Abstract. Biopellets, part of biomass, have excellent prospects to be developed further in Indonesia. The potential for developing biomass energy is estimated at 50 GWe, while the installed capacity is still around 1600 MW by 2018. This study analyzed the barriers and opportunities of bio pellets development in Indonesia. Data were collected from a systematic literature review and interviews with related stakeholders. Lack of market demand is one of the main barriers to boosting bio pellets development in Indonesia. We found that a lack of national demand was one of the barriers. National demand accounts only for about 10% of total production, with the highest coming from Java – produced for power plants and other industries such as food, cosmetics, ceramics, and furniture industries. About 90% of the biopellets market demand originates from Japan and Korea. Recently, the Indonesian government is drafting a regulation to support cofiring for coal power plants to increase national demand for biomass (including biopellets). This may open a window of opportunity to increase the national market demand for biopellets in Indonesia.

Keywords: bio pellets; market demand; policy; barriers and opportunities; Indonesia

1. Introduction

Indonesia is one of the largest fossil energy producers in the world. Until 2019, energy production from coal has reached 35.46%, followed by oil (28.12%) and natural gas (21.90%) (Nasional, 2019). Fossil energy produces carbon dioxide which is the biggest contributor to the greenhouse effect. The increasing demand every year causes a gap between production and demand for petroleum energy. With the assumption that there are no new discoveries of fossil reserves, it is estimated that fossil energy sources in Indonesia will only be sufficient for the next 9 years (Nasional, 2019). Therefore, it is necessary to find alternative energy sources to replace fossil fuels with the same level of efficiency.

Biomass as a form of renewable energy has great prospects to be developed in Indonesia. The potential for developing biomass energy is estimated at 50 GWe, while the installed capacity using biomass energy in Indonesia is around 1600 MW (Nasional, 2019). Biopellets are one of the biomass products processed by sawdust waste into alternative fuels that are smaller in size than briquettes. With an energy content of 4,280 kcal/kg, bio pellets can potentially replace the role of LPG gas as a cooking fuel (Hoefnagels, Cornelissen, Junginger, & Faaij, 2013; Proskurina, Junginger, Heinimö, Tekinel, & Vakkilainen, 2019). Apart from being more efficient, the use of biopellets as a fuel is far more economical, cleaner, and easier to use for household and power generation purposes and produces a lower carbon content than LPG. Therefore, the use of biopellets as fuel is highly recommended in Indonesia. Biopellets are categorized as recovered wood fuels, biomass that come from socio-economic activities outside the forest and wood-processing sectors. The densification method that is applied in the process of making pellets could increase calorific value per volume and also as a prospective and competitive realization for cooking fuel alternatives (Yudiartono et al., 2018). Moreover, the smoke from wood pellet stoves is less than firewood-
fueled cooking facilities and can reduce workload (Sidabutar, 2018).

Until 2020, the international market demand for biopellets has increased about 25 – 30% (Newell & Raimi, 2020). This finding shows that biopellets have been identified as one of the fastest-growing bioenergy feedstock markets. Even though bio pellets have many profitable prospects, the development of biopellets utilization in Indonesia is still lagging. The biomass energy development plan has been regulated in the National Energy General Plan (RUEN) which has a target of 5.5GW of biomass energy until 2025. Some of the challenges that arise in the realization of biomass energy in Indonesia are availability and supply of biomass energy, encouragement of domestic use, and analysis (Haryana, 2018)

As a tropical country, Indonesia has abundant resources to utilize for bio pellets production. As an increase from 2018, bio pellets production in Indonesia was relatively small, approximately 160,000 tons per year in 2019 while Thailand produced 317,000 tons, Malaysia at more than 710,000 tons per year, and Vietnam reached 3,100,000 tons production of biopellets per year (Newell & Raimi, 2020; Thrän et al., 2017). Focusing on Indonesia for our case study, we seek to answer the following research question: What are the barriers and opportunities for bio pellets development in Indonesia?

The barriers and opportunities in this study focused on the supply and demand side of bio pellets in Indonesia, which involves various production methods.

