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Scenario Analysis of Energy Demand as a Basis for Energy Efficiency Policies: A Case in Yogyakarta, Indonesia

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Abstract: Energy has a dual role, as a producer of foreign exchange through the export of energy commodities and as a driver of economic activity. Thus increasing economic growth requires energy demand will increase as well. Due to the limited energy resources so that energy use efficiency becomes very important. This research taking as a case study, was conducted to predict the future energy demand. In order to forecast energy demand in the regions in the next 20 years, this research firstly analyzes the current situation of energy consumption. Energy demand modeled by sector using intensity approach, that is calculate the amount of energy used per unit of activity. Applying LEAP model was built to analyze the future trends of energy demand, and energy structure from the base year 2011 to 2030 under different scenario composition that is Bussines As Usual (BAU), Moderate (MOD), and Optimistic (OPT) scenario. The results showed that transport sector is the largest energy users and the household sector is the second largest user. In terms of types of energy, the premium is the most dominant type of energy use, while electricity is the second largest energy types. Energy demand of Yogyakarta grew an average of 7.63% per year and the overall final energy demand are 9,848.17 thousand BOE in 2030. For both MOD and OPT scenarios, energy elasticity smaller than 1, it's mean to reach 1% of economic growth just need growth of energy use less than 1%. This suggests that energy use is efficient. Yogyakarta achieves energy efficiency by the year 2024 and 2019 recpecttively for MOD and OPT scenario. Overall, the results of this study provide insights into Yogyakarta's energy future and highlight possible steps for policy maker in this region to develop an energy efficiency policy.

Key words: Yogyakarta; energy eficiency; scenarios; LEAP
JEL code: O1

1. Background

Yogyakarta (DIY) 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

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Java-Madura-Bali (JAMALI) because there are no power stations to fulfill the electricity demand of Yogyakarta. 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, Education City, 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.

In the other hand the pattern of energy consumption is the consumptive of energy consumption. Energy majority have not 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 2011, others 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 2011 (Department of Energy and Mineral Resources of Yogyakarta). The growth of energy use to GDP growth in the same period reached 1.37. This suggests that the elasticity of energy use in Yogyakarta is wasteful or inefficient due to run sectors of economic activity with growth of 1% per year needed energy with a growth of 1.37% per year.

By this phenomenon, the Government of Yogyakarta Province, as the opinion of Cai et al. (2008) and Connolly, Lund, Mathiesen, and Leahy (2009) was supposed to arrange the proper planning of energy supply to build the strong energy security to fulfill the energy needs of society. Energy planning in order to secure supply of energy 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 and environment in the future.

2. Energy Condition of Yogya Province

As we see in Figure.1 below, 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. Natural gas is used in the generation of electric energy has a percentage of 9.60%. In 2010, the use of new and renewable energy only has a percentage of 1.90%. Renewable energy 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.

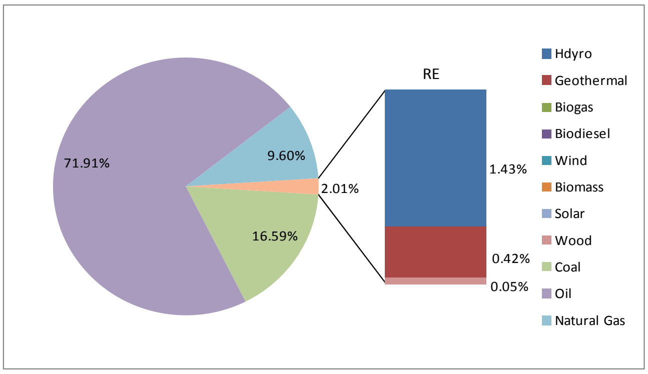

Figure 1 Primary Energy Mix 2010

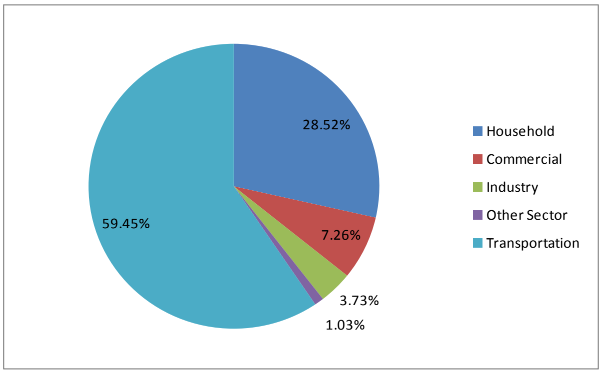

Figure 2 Energy Usage by Sector 2010

The pattern of energy consumption in the Yogyakarta Province 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 2010, 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.

