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Renewable Energy Utilizing for Clean Energy Development

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ABSTRACT

Yogyakarta is one of the provinces in Indonesia that has no fossil energy potential. All economic activities is highly depend on the stability of energy supplies from other regions. Due to the limited energy resources so that energy efficiency becomes very important. This research was conducted to predict the effects of different development alternatives on future energy consumption and carbon emission as a clean energy indicator. Energy demand modeled by sector using intensity approach, that is calculate the amount of energy used per unit of activity. Applying long range energy alternative planning model was built to analyze the future trends of energy demand, energy structure and carbon emission from the base year 2012 to 2030 under different scenario composition that is business as usual (BAU), moderate (MOD), and optimistic (OPT) scenario. The results shows that energy demand grew an average of 7.63% per year. Transportation sector is the largest energy user with a percentage of over 60% of overall energy demand, as well as the largest contributor to carbon emissions. Total energy demand in Yogyakarta under MOD and OPT scenarios is expected to reach 195.878,1 thousand BOE, and 184.695,1 thousand BOE, lower than those of the BAU scenario, respectively. Based on the MOD and OPT scenario, greenhouse gases (GHG) emissions in 2030 respectively amounted to 6.03 million tons of CO_2 equivalents and 5.75 million tons of CO_2 equivalents. With the implementation of programs that can support the OPT scenario, GHG emissions can be reduced to 12.5% when compared to the GHG emissions generated by the BAU. Overall, this research provides some important insights for Yogyakarta in terms of future energy conservation and highlights possible steps for policy makers to develop a sustainable clean-energy region.

Keywords: Yogyakarta, Carbon Emission, Energy Demand, Long Range Energy Alternative Planning Model
JEL Classifications: Q2, Q3, Q4, Q5

1. INTRODUCTION

Yogyakarta is one of the provinces in Indonesia that has no fossil energy potential, where almost all energy needs in Yogyakarta, such as fuel oil and liquid petrolium gas (LPG) supplied from outside the area with the use of energy increasing each year. Electrical energy was supplied from the inter-connection network of Java-Madura-Bali (JAMALI) because there are no power stations to fulfill the electricity demand in Yogyakarta (Law of Energy, 2007). This means that all activities of the community in Yogyakarta province is highly dependent on the stability of energy supplies from other regions. As an icon city of culture, city of education, and the second tourist destination after Bali, Yogayakrta then become one of the destinations educational and tourist potential for residents from outside the region. This condition will clearly have implications for the increasing number of economic and human activity that uses both fuel and electrical energy in the region (Wangjiranirana, 2011).

In the other hand the pattern of energy consumption is a consumptive energy consumption pattern. Energy majority have not yet been used to support economic growth. This can be seen from most existing energy used in household and transportation sectors, which reached 19.98% and 71.86% of the total energy used in 2012, the rest is the energy used in commercial and industrial sectors. The composition of the type of energy used in Yogyakarta is still dominated by fuel that reaches 74.66% of total energy consumption in 2012 (Department of Energy and Mineral Resources DIY, 2012). While the growth elasticity of energy use to regional gross domestic product (GDP) growth in the same period reached 1.37. This suggests that the energy use in Yogyakarta is wasteful or inefficient due to run 1% growth of economic activity needed 1.37% growth of energy per year. High energy consumption also affects the environmental quality due to carbon emissions.

By this phenomenon, the Government of Yogyakarta Province, as the opinion of Cai et.al. (2008) and Connolly et al. (2009) was supposed to do the proper planning on energy demand in order to build the strong energy security to fulfill the energy needs of society. Energy planing which conduct to secure energy supply is an important agenda for energy policy in Yogyakarta (Stern, 2011), if not Yogyakarta will have serious energy issues that will affect to the economy, environment, and carbon emissions in the future.

2. ENERGY CONDITION OF YOGYA PROVINCE

Figure 1 below, shows that primary energy mix is seen that the use of petroleum is very dominating, about 71.91% of all kind of energy, and coal used in electricity generation has a percentage of 16.59%. Besides being used in the generation of electricity, a small fraction of coal is also used in the industrial sector activity (Ghader, 2006). Natural gas is used in the generation of electric energy has a percentage of 9.60%. In 2012, the use of new and renewable energy (RE) only has a percentage of 1.90%. RE consists of hydropower and geothermal energy used in the generation of electricity through the JAMALI interconection system and firewood used for cooking activity in the household sector.

