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Regional Energy Master Plan based on Low Emission Scenarios: Case Study of Central Java Province, Indonesia

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Abstract: The current energy crisis momentum is the right time to redesign energy policy; otherwise, the energy deficit will continue and influence economic activities. For this reason, this research took Central Java Province as a case study. This research aims to estimate energy demand, the dominance of energy use, and energy efficiency. In this study, energy demand was modeled by sector using the intensity approach to calculate the energy used per activity unit. Low Emissions Analysis Platform (LEAP) model was then utilized to figure out future trends in energy demand and energy structure from 2015 to 2030 under different scenarios, including Business as Usual (BAU), Moderate (MOD), and Optimistic (OPT) scenarios. The results uncovered that energy demand in Central Java has grown by 5.6% per year, and the overall final energy demand is 1,683,091.24 thousand BOE. In this case, the transportation and household sectors are the largest and second-largest consumers, while premium and electricity are the dominant components in this province. In addition, efficiency energy could be achieved in 2021 and 2017, respectively, under the MOD and OPT scenarios. From the utilization of renewable energy, Central Java also contributes 1.17% to the utilization of renewable energy nationally. Overall, this research provides important insights and highlights possible steps for policymakers in developing energy efficiency policies.

Keywords: LEAP; Central Java; Energy Plan; Scenario
JEL Classification: O13; P18; P2; Q43

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Introduction

The current world energy crisis has occurred, and the energy consumption is largely controlled only by the major industrial countries in the world (Zhao, 2008). Related to the projections of the World Energy Agency (International Energy Agency-IEA), by 2030, the world's energy demand will increase by 45% or an average increase of 1.6% per year. The implication is that the security of energy supplies will continue to decline and potentially trigger another world economy recession (Connolly et al., 2010). This fact has been responded by several countries to redesign their energy planning policies, such as those in China (Tao et al., 2011), Thailand (Wangjiraniran et al., 2011), Turkey (Karabulut et al., 2008), Iran (Ghader et al., 2006), and Sweden (Nilsson & Mårtensson, 2003). Developed countries, such as California (Ghanadan & Koomey, 2005) have also even anticipated the energy crisis by preparing energy plans early.

For Central Java Province, redesigning the right energy policy is also crucial, considering the highly consumptive energy use patterns. It can be seen from the biggest energy users in the household and transportation sectors, which accounted for 19.98% and 71.86% of the total energy used, where oil energy still dominated its use, reaching 78.67%, and the efficiency of energy use was about 1.3 (RUED Central Java, 2009). This efficiency level indicates that energy use is still wasteful or inefficient because to run 1% economic growth, energy with greater growth each year is required. With this phenomenon, the Central Java Provincial Government, as the opinion of Cai et al. (2009) and Connolly et al. (2010), should have done the right energy planning so that the energy supply could produce resilient energy and use energy more efficiently; or else, Central Java will face serious energy problems that will affect economic activity and social welfare (Stern, 2010).

Energy planning is needed, among others, to ensure that energy availability is guaranteed because energy is a vital requirement for human life (Pierce, 1996; Winarno, 2007). A comprehensive plan in which energy is associated with various fields, according to Reuter and Voss (1990), Shan et al. (2012), Feng and Zhang (2012), and Cai et al. (2009), will make energy more optimized in its utilization. In addition, energy planning varies greatly and can be done from simple to complex planning systems to produce integrated energy planning (Schrattenholzer, 2004). Furthermore, Pindyck (1979) explained that various energy models had been developed to assist energy planning, both models based on econometrics or statistical techniques, to make long-term energy demand projections. Energy planning can also be done by developing and analyzing energy scenarios, as done by Ghanadan and Koomey (2005), Shan et al. (2012), and Feng and Zhang (2012).

Moreover, energy is a variable with a positive effect on economic growth, as stated in a study conducted by Stern and Cleveland (2004); Toman and Jamelkova (2003); Cleveland and Stern (1993); Ramos-Martini and Ortega-Cerda (2003); Chali and Mulugeta (2009); Aqeel and Butt (2001); Sugiyono (1999). They agreed that the entire economic process requires energy, the importance of the role of energy for economic growth and human development, and its impact on sustainable development. They further asserted that sustainable development should be perceived as another dimension of economic growth that can only be achieved with the production and use of sustainable energy. Meanwhile, many studies have emphasized the projected energy demand, intended to determine the continuity of energy supply and optimization and the impact of energy consumption on CO2 gas emissions.

