CHAPTER 1 INTRODUCTION

1.1 Background

Electricity consumption in Indonesia will continue to increase, and this increase is influence by growingly diverse technology, electricity transportation, and lifestyle. This phenomenon is directly proportional to the need for raw materials to run the power generation system [1]. In Indonesia, demand for fossil raw materials to run power plants consisting of coal, oil, and gas occupies the highest percentage compared to other energy. According to a survey from the Center for Data and Information Technology in Energy and Mineral Resources (Pusdatin ESDM), it is explained that oil and coal occupy the highest percentage of the national energy consumption needs around 38.81% and 32.9% [2]. With the use of Renewable Energy (RE) in not reaching 7%.

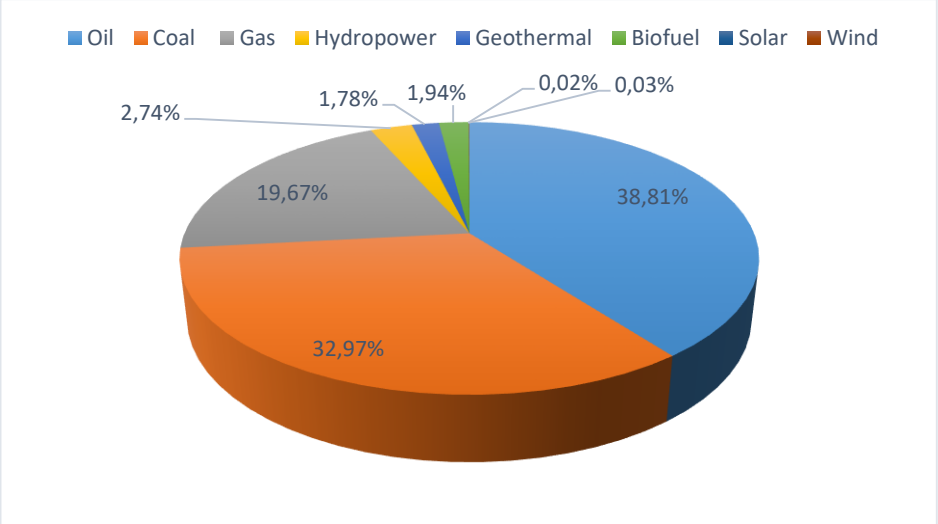

Figure 1.1 National energy consumption in 2018[2]

According to the Indonesian Central Statistics Agency (BPS), steam power generation, is the dominant electricity supplier in Indonesia, reaching 56%of national energy use [3]. And it is known that the steam power experienced a peak load of 25,325 MW on 15 September 2017 at the Java Bali plant, and is predicted to continue to increase along with the current development of Indonesia [4].

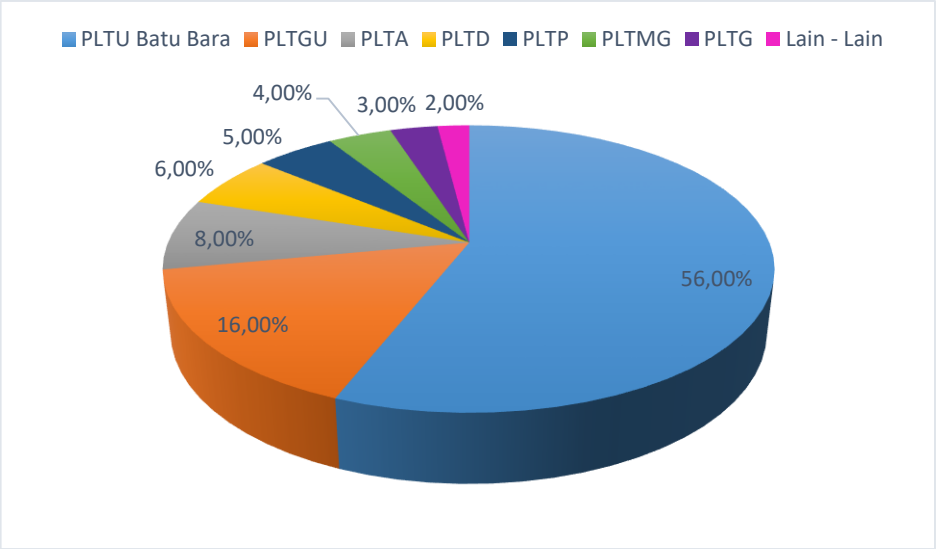

Figure 1.2 The type of national power plant based on fuel energy in 2018[1]

Meanwhile, if used continuously, fossil raw materials will undoubtedly be reduced because it is difficult to renew. The process of fossil formation takes millions of years. Fossil energy as a raw material for electricity generation is certainly not environmentally friendly because, in its processing, only about 40% of electricity is produced from processing efficiency, the rest becomes to emission such as SO_2, CO_2, NO_x, and other emissions particles [5].

