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Japan's Green Energy Strategy

1. Introduction

Following the "Japan's Green Transformation and Its Relationship with Europe", the EIJS Policy Brief of August 2024, this brief explores Japan's electric power energy strategy in greater depth from the perspective of the service ecosystem[1], focusing on current and challenges.

Japan's electricity supply has traditionally been managed by an integrated system of generation, transmission, and distribution by nine regional private electric power companies since 1951 (later expanded to ten with the inclusion of Okinawa Electric Power). However, since 1995, gradual electricity system reforms have led to the liberalization of generation and retail sectors, as well as the separation of the generation and transmission divisions. Due to the liberalization of generation and retail, many companies have entered the market, with 698 retailers and 942 generators as of December 2020. The current basic structure of electricity supply is: "fuel-producing countries → power generators → transmission and distribution companies → retailers → users (including businesses and individuals)."

Most new entrants are small-scale, and as of April 2024, the top performer, JERA (a joint venture equally owned by Tokyo Electric Power Fuel & Power and Chubu Electric Power), generated 14,902,594 thousand kW, accounting for about 30% of the total, followed by Kansai Electric Power Company (KEPCO) with 8,265,674 thousand kW, about 20% (ANRE, 2024).

1 The concept of a service ecosystem was proposed by Lusch&Vargo et.al in 2014 within the context of service research. It views the mechanism through which value co-creation emerges in services as an ecosystem. Instead of the traditional dyadic relationship between service providers and recipients, it is based on a network structure comprising three layers: macro, meso, and micro. The actors operating within this structure engage in the provision and integration of resources, with the assumption that autonomous institutions exist to coordinate the activities across these layers.

According to the Agency for Natural Resources and Energy, the total power generated by electric utilities in 2022 was 834.8 billion kWh[2], with thermal power accounting for about 80%, followed by hydropower (including pumped storage[3]) at 10%, new energy (solar, wind, geothermal, biomass) at 7%, and nuclear power, which has sharply declined since the Great East Japan Earthquake, at 6% (ANRE, 2023a). In thermal power generation, LNG (liquefied natural gas) is the main fuel at 45.4%, followed by coal at 42.2%, and oil at 3.2%. Most of the fuel is imported, with about 70% of coal and 40% of LNG sourced from Australia, and about 90% of oil imported from Saudi Arabia.

2. Differences Between Japan and Europe at the Macro Level

There are a set of differences between Japan and Asian countries compared to Europe. At the macro level, as mentioned in the previous Policy Brief, Japan is advancing its green transition based on its 2020 commitment to reducing greenhouse gas emissions. According to the EU-Japan Green Alliance, Japan and the EU share the goal of becoming climate neutral by 2050 including working together to facilitate the transition to a climate-neutral and resilient society, including phasing out government support for carbon-intensive fossil fuel energy. That goal, however, will not be easy to reach.

As an island nation with limited resources, Japan does not have contiguous neighbors connected by pipelines or power lines like Europe and relies on importing fuel via sea tankers[4]. This situation is similar for many emerging Asian countries, which often produce coal and prefer it due to its lower costs

2 In terms of energy production thermal power accounts for 666.4billion kWh, hydroelectric power for 83.2billion kWh, and nuclear power for 60.9billion kWh.
3 In pumped-storage hydroelectric power, oil is used as the energy source to pump water.
4 As a result, it was the first to liquefy natural gas and convert it into fuel for power generation, and has a current 10% share of the world market.

and more stable procurement compared to other fuels, making them reluctant to phase out coal power. Furthermore, many emerging Asian nations operate relatively new coal-fired plants that have not yet depreciated, leading to resistance against scrapping these existing facilities.

For emerging countries with growing populations and economies, increasing electricity demand is inevitable. There is a strong view that the historical CO2 emissions from developed countries are the primary cause of global warming, making it seem unfair to impose strict emissions regulations on nations that are just beginning to develop. Consequently, there is a significant divergence in the approach to green energy transitions between Europe and Asia at the macro level.

Japan, as an advanced country located in Asia, has a unique position and should seek to bridge the gap between developed countries and emerging Asian economies at the macro level.

3. Coal and Ammonia vs. LNG and Hydrogen at the Meso Level

At the meso level, the focus is on the relationships among companies and organizations in industries. After the Great East Japan Earthquake, when nuclear power plants across the country ceased operations and electricity generation plummeted[5], the power shortage was offset by reactivated thermal power plants. JERA's website even features a legendary story about how they brought back these power plants, which had been idle at that time, on an impossible schedule when closing nuclear power plants all over Japan. This indicates how deeply committed JERA and their employees are to these efforts.

5 In 2010, 54 nuclear power stations were in operation, but all were shut down after the accident, and as of January 2024, 12 stations that have passed safety regulations are in operation.

Subsequently, oil-fired power generation has declined due to economic inefficiency, while renewable energy capacity has grown significantly. However, renewables, being weather-dependent, have intermittently tightened supply and demand. According to the Japan Atomic Energy Relations Organization (JAERO), renewable energy sources like solar, wind, and hydro accounted for 43% of the total power capacity in 2023, but only 22% of the actual power generation (JAERO, 2024), indicating low utilization relative to capacity. Consequently, thermal power remains highly regarded as a cost-effective and reliable backup during adverse weather conditions.

