



## The Development of Green Energy Policy Planning Model to Improve Economic Growth in Indonesia

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**Received:** 01 March 2019

**Accepted:** 01 July 2019

**DOI:** <https://doi.org/10.32479/ijEEP.7779>

### ABSTRACT

Energy is an element that is vital in everyday life. Its use continues to increase along with the increasing demand for energy which is influenced by population growth and economic growth. Until now, energy use is still dominated by the depletion of fossil energy, while its management is still not optimal. Energy planning needs to be done as the basis of a government policy in managing energy in order to realize national energy independence and security. This paper focuses on achieving the use of new and renewable energy according to the target of the National Energy Policy in 2025 in Java Island. Energy planning is carried out using the computable general equilibrium model approach, which is an approach that can illustrate the balance between energy supply and needs. Simulations are made in the green energy scenario by including several key parameters for the year of projections 2016-2025. The simulation results show an increase in the percentage of new and renewable energy use in the energy mix in 2025 by 12%. This explains that the target of National Energy Policy towards the use of new and renewable energy is reached, which is equal to 23%.

**Keywords:** Green Energy, Projection, LEAP, New and Renewable, Computable General Equilibrium

**JEL Classifications:** P18, Q43, Q47, Q48

### 1. INTRODUCTION

The energy sector occupies a very vital position in daily life, both in households, industry, even at the level of commercial business. The use and needs continue to increase along with population growth and the economy of a society (Acheampong, 2018; Sandberg et al., 2019; Sims, 2013; Wu et al., 2017). Therefore, energy use needs to be managed as well as possible, considering that in 2012, primary energy supply in Indonesia was still dominated by fossil energy sources such as oil, coal and gas. Meanwhile, supply from new and renewable energy such as hydropower, geothermal energy and biofuels is still <5%.

The problem faced today is the lack of control of energy needs, while fossil energy as primary energy is increasingly limited (Islam and Abdul Ghani, 2018; Raza et al., 2019; Sasana et al., 2018). The production of waste biomass is a great opportunity that Java

Island has as a new and renewable energy source. The potential of hydropower and geothermal energy in Java Island is also high enough to be used as a source of new and renewable energy.

Renewable energy modelling in the form of nuclear energy in Lithuania is carried out using the computational general equilibrium (CGE) method with the aim of looking at the impact of policies on nuclear energy use on economic growth and environment (Galiniš and Leeuwen, 2000). The variables used are in the form of supply, consumption, foreign trade, and the environment. The results of this modelling state that the policy of using nuclear energy can reduce the production of carbon emissions and increase the economic growth. Meanwhile, the analysis of the influence of renewable energy policies using economic models has been carried out to see the equilibrium of the electricity market by considering new and renewable energy policies to show that the electricity market equilibrium is influenced by renewable energy policies.

Analysis of the impact of the use of new and renewable energy is in the form of solar, wind, geothermal, biomass and biofuel energy to carbon emissions (Le and Nguyen, 2019; Luqman et al., 2019; Zafar et al., 2019). In the South American panel, it was found that a 1% increase in carbon emissions per capita increased 0.219% of new and renewable energy consumption per capita. The long-term energy planning model with the general equilibrium method is one of the tools used to analyse the possible loss of long-term energy planning used by the United States since 1975.

One of the optimization of renewable energy that has been done in Margajaya Village in 2013 stated that the recommended electricity system consists of 41.2 kW hydroelectric, 5 kW biomass, and 10 kW grid (Juwito and Haryono, 2013; Juwito et al., 2015). There is an energy surplus of 321.273 kWh/year which can be sold to the grid to generate cash income in the village and can help economic growth.

Based on the literature study that has been explained, in this paper, an energy modelling using the CGE model is presented to see the effect of the equilibrium of the electricity market by considering new and renewable energy policies and making a model of long-term energy planning with Java Island general equilibrium method to streamline energy use and supply using LEAP software. Furthermore, this paper looks at and compares the simulated green energy (GREN) mix with the target of the National Energy Policy in 2025.

The systematics of writing in this paper are as follows: Section II explains some of the basic assumptions used in modelling energy planning, Section III is the result and analysis of the results of the energy planning model, and Section IV is the conclusion.