Research using the LEAP (Long-Range Energy Alternative Planning) model based on several of these scenarios has been conducted by Shan et al. (2012), Feng and Zhang (2012), Wangjiraniran et al. (2011), Tao et al. (2011), XianDong et al. (2012), and several regencies/cities in Indonesia. The empirical study results of Shan et al. (2012) and Wangjiraniran et al. (2011) revealed that the transformation of the economic development model could slow the growth rate of energy consumption, improve energy structure, reduce the share of coal and oil in primary energy consumption, increase the share of natural gas and non-fossil energy, and significantly reduce the intensity of carbon gas emissions (Feng & Zhang, 2012). A study based on the LEAP model conducted by Tao et al. (2011) used a basic scenario, a low carbon scenario, and a pessimistic low carbon scenario formulated to simulate low carbon economic development in China until 2050. The study results showed a significant reduction in CO_2 gas emissions in China due to the high energy intensity.

Therefore, this research is intended to analyze the energy demand by sector with the final energy approach used as a reference for regional energy planning related to the economic growth targets desired by the government. From this analysis, this research gives new contribution for the previous research, that is, various efforts are made to conserve energy through scenario simulations to achieve efficient energy use and formulate policies to build energy use efficiency systems. For this purpose, this research attempts to use an accounting model with LEAP software. LEAP is a model that meets the criteria in regional energy planning because it can be used to analyze energy supply and utilization (Winarno, 2007). As a predictor tool, LEAP can make projections of energy demand and supply within a certain period following the user's wishes.

Energy planning is basically an estimate of future energy demand and supply and has an essential role because it can be used as a basis for integrated energy policy development (Schrattenholzer, 2004). Principally, energy demand depends on 1) the demand for services provided, 2) the availability and ownership of energy conversion technology or capital stock, and 3) the cost of the technology conversion used (Sweeney, 2001). Dahl and Kurtubi (2001) suggested that the demand for energy resources can be seen as an effort of consumers to satisfy their needs. It can be explained by using the Marshallian demand theory that energy consumers are assumed to try to maximize the utility function by considering budget constraints. According to Dahl and Kurtubi (2001), if the consumer utility is expressed as U (E, O), and the income constraint is PeE + PoO = Y, the problem of consumer maximization using the Lagrange (λ) method can be stated as follows.

$$U = U(E, O) - \lambda (Y - PeE - PoO) \qquad (1)$$

The first derivative is $U - \lambda Pe = 0$ and $U - \lambda Po = 0$, and the second derivative is negative. After getting the values of λ by solving algebra, the energy demand function is obtained as follows:

$$E = f (Pe, Y, Po, \qquad (2)$$

E = energy demand, Pe = energy price, Y = income, Po = other goods prices, and O = other goods. This formulation can be expressed in simple static and dynamic econometric equations as follows:

$$Et = \beta 0 + \beta 1Yt + \beta 2Pt + u \qquad (3)$$

$$Et = \beta 0 + \beta 1Yt + \beta 2Pt + \beta 3Et\text{-}1 + u \qquad (4)$$

Where: Et = energy consumption at time t; Et-1 = energy consumption at time t-1; Yt = income at time t; Pt = energy price at time t; e = confounding variable.

Guertin et al. (2003) illustrated the energy demand by giving an example of a household purchasing electric utilities (KWh), fuel oil (liters), and gas (m^3), which are then transformed into energy services for lighting, cooling, heating, and appliances other electricity through technology conversion. This relationship is described between input and output energy. Energy input is related to the consumer's energy content, whereas energy output is associated with the load. Thus, the end-users are different from energy services. End-uses relate to unbundled input energy with components (heating devices, air conditioners, electric lights, in other electrical equipment), while energy services are charged provided by end-uses categories (Barnes et al., 1981), such as hot, cold, bright, and others.

Furthermore, energy demand by consumers in the form of final energy is classified by sector. In the World Energy Model (WEM) developed by the IEA in 1993, energy demand can be divided into sectors: the final energy demand of the industrial sector, the household sector, the service sector, and the transportation sector (IEA, 2008). According to the IEA, the final energy demand is modeled in detail by sector, and end energy user scope, namely: (1) Industry is separated into five sub-sectors to enable a more detailed analysis of trends and controls in the industrial sector; (2) Residential energy demand is divided into five end-users according to fuel; (3) Requests for services; (4) Energy demand in the transportation sector is modeled in detail according to modes of transportation and fuel. In other words, the final energy demand is modeled at the sector level for each WEM region, but separation is done at the end-user level.

The total final energy demand is the amount of energy consumption in each end-user sector. In each sub-sector or end-user, at least six types of energy will be displayed: coal, oil, gas, electricity, geothermal energy, and renewable energy. In each sub-sector or end-user, energy demand is assumed to result from the energy intensity and activity variables. Here, energy demand analysis can use the activity-based analysis method. In this method, the energy demand is calculated as a product of the energy activity and the energy intensity (the amount of energy used per unit of activity). This method consists of two analytical models: final energy demand analysis and useful energy demand analysis.

