ENERGY CONSUMPTION PROJECTION IN YOGYAKARTA CITY

Septiana Ria Prihandita[1], Deendarlianto[2], Rachmawan Budiarto[3]

[1]Master Program of System Engineering, Faculty of Engineering, Universitas Gadjah Mada
[2]Mechanical and Industrial Engineering Department, Faculty of Engineering, Universitas Gadjah Mada
[3]Engineering Physics Department, Faculty of Engineering, Universitas Gadjah Mada
*Corresspondence : tditha@yahoo.com

Abstract

Availability of energy is an important aspect for the success of regional development. Yogyakarta city does not have any non-renewable energy sources such as liquid fossil fuels, coal and natural gas. Consequently, these energy must be supplied from other provinces. The renewable energy potential in Yogyakarta city is not being utilized yet. Final energy consumption continues to rise along with population and economic growth. Energy planning and development need be done carefully in order to ensure the energy sustainability. This study aim to provide long-term projections in 2012-2025 periods on energy balance, energy demand and supply based on energy reserves and current condition in order to meet energy elasticity to less than 1. Energy demand projection is calculated based on trend forecasting analysis by LEAP (Long-range Energy Alternatives Planning System).

This result shows that the highest energy user sector in Yogyakarta city period 2012-2025 is transportation sector and the highest of energy demand by type is electricity and gasoline. Renewable energy potential such as biogas, solar energy, biomass and biodiesel (from using vegetable oil waste) could be developed in Yogyakarta city. Using biodiesel and solar energy could decrease diesel fuel and electricity. According to the baseline scenario, CO_2 emission reached 2,176,182 tons, the first alternative scenario reached 1,925,089 tons and the second alternative scenario reached 1,877,839. Investment cost to build renewable energy in the baseline scenario reached USD 42,045 – USD 546,585. Investment cost to build renewable energy in the first alternative scenario reached USD 10,470,775 – USD 31,002,775. Investment cost to build renewable energy in the second alternative scenario reached USD 31,641,925 - USD 52,173,925.

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1. Introduction

Final energy consumption continues to rise along with economic growth and population. Final energy consumption in Yogyakarta city has increased with average rate of 8.55% from 2008-2012 where its magnitude has increased from 960 thousand BOE (2007) to 1407 thousand BOE (2012). In line with the increase of energy consumption its energy supply will follow that increase. Yogyakarta city does not have any non-renewable energy sources such as liquid fossil fuels, coal and natural gas. Consequently, these energy must be supplied from other provinces. Electricity demand of Yogyakarta is supplied through interconnection with the transmission grid of Java-Madura-Bali (JAMALI). From the JAMALI transmission grid, electricity is connected to PLN customers through the distribution network of Yogyakarta province. The renewable energy potential in Yogyakarta city is not being utilized yet. That energy issue either nowadays or one that may arise in the future require the right solution with a comprehensive approach. Energy demand planning and development need be done carefully in order to ensure the energy sustainability.

This study aim to provide long-term projections in periods 2012-2025 on energy balance, energy demand and supply based on energy reserves and current condition. Energy types analyzed include oil fuels, LPG, electricity and other renewable energy sources. This study used a model of the LEAP (Long-range Energy Alternatives Planning System).

2. Methodology

Data required as input energy demand analysis in Yogyakarta city include Gross Domestic Product (GDP), GDP growth, population, population growth, energy consumption and renewable energy potential that has been installed. These data obtained from PT. Pertamina, PT. PLN, Central Bureau of Statistics the city of Yogyakarta, and Ministry of Energy and Mineral Resources.

In the analysis of energy demand and energy supply using tools such as computer software, namely LEAP (Long-range Energy Alternatives Planning System). The LEAP software system is a scenario-based energy-environment modeling tools developed by the Stockholm Environment Institute (SEI). It is suitable for various tasks including energy consumption forecasting, environmental emission analysis, integrated resource planning, and energy scenario-based analysis.

The LEAP serves several purposes: as a database, it provides a comprehensive system for maintaining energy information; as a forecasting tool, it enables the user to make projections of energy supply and demand over a long-term planning horizon; as a policy analysis tool, it simulates and assesses the physical, economic, and environmental effects of alternative energy programs, investments, and actions.

