Renewable energy integration for lower emission planning and achieving regional energy independence: study in Yogyakarta

Syadan Hussein Ismail[1] and *Lilies* Setiartiti[1]

[1]Master of Economics, Universitas Muhammadiyah Yogyakarta, Indonesia

Abstract. We propose and try to find a model renewable energy integration for lower emission and achieving regional energy independence. The research uses three stages. First, building an energy system model, to analyze the impact of implementing energy efficiency programs. The second stage is developing an integrated model from the energy demand and supply. Finally, arranging a mitigation scenarios to develop a low-carbon energy and achieving energy independence. Long-range Energy Alternative Planning (LEAP) software was utilized to simulate two scenarios are used to analyze energy demand and supply, namely Baseline scenarios and Mitigation scenarios. Mitigation Scenario is a combination of Energy Efficiency (EE) scenario, Fuel Substitution (FS), mode change scenario (MC), and efficient vehicle (EV) scenario and is used to analyze their impact on energy demand and GHG emissions. The results showed that mitigation scenarios can reduce energy demand by 22.86% when compared to the baseline scenario. In 2050, energy demand based on the mitigation scenario is 147.15 x 103 TJ, higher than based on the baseline scenario, which energy demand is 113.52 x 103 TJ. The cumulative of GHG emission reaches 1,369.37 x 103 Tons of CO2 Equivalent, based on the baseline scenario, can be reduced 13.54% by mitigation scenario. These results are robust. Overall, this research finding provides some possible steps to develop Yogyakarta energy independence and other regions. Keywords: Lower emission, renewable energy integration, energy independence, Yogyakarta

1 Introduction

Energy independence is a situation in which domestic energy production is adequate to meet the energy needs without depending on any foreign source [1-10]. Energy independence is a powerful concept that might look a simple to grasp, which relates to the capability of self-provide energy for itself. Energy independence as well as concern for carbon emission are policy topics, that have been frequently discussed in the public stage. Nevertheless, it can assume different interpretations depending on the subject of the matter; as energy independence on a building, a district, a village, or a country scale have different implications and issues. How we generate energy, how to provide energy security, what are the investments required, what is a policy framework coherent with the goals, how to shape the market addressing equality and energy poverty. All these questions can have different answers depending on what scale we are choosing to investigate.

Countries around the world that are currently in an energy transition, are favor electricity as the preferred final energy carrier. This a favorable from the perspective of both renewable and energy efficiency. Electricity is a sourced from renewable energy [11]. The ambition of renewable energy targets has been consistently raised in many countries, including Indonesia, for other reasons. Indonesia has targeted the share of renewable energy in the energy mix, at least 23% in 2025 and 31% in 2050 [9]. Issues related to climate change, including global warming and extreme weather, are considered one of the biggest challenges facing the world today. On 12 December 2015, nearly 200 countries at the United Nations Framework Convention on Climate Change (UNFCCC) agreed to adopt the Paris Agreement, a legally binding framework, which is an internationally coordinated effort to prevent climate change beyond 2020 [12]. This agreement implies that all countries, including Indonesia, should try to reduce their greenhouse gas emissions by 2040 and become carbon neutral by 2060/2070 [12]. One form of this commitment is that the Government of Indonesia has redesigned its energy policy.

Yogyakarta is a province that have no the energy supply to meet the people's energy demand, and almost all energy needs such as fuel oil and LPG are supplied from outside the region with usage increasing every year. Electrical energy is supplied from the Java-Madura-Bali (JAMALI) interconnection network because there is no power plant to meet the electricity needs of the people of Yogyakarta. This condition means that all community activities in Yogyakarta depend on the stability of energy supply from other regions. However, Yogyakarta has several renewable energy sources that can be optimized for energy supply.