In the final energy demand analysis, the energy demand is calculated as a result of the multiplication of the total energy use activities with the energy intensity in each technology branch. In the form of a mathematical equation, the calculation of energy demand using the final energy demand analysis is:

$$D_{b,s,t} = TA_{b,s,t} \times EI_{b,s,t} \quad (5)$$

Where D is Demand, TA is total activity, EI is Energy Intensity, b is "sector," s is a type of scenario, and t is the year when the calculation (the starting base year to the final year of calculation). Meanwhile, energy intensity is the annual average energy consumption (energy consumption = EC) per unit of activity (activity level). Mathematically, it is shown by the following equation:

$$EI = EC/\textit{Activity Level} \quad (6)$$

Then, total technological activity results from the activity level in all branches of technology that will affect the branch of demand.

$$TA_{b,s,t} = A_{b',s,t} \times A_{b'',s,t} \times A_{b''',s,t} \quad (7)$$

Where Ab is the activity level at a particular branch b, b' is the parent of branch b, b' 'is the parent branch b', and so on.

Moreover, planning is a foresight that concerns resources so that energy planning will relate to allocative planning and strategy planning (Reuter & Voss, 1990). Good energy planning can integrate all energy sub-sectors, including the rural energy sector, and aspects related to the energy sector as a whole (Schrattenholzer, 2004; Nilsson & Mårtensson, 2003). The aspects related to energy planning are socio-economic, environmental, the balance of payments, and others (Morse & Jaffe, 2001). In addition, energy planning is needed, among others, to ensure that the availability of energy is guaranteed because energy is a vital requirement for human life (Pierce, 1996; Winarno, 2007; and Wijaya & Ridwan, 2009). Thus, a comprehensive plan in which energy is associated with various fields, according to Reuter and Voss (1990); Shan et al. (2012); Feng and Zhang (2012); Cai et al. (2009), will make energy more optimized in its utilization.

Various energy models have been developed to assist energy planning, and models are both based on econometrics or statistical techniques to make long-term energy demand projections (Meier,1993). Energy planning can also be done by developing and analyzing energy scenarios, as was done by Ghanadan and Koomey (2005), Shan et al. (2012), and Feng and Zhang (2012). As for the energy supply strategy, optimization techniques with certain objective functions are widely used (Sugiyono, 1995). The use of the Markal (Market Allocation) model will determine the optimal energy supply based on linear programming techniques by considering the choice of available energy resources and technology to meet energy needs (Sugiyono & Suarna, 2006). Based on the optimum results, the number of emissions from energy use can be calculated using the emission coefficient data from each technology. In his study, Kleeman (1995) used the DEMI (Demand Energy Model for Indonesia) model to project energy requirements in the form of useful or final energy. This model calculates all energy used by end-use technology but does not cover energy used for mining, energy conversion, auto-generation and losses from energy use. Essentially, the energy used is in the form of useful energy. The final energy is used if the useful energy cannot be applied to a particular part. In the concept of useful energy, the energy price is not calculated. It is because useful energy does not depend on the type of final energy it produces.

In China, energy planning research conducted by Shan et al. (2012) was intended to project energy demand in China for the next 20 years. The initial step in the study was to analyze the existing energy conditions in China, then use the LEAP model and simulate energy demand and primary energy mix in 2020 and 2030. In this regard, projections employed different scenarios, namely economic development, energy efficiency, and energy structure scenarios. The results showed that the total primary energy demand reached 4840-5070 Mtce in 2020 and 5580-5870 Mtce in 2030. Besides, the share of coal in the composition of the primary energy mix decreased, while oil, natural gas, and non-fossil energy increased

In their study, Feng and Zhang (2012) also used the LEAP model to predict the impact of different development alternatives on future energy demand for energy structures and carbon emissions from the base year 2007-2030, based on three scenarios: the Business as Usual (BAU), based on policy (BP), and low carbon (LC). Concerning low carbon and based on policy scenarios, the industrial sector has the greatest potential to reduce energy consumption and carbon gas emissions compared to the BAU scenario. On the other hand, Ghader et al. (2006) built models and predicted electricity demand in Iran. The study was motivated by the effort that energy production and exploitation need to be programmed to realize a stable economy, as important as human resource factors, raw materials, financial sources, and other inputs. In addition, considering the current energy conditions, many countries focus more on limited energy availability. Thus, to realize electricity as a source of clean energy, the alignment between supply and demand is a challenge for policymakers

In Thailand, an energy planning study using the LEAP model was conducted by Wangjiraniran et al. (2011) to examine the impact of changes in economic structure on energy consumption patterns and the effects of greenhouse gases on energy use in two different scenarios. Based on the study by Wangjiraniran et al. (2011), national energy planning and policy must be adjusted more coherently to the country's economic development and social conditions. The study results also disclosed that energy planning should focus more on using alternative energy to replace petroleum consumption and improve efficiency in the transportation sector. In addition, community-based biofuel production is increasingly being considered to mitigate the impact of unsustainable oil supply in the agricultural sector and narrow the gap between the economy, climate, and energy policies.