In LEAP, in the final energy demand analysis, energy demand is calculated as the product of the total activity level and energy intensity at each given technology. Energy demand is calculated for the current accounts year and for each future year in each scenario.

$$D_{b,s,t} = TA_{b,s,t} \; x \; EI_{b,s,t}$$

where *D* is the energy demand, *TA* the total activity, *EI* the energy intensity, *b* the branch, *s* the scenario, and *t* the years (ranging from the base year to the end year). In this study, 2012 is chosen as a base year and the end year is 2025.

The population data as activity level for residential sector. GDP of industry sectors as activity level for industry sector. The activity level for commercial sector includes total of commercial, financial service, and other service sector. The number of vehicles as activity level for transportation sector.

This study consists of seven steps:

1. Study of literature.
2. Review current energy demand and energy supply condition.
3. Data collection.
4. Process the data that has been obtained and put it in the program LEAP.
5. Develop scenarios based on three scenarios are the baseline scenario, the first alternative scenario, and the second alternative scenario.
6. Comparing the results of the three scenarios.
7. Making conclusion.

All forecasting methods can be divided into two broad categories: qualitative and quantitative. Many forecasting techniques use past or historical data in the form of time series. A time series is simply a set of observations measured at successive points in time or over successive periods of time. Forecasts essentially provide future values of the time series on a specific variable such as sales volume.

Division of forecasting methods into qualitative and quantitative categories is based on the availability of historical time series data. Qualitative forecasting techniques generally employ the judgment of experts in the appropriate field to generate forecasts.

Quantitative forecasting methods are used when historical data on variables of interest are available. These methods are based on an analysis of historical data concerning the time series of the specific variable of interest and possibly other related time series. There are two major categories of quantitative forecasting methods. The first type uses the past trend of a particular variable to base the future forecast of the variable. As this category of forecasting methods simply uses time series on past data of the variable that is being forecasted, these techniques are called time series methods.

The second category of quantitative forecasting techniques also uses historical data. In forecasting future values of a variable, the forecaster examines the cause-and-effect relationships of the variable with other relevant variables. It is called causal method.

This study uses trend projection method is one method of time series methods. Trend projection method includes quadratic trend, linier trend and exponential trend.

- Linier Trend
  $Y_t = a + bt$
- Exponential Trend
  $Y_t = ab^t$
- Quadratic Trend
  $Y_t = a + bt + ct^2$

Scenario Development

Energy demand model has three scenarios such as baseline scenario and two alternative scenarios. Baseline scenario based on historical conditions as well as some policies that have been implemented. Alternative scenarios explore a range of policy interventions. In the baseline scenario, projecting energy demand by using trend projection model. The baseline scenario, projecting demand energy needs following assumptions:

- Population growth follows the long-term projections of BPS latest,i.e. for the period 2012-2025 the average growth is 0.575% per year.
- Gross Domestic Product (GDP) average growth rate is 6.61% per year. It is adjusted for previous growth trend.
- The electrification ratio in Yogyakarta city will be increased to 100% in 2025.
- The number of vehicles average growth rate is 9.26% per year.

The first alternatives scenario, projecting demand energy need following assumptions:

- Population growth follows the long-term projections of BPS latest, i.e. for the period 2012-2025 the average growth is 0.575% per year.
- Gross Domestic Product (GDP) follows the projection of GDP Yogyakarta province for period 2012-2025 is GDP growth rate 6.9% in 2025.
- The electrification ratio in Yogyakarta city will be increased to 100% in 2025.
- The number of vehicles average growth rate is 5.17% per year.The policy of transportation sector is the use of public transport.
- Transportation technology in 2025 is more efficient and can reduce the use of fuel oil around 2% per year. The use of new technologies in transportation is predicted around 55% in 2025.
- The government encourages biodiesel usage as a fuel mixture. Percentage of biodiesel blended to diesel oil is 3% in 2012 and up to 20% in 2025. The government also encourages bioethanol usage as substitute gasoline reached 15% in 2025.
- Utilization of solar energy in household (above R2 and R3 customers), industry customers, public customer, and social customers around 1% from electricity demand.