## 2. ENERGY PLANNING

In this paper, basic assumptions are used as supporting factors for policies that were made to achieve the energy planning targets afterwards. The basic assumptions include key parameters, reference energy system (RES), scenarios, regional regulations, and simulation validation.

### 2.1. Key Parameters

The key parameters used in this paper include economic growth, population growth, total population, number of households, and GDP (Constant Price of 2010). Table 1 shows the key parameters used in this planning.

Based on Table 1, it can be seen that economic growth and population growth are assumed to decrease by 0.53% and 0.18%, which is inversely proportional to the population

assumed to increase to 52.79 million at the end of the simulation year. This is in line with the number of households and the GDP of constant price of 2010 which are also assumed to have increased by 0.78 million and 750 trillion rupiah at the end of the simulation year.

### 2.2. RES of Java Island

RES is a flow diagram that shows the interaction of each relationship between sources of energy supply, the process of converting primary energy into other forms of energy, and end users. RES of Java Island is a diagram that illustrates the flow of energy conversion from primary energy in Java Island to the forms of secondary energy. Furthermore, the secondary energy is converted into final forms of energy which are consumed or used by end users. RES in Java Island is shown in Figure 1.

The primary energy in RES of Java Island shown in Figure 1 consists of crude oil, natural gas, coal and renewable energy. There are a number of types of new and renewable energy whose potential is identified in Java Island. The types of new and renewable energy that are added are ocean wave energy, solar energy, wind energy, biomass, municipal solid wastes, and nuclear.

Crude oil is converted into fuel oil through refineries. The results of the processing are used by end users of the industrial sector, business sector, transportation sector, and the public sector. In addition, crude oil is converted into kerosene through processing plants. The results of the processing are used by end users of the household sector.

Natural gas is converted into electricity through a gas/steam power plant. In addition, natural gas can be converted into liquid petroleum gas (LPG) and liquid natural gas (LNG) through processing plants. Electric energy is consumed by the household sector, commercial business, industry, and public facilities. LPG is consumed by the household, commercial business, and industrial sector. Meanwhile, LNG/CNG and natural gas channelled through gas pipelines are consumed by the industrial sector.

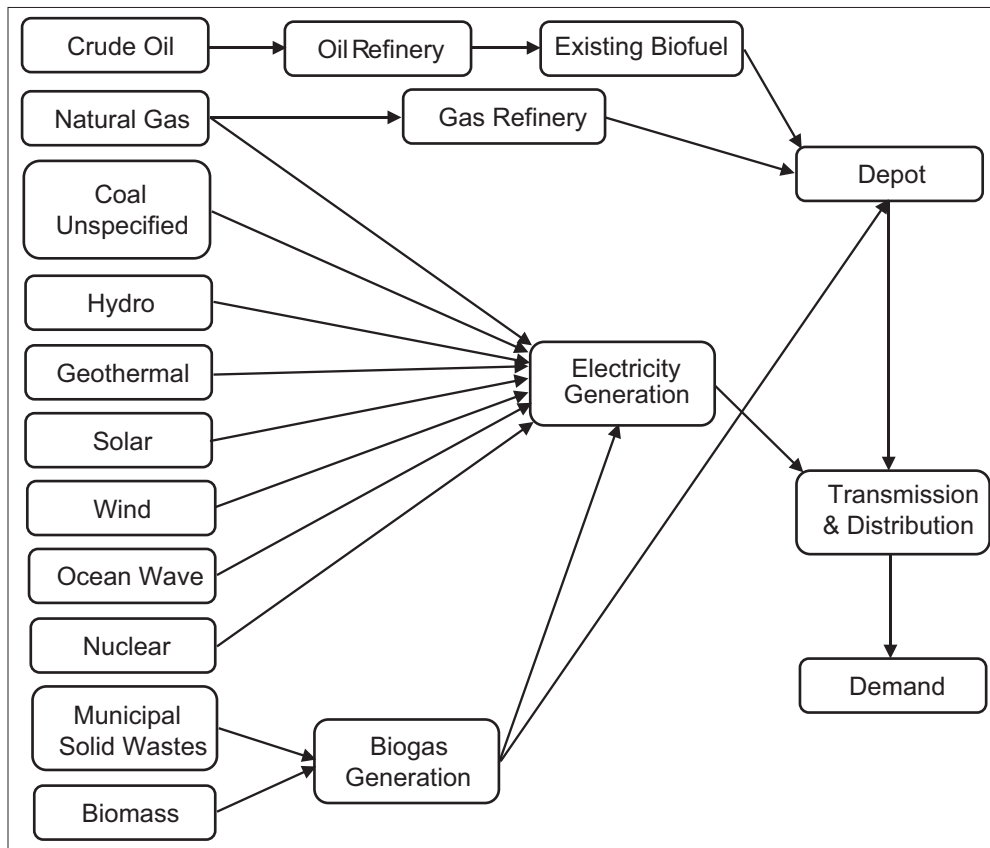
Coal is converted by coal steam power plants into electricity. Coal can also be converted directly by industry. Water and geothermal energy are converted into electricity through a hydroelectric power plant and geothermal power plant.

