Mini Review of Indonesia’s Potential Bioenergy and Regulations

A Saputra¹, B Sriyono¹, and L Pauling¹

¹PT. Chakra Giri Energi Indonesia, Central Jakarta 10160, Indonesia

Email: aji.saputra@cge.co.id

Abstract. Indonesia's bioenergy potential is enormous. Utilization of bioenergy can be a solution to future energy independence. It is predicted that fossil fuel production will start to decline in 2025 and the need for other sustainable sources of energy will be significantly increase. To turn the potential to real benefits, the supporting conditions policies, and regulations to ensure incentives, prices, and subsidies, need to be made jointly by various related structures of the government. The development of bioenergy in Indonesia shall be planned in the context of sustainability. That shall include plans for the growth of green environment, mitigation, and adaptation to changes in climate. It will be expected to give a big contribution to the Bonn Challenge, which is an attempt globally to return the 350 million hectares of green land status in 2030, as intended by The United Nations Framework Convention on Climate Change for the reduction of greenhouse gases emissions.

Keywords: Bioenergy, Biofuel, Indonesia, Regulation

1. Introduction

Indonesia has great potentials for developing bioenergy. Reducing dependence on fossil fuels and increasing energy supply across the country are the goals. Bioenergy is derived from organic matter (biomass), which includes living things, aquaculture products, as well as urban and industrial organic wastes. It is part of a new and renewable energy source. Once used, resources would be able to spring up and grow up again within a relatively short time, typically in a matter of years, compared to fossil derived fuels which need millions of decades. Fossil energy, whose availability is dwindling, has an impact on its prices. Promising use of more environmentally friendly fuel material makes bio energy a strategic enterprise. Indonesia, which lies close to and alongside the equator, is blessed with tropical climate and an abundant diversity of biological resources. For an example the total forest area is reaching 120.7 million hectares, or approximately 63% of this country land, giving a prospective and high potential in bioenergy use [1].

Indonesia has made a commitment to provide energy for the entire population through a National Energy Policy (Kebijakan Energi Nasional). Policies that are focused on the importance of diversification, environment, and efforts to cope with increasing trend of the country energy use. Oil, coal, gas, and new and renewable energy (Energy Baru dan Terbarukan or EBT) make the mix of the energy supply to be diversified further. EBT has been contributed to the nationwide energy mix and the future target in the year 2025 shall reach 23% [2]. Indonesia also has committed internationally to align with the provision of sustainable energy. Indonesian forests, rice fields, palm oil plantations, livestock, urban and industrial sewage, and solid waste, are the sources of vast amount of bio energy.
Bioenergy is a friendly environment kind of power source for not releasing out substantial amount of carbon dioxide high into our planet atmosphere. Bioenergy also generally has very low sulphur content. Various kinds of heavy metal, usually used as catalysts or additives in oil refineries to make fossil fuel products, no longer increasingly polluting the air. Bioenergy can be divided into two types, namely conventional bio energy and modern biofuels. From the beginning of civilization, bioenergy has been used by human race, today still it can be found in remote and rural areas, as firewood for household daily cooking, or as fuel in making traditional clay products. Modern biofuels are prepared, treated and processed by means of modern technology, resulting in various type of commodities, such as bioethanol, biodiesel, PPO/SVO and biogas [3].

Different efforts shall be exercised in the aspects of bioenergy development with the perspective from technology to the exploration of business model for small and medium sized enterprises. Bioenergy has been used on a proportional scale as fuel in power plants generating electricity is already showing various progress, but there are also a variety of obstacles. Constraints regarding the only electricity off-take option by the state-owned company are a major challenge in the use of bioenergy on a large scale. Factors inhibiting the use of biomass for large-scale electricity production also include the distance and infrastructure between power plant sites and electricity main network. First, cost per kilowatt hour of electricity generated from bioenergy, which may be higher than the price as regulation set it to be paid by the single off-taker belonging to the state. The fluctuation of raw material cost per ton and the biomass availability may create uncertainty in its cost structure economically.

Developing bioenergy has a great potential and promising in Indonesia. To turn the potential to real benefits, the supporting conditions such policies and regulations to ensure incentives, prices, and subsidies, need to be made jointly by various related structures of government. The development of bioenergy in Indonesia shall be planned in the context of sustainability. That shall include plans for the growth of green environment, mitigation, and adaptation to changes in climate. It will be expected to give contribution to the Bonn Challenge, which is an attempt globally to return the 350 million hectares of land in green status by the year 2030, as also intended by The United Nations Framework Convention on Climate Change for the reduction of emissions of greenhouse gases.