2. Methods

2.1. Systematic literature review

Systematic Literature Review (SLR) is a method using tailored protocol and strategy to answer the research question of a paper. The protocol consists of search strategies and screening of potential reference papers. SLR helps us to search, select, and analyze our potential reference papers (Dewey & Drahota, 2016). Our study aims at understanding the market demand for biopellets in Indonesia. In doing so, we synthesize our search strategies and screening protocol to help us answer the question.

2.1.1. Search strategies.

The first step in a systematic review is to set up a search strategy. To select search queries according to the research question, three key concepts are defined which are 1. Biomass pellet; 2. Market demand; 3. Indonesia. Search terms are formulated by searching for synonyms or related topics based on concepts contained in Table 1. These search terms are refined by doing some preliminary test searches. Systematic searches will be conducted by combining every possible combination of three categories of keywords.

| Table 1. Search terms for key concepts. |
|----------------------------------------|
| Biomass Pellet | Market Demand | Indonesia |
| Wood pellet | Consumer demand | Java |
| Wood chip | Market-driven | Bali |
| Biomass chip | Steady demand | Borneo |
| Biopellets | Pellet-fuels | Sumatra |

2.1.2. Search formula

The following formula was used based on the search terms:

("Biomass Pellet*" OR "Wood Pellet*" OR “Wood Chip*” OR "Biomass Chip*” OR "bio pellets*" OR "Pellet-fuels") AND ("Market W/3 Demand*" OR “Consumer demand*” OR "Market-driven*" OR "Steady demand") AND ("Indonesia*" OR "Java*" OR "Bali*" OR "Borneo*" OR "Sumatra*")

Three databases, Scopus, Portal Garuda, and Grey Literature (google scholar), were selected to guarantee adequate coverage for the topic. Scopus covered peer-reviewed journal articles with interdisciplinary topics
such as market demand for biomass pellets in Indonesia. Full copies of articles identified by the search, and considered to meet the inclusion criteria, based on their title, abstract, and keywords, had been obtained for data synthesis. We independently select articles against the inclusion criteria. Discrepancies in our selections had been resolved at a meeting between writers before selected articles were retrieved.

For the Scopus and Portal Garuda databases, we only use the biomass pellet and market demand keywords. Because there was no paper found if we added study area keywords to the search formula. With biopellets and market demand keywords, we found 5 papers. Our search formula for Scopus and Portal Garuda Database is:

(“Biomass Pellet*” OR "Wood Pellet*" OR “Wood Chip*” OR "Biomass Chip*" OR "bio pellets*" OR "Pellet-fuels*) AND ("Market W/3 Demand*" OR “Consumer demand*” OR "Market-driven*" OR "Steady demand*")

From Google Scholar, the keywords are similar to the general search formula but with a few modifications of the punctuations. There were 258 pieces of literature found before the screening process was done. The search formula for Google Scholar was:

"Biomass Pellet" OR "Wood Pellet" OR “Wood Chip” OR "Biomass Chip" OR "bio pellets" OR "Pellet-fuels" "Market Demand" OR “Consumer demand” OR "Market-driven" OR "Steady demand" "Indonesia" OR "Java" OR "Bali" OR "Borneo" OR "Sumatra"

2.1.3. Selection of the papers: Screening.
From the return results of the Scopus, Portal Garuda, and Grey Literatures, we screened the paper by following the Include-Exclude protocol in Table 2. The screening process was done to help us find relevant papers based on our needs.

| Included if                                                                 |   |
|----------------------------------------------------------------------------|---|
| Discussing Bioenergy Producer, Bioenergy stakeholders, Bioenergy consumer, Biofuel consumer |   |
| Context of the papers are Market demand on biofuel pellets                  |   |
| Comparison to other country’s market demand on biofuel pellets or Indonesia market demand toward other renewable energy sources |   |
| Case studies in Indonesia                                                   |   |
| Publication year: 2010-2021                                                 |   |
Figure 1. Screening Process for Selected Paper

The first screening process removed duplicate papers from the database, the second screening process excluded papers that didn’t meet the criteria in Table 2. The last screening removed papers due to some reasons such as eligibility, no author, limited access for the paper, incomplete data for bibliography, website errors, and not related to our topic.

