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Japan: Putting Hydrogen at the Core of its Decarbonization Strategy

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Summary

This chapter reviews Japan's hydrogen strategy with a particular focus on its international elements. It begins by outlining Japan's international commitment to reduce economy-wide greenhouse gas emissions. The chapter then reviews Japan's domestic policy settings designed to support the deployment of hydrogen in power generation, transport, and industrial uses. The chapter then reviews the strategy that the government is using to enable the development of international supply chains to enable the required imports to satisfy projected hydrogen use in the country. It outlines bilateral technology partnerships and international activities within multilateral forums. It concludes with a short discussion of the geopolitical implications of Japan's hydrogen strategy.

Japan has been at the forefront of global efforts to increase the role of hydrogen and ammonia as an option for supporting decarbonization. Japan's government is positioning hydrogen to play a large role in its overall decarbonisation strategy in support of its mid-century, net zero emissions reduction goal. In this context, the Japanese government is supporting the development of technologies on both the supply and demand side, informed by its understanding of feasible decarbonization pathways domestically and the industrial policy opportunities it has identified to promote Japan's technological leadership. Key features of Japan's strategy are the central focus on the need to import hydrogen and ammonia and the emphasis domestically on the use of hydrogen and ammonia co-combustion in existing thermal power generation as a transition technology, which is not emphasised in other countries' national hydrogen strategies.

In addition, the Japanese government is championing hydrogen and ammonia internationally through forums such as AZEC, which includes proposing ammonia as a technology option for reducing emissions from the power sector in the Asia-Pacific. A key near-term focus on the supply-side is testing the feasibility of different technology options for hydrogen transport, based on the strong emphasis on hydrogen and ammonia imports within Japan's hydrogen strategy. Coupled with the potential for exporting technologies for hydrogen use, this suggests that new patterns of trade and investment may emerge, although there remain crucial questions about commercial feasibility in addition to technical challenges. Indeed, Japan's hydrogen strategy is predicated on the ability to build international supply chains at scale. These are currently being enabled by public investment in early-stage projects. These testing different technology options to enable the export of hydrogen to Japan to support domestic decarbonization.

Another challenge lies in unlocking hydrogen demand given that processes using hydrogen and ammonia remain more expensive than alternatives in most cases. A case in point is FCVs, in which consumer demand remains far lower than envisioned. In response, the Japanese government is developing a series of policies to reduce the gap between hydrogen and ammonia and best available technologies. The revised 2023 NHS also signalled a shift towards emphasising Japan's technology leadership in fuel cells and taking a more neutral approach towards end-use sectors. We can expect Japan's national hydrogen strategy to continue to develop in response to the effectiveness of policies implemented domestically and internationally to increase the demand for, and supply of hydrogen and associated vectors.

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Contents

1. Introduction

At the 2019 meeting of the G20 hosted by Japan, energy and environment ministers committed to work to enable hydrogen as a low-carbon source of energy. The enthusiasm of the Japanese government in promoting multilateral cooperation in hydrogen reflected its domestic priorities. The government released a National Hydrogen Strategy in 2017 - the first amongst a large number of hydrogen roadmaps announced globally (International Renewable Energy Agency 2022) - followed by a Hydrogen and Fuel Cell Strategy Roadmap in March 2019 (Government of Japan 2017; Deliberative Council on Hydrogen and Fuel Cells 2019). Japan's hydrogen strategy is distinguished by its strong emphasis on the need to develop international supply chains for hydrogen and related vectors in the near-term in order to enable imports at scale, combined with a focus on the use of hydrogen across multiple sectors, notably in power generation.

This chapter reviews Japan’s hydrogen strategy with a particular focus on its international elements. It begins by outlining Japan’s international commitment to reduce economy-wide greenhouse gas emissions. The chapter then reviews Japan's domestic policy settings designed to support the deployment of hydrogen in power generation, transport, and industrial uses. The chapter then reviews the strategy that the government is using to enable the development of international supply chains to enable the required imports to satisfy projected hydrogen use in the country. It outlines bilateral technology partnerships and international activities within multilateral forums. It concludes with a short discussion of the geopolitical implications of Japan's hydrogen strategy.