As a result, the two major power generation companies have adopted strategies to maintain thermal power facilities while striving for carbon neutrality by co-firing existing fossil fuels with hydrogen and ammonia, which do not emit carbon dioxide when burned, and gradually increasing the co-firing ratios. JERA is primarily focusing on ammonia, while KEPCO is focusing on hydrogen, each aligning their efforts with their existing infrastructure: Tokyo Electric Power Company's (TEPCO: the parent company of JERA) has mainly uses on coal-fired power with boilers and KEPCO has mainly uses on LNG and nuclear power with gas turbines.

As of 2024, JERA is experimenting with a 20% ammonia co-firing rate with coal and aims to commercialize ammonia power generation by as early as 2027, with plans to increase the co-firing rate to 50% by the 2030s and 100% by the 2040s (JERA, 2024). The 20% co-firing with ammonia only requires burner modifications, allowing for low-cost retrofitting and minimal downtime of existing facilities. However, achieving 100% ammonia usage will necessitate the development of new boilers and gas turbines.

KEPCO has announced plans to reduce carbon dioxide emissions by 50% by 2025 compared to 2013 levels, aiming for net-zero emissions by 2050(KEPCO, 2022). While hydrogen faces global supply challenges, it has a wide range of

applications beyond power generation[6]. Kansai Electric envisions establishing a comprehensive hydrogen supply chain, centered in Himeji, a port city along the Seto Inland Sea.

Manufacturers are also diverging in their approaches. IHI is focusing on ammonia, Kawasaki Heavy Industries is concentrating on hydrogen, and Mitsubishi Heavy Industries is pursuing both hydrogen and ammonia.

4. Public Awareness and Sentiment at the Micro Level

At the micro level, the results of a survey of 309 energy-efficient companies conducted by a consulting firm on corporate reactions to the government's green strategy are not very positive: although 74% have expressed a commitment to carbon neutrality, only 16% have created a roadmap to 2050. While 44% are committed to energy conservation, only 17% are engaged in energy conversion to decarbonized fuels, for example. As for the visualization of greenhouse gas emissions, only about 30% of companies have started working on Scope 3, indicating that there is still a long way to go.

The public sentiment plays a significant role. In Japan, the liberalization of the electricity retail market in 2016 led to the establishment of many small private companies known as "new power providers." However, the severe cold wave in January 2021 caused a tightening of electricity supply and demand, leading to a spike in market prices and the subsequent withdrawal of these new power providers. By April 2021, their market share was about 20% (ANRE, 2023b approximately 26% in the low-voltage sector for households), but the ongoing Ukraine-Russia conflict and the depreciation of the yen, which drove up resource costs, caused many of these companies to withdraw or go bankrupt. Even if a contracted new power provider fails, the major

6 Hydrogen is seen as a viable alternative to fossil fuels in industries that emit large amounts of carbon dioxide, such as steelmaking, chemicals, and aircraft.

utilities' transmission and distribution divisions, ensure that power supply to homes and businesses is not abruptly cut off. However, this remains a major concern for citizens who lead highly electrified daily lives.

There are other concerns as well. Many installed solar panels have been scattered by typhoons and heavy rains, and landslides have occurred by earthquakes at installation sites cleared in forests recent years. Starting in 2030, a large number of solar panels exceeding their durability will be decommissioned, with the scale of disposal estimated by the Ministry of the Environment to reach 500,000 to 800,000 tons (MOE, 2023). Although Japan's Ministry of the Environment has issued guidelines for solar panel disposal, there are no legal regulations like the EU's EOL regulations[7]. These issues have led to numerous cases of local opposition to the installation of renewable energy facilities.

Japanese citizens' awareness of global warming and renewable energy is lower than in Europe. According to a survey by the Energy Economics Research Institute, the percentage of respondents who answered, "energy issues" to the question "What are you concerned about regarding social issues?" was just over 50% immediately after the Fukushima accident in 2011, but gradually decreased to around 20% by 2020. This ranked 12th out of 16 [8]categories, including "economic and business trends," "health and medical care," and "entertainment and hobbies." Similarly, concern for "nuclear power issues" was over 60% in 2011, comparable to "economic and business trends," but fell to around 20% by 2020. Interestingly, from 2011 to 2019, “nuclear

7 EU countries are developing national regulations in response to the WEEE Directive (Directive on Waste Electrical and Electronic Equipment: WEEE) of 2012, which mandates the recycling of solar photovoltaic modules. The EU countries have developed national regulations in response to the WEEE Directive, and a visibility fee is added to the sales price to cover future collection and recycling costs.