The pattern of energy consumption in the Yogyakarta is the consumptive patterns of energy consumption. The energy that has been used is largely not yet used to support the economic growth. This can be seen from most existing energy used in household and transportation sectors, that reached 28.52% and 59.45% of the total energy used in 2012, the rest is the energy used in commercial and industrial sectors (Figure 2). While elasticity of energy used growth to GDP growth in the same period amounted to 1.37. This suggests that the elasticity of energy use in Yogyakarta province is wasteful because to run the activity sector with growth of 1% per year, need 1.37% energy growth per year. The enormous of energy used to support economic activity has an impact on environmental quality due to carbon emission.

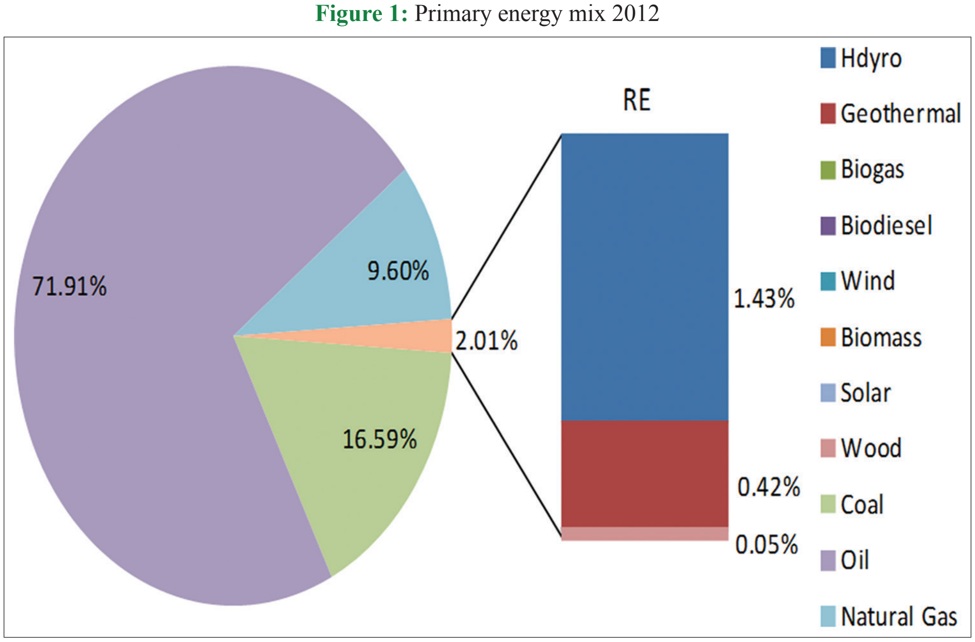
3. METHODOLOGY

3.1. Basic Assumptions of Research

The main focus of this research is to analyze the energy efficiency (EE) which is basically an estimate of the energy demand. Energy demand compiled by the year 2012 as the base year and 2030 as the year-end projection. Energy demand compiled using energy intensity (ET) methode and using long range energy alternative planning (LEAP) software as a tool for calculating the energy demand forecasts, which developed by Stockholm Environment Institute. For instance, LEAP was adopted for the scenario analysis of energy consumption and environmental impact based on how energy is consumed (Zhao,2011). The intensity of energy is the energy usage parameters for each activity (Nilsson,2002). Driving variables in this study are growing share of the economic, demographic variables consisting of the total population, number of households, population growth, and the composition of rural and urban populations.

Activity in the household represented by the number of households, so the ET is the amount of energy consumption used in each household. Activity of commercial sector, industry, and other sectors represented by the value-added of regional GDP for each sector. For these three sectors, ET parameter specifies the number of energy used for each value-added generated by these sectors. The transport sector consists of modes of highway and non-highway modes. Modes of highway transport activity consisting of passenger cars, freight cars, motorcycles, and buses that represented by the number of vehicles. For highway transportation, ET is the amount of energy used by each unit of the vehicle. As for the transportation of non-highway modes consisting of trains and aircraft, the activity represented by

Figure 1: Primary energy mix 2012



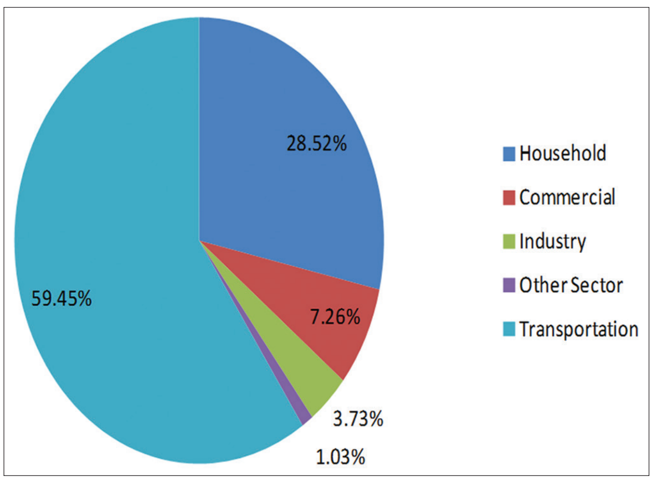
the distance. The intensity of energy for the transport sector non-highway modes is the amount of energy that is used for every kilometer mileage (Koomey, 2005).