2. Hydrogen as an option for domestic decarbonization, energy security and industrial development

The Japanese government submitted an updated Nationally Determined Contribution (NDC) in 2021 under the Paris Agreement of the United Nations Framework Convention on Climate Change (UNFCCC). In doing so, it joined a number of countries in the Asia Pacific region in committing to a net-zero target for economy-wide greenhouse gas emissions (GHG). The government also committed to the mid-term target of reducing GHG emissions on an economy-wide basis by at least 46% by 2030 relative to 2013, equivalent to a 25.4% in emissions reduction relative to 2005. This new mid-term commitment represented a substantial increase in ambition from the 26% emissions reduction commitment for the same time period made in Japan's first NDC submission.

A core challenge facing Japan in achieving its net-zero GHG emissions reduction target is the stagnation of nuclear power within the electricity sector, following the earthquake and nuclear disaster of March 11, 2011. Prior to the disaster, nuclear power was positioned as a core technology enabling decarbonization of the electricity sector while meeting energy security goals at reasonable cost (Government of Japan, 2010). In 2010 nuclear energy represented 15% of Japan's Total Primary Energy Supply (TPES) and 25% of electricity generation. This was reduced to zero in the wake of the disaster. Today Japan’s energy system is dominated by fossil fuels. In 2019 fossil fuels made up 88% of Japan’s TPES and 71% of electricity generation, despite an increase in renewable electricity generation centred on solar photovoltaics and the reentry of some nuclear generation units into service (International Energy Agency, 2021).

The more ambitious GHG emissions reduction commitment triggered a review of the policy settings supporting decarbonisation, including the role of hydrogen and associated energy vectors such as ammonia. Under the 2001 Basic Law on Energy, the Japanese Cabinet is required to review Japan's mid-term energy policy settings every three years through the Basic Energy Strategy (BES). In the 2014 BES the Japanese Cabinet identified a need to conduct a detailed assessment of the potential role of hydrogen as a decarbonization option. Through the 2021 BES, hydrogen and ammonia were then positioned as key long-run solutions to decarbonisation across a wide-range of end-uses, including power-generation, transport, industry, and the commercial and household sectors. Indeed, the 2021 BES establishes a target for hydrogen/ammonia of 1% of generated electricity in 2030 (Government of Japan, 2021; Japan Agency for Natural Resources and Energy 2022). The emphasis on enabling ammonia and hydrogen use in power generation contrasts with the national hydrogen strategies of other countries, which do not emphasise hydrogen and ammonia as fuels in the existing fleet of thermal power stations.

An important justification given for a focus on hydrogen in the energy mix is energy security. The Japanese government has long been concerned about the lack of geographic diversification associated with fossil fuels. Hydrogen is positioned as an energy carrier which can be produced using a variety of energy sources and which can be stored and transported. The current role of hydrogen in the

Japanese economy is nevertheless limited. Around 1.9 million tonnes (Mt) of hydrogen were produced in Japan in 2022, with the majority used on-site within the refining industry. In 2019, the Japanese industry used around 1.08 Mt of ammonia – a vector of hydrogen – with 80 percent produced domestically and the remainder imported, mainly from Indonesia and Malaysia (Japan Agency for Natural Resources and Energy 2022).

A second motivation for supporting hydrogen and ammonia is industry policy (Renewable Energy Institute 2022). Japanese companies are leading holders of patents related to hydrogen production, storage, distribution, and use (International Renewable Energy Agency 2022, 56). The 2023 National Hydrogen Strategy emphasizes Japanese firms' competitive advantage across five areas identified for public support: 1) hydrogen production and related infrastructure in international supply chains; 2) hydrogen and ammonia for use in power generation; 3) fuel cell technologies; 4) the direct use of hydrogen in steel, chemicals, and shipping; 5) e-methane and e-fuels. Japan's industry policy ambitions are supported by quantitative targets, including reducing the cost of alkaline and proton exchange membrane (PEM) electrolysers to ¥52,000 and ¥65,000 per kilowatt respectively by 2030, and securing 15 gigawatts (GW) of electrolyser sales by 2030 domestically and internationally. These targets are backed by public funding programs in research, development, and deployment (Government of Japan 2023).

The government also identifies an export opportunity focused on Southeast Asia, where there is a substantial fleet of coal-fired power generation. The Japanese government foresees a potential global market size of ¥1.7 trillion annually by 2050, with the primary opportunity outside fertiliser production identified as the co-combustion of ammonia in coal-fired power stations. The export opportunity is identified as ¥500 billion of investment in technologies enabling co-combustion, assuming 10% of Southeast Asia's coal plants were retrofitted. In addition, the Japanese government identifies an opportunity for hydrogen in power generation, and aims to accelerate the commercialization of hydrogen power generation turbines domestically and internationally (Government of Japan 2021).