8 The top five concerns, in descending order, are domestic political issues, economic trends, health and medical care, employment and labor environment, and international affairs.

power issues" ranked higher than "energy issues," only reversing the trend in 2020. Nonetheless, in the 2023 survey, 46.9% responded negatively and only 5.1% responded positively to the question of whether there is public understanding of the resumption of nuclear power plant operations. When asked if they were reliable sources of information on nuclear energy, the percentages of reliable vs. unreliable were 55.4% vs. 8.3% for experts, 30.5% vs. 21.5% for operators, 20.0% vs. 32.5% for the government, and 26.3% vs. 19.4% for local governments. Only with regard to the national government, "Not reliable" exceeded "reliable" by 12.5 percentage points.

The dilemma of aversion to nuclear power plants and anxiety about power shortages is mixed among the public, and this is compounded by distrust of the information provided by the government.

Logically, nuclear power issues should be considered holistically as part of energy issues. However, given Japan's unique circumstances, such as experiencing atomic bombings in World War II and the recent Fukushima nuclear accident, public interest has been more focused on nuclear power alone rather than the broader energy landscape.

The issue of nuclear power plant restarts is one of the nine key issues[9] in the upcoming Liberal Democratic Party presidential election. Notably, all 11 expected candidates support restarting nuclear plants, although their nuances differ. For instance, Shigeru Ishiba advocates for maximizing efforts to reduce nuclear power close to zero, while promoting the use of small hydro and geothermal energy. Taro Kono, who initially opposed nuclear power, shifted his stance due to the lack of consensus within the party and the expectation of a significant increase in power demand, including from data centers.

9 Energy issues are not among the nine issues of concern, including backroom corruption, constitutional reform, and married couples' surnames.

5. Technical Challenges of Hydrogen and Ammonia Power Generation

Ammonia, with a boiling point of minus 33 degrees Celsius, is easier to liquefy and transport compared to hydrogen, which has a boiling point of minus 253 degrees Celsius. Although ammonia is widely used in agriculture as fertilizer, only about 10% of the 200 million tons produced is traded globally, with most being consumed locally. It also burns less readily than natural gas (with a slower combustion rate), and improper combustion can result in high concentrations of nitrogen oxides (NOx), posing technical challenges.

Hydrogen faces challenges such as high costs, explosion risks, and stable supply chain. While hydrogen power generation itself does not emit carbon dioxide, the production of hydrogen fuel requires energy. Hydrogen can be categorized into several categories.

The major three are the followings. The green hydrogen (produced using renewable energy and uses the carbon dioxide produced in the manufacturing process for industrial purposes), gray hydrogen (produced using fossil fuels), and blue hydrogen which paired with CCS[10] and CCUS[11]. These technologies can capture and utilize or store CO2 emissions from the production process. Turquoise hydrogen, which has both of green and blue characteristics, also exists. It uses a process called methane pyrolysis method, which is produced by cracking methane, a natural gas, into hydrogen and solid carbon (carbon black).

As the byproduct, carbon black, can be widely used in industrial applications such as automobile tires, coatings, and batteries, commercial-scale plants already exist in the world. Both green and blue hydrogen are currently expensive, and their future cost reduction heavily relies on technological advancements. In April 2023, the Japanese government

[10] CCS is the Carbon Capture and Storage.
[11] CCUS is the Carbon Capture Utilization and Storage.

announced the ‘Basic Hydrogen Strategy’ aiming for hydrogen to account for one-third of total power generation by 2030, although it is expected that hydrogen costs will still be more than double those of LNG even at that time. Recently, there have been active developments in the hydrogen sector, such as a partnership between seven Japanese companies, including Imabari Shipbuilding, Japan's largest shipbuilder, and Nippon Yusen, the largest shipping company, to develop transport vessels for underground CO2 storage.

In June 2024, Japan and the European Union agreed to create a joint roadmap for public-private cooperation to promote hydrogen adoption (METI, 2024). The roadmap aims to establish international standards by sharing information necessary for setting safety requirements for production equipment and transport technologies by around 2040. This includes starting with information sharing on water electrolysis devices that produce hydrogen using renewable energy and liquefied transport technologies that efficiently transport hydrogen. Japanese agencies, such as NEDO and JOGMEC, have signed memorandums of understanding with EU governmental agencies, while in the private sector, Kawasaki Heavy Industries and Germany's Daimler Truck Holding have signed cooperation documents in the hydrogen field.

6. Conclusion

The realization of both hydrogen and ammonia power generation heavily depends on technological advancements, making technology the primary focus. However, the launch of a new industry that encompasses the complex relationships of multiple actors requires interpreting a more complex model. This can be seen as a service ecosystem influenced by cultural and legal histories, social norms, inter-company relationships, and individual ethics. From this perspective, it is meaningful to consider the institutions that govern macro, meso, and micro levels.

Europe and Japan are considered to differ greatly at the macro level in terms of geographical constraints, resource endowment, and historical background; at the meso level in terms of continuity and scalability with existing business, which directly affects cost-effectiveness; and at the micro level in terms of public awareness and sentiment.

Even in regions where the transition to renewable energy is being strongly promoted, such as Europe and Japan, the situation at the macro, meso, and micro levels is very different. It is important to understand this analysis before proceeding with the EU-Japan Green Alliance in order to ensure smooth progress.

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Agency for Natural Resources and Energy(ANRE):

https://www.enecho.meti.go.jp/en/

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