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Wind Energy in Indonesia: Current Status, Potential, Challenge, Opportunities, and Future Policy

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Abstract. Like many countries, an increase in population and economic growth has made Indonesia's energy demands significantly raise. By 2050, Indonesia hopes to have 31% of its energy supply met by tapping on renewable energy, like the wind which can yield up to 16.7% of the power. However, the development of wind energy in Indonesia is still low. One underlying reason is the average speed of wind in Indonesia quite low, making it very difficult to produce energy on a large scale. Many of Indonesia's current wind energy systems installed in remote locations, often as part of a development or research project in stand-alone or hybrid systems. These partly caused by a lack of confidence in wind power and not being sure of where could be the best locations for wind plants. This paper studies the status of wind energy in Indonesia, the challenges that it faces and future policies.

Keywords: wind energy, Indonesia, potential, future policy

1. Introduction

These days, energy has increasingly become a commodity of great significance to economic development. Countries in the world compete for this commodity to enhance the quality of citizen's lifestyles, including an increase in technological development. Unfortunately, most energy currently comes from fossil fuels whose existence is diminishing slowly (Utama *et al.*, 2014; Hu *et al.*, 2013). Also, the use of fossil fuels is the largest contributor to the perforation of ozone due to the greenhouse gas effect. Many countries invested heavily in the search for renewable energy, including from sources like hydro, wind, solar, biomass, and geothermal.

Currently, wind energy has become of great interest in the world. Although wind power capacity is quite low compared with other renewable energy such as biomass, hydro and nuclear power plant it estimated that it will supply 18% of the world's electricity by 2050 (IEA, 2001). Wind energy almost evenly distributed across the countries in the world at high or low speed. However, only a few countries have large capacities such as China, USA, India, Brazil, and Germany.

For developing countries like Indonesia, wind energy is an attractive choice for shifting their demand from energy fossil to renewable energy. However, the development of wind energy Indonesia is still low. One underlying factor is that the average wind speeds are relatively low, making it difficult to produce electricity on a large scale. Speed of wind is not high enough to be able to build a large-diameter wind turbine, because large-scale wind turbine has a cut-in which range in wind speed of 5 m/s to 7 m/s (Burton *et al*, 2001). Nonetheless, the potential for wind energy in Indonesia remains high, since it has the world's fourth longest coastline of 99,093 km (BIG, 2015) estimated to have the potential power of

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970 MW (BPPT, 2018). By the end of 2017, the installed capacity of wind energy was only about 1.96 MW (BPPT, 2018). In July 2018, President Joko Widodo inaugurated 75 MW installed capacity wind power plant, which the largest wind power plant in Indonesia, in Sindereng Rappang regency, South Sulawesi (Ditjen EBTKE KESDM, 2018). With that, the total installed capacity of wind energy in Indonesia drastically increased to 76.96 MW.

Another barrier is the reference tariff for new and renewable energy under the Ministry of Energy and Mineral Resources (MEMR) Regulation No. 12 in 2017 that raised protests from relevant parties. Based on those regulations, the selling price of electricity generated from new and renewable energy would base on the local cost of generation. In several regions, the local cost of generation is way lower than the Levelized Cost of Electricity (Cindy, 2018).

There are still challenges facing the bid to increase the development of wind energy in Indonesia. When the importance and potential of wind energy realized, it expected that policies will be formulated to encourage the development of plants to provide power throughout the country without fossil fuel emissions to the atmosphere.

This paper review the state of wind energy in Indonesia, potential, challenges, and opportunities and future policy. The Global wind energy situation is also discussed at the beginning of this paper to find out the situation, potentials, and utilization of wind energy in the world.

2. Methodology

The methodology used for this paper is a literature review. The articles in this review selected whilst bearing this question in mind concerning the following concepts: wind energy, current status, barriers, potential, challenge, opportunities, policy, and Indonesia. The articles include the research paper, publication, news, book chapter, and regulations. After collected, the articles analyzed and summarized to be included in the paper and then drawn the conclusion.