Given the importance placed on energy security and green industrial growth opportunities from hydrogen and ammonia, the Japanese government, led by the Agency for Natural Resources and Energy (ANRE) within the Ministry of Economy, Trade, and Industry (METI), has worked with industry and other stakeholders to establish a mix of policy measures to support their uptake, underpinned by quantity and price targets. This includes embedding hydrogen in a broader suite of green industrial policies (GIPs) developed in support of decarbonization. In December 2020 the government announced a Green Growth Strategy focused on 14 sectors, including hydrogen and ammonia (Government of Japan 2020). Japan's suite of GIPs was updated through legislation that entered into law in June 2023 and which required it to develop a Green Transformation ("GX") Strategy. The GX Strategy identifies hydrogen and ammonia as key technology options that can be flexibly used across power generation, transport and industry and that can contribute to energy security by increasing domestic production and absorbing excess renewable electricity generation. The GX Strategy places particular emphasis on the use of hydrogen and ammonia through co-combustion with fossil fuels in order to reduce CO2 emissions in the power sector (Government of Japan 2023a). In support of this broad vision the GX Strategy proposes ¥7 trillion in research and development (R&D) and infrastructure development support over 10 years, including ¥5 trillion for the building of large scale and resilient supply chains domestically and internationally enabling trade in hydrogen and ammonia. In addition, in 2023 the government revised its National Hydrogen Strategy (NHS). The revised NHS included quantitative targets of 3 Mt of hydrogen and ammonia use annually by 2030, 12 Mt by 2040, and 20 Mt annually by 2050. In addition, it included a 2030 price target of ¥30 per Nm3 (around ¥334/kg), falling to ¥20 per Nm3 by 2050, with the latter set to compete with gas-fired power generation (see table 1 for an overview of Japan's hydrogen-related policy targets). The NHS also emphasised the need to develop Japanese firms' competitive advantage across core technologies in hydrogen and ammonia, including establishing a target for Japanese firms to operate 15 GW of electrolyser capacity domestically and internationally. In July 2023 the government increased state capacity by creating a hydrogen/ammonia-focused division in the Agency for Natural Resources and Energy (ANRE) - Japan's key agency responsible for energy policies - to lead policy implementation.

Table 1: Japan's hydrogen-related policy targets

Target	Year
Price targets	
30 yen/Nm3 of hydrogen	2030
20 yen/Nm3 for hydrogen	2050
52,000 yen/kW for alkaline electrolyzers	2030
65,000 yen/kW for PEM electrolyzers	2030
500,000 yen per commercial & industrial fuel cell unit	2030
Hydrogen consumption and use targets	
3 million tons of domestic hydrogen consumption	2030
12 million tons of domestic hydrogen consumption	2040
20 million tons of domestic hydrogen consumption	2050
1 percent of generated electricity, including 6.7 TWh of hydrogen and 8.2 TWh of ammonia	2030
Technology deployment targets	
15 GW of global electrolyzer capacity deployed by Japanese firms	2030
800,000 equivalent fuel-cell passenger vehicle sales	2030
1000 hydrogen refuelling stations	2030

Source: Authors, based on official government documents.

3. Envisioned end-uses for hydrogen and ammonia

As outlined above, the Japanese government assigns an important role to hydrogen as a vehicle for decarbonizing a number of end-use sectors. This includes not only applications in mobility and industry, but, in contrast to other major economies, also power generation.

3.1 Power generation

The International Energy Agency (2019, 151) projects that the co-firing of ammonia will have a limited role to play as a transitional measure to reduce GHG emissions from coal-fired power plants. The climate benefit of co-combusting ammonia also depends heavily on the hydrogen production technology. Indeed, it has been estimated that the use of unabated natural gas for producing ammonia through steam methane reforming coupled with the Haber Bosch process would not reduce aggregate emissions, once upstream fugitive emissions are taken into account (Stocks et al. 2022). The Japanese government nevertheless assigns hydrogen and ammonia an important role in its decarbonization strategy for the power sector, arguing their use does not create emissions at the point of combustion. Next to the adoption of CCUS technologies, the 2023 NHS envisions ammonia co-combustion as an important option for decarbonizing thermal generation to 2050 (Government of Japan 2023b). Scenario assessments of decarbonization pathways reviewed within ANRE envision a potentially long-term role for hydrogen and ammonia in meeting Japan's Net Zero commitment. In the reference case from the Research Institute of Innovative Technology for the Earth (RITE), hydrogen and ammonia are modelled as making up 21% of the total primary energy supply (TPES) by 2050, including 13% of generated electricity. Other scenarios examined by the government include hydrogen and derivatives, representing from 16% to 26% of TPES by 2050. In the 100% renewable electricity scenario, hydrogen and derivatives range from 20% to 26% of TPES by 2050 (Agency for Natural Resources and Energy 2021a).

