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Citation (APA)
Panjaitan, T. W. S., Pandyaswargo, A. H., Atmaja, T. D., Firman, F. A., & Irsyad, M. I. A. (2024). Drawing Insights from Japan's Energy Efficiency Policies for Indonesia's Progress. *Indonesian Journal of Energy*, *7*(2). https://doi.org/10.33116/ije.v7i2.212

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IJE | INDONESIAN JOURNAL OF ENERGY
P-ISSN: 2549-1016 | E-ISSN: 2549-760X
available online at www.ije-pyc.org

Published by: The Purnomo Yusgiantoro Center

Drawing Insights from Japan's Energy Efficiency Policies for Indonesia's Progress

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Article History

Received 15 April 2024
Accepted 19 August 2024
Available 29 August 2024

Abstract

As archipelagic countries, Japan and Indonesia's electricity transmission and distribution infrastructures are island-specific. They have limited network areas and face similar risks caused by climate change. Energy conservation through technical approaches to improve energy efficiency is effective in combating climate change and generates more significant economic benefits. This study examines the strategies demonstrated by Japan to improve its energy efficiency and identifies the potential of adopting those strategies in Indonesia. This research includes an in-depth literature review and benchmarking approaches to the two countries' mitigation strategies. The study found that the Japanese approaches, such as the prioritization of strict regulations, extensive use of innovative technology, and solid industrial collaboration, can be adopted to improve energy efficiency in Indonesia. We also identified several obstacles to adopting those approaches in Indonesia, such as policy inconsistencies, limited financial incentives, and fragmented governance. Adopting the Japanese approaches in Indonesia needs clear energy labeling, more integrated energy management in large industries, appropriate electricity pricing, and efficient energy service company (ESCO) schemes.

Keywords:
energy efficiency, mitigation strategies, climate change, energy conservation

1. Introduction

Globally, energy efficiency is the technique of achieving more with less. It is about getting the most out of every energy unit (Moriarty & Honnery, 2023; Patterson, 1996). In light of the escalating climate crisis, energy efficiency has emerged as a critical strategic measure (Junne et al., 2019). Countries are competing to increase energy efficiency to reconcile the world's expanding energy needs with the preservation of the environment. It has become a global imperative amid concerns over dwindling resources, rising energy demands, and environmental impacts (Hussain et al., 2020; Rahman, 2020).
Therefore, energy efficiency is essential for halting global warming, lowering dependency on fossil fuels, and making financial savings. Enhancing energy efficiency can substantially reduce greenhouse

gas emissions and alleviate climate change effects (Grueneich, 2015; International Energy Agency [IEA], 2017; Mundaca et al., 2019). Moreover, energy efficiency curtails energy consumption and reduces reliance on fossil fuels, fostering the adoption of renewable energy sources. Additionally, it leads to cost savings, economic benefits, energy subsidies for households and businesses (IEA, 2017, 2023a; Nurliyanti et al., 2021; Panjaitan et al., 2021).

Japan is well known for its advanced energy efficiency measures, so its energy efficiency has been extensively studied and compared (Minami, 2008; Moe, 2012; Ren & Du, 2012; Tanabe, 2010). Japan's influence on energy efficiency extends beyond its borders. It has been a global leader in this field since the 1970s oil crisis, necessitating a shift towards conservation and energy diversification. Significant improvements were made between the 1970s and 1980s, primarily driven by technological advancements in the industrial sector. Progress slowed from the 1990s to the early 2000s but has since rebounded, especially in households (Aoki, 2023). However, previous studies have not explored the unique challenges and opportunities for energy efficiency in Japan as an archipelago country like Indonesia. Prior discussions mainly focused on comparing Japan with other developed or developing countries (Fowlie & Meeks, 2021; Gadgil et al., 2011; Hickel & Slamersak, 2022; Honma & Hu, 2014; Van de Putte et al., 2020).

Japan and Indonesia, despite their economic disparities, share a vested interest in energy efficiency. For Japan, which relies heavily on imported fossil fuels, efficiency has been a strategic imperative since the oil crisis of the 1970s. It can reduce its economic vulnerability and reduce its environmental impact (Aoki, 2023; Shimizu & Tiku, 2023). It has positioned the country as a global energy technology and conservation leader. Meanwhile, as a resource-rich developing or emerging country, Indonesia faces different challenges. Its continued rapid economic growth and increasing energy demand must be balanced with environmental sustainability and energy access for its population. It makes efficiency or optimizing energy use critical to reduce dependence on fossil fuels, mitigate the impacts of climate change, and improve the lives of its citizens (Setyawan, 2020; Setyawan & Wardhana, 2020). Thus, energy efficiency is critical to both countries' economic growth, environmental protection, and energy security.

