Journal of International Studies on Energy Affairs
Jisea.universitaspertamina.ac.id | jisea@universitaspertamina.ac.id
ISSN Online 2774-4213
ISSN Print 2774-6380

Energizing Indonesia through Policy Recommendations of Biomass Power Plants : A Comparative Analysis with Brazil and Germany

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History

Submission : 1 October 2023
Review Completed : 25 October 2023
Accepted : 22 November 2023
Available Online : 29 December 2023

DOI :
10.51413/jisea.Vol4.Iss2.2023.165-187

Abstract

Energy security has become increasingly important across the globe due to geopolitical tensions and ongoing energy crises. Various countries compete to produce breakthroughs in energy production due to a real threat. One option is biomass, which can be used as a biomass power plant. The United Nations believes that transitioning to clean and low-carbon energy is essential to achieving Sustainable Development Goals 7. The UN encourages and supports immediate action to support the action. This article emphasizes the significant role of biomass power plants in the power generation sector as a practical and sustainable energy option. Biomass power plants are widely utilized globally, with some nations, such as Germany, a developed country, depending primarily on biomass for energy. Brazil, a developing country, has effectively utilized sustainable biomass energy. Unfortunately, Indonesia has not fully utilized biomass energy. This article uses a comparative method to analyze the differences in policies, actions, and characteristics between Brazil and Indonesia regarding using biomass energy. The

Cite this article :
Richard, I.N., & Salsabila, P.Y. (2023). Energizing Indonesia through Policy Recommendations of Biomass Power Plants: A Comparative Analysis with Brazil and Germany. *Journal of International Studies on Energy Affairs*, *4*(2),165-187. https://doi.org/10.51413/jisea.Vol4.Iss2.2023.165-187

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ISSN Online 2774-4213
ISSN Print 2774-6380

article presents Germany as a prime example of effective biomass utilization. The author argues that Indonesia, a country with a large population and significant agricultural resources, has great potential for utilizing biomass. The author notes that Indonesia has yet to thoroughly exploit this potential compared to other nations. This article uses a comparative method with providing case study review to discuss and analyze the issue. The author aims to provide references or policy recommendations useful to national policymakers, with the ultimate goal of achieving energy security for Indonesia.

Key Words: Energy Security, Biomass, Power Plant, Electricity, Policy

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INTRODUCTION

Energy security is a major global issue that captivates international attention. The challenge of meeting growing energy demand due to the increase in the global population is becoming more significant and needs to be addressed urgently. Based on Ember Climate data, in 2022, global electricity consumption will reach 28,510 terawatt-hours (Twh). The data grew significantly compared to the previous year, reaching only 27,816 Twh. The increasing energy demand is not proportional to the supply or availability of energy globally and domestically, which ultimately threatens energy security. In international relations, security is a crucial aspect and invites much debate. The development of the times has made the concept of "security" become widespread and not only about the military, one of which is energy security. Energy security is defined as the availability of energy needed at affordable prices (Yergin, 2006). Accessing energy sources that are affordable and suitable is crucial for both nations and individuals to maintain energy security.

The emergence of the concept of energy security indicates that energy is an essential element in life. Energy is considered as a capacity to do work. In modern times, everything requires energy to support daily activities. In modern times, everything requires energy to support daily activities. Modern human life depends on electricity; this can be proven by human activities that increasingly prioritize electricity use. Shifting needs are the main factor; humans need electricity to support communication (gadgets, internet). In fact, with various innovations today, humans must adapt to using electric vehicles as an environmentally friendly innovation. The world's electricity consumption needs to reach 25,300 TWh in 2021. This indicates a significant need and reliance on energy, particularly electricity.

Unfortunately, the multifunctional use of electricity and its impact on dependence has resulted in severe threats. Regarding energy security, there are four main aspects, known as "4A", including availability, affordability, accessibility, and acceptability. These four aspects are essential indicators of achieving a country's energy security. One of the aspects is acceptability.

Acceptability is an aspect that cares about the environment. The environment and energy are inextricably linked. Directly, energy activities can help or damage environmental conditions. Currently, the world still uses fossil energy which has a rude impact on the environment; even various countries are still dependent on

fossil energy, for example, coal for power plants. The Ministry of Energy and Mineral Resources noted that every time a coal-fired power plant produces 1 GWh of electricity, it is equivalent to producing 5 million tons of CO2. The fantastic amount of CO2 will certainly damage the environment, threaten the earth's health, and trigger faster global warming.

In 2015, COP 21 formalized the Paris Agreement and was ratified by 196 countries. This agreement aims to achieve zero carbon and to reduce the earth's temperature to no more than 2 degrees. This significant agreement is a global response to the impact of climate change, which can damage the earth's future and its contents. The energy sector plays an essential role in implementing the Paris Agreement.