Energy planning studies using the LEAP model were also conducted by XianDong et al. (2012) by designing three scenarios of China's economic growth and stimulating the level of electrification in China in 2030. The results exposed that the electrification rate of China has the potential for a greater increase in the medium-long term, and there is a rapid change in economic development patterns that can help increase the level of electrification. Moreover, an interesting study has been carried out by Tao et al. (2011) in the headline for the prospect of low carbon economic development in China. The prediction results based on the scenario become an important reference for the Chinese government to develop a low carbon economy. The results showed that the total energy demand based on the three scenarios was 6095 billion tons of standard coal, 5236 billion tons of standard coal, and 6239 billion tons of standard coal in 2050.

Research Method

Research Approach

Estimation of energy demand in Central Java Province was carried out using a demand approach, meaning that energy demand was calculated from energy demand by each energy user sector. The demand approach is complicated and requires more data, but this approach of demand can better describe the actual energy demand and be more detailed in calculating energy demand per usage sector. This research also employed an end-use approach, also known as an engineering model approach, combined with a scenario method. This approach is more detailed even though the calculation uses a simpler function.

Research Assumptions

Energy demand is divided into five (5) activity sectors: household, commercial, industrial, transportation, and others. In this study, the calculation of energy demand was based on two scenarios, namely Business as Usual (BAU) and Energy Efficiency (EE) scenarios, consisting of moderate (MOD) and optimistic (OPT) scenarios. The energy efficiency scenario was developed based on the BAU scenario with energy policy interventions regarding energy efficiency and renewable energy. Then, energy conservation targets in the form of increasing energy use efficiency for the MOD scenario were based on rational targets that could be achieved at a medium cost. Whereas in the OPT scenario, the energy conservation target was the maximum target that might be achieved in accordance with the existing energy efficiency potential.

In addition, the energy efficiency scenario was based on the potential for energy efficiency obtained from the previous research.

Table 1 Potential of Energy Efficiency in Central Java Province

No	Sector	Energy Efficiency Potential (%)
1	Household	14 - 20
2	Industry	10 – 25
3	Commercial	25 – 30
4	Others	25 - 30

Source: RUED Central Java (2009)

The lower limit of energy-saving potential was used for the moderate energy efficiency scenario, while the upper limit of the energy-saving potential was employed for the optimistic energy efficiency scenario.

For the transportation sector, energy efficiency can be carried out by shifting modes to optimize the use of public transportation to meet the needs of trips in the km-passenger. The target of shifting modes from private to public transportation is to increase the bus mode load factor from 24.34% to 60% in 2030. Increasing the bus mode's load mode is done by transferring the use of motorbikes and private passenger cars. The amount of diversion from motorcycles and private passenger cars is 14% and 11% in 2030, respectively.

Moreover, in this research, the renewable energy scenario was based on the renewable energy potential in Central Java, while the development of renewable energy potentials for the MOD and OPT scenarios was based on the forum group discussion (FGD) results. Then, biogas and biodiesel were used on the demand side to replace some suitable types of energy. It is assumed that biogas can be used to replace part of the demand for LPG, firewood, and coal briquettes in the household sector. The biogas system developed in this study was a household biogas system with 2 heads of cattle. Biodiesel was also implemented to replace some of the demand for diesel oil in the commercial, industrial, transportation and other sectors.

Table 2 Renewable Energy Development for the Energy Efficiency Scenario (MOD)

No	Types of Renewable Energy	Utilizing Targeted Renewable Energy				
		2010	2015	2020	2025	2030
1	Solar	25kWp	250kWp	2000kWp	2.500kWp	3.000kWp
2	Water	25kW	50kW	600kW	650kW	750kW
3	Wind	20kW	40kW	80kW	120kW	160kW
4	Biogas	300 units	1,000 units	2,500 units	4,000 units	5,000 units
5	Biodiesel	0	05% solar	1% solar	1.5% solar	2% solar
6	Biomass	0	100kW	500kW	750kW	2 MW

Source: FGD of Central Java Province

Table 3 Development of Renewable Energy for Energy Efficiency Scenarios (OPT)

No	Types of Renewable Energy	Utilizing Targeted Renewable Energy				
		2010	2015	2020	2025	2030
1	Solar	25kWp	2MWp	5MWp	7.5MWp	10MWp
2	Water	25kW	600kW	750kW	1,300kW	1,800kW
3	Wind	20kW	50MWp	50MWp	75MWp	100MWp
4	Biogas	300 units	1,000 units	2,500 units	4,000 units	5,000 units
5	Biodiesel	0	2.5% solar	5% solar	7.5% solar	10% solar
6	Biomass	0	10 MW	500kW	750kW	20 MW

Source: FGD of Central Java Province

Also, the renewable energy scenarios were based on the Regulation of the Minister of Energy and Mineral Resources of the Republic of Indonesia Number 32 of 2008, stating that every oil business entity and the direct user is obliged to use pure biofuels in the country, as presented in Table 4 and Table 5.