In this light, our study takes a novel approach, examining electricity efficiency policy in Japan, which shares similarities with Indonesia as an archipelagic Asian nation. While other island nations could benefit from Japan's experiences, Indonesia gains the most due to the challenge of providing electricity access to its 13,466 islands, home to the fourth-largest population globally. Nurse et al. (2014) suggested that island countries face more significant risks from climate change impacts, including droughts, forest fires (Herawati & Santoso, 2011), food resource shortages (Tripathi et al., 2016), river and coastal flooding (Herawati et al., 2015; Mertz et al., 2009; Muis et al., 2015; Suroso et al., 2013), and human health issues (Boeckmann, 2016; McIver et al., 2016; Wu et al., 2016).

By comparing various indicators and contextual variables, the research seeks to map, benchmark, and understand the successes and challenges of energy efficiency initiatives in these two archipelagic nations. The significance of this study lies in its ability to provide a comparative analysis of energy efficiency initiatives in Japan and Indonesia, offering insights into the influence of economic, geographical, and cultural factors on policy effectiveness, hence guiding forthcoming energy strategies for archipelagic nations. Challenges in higher electricity production costs due to nonlinearity in the transmission grid and economic scales of power generation capacity on islands are also discussed.

This article explains the learning outcomes that can be drawn from Japan's energy efficiency policy for Indonesia's progress. It is done by identifying and analyzing the critical factors influencing the effectiveness of energy efficiency programs in Japan and Indonesia. These countries were selected for the case study because Indonesia is the largest archipelagic state, and Japan is one of the world's most energy-efficient. The remainder of the article is structured as follows: Section 2 outlines the materials and methods used in the review. Section 3 compares energy conservation policies in both countries, and discusses factors influencing electricity consumption. Chapter 4 concludes the study.

2. Methods

This study conducts a comparative analysis of energy efficiency policies in Indonesia and Japan, employing a rigorous methodological approach. The research draws upon a comprehensive academic literature review, government reports, and policy documents. A systematic literature search was conducted using relevant keywords and databases (specify databases, e.g., Scopus, Web of Science, JSTOR) to identify studies focusing on energy efficiency policies, strategies, and their impacts in both countries. The selection criteria for literature included: (1) Relevance: Studies directly addressing energy efficiency policies, strategies, and their outcomes in Indonesia and Japan; (2) Methodology: Research employing robust research designs and data collection methods; and (3) Timeliness: Recent publications to capture the latest developments in the field.

By examining key indicators such as energy consumption, intensity, and other relevant metrics, the study seeks to establish a comparative analysis between Japan's energy efficiency accomplishments and Indonesia's current status while exploring avenues for energy efficiency improvements in Indonesia. The chosen indicators for comparison were selected based on their relevance to energy efficiency, data availability, and comparability between the two countries. Key indicators include (1) total and per capita energy consumption to assess overall energy use patterns. (2) energy intensity: energy consumption per unit of GDP to measure energy efficiency; (3) a variety of policy tools or policy instruments employed by both countries, such as regulations, subsidies, and market-based mechanisms; and (4) indicators of policy effectiveness, such as energy savings, emissions reductions, and economic impacts. By comparing these indicators, the study aims to identify best practices, lessons learned, and potential policy transfer opportunities between Japan and Indonesia. Furthermore, the analysis incorporates qualitative insights from case studies and expert opinions to enrich the understanding the complex factors influencing energy efficiency.

The study further incorporates insights into the barriers to energy efficiency, including behavioral obstacles and the disparity between theoretical potential and actual energy efficiency levels, as highlighted by Moktar et al. (2023). We also consider the specific challenges encountered by various sectors, such as the private rented sector in Europe, offering valuable lessons on structural barriers that may apply to Indonesia, as discussed by Bungau et al. (2023). By mapping and benchmarking collected data, our study assesses Japan's achievements in energy efficiency and identifies opportunities and challenges for Indonesia. This approach, relying solely on secondary data, minimizes biases and ensures a comprehensive understanding of the distinct contexts between the two countries, aiming to pinpoint critical factors that influence the effectiveness of energy efficiency programs (Bensouda & Benali, 2022). Therefore, this approach, grounded in a systematic literature review and using relevant indicators, provides a robust foundation for comparing energy efficiency policies and identifying potential pathways for Indonesia to enhance its energy efficiency performance.

3. Results and Discussions

3.1 Electricity, Geography, and Climate Change

Electricity, geography, and climate change are inextricably linked in the pursuit of energy efficiency. Geography influences the availability of energy resources, infrastructure development, and consumption patterns, while climate change impacts energy demand and supply. Electricity, as the primary energy carrier, is affected by both these factors. By examining these elements together, the paper can effectively analyze Japan's energy efficiency strategies and identify transferable solutions for Indonesia, considering its unique geographical and climatic context. This integrated approach is crucial for developing effective policies to mitigate climate change and enhance energy security.

Previous studies have highlighted that the limited reach of electricity infrastructure has led to oil dependency in island communities and scattered remote areas, especially in large islands (Lazrus, 2012; Surroop et al., 2018). Indonesia is a prime example, where oil-based power plants offer a cost-effective solution to supply electricity in such areas with relatively low upfront costs. Figure 1 illustrates the growth of oil-based power plants for electricity supply in Indonesia, rising from 14 kWh to 165 kWh per capita between 1971 and 1990 (World Bank, 2024a). However, the utilization of oil-based power plants has declined since the second oil price shock in 1979, with coal-fired power plants gradually replacing them after 1984.