In order to realize zero carbon and keep the earth's temperature from rising more than 2 degrees, followed by the acceptability aspect, energy sources must pay attention to the environment. Globally, energy use is still the largest contributor to emissions. The United States is the largest contributor to CO2 in the world due to the widespread use of coal.

The international community is haunted by energy threats that intersect with the environment. Decisive geopolitical factors are hampering the energy supply and disrupting global energy security. It means various political tensions worldwide, especially the Russia-Ukraine war, have minimized energy availability. Wars that produce various outputs, especially export/import ban policies, trade embargoes, and global sanctions, make energy transportation limited. Therefore, the global natural gas crisis, especially in Europe, should drive a clean energy transition (Samantha Gross, 2022). This will support energy security, especially the acceptability aspect.

Meanwhile, in Indonesia, coal energy is an abundant resource. The Geological Agency of the Ministry of Energy and Mineral Resources shows data on the number of coal reserves in Indonesia in 2021 of 186 billion tons spread across Kalimantan, Sumatra and Java. Currently, coal is still the main ingredient for power plants in Indonesia. Indonesia also utilizes coal as an export commodity. This makes the amount of coal energy continue to decline every year. However, over time the amount of coal energy use continues to increase due to the decline in petroleum production and causes various industries to start changing their energy to coal.

With the depletion of these reserves by mid-2022, energy prices such as crude oil, coal and natural gas will increase by 2 - 4 times compared to 2019. Therefore, any disruption to the accessibility of electricity poses a significant threat to energy

availability. Various policies, such as Domestic Market Obligation (DMO) and subsidies for fossil fuels and coal, have been issued by the government for short-term solutions. Unfortunately, these policies cannot be a long-term solution because Indonesia's coal, oil and natural gas reserves continue to decline every year, and these solutions tend to produce new problems. This is because, on the other hand, Indonesia's dependence on coal, if not immediately made a green transition, can have a negative impact on the health of the earth and the Indonesian environment, even globally. The CO2 waste produced, when adjusted to Indonesia's coal capacity, certainly accelerates climate change. Therefore, an energy transition solution must be carried out immediately to avoid Indonesia from the threat of an energy crisis in the future.

Biomass-based power generation is one of the solutions to making the energy transition. The use of biomass power plants in Indonesia is still relatively low compared to the use of fossil energy sources. However, the Indonesian government has shown a commitment to increasing the use of renewable energy, including biomass. Biomass is a renewable energy source obtained from organic waste such as agricultural residues, wood waste, palm oil mill waste, and other organic waste. In Indonesia, biomass can be generated from various sources, such as palm oil mill waste, agricultural residues, and organic waste.

A country's energy policy is influenced by various factors such as its background, characteristics, geographical location, and national policies. Countries like Germany, Sweden and Finland have successfully developed biomass power plants for long-term solutions. These countries have successfully used biomass for their energy needs based on global efforts to address climate change, global warming, and national potential.

On the other hand, Brazil, which is economically different from Germany and other European countries, has proven successful in using renewable energy. The Ministry of Energy and Mineral Resources noted that Brazil's utilization of renewable energy for electricity far exceeds Japan and Indonesia. This is a question for Indonesia. Until now, Indonesia is still relatively minimal in the use of renewable energy, especially biomass energy. With the abundance of raw materials for biomass power plants in Indonesia, especially in rural areas through livestock and plantations, Indonesia should be considered capable of making a renewable energy transition and maximizing it to be free from future energy crises and a form of concern for the environment. .

Brazil, a developing country with many similarities with Indonesia, one of which is the potential for large natural resources, has proven successful in using biomass. Energy transition certainly does not only depend on the potential of natural resources owned; there are various other factors, ranging from technology, funding, science, and public support to national policies. Therefore, this journal will analyze the comparison between Brazil and Indonesia in using renewable energy, especially biomass, ranging from biomass potential to national policies. Analyzing the comparison can be a reference for Indonesia in making decisions and further actions in using biomass energy (policy). In this discussion, the author also uses Germany as a reference for other developing countries to optimize the use of biomass as renewable energy.

Previously, various studies have been conducted to determine and analyze the potential use of biomass in Indonesia. Research conducted by Febijanto (2010) showed that Indonesia has much potential to use biomass, especially palm oil. However, the study confirms that this potential is not used optimally; even the remaining oil palm is only used as fertilizer or burned for nothing. The potential of Palm Oil during 2020 - 2030 as a biomass source was also clarified through the research of Hambali, E., & Rivai, M. (2017). Primadita et al. (2020) also provided a nationwide distribution of Indonesia's biomass potential materials. The study also showed that the realization of Indonesia's biomass electricity, the majority still needs to reach the target. Then Nurul et al. (2020) also explained why Indonesia still needs to improve in applying renewable energy. Dani, S., & Wibawa, A. (2018) explain the dynamics of policy and Indonesia's challenges in using biomass. Based on various existing studies, it is evident that Indonesia still needs access to biomass energy sources. However, no research compares Indonesia's potential with the potential of other countries with similar backgrounds, such as Brazil. The concept of this comparison can provide Brazil's strong points in biomass, which Indonesia can do. Therefore, this paper is here to find the differences between Indonesia and Brazil and to provide a reference to a developed country, Germany, so that Indonesia can maximize the use of biomass as an energy source with various policy recommendations.