Waste biomass, ocean wave energy, solar energy, wind energy, and nuclear are converted into electricity respectively through waste power plant, ocean wave power plant, solar power plant, wind power plant, and nuclear power plant. Meanwhile, plant biomass is converted into fuel oil/biofuels through processing plants.

**Table 1: Key parameters (West Java General Regional Energy Plan, 2016)**

Assumption	Unit	2015 (Base year)	2025 (End year)
Economic growth	%	5.03	4.5
Population growth	%	1.3	1.12
Total population	Million people	46.7096	52.79
Number of households	Million	12.41	13.19
GDP (Constant Price of 2010)	Trillion Rupiah	1.207	1.957

Figure 1: Reference energy system



### 2.3. Scenario

Energy planning scenario is an assumption or direction of policy in energy planning that will be carried out. In energy planning, there are data on the use of various energy sources consisting of coal, natural gas, crude oil, and renewable energy. This paper focuses on the use of renewable energy, so the scenario of the Java Island energy planning used in this paper is the GREN scenario.

The GREN scenario is a scenario that seeks to increase the use of new and renewable energy as one of the primary energy sources, adding waste and plant biomass energy, ocean wave energy, solar energy, wind energy, and nuclear in addition to the utilization of new and renewable energy which will mostly be converted into electrical energy used by each sector. Meanwhile, plant biomass will be converted into fuel oil (biofuels) which will be more environmentally friendly. In the academic paper in 2025, the government sets the National Energy Policy target for the use of new and renewable energy to reach  $\geq 23\%$  of the total energy sources used. In addition to increasing the use of GREN, the use of advance technology will be used in this scenario, including the steam power plant with super critical and ultra-super critical (USC) technologies that have higher efficiency than the current subcritical steam power plant.

### 2.4. Java Island Regional Regulation

As a central industrial area and a centre for technological development, Java Island has regional regulations in the energy sector which are based on incentives for the use of

advance technology that encourage increased energy conversion efficiency (West Java General Regional Energy Plan, 2016). The industrial sector which is the largest end user of energy in Java Island always makes economic considerations a key consideration in high-tech regulation-based election decision making.

The Java Island energy planning regulation is based on the use of advance technology. Thus, the Java Island energy planning regulation must follow the road map for the development of energy technology on the supply side and end user/energy conservation side. Table 2 shows the matrix of regulations used in Java Island energy planning.

### 2.5. Simulation Validation

After the model was created using LEAP software, the model must be validated in order to describe the real situation. Simulation validation was done by comparing the Java Island energy mix in 2015 with the base year energy mix in the LEAP simulation. In 2015, Java Island was still dominated by the use of crude oil as a primary energy source which reached 42% of total primary energy use. Meanwhile, the use of new renewable energy is still at 11%. Figure 2 shows the comparison of the 2015 energy mix with the 2015 energy mix in the LEAP simulation.