Based on the Yogyakarta Regional Energy Plan (RUED), energy demand for the transportation sector is very dominant, reaching 2,735.45 thousand TOE in 2030 or 83.81% of the total energy use. The rest are in industrial sectors, commercial, and other sectors, each amounting to 1.49%, 5.69%, and 0.82%, which is consumptive rather than productive. The use of fuel oil reached 90.42% or 2,951.23 thousand TOE, while the share of renewable energy was only 9.45%, the impact on carbon dioxide gas emissions of 7,522.33 thousand tons of CO2 in 2030 with a growth of 8.36% per year. The elasticity of energy use growth to GRDP growth in Yogyakarta reached 1.3. This indicates that energy use is still wasteful or inefficient where to run the economic activity of 1% per year requires energy with growth 1.3%. With this fact, the government should redesign a proper energy planning to carried out the strong energy security. Securing energy supply can be done by converting the energy systems that depend on fossil to renewable energy based. On the other hand, large-scale energy activities without proper planning cause a large impact on the environment, ecosystems and human health. Achieving energy independence by integrating renewable energy requires methodological transparency so that there is a synergy between policy, implementation, and technological innovation

Utilization of potential renewable energy sources is a new policy for Turkey in an effort to increase energy independence after experiencing an electrical energy deficit due to the dominance of imports of fossil fuels as the main supplier of primary energy. This deficit occurs due to high demand for electrical energy, increasing dependence on imported natural gas and hard coal, while the utilization of renewable energy is still relatively low. Increasing the utilization of coal reserves as the main fuel for power generation, Turkey's self-sufficiency rate in power generation fell from 77% in 1980 to 37% in 2014 [15]. Energy planning in order to achieve electrical energy independence is also carried out in India (Rhytm, 2018) by combining two renewable energy growth scenarios and three energy demand growth scenarios. The results of his study show that the share of electricity generated from the use of renewable energy continues to increase, from only 6% today to 43-44% in the period from 2031 to 2032. Developing renewable replacements for each of these products will not only reduce the demand for oil but will also open the possibility to reduce the energy used to derive these products [16].

Energy independence is a comprehensive concept, referring to the ability to self-provide energy for itself. The essence of energy independence is how to produce energy, provide energy security, what investments are needed, what policy frameworks are needed, and how to shape markets that address energy equality and poverty. Efforts to achieve electrical energy independence by integrating renewable energy have also been carried out in Slovenia. Renewable energy integration is carried out through energy supply networks at companies at the regional level to maximize energy supply. The MILP (Mixed-Integer Linear Programming) model has been developed for the synthesis of the enterprise supply network using various types of renewable energy as a source of enterprise energy supply, and is embedded into the MILP model, previously developed, for the synthesis of regional biomass production and supply networks. The integrated synthesis model was applied to existing large-scale meat companies. This research uses the LEAP model and integrates renewable energy to produce energy and energy security in achieving regional energy independence.

2 Research Methodology

In general, the research is carried out in three stages, namely developing an energy system model from the energy demand side. In the development of the energy demand model, the potential energy efficiency in each sector obtained from the survey results is integrated into the energy demand model. This model is then used to analyze the impact of implementing energy efficiency programs on energy demand. The second stage is to develop an integrated model of the demand and supply side of energy. This integrated model includes environmental impacts in the form of CO2 gas emissions as a result of the use of primary energy from fossil fuels. The role of efficiency programs and optimization of renewable energy sources in supporting low-carbon development can be analyzed using an integrated energy model. The last stage is developing a scenario for renewable energy in the development of low-carbon energy and efforts to increase energy independence.

2.1. LEAP Model

LEAP (Long-range Energy Alternatives Planning) is an integrated modelling tool that can be used to track energy consumption, production, and resource extraction in all sectors of an economy, which is developed by the Stockholm Environment Institute. LEAP provides easy-to-use tools to input data sets and has been promoted in many studies [1]-[2]. LEAP has been used for over 70 peer-reviewed journal papers including an investigation into CCS in Korea [3], analysis of the potential reductions in energy demand and GHG emissions within road transportation in China [4], identifying the feasible penetration of sustainable energy on the Greek island of Crete [5], and also an investigation into the benefits of improved building energy-efficiency in China [6]. The environmental impact of the energy sector is calculated by LEAP based on Tier 1 GHG emission factor of the global warming potential (GWP) of the fifth report of the inter-government panel on climate change (IPCC). GWP potential was implemented as a technology and environmental database (TED) inside the LEAP software to calculate the GHG emission as air pollution.