METHOD

In conducting this research, we utilized the comparative method to thoroughly examine the variations in biomass utilization among Indonesia, Brazil, and Germany - a benchmark developed country. Our team gathered information on Germany's biomass usage from various sources, such as energy reports and

previous journals. We repeated the same rigorous process for Brazil and compared the data with Indonesia's current situation. Based on our thorough analysis, the author strongly recommended that Indonesia optimize their use of biomass energy sources.

RESULT AND DISCUSSION

Germany's Use of Biomass for Electricity

Germany is the fourth largest country in the European Union, with 83 million people. The data shows that Germany has a high demand for energy to meet the needs of the country's activities, especially the use of electricity. Power generation energy is an important component with various potential energy sources, ranging from fossil to renewable energy.

Germany is one of the countries that prioritize using renewable energy as a form of transition to renewable energy. Germany does this as a form of global concern and commitment to climate change and the sustainability of green earth. Although data in 2019 shows that Germany's energy sources are still dominated by fossil energy, this does not close the way for the use of renewable energy. In the same year, Germany reached the 18% mark for using renewable energy sources from total energy sources. The 18% figure is divided into various renewable energy sectors, with biomass being Germany's most dominant renewable energy and able to meet 7.2% of overall energy needs. (IEA Bioenergy Germany, 2021)

Germany's potential to use biomass is high. Overall, Germany has one of the largest biomass potentials in Europe. There are 14,922 biomass power plants in Germany, which is the highest in Europe. Germany's biomass potential is dominated by forestry biomass (44.43%), followed by agricultural biomass (32.6%) and waste biomass (21.6%). All three biomass potentials are utilized by Germany to the fullest, resulting in good output.

Germany has a significant amount of forests, covering approximately one-third of the country's land area, which amounts to 11 million hectares. This makes Germany one of the most forested countries in Europe, with a high potential for biomass production from forest products. These forests consist of a wide variety of species, ranging from trees (28%) to pines (23%) and others. This forest potential has led to energy solutions using firewood (forest products). In the midst of a crisis for several years. In recent years, firewood has become an important component of Germany's energy supply. This is due to rising global energy prices and the

efforts of many countries, especially the European Union, to transition to renewable energy.

Second, in terms of agriculture. Germany has an advantage in agriculture over other EU countries. Almost half of Germany's (46%) area is agricultural land or around 17 million hectares. 71% of this area is arable land. Straw is Germany's most highly used agricultural biomass product (86%). Straw is an important component of the future energy supply. According to a study by the Thueringian regional institute for Agriculture (TLL), 30 million tons of straw could meet the electricity needs of 1.7 to 2.5 million households (UFZ, 2013). In addition, using a straw is 73 to 92% more environmentally friendly than fossil energy due to the reduction of greenhouse effect gases

Third, waste biomass. Germany uses waste for energy supply processes, especially municipal waste. Solid municipal waste is one of the main problems that has the potential to damage the environment. However, on the other hand, this waste has the potential to become an alternative energy source. This requires several stages or processes, from waste collection, storage, and transportation to converting waste into energy sources.

Germany utilizes its biomass potential to fulfil energy requirements in different sectors, particularly power generation. In the European Union, Germany has the highest consumption of bioelectricity, ahead of the UK, Italy, and other countries. Bioelectricity is a combination of various kinds of energy - electrical energy generated from the processing of living things, including the remains of living things (biomass).

Power generation in Germany is an important and growing aspect. Based on Germany's population data, the energy demand will certainly increase. Before the innovation of biomass and other renewable energy, Germany relied heavily on fossil fuels, especially coal. Until now, Germany still uses coal but on a smaller scale. In the 2000s, Germany's dependence on coal was more than 50%. Subsequently, Germany began using renewable energy to support domestic electricity needs, ranging from wind, water, and solar power to biomass. In 2000 Germany's renewable energy consumption was only 6%, but it grew significantly in the following years. In 2019, it reached 42%. In the electricity sector, biomass is able to fulfil 8.8% of energy needs.

With biomass playing a significant role in the energy supply of many sectors and even dominating, the German government has adopted various policies and

measures to harness its potential. Most importantly, the German government believes in and is consistent with the green energy transition. In the midst of the crisis that hit the world, Germany did not turn away from the energy transition. This can be proven through the use of biomass in various sectors; when viewed in terms of numbers, the use of coal in Germany is still relatively high. However, at the same time, Germany continues to prioritize and develop other renewable energies, and it is proven that from year to year, it helps the energy supply gradually.