Table 4 Target Stages Percentage of Biodiesel Use

Sector	2010	2015	2020	2025	2030
Transportation PSO	2.5%	5%	10%	20%	20%
Transportation Non PSO	3%	7%	10%	20%	20%
Industry & Commercial	5%	10%	15%	20%	20%
Power Plants	1%	10%	15%	20%	20%

Source: Ministry of Energy and Mineral Resources of the Republic of Indonesia

Table 5 Target Stages Percentage of Bioethanol Use

Sector	2010	2015	2020	2025	2030
Transportation PSO	3%	5%	10%	15%	20%
Transportation Non PSO	7%	10%	12%	15%	20%
Industry & Commercial	7%	10%	12%	15%	20%

Source: Ministry of Energy and Mineral Resources of the Republic of Indonesia

Energy Demand Model

Energy demand modeling in this research used the final energy approach (final used), where the final energy demand by sector is stated as follows. Aggregate energy intensity (et) can be written as a function of energy use by sector (Eit) and activity by sector (ait):

$$et = \frac{Et}{Yt} = \sum\left(\frac{\text{Eit}}{\text{Yit}}\right)\left(\frac{Yit}{Yt}\right) = \sum eit\ .ait \qquad (8)$$

In the end-use approach, aggregate energy demand is obtained by summing energy demand at the sector level. Thus, the energy demand per sector is designed as follows:

1. Household Sector Energy Demand Model:

$$Ed_h \ = \sum_1^4 Ih\ x\ (H_{t-1}\ \ x\ g)\ x\ A_{Ih}\ x\ K_h \qquad (9)$$

2. Transportation Sector Energy Demand Model:

$$Ed_T \ = \sum_{h=1}^6 ITx\ (T_{t-1}\ \ x\ g)\ x\ A_i\ x\ K_h \qquad (10)$$

3. Industrial Sector Energy Demand Model:

$$Ed_I \ = \sum_{h=1}^8 IDx\ (T_{t-1}\ \ x\ g)\ x\ A_i\ x\ K_h \qquad (11)$$

4. Commercial Sector Energy Demand Model:

$$Ed_I \ = \sum_{h=1}^6 IK\ x\ (T_{t-1}\ \ x\ g)\ x\ A_i\ x\ K_h \qquad (12)$$

5. Other Sector Energy Demand Model:

$$Ed_I \ = \sum_{h=1}^3 IL\ x\ (T_{t-1}\ \ x\ g)\ x\ A_i\ x\ K_h \qquad (13)$$

Where Ed indicates Energy demand indicates Energy intensity of the household sector literacy for the Ih , IT indicates the availability of Energy intensity of the transportation sector, ID indicates the availability of Energy intensity of the industrial sector, IK indicates the availability of Energy intensity of the commercial sector, IL indicates the availability of Energy intensity of other sectors, Ai indicates the availability of Sectoral activity, Kh indicates the availability of Number of sub-sectors, g indicates the availability of Sectoral growth.

Result and Discussion

Estimated Overall Final Energy Demand

A series of analyses on energy demand and energy efficiency carried out, in general, illustrated that the simulation of the implementation of energy efficiency programs through the utilization of energy efficiency potential and the development of renewable energy becomes more efficient. Road map implementation of conservation programs through the development of renewable energy and the utilization of energy efficiency potential into the simulation projection scenario for energy use showed that overall energy use has been decreasing every year. Overall energy demand in Central Java using BAU scenario, moderate energy efficiency, and an optimistic scenario revealed diminishing use. This condition can be seen in Table 6.

Table 6 Impact of Efficiency Potential Utilization and Renewable Energy Development on Energy Use in Central Java Province (Thousand SBM)

Scenarios	Year				Growth (%)	Total Energy Use
	2015	2020	2025	2030		
BAU	61,608.51	79,949.81	105,000.94	121,890.90	6.65	1,683,091.24
MOD	59,410.38	75,040.74	94,412.92	106,758.65	5.45	1,554,163.05
OPT	58,252.66	66,511.66	75,441.62	85,401.03	4.72	1,405,829.46

Overall, the final energy demand in Central Java Province based on the BAU scenario is 1,683,091.24 thousand SBM. Based on the moderate and optimistic energy efficiency scenario, energy use decreases by 1,554,163.05 thousand SBM and 1,405,829.46 thousand SBM. It means that the use of the OPT scenario reduces energy use by 16.47% compared to the energy demand using the BAU scenario. This condition can be seen in Figure 1.