3. Global Wind Energy

In December of 2015, 186 countries gathered to sign the Paris Agreement to mitigate climate change, including greenhouse gas emissions produced by fossil fuels (GWEC, 2015). Meeting these objectives will require significant efforts to promote the growth of renewable, green energy. The main sources of renewable energy include wind. From 2001 to 2017, the total installed capacity of wind power increased yearly. At the end of 2017, the total wind power capacity was about 532 GW (GWEC, 2018).

Currently, nine countries have more than 10 GW wind power installed. They include China, the United States of America (USA), Germany, India, Spain, the United Kingdom, France, Brazil, Canada, and Italy. China installed 188 GW, about 35% of the total world wind power (see Figure 1) (GWEC, 2018). The feed-in tariff has been the main driver for wind energy development in China (GWEC, 2018). At the end of 2017, there was 52 GW new wind power installed in the world. Much of this was in China, which added 19.660 GW (37%) (see Figure 2) (GWEC, 2018). Total new investment in clean energy increase to US$ 333.5 billion in 2017, up 3% in 2016, but still lower than the record investment of US$ 348.5 billion in 2015. China contributed 40% or around US$ 133 billion while the Asia Pacific region as a whole accounted for 57% of the total investment, around US$ 187 billion.

The wind energy in China developed rapidly over the past decades. China’s government adjusts various price policies and non-price policies which supports the development of wind energy. Among all those policies, the feed-in tariff policy considered the most influential towards the rapid development of wind energy in China. The feed-in tariff policy in China determined by wind resources distribution. There are four categories of wind resources classified by China government. The lower wind resources in the area, the higher feed-in tariff will provide (Zhang, Ni, Shen, & Wong, 2019).

In Germany, feed-in tariff policy instituted in 1991. As a response to the regulation, investors invested their money in renewable energy, especially wind energy. As a result, wind energy in Germany growing nearly three-hundred-fold from 0.1 GW in 1991 to 49 GW in 2016. Increasing feed-in tariff rate by €1 cent/kWh would increase addition to wind power capacity average 796 MW per year from 1996-2010 (Hitaj & Loschel, 2019).

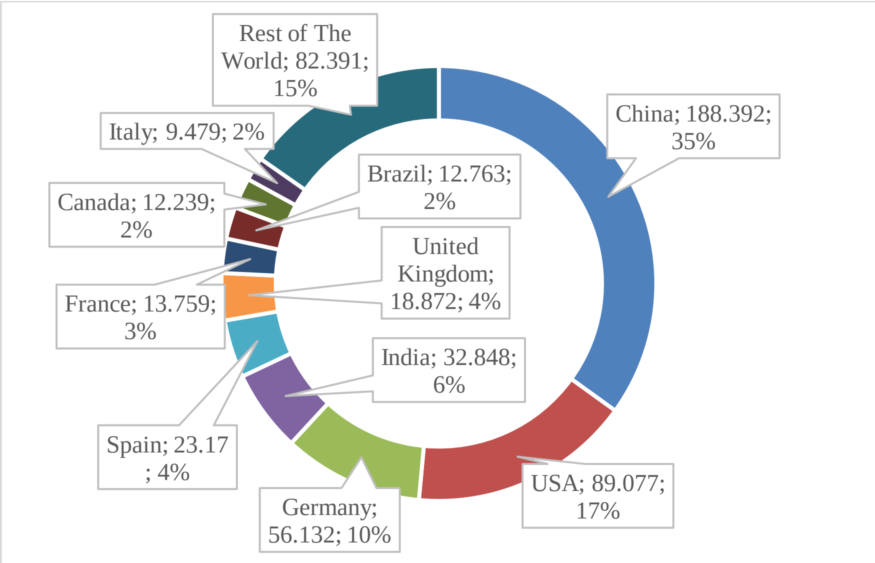

Figure 1. Total installed capacity (in GW) of wind power in the world (GWEC, 2018).

