Indonesia’s Road to Fulfill National Renewable Energy Plan Target in 2025 and 2050: Current Progress, Challenges, and Management Recommendations – A Small Review

A W Budiarto* and A Surjosatyo

1 Department of Energy System Engineering, Faculty of Engineering, Universitas Indonesia, Depok 16424, Indonesia. ORCID ID: 0000-0002-1430-2398, 0000-0001-7086-9287

Abstract. Indonesia has a large amount of energy consumption, domestically and industrially. Indonesia’s energy mix is still dominated by fossil fuels and coals, with the percentage of 35.64% and 50% respectively in 2020. This is caused by Indonesia’s rich supply of oil and coal, even though experts have predicted that these supplies will run out in 10 years ahead. One option to preserve Indonesia’s energy security is to start using renewable energy. Indonesia’s renewable energy potential is predicted to be around 443 GW of installed capacity, and already made renewable energy mix percentage target of 23% in 2025 and 31% in 2050 in their National Energy Plan. However, Indonesia’s renewable energy percentage in their 2020 national energy mix is only 14.71%. Therefore, to reach their national renewable energy target, Indonesia needs to solve their problems by finding the right actions and strategies in their energy management through stakeholders such as the government, public, and investors. This review will be made by using the literature based research method.

1. Introduction
Indonesia is a country located in the South East Asian region, situated between the Pacific and Hindia ocean. Indonesia is the 4th highest population country in the world, with a total population of 270,203,917 according to its 2020 census [1]. With a total land area of 1,904,569 km², Indonesia is considered to be the 14th largest country in the world. Indonesia’s rate of population growth has reached 1.3% per year. It is estimated that Indonesia’s population total in 2030 and 2050 will reach around 295 million and 321 million respectively [2]. This leads to Indonesia’s high economic performance as the only ASEAN country that joins the G20 and considered to be a new industrial country. Until 2021, Indonesia becomes the 16th largest GDP earner country in the world, with a total GDP earned of US$1.159 trillion. Three of Indonesia’s main economy sectors are services with 43.4% of the total GDP earned, followed by the industrial sector with 39.7% and the agricultural sector with 12.8% [3].

The economy sector becomes one of Indonesia’s highest energy consuming sector, followed by commercial and domestic. According to the nation’s energy consumption mix in 2014, industrial sector dominated with a percentage of 36% [4]. The same source also predicted that the mentioned sector will have an increase in energy consumption percentage mix to 44% due to their economic growth in 2030, according to some projections. However in 2018, the industrial and transportation sector were dominating the nation’s energy consumption mix with a percentage of 36% and 40% respectively.
according to the diagram served in Figure 1 [5]. The high percentage number of the transportation sector could be caused by the fact that the services sector becomes one of the strongest Indonesia’s economy influence these days.

![Figure 1. Indonesia’s energy consumption mix in 2018. [5]](image1)

In 2017, Indonesia became the 15th highest energy consuming country in the world with a total energy consumption of 2,100 TWh [6]. The high number of energy consumption however, can still be covered and handled by the fact that Indonesia is also the top ten highest energy producing country globally with a total energy production of 4,200 TWh in the same year. From that total number of energy production, at least around 50% of it were electricity production. In 2020, Indonesia’s production and consumption of electricity reached 235.4 billion kWh and 213.6 billion kWh respectively [7]. These large numbers of production can be covered by Indonesia’s sky-rocketing number of gas, oil, and coal supply. Until now, there are about 22 billion barrels of gas and conventional oil, 8 billion barrels of coal-based methane, and 28 billion tonnes of coal supply in Indonesia [8].

![Figure 2. Indonesia’s energy mix by sources in 2020. [9]](image2)

The large amount of non-renewable supplies caused Indonesia’s reliability in fossil fuel and other non-renewable energy sources, which will run out someday. In 2020, as shown in Figure 2, Indonesia’s energy mix production was still dominated by 50% coal, followed by gas and oil with a total percentage of 35.64%[9]. According to the same mix, renewable energy’s contribution to the mix was only 14.71%. The small number of renewable energy contribution leads to a fact that Indonesia still have a long road ahead to reach their renewable energy percentage target of 23% in 2025 and 31% in 2050 made in their National Energy Plan or RUEN, as these targets are made according to their commitment to take responsibility in reducing the global warming.
This article will present a small review about Indonesia’s progress in their renewable energy implementation to fulfill the National Energy Plan targets ahead, added by a blink explanation of challenges that Indonesia’s facing nowadays and some recommendations that the author imply in reaching the targets mentioned above.