Based on Figure 2, the percentage of LEAP simulation in the oil section is 1% smaller and coal is 1% greater than the Java Island energy mix in 2015. However, due to the relatively small percentage difference ( $<10\%$ ), the model used for energy planning simulation can be declared valid.

### 3. RESULTS AND ANALYSIS OF RESULTS

#### 3.1. Energy Planning Model

In general, the energy planning model in this paper is as shown in Figure 3.

The energy planning model consists of primary energy, secondary energy, and energy needs. Primary energy is converted to secondary energy which is then directly used according to the needs of the end user. Target settings will affect the volume of secondary energy output and energy needs. This is where government policies and regulations affect energy planning, while key parameters affect energy needs. The volume of energy needs affects energy supply, both secondary and primary energy.

In the case study in this paper, the Java Island energy planning model has characteristics such as Figure 4.

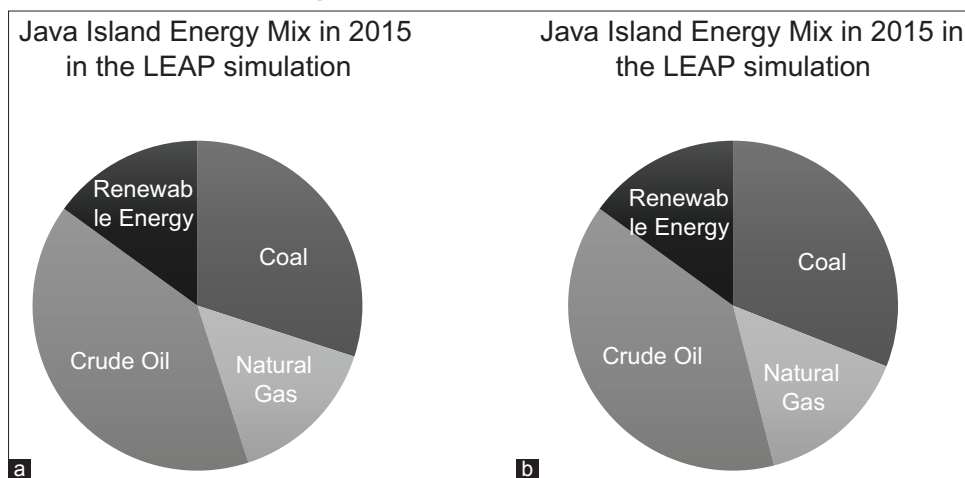
In the Java Island energy planning model, primary energy consists of fossil energy in the form of natural gas, crude oil, and coal, and new and renewable energy/GREN in the form of water, geothermal, solar, waste, wind, ocean wave, nuclear, and plant biomass. Primary energy is converted to secondary energy through a transformation process with certain techniques. Secondary energy in the Java Island energy planning model consists of four types, namely LNG/CNG (gas fuel), LPG, fuel oil (gasoline, diesel, kerosene, biofuel), and electricity. This secondary energy is then consumed by the end user.

**Table 2: Regional regulation**

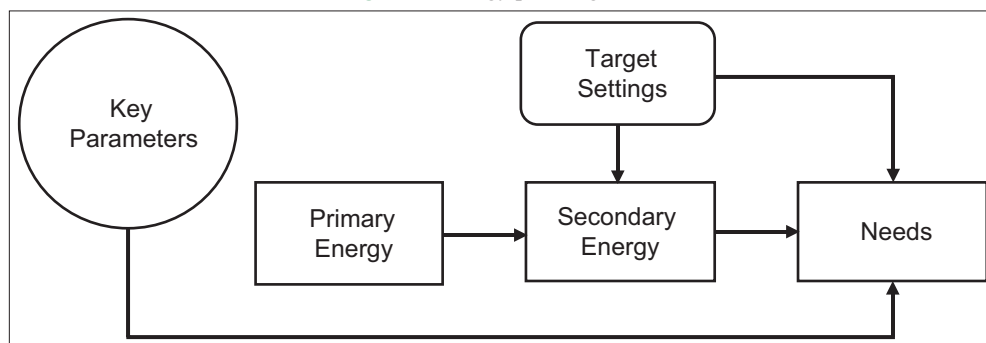
Description	Type	Regional regulation
End user	Energy saving equipment	Use of LED
	Fuel	The use of biofuels as an alternative use of fuel oil
Supply	Advance technology	Construction of incineration waste power plant Construction of supercritical steam power plant (2019) and ultra-supercritical steam power plant (2020) Construction of generation IV nuclear power plant type of VHTR
	Power plant	Increasing electricity supply by maximizing wind energy potential (2-3 m/s) and ocean wave energy (1-2.5 m/s) Addition of power plants of water energy (203.9 MW), geothermal energy (905 MW), and solar energy (8 MW)