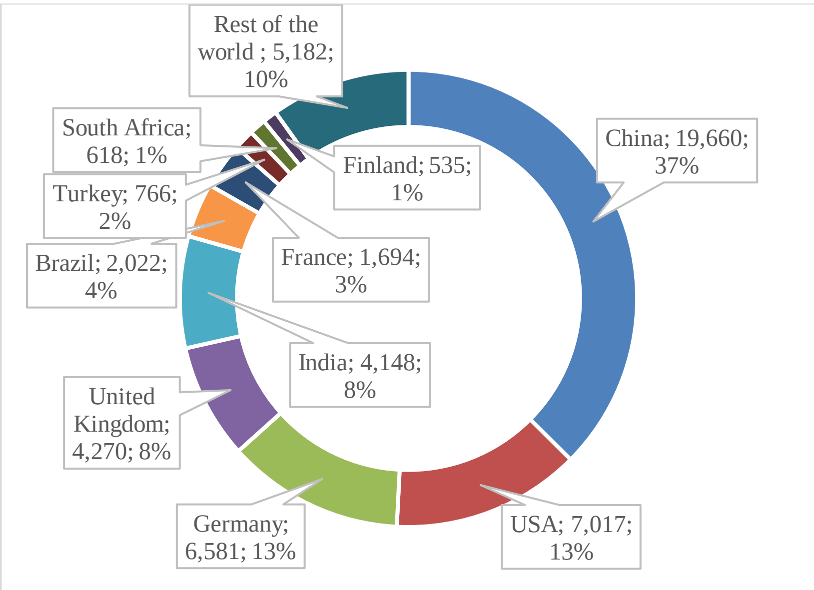

Figure 2. New installed capacity (in MW) of wind power in the world (GWEC, 2018).

4. Energy Mix and Wind Power Potential in Indonesia

Over the next several decades, Indonesia is expected to lower its reliance on oil. In 2016, oil supplied 38% of the energy mix, but by 2030, it is expected to supply only 34% (see in Figure 3). However, the country will not entirely stop relying on fossil fuels according to this plan. In 2050, oil consumption will reduce to only 31% of the total energy. Meanwhile, coal, which made up 30% of the total energy in 2013, is expected to supply 36% of Indonesia's energy by 2050. Domestically produced natural gas, which in 2013 supplied 22% of the total energy, is expected to drop to 18% by 2050. Indonesia is projected to have 14% of its energy supply needs to be met by new and renewable energy by 2050 (BPPT, 2018).

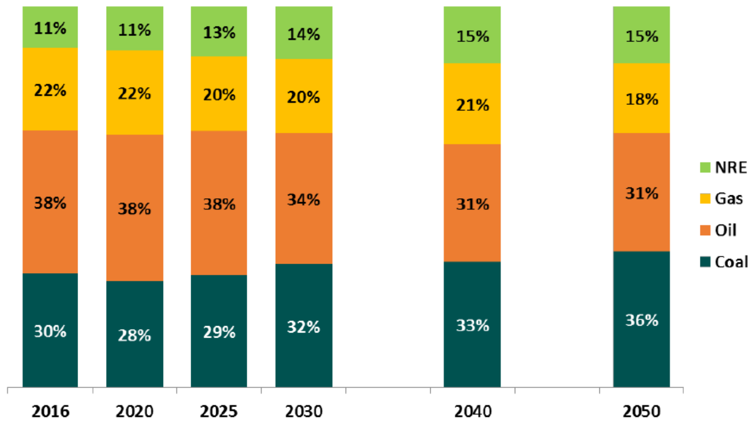

Figure 3. Energy mix situation and projection in Indonesia (BPPT, 2018).