2. Method
This review will be made by using the literature research method, in which it collects sources such as books, journals, and any other type of literatures and try to mix all of the necessary or topic-related informations from the related sources into one new full article. The method can sometimes be described as naturalistic research [10]. The review will also be served mostly as a narrative written one. Literature research method also means that the author won’t have to do experiment to collect data, as data can be provided from any type of literature resources as long as they are reliable and validated [11].

First of all, the review will provide a few information about the current situation of Indonesia’s progress in their transition to using renewable energy as their main energy sources. It will also mention the national target of renewable energy mix in the upcoming years, mainly 2025 and 2050 made by the nation’s Ministry of Energy and Mineral Resources. Next, it will explain the challenges and problems faced by Indonesia while progressing to fulfill the mentioned target. The results in this review will be several recommendations of minor solutions that can possibly solve the problems mentioned before.

3. Results and discussion
3.1. Indonesia’s renewable energy implementation nowadays
Today, Indonesia has implemented many renewable energy variants such as wind energy, biomass, solar energy, geothermal, and hydropower. In 2019, Indonesia has installed around 10.3 GW of renewable energy variants capacity [12]. As a country that has a large number of river streams, lakes, and seas, the number of hydropower-installed capacity in Indonesia has reached around 5.98 GW or 58% of the nation’s renewable energy installed capacity in total, followed by geothermal and biomass with a total installed capacity of 2.13 GW and 1.87 GW respectively [13]. There are some renewable energy variants that still hold small numbers of installed capacity, such as wind and solar energy which capacity number are still around the range of 15 to 155 MW based on Table 1.

Table 1. Installed capacity of renewable energy variants in Indonesia 2008-2019. [13]

| Year | Installed Capacity of Renewable Energy Plants (MW) |
|------|-----------------------------------------------------|
|      | Hybrid | Wind | Bio Energy | Solar | Waste Energy | Geothermal | Hydro | TOTAL  |
|------|--------|------|------------|-------|--------------|------------|-------|--------|
| 2008 | 0.86   | 2.44 | 2.72       | -     | 1,068.50     | 4,784.9    | 5,859.49 |
| 2009 | 0.86   | 25.44| 2.72       | -     | 1,205.80     | 4,801.6    | 6,036.51 |
| 2010 | 1.46   | 41.44| 3.02       | -     | 1,205.80     | 4,821.8    | 6,073.61 |
| 2011 | 1.46   | 64.44| 3.53       | -     | 1,225.80     | 4,925.4    | 6,220.66 |
| 2012 | 0.06   | 1.46 | 755.48     | 10.81 | 1,335.80     | 5,128.4    | 7,232.01 |
| 2013 | 0.08   | 1.46 | 1,364.67   | 18.65 | 1,398.50     | 5,181.0    | 7,964.25 |
| 2014 | 0.08   | 1.46 | 1,388.67   | 22.74 | 1,403.30     | 5,206.8    | 8,037.06 |
Indonesia’s first ever attempt in their transition to renewable energy as main energy source started from the policy written in UU RI 30/2007 about Indonesia’s National Energy Policies. The policy has stated that to fulfill their road to renewable energy transition, they need to implement energy diversification, of which one of the example is renewable energy development, as noted that non-renewable energy sources such as fossil fuel and coal supply will run out someday in the future. Other than that, the non-renewable energy sources had contributed to the environment degradation and quality decline from the emissions produced, which led to global warming. Indonesia also takes part in the Paris Agreement held in 2015, in which they made the commitment to stave off the increase of global temperature at 1.5°C and prevent it to surpass 2°C [14]. The task to keep the global temperature can be done by decreasing greenhouse gases emission by around 29% by Indonesia’s own and 41% with the help from other countries, as mentioned in UU RI 16/2016 about the ratification of greenhouse gases reduction in 2030 [13]. According to the greenhouse gases reduction percentage, Indonesia can reduce around 314 to 398 million tonnes of CO₂. One way to reduce that large amount of gases is to broadly implement renewable energy variants as the main sources to generate electricity and any other types of energies.