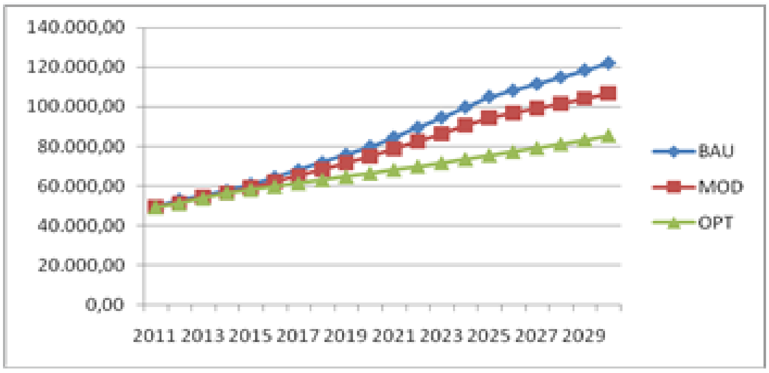

Figure 1 Estimated Final Energy Demand for Central Java Province

The decrease in total energy use during the projected year through the utilization of energy efficiency potential and renewable energy development programs is in line with the energy mix out-look issued by the Ministry of Energy and Mineral Resources of the Republic of Indonesia in 2011-2030. Based on out-look, at the end of 2030, the share of fossil energy will decrease, whereas the role of renewable energy will increase, from 4.7%

in 2010 to 13.5% in 2030 (see Figure 2). From the use of renewable energy, Central Java Province contributes 1.17% to the utilization of renewable energy nationally. As an integrated energy development system, the Central Java Province cannot be separated from the national energy policy. Therefore, one basic policy that needs to be emphasized in energy efficiency planning in this region is to support the implementation of national energy policies.

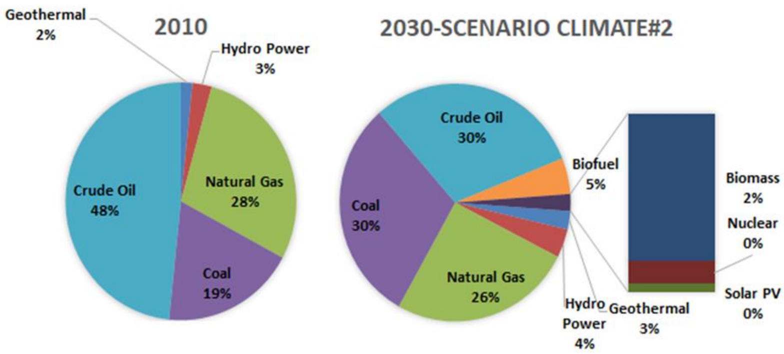

Figure 2 Energy Out-Look

Estimated Final Energy Demand by Sector

By sector, energy use in Central Java Province is the largest consumer, dominated by the transportation sector, with energy use reaching more than 60% of overall final energy. In comparison, the household sector is the second largest consumer at 20.67% of final energy overall. By transportation type, two-wheeled modes and private cars dominate energy use, while by income groups in the household sector, the middle-income group is the largest consumer, accounting for 43.34% of the overall final energy demand. This condition can be understood because the number of middle-class households is the largest of the total number of households. It can be seen in Figure 3 and Figure 4. The final energy estimation by sector in Central Java Province implies that the government must be able to provide energy needs to guarantee energy supply in this region.

