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JAPAN–EU COOPERATION IN THE DEVELOPMENT OF HYDROGEN-BASED ECONOMY

Abstract

- *Goal* – the paper aims to identify the main areas and motives for Japan–EU cooperation in the development of a hydrogen-based economy.
- *Research methodology* – text analysis of governmental documents, institutional reports, companies' websites, and articles in the specialized press.
- *Score/results* – the example of several Japanese companies shows that Japan–EU cooperation has been intensifying, mostly in hydrogen-based mobility in Europe, natural gas transformation and supply in Japan, and renewable hydrogen generation in the EU and Japan. Japanese companies seek new markets and competition to advance and popularize their technologies. The ability to comply with the EU environmental regulations makes them a significant player in global efforts to accelerate GHG emissions reduction.
- *Originality/value* – the research on international cooperation in hydrogen is scarce but crucial. The development of a hydrogen-based economy will change both economic and geopolitical dynamics, which is especially important in the face of the economic consequences of Russia's invasion of Ukraine.

Keywords: cooperation, EU, hydrogen technologies, hydrogen-based economy, Japan.

1. Introduction

Japan depends on foreign fossil fuels, 94 percent of its primary energy supply comes from imports. Japan's energy self-sufficiency rate remains at a low level of 6–7 percent [IEA, 2020]. Due to its geographical characteristics, renewable energy in Japan is scarce. Moreover, the energy supply issue has worsened since the Fukushima nuclear disaster in 2011, after which nuclear power plants were closed. As a consequence, hydrogen has again gained interest. During his second term, Prime Minister Shinzo Abe announced that Japan would become the first hydrogen-based society in the world. At the same time, the European Union has been tightening its environmental regulations, setting new global standards for the industry and consumers.

The current situation related to Russia's invasion of Ukraine puts pressure on both Europe and Japan to look for substitutes for Russian raw materials. This creates new opportunities for cooperation, notably in the area of the development of a hydrogen-based economy. This paper aims to identify the main motives for Japan–EU cooperation in the development of a hydrogen-based economy and to examine how the EU and Japan's national policies shape this cooperation. The analysis draws on data from governmental documents, institutional reports, companies' websites, articles from the specialized press, and others.

2. Overview of hydrogen policies in the EU and Japan

1.1. Hydrogen-related policies in Japan

Due to the closure of nuclear power plants after the Fukushima disaster and the resulting issues with energy supplies, coupled with the global move toward a decarbonized economy, Japan has returned to its concept of hydrogen as a viable source of energy in the economy. In 2014, the government mentioned in its *Strategic Energy Plan* the idea of a society in which hydrogen is a major energy source and in which hydrogen-based products such as fuel vehicles, buses, trains, etc. are widely used in the economy. This was followed by a document called the *Strategic Roadmap for Hydrogen and Fuel Cells*, also published in 2014, which presented the three phases of hydrogen implementation in the society and economy.

In 2017, Japan announced the first world hydrogen strategy, *Basic Hydrogen Strategy*, and declared that it would become a "world-leading hydrogen-based society" [METI, 2017]. In 2019, along with the document the *Strategy for Developing Hydrogen and Fuel Cell Technologies,* Japan made it officially known that it would grow into the world's leading fuel cell exporter. Japan has intensified its activity in hydrogen supply chain projects and accelerated its hydrogen technologies with a clear target of hydrogen cost reduction. Moreover, in formulating policies, the government focused on building energy independence, industrial competitiveness, and decarbonization, marking an evident turn towards clean hydrogen technologies. Fuel cells, hydrogen supply chains, and water electrolysis were named the three key areas of technology development for hydrogen-based society implementation.

On top of that, in 2020 PM Yoshihide Suga announced the *Green Growth Strategy for 2050 Carbon Neutrality* (2020), an ambitious plan to reduce GHG emissions to net-zero by 2050. To support the efforts, the Ministry of Economy, Trade and Industry (METI) established the Green Innovation Fund (2021) playing the role of major funding for hydrogen-related projects.

1.2. Recent hydrogen policies in the EU

The *European Green Deal,* presented in 2019 and adopted in the following year, stated that hydrogen has been crucial for realizing a clean and circular economy. It communicates priority areas such as "clean hydrogen, fuel cells and other alternative fuels, energy storage, and carbon capture, storage and utilisation" (fch.europa.eu). Cooperation with industry and member states is viewed as a crucial factor in advancing research and innovation on clean hydrogen and transport in general.