2.1.4. Data analysis. After the screening process, we continued with the data extraction sheet method. This process claimed to obtain the necessary information about study characteristics and findings from the included studies. The approach process for data extraction methods is finding electronic databases, visually scanning reference lists from relevant studies, determining which article or journal is suitable for our paper – based on the inclusion criteria in Table 2.

Selected papers were analyzed using content analysis by finding and determining the information based on keywords (production, supply, demand, policy). We extracted data in the paper by following the categories or extraction sheet in Appendix 1. Data in the sheet was further analyzed and we took it as a reference for concluding.

2.2. Interviews
The data was also collected by conducting interviews with several parties related to the topic of this paper. The interview session aims to gain qualitative data from respondents to follow up on a particular issue which in this case is bio pellets market demand in Indonesia. This method also helped us to clarify
concepts or check the credibility and existing condition of data that is missing from the systematic review. Due to the pandemic situation, the interviews were conducted online in a structured way. The respondents were chosen based on their backgrounds such as from the academic sector, non-governmental organizations, the government, and the industry that produces biopellets. From the academic sector, we interviewed Rudianto Amirta, Dean of Faculty of Forestry Universitas Mulawarman; from the non-governmental organization we interviewed Lembaga Kajian Nawacita Komite Upgrading Biomassa Indonesia (LKN Kubmindo) and Masyarakat Energi Biomassa Indonesia (MEBI); from the government sector we interviewed the Ministry of Energy and Mineral Resources (ESDM) Bali Region, and from the industry, we interviewed Produsen Energi Biomassa Indonesia (PEBI). Each interview was conducted on average for 2 hours with 20 questions related to the search query in the SLR.

The same analysis approach was applied to the interview results. Each interview was transcribed into full notes and then analyzed using content analysis by finding and determining the information based on keywords (production, supply, demand, policy). The relevant information is then merged into the sheet in Appendix 1 and further analyzed together with the results of SLR, to answer the research question.

3. Results
The barriers and opportunities in this study focused on the supply and demand side of bio pellets in Indonesia, which involves various production methods.

To increase the volume and quality of bio pellets production, Indonesia has to deal with feedstock availability, product quality, financial strength and reliability, and competitive prices (Fransiska, 2020). The demand for bio pellets in Indonesia mostly comes from the food industry that is located in East Java, West Java, and Borneo. Most of the biopellets that used in the drying process or energy-based drying materials derived from Indonesia produced 40,000 to 80,000 tons of wood pellets from 2013 until 2018 (Nasional, 2019), where more than 94% were exported to South Korea, 2.2% to Japan, and less than 1% to European countries (Eastin, Sasatani, & Aikawa, 2020). Unfortunately, the limited stock of biopellets and the use of modern cooking stoves have become one of the barriers to bio pellets development in Indonesia.

3.1 Biopellet production and market demand in Indonesia
Indonesia is one of the countries with the most diverse flora and fauna globally because of its geographic and geological features and history. As an archipelago, every region in Indonesia has its distinctive flora and fauna species. The Wallace, Webber, and Lydecker line that split Indonesia into four biodiversity regions can be proved by this. This biodiversity makes Indonesia have massive potential in biomass utilization, especially in wood and biowaste-derived products, because of its vast area of industrial forest that reaches 11 million hectares and huge amounts of waste from the forestry and palm oil industry. However, in reality, Indonesia is behind in world bio pellets production and domestic consumption. Even between Southeast Asian countries such as Vietnam, Thailand, and Malaysia.