LED: Light emitting diode, VHTR: Very high temperature reactor

**Figure 2:** (a and b) Simulation validation



**Figure 3:** Energy planning model



By using the CGE method, there are several conditions in the model, namely as follows:

$$\text{Energy}_{\text{Secondary}} = \text{Demand} \tag{1}$$

$$\text{Energy}_{\text{Primary}} = \text{Energy}_{\text{Secondary}} + \text{Losses} \tag{2}$$

The above equation illustrates that the CGE method in general in the form of energy supply must be greater or equal to energy needs and losses.

### 3.2. Energy Equilibrium

With several iterations of incorporating key planning values in accordance with regional regulations, the results of the projections of energy equilibrium in 2025 are obtained as in Figure 5 and Table 3.

Figure 5 illustrates that to achieve energy equilibrium according to the CGE method, imports are carried out in every energy source. Furthermore, in Table 3, it is shown that the largest import occurs in oil worth 12.54 MTOE, then followed by coal energy at

9.48 MTOE. Import with the smallest value occurs in electrical energy worth 0.09 MTOE. Primary energy is mostly converted into electricity and fuel oil so that the import of electricity and fuel is smaller than other energy.

Based on the data in Table 3, an energy mix graph can be made in 2025 based on the GREN scenario as follows:

From the graph in Figure 6, it is seen that the percentage of renewable energy use is planned to increase by 12% from 2015 to 23% in 2025. These results have met the National Energy Policy target regarding the use of renewable energy in 2025, namely 23%.

### 3.3. Comparison with National Energy Policy Targets

After simulating the supply and use of energy into the LEAP software, the results of the comparison are obtained as shown in Figure 7.

Figure 7 shows the comparison of the GREN scenario in 2025 with National Energy Policy. The GREN scenario shows a decrease in