The *EU Hydrogen Strategy for Climate Neutral Europe* was adopted in July 2020. The document sets new targes as to the capacity of hydrogen electrolytic cells and for the generation of green hydrogen to reach at least 6GW and 1 million tons by 2024 and 40GW and 10 million tons by 2030 [EC, 2020: 5–6]. Currently, only 2 percent of Europe's energy consumption is supplied by hydrogen, mostly used for the production of chemical products, plastics and fertilizers. 96 percent of this hydrogen is generated from natural gas, in a process that emits a substantial quantity of CO_2 [EC, 2021]. Recent EU policies have been promoting hydrogen created from renewable sources, by means of electrolyzers. Europe prides itself on the technical capabilities in electrolyzer manufacturing. The emerging specialization is expected to create new jobs, stimulate economic growth and help the EU to recover from the COVID-19 crisis.

Fit for 55 package proposed in 2021 sets the framework for hydrogen-based economy development in the EU. It covers such sectors as industry, transportation, and aviation, introducing instruments to support hydrogen upscaling and innovation, including the *ETS Innovation Fund,* which focuses on the production and use of hydrogen. It also gives a stimulus to the progress of hydrogen infrastructure building by e.g. setting the requirement for hydrogen refueling stations availability at "every 150 km on highways for compressed hydrogen and every 450 km for liquid hydrogen by 2030" [James, 2021]. Also, according to the package which guarantees green hydrogen use in transportation, fuel cell vehicles classify as zero-emission vehicles. The package constitutes an action plan for the EU hydrogen market. The entity responsible for the promotion of investment in the European clean hydrogen value chain is the Clean Hydrogen Joint Undertaking (JU), a partnership formed by the Clean Hydrogen Partnership, European Commission, and Hydrogen Europe.

Finally, after Russia's invasion of Ukraine, the European Commission announced a plan to escape from Russian fossil fuels, the *REPowerEU Plan*. The newly established energy platform would facilitate the common purchasing of green hydrogen. Further, the EU External Energy Strategy would assist in building partnerships "including cooperation on hydrogen or other green technologies" [EC, 2022]. If implemented successfully, the EU "would see to quadruple the supply of hydrogen by 2030" [Plhák, 2022].

3. Institutional background for the EU–Japan cooperation in hydrogen

In 2018 the EU and Japan signed two documents, the *EU–Japan Economic Partnership Agreement* (*EPA*), which entered into force in February 2019 opening a new era for the EU and Japan (thejapantimes.co.jp, 2019), and the *EU–Japan Strategic Partnership Agreement* (*SPA*). Among others, the EPA unifies procedures that block entry to the car market, including fuel cell vehicle-related regulations. FCVs approved by European authorities will be authorized by Japanese authorities, enabling the parties to export such cars without any technical adjustments [Frenkel, Walter, 2017]. The SPA establishes an outline covering 40 areas of collaboration but the objective defined in the agreement is "more abstract" [Sekine, 2020]. Apart from "economic synergy or industrial reliance" the document underscores "values" and "principles", which suggests that the EU and Japan aspire to recognize the partnership "as a new soft-power reliance lasting over many decades" [ibidem]. Article 17 on industrial cooperation instructs to exchange views and best practices on industrial policies in innovation, climate change, energy efficiency, and facilitate the bilateral collaboration of enterprises

[*SPA Agreement*, 17]. Article 26 on energy guides toward "close coordination in international organisations", including "global energy trade and investment" and "energy-related technologies" [ibidem, 23].

Besides the EPA and SPA, the EU and Japan established the *Partnership on Sustainable Connectivity and Quality Infrastructure between the European Union and Japan (Connectivity Partnership)* in September 2019. In Point 8 of the document, the EU and Japan guarantee to cooperate further on "hydrogen and fuel cells, electricity markets regulation and the global market for liquefied natural gas (LNG) and support sustainable energy connectivity" [*The Partnership*, 2]. The two parties would "discuss sustainable energy infrastructure investments, with a view to strengthening […] energy innovation in order to facilitate the transformation to low-carbon energy systems" [ibidem, 3]. Europe may help Japan in reforming its electricity grid, while the EU can learn from Japan moving forward the hydrogen economy [Midford, 2021]. The EPA and SPA signed between the EU and Japan, along with Connectivity Partnership "form a solid basis for joint action" [Flor, 2021].

In the *Joint Statement EU–Japan Summit 2022* the partners declared to cooperate to diversify Europe's energy supply sources, increase its independence from Russia, "and acknowledge the need for investments to achieve this" [European Council, 2022]. They stress the role of low carbon hydrogen and confirmed that the Memorandum of Cooperation on hydrogen has been in progress, but also underscored the meaning of natural gas in the energy transition. To foster the EU–Japan collaboration, the parties have opened negotiations on Japan's association to the Horizon Europe Research & Innovation Framework Programme. Horizon Europe association would give Japan's researchers access to billions of Euros for research on an equal basis with EU counterparts [ibidem].