2. Utilization of bioenergy in Indonesia
Currently, the development of bioenergy in Indonesia has started to step forward for its use as commercial energy. Bioenergy has been used as a fuel for generating electricity. In accordance with the BBN policy, bioenergy as a fuel shall be implemented. Bioenergy can be used as a component of fuel in the form of liquid (biodiesel, bioethanol), gas (biogas) and solid pellet fuel. Utilization of Bioenergy can be a solution to energy independence ahead in the future. The production of fossil fuel is estimated to decline. Sources of energy that can continue to be produced and provided in a period of longer time will be urgently needed. The excellent factors in utilization of bioenergy, first, is the increasing growth of the economy, then improving the quality of the environment by reducing emissions of greenhouse gases formerly emitted from the use of fossil fuels. The last is reducing dependency on fossil fuel which reserves in nature is getting unavoidably depleted. The following are various form of fuels made from bioenergy in Indonesia:

2.1 Biodiesel
Fatty acid methyl ester (FAME), commonly referred to as biodiesel, is a type of first-generation biofuel. Biodiesel is produced via transesterification. Biodiesel can be produced in small batches in small industries and facilities. It has relatively low capital expenses. Oil Palm plantations in many areas are one of Indonesia's abundant natural resources. Processing fresh fruit bunches will produce bioenergy, as the downstream step further after palm oil processing. Indonesia's main raw biodiesel is Crude Palm Oil (CPO).

The main commodity in Indonesia is the enormous quantity of raw palm oil (CPO), with an average annual output of ±31 million tonnes. Approximately 8.4 million tonnes, for food and biodiesel requirements, of overall CPO output is used locally (the biodiesel need is now only ±1.6 million tonnes),
and the rest are exported. Other than from Oil Palm plantations, Biodiesel raw materials can be obtained from a variety of sources, including jatropha, nyamplung, kemiri sunan, coconut, corn, and others. Up to this date, the installed biodiesel processing capacity had already reached 3.9 million kL/year. In addition to CPO, industrial waste from coconut oil also has a potential for processing into energy.

However, challenges were found in terms of processing CPO (Crude Palm Oil) in the country for the implementation of biodiesel which led to reduced state revenues from CPO exports. The different between biodiesel production cost and its real market is relatively narrow because the price of biodiesel is aligned with price of diesel fuel which is still be subsidized. In addition, biodiesel's technological processing is still need of improvement to achieve the market's desired quality. As a result of the development of large-scale plantations of oil palms in Indonesia, certain parties have voiced their concerns about the development of bioenergy from the oil palm for the issue of deforestation.

Biodiesel is not fully compatible with conventional diesel vehicles and usually is blended with fossil fuel at low percentages. The Worldwide Fuel Charter recommends up to 5% biodiesel blending in fossil diesel. The higher volumes will lead to a reduction in fuel economy, the increase in pollutants and degradation of some vehicle materials and parts. Most countries with biofuel programs blend biodiesel at maximum rates between 5% and 10%. Currently, Indonesia is the only country that has a higher biodiesel blending mandate of 30% (B30) [4].

2.2 Bioethanol
Bioethanol in Indonesia come out from base substances of molasses and cassava. The average annual production of molasses is 1.5 million tons, and for cassava is 22 million tons respectively. Several other sources of bioethanol potentially to be developed are: cassava, sago, sorghum, and some small other sources. Bioethanol is basically ethanol, made by means of biomass fermentation which contains starch, sugar, and plant cellulose. Raw material sources which can identified as the most prospective in Indonesia are yams (sweet wood), sweet potatoes, molasses sugar, sago, sap of coconut, palm wine palm, sorghum, and seaweed. Utilization of bioethanol is as stove fuel for domestic / household sector. Based on research obtained the result that the efficiency of the stove ethanol is the highest by 53.43%. Conditions of the highest efficiency are obtained at the burner diameter variation of 0.6 mm, a distance between the tip of ethanol nozzle and the burner tip is 5 cm and the air pressure of 0.2 MPa. Further studies were carried out, with the analysis of mathematical and economical use of methanol and ethanol in the "HD" stoves, to test the fuel efficiency required a specific and suitable stove for the purpose. In research, appliance makers use "HD" stoves. A method using measurement of boiled water is used to determine the level of efficiency for the use of methanol and ethanol fuels. Based on the results of the analysis of mathematics, bioethanol with levels of 60%, 70%, 80% and 90% can be used for the household consumption fueling the stove as the substitution of kerosene [5].