The second alternatives scenario, projecting demand energy need following assumptions:

- Population growth follows the long-term projections of BPS latest, i.e. for the period 2012-2025 the average growth is 0.575% per year.
- Gross Domestic Product (GDP) follows the projection of GDP Yogyakarta province for period 2012-2025 is GDP growth rate 6.9% in 2025.
- The electrification ratio in Yogyakarta city will be increased to 100% in 2025.
- The number of vehicles average growth rate is 5.17% per year.The policy of transportation sector is the use of public transport.

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- The government encourages biodiesel usage as a fuel mixture. Percentage of biodiesel blended to diesel oil is 3% in 2012 and up to 20% in 2025. The government also encourages bioethanol usage as substitute gasoline reached 15% in 2025.
- Utilization of solar energy in household (above R2 and R3 customers), industry customers, public customer, and social customers around 5% from electricity demand.

3. Results and Discussion

Current Energy Condition

Based on BPS in 2012, number of population in Yogyakarta city reached 394,012 persons, consisting of 202,567 female and 191,445 male. The growth rate of population in Yogyakarta city 0.21% from 2008-2012. Total area of Yogyakarta city is 32.50 square kilometres, population density in 2012 is 12,123 persons per square kilometres. The highest population density occurs in Yogyakarta city than other regencies such as Kulonprogo regency, Sleman regency, Bantul regency and Gunungkidul regency.

Table 1. Population in Yogyakarta City

No.	District	Area (km^2)	Population (person)		
			2010	2011	2012
1	Mantrijeron	2.61	31,267	31,421	31,695
2	Kraton	1.40	17,471	17,557	17,561
3	Mergangsan	2.31	29,292	29,437	29,448
4	Umbulharjo	8.12	76,743	77,127	78,831
5	Kotagede	3.07	31,152	31,308	32,052
6	Gondokusuman	3.99	45,293	45,517	45,526
7	Danurejan	1.10	18,342	18,433	18,433
8	Pakualaman	0.63	9,316	9,362	9,366
9	Gondomanan	1.12	13,029	13,093	13,097
10	Ngampilan	0.82	16,320	16,401	16,402
11	Wirobrajan	1.76	24,840	24,962	24,969
12	Gedongtengen	0.96	17,185	17,270	17,273
13	Jetis	1.70	23,454	23,570	23,570
14	Tegalrejo	2.91	34,923	35,096	35,789
	TOTAL	**32.50**	**388,627**	**390,553**	**394,012**

Gross Domestic Product (GDP) Yogyakarta city in 2012 reached 6,152 billion rupiah (constant prices 2000) with GDP growth rate 5.19% from 2007-2012. Based on GDP constant prices 2000, the contribution of commercial, transportation and social sector has the three highest shares in economics of Yogyakarta city. Commercial, transportation and social sector are around 25.34%, 20.63%, and 20.64%. Mining sector has the smallest share, only 0.0048% from total GDP constant prices 2000.

Table 2. GDP Constant Price 2000 in Yogyakarta City

Sector	GDP (Constant Price 2000) (million rupiah)		
	2010	2011	2012
Agriculture	17,455.38	17,755.18	17,939.17
Mining	272.45	293.41	296.04
Manufacture industry	594,845.37	606,849.37	598,158.97
Utility	68,725.45	71,776.67	75,935.64
Construction	426,739.51	449,854.03	475,072.61
Commercial Service	1,393,111.28	1,460,971.26	1,559,069.54
Transportation	1,098,382.57	1,185,006.38	1,268,866.02
Financial Service	770,658.43	820,764.58	886,590.61
Other Service	1,135,751.23	1,203,296.95	1,269,750.81

In 2012, the electrification ratio in Yogyakarta city was 67% and in Yogyakarta province was 77%.

The shares of final consumption in 2012 are household (18.48%), industry (5.62%), transportation (48.49%), and commercial (27.4%). Final energy consumption by type in the period 2010-2012 was dominated by gasoline, electricity and LPG.