The task of implementing renewable energy variants at high rate to fulfill targets surely would be easy for Indonesia, as it is considered as one of the countries with the largest amount of renewable energy potential. The potential mentioned could reach around 443 GW of installed capacity [14]. The solar and hydropower energy became the two most potential amongst the other renewable energy variants in Indonesia, with a total potential of 207 GW and 75 GW of installed capacity respectively. But in reality, the number of potential being actually utilized is still low. Not even one of the renewable energy variants in Indonesia has at least 10% of their total potential being used and utilized until now. For example, out of the total potential of 207 GW, the total installed capacity of solar energy in Indonesia is still around 78.5 MW or 0.04% from their solar energy potential according to Table 2. However, Indonesia has installed 4,826.7 MW of hydropower capacity, or around 6.4% from their hydropower potential.

| Year | Type of Energy | Potential (MW) | Installed Capacity so far (MW) | Installed Capacity per Potential Percentage (%) |
|------|----------------|----------------|--------------------------------|-----------------------------------------------|
| 2015 | Geothermal     | 29,544         | 1,438.5                        | 4.9                                          |
|      | Hydro          | 75,091         | 4,826.7                        | 6.4                                          |
|      | Mini/Micro Hydro | 19,385       | 197.4                          | 1                                            |
|      | Solar          | 207,898        | 78.5                           | 0.04                                         |
|      | Wind           | 60,647         | 3.1                            | 0.01                                         |
|      | Bioenergy      | 32,654         | 1,671                          | 5.1                                          |
|      | Marine         | 17,989         | 0.3                            | 0.002                                        |

Table 2. The renewable energy potential and installed capacity so far in Indonesia year 2017. [14]
The target set for Indonesia’s renewable energy was not that high, but judging by the data served by the table above, those targets would be hard to reach. The PP RI 79/2014 about the revised National Energy Policies stated that Indonesia must reach at least 23% of renewable energy variants in the national energy mix for 2025 and 31% for 2050. These targets have been made by IESR and Indonesia’s Ministry of Energy and Mineral Resources (KESDM) in National Energy Plan (RUEN) that specifies the renewable energy mix target each year. According to their projections until 2050, there would be no significant decrease in fossil fuel’s percentage. In 2020, fossil fuel and other non-renewable energy sources were still dominating the national energy mix with 87%, and in 2050 by projection. These sources will still dominate with a percentage of 69%, and the other 31% are renewable energy variants [15]. The decrease, however, will still fulfill Indonesia’s promise in Paris Agreement to reduce greenhouse gases emission, but of course there are other dreams for Indonesia to surpass even higher from their targets for their renewable energy mix as future’s main energy source.

3.2. Indonesia face challenges for their road to fulfill RUEN’s target

The challenges that Indonesia face due to their progress to reach their renewable energy targets were not only related to infrastructure and operational, but also their human resources. The main challenge that slows down Indonesia’s renewable energy implementation progress is the fact that Indonesia’s still too dependant to fossil fuels [16]. The dependency may be caused by Indonesia’s high number of fossil fuels, coals, and other non-renewable energy sources. The dependency may also be caused by the government providing fossil fuels subsidies to the public. In 2017, the Indonesia government had at least spent 77 trillion rupiahs or about 4.4% of the Nation’s Spending Plan or APBN for energy subsidies, causing the fossil fuels price in the mentioned nation to decrease greatly, increasing the public’s interests in buying and using fossil fuels [17].

Indonesia’s renewable energy potential may be high, but in reality not all of their population have used any kind of energy at least once in their lives, especially electricity. The Ministry of Energy and Mineral Resources or KESDM has stated that around 12,659 villages in Indonesia were not electrified or didn’t receive any kind of electricity services, of which 65% of the villages are located in the eastern part of Indonesia. Note that most of the villages in that part of the country have high solar and wind energy potential. This will be a great start to implement most of the mentioned renewable energy variants in those villages, so that the population of the villages can finally have electricity to be used. However, these places are mostly isolated and all the people that lives there have minimum education to do things such as creating and operating renewable energy technologies. They can be assisted by sending experts to the isolated places, but it will cost a lot of fortune. This is also one of the most challenging problems which is of less interest of investors in renewable energy projects. Renewable energy projects already cost a lot from finding potential places with sources, experts, and rare technologies, but the investors felt that the government should have done more to help them deal with the high expenses.

Other problems might be present in the KESDM, as not much focus is being given to renewable energy issues. From 2011 to 2017, the KESDM has built around 686 renewable energy plants across Indonesia for 3 trillion rupiahs. This surely was a big action to speed up Indonesia’s renewable energy progress. However, they have faced several problems in 2017, as they reported several malfunction problems from the renewable energy plants and most of the plants need serious fixing and maintenances. The KESDM has agreed to give 8.9 until 17.68 billion rupiahs for the maintenance in 2018 [16] but it was stopped due to not having enough available experts in the country to deal with the maintenance. So, the funds therefore were redirected for other things. The renewable energy plants had to operate with some issues, but some others had to stop operations completely.