In the near to medium term, the government established a target for hydrogen and ammonia to make up around 1% of generated electricity, with hydrogen at 6.7 TWh and ammonia at 8.2 TWh by 2030 (see table 1 above). This is planned through ammonia co-combustion within Japan's existing thermal power generation fleet and the direct use of hydrogen turbines (Agency for Natural Resources and Energy 2021c). The New Energy Development Organisation (NEDO) – Japan's primary energy-related public research organization – funded a three-year demonstration project to support the ammonia co-combustion target – collaborating with electricity utilities to deploy burners capable of injecting ammonia as fuel into the existing coal fleet. Japan's largest operator of thermal power generation, JERA, is responsible for demonstrating the feasibility of 20% co-combustion of ammonia within an existing power generation unit. The demonstration project is in the design phase at the 1000MW 4th unit of the Hekinan power plant in Aichi Prefecture and is expected to operate through June 2024. Commercial operation is planned for the latter half of this decade. JERA is also planning to test the co-combustion of a minimum of 50% of the fuel load beginning with a demonstration phase in fiscal year 2028 and with commercial operation to begin in the first part of the 2030s. The project is being developed with IHI and Mitsubishi Heavy Industries and commenced in 2021 (JERA 2022).

The government is also investing R&D funds in turbine technology with the goal of enabling the direct combustion of hydrogen. Mitsubishi Heavy Industries has a turbine of more than 10MW under development and has developed a burner capable of co-combusting 10% of the fuel load with hydrogen. JERA is also trialling the use of hydrogen within gas generation. A feasibility study, which commenced in October 2021, foresees the construction of hydrogen supply facilities and a burner enabling the co-combustion of hydrogen and LNG in an existing gas turbine, with the intention to begin testing co-combustion of 30% of the gas fuel load on a volumetric basis, or 10% on a heat basis, from FY2025 (JERA 2022). Other electricity utilities are also planning entry into the market for hydrogen technologies. Kansai Electric is intending to participate in hydrogen across the value chain, including production internationally, the operation of hydrogen import facilities and using hydrogen in power generation. It is carrying out a feasibility study utilising funds from NEDO to examine combusting hydrogen in an existing gas turbine, including examining the feasibility of supply, storage, and regasification (Kansai Electric Power Company 2022).

3.2 Mobility

Sectoral policies also target a role for hydrogen and ammonia in transport. A focus has been passenger vehicles, where the Japanese government’s approach to reducing emissions centres on the technology neutral concept of “next generation vehicles” (NGV), defined to include battery electric vehicles (BEV), fuel cell vehicles (FCV) and hybrid vehicles. For FCV, the 2010 NGV strategy established a deployment target of 1% of vehicles on the road by 2020 and 3% by 2030 (Bose Styczynski and Hughes 2019). Deployment rates fell short, however, with FCV sales of passenger vehicles stagnating at around 6,600 units by March 2022 (Japan Agency for Natural Resources and Energy 2022). Implicitly recognising the lack of demand, the 2023 revision to the NHS shifts emphasis to technology leadership in fuel cells and gives priority to commercial vehicles, where more demand for hydrogen is expected and the advantages of FCVs may be more easily exploitable (Government of Japan 2023b). The new strategy targets the equivalent of 800,000 fuel-cell electric vehicle sales by 2030 and introduces a price target of 500,000 yen per commercial or industrial fuel cell by 2030.

The government has argued that one barrier to FCV uptake is the need for fuelling infrastructure. Accordingly, the BES stated the need for public investment in the deployment of hydrogen fuelling stations to help the deployment of FCVs and fuel cell trucks. As of March 2022, 169 hydrogen stations were installed domestically, with a policy target of 1,000 stations by 2030. ANRE provided a subsidy of ¥11 billion in fiscal year 2021 and ¥12 billion in FY2020, covering up to two-thirds of installation costs. Given the high cost of installing hydrogen fuelling stations, an additional cost target was created to reduce the installation cost to ¥200 million per station as the mean 2021 installation cost, down from ¥330 million (Agency for Natural Resources and Energy 2021b).