The high of final energy consumption on transportation sector is caused by the rapid growth in motor vehicles for about 6.21%. The high rate of growth in commercial sector is caused by rapid increase in number of hotels, malls, and buildings.

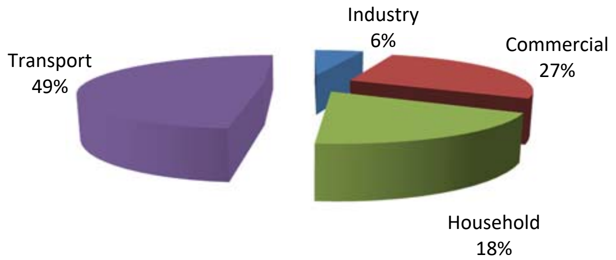

Figure 1. The final energy demand in 2012

The renewable energy potential in Yogyakarta city has only solar energy, biogas, biomass and biodiesel. Based on NASA sources (eosweb.larc.nasa.gov/sse/), the monthly average of solar radiation in Yogyakarta city is 5.36 kWh/m^2/day. Yogyakarta city has also biogas from animal and human waste. In 2012, biogas has been installed and capacity of 84.09 kW. Biomass potential can also be converted to biofuel or electricity from coconut, sugar cane and rice.

The increasing awareness of the depletion of fossil fuel resources and the environmental benefits of biodiesel fuel has made it more attractive in recent times. Its primary advantages deal with it being one of the most renewable fuels currently available and it is also non-toxic and biodegradable. It can also be used directly in most diesel engines without requiring extensive engine modifications. Using oil vegetable waste is one of the economical sources for biodiesel production along with increased population growth and oil consumption.

Table 3. Renewable Energy Potential in Yogyakarta City

Type of Renewable Energy	Renewable Energy Potential
Biogas	506 kilowatt
Biomass	6,475 Gigajoule
Biodiesel	0,17 Gigajoule

Table 4. Renewable Energy Policy in Yogyakarta Province

Type	Target			
	2010	2015	2020	2025
Solar energy	25 kWp	250 kWp	2,000 kWp	3,000 kWp
Micro hydro	8 installed unit	15 installed unit	20 installed unit	25 installed unit
Wind energy	20 KW	40 KW	80 KW	160 KW
Biogas	300 installed unit	1,000 installed unit	2,500 installed unit	5,000 installed unit
Biomass	0	100 kW	500 kW	2 MW
Biodiesel	0	0.5% consumption	1% consumption	1.5% consumption
Village Independent Energy	0	3 village	5 village	3 village

Projection Energy Consumption

Energy consumption by energy sector is dominated by transportation sector. Energy consumption in transportation sector in the first alternative scenario is equal to energy consumption in transportation sector in the second alternative scenario. In transportation sector, energy consumption in the alternative sector is smaller than in the baseline scenario.

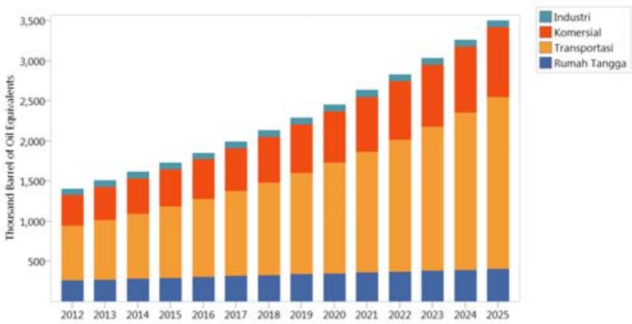

Figure 2. Projection of total final energy demand by energy sector in the baseline scenario

In the baseline scenario, energy consumption industry sector, commercial sector, transportation sector, and household sector in 2025 is 83.72 thousand BOE 871.12 thousand BOE, 2142.1 thousand BOE, and 403.32 thousand BOE. Final energy consumption increased by more than 2.5–fold final energy demand of 2012.

In the first alternative scenario, energy consumption industry sector, commercial sector, transportation sector, and household sector in 2025 is 159.66 thousand BOE, 864.42 thousand BOE, 1630.42 thousand BOE, and 401.13 thousand BOE. Final energy consumption increased by more than 2.17–fold final energy demand of 2012.