On the other hand, the government forecasted that NRE could contribute 23% of primary energy in 2025 and 31% by 2050. From that share, wind power is expected to supply 4% or 1.8 GW by 2025 and 16.7% or 28 GW by 2050 (President Regulation No. 22 in 2017). There are many advantages of using wind power. First, wind turbines can construct in rural areas where the infrastructure necessary to transport other fuel supplies is not available. Secondly, wind power is freely available, and it does not contribute to greenhouse emissions. Thirdly, it is capital intensive, meaning the initial construction of wind turbines can be an expensive investment. However, once the turbine is running, the wind power it produces is available for free. There are no fuel costs, unlike in power plants that are required to burn fossil fuels. These make the availability and price of wind power significantly lower than fossil fuel, which is usually volatile depending on supply, demand, and global politics. The reduced emissions will also help in the global effort to prevent and mitigate climate change.

Many of Indonesia's current wind energy plants installed in rural areas, often as part of a development or research project in stand-alone or hybrid systems. In total, less than 2 MW have been installed, sparsely across remote areas of the country. By 2011, the MEMR had installed just 100 kW of wind turbines at Sukabumi in West Java and Selayar in South Sulawesi. A larger on-grid facility was installed at Nusa Penida in Bali with a capacity of 735 kW. At Sangihe, North Sulawesi, MEMR installations and PT.PLN provided 240 kW to the PLN's grid (Martosaputro & Murti, 2014).

MEMR surveyed 153 sites and released wind speed data as shown in Table 1. From the data, 66 sites have poor potential with wind speed at 50 meters just under 3 meters per second and power density of less than 45 W/m^2. These sites include Maluku, Papua, Sumba, Mentawi, Bengkulu, Jambi, East Nusa Tenggara, West Nusa Tenggara, North Sumatra, Southeast Sulawesi, and North Sulawesi. On the other hand, 34 sites were found to have average potential, with wind speeds of 3-4 m/s and power density of slightly under 75 W/m^2. These sites are in Central Java, Maluku, Yogyakarta, Lampung, South Kalimantan, East Nusa Tenggara, West Nusa Tenggara, South Sulawesi, North Sulawesi, Central Sulawesi, and North Sumatra. Another 34 sites have wind speeds of 4.1-5 m/s with the power density of between 75-150 W/m^2. They include sites at Central and East Java, Yogyakarta, Bali, Bengkulu, East Nusa Tenggara, West Nusa Tenggara, South Sulawesi, and Central Sulawesi. The last 19 sites were found to have "good" potential, with wind speeds of greater than 5 m/s and power density of greater than 150 W/m2. These sites include locations in Banten, Jakarta, Central Java, Yogyakarta, East Nusa Tenggara, West Nusa Tenggara, Southeast Sulawesi, North Sulawesi, and South Sulawesi. These sites have the best potential to produce sufficient wind power, but even those other areas with less potential may be good enough sites for smaller turbines to supply power to the locals or supplement the energy grid (KESDM, 2016).

Table 1. Wind speed and power density in several locations (KESDM, 2016).

Resources potential	Wind Speed at 50 m (m/s)	Wind Power density at 50 m (W/m^2)	Total Sites	Provinces
Poor	<3	<45	66	Maluku, Papua, Sumba, Mentawi, Bengkulu, Jambi, East Nusa Tenggara, West Nusa Tenggara, Southeast Sulawesi, North Sulawesi, and North Sumatra.
Low	3 – 4	<75	34	Central Java, Maluku, Yogyakarta, Lampung, South Kalimantan, East Nusa Tenggara, West Nusa Tenggara, South Sulawesi, North Sulawesi, Central Sulawesi, and North Sumatra.
Intermediate	4.1 – 5.0	75 – 150	34	Central Java, East Java, Yogyakarta, Bali, Bengkulu, East Nusa Tenggara, West Nusa Tenggara, South Sulawesi, and Central Sulawesi.
Good	>5	>150	19	Banten, Jakarta, Central Java, Yogyakarta, East Nusa Tenggara, West Nusa Tenggara, Southeast Sulawesi, North Sulawesi, and South Sulawesi.