Additional areas of development are shipping and aviation. The Green Innovation Fund includes ¥35 billion over ten years in R&D support for the development of “zero-emissions” shipping through hydrogen and ammonia-fired engines, including the development of tanks and supply infrastructure, with commercialisation targeted for the latter part of the 2020s (MLIT 2024). Additional funds are allocated to R&D in the use of hydrogen in aircraft.

3.3 Industry

Japan was the fourth largest producer of crude steel in 2021, manufacturing more than 96,000 tonnes of crude steel, which represented around 5% of global production. Japan was also the second largest exporter of semi-finished and finished steel products in the same year, exporting more than 33.7 thousand tonnes of products and a 7.3% share of global exports (World Steel Association 2022a). In 2021 the Nippon Steel Corporation was the 4th largest producer globally, manufacturing around 49.5 Mt of steel. Japan's JFE Steel Corporation was the 13th largest steel manufacturer globally, producing almost

27 Mt of steel in the same year (World Steel Association 2022b).

Steel is the largest emitter of carbon dioxide within the Japanese industrial sector, and hydrogen is being tested as a technology for reducing marginal emissions from the sector. The primary initiative for reducing CO2 emissions is the industry-led CO2 Ultimate Reduction System for Cool Earth 50 (COURSE50), supported by NEDO and involving Nippon Steel, JFE, Kobelco, and Nippon Steel Engineering. COURSE50 is implemented through a series of five-year plans beginning in 2008 and is supported by GX investments. Near-term measures focus on improving the efficiency of the steel manufacturing process. In the medium-term hydrogen is proposed to be used in the process for reducing iron ore, cutting CO2 emissions from the blast furnace through the injection of hydrogen as a partial substitute for coking coal. Carbon dioxide would then be separated from the blast furnace gas, with a target of reducing 30% of carbon dioxide emissions from steelmaking by 2030 relative to a 2013 baseline (Agency for Natural Resources and Energy 2021c). Longer-term research and development spending focuses on the direct reduction of iron using hydrogen (H2-DRI). Given the cost implications if importing large quantities of hydrogen, a further option is to relocate iron-making processes to countries that have abundant and low-cost sources of renewable energy available for use in green hydrogen production (Devlin and Yang 2022), although this option is not currently being considered by the government. In contrast to power generation and mobility, Japan has not set any quantitative policy targets for hydrogen use in the industrial sector.

4. Supplying hydrogen and ammonia

Japan has historically been almost wholly reliant on trade to supply the energy commodities, chiefly oil, coal, and gas, used as inputs into economic activities (Government of Japan 2023c). From an energy security perspective Japan's National Hydrogen Strategy supports the domestic production of hydrogen, potentially through the use of otherwise curtailed renewable electricity. However, it does not identify a national target for domestic hydrogen production. Instead, the strategy targets the deployment of 15 GW of global electrolyzer capacity by Japanese firms by 2030, without prioritizing domestic deployment. To realize this goal, it has adopted the Hydrogen Society Promotion Act, which includes a scheme to provide a 15-year subsidy for so-called low-carbon hydrogen, produced either domestically or abroad.

In line with this, the Japanese government expects the availability of domestically produced hydrogen to be insufficient to meet the policy target of up to 3 million tonnes of hydrogen demand by 2030, 12 million tonnes by 2040, and 20 million tonnes by 2050 (Government of Japan 2023b). As a result, the promotion of international supply chains plays a central role in the hydrogen strategy. The government is taking a technology agnostic approach towards hydrogen production when supporting the development and testing of supply chains for hydrogen. Whilst the substitution of hydrogen and ammonia for emissions intensive processes within Japan results in a reduction of emissions domestically regardless of production method, the government is taking an interest in shaping the rules governing the emissions intensity of hydrogen through global technical regulations under the International Partnership for Hydrogen and Fuel Cells in the Economy and other forums (see below). This includes committing to introducing an emissions intensity standard domestically that is broadly consistent with those adopted by other countries.

4.1 Developing global supply chains for hydrogen

International trade plays a central role in Japan's hydrogen strategy, requiring large capital investments in transport technologies such as transforming hydrogen from gaseous form into liquid hydrogen, the use of ammonia, or the use of a liquid organic hydrogen carrier such as methylcyclohexane (MCH). A core focus of government policy is building supply chains for hydrogen and ammonia as internationally traded commodities, making Japan's GIP in support of hydrogen interdependent with those of other countries (Meckling and Hughes 2018). Japanese government and industry are pursuing bilateral partnerships with the aim of testing the techno-economic feasibility of different hydrogen transport technology pathways. The International Renewable Energy Agency (2022) notes there are important geopolitical implications that emerge from the construction of new value chains in hydrogen. An interesting feature of efforts to build international supply chains is that some are occurring through partnerships with countries with which Japan currently trades energy-related commodities.