Figure 4: Java Island energy planning model

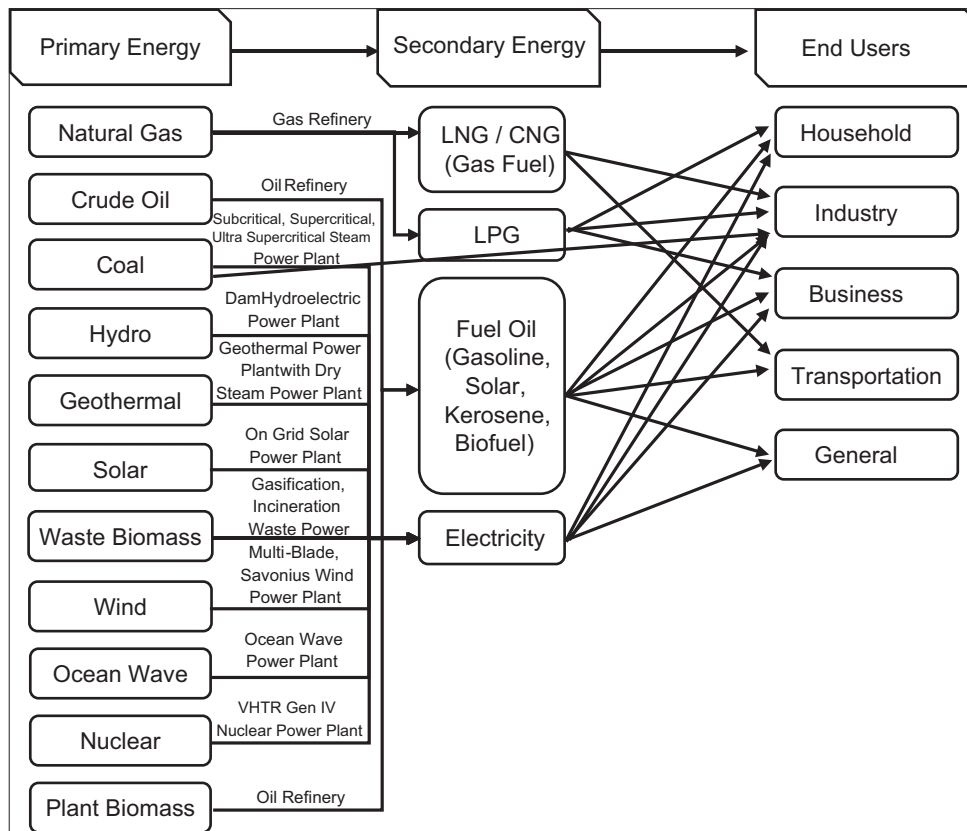


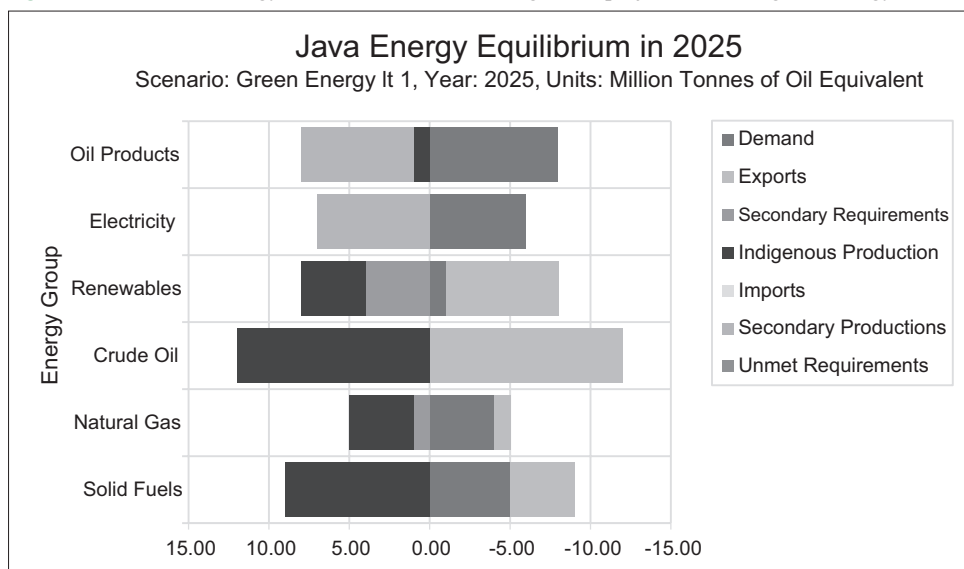
Table 3: Java Island energy equilibrium from the results of GREN scenario projection in 2025 (In Million Tonnes of Oil Equivalent/MTOE)

Supply projection	Coal	Natural gas	Crude oil	Renewable energy	Electricity	Fuel oil	Total
Production	-	0.38	-	3.78	-	-	4.16
Imports	9.48	4.66	12.54	4.34	0.09	0.96	32.06
Total primary supply	9.48	5.04	12.54	8.12	0.09	0.96	36.22
Total secondary supply	-4.37	-1.08	-12.54	-7.60	6.09	7.47	-12.04
Total needs	5.11	3.96	-	0.52	6.17	8.43	24.19