3. Metodology

3.1 Basic Assumptions of Research

The main focus of this research is to analyze the energy efficiency plan which is basically an estimate of the energy demand. Energy demand compiled by the year 2010 as the base year and 2030 as the year-end projection. Energy demand compiled using energy intensity methode and using LEAP software as a tool for calculating the energy demand forecasts. The intensity of energy is the energy usage parameters for each activity. 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 energy intensity is the amount of energy consumption used in each household. Activity of commercial sector, industry, and other sectors represented by the value-added GDP for each sector. For these three sectors, energy intensity 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, energy intensity 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 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.

Furthermore, calculating of the energy demand is based on two scenarios, namely the business as usual scenario (BAU), and Energy Efficiency (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 renewable energy. Energy Efficiency scenario both the Moderate (MOD) and optimistic (OPT) was developed based on the BAU scenario with energy policy interventions based on energy efficiency potential and renewable energy implementation.

Energy Efficiency scenario based on energy efficiency potential derived from previous research. Potential energy efficiency can be seen in Tabel 1.

Table 1 Energy Efficiency Potential in Yogyakarta

No.	Sector	Energy Efficiency Potential
1	Industrial	15 – 20%
2	Household	10 – 25%
3	Commercial	25 – 30%
4	Others	25 – 30%

Source : Energy Office of Yogyakarta, 2010

For transport sector, energy efficiency 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. Lower limit of the potential energy savings as a basic of MOD scenario, while the upper limit as the base of OPT scenario.

Renewable energy scenario is based on the potential of renewable energy. Types of renewable energy 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.

Table 2 Development of Renewable Energy for Energy Efficiency 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	Biodisel	0	0,5% M. Solar	1% M. Solar	1,5% mM. Solar	2% M. Solar
6	Biomassa	0	100 kW	500 kW	750 kW	2 MW

Tabel 3 Development of Renewable Energy for Energy Efficiency 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

3.2 Data Analysis

Refers to the IEA (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, namely: (1) industrial 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 GDP, (4) other sectors based on sub-sector share to the formation of value added to GDP, and (5) energy demand in the transport sector is modeled in detail according to the mode of transport.

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 renewable energy in the Yogyakarta province which obtained from field survey. Energy demand modeling in this study using energy final used approach where final energy demand by sector is expressed as follows. Aggregate energy intensity (et) can be written as a function of energy use sector (EIT) and sector activity (ait):

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

Where *Et* is the aggregate energy consumption in year *t*, *Eit* is the energy consumption in sector *i* in year *t*, *Yt* is 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 the energy demand in the sector level. Thus, the energy demand by sector was designed as follows:

(a) Household Energy Demand: $Ed_h = \sum_1^4 Ih \ x \ (H_{t-1} \ x \ g) \ x \ A_{Ih} \ x \ K_h$

(b) Transport Energy Demand: $Ed_T = \sum_{h=1}^6 ITx \ (T_{t-1} \ x \ g) \ x \ A_i \ x \ K_h$

(c) Industrial Energy Demand: $Ed_I = \sum_{h=1}^8 IDx \ (T_{t-1} \ x \ g) \ x \ A_i \ x \ K_h$

(d) Commercial Energy Demand: $Ed_I = \sum_{h=1}^6 IK \ x \ (T_{t-1} \ x \ g) \ x \ A_i \ x \ K_h$

(e) Others Energy Demand: $Ed_I = \sum_{h=1}^3 IL \ x \ (T_{t-1} \ x \ g) \ x \ A_i \ x \ K_h$

Planning and energy models are designed with software tools, LEAP (*Long Range Energy Alternative Planning*). 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. The timeframe used for projecting the energy supply and energy demand in Yogyakarta Province is for 20 years (2011-2030) by the year 2010 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 Renewable Energy (RE) lowered depending on the targeted use of RE

4. Result and discussion

4.1 Energy Demand Projection

Calculation of energy demand is based on three scenarios, that is Business as Usual (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 renewable energy. Based on that scenario, projection of energy demand of Yogyakarta Province shown in the Figure 1. Based on Figure 3, we can see that implementation of energy efficiency scenario resulted in diminishing energy use.