An additional issue relevant to trade in hydrogen is how to manage the emissions embedded in hydrogen and derivatives such as ammonia, as these can vary substantially depending on the production technology. The International Partnership for Hydrogen and Fuel Cells in the Economy (IPHE) has played a role as an intergovernmental forum, and the Japanese government has been a member of the taskforces focused on developing a common method for calculating embedded emissions and low emissions hydrogen certification, and focused on trade rules. It has also engaged in dialogue with the European Union, signing It has also contributed to the taskforce on skills development, along with IPHE working groups on education and outreach, regulations, codes and standards.

From 2019 the IPHE Hydrogen Production Analysis Task Force worked to develop a common methodology for determining emissions intensities of different hydrogen production technologies that could form the foundations for a certification scheme, while leaving emissions intensity thresholds for national governments to determine. The 2023 NHS revision notes the government intends to adopt an approach to measuring hydrogen emissions intensity that is aligned with methodologies developed through the IPHE. It also proposes using a Well-to-Production-Gate method for calculating emissions embedded in hydrogen, with a standard of 3.4kg/CO2e, set for defining hydrogen as low emissions, and using a Gate-to-Gate approach for ammonia (including the emissions from hydrogen production) with low ammonia proposed to be defined as below 0.84kg/CO2e/kg-NH3.

4.2 Bilateral partnerships

The Japanese government is taking a technology-agnostic approach to hydrogen production and transport technologies and is testing different approaches through supporting a series of bilateral partnerships, financed by the GI Fund with up to ¥300 billion. The government has also increased its capacity for delivering on hydrogen and ammonia projects. The Japan Organization for Metals and Energy Security (JOGMEC) supports early project development in natural resources, and in 2022 the law governing JOGMEC was revised to broaden the scope of investment and loan guarantees to include hydrogen and ammonia. A unit focused on hydrogen and carbon, capture and storage (CCS) was also established to facilitate lending. Through the new structure, JOGMEC can provide lending of up to 50% of capital requirements, and up to 3/4 of total capital requirements to companies building hydrogen/ammonia production and storage facilities for projects identified as nationally significant. It can also provide loan guarantees to companies that obtain private sector financing. The Japan Bank for International Cooperation (JBIC) also reorganised internally in 2022, creating an Energy Transformation Strategy Office to invest in hydrogen and ammonia.

A key strategy incorporated in the NHS is the testing of different hydrogen carriers in international supply chains through to 2025. Liquid hydrogen is being tested at a demonstration scale through the Hydrogen Energy Supply Chain (HESC) project, involving Japanese and Australian partners. On the Japanese side, it is financed through the Hydrogen Energy Supply-chain Technology Research Association “HySTRA” project, which has included Shell Japan, Iwatani Corporation, Kawasaki Heavy Industries, J-Power (2016-2023), Marubeni Corporation (2016-2023), ENEOS Corporation(2016-2023), and Kawasaki Kisen (2019-2023). The project is examining the feasibility of shipping liquid hydrogen produced via coal gasification from Latrobe Valley in the Australian State of Victoria to Japan using dedicated shipping technology. In Japan, a receiving terminal in Kobe Port was completed in June 2020, and regasification infrastructure was finished in October 2020. Subsequent steps include construction of storage tanks, an increase of the carrying capability of the dedicated tanker and testing of direct hydrogen combustion (Japan Agency for Natural Resources and Energy 2022). The project has committed to commercialisation only with the application of CCS. Any residual emissions from the hydrogen production process would be accounted for under Australia’s emissions commitments, given national accounting for carbon emissions under UNFCCC processes.

A second project led by Chiyoda Corporation and subsidised by NEDO examines the feasibility of MCH as a liquid organic hydrogen carrier for transportation, in partnership with Brunei. Mitsubishi Corp and Mitsui Corp are participating in the demonstration project, in addition to the shipping company NYK Line. Under the project hydrogen is extracted from methane using SMR and combined with Toluene (C7H8) before being shipped and dehydrogenated. The technology is being championed by Chiyoda Corporation under the SPERA Hydrogen label.