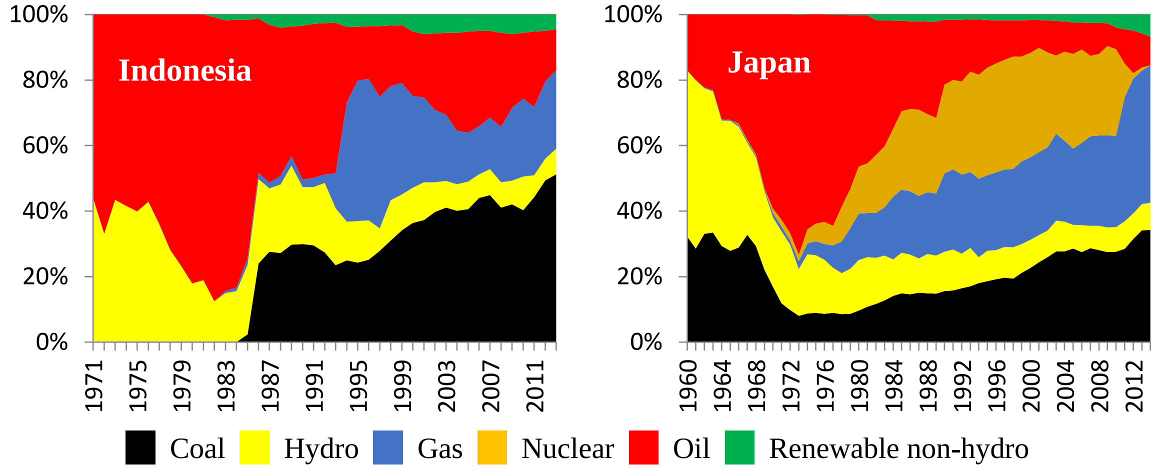

Figure 1. Electricity productions in Indonesia and Japan, 1971–2012 (World Bank, 2024b).

Coal offers lower electricity generation costs, and Indonesia boasts abundant coal production, with a reserve of 28 billion tons and an annual output of 458 million tons, securing its supply for 61 years. Moreover, Indonesia primarily exports coal, with domestic consumption accounting for only 22% of total production, making it a significant global coal exporter (British Petroleum, 2022). However, coal-fired power plants are not economical for supplying small electricity loads in isolated islands or isolated areas not connected to transmission grids. Unlike oil-based power plants, coal-based ones are larger in capacity and thus more suitable for extensive land areas, making grid extension easier. However, extending electricity grids to smaller islands faces challenges such as separation by sea, low population density, and financial limitations (Novitasari et al., 2020; Stich et al., 2016).

The electricity sector is poised to become the leading polluter due to increased economic and population growth and coal utilization. Hasan et al. (2012) estimated that the 8.4% annual growth in electricity consumption from 1987 to 2009 increased CO_2 by 7.6%, NOx by 10.1%, SO_2 by 4.4%, and CO by 6.4%. Consequently, Indonesia faces significant climate change impacts, including rising sea levels and forest fires. Climate change is also expected to elevate the risk of river and coastal floods (Muis et al., 2015). Suroso et al. (2013) projected a 13.5 + 6.1 cm sea level rise in South Sumatra from 2000 to 2030. The sea level is forecasted to rise by 25 and 50 cm by 2050 and 2100, respectively, resulting in flooding covering 25 to 50% of coastal city areas (Boer, 2010). Meanwhile, due to climate change, Herawati et al. (2015) predicted alterations in the Kapuas River's streamflow in West Borneo.

Conversely, Japan faces energy resource scarcity and relies heavily on foreign primary energy supplies. For instance, in 2010, Japan imported 96% of its primary energy supply and 99.6% of its total oil supply, primarily from the Middle East (Honma & Hu, 2014; Zhang et al., 2012). The first oil shock in 1973 compelled Japan to diversify its energy mix in power plants, as depicted in Figure 1. Over time, the share of oil in total final energy consumption decreased from 45% in 2007 to 38% in 2021 (Energy Information Administration [EIA], 2023). Nuclear power received significant attention, with 64% of research and development budgets typically allocated to nuclear technology and infrastructure. In 2010, Japan operated 54 nuclear power plants, ranking among the top three nuclear-generating countries (Portugal-Pereira & Esteban, 2014; Zhang et al., 2012).

The Japanese archipelago comprises four main islands (i.e., Honshû, Shikoku, Kyûshû, and Hokkaidô) and thousands of smaller surrounding islands, with the majority of the population residing in concentrated areas (Asia for Educators [AFE], 2024). The urban-rural population ratio in Japan increased from 1.8 in 1960 to 14.4 in 2010, compared to Indonesia's figures of 0.2 and 1.2, respectively (Takeuchi & Shaw, 2010). These statistics underscore the feasibility of nuclear power plants and transmission grid connections between islands in Japan. However, the Fukushima Daiichi nuclear plant disaster in 2011 led to a decline in the role of nuclear sources in Japan's energy system. Fossil fuel power plants gradually replaced nuclear ones, resulting in increased greenhouse gas emissions (Portugal-Pereira & Esteban, 2014). Emissions from Japan's energy sector surged by 43.9%, from 324 million tons of CO_{2eq} ($MtCO_2eq$) in 1990 to 467 $MtCO_{2eq}$ in 2011, with the energy sector being the primary emitter.