In early May 2015, the government began construction of Indonesia's first on-shore wind turbine farm in Bantul, Yogyakarta. The coastal plant will include 33 wind turbines, with each turbine expected to have the capacity of 1.5-2 megawatts. At the potential of 50 MW total, the farm will significantly increase Indonesia's wind power capacity after it completed in 2019. The average wind speed at Bantul is sufficient, at around 5 m/s, but not the best in the country. In the southeast, around Flores and Nusa Tenggara, wind speeds can be as high as 6-7 m/s (The Jakarta Post, 2015).

The first and the largest wind power plant in Indonesia commissioned in Sidenreng Rappang, South Sulawesi, by July 2018. This wind power plant, whose construction begun by August 2015 and finished by March 2018, has 30 wind turbines with each turbine having 2.5 MW capacity (Ditjen EBTKE KESDM, 2018).

5. Challenges and Opportunities

The wind energy market in Indonesia has remained underdeveloped. The underdeveloped wind energy market in Indonesia is because of the government's reluctance to invest in wind power and uncertainty of best locations for wind plants, though these barriers being slowly overcome by the work of WHyPGen through wind mapping and location assessment. However, this has brought to light some challenges, with areas with strong wind power not conveniently located about electric grids.

The wind power plant is an energy generator with recurrent energy sources. While in operation, a backup generator needed for when there is a decrease in wind speed below the limits of turbine design. With that in mind, each region needs a different feasibility study of the wind power plant, especially a large-scale wind power plant (KESDM, 2016).

Another challenge is the high initial investment costs required to incorporate new technology in the wind energy generation. The International Renewable Energy Agency (IRENA) shows that it costs in the region of US$ 3 million to US$ 4 million per MW to construct offshore wind turbines, while geothermal power plants cost between US$ 2 million and US$ 3 million per MW while coal-fired plants have an average capital cost of below US$ 1 million per megawatt (IRENA, 2012). Funding from international investors is required, although subsidies for green energy may be necessary to attract project developers. Pricing policies such as feed-in tariffs that guarantee investors will receive a competitive price can also encourage the development of wind power. The purchase price of electricity from the wind power plant is regulated by the MEMR Regulation No. 12 in 2017. As can be seen in the regulation, compared to fossil fuels, the electricity tariff for wind energy is not sufficiently low. Lack of sufficient funding can make it hard to hire skilled technical workers or to train new workers; also, the required spare parts are not always readily available in the local market.

Once wind power generated, it contains a relatively low cost per unit, since turbines capture free air. However, the initial construction of wind farms may require high costs in terms of equipment and land acquisition. Therefore license and big fund sources are necessary. Because financing institutions usually tend to think renewable energy investments are associated with high-risks, interest rates on capital funding can be high.

The Jeneponto installation is funded through 25% equity from the World Bank's International Finance Corp, Asia Green Capital Partners Pte Ltd., and loans from EKF, Denmark's export credit agency (IFC, 2015). The project investment is estimated to be US$ 160.7 million and has reached 96.68% completion (Kompas.com, 2018).

Earlier projects built in collaborations between MEMR and PT PLN, which one of the installations contributed 240 kW to PT PLN's grid. A power purchase agreement (PPA) made with PT PLN for a second wind farm, the 75 MW installation in Sidenreng Rappang, South Sulawesi, that will be overseen by UPC Sidrap Bayu Energy, a joint venture of US renewable energy company UPC Renewables and local firm Binatek Energi Terbarukan (UPC, 2015). The wind power plant, which construction started in August 2015 and finished by March 2018, has 30 wind turbines, with each turbine having 2.5 MW capacity.