Therefore, to understand the barriers and opportunities of bio pellets fuel in Indonesia, we dissect the analysis into four different regions (Borneo, Sumatra, Java, and Bali, and Nusa Tenggara) and the impact of local and central government policy for the bio pellets industries in Indonesia.
3.1.1. Borneo: The imbalances of feedstock, production, and domestic demand. Borneo’s forests are some of the most biodiverse on the planet and consist of more than 15,000 plant species. As one of the provinces that has abundant biomass reserves, Borneo has strong potential to support bio pellets production in Indonesia. The potential for bioenergy in Borneo reaches approximately 1842 MW for East Borneo and Central Borneo (Dani & Wibawa). In addition to having a wide and diverse forest area that produces many forest products, wood waste can also be used as raw material for bio pellets production. The production process from wood waste into biopellets can be a new strategy to increase profits through cost efficiency and a promising market for sustainable wood pellet production (Malek, Hasanuzzaman, & Abd Rahim, 2020). In 2020, the wood waste reached 1 million logs. Some biopellets producers are located in Borneo such as PT Kyong Dong Mineral, PT. Pellet Biomassa Indonesia, PT Saminda Indo Prawira, and PT Jhonlin Agro Mandiri. In East Borneo, there are 83 companies awarded License of Utilization Timber Forest Products in Natural Forest (IUPHHK-HA) (Wahyuni, 2021). However, the biopellets companies are focusing on export activity in the global market, especially in Japan, South Korea, and China (Sadirsan, Siregar, & Legowo, 2015). Research in Borneo by Ruslandi and Malik (2019) calculated that selling the
wood waste for bio pellets production could make a profit of USD 570,000 per year instead of doing nothing for the wood waste (Novita & Malik, 2020).

Unfortunately, the high amount of feedstock is not followed by the available domestic market demand. Approximately 70% of the local bio pellets market demand comes from Java and Bali, as the center of the energy sector, manufacturing base, and industries in Indonesia. In other words, Borneo’s forest provides other regions’ bio pellets stocks more than in Borneo itself (Siska & Indrayanti). The community took an important role in the biopellets market demand. Yet, the convenience of using bio pellets-based equipment is still time-consuming. Consequently, the community tends to choose LPG as their main fuel for kitchen activities rather than a bio pellets-based stove.

3.1.2. Sumatera: No local demand. Raw materials for the fulfillment of bio pellets production in Indonesia are still limited. The existing production capacity can only produce 400 thousand tons of biopellets while the existing demand is 20 million tons, where approximately 90% of the total demand comes from foreign demand in which the palm oil is chosen.

The Central Statistics Agency (BPS) noted that the trend in the area of oil palm plantations in Indonesia during 2015-2019 was volatile. It was recorded that in 2019 the area reached 14.60 million ha. Riau province has the largest oil palm plantation area with 2.82 million ha in 2019, or 19.31% of the total area of oil palm plantations in this country (Descals et al., 2019). The increase in oil palm plantations has implications for increasing the amount of solid waste biomass from the garden, such as replanted stems, midribs, empty oil palm fruit bunches, shells, and fruit fiber. This palm waste has the potential to be used as biopellets to fulfill the demand.

The trial of making pellets has been carried out by the Palm Oil Research Center (PPKS) Medan in collaboration with DMSI and the Palm Oil Plantation Fund Management Agency (BPDPKA) and has been introduced to Japan. Japan, he said, was interested in the product. The manufacture of pellets from oil palm trunks and export would provide benefits for economic growth (Casson, 2000). However, unfortunately, local demand for these biopellets is still low. This condition is caused by the price of biopellets that can still not compete with the existing fuel. Furthermore, based on our interview, communities tend to choose the now-available convenient option (LPG) rather than the biopellets stove which isn’t convenient to use.

Based on the BPS data, there are as many as 25,899 UMKM units in Sumatra, which in their production activities still use subsidized liquid petroleum gas (LPG). This LPG gas is often in short supply, which causes the price to soar up quickly. This condition is burdensome for several UMKM owners so that biopellets can be an alternative fuel solution to replace the role of LPG gas in carrying out their business activities. With the large number of UMKM in Sumatra, which continues to increase from year to year, and the scarcity of LPG fuel, the local market demand for biopellets can potentially be higher.

3.1.3. Bali and West Nusa Tenggara. Bali currently still focuses on waste processing and solar energy development in solar power plants. The biopellets ecosystem in Bali has not yet been formed, which results in market demand for biopellets. The lack of socialization from the government about bio pellets to the Balinese people and the Balinese paradigm that prioritizes practicality are obstacles in developing bio pellets where people prefer to use LPG, which is easier to obtain and cheaper. In Bali, there is no practice based on the need for biopellets. Still, there have been efforts to make biopellets in Klungkung Regency in collaboration with Indonesia Power to process organic waste into biopellets used for fuel mixtures for power plant trials at PLTU Jeranjang, West Nusa Tenggara.