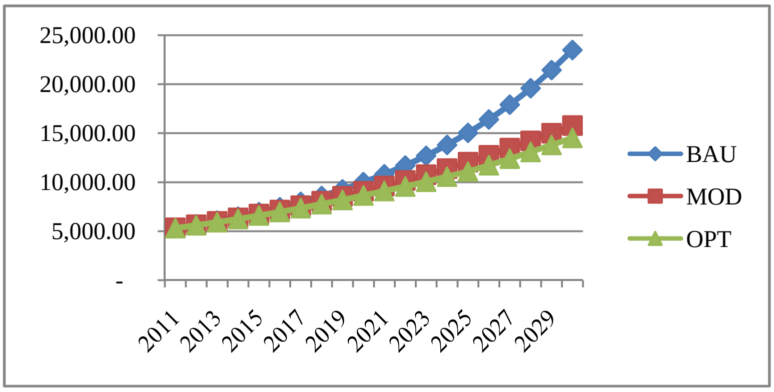

Figure 3 Energy Final Use Projection

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. Until the end of the projection, transport sector still dominates energy use (63%) and the household sector is the second largest sector of energy use in Yogyakarta Province (19%).

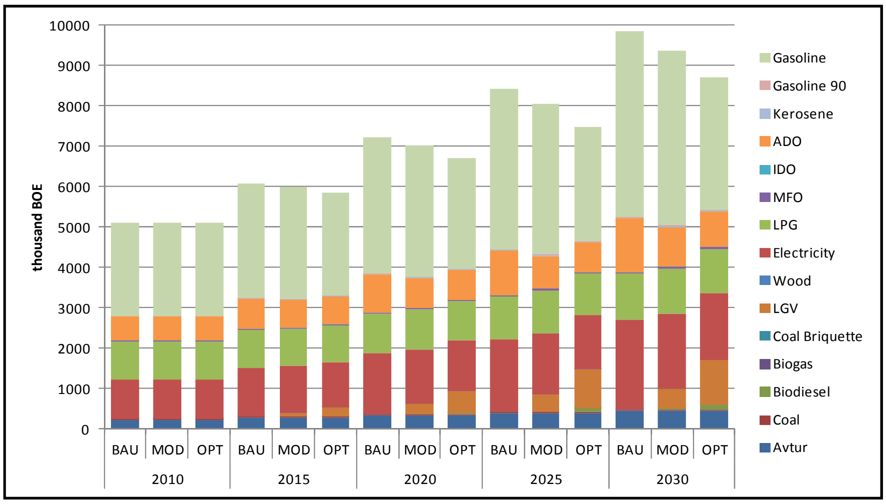

Figure 4 Final Energy Demand by Type of Energy

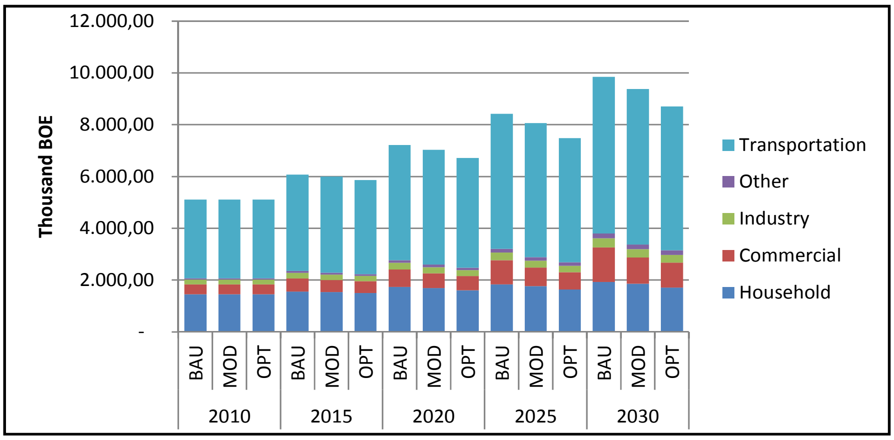

Figure 5 Final Energy Demand by Sectors

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.