These emissions have contributed to a temperature increase of 1.15 °C per 100 years, exceeding the global average of 0.68 °C per 100 years. Japan's temperature is projected to rise by 2.1 to 4.0 °C, higher than the global average of 1.8 to 3.4 °C. Climate change is anticipated to threaten water resources, coastal areas, increase flooding, landslides, affect vegetation and animal populations, food production, and human health (Government of Japan, 2016). Another significant impact of climate change on archipelagic states is the rise of sea levels, mainly observed in Japan, especially in the Sea of Japan (Mimura, 2013). This increase is projected to be 5 to 10 cm greater than the global average, except for eastern Hokkaido (Japan Meteorological Agency, 2023). Nevertheless, Japan's experiences with natural disaster adaptation strategies could be adapted to help mitigate the impacts of climate change (Boeckmann, 2016).

3.2 Energy Efficiency Policies

Although energy efficiency goes beyond electricity to encompass all energy sources, this paper will focus on electricity. Electricity is a critical component of modern society and a significant contributor to overall energy consumption. By examining electricity, geography, and climate change, this study can provide a broader perspective on energy efficiency and identify potential synergies among different energy sectors. Comparing the energy efficiency performance of the two countries poses challenges due to differences in energy access, economic structures, and exchange rates. Figure 2 illustrates that Indonesia exhibits lower electricity consumption per capita, primarily influenced by its lower electricity access. By contrast, in the 1990s, Japan had achieved a high level of electrification, with nearly all households having access to electricity (Morimoto, 2023). Presently, Indonesia's electrification ratio has not yet reached 100%. While some areas boast a 99% electrification rate, others have as low as 33% (da Costa, 2024; Permana et al., 2021).

Another important indicator is electricity intensity, which measures electricity consumption per constant gross domestic product (GDP), reflecting the amount of electricity used to produce one unit of GDP. As depicted in Figure 2, Indonesia exhibited lower electricity intensity than Japan until 2004, when the two countries converged. However, GDP-based indicators may yield misleading efficiency conclusions due to differences in the monetary value of each country's GDP. Mielnik and Goldemberg (2000) argue for using constant purchasing power parity (PPP) instead of constant GDP, demonstrating that Indonesia consistently exhibits lower electricity intensity than Japan when assessed using PPP. Nonetheless, the PPP-based indicator fails to differentiate economic structure (Farla et al., 1997), leading to lower intensity in oil and gas-producing and labor-intensive countries (Geller et al., 2006; Hu & Kao, 2007).

Despite ongoing debates and evolving studies on energy efficiency indicators (Chang, 2013; Duro et al., 2010; Hu & Kao, 2007; Huang & Wang, 2017), Figure 2 clearly illustrates a declining trend in all indicators in Japan, while an increasing trend is observed in Indonesia. Consequently, a comparison of Japanese and Indonesian policies on electricity efficiency, as presented in Table 1, can help identify potential areas for improvement.

