



The Efficient Implementation of Hybrid Power Plants in Indonesia

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ABSTRACT

The energy crisis is a serious issue that all countries around the world are dealing with, particularly the energy sources used to generate electricity. There are numerous alternative energy sources available in nature, such as solar energy, wind energy, and so on. Wind and solar energy as hybrid energy sources are thought to be promising in electric generation technology. Hybrid Power Plants can also be used to address the issue of limited electrical energy supply in Indonesia's remote areas. The purpose of this study is to describe the effectiveness of the hybrid power plants implementation in Indonesia. The study was conducted using the narrative literature review method. It can be inferred that the purpose of developing this hybrid technology, among others, is to obtain more efficient electrical energy generation by combining the advantages of two or more types of power generation systems that work in an integrated manner as a compact system. The produced electric energy can be stored in the battery. In terms of use, the produced direct current (DC) is converted into alternating current (AC) using the inverter system prior to distribution to consumers. Therefore, this hybrid power plant is suitable for implementation in Indonesia.

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1. INTRODUCTION

Currently, one of the serious problems faced by all countries in the World is the energy crisis, where its demand increases day by day, - on the other hand, the resources availability is rapidly depleting and will soon run out. In such case, more attention needs to be paid to renewable energy sources (Khan *et al.*, 2017). This crisis occurs due to several factors, such as the excessive- energy use, non-renewable sources, rapid increase of world population, and so on. This crisis has undesired impact on all aspects of life, one of them is the source of electricity that still largely depends on the fossil energy, namely coal. Coal is a resource primarily used for electric power generation, and currently supplies 41% of global electricity needs (Dai & Finkelman, 2018).

Electricity plays a vital role in supporting the economic and social development of a country (Lin & Zhu, 2020). The electricity sector is also crucial for the sustainable development of a country as it affects various environmental, economic and social issues throughout the supply chain (Atilgan & Azapagic, 2016). The increasing world population and availability of energy smart devices are main reasons for terrifyingly high electricity consumption in the current times (Bedi & Toshniwal, 2019).

Renewable energy is not subject to such cost-drivers. Learning by practice, on the other hand, reduces costs. While renewable electricity was initially more costly, with time and practice, it has become effective enough to outcompete non-renewable sources (Kåberger, 2018).

The natural variability of climate factors such as air temperature, wind velocity, solar radiation, precipitation, evaporation, and river runoff characterizes a significant portion of renewable electricity production. Weather and climate conditions have a large impact on both electricity production and demand. This influence will grow as the potential and prospects of renewable energy grow on a global scale (Engeland *et al.*, 2017).

Global energy consumption continues to rise, and while standards are no longer adequate to meet energy demand, resulting in energy crises, the use of renewable energy is critically important for the world (Guo *et al.*, 2018). These resources have the advantage of being environmentally friendly and sustainable, but they also have disadvantages such as higher investment costs and insufficient system reliability to meet energy needs on an ongoing basis. To address this shortcoming, hybrid systems involving the use of more than one type of renewable energy resource and integration with storage have been developed (Tezer *et al.*, 2017). By combining multiple renewable energy sources, hybrid renewable energy systems can be highly efficient and are regarded as a promising solution to the problem (Guo *et al.*, 2018).

The purpose of this study is to describe the effectiveness of the implementation of this Hybrid Power Plant in Indonesia in order to be a solution to the energy crisis problem as well as an effort to increase the proportion of renewable energy in the energy mixture.

2. METHODS

The method used in this study is a narrative review. The narrative review method aims to identify and summarize previously published articles, avoid duplication of research, and look for new areas of study that have not been researched (Ferrari, 2015). The review method was carried out in this study consists of determining the topic, searching the relevant literatures from the main sources of journals, selecting literature, processing data, and drawing conclusions.

Figure 1 shows the flow of this study. First, determine the topic that will be the focus of the discussion. For literature searches, the main sources come from journals and from several other relevant sources. They have been obtained by applying specific keywords on the search engine. Further it will be selected according to the needs of the discussion. All data that has been selected are then processed and presented as information, and finally conclusions are drawn.