3.3. Some Recommendations can be considered for the Indonesia’s Renewable Energy Management to face challenges

Indonesia needs to consider some actions to face at least some of the challenges that are already mentioned above for their quest to fulfill renewable energy targets. Some of these recommendations
below can be used as consideration. Most of the recommendations were results of reviewing some articles and writings written by mostly experts from other countries and energy organizations:

- Try to separate renewable energy focus from the KESDM, and form a legal own policy body just to focus on the nation’s renewable energy issues: At the moment, the KESDM leads two smaller government bodies responsible for renewable energy issues, which is the Directorate General of New Renewable Energy and Energy Conservation and the Directorate General of Electricity based on Figure 3. The Directorate of Renewable Energy needs to have full privilege to decide what they think the best decisions to renewable energy actions and policies would be. By separating the mentioned Directorate to form an own ministry department, it will help the government in focusing Indonesia’s renewable energy issues. Also, the new ministry can quickly revise or decide to make new policies about the nation’s renewable energy development, such as new policies that will help renewable energy project’s investors [18].

![Main energy body](image)

**Figure 3.** Indonesia’s energy sector government charts. [18]

- Prioritize renewable energy issues in the regulations agenda: The government have made considerations to put renewable energy issues as Indonesia’s main concern after the Paris Agreement in 2015. According to Table 3, Indonesia actually has a more complete set of policies variety about their renewable energy issues in comparison to most of the countries in the ASEAN region. Most of these policies were forgotten and off of the priorities concerned by the government as these policies need to be revised, such as low incentives being given to the investors of the renewable energy projects. The government could take action to revise the incentives, feed in tariffs regulation, risk managements or the help to organize and plan the costs of renewable energy projects.

**Table 3.** Comparison of renewable energy policies components in ASEAN countries. [18]

| Type of Policy | Availability | ASEAN Country Member |
|---------------|--------------|----------------------|
|               |              | IDN | PHI | VIE | MAY | THA | SIN | MYA | LAO | CAM | BRU |
| Renewable energy in INDC or NDC | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
| Renewable energy targets | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
| FIT/auctions/premium payment | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
| Net metering/billing | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
| Biofuel blend obligation/mandate/target | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
| Electricity utility quota obligation/RPS | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
| Tradable REC | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
| Renewable heat obligation/mandate | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
| Tax incentives | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
| Public investment/loans/grants/subsidies | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
| Reductions in sales, GHG, VAT or taxes | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
| Tendering | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
| Investment or production tax credits | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
| Energy production payment | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
Increasing the quality of the energy grid and the grid management: The quality of the grid or the grid management nowadays could be one of the main reason why some of the population in Indonesia can’t receive energy or electricity services. The improvement of these grid issues can be done to increase the electrification of the nation so even the most isolated places or villages can receive electricity. The nation can reconsider new grid designs and structures so that the grid system could compensate for the inconsistent or the intermittent effect made by the renewable energy variants electricity production such as solar and wind energy. The implementation of smart grid system could be considered as this type of grid can handle most of the grid problems mentioned before. Smart grids also have the ability to transfer energy production from the plant generators to the consumers directly and efficiently while also reducing the energy loss form grid interconnection [19].

Giving instructions to domestic banks to support investors financing the renewable energy’s projects: Other than incentives from the government, the domestic banks can also help by giving easy loans to the investors, as incentives will not be enough to cover up investors’ funds for renewable energy projects.

Stop the subsidies of fossil fuels: The subsidies should be stopped by the government as it would cause an even bigger consumption of fossil fuels by the public. The government can consider to subsidize for green energy such as biosolar or any other biofuels types to persuade public to start using green energies.

Creating new market opportunities to small entrepreneurs such as selling recycle-potential garbages or food wastes as sources for biomass plants and building synergies with towns or village governments to create renewable energy projects or workshops, for example: Pengembangan Proyek Surya Nusantara [13].

4. Conclusion
Some conclusions that can be taken from this small review are as follows:

In 2020, renewable energy variants in Indonesia’s energy production mix percentage was at 14.71%; still dominated by fossil fuels such as oil and coal with a percentage of 85.64%. The number of percentage was still far from Indonesia’s RUEN target for renewable energy mix percentage of 23% in 2025 and 31% in 2050. This should be easy considering Indonesia has around 443 GW of installed capacity of renewable energy variants potential. However, Indonesia still utilize only a small part of the renewable energy potential and is facing some challenges and problems in fulfilling the mentioned targets.

The challenges faced by Indonesia for fulfilling renewable energy targets are: high dependency to fossil fuels, less focus from the KESDM, low availability of renewable energy technology or system resources such as funds and experts, and the low interest from investors.