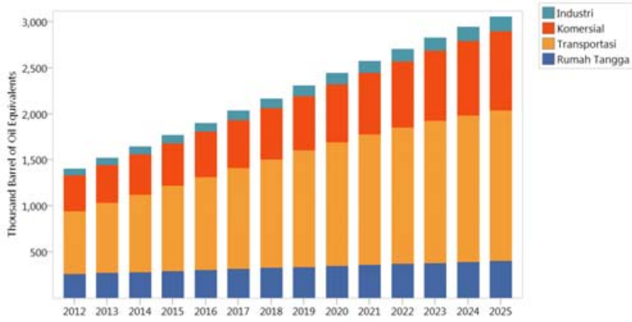

Figure 3. Projection of total final energy demand by energy sector in the first alternative scenario

In the second alternative scenario, energy consumption industry sector, commercial sector, transportation sector, and household sector in 2025 is 161.36 thousand BOE, 881.76 thousand BOE, 1630.42 thousand BOE, and 392.37 thousand BOE. Final energy consumption increased by more than 2.18–fold final energy demand of 2012.

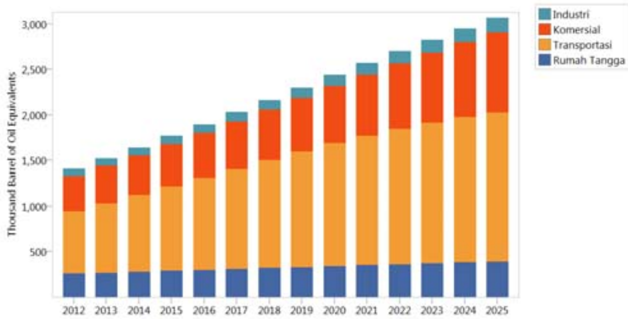

Figure 4. Projection of total final energy demand by energy sector in the second alternative scenario

The use of oil fossil energy (gasoline and pertamax) still dominates the energy demand in Yogyakarta city due to the increasing number of passenger cars and motorcycles. In 2025, electricity utilization and LPG is projected to also increase rapidly.

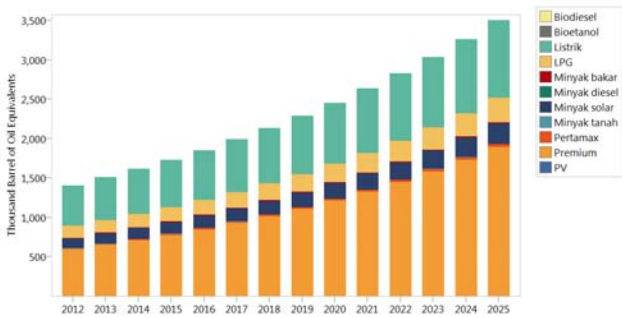

Figure 5. Projection of total final energy demand by fuel type in the baseline scenario

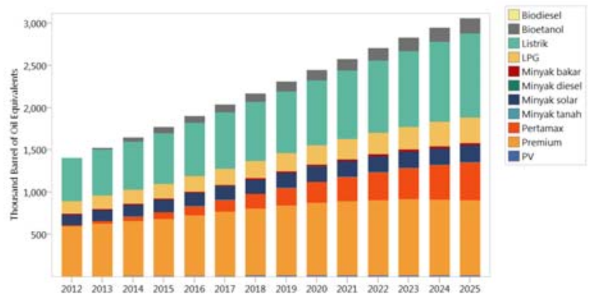

Figure 6. Projection of total final energy demand by fuel type in the first alternative scenario

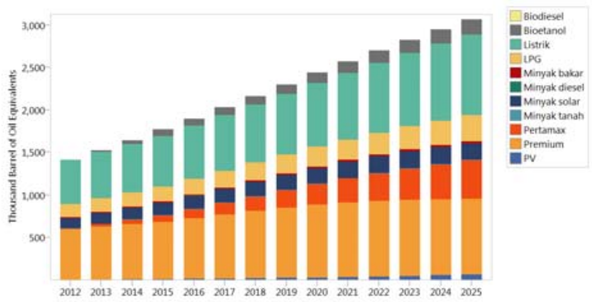

Figure 7. Projection of total final energy demand by fuel type in the second alternative scenario