3. RESULTS AND DISCUSSION

The development of renewable energy in the world will be accompanied by technological advancements, lowering the cost of investment and renewable energy tariffs, making them more competitive with electricity generated by fossil fuels. Indonesia currently has 57 gigatonnes of installed power generation capacity, with 86 percent still using fossil energy and the remainder using renewable energy (Arafah *et al.*, 2018).

It is well understood that fossil fuels will eventually deplete because they cannot be replenished. Furthermore, the use of fossil fuel power plants has negative consequences such as air pollution, global warming, and climate anomalies. Renewable energy has emerged as a powerful alternative in Indonesia, where the energy source is determined by the geographical area and the type of energy produced.

Based on these factors, a power plant derived from renewable energy sources, such as hydro, solar, geothermal, wind, biomass, and so on, is developed. Renewable energy tends to be more environmentally friendly in terms of energy supply. However, increasing technology and the willingness of various parties to make it happen is required so that electricity costs become competitive compare to fossil energy.

Traditional uses of bioenergy (primarily for cooking) in the country's rural areas and remote islands account for the vast majority of renewable energy use in Indonesia.

Aside from the geographical factor of Indonesia being a maritime country, the Indonesian state is also located on the equatorial horizon line, which causes Indonesia to be a tropical climate country. This has a positive impact on the potential for new and renewable energy in Indonesia, as most of the country receives sunlight almost all year (Caraka, 2016).

The use of energy via solar cells is the most potent alternative to be used in Indonesia, out of the many renewable energy sources. Solar energy is one of the energies that the Indonesian government is actively developing because, as a tropical country, Indonesia has significant solar energy potential. Solar energy is exceptional because it is not a pollutant, cannot be depleted, can be trusted, and does not require purchase. Solar energy can provide continuous power because it is a renewable energy source that is also clean and environmentally friendly, helping to reduce greenhouse gas emissions. Furthermore, solar electricity can provide electricity quickly and without individual maintenance costs, and it can meet electricity needs in rural areas, isolated areas, and islands that are not electrified by the government (Hardianto, 2019).

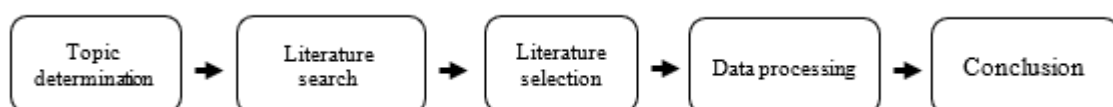


Figure 1. Flowchart of Narrative Review.

Then, because the Indonesian territory is surrounded by oceans, wind speeds in various regions of Indonesia are relatively high. Indonesia is considered an archipelago, with many areas suitable for the construction of wind farms. However, there are a variety of factors that can influence the location of a wind farm (Pambudi & Nananukul, 2019). The current installed capacity of wind energy power plants in Indonesia is 1.96 MW, with a total available capacity of 970MW. Wind turbines emit less carbon. As a result, wind power is one of the options for environmentally friendly power plants (Noviani, 2019).

Table 1 shows that the utilization of solar and wind energy in Indonesia is still very low, only less than 1%. Given the potential of these two energy sources, if used and developed as an alternative energy source from power plants in Indonesia, it has the potential to reduce reliance on coal, which is currently the primary energy source for electricity generation. In the following section, we can compare the electricity demand and production from each sector.

Figure 2 depicts the total demand for and production of electricity in each sector. Every sector, including industrial, transportation, residential, and commercial, grows year after year, with electricity production always exceeding demand. One of the most basic human needs is electricity (Hajar et al., 2018). As a result, we can conclude that the demand for electricity will continue to rise year after year because, in essence, humans engage in a variety of activities that require the presence of electricity. Electricity comes from a variety of sources, which serve as the foundation for existing power plants. The chart below compares the sources of electricity generation from year to year.

Figure 3 shows that almost every source of electricity generation increases year after year. However, coal continues to be the most widely used source of electricity generation. Other electrical energy sources, such as wind, solar, and others, continue to grow year after year, but they still account for a small percentage of total energy consumption. Among all renewable energy sources, wind energy is the most dominant. This energy is currently the most popular on a global scale. Many countries have begun to make projections in this sector (Sahu, 2018). Wind and solar energy are gaining popularity due to their abundance, availability, and ease of control for generating electrical power (Jenkins et al., 2019). As a result, renewable energy sources such as wind and solar are unquestionably required in Indonesia.