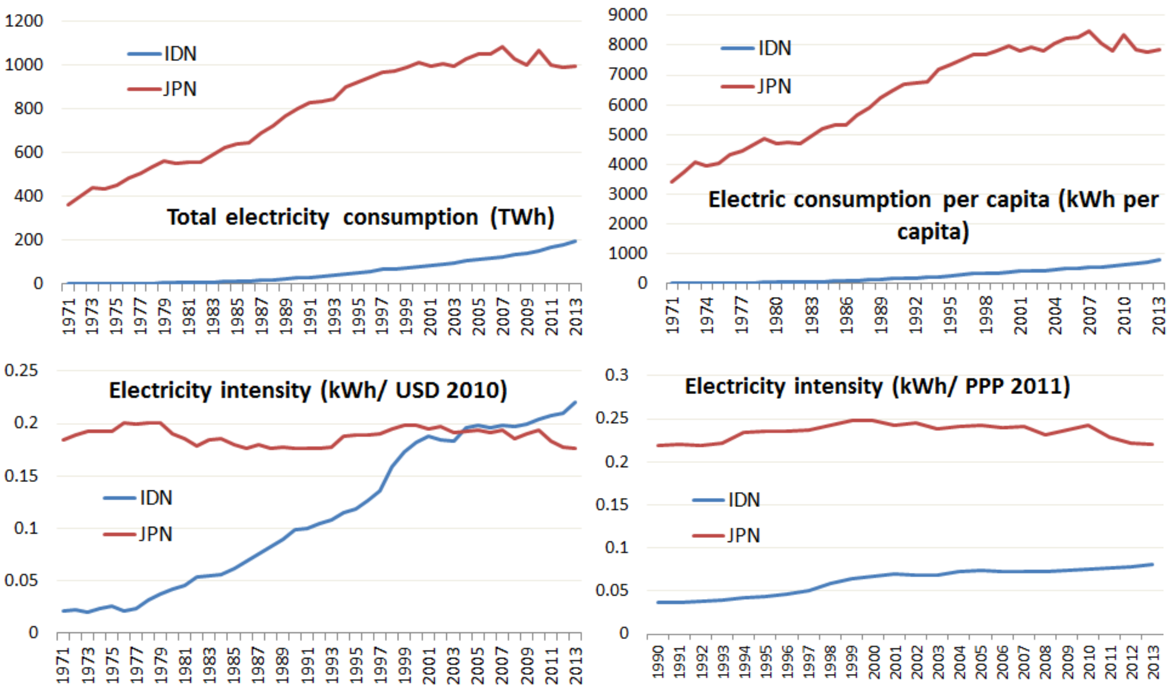

Figure 2. Conventional electricity efficiency indicators (World Bank, 2024b).

Both Japan and Indonesia recognize the importance of driving industrial growth and ensuring energy supply, particularly electricity, to enhance the quality of life for their citizens. Given that energy sources are vital for producing goods and services, action or policy is necessary to facilitate the transition to a low-carbon economy, primarily through implementing energy efficiency strategies and utilizing renewable energy sources.

Electricity was first introduced in Japan in 1878, with the establishment of the Tokyo Electric Light Company five years later to provide lighting services (Kobori, 2006). The electricity industry rapidly evolved, resulting in a highly competitive atmosphere, electricity oversupply, and high pollution levels (Salameh, 2014). The increasing electricity supply supported a 9% economic growth between 1965 and 1973, accompanied by a 10.9% growth in energy demand until the first oil shock in 1973, which caused a 10% decrease in economic development and a 23.2% inflation rate (Mihut & Daniel, 2012; Tanabe, 2010).

As depicted in Table 1, energy conservation measures in Japan were initiated following the Petroleum Supply and Demand Optimization Law in 1973 to limit oil usage immediately. Subsequently, the Energy Conservation Centre and the Moonlight Project were established in 1978 to support energy conservation efforts in the industry and develop large-scale, highly efficient technologies, such as industrial furnaces, gas turbines, waste heat recovery systems, heat pumps, and fuel cells (Geller et al., 2006; Minami, 2008; United Nations Environment Programme, 2012).

Following the second oil shock in 1979, Japan enacted the Law Concerning the Rational Use of Energy Number 49, prioritizing energy efficiency in the industry sector and extending to households, commercial buildings, and appliances for more efficient fuel utilization (Ren & Du, 2012). Under this law, industries were required to appoint energy managers and submit periodic reports on energy consumption, along with planning documents for short and long-term energy conservation. Industries failing to meet energy standards were mandated to implement energy rationalization plans, while those demonstrating energy efficiency could qualify for financial support, such as tax credits for licensed energy management systems and reporting systems. Subsequent initiatives included the implementation of energy management systems in office buildings in 2002, the introduction of reporting systems on energy by carriers in 2005, company-based regulations in 2008, and the establishment of peak demand management and top-runner programs for building materials in 2012 (Minami, 2008; Nishiyama, 2013; Ren & Du, 2012).

Table 1. Comparisons of energy efficiency policy.

Policy	Japan	Indonesia
Law and other regulations	Petroleum Supply and Demand Optimization in 1973; Energy Conservation Centre and the Moonlight Project in 1978; Rational Use of Energy Number 49/1979; Energy Management Systems in 1983; Periodical Reporting Systems in 1993; Top runner program for automobile and home appliances 1998; Energy management of office buildings in 2002; Reporting systems on energy by carriers in 2005; Company based regulation in 2008; Peak demand management and top runner programs for building material in 2012.	Presidential Instruction number 8/1982 for energy conservation and its revisions; National Energy Conservation Master Plan in 1995 and its revision in 2005; National Energy Policy in 2006 and its revision in 2014; Energy Conservation Regulation number 70/2009 and its revision in 2023; Ministry regulation No. 14/2012 for Energy Management; Ministry regulation No.14/2014 for the label of self-ballasted lamps; Ministry regulations for MEPS and energy label of air conditioners in 2015 and LED lamps in 2022; Ministry regulation No.14/2016 for Energy conservation business.
Research collaboration with industry	Intensive	Small-scale and unsustainable.
Minimum Energy Performance Standards (MEPS)/ Top runner program/ Energy label	28 products	Three products
Standby power consumption	Less than 1 watt	Not regulated
Energy efficiency standard for buildings	Voluntary	Voluntary
Fiscal incentives for energy conservation	Implemented	Allowed but not implemented yet
Free energy audits for industry	Yes	Yes
Energy management is mandatory in the industry	Since 1979, well established	Since 2012, struggling
Smart technology	Smart meter, smart office, HEMS, Smart Office, BEMS.	Yes
Electricity tariff	Taxed	Subsidized
Energy mix	36%–38% renewable sources (solar, wind, hydropower, geothermal, and biomass), 20%–22% nuclear generation, and 40–56% fossil fuels by 2030 (EIA, 2024).	25% oil, 30% coal, 22% natural gas, and 23% renewable energy by 2025 (Wahyuni & Ardiansyah, 2022).