Furthermore, projection of the energy demand is based on two scenarios, namely the business as usual (BAU) scenario, and EE which consists of a moderate efficiency scenario (MOD), and optimistic (OPT). In BAU scenario, the calculation of the energy forecasts are based on the same pattern of energy use as happened in the base year. In this scenario, there is no new policy interventions regarding energy consumption such as energy conservation and use of RE. EE scenario both the moderate (MOD) and optimistic (OPT) was developed based on the BAU scenario with energy policy interventions based on energy saving potential and RE implementation.

EE scenario based on energy saving potential derived from previous research. Potential energy saving can be seen in Table 1.

For transport sector, EE is done by shifting modes to optimize the use of public transport. The target of transfer mode from personal to public transportation modes is to increase the load factor of the bus modes from 24.34% to 60% in 2030. The transfer motorcycles and private passenger cars are respectively 14% and 11% in 2030.

Figure 2: Energy Usage by Sector 2012



RE scenario is based on the potential of RE. Types of RE such as solar energy, wind energy, hydropower, and biomass developed as primary energy in the electricity production. Biogas and biodiesel used to replace the demand of LPG, firewood, coal and briquettes in the household sector (Tables 2 and 3).

3.2. Data Analysis

Refers to the International Energy Assosiation provision, energy demand model in this research using final energy approach (final used), where the final energy demand is modeled by sector, and energy end users in detail. Five end-use sectors are included in the model: (1) Industry sector separated into five sub-sectors, (2) energy demand in the household sector (residential) were separated into four groups according to income, (3) commercial sectors based on the share of sub-sector to the formation of value added to regional GDP, (4) other sectors based on sub-sector share to the formation of value added to regional GDP, and (5) energy demand in the transport sector is modeled in detail according to the mode of transport. Depending on the characteristics of the energy demand in each sector, its sub-sectors, energy-using devices and fuel types were included in scenario modeling.

This study used secondary data, namely: The demographics that consists of the total population, number of households, population growth, and the composition of the villages and towns, as well as data of economic growth and inflation. Supporting data include data on energy supply, can be obtained from the PLN and Pertamina, data of potential for RE in the Yogyakarta which obtained from RE road map from energy office. Energy demand modeling in this study using energy final used approach (Karabulut, 2008) where final energy demand by sector is expressed as follows. Aggregate ET can be written as a function of energy use sector (EIT) and sector activity (ait):

Table 2: Development of RE for EE scenario (MOD)

No.	Type of RE	Target of development				
		2010	2015	2020	2025	2030
1	Solar	25 kWp	250 kWp	2.000 kWp	2.500 kW	3.000 kWp
2	Hydro	25 kW	50 kW	600 kW	650 kW	750 kW
3	Wind	20 kW	40 kW	80 kW	120 kW	160 kW
4	Biogass	300 unit	1.000 unit	2.500 unit	4.000 unit	5.000 unit
5	Biodiesel	0	0.5% M. Solar	1% M. Solar	1.5% M. Solar	2% M. Solar
6	Biomass	0	100 kW	500 kW	750 kW	2 MW

Source: RE road map, energy office of Yogyakarta, 2010-2030. EE: Energy efficiency, RE: Renewable energy

Table 3: Development of RE for EE scenario (OPT)

No.	Type of RE	Target of Development				
		2010	2015	2020	2025	2030
1	Solar	25 kWp	2 MWp	5 MWp	7.5 MW	10 MWp
2	Hydro	25 kW	600 kW	750 kW	1.300 kW	1.800 kW
3	Wind	20 kW	50 MWp	50 MW	75 MW	100 MW
4	Biogass	300 unit	1.000 unit	2.500 unit	4.000 unit	5.000 unit
5	Biodisel	0	2.5% M. Solar	5% M. Solar	7.5% M. Solar	10% M. Solar
6	Biomassa	0	10 MW	15 MW	17,5 MW	20 MW

Source: RE road map, energy office of Yogyakarta, 2010-2030. EE: Energy efficiency, RE: Renewable energy