Some recommendations that can be considered to face those challenges mentioned above: forming a new ministry just to focus on Indonesia’s renewable energy issues, putting renewable energy issues as priorities for the regulations agenda and government’s concerns, increasing the grid quality and management of the grid, advising domestic banks to support the renewable energy projects investors, stopping the subsidies of fossil fuels and instead giving subsidies to green energies and biofuels, and creating new renewable energy market opportunities to increase the contribution of public and entrepreneurs.
Acknowledgements
The author wanted to appreciate all the help that were given by the Department of Energy System Engineering of Universitas Indonesia, especially Mr. Adi Surjosatyo during the writing of this review.

References
[1] Badan Pusat Statistik Republik Indonesia 2021 Hasil Sensus Penduduk 2020 (The Result of 2020’s population census) (Jakarta: Indonesia’s Statistics Department)
[2] United Nations 2017 World Population Prospects 2017 Revision (San Fransisco: United Nations, Department of Economics and Social Affairs)
[3] Statista 2020 Indonesia: Share of economic sectors in the gross domestic product (GDP) from 2009 to 2019 (Retrieved from: https://www.statista.com/statistics/319236/share-of-economic-sectors-in-the-gdp-in-indonesia/)
[4] International Renewable Energy Agency 2017 Renewable Energy Prospects: Indonesia (Abu Dhabi: International Renewable Energy Agency Remap)
[5] Badan Pengkajian dan Penerapan Teknologi 2020 Outlook Energi Indonesia 2020 Edisi Khusus: Dampak Pandemi COVID-19 terhadap Sektor Energi di Indonesia (Indonesia’s Energy Outlook in 2020, Special Edition: COVID-19 Pandemic Impacts on Indonesia’s Energy Sector) (Jakarta: BPPT’s Research Party for Processing Industry and Energy)
[6] United States Energy Information Administration 2020 Overview: Indonesia (Washington DC: United States Energy Information Administration)
[7] Index Mundi 2020 Indonesia Electricity Production and Consumption (Retrieved from: https://indexmundi.com/indonesia-electricity-production-and-consumption)
[8] Budiman A, Das K, Mohammad A, Tee Tan K and Tonby O 2014 Ten ideas to reshape Indonesia’s energy sector (Chicago: McKinsey & Company)
[9] Statista 2020 Indonesia’s Energy Mix Consumption in 2020 (Retrieved from: www.statista.com/indonesias-energy-mix-consumption-in-2020)
[10] Sugiyono 2014 Metode Penelitian Kuantitatif, Kualitatif, dan Kombinasi (Mixed Method) (Mixed Method, Quantitative, and Qualitative Research Method) (Bandung: Alfabeta)
[11] Zed M 2014 Metode Penelitian Kepustakaan (Literature Research Method) (Jakarta: Yayasan Obor Indonesia)
[12] Institute of Essential Services Reform 2019 Indonesia Clean Energy Outlook: Reviewing 2018, Outlooking 2019 (Jakarta: Institute for Essential Services Reform EIA)
[13] Direktorat Jenderal Energi Baru Terbarukan dan Konservasi Energi 2020 Roadmap Dan Strategi Pengembangan Energi Baru Terbarukan Di Indonesia (Indonesia’s Roadmap and Strategy for Renewable Energy Development) (Jakarta: Indonesia’s Ministry of Energy and Mineral Resources)
[14] Institute of Essential Services Reform 2017 Energi Terbarukan, Energi Kini dan Nanti (Renewable Energy, the Energy for Today and the Future) (Jakarta: Institute for Essential Services Reform)
[15] Tampubolon A 2020 Transisi energi dan Prospek Energi Terbarukan di Indonesia tahun 2020 (Indonesia’s Energy Transition and Renewable Energy Prospect) (Jakarta: Institute for Essential Services Reform)
[16] Udin 2020 Renewable Energy and Human Resource Development: Challenges and Opportunities in Indonesia International Journal of Energy Economics and Policy 10(2) 233-237.
[17] Pusdatin E 2016 Handbook of Energy and Economic Statistics of Indonesia (Jakarta: Ministry of Energy and Mineral Resources Republic of Indonesia)
[18] Vakulchuk R et al 2020 Indonesia: How to Boost Investment in Renewable Energy (Jakarta: ASEAN Centre for Energy)
[19] Back A, Evens C, Hukki K, Manner P, Niska H, Pykala M-L, Saarenpaa J and Simila L 2011 Consumer acceptability and adoption of Smart Grid (Helsinki: CLEEN Ltd)