West Nusa Tenggara Regency has the potential for the development of the biomass industry, including biopellets, due to the availability of sufficient land that can be used as an energy plantation area. The gold mining company’s existence could be one of the driving factors of the energy plantation development and reforestation on mine locations (Sarumpaet, Kumara, & Ariastina, 2020).
3.1.4 Java: Potential to meet demand from local industries. The market demand for biopellets in Java generally comes from the food industry that is located in Gresik, East Java as a fuel in the drying process of chips, peanuts, and other food industries (Simangunsong et al., 2017). In Wonosobo, the industries use biopellets as fuel in the tofu and tempeh factories and reach 40,422 tons of biopellets every year. In 2013, biopellets were used in 106 tofu factories and 1604 tempeh factories. The biopellets are made from sawdust, where it only contributes 10.6% of total wood waste in Wonosobo (Sylvani & Suryandari, 2013). Not only food industries, other industries such as textile, furniture, cosmetics, and ceramics also used bio pellets as their fuel. In 2021, the biggest demand for bio pellets came from the ceramics industry.

The use of bio pellets has also been proven in several small factories in Cibinong, West Java. They admit that there has been an increase in production, time-saving processes, and better air quality around the production site since they started to use biopellets as their fuel. The main raw materials for Java’s bio pellets production are sawdusts. Based on the conducted interview, the biggest biomass-based industry is located in Java. Even though there are some products from Borneo or Sulawesi, the biopellets do not fulfill the specifications and are not sold in Indonesia because of the high price caused by the high cost of the distribution from Borneo to Java. However, the biopellets industries outside Java do not produce biopellets as the main business. This is in contrast to Java, where the biopellets become the main business for bio pellets producers including domestic and international market demand.

Practically, Java has some potential feedstocks to be developed with such as bagasse and calliandra (Danu et al., 2020). Ciamis Regency, West Java, is covered with 27,420 ha community forest with 10,968,064 stands. There are 387 sawmills and bio pellets processing industries that potentially generate abundant biopellets. The development of bio pellets in the Ciamis Regency can reach 1,316,644 tons of wood and enough for 842,652 tons of biopellets. With this basis, the surrounding area of the Ciamis Regency has a huge potential to be a bio pellets producer (Widiyanto, 2019b). The potential resources of the community forest include calliandra, lamtoro, gamal, turi, akor, and sengon. Another method to increase the productivity of biopellets is to develop the wood energy plantation forest (HTE) that can be the base of bio pellets production and also enhance the opportunities for business development. Not only a community forest in Ciamis Regency, an educational forest in Sukabumi can generate electricity for approximately 123,863.79 MWh (Siregar, Damayanti, & Dwiyanti, 2020; Widiyanto, 2019a). Observation and identification of bio pellets marketing are necessary to accelerate the market demand for non-industrial sectors.

3.2 Policy barriers and opportunities

The associated policies should drive innovation and regulations that support the development of bio pellets production, distribution, and consumption processes. The Indonesian Government is seeking a breakthrough in the use of biomass to reduce the role of coal which is still dominant in national use and to encourage the achievement of the target of the renewable energy mix by 2025. To prove a good commitment to renewable energy development, the Indonesian government put co-firing method (using biomass as coal substitution) on thermal power plants in National Electricity Master Plan 2019-2038. The Ministry of Energy is currently drafting a specific regulation to further support the implementation of that plan - a cofiring program for coal power plants.

The mixing of biomass with coal is claimed as the best option from both economic and environmental perspectives, slowly increasing biomass contribution in the power generation (Idris, Hashim, & Razak, 2018). The government has 114 existing coal-fired power plants as the cofiring target in 2024. The cofiring plan has also been reviewed by the Ministry of Energy and Mineral Resources (MEMR) which states that there is an opportunity for the growth of the biomass industry to provide stable supplies between 4 to 9 million tonnes annually.