Where Et is the aggregate energy consumption in year t, Eit is the energy consumption in sector i in year t, Yt is regional GDP in year t, and YIT is a measure of economic activity in the sector i in year t. In the end-use approach, aggregate energy demand is obtained by summing up the energy demand in the sector level. Thus, the energy demand by sector was designed as follows:

$$et = \frac{Et}{Yt} = \Sigma\left(\frac{Eit}{Yit}\right)\left(\frac{Yit}{Yt}\right) = \Sigma eit.\ ait$$

a. Household energy demand: $Ed_h = \sum_{1}^{4} Ihx(H_{t-1}xg)\ xA_{Ih}xK_h$

b. Transport energy demand: $Ed_T = \sum_{h=1}^{6} ITx(T_{t-1}xg)xA_i xK_h$

c. Industrial energy demand: $Ed_I = \sum_{h=1}^{8} IDx(T_{t-1}xg)\ xA_i xK_h$

d. Commercial energy demand: $Ed_I = \sum_{h=1}^{6} IKx(T_{t-1}xg)xA_i xK_h$

e. Others energy demand:. $Ed_I = \sum_{h=1}^{3} ILx(T_{t-1}xg)xA_i xK_h$

Planning and energy models are designed with software tools, LEAP. LEAP software will be generated an energy model based on energy scenarios that have been designed before, that is BAU scenario, moderate (MOD), and optimictic (MOD) scenario. A scenario is a self-consistent description of how an energy system might evolve over time under a given set of conditions. The time frame used for projecting the supply and demand for energy in Yogyakarta Province is for 15 years (2015-2030) by the year 2015 as the base year. Energy conservation scenario described in more detail for each activity energy consumption, based on the energy saving potential in every sector. Energy intensity in each sector is reduced interpolated according to the potential energy savings to the end of the projection. As for the diversification of energy scenario, energy intensity will be substituted by RE lowered depending on the targeted use of RE.

4. RESULTS AND DISCUSSION

4.1. Energy Demand Projection

Calculation of energy demand is based on three scenarios that is BAU, moderate (MOD), and optimistic (OPT). In the BAU scenario, the calculation of energy forecasts are based on the pattern of energy used as they did in the base year. OPT and MOD scenario was developed based on the energy policy of intervention, in terms of energy conservation and RE. Based on that scenario, projection of energy demand of Yogyakarta shown in the Table 4. Based on Table 4, we can see that implementation of EE scenario resulted in diminishing energy use.

Until the end of the projection, energy use in Yogyakarta is dominated by transportation sector as the largest consumer, with energy use reaching more than 60% of overall final energy. While the household sector is the second largest consumer with a percentage of 19.5%. In terms of the transportation sector, motorcycles and private cars dominate energy use, while the middle-income household sector is the largest consumer, expected to reach 55% of overall energy demand (Figures 3 and 4).

Overall, demand for fuel oil in 2030 was 6,861.35 thousand BOE, 6,782.24 thousand BOE, and 6,651.82 thousand BOE respectively for BAU scenario, MOD, and OPT. At the same period the demand for electricity is at 2,417.11 thousand BOE, 1994.96 thousand BOE, and 1,807.06 thousand BOE respectively for BAU, MOD, and OPT scenarios. Demand for LPG in 2030 was 1,156.29 thousand BOE for the BAU and the MOD scenarios, and 1,151.49 thousand BOE for OPT scenarios. Demand for energy-dense types consisting of coal, coal briquettes and firewood in 2030 amounted to 31.01 thousand BOE, 25.04 thousand BOE and 25.65 thousand BOE respectively for BAU, MOD, and OPT scenarios.

Demand for gasoline is greatest during the forecast period, 46% of the total final energy demand for all scenarios. While the demand for electricity and gas (LPG) is the next largest, for all scenarios (Figure 5).

4.2. Energy Supply Projection

Energy supply in Yogyakarta province is also compiled by the year 2012 as the base year and the year 2030 as the year of the end of the projection. Energy supply calculation is based on three scenarios, that is BAU, moderate (MOD), and optimistic (OPT). Based on MOD and OPT scenarios, the primary energy mix in 2030 is shown in Figures 6 and 7. From Figure 7, the primary energy used of oil just 66.69% be lowered by increasing the percentage of natural gas (14.11%) and RE (3.35%). From Figure 6 oil and coal's role in providing energy in Yogyakarta can be further reduced through the implementation of programs within the OPT scenario. Meanwhile, increased use of RE compared with the MOD scenario. The implication is the supply of oil energy will decrease.