Power plants are the main topic in this study because the majority of power plants in Indonesia use coal (steam power plant). With total emissions of 175.62 million tons of CO in 2015. The most prominent emission came from coal combustion by 70%. In 2017 it turned out that emissions from electricity generation continue to increase. Meanwhile, Greenpeace, which is a non-governmental global environmental organization based in Amsterdam and has more than 40 branches in the world, states that Jakarta is the most polluted country in Southeast Asia, with electricity generation as the second-largest contributor of emissions after the transportation sector. Indonesia is among the top 20 polluting countries in Asia [6], and is the fifth-largest contributor to Greenhouse Gases (GHG) in the world.

Indonesia is determined to reduce pollution by following the Paris Agreement 2015, which in 2020 targets to maintain an increase in global temperature of 1.5ºC so that Indonesia has a goal of reducing GHG emissions by 42% with foreign investment in 2030. Therefore the government makes various

policies so that Indonesia can immediately switch to RE or at least maximize the use of existing RE. Like the Ministry of Environment and Forestry make Ministerial Regulation Number P.15/MENLHK/SETJEN/KUM.1/4/2019 on Emission Quality Standard of Thermal Power Plants, stating that the emission standards allowed emissions are as follows.

Table 1.1 Standar Emisi untuk Sistem Pembangkit Listrik Tenaga Uap Sebelum Peraturan Menteri Nomor P.15/MENLHK/SETJEN/KUM.1/4/2019 Berlaku[7]

No.	Parameter	Maximum Level		
		Batubara (mg/Nm^3)	Minyak Solar (mg/Nm^3)	Gas (mg/Nm^3)
1.	Sulfur Dioksida (SO_2)	550	650	50
2.	Nitrogen Dioksida (NO_x)	550	450	320
3	Partikulat (PM)	100	75	30
4.	Merkuri (Hg)	0,03	-	-

Table 1.2 Standar Emisi untuk Sistem Pembangkit Listrik Tenaga Uap Setelah Peraturan Menteri Nomor P.15/MENLHK/SETJEN/KUM.1/4/2019 Berlaku[7]

No.	Parameter	Kadar Maksimum		
		Batubara (mg/Nm^3)	Minyak Solar (mg/Nm^3)	Gas (mg/Nm^3)
1.	Sulfur Dioksida (SO_2)	200	350	25
2.	Nitrogen Dioksida (NO_x)	200	250	100
3	Partikulat (PM)	50	30	10
4.	Merkuri (Hg)	0,03	-	-

Perusahaan Listrik Negara (PLN) is the leading supplier of electricity needs in Indonesia and implements a low carbon technology, namely Clean Coal Technology, to reduce the greenhouse effect. At the same time, the private sector must apply air pollution control technology. PLN through the 2019-2028 Rencana Usaha Penyediaan Tenaga Listrik (RUPTL), which targets the application of the power plant energy mix with a total of 23.2% RE [8]. With the implementation of the use of RE 23.2%, can reduce emissions by 137 million tons of CO_2 [8].

Because these targets make researchers make innovations to reduce levels of emissions in power plants. Many ways to minimize the impact of pollution by steam power plants, one of which is on the island of Karimunjawa, to reduce emissions a simulation of the use of hybrid or hybrid power plants using the HOMER software optimization system for hydro, wind, solar, biomass, and diesel as a reserve [9]. In Lebanon, research has been carried out on the use of the Cogeneration algorithm, which is integrated with RE to meet power requirements at low cost and emissions [10].