4.2 Energy Supply Projection

Energy supply in Yogyakarta Province is also compiled by the year 2010 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 business as usual (BAU), moderate (MOD), and optimistic (OPT). Based on MOD and OPT scenarios, the primary energy mix in 2030 is shown in Figure 6 and Figure 7. From Figure 6, the primary energy used of oil just 66.69% be lowered by increasing the percentage of natural gas (14.11%) and renewable energy (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 renewable energy compared with the MOD scenario. The implication is the supply of oil energy will decrease.

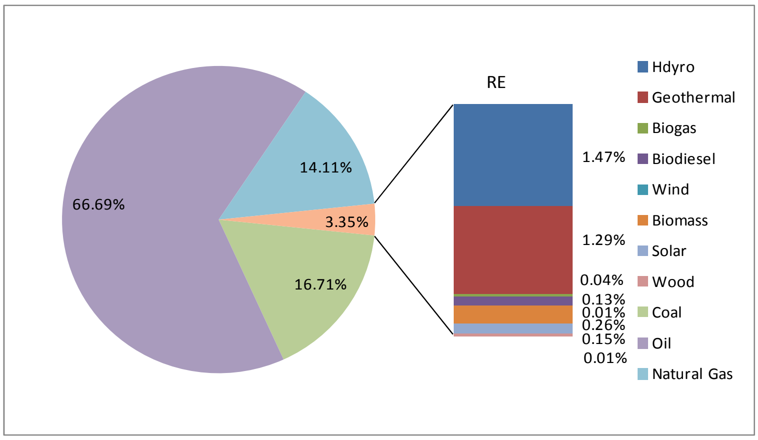

Figure 6 Primary Energy Mix by MOD Scenario

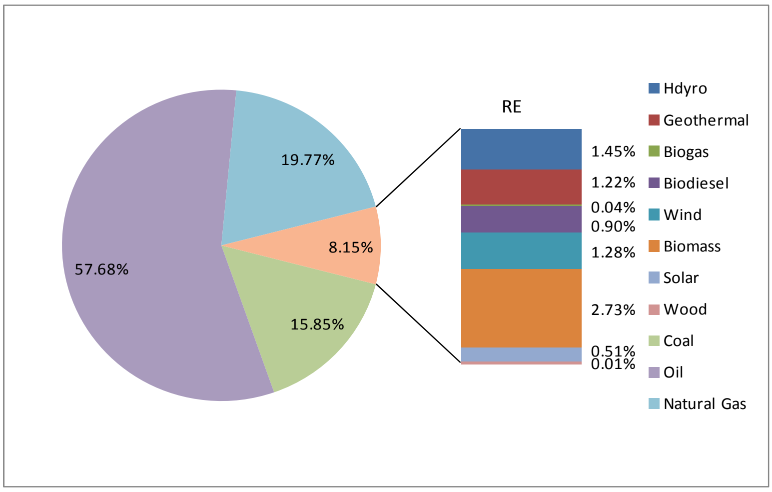

Figure 7 Primary Energy Mix by OPT Scenario

4.3 Carbon Emission

Environmental impact of energy used on the demand side can be represented by the emission of greenhouse gases (GHG) produced as air pollution. GHG emissions based on the scenarios that have been prepared, showing that the impact of the implementation of energy efficiency and renewable energy 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 pest scenario, GHG emissions in 2030 respectively amounted to 6.03 million tonnes of CO_2 equivalents and 5.75 million tons of CO_2 equivalents. With the implementation of programs that can support the pest scenario, GHG emissions can be reduced to 12.5% when compared to the GHG emissions generated by the BAU scenario. These conditions can be seen in Table 4 below:

Table 4 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

Furthermore, energy conservation through development of the existing potential for renewable energy, it will also result in increased environmental health due to reduction in emissions of CO_2 gas. Therefore in this study, energy demand was built 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, the added value generated each sector is added value contribute to a healthier environment. This is what we call as well as a Green Economy through energy conservation approach. Green economy is an economy that produces social welfare and reduce the economy disparity and not make the future generations facing the environmental risk because of the economic activity.

4.4 Energy Elasticity

The index used to measure the energy needs for economic development of a country is the energy elasticity, 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 Province can be seen in Figure 7 below. From the figure it appears that Energy Elasticity using BAU scenario until the end of the projection is greater than 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 Province until the end of the projection record numbers smaller than 1 ($e < 1$), This shows that with the implementation of conservation programs Yogyakarta Province can optimize energy used becomes more efficient.