In terms of the quality of bio pellets production, Indonesia already has a quality standard that is regulated in Standard Nasional Indonesia (SNI) 8021:2014. The standard includes quality analysis of moisture content, fly ash bottom ash (FABA), carbon production, and the caloric value of biopellets
products. Until 2018, nine regulations are related to the development of renewable energy in Indonesia (Nasional, 2019). Nonetheless, the national standard still has a big gap when it is compared to the international standards to fulfill the global bio pellets market demand. The absence of a specific policy for the use of biopellets under Presidential Regulation No. 5 of 2006 has motivated wood pellet producers to prioritize the export market for their product sales. However, no regulation regulates domestic demand from the public to increase national market demand.

3.3. Other barriers
Three main problems are facing the development and utilization of bioenergy in Indonesia, namely: (1) development of biomass energy production to meet market demand, (2) development of domestic utilization and awareness of bio pellets demand, and (3) development of the market and institutional regulatory systems (Budiman, 2021; Haryana, 2018). We found that these three barriers are applicable in the biopellet sector.

The fact that the potential resources are scattered, lack human resources, and poor infrastructure have become the barriers to bio pellets development in Indonesia [34]. Besides, the challenge also lies in its economic feasibility. A scholar from Mulawarman University said in our interview that small-scale Combined Heat and Power (CHP) in Kalimantan as small microgrids are feasible due to their high amount of feedstock, sparse population, and low connectivity between villages and cities. This small-scale CHP will provide the village in Kalimantan with power and heat for boiling water due to the lack of fresh water. This small-scale CHP could help Borneo's energy and clean water. Unfortunately, due to lack of investment. The small CHP project was canceled. And the last type (Small Residential Heating) is not applicable in Indonesia because the tropical climate in Indonesia and relatively high temperature all over the year make Indonesian needs for residential heating incredibly low.

4. Discussion
4.1. Global market of biopellets and the utilization of biopellets
Roughly 10% of the world’s primary energy demand is satisfied from biomass, significantly for the power and Combined Heat and Power (CHP) generating sectors. There are 60 GWe of dedicated biomass-fired power (and CHP) stations worldwide (Baruya, 2015). In this discussion, we will dive deeper into the global market of bio pellets, how they use biopellets, and what Indonesia can learn from the global market.

The global market’s demand for bio pellets fuel is dominated by developed countries. It can be seen from the top 5 biggest wood pellet importers: UK, Denmark, Italy, Korean Republic, and Belgium. From the biggest wood pellet importers data, we also conclude that the European Union is the world’s major timber market and consumer of bio pellets (Newell & Raimi, 2020). In 2015, the EU consumed around 20 million tons of wood pellets per annum. There are 3 different types of usage of biomass for bioenergy. The first type is large-scale power production in which countries including the UK, Belgium, and the Netherlands make use of this approach. They imported the bio pellets outside the EU. Due to the Government’s target on Renewable energy contribution increased to 30% of total energy production, the United Kingdom needs between 9-16 Million tons of biomass per annum to achieve the goal [29].

The second type is a medium-scale plan combining heat and power production. CHP used in Nordic countries have forestry industries, therefore they rarely import from the EU. In Estonia, biomass is used in biomass boilers with a capacity of 6.5 MW with an efficiency of less than 85%. Electricity is used to power the district heating region in Estonia. Latvia also adopted CHP to supply its electricity and heat. Latvia uses the wood pellet for the combined heat and power plant, with bio pellets only contributing 1% to the power source of CHP (Abdullah et al., 2020; Garanti, Zvirbule-Berzina, & Yesilada, 2014). In Denmark, the government provides incentives on bio pellets production which caused a shift in consumer demand. Consumers start shifting from gas to biopellets. The cause of this phenomenon is that gas price becomes two times more expensive than the bio pellets price due to government incentives (Rathna & Ravikumar).

The last type is small-scale residential heating with countries such as Germany, Austria, and Italy
adopting this approach. The high use of biopellets in the European Union is caused by the use of heaters in winter. There were 4.9 million boilers in EU-28 in 2013. There are also shifts happening in the energy source, from wood pellets to boiler pellets (Palage, Lundmark, & Söderholm, 2019). The EU's high demand for bio pellets was caused by the EU Emissions Trading System. EU countries have to reduce their carbon dioxide emission and their industry machinery usage (Rogge, Schneider, & Hoffmann, 2011). EU’s demand for wood pellets will grow up to 70 million tons by 2030 (Newell & Raimi, 2020).