Based on the data that has been presented, Indonesia itself still cannot be separated from fossil energy sources at least until 2050. So to reduce carbon emissions for steam power plants, Economic Emission Dispatch (EED) system is made. Where an integrated power plant can calculate cost value and emissions value, and be executed by an algorithm (according to power requirements by taking into account its lowest emission value). This method has been widely studied by several researchers, such as [11] [12], conducting EED research using Whale Optimization Algorithm (WOA), which was tested on the IEEE 30 bus system, where this algorithm provides an optimal solution. From the analysis that has been done, it is explained that WOA is better than the Particle Swam Algorithm (PSO), where a good convergence result is obtained. But for more effective results, a combinational algorithm is needed. Furthermore, the study of the use of EEDs for the Java Bali 500kV grid uses the Modified Artificial Bee Colony (MABCA) algorithm, which is simulated using a weighting factor by weighting each function with a value of 1 for the overall weighting. The results obtained in the form a large of power plant cost that depends on the cost function and emission function, the higher the emission that is needed, the more expensive the generation costs, and vice versa. [12]. In Mardiyanto's research on the involvement of emissions in the optimal power flow in the Java Bali electric power system, he's using a multistage multilevel algorithm, which combines two optimization methods so that they can be adjusted according to their needs[13]. When power plants making a decision, the algorithm will always choose hydropower as a source of low-emission power plants, but if in daily use, this algorithm has a weakness in the preparation of the plant if at any time there is a sudden change in the status of the generator.

In the Java-Bali electric power system, they have a control center to regulate the required power load. In the control center, there is data processing from the existing power plants in Java - Bali. So if a power load is needed, the program will automatically notify that the generator needs to be turned on. However, the system has not yet included emissions as its main parameter. So in this study, emission parameters are used to create an algorithm that is following the instructions of the Ministry of Environment and Forestry regarding the use of maximum emissions limits for power plants. So that Indonesia will succeed in creating a pollution-less environment starting from the power plant.

WOA algorithm is inspired by the behavior of foraging for humpback whales. With this algorithm, it can be sought which generator takes precedence to meet the needs of the power load and consider environmental criteria or emissions generated by the power plant to reduce the production of emissions from conventional power plants. WOA be a choice for an optimization scheme because it can easily find the optimal solution, high convergence, and requires fewer iterations. WOA has two mechanisms for finding the optimal value of a function. So by using this algorithm, the results of the solution are very good (superior) compared to other optimization algorithms and avoid the optimum local[14].

1.2 Problem Identification

Coal is still the leading supplier of power plant sources in Indonesia. Its use will increase over the next few years because this steam power plant generates electricity at a low price of USD 4 per kWh. It doesn't matter if coal processing produces emissions that can cause latent hazards, such as global warming and pollution that damage the health of people who live in the area of the power plant, like shortness of breath, respiratory cancer to death. Regulations in Indonesia are also less strict in making changes towards low-emission power plants.

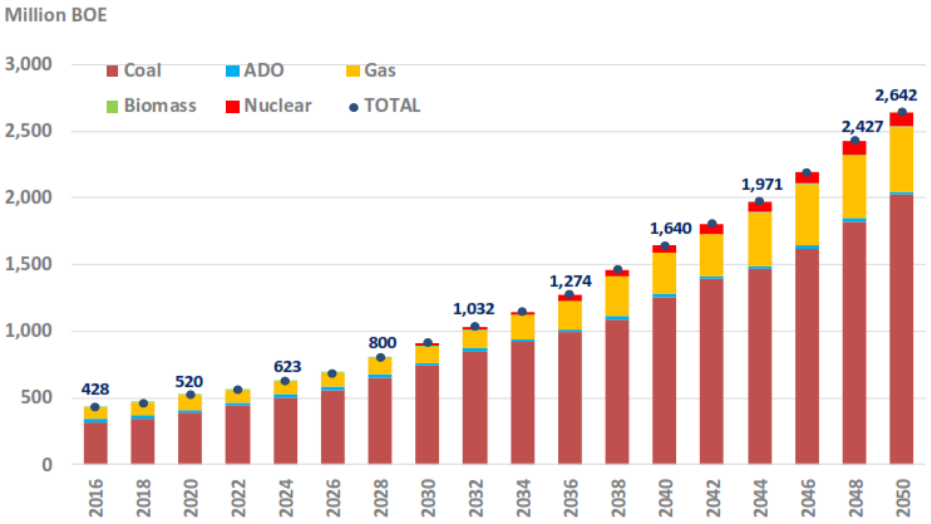

Figure 1.3 Power Needs for Power Plants [1]

Because many factors affect the use of coal, so it can not switch to RE quickly [15],[16]. Indonesia, which is a coal producer, causes the price of raw materials to be cheap because, for now, it is easy to obtain for power plants. It's also known that coal fuel will increase significantly until 2050. To solve this problem, EED using WOA is the right choice to reduce emission value. Where the algorithm works at a load management center that can control which generator is needed to meet capacity power, EED also can reduce pollution, by maximizing the use of plants with the lowest emissions and conducting studies on energy policies for Indonesia.