The adoption of the Kyoto Protocol in 1997 spurred the introduction of the top-runner program, an innovation competition to enhance energy efficiency among manufacturers. Launched in 1998, this program sets the most efficient brand in each product category as a benchmark for other manufacturers to achieve within 4 to 8 years, depending on the product type. Over time, even the least energy-efficient brands are expected to meet these targets, leading to significant improvements in efficiency across 28 designated products, including air conditioners (32.3%) and refrigerators (43%), between 2005 and 2010 (Nishiyama, 2013; Ren & Du, 2012).

As a supplementary strategy, Japan has implemented energy labeling, which categorizes products into green-colored labels for those meeting top-runner standards and red-colored labels for low-energy performers. Since 2006, retailers have been mandated to display uniform energy-saving labels indicating a product's yearly operating cost and energy consumption (Akahoshi, 2008). Additionally, the Japanese Government encourages manufacturers to reduce standby power consumption in their products voluntarily and promotes energy conservation in households and commercial sectors through information technology. It includes systems like the Home Energy Management System (HEMS), Smart Office Environment System, and Building Energy Management System (BEMS) (Akahoshi, 2008; Nishimura & Giri, 2008; Wakabayashi, 2013).

Similarly, Indonesia recognizes the importance of demand-side management for ensuring energy security, as evidenced by the stringency of regulations issued, as shown in Table 1. In 1982, the Indonesian Government issued Presidential Instruction 8/1982 on energy conservation. Subsequently, it was reinforced in 1991, 2005, 2008, and 2011, with energy conservation guidelines for the public sector complementing these efforts. However, the outcomes were unexpected: electricity consumption in government buildings increased from 19.6 to 23.8 MWh/customer between 2006 and 2014. Some weaknesses of these instructions include a lack of incentives, penalties, commitment, and funding; additionally, some instructions are perceived as irrational and difficult to understand. For instance, local governments lack sufficient funding, human resources, or technology to implement Ministerial Regulations that mandate a 50% reduction in energy consumption in street lighting systems from midnight until 5:30 am, except under rainy conditions (Al Irsyad & Nepal, 2016). Smart energy-saving technologies for street lighting have indeed been deployed as a solution; however, their implementation remains limited, necessitating innovative funding schemes involving the private sector as investors (Al Irsyad et al., 2019; Anggono et al., 2021).

More extensive energy conservation measures were regulated by the National Energy Conservation Master Plan in 1995 and its revision in 2005, the National Energy Policy in 2006 and its revision in 2014 (Government of Indonesia [GOI], 2006, 2014), and the Energy Conservation Regulation Number 70/2009 (GOI, 2009), which was then strengthened by the Government Regulation Number 33/2023 concerning energy conservation (GOI, 2023). The Master Plan sets a target of a one percent reduction in energy intensity per year based on energy conservation potential from industry, commercial buildings, and households (Asia-Pacific Economic Cooperation [APEC], 2011). The energy conservation regulation governs energy conservation at upstream and downstream management stages, which energy providers and users must implement. Some of these obligations include energy management, MEPS, and energy-saving labels. Additionally, the regulation encourages the development of energy conservation service businesses and enhances human resource capacity in this field.

In addition, the Ministry of Energy and Mineral Resources (MEMR) has issued several ministerial regulations, such as those for energy management (Ministry of Energy and Mineral Resources [MEMR], 2012), MEPS for electrical appliances including light-emitting diode (LED) lamps (MEMR, 2021, 2022), and regulations related to energy conservation businesses (MEMR, 2016). However, energy conservation practice in Indonesia still faces challenges due to compliance issues, leading to the abolition or revision of many related regulations. Moreover, despite the potential for financial incentives for energy efficiency under the energy conservation regulation, such incentives have not been provided (Setyawan, 2014).

3.3 Discussions

Energy efficiency and energy conservation are complementary strategies for reducing energy consumption. Efficiency focuses on using less energy to perform the same task through technological advancements, while conservation emphasizes behavioral changes and reducing unnecessary energy use. Both are essential for achieving sustainable energy goals. Energy conservation is a multifaceted issue that can be examined from various angles. Indonesia faces three significant challenges (human behavior, technology innovation, and energy management coordination) in energy conservation. From an economic perspective, increasing energy prices can significantly reduce energy consumption (Jacobsen, 2009; Tanabe, 2010). In Indonesia, electricity prices have been subsidized since 2000, amounting to IDR 3.93 trillion initially and peaking at IDR 101.82 trillion in 2014 (Ahdiat, 2023). While the industry sector enjoyed the lowest average electricity price until 2000, residential prices became the lowest. Despite the current increase in tariffs, the actual value of the electricity tariff is diminishing over time.