Not only deployed by developed countries, but the biopellets industry is also flourishing in developing countries. Vietnam is the second-largest wood pellet industry in the world. There are more than 80 wood pellet producer facilities that produce wood pellets in various production capacities with a total production capacity of nearly 4.5 million tons in Vietnam (Truong, Huong, Xuan, Trung, & Khanh, 2016). From the total production in 2020, 3.2 million tons of wood pellets were exported to two major importers, Japan (1.21 million tons) and Korea Republic (1.98 million tons). This rise of the bio pellets industry in Vietnam caused higher supply and lower price of the biopellets. There also emerged registered bio pellets producers that produced low-quality products that hurt the price even more. Based on the export data of the General Department of Vietnam Customs, the Free On Board (FOB) price of wood pellets exported from Vietnam in 2020 is 111 US$/ton [24], which is lower than Indonesia FOB price in 2020 that reaches 140US$/ton.

4.2. Policy: The comparison between Indonesia and other countries

Both Japan and Korea have the majority of industrial wood pellet demand in Asia because of their cofiring policies. The policy successfully drove the market for creating a high demand as a coal replacement in power plants (Xu, Yang, Zhou, & Zhao, 2020). Compared to Indonesia, the cofiring policy might be defined as a milestone to achieve the National Energy General Plan (RUEN) targets in 2025. For the past few years, Indonesia’s policies only mentioned the targets without arranging a social approach to reach the civil society. Community-based social movements and subsidies from the government are essential to accelerate renewable energy development. The regulations in Indonesia should provide a systematic implementation strategy including social approach, action plan, educational system, and better promotion for renewable energy especially biopellets. The regularity of the new strategy will create an easy monitoring and evaluation system to make it more efficient in finding solutions if there are deficiencies. Indonesia still needs a lot of technology development to support bio pellets production. Other aspects such as competitive price, conveniences in utilization, and accessible products should also be considered before creating a new policy to increase the national market demand. The comparison of bio pellets policy in Indonesia, Japan, and Korea can be seen in Appendix 2.

4.3. What Indonesia can learn?

From the world bio pellets market demand section, we know there are 3 different types of the usage of biomass for bioenergy. The implementation of this first type (Large Scale Power Production) has already happened in Indonesia. Because in 2019, Indonesia Government started a cofiring program to substitute 1-5% of its Coal Power Plant coal with bio pellets and Refuse Derived Fuel (RDF). Currently, 17 coal power plants in Indonesia do cofire by mixing their fuel with bio pellets and RDF all over Indonesia. But the economic feasibility is in question because biopellets cost more than coal.

Indonesia could learn from Vietnam about how the government regulates and interacts with the bio pellets industries. We know that there is a lack of accurate data on how large the existing bio pellets industries are in Vietnam. The case also happened in Indonesia due to the lack of data collecting and stocktaking from the local government. Indonesia could improve their data by starting data collecting on the production rate of the biopellets industry. By having accurate data on how the existing industry works, Indonesia could readjust its policy to the actual state of the industry so the apt policy could be created.

Subsidies on the biopellets for industries or households could be one of the solutions for the low bio pellets market demand. Denmark’s Government incentives on bio pellets production caused a shift in
consumer demand. Consumers start shifting from gas to biopellets. The cause of this phenomenon is the gas price is two times more expensive than the bio pellets price due to the government incentives.

4.3.1. Consumer behavior and government control in Indonesia. From the community perspective, practicality is one of the reasons for the low local demand for bio pellets. Currently, bio pellets-fueled stoves are going through the ignition process, so it takes longer than stoves that use LPG fuel. This results in the low use of bio pellets-fueled stoves for households. The availability of bio pellets is currently only available for large markets and is still challenging to obtain for people in rural areas where large amounts of biomass surround them. The absence of policies regarding bio pellets and the lack of public education have caused bio pellets to not become common in Indonesian communities. Improving bio pellets-fueled stove technology to become more practical to use and enhance socialization about bio pellets to the community will increase the demand for the local bio pellets market in Indonesia.