The ever-growing use of renewable energy, especially the use of biomass energy, is inseparable from the comprehensive policies carried out by the German government, among others. First, Germany adopted the goals put forward by the European Union to reduce the use of greenhouse gases. This goal is also in line with the global goal stated in the Paris Agreement in 2015. Second, Germany adopted the "Electricity Feed-in Law" policy regarding power generation. This policy has greatly influenced the development of renewable energy in power generation. This law triggers an increase in electricity production from biomass. This is because the main thrust of the law is to ensure that the supply of electricity generated is from renewable energy sources.

Electricity Feed-in Law has been implemented by Germany since 2000; the implementation of this policy has successfully developed renewable energy, especially power generation. This policy has even become a reference for various countries to develop similar policies to promote the use of renewable energy in electricity. The key is that this policy gives top priority to access to renewable energy; this policy provides investment guarantees and financial support for all renewable energy use, making Germany excel in electricity consumption from renewable energy.

Brazil's Use of Biomass for Electricity

Energy consumption is growing rapidly. Since 1990, Brazil's energy demand has doubled by 2020. This is, of course, due to the high population growth as well as Brazil's economic growth. At 2020. The use of fossil energy in Brazil to meet national energy needs or supply shows a downward trend. The consumption and use of renewable energy have reached 46% of Brazil's total energy supply, which is almost half of the primary energy sources (IEA Bioenergy, 2021). This makes Brazil one of the cleanest energy-using countries in the world.

The use of renewable energy is dominated by biomass, reaching 70% (IEA Bioenergy, 2021). One of its uses is the power generation sector. Hydropower is still the highest source of electrical energy in Brazil, reaching 65.2% (IEA Brazil, 2020). Furthermore, biomass through sugarcane biomass accounts for almost 19% of electricity use. However, based on the data, water use as a power plant shows a declining trend. In 2010, its use reached 78% and dropped to 65% in 2019. This trend is influenced by the growing use of massive bioenergy to cover national electricity demand, especially biomass. Brazil ranks fifth globally in biomass electricity use, surpassing Indonesia by a large margin, despite it being below hydropower usage.

Geographically, Brazil has excellent potential for using biomass energy. Brazil is the largest country in the South American region. Brazil has a total area of 8.36 million square kilometres, 60% of which is forestry land, followed by agricultural land at 29%. This geographical location makes Brazil rich in natural resources, especially from living things that have the potential to be used as energy sources, especially electricity sources. So far, Brazil has managed to meet the electricity needs of 211 million people, 65% of which comes from renewable energy sources. This figure surpasses the use of fossil energy, which is terrible for the environment.

Brazil's biomass potential is diverse, ranging from agricultural crops to various types of waste (forestry and animal). Brazil is the largest producer of sugar and sugar cane on the planet. Each year, Brazil produces 650 million tons of sugarcane. Therefore, the use of sugarcane to produce biomass energy is auspicious. Brazil has successfully utilized it as a source of electrical energy. Along with the times, sugarcane biomass is increasingly used for power generation due to its easy access to electricity consumption centres (cities) and is considered to be able to help hydropower. Sugarcane biomass has contributed 11,399 GWh of bioelectricity consumption in Brazil. In fact, 220 sugar factories, out of a total of 366, already use the potential of sugarcane to generate electricity and sell it.

With these data, it shows that Brazil is successful in using its renewable energy potential to supply domestic electricity and other sectors. Brazil is a developing country but has proven successful in using renewable energy. Large land potential, including water and soil, is fully utilized. Brazil is a country with many waterways, including the Amazon River. With that, Brazil uses this as hydropower potential. On the other hand, with such a large land area and the highest sugar production, Brazil uses sugar cane for biomass power plants. All renewable energy sources help each other, realizing Brazil's towards clean energy. This success is certainly

inseparable from various domestic policies of the Brazilian government to develop renewable energy, such as:

a. Program of Incentives for Alternative Electricity Sources (PROINFA)

   This policy has been issued by the Brazilian government since 2000. Brazil created this program to promote using renewable energy as an energy source for electricity generation. This program was launched in 2002 and ended in 2011 and shows Brazil's commitment as a country that cares about the environment and energy security, even decades ago. The program involves consumers paying more for energy use and is funded by the Brazilian National Development Bank (BNDES). In short, the program is divided into two sessions. The first session targeted renewable energy sources of electricity from biomass, and wind, amounting to 3,300 MWh> The target was realized with subsidies and intensive from the energy development balance sheet. Then the second session, increasing the target so that renewable energy can cover 10% of Brazil's annual consumption. This policy is considered the first step and stepping stone for Brazil's investment in renewable energy.

b. Energy and Alternative Energy Auction

   Since 2004, Brazil has used an auction system for electricity sources for various periods, from short to long-term. The policy was amended to add the importance of renewable energy, and in 2008 the first auction for renewable electricity generation, biomass energy, was held. The contract system for biomass is a 20-year term, and the contracted company must start operations 3 to 5 years after the auction. This system is carried out once a year so that the contract runs significantly. From 2009 to 2023, they generated 7,568 electricity capacity through biomass energy.