6. Future Policies and Scenario

Wind power energy in Indonesia will be crucial in meeting renewable energy goals to supply the country's growing electricity needs and to satisfy GHG emissions goals by using low-carbon emission resources. Challenges facing this goal include the need for infrastructure improvement, increased technical capacity, the removal of barriers, and access to financing from government and businesses.

Indonesia's strategy and action plan to support wind power for energy diversification include wind installation that will be financed by the state budget, ministry budget, and a special allocation fund. In 2015, 2.7 MW of wind turbine power plant installed, out of this, 2 MW financed by the state budget, 0.5 MW from the ministry budget, and 0.2 MW from the allocation fund. The new installations brought the country's total installed capacity to 5.8 MW. Total capacity may double with planned installations of 5.7 MW in 2016. The state budget will cover 5 MW, the ministry budget 0.2 MW, and the allocation fund another 0.5 MW. By 2018, the ministry budget and special allocation funds will each be covering 1 MW of installation and the state budget another 9, resulting in a total of new 11 MW of energy and national capacity of 30.8 MW. Lastly, 2019 will be another year of main installations, with 16.2 MW installed. The state budget will cover 13 MW, the ministry budget will cover 2 MW, and the special allocation fund will cover the remaining 1.2 MW totaling 47 MW. At the end of 2017, the total installed capacity was only 1.96 MW (KESDM, 2016).

Table 2. Wind Turbine Policy (KESDM, 2016).

Action plan	Unit	2015	2016	2017	2018	2019
Total wind power plant	MW	2.7	5.7	8.3	11	16.2
State budge	MW	2	5	7	9	13
Ministry budget	MW	0.5	0.2	0.5	1	2
Special allocation fund	MW	0.2	0.5	0.8	1	1.2
Total capacity installed	MW	5.8	11.5	19.8	30.8	47

The potential of wind energy production in Indonesia has identified in several locations, especially in the regions of Java, South Sulawesi, Nusa Tenggara, and Maluku. Developers have suggested the construction of wind power plants in several locations such as Sukabumi, Banten, Sidenreng Rappang, Tanah Laut, Bantul, and Jeneponto. In locations such as Sidenreng Rappang, Jeneponto, and Tanah Laut, the development is ready to commence, while the remaining locations further study needed. One of the factors that will determine the entry of wind power plants into the national system is the ability of the system to accept the inclusion of wind power plants units (KESDM, 2016).

MEMR has set the development roadmap of NRE from 2018 to 2027. From that roadmap, an installed capacity of wind power is targeted to reach 589 MW in 2027 (see in Figure 4). It is still far from the government's goal of 1.8 GW from wind power by 2025.

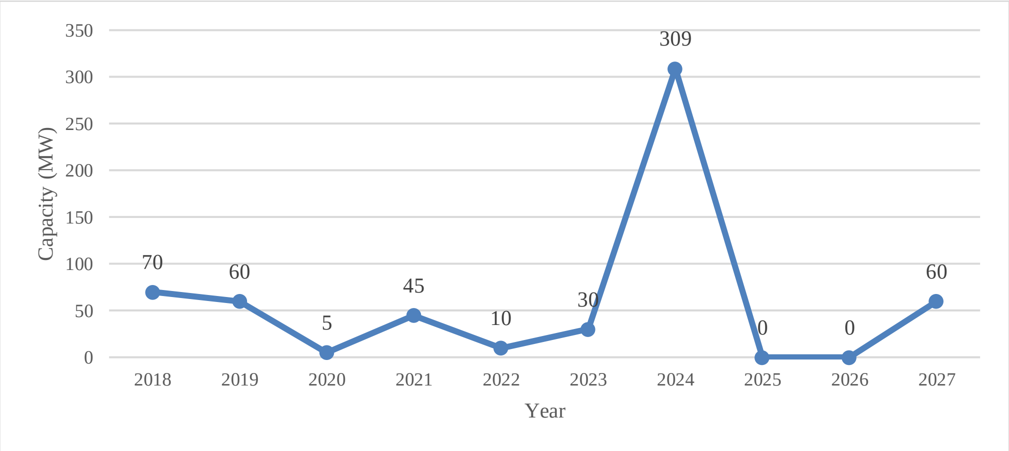

Figure 4. Planning development of wind power (KESDM, 2016).