There are a number of other projects examining the commerciality of long-range transport of hydrogen and ammonia. Tokyo Gas and Osaka Gas are examining the possibility of enabling hydrogen transport through methanation, in which hydrogen is reacted with CO2 to produce synthetic methane. Osaka Gas has developed a test facility with Japanese energy sub-major INPEX, with costs partly offset by NEDO. The demonstration project will begin operations in FY2024, with the syngas used in the local gas supply network. If the project is successful, INPEX has announced the next phase will seek to demonstrate the feasibility of methanation at a commercial scale outside Japan. A pre-feasibility, commercial-scale study has been announced between INPEX and Australia's Commonwealth Scientific and Industrial Research Organisation (CSIRO), as part of the Japan-Australia Carbon Recycling Co-operation Memorandum signed between the two governments in 2019. Feasibility studies are also being conducted with Japanese companies and partners in Malaysia, North America, and the Middle East (Japan Agency for Natural Resources and Energy 2022).

Mitsui is also conducting a feasibility study for a project in Western Australia that would produce one million tonnes of ammonia annually and is proposing to use depleted gas wells for storing CO2. The project is being considered with Australian company Wesfarmers, with final investment decision expected in 2025 (Mitsui and Company 2022). Mitsui is also developing an ammonia project in Louisiana, United States, in partnership with ammonia producer CF Industries, signing a post-feasibility study, front-end engineering design (FEED) contract in November 2022. The ammonia would be produced using methane and CCS, with an offtake agreement with ExxonMobil completed and the intention to begin production and marketing from 2027 (Mitsui and Company 2022).

Additional studies and demonstration projects are under way with the goal of testing the feasibility of international transport of hydrogen and ammonia at scale. Kansai Electric is carrying out a feasibility study for the development of green hydrogen supply chain between Japan and Australia, partnering with the Iwatani industries, Kawasaki Heavy Industries, Australia's Stanwell Corporation, and others. Idemitsu Corporation is testing the feasibility of a hydrogen supply chain in the United Arab Emirates (UAE) using hydrogen produced from methane, with the waste CO2 from the SMR process captured and used in enhanced oil recovery (EOR). Idemitsu Renewable Development Australia is also examining the feasibility of hydrogen exports through the Port of Newcastle Hydrogen Hub in Australia (Idemitsu 2022).

International partnerships at the project level are supplemented by a growing number of bilateral agreements between public entities. JBIC has been particularly active, signing more than 20 Memoranda of Understanding (MoU) related to hydrogen by January 2024 with a wide array of governments and public bodies internationally, including the Clean Energy Finance Corporation (Australia), The Chilean Ministry of Energy, the Inter-American Development Back, Indonesian state-owned oil and gas company PT Pertamina (Indonesia), UK Export Finance, the state government of Western Australia, and others. JOGMEC has also signed hydrogen-related agreements with PetroVietnam, Saudi Aramco, Petronas, PT Pertamina, and others. In April 2021 the governments of Japan and the UAE signed a memorandum of understanding (MoU) focused on cooperation in hydrogen. The MoU focus on information sharing on policy settings, including regulation and standards, as well as reaching agreement on the need to support the development of a hydrogen supply chain. In November 2022, JOGMEC Signed a MoU with the Vietnamese national oil company PetroVietnam that includes facilitating opportunities to explore ammonia and hydrogen production, along Carbon Capture, Use and Storage (CCUS) opportunities between the two countries. In December 2022, JOGMEC has also signed a memorandum of understanding with the state government of WA that is designed to facilitate investments in hydrogen and ammonia, in addition to other technologies.

In addition, the Japanese government has signed a number of inter-governmental agreements, with primary focus on information sharing rather than project development. Since the 2019 NHS the government has announced bilateral arrangements involving hydrogen with the United Arab Emirates

(2021), Brunei Darussalam (2022), Singapore (2022), the European Commission (2022), Chile (2023), and Saudi Arabia (2023).

Notably, in February 2024 the Director-General of Japan's Energy Conservation and Renewable Energy Department, Agency for Natural Resources and Energy, METI, and the Director-General, of the Hydrogen Economy Policy Bureau, at South Korea's Ministry of Trade, industry and Energy also agreed to establish a bilateral dialogue on hydrogen and ammonia to facilitate cooperation. In June 2024, Japan and the EU announced an agreement to deepen exchange on hydrogen support policies, to promote the harmonization of standards and regulations on hydrogen, including electrolysers, large-scale liquefied hydrogen tanks, refuelling infrastructure for heavy duty vehicles and jointly support open and rules-based hydrogen trade.