2.3 Biogas
Biogas can be produced from a variety of organic wastes, which contain the following compounds:

a. Cattle waste: dung cow dairy, cattle beef, buffalo, pigs;
b. Agricultural waste: rice straw;
c. Water crops: hyacinth, seaweed;
d. Waste of industrial agriculture: waste of liquid effluent, liquid palm oil processing waste, waste from solid tapioca production.
e. Waste household and urban: trash the homes, and humans sanitary flushed waste.

Generally, treatment of waste is becoming a problem, but by conversion to produce biogas, the waste becomes a useful material. Potential of home scale biogas that come out from animal farms in Indonesia is estimated to reach 1 (one) million units. If the potential is utilized at maximum, then Indonesia will be able to save about 700 thousand tons of LPG or equal to 900 million liters of oil. The potential of biogas in accordance with an estimate, set forth in the General Plan of National Energy. The target is 2602.6 MW scattered in 33 provinces with a top potential site is in the province of West Java amounted.
to 574.3 MW, as indicated in Table 1. In the development of biogas, approach to programs implemented by government, divided into two classifications, namely:
Based on development scale:
  a. Small scale, usually for the purpose of cooking and lighting.
  b. Large scale, usually intended for the generation of electricity.
Based on type of business:
  a. Non-commercialization
     Implemented for areas where there are potential biogas developments but have not been utilized. It is intended to provide an example directly to the public to create awareness about benefits from its development. Special allocation fund for rural energy is one of the funding mechanisms.
  b. Semi-commercialization
     Combining ability and responsibility accountable by the public. The subsidy is given only in part to increase the sense of ownership and ensure sustainability. The example is BIRU Program (Biogas Rumah Tangga).
  c. Commercialization
     The government is only to facilitate, for example, in the aspect of quality assurance, operation, security, tariffs, and others. Furthermore, the private sector will be working on it.

2.4 Biomass
Biomass can be obtained as waste or side product of industrial processing and agriculture. In theory, the biomass which will be used as energy are the excess in material balance and are not going to reduce the supply of food for humans. Generally, biomass as fuel materials like wood, industrial wood waste of, straw, and the results of agriculture such as sugarcane that can be processed into the combustible material for fuel. Generally, biomass refers to the material of plant or animal that is used to produce fibers, materials chemistry, or heat. May also include biodegradable waste that can be burned as fuel. Biomass is also produced from organisms such as plants, animals, and their waste. Feces of animals and garbage plants also is biomass that can be used to produce bioenergy. Energy from biomass is one of the parts of the cycle of carbon. Examples of waste biomass has been used as a source of energy in industrial processing are bagasse which is used as an energy source in sugarcane processing plants, and empty palm oil bunches are used in the palm oil processing industry. Indonesia's biomass potential is very abundant, as shown in Table 1 [6][7].

| No | Province            | Potency     |
|----|---------------------|-------------|
|    |                     | Biomass / Biofuel | Biogas | Total (MW) |
| 1  | Riau                | 4,157.4     | 37.7   | 4,195.1    |
| 2  | East Java           | 2,851.3     | 569.6  | 3,420.9    |
| 3  | North Sumatera      | 2,796.1     | 115.5  | 2,911.6    |
| 4  | West Java           | 1,979.8     | 574.3  | 2,554.1    |
| 5  | Central Java        | 1,885.1     | 384.4  | 2,232.5    |
| 6  | South Sumatera      | 2,061.4     | 71.2   | 2,132.6    |
| 7  | Jambi               | 1,821       | 18.9   | 1,839.9    |
| 8  | Centra Kalimantan   | 1,486.7     | 12.2   | 1,498.9    |
| 9  | Lampung             | 1,407.6     | 84.5   | 1,492.1    |
| 10 | West Kalimantan     | 1,279.3     | 28.9   | 1,308.2    |
| 11 | South Kalimantan    | 1,266.3     | 23.6   | 1,289.9    |
| 12 | Aceh                | 1,136.6     | 37.7   | 1,174.3    |
In numerous huge quantities Indonesia has various forms of biomass waste created from industrial, forest and town trash or waste. The Electricity Generation Based on Bioenergy is split into 3 (3): Biomass Power Plants (PLTBm), Biogas Power Plants and Garbage City Power Plants (PLTSa). Below is the potential biomass from waste plantations, biogas from oil palm waste and prospective waste town to produce energy. Bioenergy plant investment prospects in Indonesia are appealing because of the vast potential raw material sources. The aim of the bio-energy plant development is to meet the need for energy in the region which is non-connected to the PLN (off grid) electric grid, increase reliability of electricity supplies and reduce the use of fossil fuel to generate electricity separately. The objective of the project is to reduce the energy supply. The conditions for on-grid bioenergy plants amounted to 119.6 MW by 2015, and for off-grid plants to 1,626 MW. All these facilities are based on biomass, biogas, and cities of waste.