4.3. Carbon Emission

Eenvironmental impact of energy used on the demand side can be represented by the emission of greenhouse gases (GHG)

Figure 3: Energy final use projection

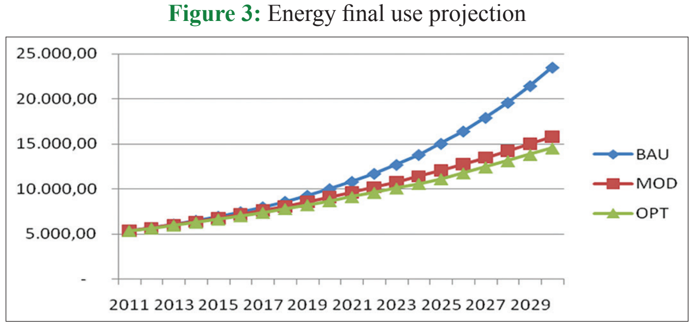


Table 4: Energy consumption under three scenarios from 2015 to 2030 (thousand BOE)

Skenario	Tahun				Pertumb (%)	Total Penggunaan Energi
	2015	2020	2025	2030		
BAU	6.955,45	10.015,10	15.040,99	23.500,77	10.03	236.923,6
MOD	6.7	9.082,97	12.045,89	15.785,22	6.53	195.878,1
OPT	6.605,98	8.656,25	11.096,85	14.528,73	5.99	184.695,1

Figure 4: Final energy demand projection by sector

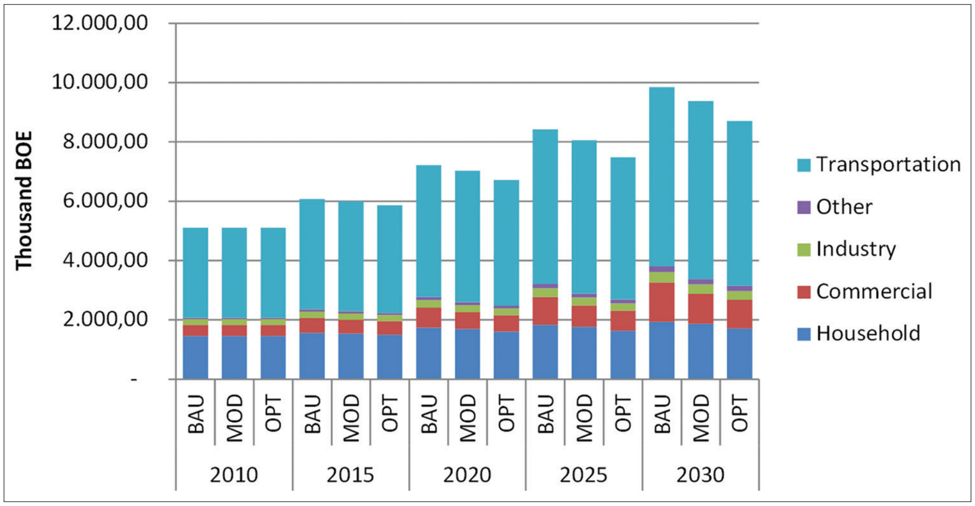
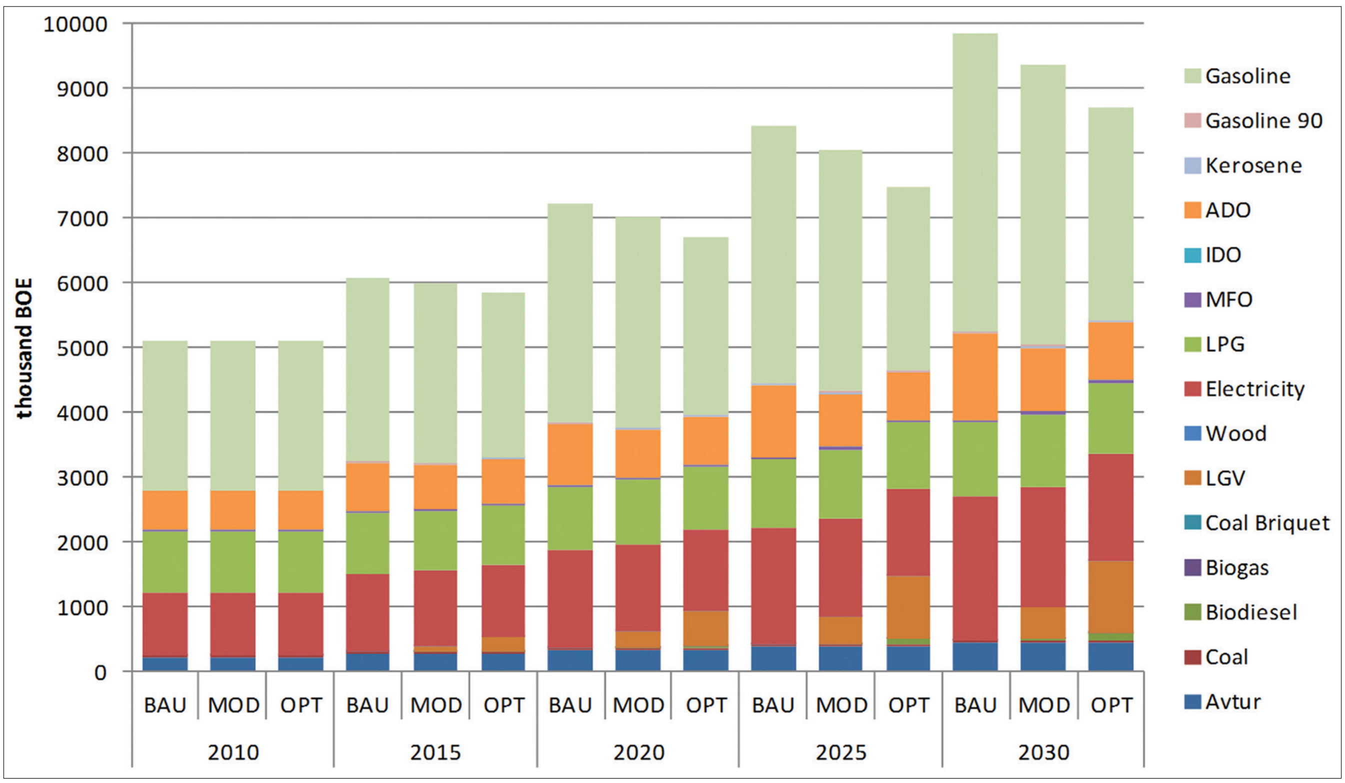