Condition & Potential of Biomass Electricity Usage in Indonesia

Fossil fuel consumption in Indonesia continues to increase as the population grows. According to the Ministry of Energy and Mineral Resources (ESDM), 87.4% of the national energy mix is currently dominated by fossil energy, such as coal, oil and gas. The remaining 12.6% comes from renewable energy. In the energy transition forum, Dadan Kusdiana, Director General of Electricity of the Ministry of Energy and Mineral Resources, also said that the amount of renewable energy continues to increase even though it is not too significant. One of the contributions of renewable

energy can be made through power plants. Several renewable energy power plants continue to be added and developed by the government little by little, adding 500 Megawatts each year to renewable energy power plants. However, an additional 2,000 Megawatts is needed to pursue Indonesia's carbon-free target or four times more than the amount currently fulfilled. Excessive consumption of fossil fuels will also lead to increased emissions that cause global warming and can affect human life patterns. Therefore, the use of new renewable energy, especially in power generation, needs to be maximized. One of the power plants using renewable energy that attracts attention is the Biomass Power Plant.

With a population of 270 million and an Indonesian forest area of 100 million hectares, Indonesia should be capable of developing and maximizing biomass power plants as part of energy diversification and efforts to reduce greenhouse gas emissions. Biomass is a new renewable energy (EBT) that requires organic fuel, which is abundant in Indonesia; the fuel is in the form of agricultural waste, wood waste, waste from the palm oil processing industry, and the main one is organic waste.

Indonesia's advantages in supporting the energy transition through Biomass Power Plants can be seen from various sides. One of them is the abundance of basic materials or fuel. Many Indonesians will automatically produce abundant community waste, especially organic waste, which can be used as raw material for biomass power plants. Organic waste is the largest component in Indonesia's total waste volume. According to data from the Ministry of Environment and Forestry, in 2020, around 60% of the total waste produced was organic waste. So the raw material supply problem can be solved with good and correct waste management. In addition, agricultural waste such as rice straws, corn stalks, peanut shells, and rice husks are straightforward to find and can certainly be utilized as biomass power plant fuel.

Food industry waste can also be used as fuel for biomass power plants. These wastes include sugarcane bagasse, oil palm bagasse, rice milling waste, and sago processing waste. The food industry in Indonesia continues to grow, as evidenced by the large contribution of the food industry to GDP of 37.82%, according to the Director General of Agro-Industry of the Ministry of Industry, Putu Juli Ardika. The food industry creates waste that can be reprocessed, including raw materials for biomass power plants.

In addition, there are many wood wastes such as wood powder, sawdust, and waste wood chips from the wood processing or forestry industry. Biomass from the forestry sector can also be used as fuel for Biomass Power Plants. Waste from oil palm plantations, such as oil palm empty fruit bunches (EFB), oil palm shells, and oil palm fibres, are important biomass fuel sources in Biomass Power Plants. From this, Indonesia has the opportunity to maximize Biomass Power Plant through abundant and diverse Biomass Power Plant fuels. Material Biomass fuels used in Biomass Power Plants in Indonesia can be customized through local availability, government policy, the technology used, and economic factors.

According to the Indonesian Biomass Energy Society (MEBI) organization, in 2021, the resource potential of Biomass power generation reached 32.6 Giga Watts. As an illustration, Indonesia's average annual household electricity consumption was 1,109 Kilowatt Hours (kWh) in 2021. If the potential of Biomass energy is maximally utilized as a power plant, Indonesia can supply electricity consumption for more than 29,000 households in a year.

Several biomass power plants have been successfully built in several villages in Indonesia, such as the Sembcorp Biomass Power Plant in South Sumatra, which has been operating since 2007 and has a generation capacity of around 20 megawatts (MW). This power plant uses palm fibre waste as biomass fuel. Then in Riau, there is the Asian Agri Biomass Power Plant which uses oil palm shells as biomass fuel. This Biomass power plant has been operating since 2009 and has a generation capacity of around 15 MW. On the island of Kalimantan, to be precise in West Kalimantan, there is the Astra Agro Lestari biomass power plant that has been operating since 2013 using oil palm empty fruit bunch waste as biomass fuel, and there are many more PLTBm that still survive and operate.

However, only a few have succeeded in the development process, such as the Siberut Bamboo Biomass Power Plant built in Mentawai Regency, West Sumatra in 2018. That Biomass Power plant uses bamboo as the main fuel for the three biomass power plants. Saliguma Village received electricity with a capacity of 250 Kwh, Madobag Village with 300 Kwh, and Mototonan Village with 150 Kwh. However, in 2022, these power plants stopped completely due to bamboo fuel supply problems. Initially, the community was very enthusiastic about this electricity switch because the biomass power plant requires organic fuel that can be purchased in the community. Since constructing the Biomass power plant, the village community has jointly planted bamboo to be sold to the biomass power plant for Rp 700 per kilogram. This makes the biomass power plant considered

profitable in terms of electricity and helps the income of the surrounding community. However, strong support from the government needs to be done to maximize the use of biomass power plants.