Indonesia is also facing the same problem as Vietnam, which is a lack of sufficient attention from the government. Even though Vietnam is one of the largest exporters of bio pellets in the world, the government control on the industries is low. The lack of sufficient attention from the government caused low-quality products because of the uncontrolled and untraceable bio pellets feedstock (Novita & Malik, 2020). The low-quality product generally causes the price of the bio pellets to be considerably lower than other exporters such as Indonesia. The local energy agency in Bali mentioned that there is no industry in Bali registered as a bio pellets industry. One of the alternative solutions for tracking bio pellets market demand is by looking for export-import data of biopellets. However, the export data itself has inadequacy on every type of bio pellets because the Harmonized System (HS) code of the bio pellets trade is still not well defined, only wood pellets with HS code 440131 are well defined for the export-import of biopellets.

5. Conclusion and recommendation
This study aims to find barriers and opportunities regarding the development of biopellets in Indonesia. We found that one of the main barriers is the fact that the local market demand is still very small - only 10% of the total market demand. The rest of the production went to the international market. The biopellets industry in Indonesia is mostly located in Java, while the biopellets industry outside Java is still not growing rapidly. The biopellets industry in Java covers domestic and international market demand.

Indonesia already has numerous policies on regulating biomass. However, there is no specific regulation that directly mentions the development of biopellets. The cofiring targets for bio pellets mixing should be increased and specifically mentioned in the upcoming specific cofiring regulation by the MEMR. Besides, the raw material for biopellets also needed to develop more, since the Indonesian Electricity Master Plan 2019-38 only mentioned the utilization of bio pellets from organic waste and sawdust. The government needs to improve the potential area for bio pellets production to fulfill the local and foreign market demand. If the regulation has already been issued and enforced to the business actors, it will support the growth of the domestic market demand for biopellets. The legitimation of the new biopellets regulation should be balanced with the convenience of consuming or utilizing the biopellets. This will help to realize Indonesia’s huge potential in developing biopellets.

Further research should focus on the awareness of bio pellets utilization for the consumers, the development of bio pellets production for producers, and improving the policies especially for the implementation of bio pellets utilization.

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## APPENDIX A

### Table A1. Data extraction sheet from SLR

| Topic                  | Paper | Provinces | Indonesia | Outside Indonesia |
|------------------------|-------|-----------|-----------|-------------------|
|                        |       | East Java | Bali      | Borneo            |
| Market demand          |       |           |           |                   |
| Policy                 |       |           |           |                   |
| Biopellets production |       |           |           |                   |
### APPENDIX B

**Table B1. The comparison of bio pellets conditions in Japan, Korea, and Indonesia**

|                        | Japan                                                                 | Korea                                                                 | Indonesia                                                                                                                                 |
|------------------------|----------------------------------------------------------------------|----------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------|
| **Existing condition** | The government is active in gaining public trust by conveying information related to renewable energy (through symposiums and official websites). | The implementation of The One Million Green Homes Initiative or currently known as the Housing Support Scheme is a program that provides subsidies for people who use renewable energy in their homes (IEA, 2020). | Indonesian people still depend on the practical use of LPG compared to the use of bio pellets. Still small awareness of bio pellets utilization. |
| **Regulations**        | An outline strategy is called strategic energy plans (SEPs) which have principles to achieve energy security, economic efficiency, and environmental sustainability (3Es). | Feed-in tariff for any renewable energy source and implementation. Renewable Portfolio Standard (RPS) to accelerate the development of renewable energy utilization and production. This scheme has succeeded in increasing the use of biopellets in the industrial sector because of its cheap price compared to other advanced technologies. | No specific regulations for bio pellet utilization (Amirta, 2018). The existence of a specific policy for bio pellets can create a social innovation concept that will form a new community as a part of the solution for the low local demand for biopellets in Indonesia (Budiman, 2018). |
| **Challenges**         | The government still trying to improve communication and community engagement with renewable energy (IEA, 2021). | The amount of funds needed to facilitate renewable energy sources is getting higher over time. | LPG fuel is easier to find in general minimarkets, while sales of bio pellets are still limited to industrial production intended for export and the food, cosmetic, furniture, ceramics, and other industries. The role of the community in the use of biopellets greatly influences the increase in domestic demand for biopellets in Indonesia |
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