### Challenges in bioenergy plant development including:

- **a. Continuity guaranteed raw material supply.**
- **b. A guaranteed price stability for biomass waste.**
- **c. Capital expenditure is still expensive at the start of the project; (biomass fuel).**
- **d. PLN's readiness to link the network to the power plant for biomass.**

| No | Province                  | Biomass | Biogas | Waste |
|----|---------------------------|---------|--------|-------|
| 13 | East/North Kalimantan     | 946.6   | 17.7   | 964.3 |
| 14 | South Sulawesi            | 890.3   | 69.1   | 959.4 |
| 15 | West Sumatera             | 923.1   | 34.7   | 957.8 |
| 16 | Bengkulu                  | 633     | 11.8   | 644.8 |
| 17 | Banten                    | 346.5   | 118.6  | 465.1 |
| 18 | West Nusa Tenggara       | 341.3   | 52.8   | 394.1 |
| 19 | Central Sulawesi          | 307.4   | 19.5   | 326.9 |
| 20 | East Nusa Tenggara       | 192.5   | 48     | 240.5 |
| 21 | D.I. Yogyakarta           | 183.1   | 41.1   | 224.2 |
| 22 | Bangka Belitung           | 217.7   | 5.4    | 223.1 |
| 23 | West Sulawesi             | 197.8   | 8.1    | 205.9 |
| 24 | Bali                      | 146.9   | 44.7   | 191.6 |
| 25 | North Sulawesi            | 150.2   | 13.8   | 164   |
| 26 | Southeast Sulawesi        | 132.8   | 17.7   | 150.5 |
| 27 | Gorontalo                 | 119.1   | 11.5   | 130.6 |
| 28 | DKI Jakarta               | 0.5     | 126.1  | 126.6 |
| 29 | Papua                     | 81.4    | 15.1   | 96.5  |
| 30 | West Papua                | 50.8    | 4.1    | 54.9  |
| 31 | North Maluku              | 27.5    | 7      | 34.5  |
| 32 | Maluku                    | 23.6    | 9      | 32.6  |
| 33 | Kepulauan Riau            | 11.6    | 4.3    | 15.9  |

| Total | 30,051.2 | 2,602.6 | 32,653.8 |
3. Indonesian biofuel production and consumption projections

![Figure 1. Indonesia’s biofuel data forecasting.](image)

The introduction of the Mandatory B30 Program (a blend of 30% biodiesel and 70% diesel fuel), which was formally inaugurated by the President of the Republic of Indonesia on December 23, 2019, demonstrates the government's commitment to expanding biofuels use in Indonesia. The beneficial impact of utilizing biodiesel is projected to boost farmers’ income, and the adoption of B30 is thought to have an influence on raising domestic demand for CPO (Crude Palm Oil), as well as generating a multiplier effect for Indonesia’s 16.5 million oil palm growers.

Machine learning is used to forecast Indonesian biofuel data using the ARIMA forecasting model for data generation and the Simple Exponential Smoothing model for data consumption. The forecasting is done through 2030, using data from 2005 to 2020. Biofuel production is rising considerably in comparison to consumption, according to forecasting findings. The MAPE (Mean Average Percentage Error) value of the biofuel forecasting data was found to be 13%. These findings suggest that the model performed well in terms of predicting. Demand for biofuels is expected to grow in Indonesia due to expected developments in transportation fleets, domestic policies that favour higher blends, and greater demand from consumers.