Energy efficiency achieved by the Moderate scenario began in 2024 until the end of the projection, while based on Optimistic scenario, energy efficiency 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.

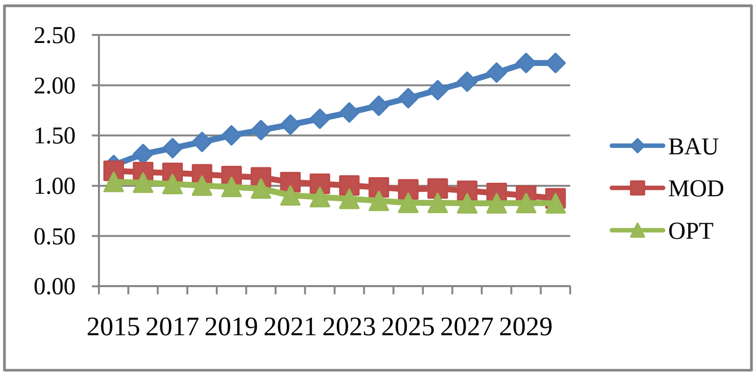

Figure 8 Energy Elasticity for All the Three Scenarios

5. Conclusion

The total primary energy demand will reach 9,848.17 thousand BOE, 9,374.99 thousand BOE, and 8,706.95 thousand BOE respectively for BAU scenario, MOD, and OPT scenario. In the next 20 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 the pattern of 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. For all the three scenarios, 8.09-12.5% carbon intensity reduction targets can be realized. Energy use in Yogyakarta Province still not efficient under the BAU scenario, but with a variety of energy conservation programs, until the end of the projection (2030) energy use shows the efficiency. This is evident from the Figure 7 that the elasticity of energy use is less than 1.

Energy efficiency by the Moderate scenario achieved in 2024 until the end of the projection, while based on Optimistic scenario energy efficiency has been achieved in 2019. This shows that the 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 to reduced exhaust emissions on energy consumption.

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References:

Connolly D., Lund H., Mathiesen B. V. and Leahy M. (2009). "A review of computer tools for analyzing the integration of renewable energy into various energy systems", *Journal of Applied Energy*, Vol. 87, pp. 1059-1082.

International Energy Agency (IEA) (2007). *Key World Energy Statisctic 2007*.

Ghader S. F., Azadeh M. A. and Sh. Mohammad Zadeh (2006). "Modeling and forecasting the electricity demand for major economic sectors of Iran", *Information Technology Journal*, Vol. 5, No. 2, pp. 260-266.

Ghanadan dan Koomey (2005). "Using energy scenarios to explore alternative energy pathways in California", *Journal of Energy Policy*, Vol. 33, pp. 1117-1142.

Stern David (2011). "The role of energy in economic growth", *Energy Bulletin, The Oil Drum*, Oct. 20.

Tambunan Mangara (2006). *The Second High Cycle of World Oil (Energy) Price Crisis: Challenges and Option. Global Dialogue on Natural Resources*, Washington DC, USA, April 4th-5th.

Tubss W. J. (2008). "A simulation model of energy supply and demand for climate policy analysis", available online at: http://www.bill.tubbs.name/thesis2008/USAEEpaper_BTubbs.pdf.

Zhao Taoa, Liu Zhaoa and Zhao Changxin (2011). "Research on the prospects of low-carbon economic development in China based on LEAP model", *Energy Procedia*, Vol. 5, pp. 695-699.

Weerin Wangjiranirana, Supawat Vivanpatarakij and Raksanai Nidhiritdhikrai (2011). "Impact of economic restructuring on the energy system in Thailand", *Energy Procedia*, Vol. 9, pp. 25-34.

Cai Y. P., Huang G. H., Yang Z. F. and Tan Q. (2008). "Identification of optimal strategies for energy management systems planning under multiple uncertainties", *Journal of Applied Energy*, Vol. 86, pp. 480-495.

Karabulut Alkan and Yilmaz (2008). "Long term energy consumption forecasting using genetic programming", *Mathematical and Computational Applications*, Vol. 13, No. 2, pp. 71-80.

Stenlund Nilsson J. and Martensson A. (2002). "Municipal energy-planning and development of local energy-systems", *Journal of Applied Energy*, Vol. 76, pp. 179-187.