Indonesia is a country that is blessed with abundant solar energy throughout the year and has quite good wind energy potential; combining solar and wind power to create a Hybrid Power Plant could be one of the most appropriate solutions for system isolated generation with a larger network such as the PLN network, which is expected to be one of the steps toward decarbonization and to improve national energy security (Saodah, 2019). Wind, solar photovoltaic (PV), diesel, and energy storage in hybrid combinations are among the renewables that can provide continuous energy for all sizes of implementations (Rehman, 2021). Hybrid power plants are combined power plants made up of two or more generators that use different types of energy (Hidayanti, 2020). This system combines wind and solar energy, which are used to generate power from each other. The hybrid system has an advantage over systems that rely on a single energy source. Researchers face a difficult task in maximizing total energy output from the system while keeping costs and reliability low (Wagh and Walke, 2017). Because wind and solar as renewable energy sources are, of course, weather-dependent, the effectiveness of wind and solar energy sources will be reduced in certain weather conditions. However, combining solar and wind power to create a Hybrid Power Plant can be one way to maximize the efficiency of electricity generation.

Table 1. Renewable energy potential in Indonesia (IESR, 2016).

Energy Type	Potency (MV)	Installed Capacity (MW)	Utilization (%)
Geothermal	29.544	1.438,5	4,9
Water	75.091	4.826,7	6,4
Mini and micro hydro	19.385	197.4	1
Sun	207.898	78.5	0,04
Wind	60.647	3.1	0,01
Bioenergy	32.654	1.671	5,1
Ocean	17.989	0.3	0,002

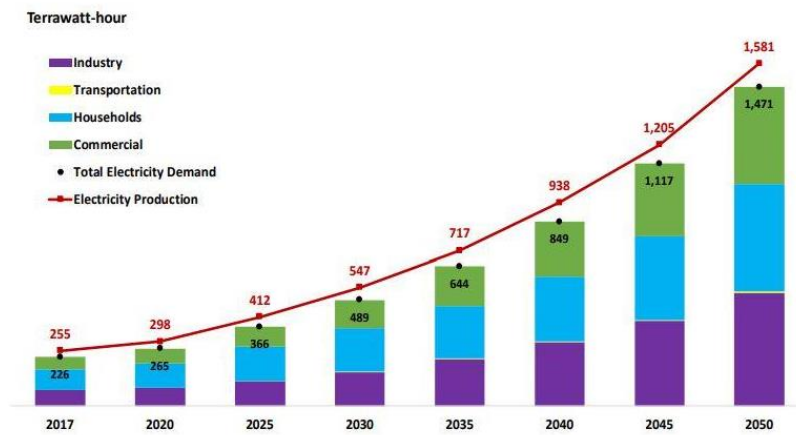


Figure 2. Total Electricity Demand and Production each Sector (BPPT, 2019).

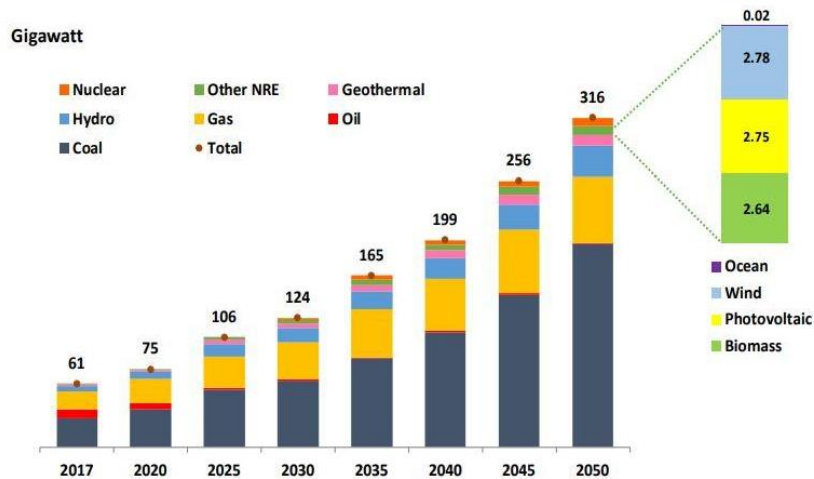


Figure 3. Power Generation Capacity (BPPT, 2019).