4. Japanese and European companies' cooperation in hydrogen-related technologies

Key areas for the cooperation between Japanese and European companies lie in the development of fuel cell technology and all parts of the (green) hydrogen supply chain. The challenge in hydrogen research, however, is to carefully govern the "regulatory framework, joint promotion of technological innovation and implementation of supply chains" [Sekine, 2020], all to accelerate the deployment and use of hydrogen. Japanese firms have been advancing innovation in particular hydrogen specializations, building their competitive advantage in fierce global competition. At the same time in Europe, it is players like German Siemens, who are at the heart of hydrogen strategy and who make efforts to integrate the whole hydrogen value chain [Tachino, Yabuuchi, 2021]. Japan is a laggard in terms of renewable energy, as it is estimated that it would increase the cost of green hydrogen generation approx. 10 times compared to the current price of hydrogen [Nikkei Asia, 2021b]. From Japan's point of view, cheaper green hydrogen is only possible when considerable investments are made in CO_2 capture technology, hydrogen plants, carriers and import terminals [ibidem]. Among the Japanese companies that lead the advancement of hydrogen-related technologies, there are: Iwatani Corporation, which produces 70 percent of liquid hydrogen in Japan [Nikkei Asia 2021a], Kawasaki Heavy Industry, Mitsubishi Corporation, Mitsui & Co., Ltd., Toshiba Energy Systems & Solutions Corporation, and Toyota Motor Corporation, all placing hydrogen as a promising source of energy in future.

According to WIPO [2022: 19], companies account for 77 percent of patent filings in fuel cell-related technologies in general. In FC technologies for transportation, Japan is the second inventor (22 percent in 2019) after China (42 percent in 2019), and Germany is the third one with the share of 14 percent of patent filing. China, Japan, Germany, the Republic of Korea, and the U.S. are the top five inventor origin responsible for 94 percent of total filings [ibidem, 37]. The most appealing markets for the Japanese companies are the key global hydrogen technology players being Japan itself, China, the U. S., Germany, and the Republic of Korea [ibidem, 46]. Toyota is an unquestioned leader in FCs for transportation "with 2,720 active patent families in 2021, followed by Hyundai (1,402), Honda (1,191), General Motors (GM) (697), and VW Group (671)" [ibidem, 47].

Toyota's flagship fuel cell vehicle Mirai was introduced into the market in 2014. Despite its cost of USD 49,500 [Omoto, 2021], its sales in Europe have been growing, reaching 692 units in 2021, compared to 132 in 2017 (carsalesbase.com). Toyota Motor predicts that global fuel cell system sales will grow 10-fold in the short term [Toyota, 2021a]. Along with expectations, Toyota decided on producing, starting in January 2022, its new second-generation fuel cell modules at Toyota Motor Europe's (TME) Research and Development facility, in Zaventem, Brussels [Toyota, 2021b]. Moreover, as early as 2013, Toyota established a fuel cell vehicle alliance with BMW to stimulate the manufacturing of hydrogen vehicles by competition, releasing its patents on fuel cell technologies [Sugimoto, 2015]. Toyota's partner believes that FCVs may benefit from consistent public policy support for industrializing the generation of hydrogen. Co-development of FCVs will also help BMW to economize by reducing its portfolio of models [Reuters, 2020]. TME has also engaged in a three-party partnership with Air Liquide, French industrial gas supplier, and CaetanoBus to, besides contributing to the greening of transport, “accelerate the development of local hydrogen ecosystems for multiple mobility applications” [Toyota, 2022]. The partners signed a Memorandum of Understanding in May 2022. The companies will collaborate to spread hydrogen mobility in both segments of light and heavy-duty trucks by deploying vehicle fleets and infrastructure development.

Also Japanese trading company Itochu has united efforts with Air Liquide. The companies announced to develop one of the largest liquid hydrogen plants in the world, located in central Japan [Nikkei Asia, 2021a]. The plant will deliver liquid hydrogen out of liquefied natural gas, the so-called blue hydrogen, supplied for power generation and as a fuel for FCVs. Apart from this project, Itochu and Air Liquide established a strategic partnership agreement to build a new gas supply network in Japan.

In 2020, Mitsubishi Power Europe was commissioned to supply the first Solid Oxide Fuel Cell (SOFC), a power generating system, in Europe [Mitsubishi, 2020]. The demonstration plant operated by the Gas- und Wärme-Institut Essen e.V. (GWI) is located in Essen. The project is called “a milestone in resource-saving energy technology” and GWI calls itself “technology-open energy institute” that together with its all stakeholders shapes the energy future [Mitsubishi, 2021b]. In May 2021 HydrogenPro (HYPRO), H2V Industry and Mitsubishi Power Europe signed a MoU establishing a consortium focused on the development of green industrial hydrogen projects. H2V Industry belongs to the French Samfi Invest group and is a major player in hydrogen in France. H2V Industry has been involved in plural green industrial-scale hydrogen projects. The one with Mistubishi HydrogenPro has been commissioned to deliver the electrolyzer installations for the sites [Mitsubishi, 2021a].