Figure 5: Final energy demand projection by type of energy



produced (Tubss, 2008) as air pollution as clean energy indicator. GHG emissions based on the scenarios that have been prepared, showing that the impact of the implementation of EE and RE can reduce greenhouse gas emissions, generated by the use of energy to run the activity sectors. In 2030, the overall GHG emissions generated by the BAU scenario is by 6.56 million tons of CO_2 equivalents. Based on the MOD and OPT scenario, GHG emissions in 2030 respectively amounted to 6.03 million tons of CO_2 equivalents and 5.75 million tons of CO_2 equivalents. With the implementation of programs that can support the OPT scenario, GHG emissions can be reduced to 12.5% when compared to the GHG emissions generated by the BAU scenario. Shown in Table 5 are the carbon emission intensity values under the BAU, MOD and OPT scenarios. For the three scenarios, respectively, all presenting a downward trend.

Based on the activity sector, the transportation sector generates the greatest GHG emissions, produces 45% of the total GHG emissions generated. In 2030, CO_2 emissions generated by activity in the transport sector amounted to 2.63 million ton of equivalent CO_2, 2.63 million tone of equivalent CO_2, and 2.56 million ton of CO_2 equivalent for BAU, MOD and OPT scenarios. Implementation of RE in the transport sector by replacing some of diesel oil with biodiesel can reduce GHG emissions by 1.75% based on OPT scenarios when compared to GHG emissions based on BAU scenario. The second largest contributor is the household