Through Presidential Regulation No. 22 in 2017, The Government provide State-Owned Enterprise (SOEs) to conduct pre-feasibility studies for areas that already have the potential of wind energy production and continue with feasibility studies on wind power plant development. The Government also require the Regional Government to build and manage wind power plant through Regional-Owned Enterprise (ROEs) (Presidential Regulation No. 22 in 2017).

In Indonesia, the energy rates of wind energy cannot still compete with conventional plants powered by coal and fossil fuels. In 2016, the Indonesia power plant capacity reached 57.1 GW. Coal-fired power plants share the biggest installed capacity, with 54% or around 30.8 GW (BPPT, 2016). The lowest electricity production cost per kWh for coal-fired plants among other power plants is one of the reasons why dependency for coal remains high.

Other countries have enabling technologies and policies that make renewable energy more competitive. This policy, for instance, include a feed-in tariff that offers favorable prices for renewable, increasing its consumption level. The purchase price of electricity from the wind power plant is regulated by the MEMR Regulation No. 12 in 2017. From the regulation, it can be noticed that, compared to fossil fuels, the electricity tariff for wind energy is high because the cost of electricity production from wind is higher than national electricity cost production average, PT PLN can only buy electricity power at a maximum of 85% of national electricity production cost (MEMR Regulation No. 12 in 2017).

The cost of purchasing wind turbine electricity by PLN in each region is different because it depends on the national electricity cost production average. Thus, the purchase price of PT PLN and Independent Power Producers (IPP) requires negotiation, time, and mutual agreement with enough money and requires a considerable amount of time. Because of that, the government needs to increase energy rates of new and renewable energy, especially wind energy, so that wind energy can compete with conventional power plants. Implementation feed-in tariff in China and Germany can provide a good example in implementing feed-in tariff policy to increase the development of wind energy in Indonesia. Several benefits can derive from wind energy, including the lowest global warming potential per unit of electrical energy generated more than all low carbon power sources. It emits an extremely low end of 0.4 g CO_2-eq/kWh and the extremely high end of 364.8 g CO_2-eq/kWh (Nugent & Sovacool, 2014). Furthermore, despite the expensive initial installation cost, wind power after that is almost free. It expects that more investment will be attracted to wind energy production through further education about the potential of wind energy and further technological developments.

7. Conclusion

As the world moves towards achieving the Paris Agreement on Climate change, Wind energy consumption is expected to increase as an alternative to fossils fuel. The development of wind energy in Indonesia is still relatively low as compared to developed countries. One underlying factor is that the average wind speed in Indonesia is quite low and, making it difficult to produce electricity on a large scale. Nonetheless, the wind energy potential in Indonesia remains very high, because the world's fourth-largest coastline is in Indonesia (99,093 km) with the potential to generate 970 MW of power. However, the installed capacity of wind energy is currently about 76.96 MW.

In Indonesia, the energy rates of wind energy cannot still compete with conventional plants powered by coal and fossil fuels. Based on the MEMR Regulation No. 12 in 2017, the selling price of electricity generated from new and renewable energy would base on the local cost of generation. In several regions, the local cost of generation is way lower than the Levelized Cost of Electricity. Implementation feed-in tariff in China and Germany can provide a good example in implementing feed-in tariff policy to increase the development of wind energy in Indonesia.

Indonesia's strategy and action plan to support wind power for energy diversification include planned wind installation that will be financed by the state budget, ministry budget, and a special allocation fund. Therefore, wind power energy exploration in Indonesia is expected to increase significantly shortly, and more clean energy will become available for use in the country when all the potential areas fully exploited.

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