The Indonesian government has provided support for the development of renewable energy, including biomass power generation. The following are policies and incentives issued by Indonesia to maximize the transition to new renewable energy:

1. National General Energy Plan : This is a strategic planning document regulating energy source development in Indonesia. RUEN recognizes the importance of renewable energy development, including Biomass Power Plant, in achieving energy diversification targets and reducing greenhouse gas emissions.
2. Minister of Energy and Mineral Resources (ESDM) Regulation No. 5/2017 regulates the electricity tariff provided to producers from biomass sources through the Feed-in Tariff (FiT) scheme. The FiT provides attractive price incentives to biomass power producers to spur the development of biomass power plants.
3. Presidential Regulation No. 22/2017: This regulation concerns the policy on the procurement of electricity from renewable energy sources by PT PLN *(Persero)*, which also includes the procurement of electricity from Biomass Power Plants. It ensures that PLN must purchase electricity generated from Biomass Power Plants in accordance with the price stipulated in the regulation.
4. National Economic Recovery Program: This program, launched by the government to address the economic impact of the COVID-19 pandemic, also provides support for the development of renewable energy, including Biomass Power Plants, as part of efforts to accelerate economic recovery and create jobs.

In addition to the above policies, the Indonesian government has encouraged the development of Biomass Power Plant through research programs, technology development, and investment in the renewable energy sector. The government also cooperates with international institutions and the private sector to encourage investment and technology transfer in developing Biomass Power Plant in Indonesia.

From this, Indonesia is ready and able to build biomass power plants in order to make an energy transition and a sustainable future. However, parties have yet to synergize effectively and efficiently to build and develop large-capacity biomass power plants. This happens because most biomass power plant projects need help funding and managing fuel sources. Furthermore, recognizing the significance of using biomass fuels has yet to reach its maximum point. It requires commitment. The government, companies, and communities must take concrete steps to foster the full development of Biomass Power Plant. The synergy between relevant parties will be essential in building infrastructure, improving regulations, and providing incentives encouraging investment and adoption of Biomass Power Plant technology across the country.

Comparison of Indonesia and Brazil in the development of Biomass Power Plant

Brazil and Indonesia are in the same position based on their status as developing countries. Even based on land area and geographical factors, Brazil and Indonesia have great potential for access to abundant resources, high population growth, and even have the same climate, namely tropical. Unfortunately, based on data, the implementation of Biomass Power Plant in Brazil is considered far more advanced than in Indonesia. Brazil is one of the countries in the Americas with the world's oldest renewable energy programs. Therefore, Brazil's implementation in maximizing renewable energy has long been done. The potential of Brazil is almost the same as the potential of Indonesia, especially in the aspect of natural resources. However, Indonesia can still not maximize its biomass power plants due to several factors. The following are various comparative factors between Brazil and Indonesia in using biomass energy, especially in the electricity sector.

1. Government Policy and Support:

- Brazil has implemented more comprehensive and structured policies and regulations for Biomass Power Plant development. Brazil has clear, supportive policies, such as the PROINFA Program. In addition, the Brazilian government has provided strong and consistent government support for Biomass Power Plant development, including fiscal incentives, energy purchase programs, and public-private collaboration.
- Indonesia: The Indonesian government has also implemented policies and regulations supporting renewable energy development, including Biomass

Power Plant. However, Despite incentives such as the FiT, challenges in implementation and policy certainty still need to be addressed. Such issues include high costs, budget uncertainty, risk of overcompensation, and inconsistent policies. while Indonesia is still in the process of developing and integrating policies and regulations for Biomass Power Plant.

2. Technology Development:

- Brazil: Brazil has more mature infrastructure and technology in developing Biomass Power Plant, such as efficient biomass processing and integrated biomass transportation systems. This is because Brazil has more extensive experience in using advanced technologies, such as direct combustion, gasification, and Organic Rankine cycle (ORC) steam generation, allowing them to utilize biomass more efficiently. Its also supported by Brazil's financial policies for renewable energy, especially The Brazilian Development Bank (BNDES). The bank is able to finance up to 80% of renewable energy projects and uses long and affordable interest rates. BNDES also actively supports the development of small-scale energy projects in remote areas (Rennekamp & Westin, 2017), particularly for biomass. Along with wind and hydro energy, BNDES support totals 70%. This financial support is certainly constructive for developing supporting technologies for biomass power plants in Brazil. Indonesia: The development of Biomass Power Plant technology in Indonesia still needs to be improved. In some cases, the technology used is still conventional and has yet to adopt the latest innovations that can improve the efficiency and performance of Biomass Power Plant. Indonesia still has limitations in the development of Biomass Power Plant technology. Although some Biomass Power Plants are already in operation, more research and collaboration are needed to improve the technological advancement and efficiency of Biomass Power Plants. Funding is also a challenge in the development of Biomass Power Plant in Indonesia. Although there are some incentives and support programs from the government, further efforts are needed to improve access to affordable financing for Biomass Power Plant developers.