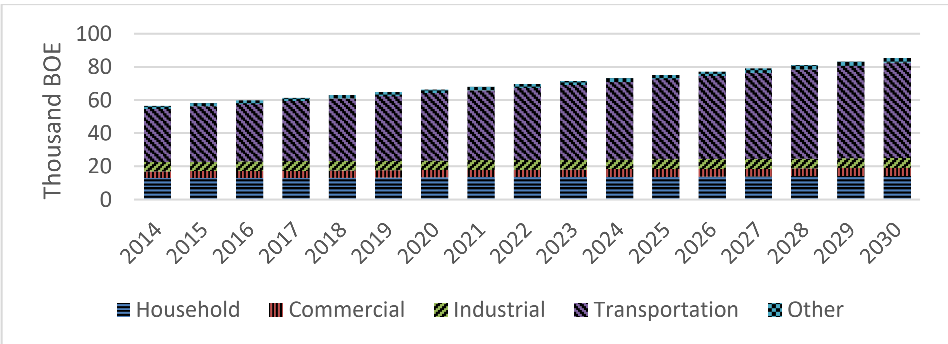

Figure 3 BAU Final Energy Demand by Sector

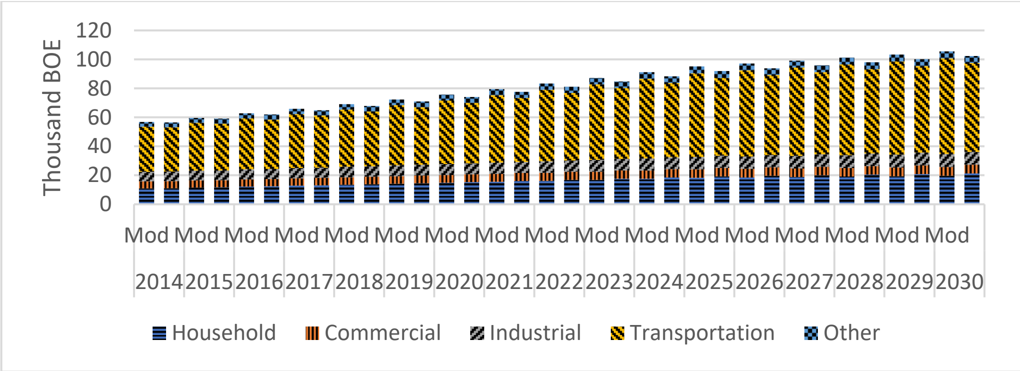

Figure 4 MOD and POT Final Energy Demand by Sector

Estimated Final Energy Demand by Energy Types

The final energy demand by energy type for all activity sectors under the BAU scenario is shown in Figure 5. The demand for premium energy types in Central Java Province is the biggest energy use during the projection period. In 2030, premium demand will be 33,342.88 thousand SBM or 39.04% of the total energy demand. The use of diesel oil or Automotive Diesel Oil (ADO) will be a fuel energy type with the second largest use after premium, reaching 25,638.15 thousand SBM or 30% of the total final energy use. Then, kerosene will be the third-largest type of energy usage, reaching 7,942.88 thousand SBM, or 9.3% of the total final energy in 2030. Under the MOD and OPT energy efficiency scenarios, the premium will also be the biggest energy use during the projection period, reaching 33,342.88 thousand SBM or 39.04% of the total final energy demand. The use of electricity during the projection year is also still quite large due to the large population and many middle-class industries in this province. In detail, this condition can be seen in Figure 6. As the price of kerosene is released through the market mechanism and converted to LPG, the use of firewood becomes greater during the projected year. This condition indicates that not all communities targeted by the government to use LPG use this energy. It is because the community feels less familiar with the use of gas stoves as cooking tools, and many industries or household businesses are still loyal to using firewood for cooking.

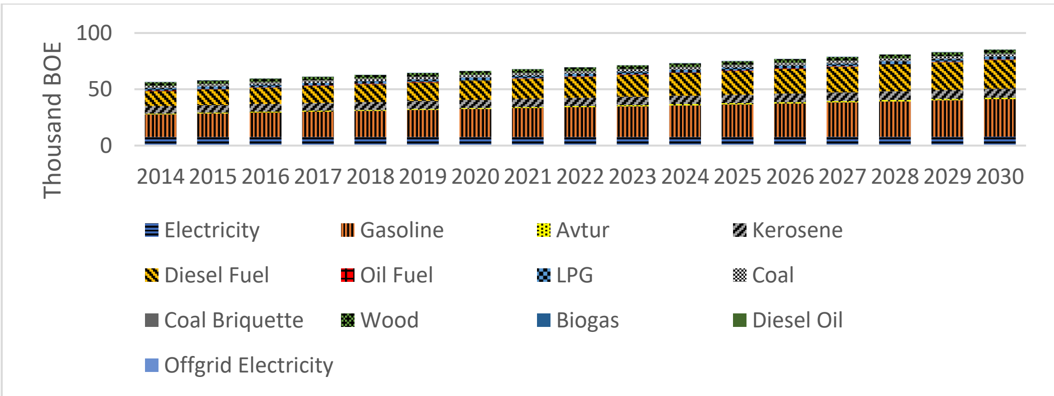

Figure 5 BAU Final Energy Demand by Energy Types

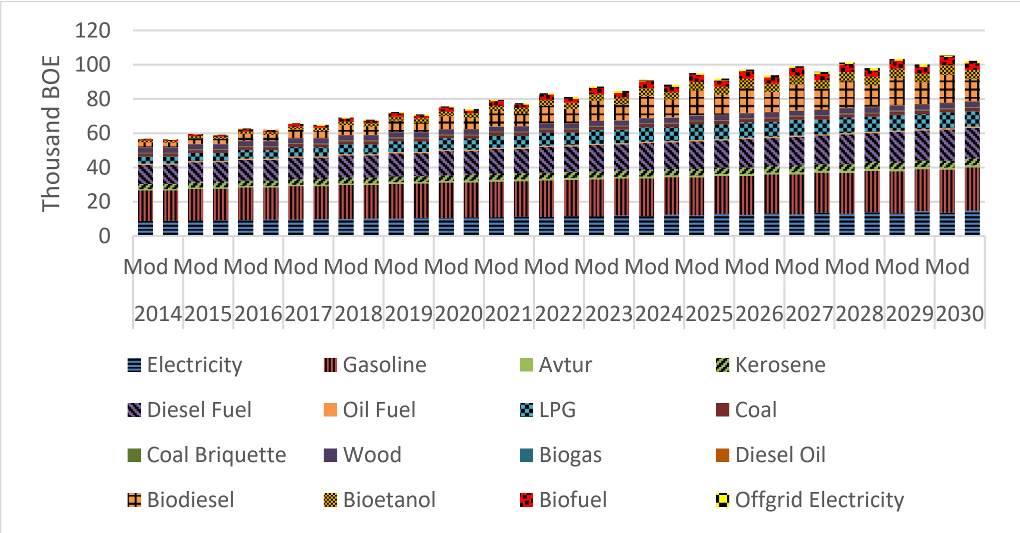

Figure 6 MOD and POT Final Energy Demand by Energy Types

Implications of the final energy estimates per sector in Central Java Province are then to ensure energy supply in this region, and the government must be able to provide energy needs, as shown in the following Table 7.