Moreover, in April 2022, Mitsui & Co., Ltd. invested 10 million euro in Lhyfe, a French producer of green hydrogen for local consumption [Mitsui, 2022]. Lhyfe is present in ten European countries, and its more than 90 pipeline projects across 11 countries will start production between 2022 and 2028. French company targets mobility and industry usage. Thanks to the investment Mitsui “will become an insider in the European hydrogen market”, and will be able to “develop customers and leveraging synergies with its existing hydrogen-related business” [ibidem]. Mitsui also plans to set up “a hydrogen profit base in Europe” and, through its active role in developing the European green hydrogen industry, support speeding up GHG emissions reduction.

The same month 2022 Kawasaki Heavy Industries and Airbus have signed a MoU to cooperate on the formation of the hydrogen-based ecosystem. It will contain different parts of the hydrogen supply chain for airports and onboard aircraft. The companies declared formulating a roadmap to support and respond to hydrogen aviation needs. The partners "will also pioneer the deployment of a hydrogen infrastructure for aviation with a particular focus on the development of Airport Hydrogen Hubs" [Airbus, 2022].

Last but not least, in 2021 Siemens Energy K.K., the Japanese subsidiary of Siemens Energy AG, and Toray Industries, Inc. joined the Green Hydrogen Project in Japan, funded by Green Innovation Funding Program managed by METI and NEDO. In Japan, the two companies will collaborate on the "development and demonstration of the largest multi-megawatt class PEM" (Polymer Electrolyte Membrane) electrolysis with Toray's new membrane technology [Toray, 2021]). In the EU Siemens has been developing water electrolysis equipment, which is the core of the value chain in the green hydrogen generation. The company is said to aim to become the champion of the European hydrogen industry by building a new value chain centered on water electrolyzers [Tachino, Yabuuchi, 2021].

5. Conclusions

For Japan, a major future importer of hydrogen, further advancements in hydrogen-related technologies, its storage, and transportation are critical. Currently, as hydrogen is mostly produced from fossil fuels, primarily natural gas, the government needs to rely on the usage of advanced emission reduction technologies, such as CO_2 Capture and Storage (CCS), and Carbon Capture and Utilisation (CCU), to be able to call the process "low-carbon" or even "clean". On the other hand, the EU focuses on clean, i.e. renewable hydrogen, resourced from renewable energy. The definition of low carbon hydrogen is yet to be established [European Clean…, 3].

The price of green hydrogen depends on the cost of electrolysers and the cost of renewable electricity [DeLorenzo, 2022]. The EU sees three barriers to scaling up the manufacturing capacity of electrolyzers: deficient regulations in favour of the large-scale deployment of hydrogen, large investment due to uncertainty as to the future demand for electrolysers, and creation of integrated supply chains and the risks associated with the availability of components and raw materials for that purpose [European Clean…, 2]. The EU and member states have been working on a favourable regulatory framework and have presented ambitious plans for developing hydrogen infrastructure across Europe. "An integrated European electrolyser supply chain is only emerging" ([ibidem, 5], and Japanese companies set the grounds for expansion in this field.

There are several differences between the EU and Japan in the approach to hydrogen. First, in contrast to the EU, renewable energy in Japan is scarce, hence greater interest in fossil fuels-based hydrogen generation with the use of CCS/CCU. While Japan is focused on becoming a leading exporter of hydrogen technology in the world, the EU seems more determined to promote and lay the foundation for a net zero-emission economy, playing the role of a major rule-maker of environmental norms. As Japan is not self-sufficient in terms of hydrogen production, it is being pushed towards cooperation with other countries in creating new hydrogen supply chains based on diversified technologies. EU is an attractive partner due to its advanced renewable hydrogen generation and water electrolyzer technologies. Its varied internal market, infrastructure, and companies' competitiveness allow for bringing in and developing new technologies, like new FC modules or SOFC systems.

In the face of war in Ukraine and the suspension of energy supplies from Russia, the development of energy infrastructure for the transport of hydrogen by sea may become a reliable way for the EU to increase the security of supplies and reduce the risk for companies willing to invest in the hydrogen market [Ruszel, 2022: 16]. Large and successful projects run by Japanese companies in Asia make their experience priceless. Also, if Japan's position in Asian hydrogen value chains settles, the country will undoubtedly be a key player in the new production structures.

Japan may soon be granted access to substantial funds within the Horizon framework. Individual member states also offer financial support for international partnerships for the development of a hydrogen-based economy. Such incentives would accelerate collaboration in green hydrogen technology advancement, especially since Japanese companies are already cooperating with leading European firms. They have become "insiders" to the EU market, have access to the member states' markets, and are able to test their hydrogen-related technologies against high environmental standards. They may also leverage their first-mover advantage in clean hydrogen in other regions, notably in Asia.

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