3. Biomass Resource Availability:

Brazil: Brazil has enormous biomass potential. Brazil has abundant natural resources, including various types of biomass that can be utilized for biomass power plants. One of them is sugarcane biomass. With the world's largest sugarcane production potential, Brazil can utilize it for power generation.

Indonesia: Meanwhile, Indonesia also has significant biomass potential, especially from palm oil waste such as shells and empty fruit bunches. However, in its implementation, this natural wealth has not been able to be used optimally for energy sources. Compared to Brazil, which uses its main potential for energy sources, Indonesia still needs to be clear that it will focus on a particular biomass source. Indonesia's potential to use palm oil waste is very high. Therefore, Indonesia should focus on using this potential. In addition, the distribution of biomass has yet to be optimized. Infrastructure for biomass collection, processing, and transportation also needs to be improved to support the widespread development of Biomass Power Plant.

4. The scale of development:

Brazil: Brazil has a much larger installed capacity of Biomass Power Plant than Indonesia. Brazil has developed Biomass Power Plant with a capacity that reaches around 50 thousand GW and puts Brazil in fifth place globally. The contribution of electricity from Biomass Power Plant produced is significant, so Biomass Power Plant in Brazil has become one of the main sources providing electrical energy for its people. Biomass Power Plant has been distributed evenly across all geographical locations during its development and installation.

Indonesia: Although Indonesia already has some Biomass Power Plants, most still operate on a smaller scale. Biomass Power Plant development is still concentrated in a few locations or areas with high biomass potential. Therefore, the contribution of Biomass Power Plant in Indonesia still needs to be higher. Therefore, there is still a long way to go in maximizing Biomass Power Plant.

This comparison emphasizes the importance of the government's role in providing strong support for the development of Biomass Power Plant through policies, regulations, incentives, financial support and collaboration with relevant stakeholders. As a developing country, Brazil is also not free from classic problems, such as poverty, public health, unemployment, and others. However, Brazil is one of the countries with the most significant efforts to fight climate change and is a country that has long been a leader in the development of bioenergy, including Biomass Power Plant. Brazil's experience and credibility in developing technology,infrastructure,and know how related to the CBM provide an advantage in creating effective policies and the best solutions in CBM development

Policy Recommendations for Maximizing Biomass Power Plant in Indonesia

Seeing the same opportunity, Indonesia can adopt some of Brazil's Biomass Power Plant policies to develop and maximize Biomass Power Plant. Setting renewable energy targets like Brazil's can create a sense of ambition, and attractive fiscal incentives, tax exemptions, or low-interest rate credits will bring in investors. In addition, Indonesia could implement a guaranteed tariff energy purchase program to encourage investment in Biomass Power Plant. This will provide certainty for Biomass Power Plant project developers regarding the competitive selling price of electricity.

Increase community participation in the use of Biomass Energy.

In the development of small-scale Biomass Power Plants currently carried out by the government, the main problem that still needs to be resolved is the problem of fuel supply. If we look at the Siberut Bamboo Biomass Power Plant built-in Mentawai Regency, Sumatra, it uses bamboo as the fuel for the Biomass Power Plant. Bamboo fuel is obtained from the community by buying bamboo that they plant with a benchmark of Rp 700 per kilogram. From here, the participation of the village community is greatly increased because, in addition to producing lighting in the village, the existence of the Biomass Power Plant can increase their income. However, the lack of fuel supply that occurs is caused by community participation on a small scale. The only people who sell bamboo are the village community. To ensure a stable supply of bamboo, it's important to have a diverse group of villagers involved in its production. If only a few people are relied upon, the Siberut Bamboo CBM plant may cease operations by 2021.

The case of the Siberut Bamboo Biomass Power Plant can be used as a lesson in developing the next Biomass Power Plant. The development of the Siberut Bamboo CBM involves the participation and empowerment of local communities in resource management and CBM operations. In this case, local communities plant, process, and transport bamboo as fuel. This can provide social and economic benefits to the local community and raise awareness of the importance of sustainable practices in the Biomass Power Plant.

Utilizing natural resources. Furthermore, the Siberut Bamboo CBM demonstrates the importance of energy source diversification in ensuring a sustainable fuel supply. Energy source diversification refers to the strategy of reducing dependence

on a single type of energy source by using various types of energy sources. The aim is to reduce risk and increase the sustainability of energy supply. The use of bamboo as a fuel requires sustainable management of the resource. The Siberut Bamboo CBM can serve as an example of sustainable management of forests as fuel suppliers, including wise planting, maintenance and harvesting. Thus, the fuel supply of the Biomass Power Plant can be sustained and does not damage the local ecosystem. By studying the experience of the Siberut Bamboo Biomass Power Plant, we can gain insight into the importance of local resource management, energy source diversification, technology development, and community empowerment in overcoming fuel supply challenges in Biomass Power Plant development.