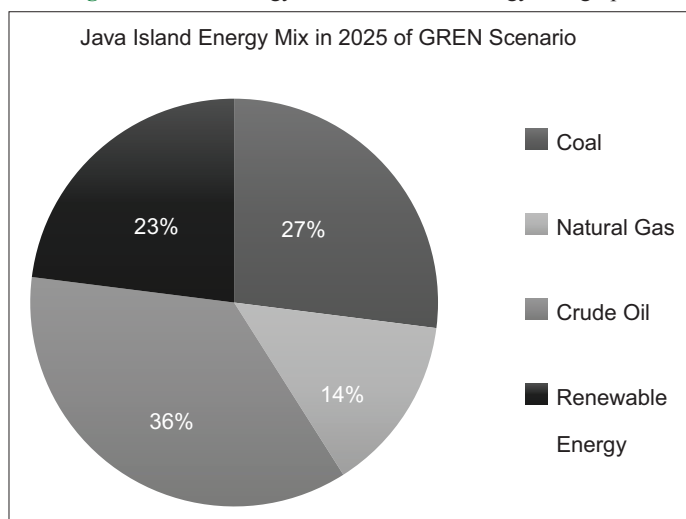
GREN: Green energy



**Figure 5:** Java Island energy balance in 2025 according to the projection of the green energy scenario



**Figure 6:** Green energy scenario of 2025 energy mix graph



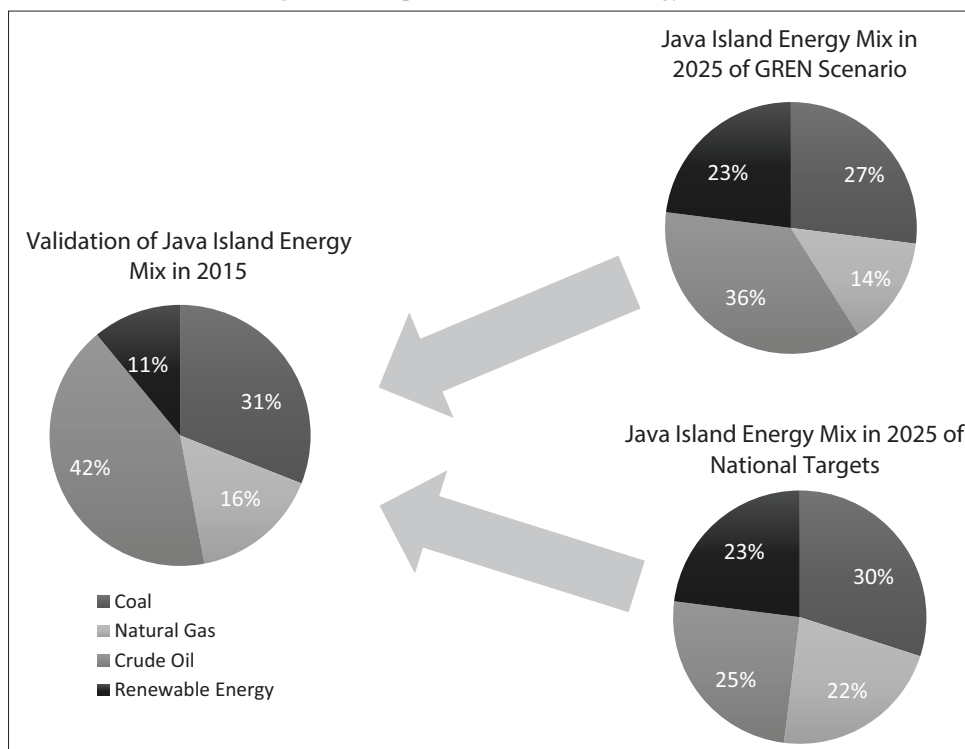
the use of coal and natural gas, each by 3% and 8%, as well as an increase in the use of oil and renewable energy, each by 11% and 12%. This scenario meets the National Energy Policy targets regarding the use of renewable energy in 2025, which is 23% of the total primary energy use in Java Island.

The GREN scenario can meet the KEN target with key planning according to regional regulations. From the supply side, there are key planning as follows:

- Maximizing the potential of water as the source of Hydroelectric Power Plant of 2,312 MW (2019) with dam technology. This technology is a plant with a dam across the river. The making of the dam is intended to raise the water level in the upper part of the river in order to generate greater potential energy as the turbine driver.
- Construction of Geothermal Power Plant in accordance with RUPTL 2017 totalling 905 MW (2025) with Dry Steam Power Plant technology. The way the generator works with this technology is to directly direct the geothermal steam from

the production well to the turbine and activate the generator to produce electricity. The rest of the heat coming from production well is flowed back into the reservoir through the injection well.