4.3 Shaping hydrogen governance through multilateral forums

A second component of Japan's international hydrogen strategy is supporting the uptake of hydrogen and ammonia as decarbonization options in multilateral forums. The G7 Climate, Energy and Environment Ministers Joint Communiqué in 2023, when Japan was host, identified the potential role of hydrogen in decarbonizing hard-to-abate sectors. Notably, the final draft stated the use of hydrogen and ammonia in thermal power generation should be aligned with a 1.5 degree Celsius pathway, with the goal of achieving a predominantly decarbonized power sector by 2035. The conditional nature of the statement reportedly reflected concerns from other governments about the use of hydrogen and ammonia as decarbonization options in the power sector being championed by the Japanese government (Yamazaki and Abnett 2023).

In addition to the IPHE (see above), a key initiative pioneered by the Japanese government is the Asia Zero Emissions Community (AZEC), announced in 2022 by the Kishida Administration as a Japan-led multilateral program focused on Asia-Pacific region. The first ministerial meeting under the AZEC banner was held in March 2023 in Tokyo, with representation from Australia, Brunei, Cambodia, Indonesia, Laos, Malaysia, the Philippines, Singapore, Thailand, and Vietnam. The ministerial statement released noted there are "various and practical pathways toward carbon neutrality/net-zero emissions depending on the circumstances of each country" and that the AZEC initiative promotes cooperation in decarbonization strategies and technologies including hydrogen and ammonia. An important initiative within AZEC is the Public-Private Investment Forum. At the ministerial meeting, Memoranda of Understanding were announced under the AZEC initiative, of which many focused on bilateral collaboration in the power sector, with some focusing on the potential for ammonia co-combustion regionally. An MoU was signed between Japanese firm IHI and Pupuk Indonesia, for example, to carry out a technical study and feasibility assessment for the construction of a green ammonia production plant at a fertiliser facility near Surabaya in Indonesia, coupled with a technical study on the potential to co-combust ammonia in the existing coal-fired power plant at the location. Another announcement was signed between Japanese companies Mitsubishi Corporation (Thailand), Chiyoda Corporation, and Mitsui OSK lines, with the Electricity Generating Authority of Thailand (EGAT) to jointly study the development of a supply chain for ammonia and hydrogen in Thailand's southern provinces, including production, storage, transport, and utilisation.

5. Conclusion

Japan has been at the forefront of global efforts to increase the role of hydrogen and ammonia as an option for supporting decarbonization. Japan's government is positioning hydrogen as playing a large role in its overall decarbonisation strategy in support of its mid-century, net zero emissions reduction goal. In this context, the Japanese government is supporting the development of technologies on both the supply and demand side, informed by its understanding of feasible decarbonization pathways domestically and the industrial policy opportunities it has identified to promote Japan's technological leadership. Key features of Japan's strategy are the central focus on the need to import hydrogen and ammonia. and the emphasis domestically on the use of hydrogen and ammonia co-combustion in existing thermal power generation as a transition technology, which is not emphasised in other countries' national hydrogen strategies.

In addition, the Japanese government is championing hydrogen and ammonia internationally through forums such as AZEC, which includes proposing ammonia as a technology option for reducing emissions from the power sector in the Asia-Pacific. A key near-term focus on the supply-side is testing the feasibility of different technology options for hydrogen transport, based on the strong emphasis on hydrogen and ammonia imports within Japan's hydrogen strategy. Coupled with the potential for exporting technologies for hydrogen use, this suggests that new patterns of trade and investment may emerge, although there remain crucial questions about commercial feasibility in addition to technical challenges. Indeed, Japan's hydrogen strategy is predicated on the ability to build international supply chains at scale. These are currently being enabled by public investment in early-stage projects. These testing different technology options to enable the export of hydrogen to Japan to support domestic decarbonization.

Another challenge lies in unlocking hydrogen demand given that processes using hydrogen and ammonia remain more expensive than alternatives in most cases. A case in point is FCVs, in which consumer demand remains far lower than envisioned. In response, the Japanese government is developing a series of policies to reduce the gap between hydrogen and ammonia and best available technologies. The revised 2023 NHS also signalled a shift towards emphasising Japan's technology leadership in fuel cells and taking a more neutral approach towards end-use sectors. We can expect Japan's national hydrogen strategy to continue to develop in response to the effectiveness of policies implemented domestically and internationally to increase the demand for, and supply of hydrogen and associated vectors.

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