chain demonstration project in 2020, when the Tokyo Olympic Games and Paralympic Games were to have taken place. The project produces hydrogen by steam reforming processed gas derived from the natural gas liquefaction plant of Brunei LNG. The hydrogen is converted into MCH and transported by sea to Japan. The project targets supplying 210 tonnes (maximum) of gaseous hydrogen in 2020, equivalent to fuel demand of 40,000 FCEVs.

Kawasaki Heavy Industry and its partners (J-Power, Shell Japan, Iwatani, Marubeni, JXTG Nippon Oil & Energy, and 'K' Line) from the Hydrogen Energy Supply-chain Technology Research Association (HySTRA) represent the other technical pathway – liquefied-hydrogen transport. The alliance is embarking on a pilot project to demonstrate brown coal gasification and hydrogen refining at Latrobe Valley in Australia, hydrogen liquefaction and storage of liquefied hydrogen at Hastings in Australia, and marine transport of liquefied hydrogen from Australia to Japan in 2020–2021.[7] The project will treat 160 tonnes of inexpensive lignite to produce 3 tonnes of hydrogen. The decision to proceed to a

[5] https://www.toshiba-energy.com/en/info/info2018_0524.htm (accessed on 12 May 2020)
[6] https://www.chiyodacorp.com/en/service/spera-hydrogen/innovations/ (accessed on 12 May 2020)
[7] http://www.hystra.or.jp/en/project/ (accessed on 12 May 2020)

commercial phase will be made in the 2020s, with operations targeted in the 2030s, depending on the successful completion of the pilot phase, regulatory approvals, social license to operate, and hydrogen demand.[8]

The latest development and upscaling of demonstrating how to produce hydrogen energy from renewables is in Fukushima Prefecture. The New Energy and Industrial Technology Development Organization (NEDO) leads the **Fukushima Hydrogen Energy Research Field (FH2R)** with Toshiba ESS, Tohoku Electric Power, and Iwatani. The project will be completed in 2020 at Namie town of Fukushima. FH2R can produce as much as 1,200 Nm^3 of hydrogen per hour (rated power operation) or 900 tonnes per year using renewable energy, mainly from some 20 MW of solar PV capacity. Electrolyser capacity stands at a rated power of 6 MW, with maximum power up to 10 MW. Considering solar energy's intermittency, FH2R is integrated with the local power grid. Hydrogen from the project will be used not only for FCEVs but also for stationary power applications. The project is able to power up to 560 fuel cell passenger cars.

The most important challenge is to use the hydrogen energy management system to optimally combine production and storage of hydrogen and the power grid supply–demand balance without using battery storage. Testing will begin to identify the optimal operation control technology that combines power grid demand response with hydrogen supply and demand response, using units of equipment that have their own operating cycles.[9]

The system is developed to undertake economic evaluation of a hydrogen supply chain based on renewable energy. Under current design and market conditions, the system expects economic return from balancing services for the power grid, hydrogen sales, and electricity sales.

The scale of demonstration of hydrogen and fuel cell technologies and hydrogen supply chains has been increasing in Japan. This implies that technologies, supply chains, and infrastructure are not only maturing but also about to become commercially competitive.

[8] https://hydrogenenergysupplychain.com/about-hesc/ (accessed on 12 May 2020)
[9] https://www.nedo.go.jp/english/news/AA5en_100422.html and https://www.nedo.go.jp/content/100899755.pdf (accessed on 12 May 2020)