- Construction of Solar Power Plant of 8 MW (2025). The Solar Power Plant technology that allows it to be used in Java Island is On Grid Solar Power Plant. This system will remain connected with the power plant network by optimizing the use of solar modules to produce electricity as much as possible. During the day, the installed solar module converts sunlight into direct current electrical energy which is then converted into alternating current electricity by a component called the grid-inverter, so that it can supply electricity. The energy produced by the on grid solar power plant will reduce supply from power plant that the majority of which are still using fossil energy as an energy source for electricity generation, so that the use of fossil energy can be reduced.
- Construction of waste power plant of 250 MW (2025). Waste power plant technology used is a modern incinerator technology equipped with combustion control equipment and a continuous exhaust emission monitoring system, which will produce electricity. The results of the combustion are converted to steam to drive the generator of electricity.
- Construction of wind power plant and ocean wave power plant, each of 4 MW (2024). The wind power plant technology with multi-blade and savonius windmill is the type of windmill that is most suitable for low wind speeds in Java Island. A suitable Ocean Wave Power Plant built along the southern coast of Java Island is the plant that uses ocean wave technology. The ocean wave flow that has kinetic energy enters the wave energy conversion engine, then from the conversion engine, it flows to the turbine. Ocean waves that produce kinetic energy are used to rotate the rotor connected to a generator which then converts that energy into electrical energy. However, both of these plants have constraints in terms of investment costs, operations, and availability of energy sources in Java Island, so that the realization of development has a low percentage of possibilities.

**Figure 7:** Comparison of Java Island energy mix

- Construction of Nuclear Power Plant of 1,700 MW (2025). Based on research carried out by several researchers at the BATAN National Energy Development Centre, among the six types of Generation IV power reactors, the type most suitable for use in Indonesia is the very high temperature reactor (VHTR) type, because it has advantages in the aspect of economy, safety and reliability, and the development costs that are relatively lower compared to the other five types, namely gas-cooled fast reactor, lead-cooled fast reactor, sodium-cooled fast reactor, super critical water-cooled reactor, and molten salt reactor. The realization of the construction of this plant is the one that has the most obstacles, both in terms of the length of development, investment costs, operations, to social problems.
- Construction of super-critical Steam Power Plant of 1,100 MW (2019), 1,100 MW (2025) and USC Steam Power Plant of 500 MW (2020) to increase the use of subcritical Steam Power Plant technology currently available. Super critical Steam Power Plant has a higher energy conversion efficiency compared to subcritical Steam Power Plant technology with the efficiency of 30-35%, which is 38-40%. While the USC Steam Power Plant has an efficiency of 40-45%.

Meanwhile, key planning on the end user side is as follows:

- The use of energy-saving lamps with an average reduction of 0.31% from electricity consumption.
- The use of  $\pm 30\%$  biofuel as an alternative use of fuel oil.

#### 4. CONCLUSION

This paper has produced a Java Island energy planning model using the GREN scenario. The energy planning model consists

of primary energy, secondary energy, and energy needs. Energy needs are influenced by the basic assumptions of planning, target settings affect policies in the processes of secondary energy and end users. This model can be used as a consideration for Java Island energy policy making until 2025.

Projections in the GREN Scenario are able to reach the National Energy Policy targets using new and renewable energy with several plans as follows: On the end user side is the use of energy-saving equipment with an average reduction in energy use by 0.31%, and the use of biofuel as an alternative to the use of fuel oil of  $\pm 30\%$ . Meanwhile, key planning on the supply side is as follows: Hydroelectric Power Plant with dam technology with a capacity of 2,312 MW; Geothermal Power Plant with Dry Steam Power Plant technology with a capacity of 905 MW; On Grid Solar Power Plant with a capacity of 8 MW; waste power plant with incinerator technology with a capacity of 250 MW; Wind Power Plant with multi-blade and savonius windmill with a capacity of 4 MW; Ocean Wave Power Plant with ocean wave technology with a capacity of 4 MW; Nuclear Power Plant generation IV type VHTR with a capacity of 1,700 MW, and Steam Power Plant with super critical technology and USC with a total capacity of 2,200 MW.

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