4. Potential of bioenergy area in Indonesia

The Ministry of the Environment and Forestry (KLHK) is targeting 100,000 ha of land as Energy Plant Forest (EPT). This is emphasizing the very potential for program development sectors of bioenergy in Indonesia. Based on data from the Ministry of ATR/BPN, the potential for cleared and abandoned land, is around 27,800.69 ha, of which 24,972.76 ha has not been designated. EPT covering an area of 104 thousand hectares will be built on land the Forest Protection and Forest Production which is managed by Perhutani with a system cluster between 4000-6000 ha per cluster that can produce wood pellets approximately 6,000 tons per year in the province of Central Java and East Java. Wood pellets are produced from EPT is expected to be used for the mixture of coal at the plant. The trial test of co-firing by PLN was done using a mix of coal (95%) with wood pellets (5%) in West Lombok Jeranjang power plant inside the Circulating Fluidized Bed (CFB) boiler. The result of trial to co-fire with the operation of the plant normally produces small emissions of NOx. This trial is giving hope to reduce dependence on fossil energy in the future use of coal by partial substitution from wood pellets. For the sectors of electricity, the use of bioenergy in 2017 to generate power almost reached the target. Targets planned for the capacity installed (off-grid / on-grid) bioenergy power plant shall be 1,881 MW and can be
realized by 1839.5 MW [8]. Bioenergy power plants projects now are spread over several areas in Sumatra, Java-Bali, Kalimantan, Sulawesi, and Papua [9].

5. Market opportunity
Indonesia has the comparative advantage to the production of biofuels because of the availability of land, the conditions of climate which is favourable to agriculture and the relatively low cost of labour. However, there are implications for socio-economic and environment that affect the potential to earn a profit from the increase in local and global needs of bioenergy. The Government has guaranteed market opportunities for biofuels in that nation when the compulsory usage of biofuels has been implemented. This was established by Regulation No 32 Year 2008 of the Minister of Energy and Mineral Resources and revised by Regulations No 20 Year 2014 of the Minister of Energy and Minerals. Compulsory implementation That is the government's endeavour to create the country's biofuel market. With the implementation of mandatory biofuel, one of only biodiesel and projected needs of diesel fuel to the front, which is getting increased, the estimate of needs demand biodiesel to the front will be increasingly large. With the condition of biodiesel supply from existing producers and an estimated increase in the business-as-usual scheme, there will be a shortage of biodiesel supply in the future. With the condition of the market that a captive market of products of biodiesel already surely will further increase the opportunities and potential investments in the field of processing / production of biodiesel to the front is very promising and open wide [8].

6. Bioenergy regulations
The government has made and will create different rules targeted at enabling various sectors in producing bioenergy in Indonesia in order to encourage the growth of bioenergy in the country. Indonesia has enacted the following regulations [8]:

6.1 Basic regulations
a. Energy Law No. 30 of 2007 about Biofuel is one of the top objectives for the provision and use of EBT.

b. Presidential Regulation No. 66 / 2018 about the Second Amendment to Presidential Regulation Number 61/2015 Concerning Palm Oil Plantation Funds Association and Use

c. Biofuels as Other Fuels: Presidential Instruction No. 1 of 2006 of the Republic of Indonesia

d. Regulation No. 10 of 2012 of the Minister of Energy and Mineral Resources on Physical Activities of Utilizing New Energy and Renewable Energy.

e. Indonesian Government Regulation No. 79 of 2014 on National Energy Policy: In 2025, the NRE objective is 23% of the entire National Energy Mix.

f. Indonesian Presidential Regulation No. 38 of 2015 on Government Cooperation with Business Entities in Infrastructure Provision

6.2 Regulations related feed in tariff bioenergy power plant
a. Minister of Energy and Mineral Resources Regulation No. 44 of 2015 concerning the Purchase of Electricity by PT PLN (Persero) from Municipal Waste-Based Power Plants.

b. Minister of Energy and Mineral Resources Regulation No. 27 of 2014 concerning the Purchase of Electricity from Biomass Power Plants and Biogas Power Plants by PT Perusahaan Listrik Negara (Persero).

6.3 Regulations related to vegetable fuel
a. Minister of Energy and Mineral Resources Regulation No. 25 of 2013, No. 20 of 2014 and No. 12 of 2015 concerning the First, Second and Third Amendments to the Regulation of the Minister of Energy and Mineral Resources No. 32 of 2008 concerning the provision, utilization, and trade system of biofuels as other fuels.
8

b. Minister of Energy and Mineral Resources Regulation No. 20 of 2015 concerning the Provision and Utilization of Biodiesel Types of Biofuels in the Financing Framework by the Oil Palm Plantation Fund Management Agency.