Conversely, Japan's electricity prices rank among the highest among OECD countries due to various factors: expensive land, stringent safety standards including those for natural disaster preparedness, high environmental standards, compensations to local communities near power plants, high transmission costs across seas, lower load factors, and taxes (IEA, 1999). However, as discussed earlier, government support in Japan has contributed to efficiency restoration and improved industry competitiveness. For Indonesia, Setyawan (2014) proposed a similar supportive program called the revolving fund scheme. Under this scheme, small and medium enterprises could apply for loans ranging from 1 to 10 billion IDR at an annual interest rate of 5 to 6%, facilitated through designated banks that evaluate loan proposals in collaboration with the government.

From a technological perspective, innovation serves as Japan's primary driver of energy efficiency, facilitated by close collaboration among industry, universities, and the government (Ishida, 2015; Tanabe, 2010). The combination of incentives, mandatory energy management practices, and government support has effectively propelled advancements in production technology within the industry. In Japanese companies, every division must submit energy-efficiency improvement proposals at least once a year, and those whose proposals are selected receive rewards for their efforts, extending even to their family members. Consequently, energy-saving technology becomes deeply integrated into manufacturing processes (IEA, 2023b).

Political considerations are intertwined with energy conservation policies, as stringent environmental standards often accompany industrial competitiveness (Hu & Kao, 2007; Wakabayashi, 2013). Indonesia's National Energy Policy explicitly underscores the importance of energy efficiency in the industrial sector within the context of competition, highlighting the critical role of domestic industry in shaping energy conservation policies, particularly in establishing local environmental standards. These standards should be tailored to Indonesia's unique climatic conditions, diverging from international norms, and will serve as a crucial measure for local industries to enhance the efficiency of their products (Nurliyanti et al., 2022).

During the first oil shock in 1973, Japanese industries and society recognized the imperative of energy conservation policies and the necessity to reduce oil dependency, even at additional costs (Moe, 2012; Nishimura & Giri, 2008). This commitment to energy conservation was reaffirmed during the Fukushima incident in March 2011. The threat of rolling blackouts in East Japan arose as many power plants were offline (Mizobuchi & Takeuchi, 2013; Moe, 2012). Despite the interconnectedness of the four main Japanese islands through transmission grids, power plants in the western regions faced challenges supplying additional electricity due to frequency differences. The maximum capacity of frequency converters, which bridge the 60 Hz electricity in the west and the 50 Hz in the east, was only 1,200 MW, while the power deficit reached 10,000 MW MW (Nishiyama, 2013; Portugal-Pereira & Esteban, 2014). Consequently, the government mandated a comprehensive nationwide reduction in electricity usage, resulting in reductions of 29% in large industries, 19% in small industries, and 6% in households (Mizobuchi & Takeuchi, 2013).

From social and cultural perspectives, younger generations and higher education in European Union (EU) countries are associated with greater adoption of energy-efficient technology (Mills & Schleich, 2012), although this does not necessarily translate to lower electricity consumption. Despite being an aging society with a declining population, Japan maintains its reputation as one of the most energy-efficient nations. However, evolving lifestyles have led to increased ownership of electrical appliances (Minami, 2008; Portugal-Pereira & Esteban, 2014). In Indonesia, different regions exhibit varying lifestyles, with education and time spent at home positively influencing residential electricity consumption in Bandung City but negatively impacting Yogyakarta City, known for its simple and frugal culture (Wijaya & Tezuka, 2013). Other social factors contributing to higher electricity consumption include higher income and larger family size (Al Irsyad et al., 2018; Batih & Sorapipatana, 2016; Wijaya & Tezuka, 2013). Therefore, the lesson learned is the importance of promoting energy-efficient behavior alongside enforcing stringent environmental standards.

Organization and institutional issues are vital components contributing to Japan's success in energy efficiency. The establishment of the Energy Conservation Centre Japan (ECCJ) in 1978 under the Ministry of International Trade and Industry played a crucial role. The ECCJ provided services for energy manager certification, public dissemination, and training, allowing it to achieve financial independence. Furthermore, the Japanese Government supported energy service companies (ESCOs) by offering partial subsidies and low-interest loans, leading to substantial growth in the ESCO sector from 170 billion yen in 1998 to 497 billion yen in 2005 (Akahoshi, 2008).

In contrast, in Indonesia, the fertilizer industry spearheaded the establishment of the Industrial Energy Conservation Corporation (PT Konservasi Energi Abadi/KONEBA) with a World Bank loan in 1984 (Yang & Rumsey, 1997). However, the company could not repay the loan, which led to its acquisition by the government in 1991. Following a name change to Energy Management Indonesia (EMI) Corporation in 2006, the company became one of the 17 ESCOs comprising the Indonesia Association of Energy Support Company (APKENINDO) in 2011. In 2010, MEMR established the Directorate General of Renewable Energy and Energy Conservation (DGREEC) to regulate the energy conservation market and its implementation. Previously, research and training centers for energy conservation activities were set up in 2001.