Figure 6: Primary energy mix by MOD scenario

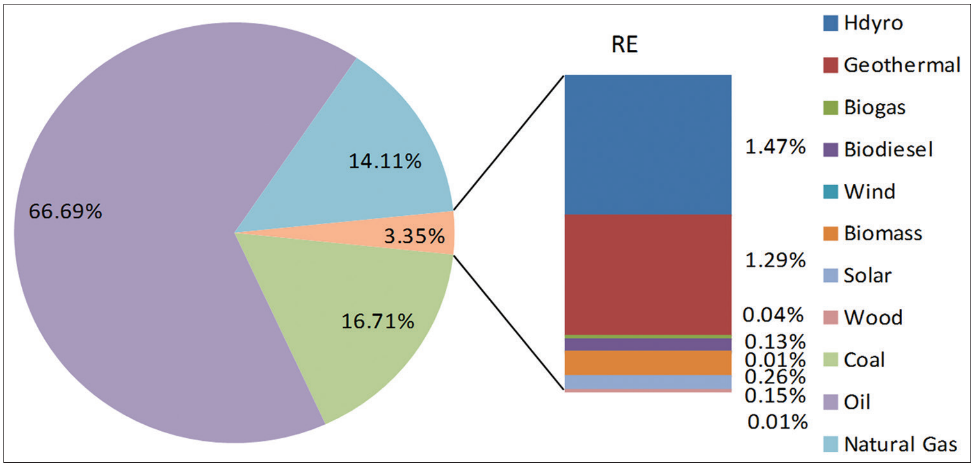


Figure 7: Primary energy mix by OPT scenario

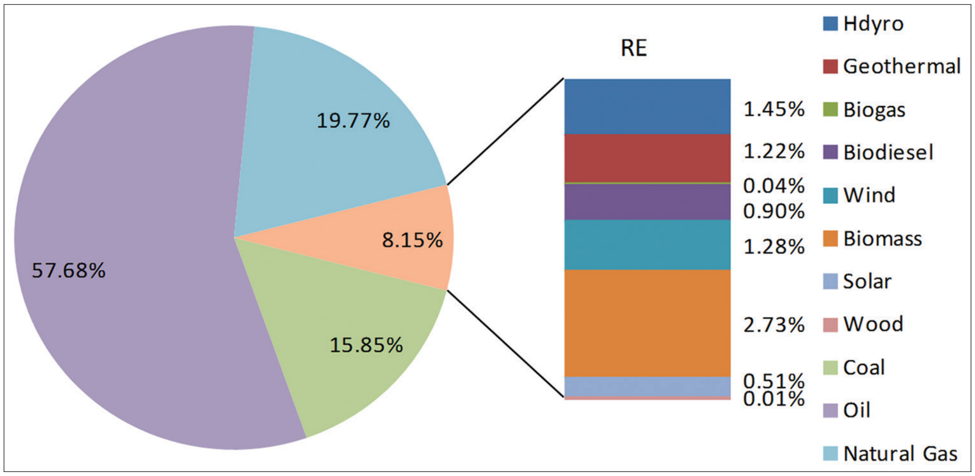
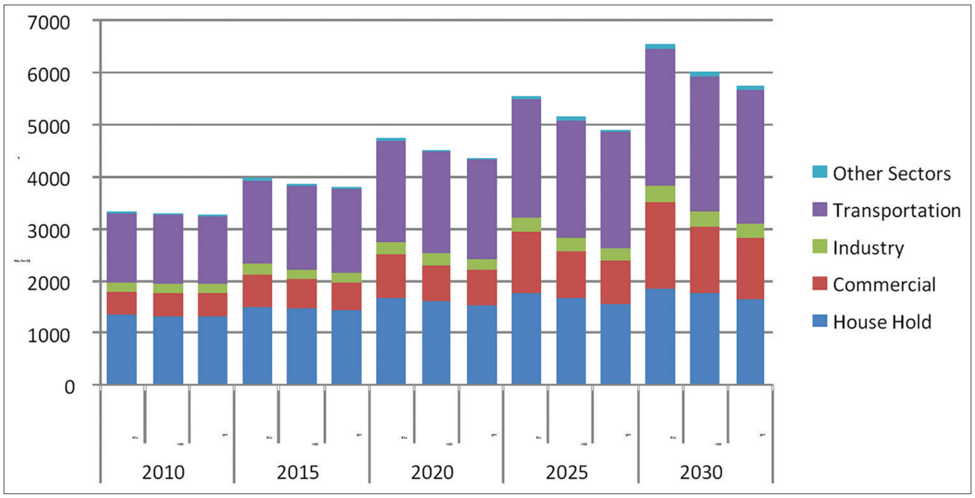


Figure 8: Greenhouse gases emissions by sector



sector, amounting to 28% of the total GHG emissions generated (Figure 8).

Furthermore, energy conservation through development of the existing RE potential and utilizing energy saving potential, will also impact the increasing health of the environment due to reduction in CO_2 emissions. Energy demand was made to all economic activity, namely the household sector, transport, industrial, commercial, and other sectors where these sectors are forming the added value of the regional economy or regional GDP. Added value generated by each sector contributed to better quality of the environmental.

Table 5: Total GHG emissions in 2030

No	Scenarios	Total emission
1	BAU	6.56 million tons of CO_2 equivalent
2	Moderat (MOD)	6.03 million tons of CO_2 equivalent
3	Optimis (OPT)	5.75 million tons of CO_2 equivalent

GHG: Greenhouse gases

This is what also call as well as a green economy through energy conservation approach. Green economy: One that has results in improved human well-being and social equity, while significantly reducing environmental risks and ecological scarcity. It is low carbon, resource efficient and socially (UNEP, 2011).

In this case there is a correlation between carbon emissions to the green economy and the additional element that needs to be done to continue to be a concrete step and towards sustainable clean energy development. The pace and direction of the scenarios must be done consistently and continuously in order to maintain that sustainable development can be a non-depleting path, while maintaining energy resources.