Energy elasticity is the ratio of energy consumption to economic growth or GDP. The energy elasticity is small, then the more efficient energy consumption. Based on the data, the average growth of energy consumption in 2010-2012 was 1.82% per year and the average GDP growth in 2010-2012 was 5.70% per year, then the elasticity of the city of Yogyakarta in 2012 of 0.32. Energy elasticity below 1 indicates that the energy consumption in the city of Yogyakarta is very efficient.

Table 5. Energy Elasticity Projection

Year	Energy Elasticity		
	Baseline Scenario	First Alternative Scenario	Second Alternative Scenario
2012	1,4	1,4	1,4
2013	1,1	1,4	1,4
2014	1,1	1,3	1,3
2015	1,1	1,3	1,3
2016	1,1	1,2	1,2
2017	1,1	1,1	1,1
2018	1,1	1,1	1,1
2019	1,1	1,0	1,0
2020	1,1	0,9	0,9
2021	1,1	0,8	0,8
2022	1,1	0,8	0,8
2023	1,1	0,7	0,7
2024	1,1	0,6	0,6
2025	1,1	0,6	0,6

In Figure 8, it can be seen that all energy that is used in DIY Province is imported from outside DIY Province. The only energy that is produced by Yogyakarta city is biogas with capacity of 84.09 kW.

In Figure 9, it can be seen that all energy that is used in DIY Province is imported from outside DIY Province. The only energy that is produced by Yogyakarta city is biogas with 5000 installed unit, biomass with capacity of 2 MW, and solar energy (photovoltaic) with capacity of 1% from electricity demand (household customers, industry customers, public customer, and social customers).

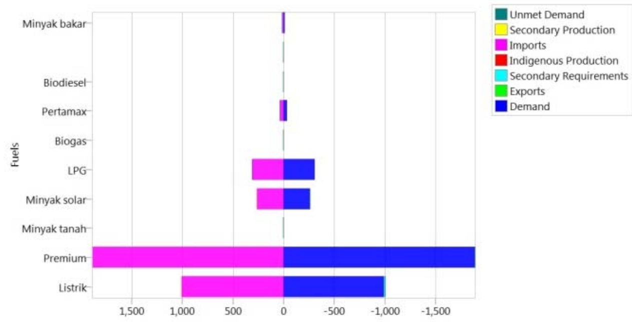

Figure 8. Energy balance in the baseline scenario

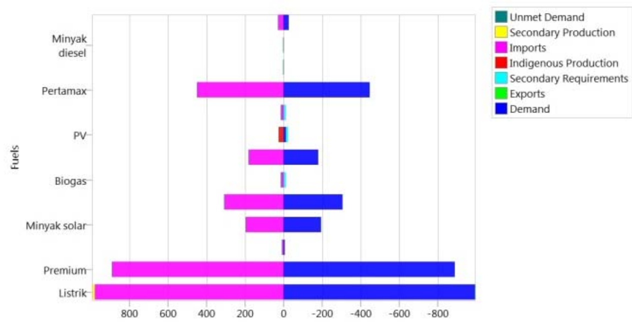

Figure 9. Energy balance in the first alternative scenario

In Figure 10, it can be seen that all energy that is used in DIY Province is imported from outside DIY Province. The only energy that is produced by Yogyakarta city is biogas with 5000 installed unit, biomass with capacity of 2 MW, and solar energy (photovoltaic) with capacity of 5% from electricity demand (household customers, industry customers, public customer, and social customers).