Nevertheless, Indonesia still lacks accredited laboratories to support the energy labelling scheme. As a result, the energy label was only applied to self-ballasted lamps after 2011, air conditioners after 2015, and light-emitting diode (LED) lamps after 2022, despite the energy label being used since 2003. In the short term, the Indonesian Government must promptly implement MEPS and energy labels for induction cooktops, a crucial program for enhancing efficiency and reducing energy subsidies for cooking (Al Irsyad et al., 2022). Without MEPS and energy labels, the benefits of reducing subsidies and emissions from the induction cooktop program would not be optimal.

Furthermore, several studies have suggested that local customs, economic structures, and political environments significantly influence energy efficiency efforts (Grabowski et al., 2023; Popescu et al., 2012; Spandagos et al., 2021). Cultural norms and lifestyles influence energy consumption patterns (Filippini & Wekhof, 2021), with countries such as Japan, known for its energy-conscious practices, differing from Indonesia’s more diverse customs. Economic factors, such as industrialization and income, determine the capacity to invest in energy-efficient technologies, while political will and policy frameworks shape the regulatory environment. Developed countries like Japan often have more robust energy efficiency policies due to resource scarcity and environmental concerns. In contrast, developing countries such as Indonesia may prioritize economic growth, leading to slower progress in energy efficiency. These interrelated factors create different energy efficiency landscapes, underscoring the importance of tailored policies and strategies for each country.

4. Conclusions

This study compared energy efficiency conditions in two archipelagic states, Japan and Indonesia. Japan, confronting more severe climate change impacts stemming from emissions linked to higher electricity consumption, has bolstered its climate change adaptation efforts through the insights gained from frequent natural disasters. In terms of mitigation strategies, Japan has reinforced its energy conservation policies following the ratification of the Kyoto Protocol. Conversely, Indonesia exhibits lower electricity consumption and intensity. However, both indicators are rising due to economic growth and enhancements in the electrification program.

The strategies employed by Indonesia and Japan in addressing energy scarcity differ significantly. Whereas Japan demonstrated a willingness to accept high energy prices and stringent environmental standards during the first oil shock, Indonesians have been more resistant to such measures, continuing to demand electricity subsidies and showing reluctance towards energy efficiency standards for the sake of competitiveness, even after Indonesia transitioned into a net oil importer. Drawing lessons from Japan's experience, Indonesia would benefit from fostering more significant technological innovation within its industries to reduce energy consumption in production, mirroring the success achieved by Japan in this regard. To facilitate this transition, Indonesia should offer compelling incentives to support the implementation of such policies.

In conclusion, Indonesia faces three significant challenges in energy conservation. Firstly, *human behavior* contributes to high energy consumption, particularly among the middle and upper classes, who possess greater purchasing power. Follows and Jobber (2000) suggested that consumers' environmental awareness influences their purchasing decisions and willingness to buy products with minimal environmental impact. In Indonesia, the problem of human behavior is compounded by a large segment of the population with limited knowledge of green products. Consequently, producers and the government must educate the public and ensure the availability of environmentally friendly products (Hadriana & Hudrasyah, 2013). However, adopting eco-friendly behavior is heavily influenced by the affordability of green products.

Second, *technology innovation* is also the primary driver of energy efficiency and, therefore, should be conducted through intensive collaboration between industry, higher education, and the government. Japan has successfully proven that innovation will reduce energy costs and improve industry competitiveness. These innovations should be focused on the most significant energy-consuming sector, the residential sector.

The third challenge revolves around *energy management coordination*, wherein each ministry pursues distinct economic development objectives. It is crucial to synchronize these policies to maximize national benefits over the long term. While some benefits may be linked to economic growth, the primary focus should be improving overall quality of life. Despite uncertainties surrounding climate change risks, factors such as energy subsidies, scarcity, and escalating prices indicate the need to enhance energy management coordination. This coordination hinges on proactive executive leadership and effective engagement with community representatives, which is essential for fostering cooperation.

Further research is imperative, mainly to delve deeper into the challenges and opportunities associated with implementing energy efficiency strategies in Indonesia, drawing insights from Japan's experience. Research avenues should encompass social and cultural aspects, policy coherence, financial incentives or financing mechanisms, governance frameworks, energy labeling systems, integrated energy management approaches, electricity pricing mechanisms, and ESCO schemes. This comprehensive approach aims to provide broader and more insightful perspectives on how Indonesia can enhance its energy efficiency initiatives and foster a more sustainable and resilient energy sector. Achieving substantial progress in energy efficiency necessitates unwavering commitment from the government and all stakeholders, along with the development of robust and sustainable energy efficiency strategies. Such endeavors promise to advance climate change mitigation efforts, drive economic growth, foster technological innovation, and promote sustainable development across Indonesia. Moreover, a detailed economic analysis, including cost-benefit assessments of proposed policies and technologies, is crucial to strengthen the case for adopting Japanese strategies. This analysis should consider both short-term and long-term economic impacts across various sectors.

Funding Statement

This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors.

Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

AI Utilization Statement

In preparing this manuscript, the authors utilized AI-assisted technology to improve the clarity of the language. Following this tool, the authors carefully reviewed and made necessary revisions to the content. The authors assume full responsibility for the content of this publication.

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