4.4. Energy Elasticity

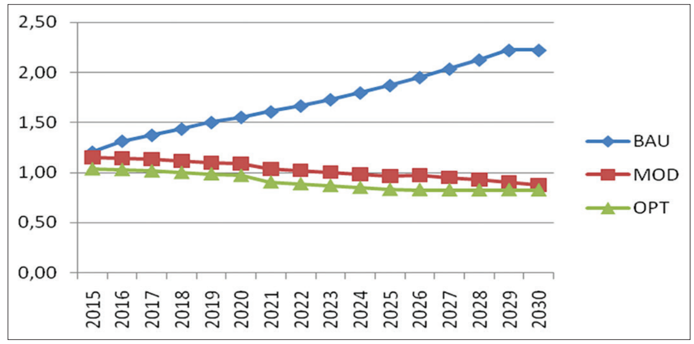
The index used to measure the energy needs for economic development of a country is the energy elasticity (Cai, 2008), which describes the growing energy needs required to achieve the certain level of economic growth (GDP). Based on a series of analyzes that have been conducted, energy elasticity of Yogya can be seen in Figure 9 below. From this figure it appears that energy elasticity using BAU scenario until the end of the projection is >1 (e>1). This condition illustrates that the energy consumption in the Yogya province have not been efficient or wasteful, due to increase of 1% economic growth requires energy in larger quantities. Meanwhile, based on moderate and optimistic scenario by including aspects of energy conservation policy as outlined above, energy elasticity of Yogyakarta until the end of the projection record numbers smaller than 1 (e<1), this shows that with the implementation of conservation programs Yogyakarta can optimize energy used becomes more efficient.

EE achieved by the moderate scenario began in 2024 until the end of the projection, while based on optimistic scenario, EE has been achieved by the year 2019. This shows that the implementation of the energy conservation programs, DIY can optimize energy use becomes more efficient. The implication is that in order to increase the economic growth of 1% will only require the use of less energy, and the energy that is available to be used productively. Lower energy use relative to the rate of economic growth will be achieved social welfare and better of environmental quality due to reduced exhaust emissions (negative externalities) on energy consumption.

5. CONCLUSION

In this study, three alternative scenarios were conceived using the LEAP modeling tool to represent different development pathways of Yogyakarta energy future from 2015 to 2030. The results show that scenario energy models will have a significant impact on energy consumption and carbon emission.

Figure 9: Energy elasticity for all the three scenarios



The total energy demand will reach 236.923,6 thousand BOE, 195.878,1 thousand BOE, and 184.695,1 thousand BOE respectively for BAU scenario, MOD, and OPT scenario. In the next 15 years, Yogyakarta primary energy consumption will be still dominated by oil, but the proportion will decrease, while the share of non-fossil energy will rise. By sector energy consumption, transport sectors will occupy the dominant position in final energy consumption, with the percentage of more than 60% of the overall final energy demand. The average growth of final energy demand in the transport sector over the forecast period of 3.5% per year. The household sector is the second largest consumer of the percentage 19.5%. Based on energy final use per type of energy, gasoline is a type of energy use is dominated at 46% of overall energy use. While the electrical energy is the second largest amounting to 22% of overall energy use. Transportation sector also generates the greatest GHG emissions, produces 45% of the total GHG emissions generated.

The implementation of EE development not only relieves energy demand, but also mitigates carbon emission; this will have multiple positive effects on long-term energy utilization and environmental conservation in Yogyakarta. For all the three scenarios, 8.09-12.5% carbon intensity reduction targets can be realized. This condition will also impact the increasing health of the environment due to reduction in CO_2 emissions. This indicates that the optimization of energy structure, as in LC, will play a key role in improving EE and reducing total energy consumption and carbon emission in Yogyakarta.

Energy use in Yogyakarta still not efficient under the BAU scenario, but a variety of energy conservation programs, until the end of the projection (2030) energy use shows the efficiency. This is evident from the Figure 9 that the elasticity of energy use is less than 1. EE by the moderate scenario achieved in 2024 until the end of the projection, while based on optimistic scenario EE has been achieved in 2019. This shows that implementation of the various conservation programs, Yogyakarta can optimize energy use becomes more efficient. The implication is in order to increase economic growth of 1% will only require the use of less energy, and energy can be utilized productively. Lower energy use relative to the rate of economic growth will be achieved social wefare and the better quality of the environment due clean energy by reducing exhaust emissions of CO_2 from energy consumption. Therefore, in order to achieve reductions in energy consumption and carbon emission, a comprehensive and integrated low carbon sustainability strategy is required. This should not focus on technological aspects alone, but also address the vital role that effective management and behavioural change can play in energy conservation.

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