Table 7 Energy Needs in 2030

No	Central Java Province	
	Energy Types	**Energy Needs**
1	Electricity (MWh)	12,837,719.22
2	Oil/Premium (KL)	8,087,759.69
3	LPG (Ton)	1,050,735.52
4	Coal (Ton)	459,523.92
5	Coal Briquettes (Ton)	134,101.24

Energy Use Efficiency

Conservation actions and programs for energy use in accordance with the scenarios used, namely efficiency measures by utilizing existing potential energy efficiency, conservation, and diversification through the development of renewable energy, have resulted in more efficient use of energy. Energy use efficiency is indicated by the elasticity level of energy use to economic value added. Energy elasticity below 1.0 will be achieved if the available energy has been used productively. High energy efficiency figures indicate that energy use is inefficient or wasteful. This condition also indicates the low competitiveness of the industry due to energy inefficiencies that have an impact on high production costs. Energy efficiency in Central Java Province can be seen in Figure 7.

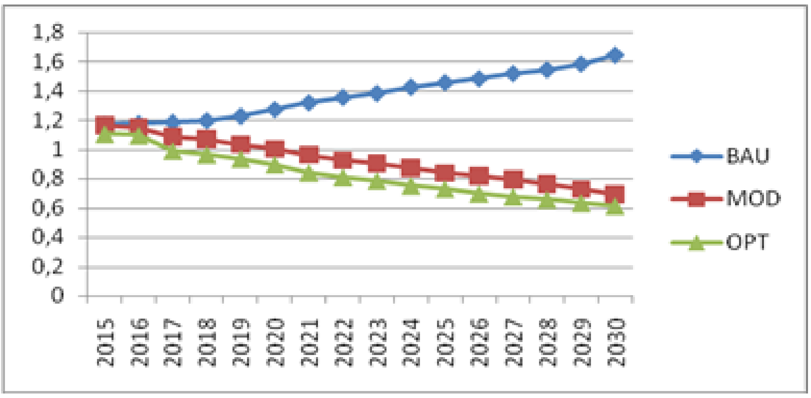

Figure 7 Energy Use Efficiency in Central Java Province

Figure 7 confirms energy efficiency in the Central Java Province by using the BAU scenario until the end of the year that the projection is still greater than 1 (e> 1), both for electricity and fuel energy. This condition illustrates that energy use in the Central Java Province has not been efficient or wasteful because increasing 1% economic growth requires greater amounts of energy. Meanwhile, based on energy efficiency scenarios, both moderate and optimistic, by including aspects of energy conservation policies as stated above, energy efficiency in Central Java Province until the end of the year is projected to be less than 1 (e <1), both for electricity and oil. The efficiency of energy use based on the MOD scenario started to be achieved in 2021 until the end of the projection year, whereas based on the OPT scenario, energy efficiency was achieved in 2017. It signifies that the Central Java Province can optimize energy use to be more efficient with the various implementation of conservation programs. The implication is that increasing economic growth by 1% will only require less energy, and the available energy will be used productively.

Conclusion

Based on the projected final energy demand per sector, in 2030, the use of energy in the Central Java Province region will increase by an average of 5.6% per year, with the overall final energy demand of 1,683,091.24 thousand SBM, 1,554,163 thousand SBM, and 1,405,829.46 thousand SBM for each BAU, MOD, and OPT scenarios. The decline in overall energy use based on the scenarios developed will occur due to the utilization of energy efficiency potentials and the development of renewable energy potentials in the roadmap of the 5-year renewable energy development program up to 2030. The transportation sector still dominates energy demand in Central Java, with a percentage of use of more than 60% of the overall final energy demand. The household sector is the second largest consumer at 20.67%.

Under the BAU scenario, energy use in Central Java during the projection year will still be inefficient (e> 1). This condition indicates the low economic sector competitiveness due to energy inefficiency that will impact high production costs. Energy use in the Central Java Province began to achieve efficiency in 2021 and 2017, respectively, based on moderate and optimistic scenarios. It indicates the need for energy efficiency programs where energy use is efficient and rational without reducing the energy needed to support regional economic development.

In this study, the end-use approach was used as a parameter of energy demand for each sector. The economic sector's amount of energy used or consumed to carry out its activities was revealed. Thus, this approach can be used as a reference in developing non-price-based energy demand models or non-price-based energy policies.

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