1.3 Objective

To identifying the use of minimally emitted power plants so that they can meet electricity needs, where the system offered has the benefit of efficient resource management for both the community and the country. And what policies must be implemented when the system was successfully running. Then what essential factors influence the successful use of the electric power system and emissions as the main parameters in Indonesia.

1.4 Scope of Work

This study performs EED calculations with WOA optimization so that it can reduce emissions released into the air and maximize environmentally friendly resources. With the integration of RE and conventional power plants to meet the

demand for electricity in Indonesia for the Java-Bali region, the losses from the distribution of electricity transmission will be ignored in this study. Then the Objective Value of each function (Cost and Emission) uses only one reference [17]. After doing the simulation, this research is directed to find a National policy solution for environmentally friendly power generation systems so that programs to reduce the effects of global warming can be realized, and can reduce adverse effects on public health.

1.5 Hypothesis

The referral journal discusses the use of integrated Java-Bali Hydrothermal power plants, which can manage the optimized electricity production following the requested power and pay attention to economic and environmental factors [13]. If these factors are taken into account, the system will execute which generator must be operated. Then in research in Sudan, diesel is used as a power plant that is integrated with wind power and solar photovoltaic with a compressed air energy storage system (CAES) for the power plant. The proposed system was then formulated as mixed-integer programming, which was completed in CPLEX 12.7.0. and the results show that the proposed model is suitable for renewable integration into the electricity grid system with energy storage systems [10]. EED research in Indonesia has also been carried out for Java-Bali power plants by using multistage optimization to analyze which plants emit the smallest emissions so that these plants can be used first to meet national power consumption needs.

Therefore this study will carry out technical and regulatory studies using Java-Bali power plants. Then the most environmentally friendly power plants will be chosen of power load requests, which can reduce pollution, with Indonesia being the first country with the worst air quality in Southeast Asia [6]. And this research also supports the government's movement to reduce emissions from electricity generation that causes GHG.

1.6 Research Method

The main objective of solving emission problems using WOA is to monitor and simulate the electricity network by considering the emissions produced in the production of Hydrothermal electricity [13]. So that if an electric power load is needed, then the power plant with the lowest emissions will be selected optimally

according to economic and environmental criteria, and the system can optimal by using the WOA algorithm.

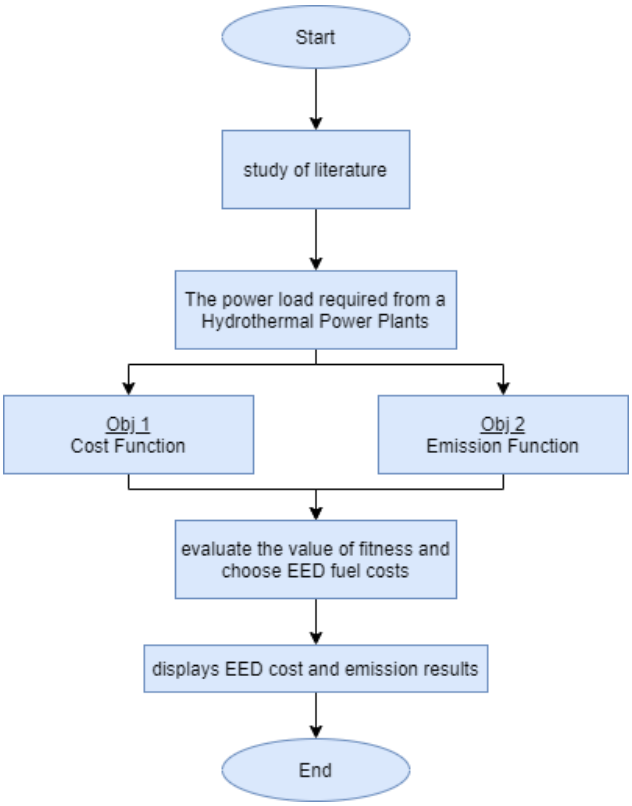

Figure 1.4 Framework Research Method

These economic and environmental criteria can be symbolized as an objective function of cost and an objective function of emissions, where the two functions are combined into a multi-objective equation through the Weighted Sum method. So, when the function is initialized, the WOA algorithm will iterate to find the fitness value. If an optimal value is obtained, the algorithm will display the results in the form of generation costs and emissions value.