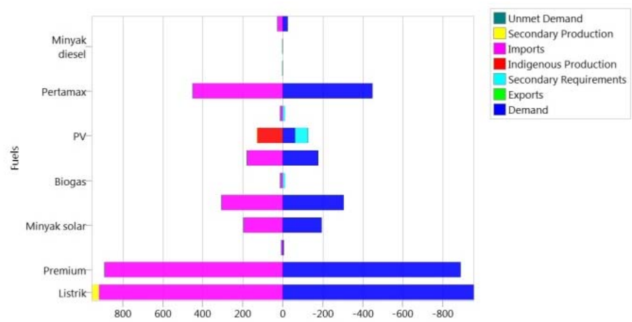

Figure 10. Energy balance in the second alternative scenario

Emission has two types such as direct emission and indirect emission. Direct emission mainly arises from many activities such as generation of energy, combustion of fuel in those transportation, etc. Indirect emission mainly arises from the use of electricity. The basic of calculation greenhouse gas emission are "activity data" which quantify an activity, and "emission factor" which convert energy use to the amount of emissions produced based on emissions per unit of energy or fuel used. Example of activity data include kilowatt-hours of electricity used to light an operate equipment. Emissions factors are determined and disseminated by a variety of government agencies and organizations, and apply to specific types of energy sources. The amount of emission was produced by multiplying activity data with emission factor.

Table 6. Emission CO_2 Coefficient

	Emission Coefficient		
	Tons/Gigajoules	Kg/kWh	Kg/BOE
Gasoline	0.069	-	-
Pert Amax	0.069	-	-
Diesel Oil	0.074	-	-
Fuel Oil	0.077	-	-
Kerosene	0.072	-	-
Electricity	-	0.728	-
LPG	-	-	396

According the baseline scenario, total CO_2 emission reached 2.1 million tons. The first alternative scenario, total CO_2 emission reached 1.9 million tons. The second alternative scenario, total CO_2 emission reached 1.8 million tons.

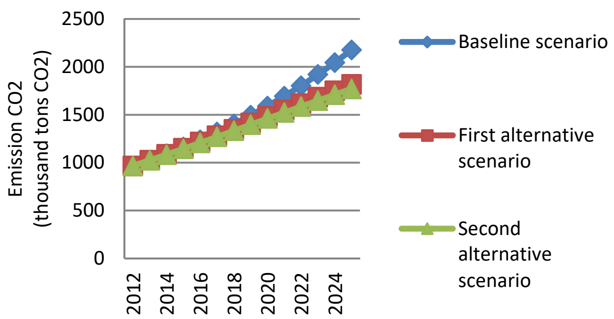

Figure 11. Emission CO_2

Feed-in tariff policies establishes by the government through MEMR Regulation No. 4 of 2012 of the Power Purchase by PT. PLN (Persero) from biogas and biomass power generation and MEMR Regulation No. 17 of 2013 of the Power Purchase by PT. PLN (Persero) of solar photovoltaic. Price of electricity using biogas and biomass is Rp. 975/kWh and using solar photovoltaic is maximum US$ 25 cents/kWh.

Table 7. Investment Cost

Scenario	Renewable Energy	Capacity (kW)	The Maximum Investment Cost (USD)	The Minimal Investment Cost (USD)
Baseline scenario	Biogas	84,09	546.585	42.045
First Alternative Scenario	PLTS	2301	5.234.775	5.234.775
	Biogas	2272	14.768.000	1.136.000
	Biomassa	2000	11.000.000	4.100.000
Second Alternative Scenario	PLTS	11607	26.405.925	26.405.925
	Biogas	2272	14.768.000	1.136.000
	Biomassa	2000	11.000.000	4.100.000

Investment cost is initial cost before any operations are conducted. Investment cost in renewable energy development in the baseline scenario reached USD 42.045 – USD 546.585. Investment cost in renewable energy development in the first alternative scenario reached USD 10.470.775 – USD 31.002.775. Investment cost in renewable energy development in the second alternative scenario reached USD 31.641.925 - USD 52.173.925.

4. Conclusion

Energy consumption is dominated by gasoline, pertamax, and electricity. The government has made a policy on utilization of renewable energy to overcome the increasing energy demand along with the depletion of fossil energy reserves. The utilization of renewable energy is solar energy, biogas, and biomass. So, it reduces emissions by about 251 thousand tons of CO_2 in the first alternative scenario and 298 thousand tons of CO_2 in the second alternative scenario. This scenario would be achieved if the Indonesian government and the Indonesian people support them.

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