6.4 Regulations related to vegetable fuel specifications

a. Regulation of the Minister of Energy and Mineral Resources Number 0048/2005 concerning Standards and Quality (Specifications) and Supervision of BBM, Gas Fuel, Other Fuels, LPG, LNG, and Processed Products marketed domestically.

b. Kepdirjen EBTKE No. 100 K/10/DJE/2016 concerning Standards and Quality (Specifications) of Biodiesel Types of Biofuels as Other Fuels Marketed Domestically. The biodiesel specification refers to SNI 7182:2015.

c. Minister of Energy and Mineral Resources Decree 3239 K/12/MEM/2015 Concerning Market Index Prices of Biofuels (Biofuels) mixed into certain types of fuel oil and specific types of fuel oil for assignment.

d. Kepdirjen EBTKE No. 722 K/10/DJE/2013 concerning Standards and Quality (Specifications) of Biofuel Types of Bioethanol as Other Fuels Marketed Domestically. The bioethanol specification refers to SNI 7390:2012.

e. Kepdirjen EBTKE No. 903 K/10/DJE/2013 concerning Standards and Quality (Specifications) of Biofuels for Types of Pure Vegetable Oils for Medium Speed Diesel Motor Fuel.

f. Kepdirjen EBTKE No. 830 K/10/DJE/2013 concerning Standards and Quality (Specifications) of Partially Esterified Biofuels for Medium Speed Diesel Motors.

g. Director General of Oil and Gas No. 933.K/10/DJM.S/2013 concerning Standards and Quality (Specifications) of 48 Diesel Fuel Types Marketed Domestically (the obligation to blend biodiesel according to the mandatory target).

h. Director General of Oil and Gas No. 933.K/DJM.S/2013 concerning Standards and Quality (Specifications) of Type 88 Gasoline Fuel Oil Marketed Domestically (the obligation to blend biodiesel according to the mandatory target).

i. SNI 7182:2015 concerning Biodiesel.

j. SNI 7390:2012 concerning Denatured Bioethanol for Gasohol.

k. SNI 7926:2013 concerning Biomass Furnace Performance.

l. SNI 7929:2013 concerning Biogas Unit Network Equipment.

m. SNI 7431:2015: Pure Vegetable Oil for Medium Speed Diesel Motor Fuel.

7. Conclusions

This research on bioenergy in Indonesia had progressed, but it has not been widely implemented. Bioenergy development in Indonesia shall be supported by creative and innovative action plans in energy sources, covering cross-sectoral collaboration in developing initiatives. Bioenergy is used extensively as a fuel, and it is already showing some progress in generating electricity, but there are also several obstacles to overcome. Constraints regarding the only off-take option of electricity by state-owned company are a major challenge in the use of bioenergy on a large scale. Factors inhibiting the use of biomass for large-scale electricity production also include the distance and infrastructure between power plant sites and electricity main network. First, cost per kilowatt hour of electricity generated from bioenergy, which may be higher than the price as regulation set to be paid by the single off taker belonging to the state. The fluctuation of raw material cost per ton and the biomass availability may create uncertainty in cost structure economically. To maximize potential, different government structures must work together. According to the Bonn Challenge, which aims to return 350 million hectares of land to green status by 2030, Indonesia's bioenergy development must be planned in a sustainable way.
Acknowledgement
This project would not have been possible without the support of many people. We thank our colleagues from PT. Chakra Giri Energi Indonesia who provided insight and expertise that greatly assisted the research. We also thank the AICEE committee for giving us the opportunity to present our thoughts on renewable energy.

References
[1] Research, Development and Innovation Agency, Ministry of Environment and Forestry 2020 Indonesia Forestry Vademecum 2020.
[2] Secretariat General of The National Energy Council, National Energy Council 2019 Indonesia Energy Outlook 2019.
[3] Dharmawan AH, Nuva, Sudaryanti DA, Prameswari AA, Amalia R and Dermawan A 2018 Bioenergy development in Indonesia: Opportunities and challenges for biodiesel industry policy. (Bogor, Indonesia: CIFOR).
[4] Kristiana, T. and Baldino, C 2021 Potential Biofuel Production Pathways in Indonesia: Overview of Processes, Feedstocks, and Types of Fuel. (Washington DC: ICCT).
[5] Secretariat General of The National Energy Council, National Energy Council 2019 Indonesian Energy Security Book 2019.
[6] Secretariat General of The National Energy Council, National Energy Council 2019 National Energy Balance Study Report 2019.
[7] Secretariat General of The National Energy Council, National Energy Council 2020 National Energy Balance Study Report 2020.
[8] Directorate of Bioenergy, Directorate General of New, Renewable Energy and Energy Conservation, Ministry of Energy and Mineral Resources 2016 Guidebook for Bioenergy Investment in Indonesia 2016.
[9] Directorate General of New Renewable Energy and Energy Conservation 2018 Performance Report 2018.