Maximizing close cooperation between the government and the private sector in the construction and development of Biomass Power Plants should also be done. The Brazilian government is actively collaborating with the private sector to develop Biomass Power Plants. Through this collaboration, investment, technology transfer and knowledge exchange can take place more effectively. Seeing that so far, Indonesia still has small-scale Biomass Power Plants, the majority of which are privately owned, cooperation can accelerate the development of Biomass Power Plants. Then, more than the movement from the government is needed to support the EBT transition. So, the role of the community is needed who can work together in supporting and maintaining Biomass Power Plant. Therefore, Indonesia can increase the community's and stakeholders' awareness and knowledge regarding Biomass Power Plant's benefits and potential through educational campaigns, training, and workshops. This will help change perceptions and accelerate the adoption of Biomass Power Plant technology. If all parties are ready to synergize in making the EBT transition, strong government support through financing and incentives can launch the development of Biomass Power Plant. By adopting some aspects of policies and approaches that have proven successful in Brazil, Indonesia can accelerate the development of Biomass Power Plant and increase its contribution as a renewable energy source.

Maximize the development of domestic biomass potential.

The palm oil industry in Indonesia produces a large amount of waste, especially empty fruit bunches (EFB) and palm fibres. This waste can be used as fuel for Biomass Power Plants. The potential of palm oil waste as a Biomass Power Plant fuel can be utilized on a large scale due to the availability of a fairly abundant amount of waste from the palm oil industry. The potential for palm oil waste is very

large and spread across various islands in Indonesia. However, this potential has yet to be maximally utilized for domestic needs. Indonesia's palm kernel shell production is the highest globally, and Japan is eyeing this potential as an import hotbed. Japan is making great efforts to use biomass power plants as an energy source and utilize palm kernel shells, thus requiring imports from Indonesia. Economically, this is very beneficial for Indonesia. Indonesia has the potential to use these shells as feedstock for domestic biomass power plants. Therefore, it is crucial to fully utilize biomass for domestic purposes—land optimization based on local biomass potential

The territory of Indonesia is covered by various potential natural resources, according to their respective characteristics. For example, oil palm is dominantly found in the Sumatra region. Numerous other potential biomass resources exist, including sugarcane, rice, coconut, corn, cassava, and more, spanning Sumatra to Papua. In order to maximize biomass potential, Indonesia must be able to maximize the potential of each region. If done in large numbers, the small scale of development in various regions will certainly have a maximum impact. In particular, this is true for areas without access to electricity. Such areas are mostly found in rural regions, where various types of superior biomass are available for production. Therefore, it is necessary to analyze the potential of the land used to develop Biomass Power Plant. When developing a Biomass Power Plant, it is important to consider several factors, such as the availability of biomass, accessibility of land, quality of soil, and necessary permits for land use. Conduct mapping and inventory of potential land for Biomass Power Plant. This will help identify optimal locations for power plant development and ensure efficient and sustainable land use. Establishing land use policies that support Biomass Power Plant development should also be done. The government can allocate suitable land, either. We can effectively manage and preserve natural resources by assessing current land usage and determining areas that can be transformed into conservation priority areas.

Increase public attention and investor attraction through marketing and promotion of biomass energy.

Renewable energy in Indonesia is still very much synonymous with using hydropower. Ordinary people seem to only know about hydroelectric power plants. The potential for renewable energy sources in Indonesia is very abundant, ranging from wind to solar, especially biomass. Therefore, more detailed promotion and counselling to the Indonesian people regarding the potential use of biomass is

needed; this also has the potential to maximize land optimization in the regions. For example, Brazil actively promotes and markets biomass power plants to local communities. This is done in various ways, such as conferences, exhibitions, and industrial visits. The aim is to introduce the potential of biomass to the public. The Indonesian government can use similar methods to create high public awareness of the use of biomass.

CONCLUSION

The development of biomass power generation in Indonesia faces several barriers, including feedstock availability, agricultural waste management, regulation and policy, technology and infrastructure, and awareness and education. Cooperation between the government, private sector, and communities is needed to overcome these barriers to create an enabling environment for sustainable and efficient biomass power development in Indonesia. One of the steps that can be taken is how Indonesia can improve and develop policies regarding the transition to renewable energy through biomass power plants. Indonesia needs to pay more attention to biomass Power Plants, such as providing financial support, maximizing the use of natural resources such as biomass raw materials and other attention to strengthen energy transition policies. Therefore, with the proposed policy recommendations, Indonesia can maximize its potential in using biomass renewable energy to achieve energy security.

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