Figure 4 depicts the layout of a hybrid system powered by solar and wind energy. The energy absorbed by the turbine and PV array will be transferred to the control unit and stored in the battery. The current is then converted by the inverter into Alternating Current (AC) and distributed to consumers.

According to previous research, the potential for solar and wind energy as an alternative energy source to fossil fuels is still very high. According to NASA (National Aeronautics and Space Administration) data, the average wind speed in this case is 4.42 m/s at an altitude of 50 m. In August, the highest wind speed is 6.15 m/s, while the lowest wind speed is 2.91 m/s.

NASA provided monthly solar radiation data in December for this study. The highest solar radiation was obtained in September, namely 6.56 kWh / m² / day with a clarity index of 0.646, while the lowest solar radiation was 5.08 kWh / m² / day in January with a clarity index of 0.469 (Pae et al., 2017).

Renewable energy sources such as wind and solar are both universal and environmentally friendly. This renewable energy source is the best option to meet the world's energy needs, but its availability cannot be predicted due to natural factors. Solar and wind hybrid renewable energy systems will be the best option for utilizing this available resource (Wagh and Walke, 2017).

The goal of developing this hybrid technology is to achieve maximum efficiency by combining the benefits of two or more types of power generation systems that work together as a compact system (Hidayanti, 2020). The energy produced by all existing power sources, including the solar cell system and the wind energy system, is channeled to the control unit to power the hybrid system. Direct current electricity is used to power the control unit. If there is excess energy, it is stored in the battery before being distributed to consumers. Direct current energy is converted to alternating current energy by the inverter before being distributed to consumers. Energy is flowed through the distribution of alternating current to consumers of various types and needs after it is converted into alternating current energy. According to the results of previous studies, hybrid energy can produce 1000 W of power and can meet the electricity needs of a house (Tharo, 2019).

Furthermore, wind and solar power plants have the potential to be built because natural and wind resources can be exploited. In this case, solar and wind power hybrids with a capacity of 24.8 kW can generate 438,073kWh of electricity per year (Mubarak and Farid, 2019).

4. CONCLUSION

Hybrid power plants can adapt to more changes in weather, installation does not require a large-scale projection, and the power plant's performance is superior to relying on a single energy source. In this case, hybrid power plants are effective for implementing in various regions throughout Indonesia, particularly in areas that are still difficult to reach or have not yet received electricity. Given the high effectiveness of hybrid power plants, it is hoped that increased implementation of hybrid power plants in Indonesia will help to solve Indonesia's energy and electricity problems.

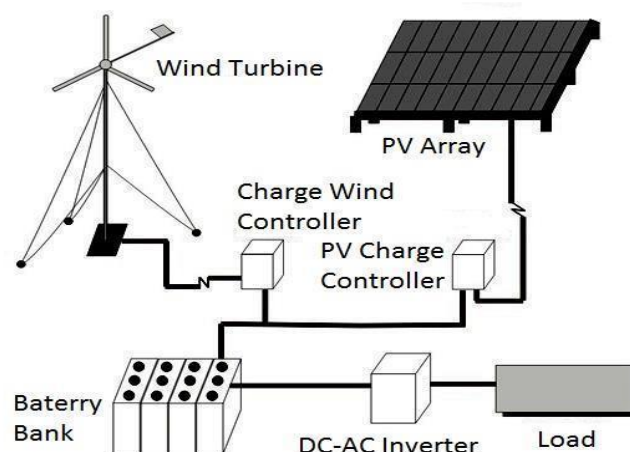


Figure 4. Hybrid power plant configuration (Hidayanti, 2020).

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6. AUTHORS' NOTE

The authors declare that there is no conflict of interest regarding the publication of this article. Authors confirmed that the paper was free of plagiarism.

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