LEAP functions using an annual time-step, and the time horizon can extend for an unlimited number of years (typically between 20 and 50). LEAP supports a number of different modelling methodologies; on the demand side these range from bottom-up, end-use accounting techniques to top-down macroeconomic modelling. On the supply side, LEAP provides a range of accounting and simulation methodologies for modelling electric sector generation and capacity expansion planning. LEAP's modelling capabilities operate at two basic conceptual levels. At one level, LEAP's built-in calculation handle all of the "non-controversial" energy, emission, and cost-benefit accounting calculation. At the second level, users enter spreadsheet-like expression that ca be used to specify time-varying data or to create a wide variety of sophisticated multi-variable models, thus enabling econometric and simulation approach to be embedded within LEAP's overall accounting framework. Overall, LEAP can simulate all sectors and all technologies within energy system. LEAP also includes a scenario manager that can be used to describe individual policy measures. These can the be combined in different combination and to create alternative integrated scenarios. The comparison provided by LEAP assists in the identification of policies which will have the most significant impact on energy efficiency and the reduction of GHG emission [7]. Overall, LEAP facilitates the design of environmental related scenarios [8]. The analysis of scenarios is considered the main feature of LEAP.

2.2. Analytical Procedure

In general, the analytical model for determining energy in LEAP is

$$FC = \sum_{i} A_i \times I_i$$

where FC is energy consumption, A_i is activity level for sub sector i, and I is energy intensity for sub sector i. For the household sector, the sub-sector consists of people living in villages and cities. For each household sub-sector, a smaller division is made by dividing the population living in the village into two groups, namely households with and without electricity from the electricity company. Energy intensity in the household sector states the amount of energy used for each household in one year.

For the industrial and commercial sectors, the sub-sector consists of the industrial sub-sector and the commercial sub-sector. The industrial sector consists of 14 sub-sectors, namely the food industry, tobacco processing industry, textile industry, leather industry, wood industry, paper industry, chemical industry, rubber industry, metal and non-metal mining industry, metal goods industry, furniture industry, and other processing industries. The commercial sector is divided into 2 sub-sectors, namely the government and the private sector. Activities in the industrial and transportation sectors represent GRDP for each of these sectors, while energy intensity represents energy consumption per unit of GRDP in one year.

The transportation sector consists of passenger and freight transportation. Passenger transportation is divided into motorbikes, private cars, buses, trains, and airplanes. Passenger transportation activity states the number of passanger-km in one year with energy intensity being the energy consumption for each passanger-km. Freight transportation consists of trucks and trains. Goods transportation activity states the number of Ton-km in one year with energy intensity being the energy consumption for each Ton-km. Energy use in the transportation sector is calculated in two steps. First, calculate the energy intensity and its activities which is represented as a travel demand. These steps detailed below.

$$TD_{i,t} \text{ (pass-km or ton-km)} = \sum V_{i,t}\, AVT_{i,t}\, VOR_{i,t} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ (1)$$

$$V_{i,t} = V_{i(t-1)}\,(1+\Delta G * e_i) \quad \ldots\ldots\ldots\ldots\ldots\ldots\ (2)$$

$$V_{i,t} = Vi_{(t-1)}\,(1+\Delta P * e_i) \quad \ldots\ldots\ldots\ldots\ldots\ldots\ (3)$$

Where:

$TD_{i,t}$: Travel Demand in pass-km or ton-km
$V_{i,t}$: total number of vehicles in category i and dependent on population and GDP
$AVT_{i,t}$: average annual vehicle trips per category i vehicle in kilometers
t : the year index used in the LEAP.
ΔG : growth of GDP
ΔP : growth of population
e_i : elasticity of transportation to the GDP and population growth.

Energy intensity of transportation sector ($EI_{i,j,t}$) can be seen at the equation (4) in detailed below. Equation (4) confirmed that $FE_{i,j,t}$ is the fuel saving for each type j and each vehicle category i in vehicle kilometers per litre

$$EI_{i,j,t} \text{ (litre/pass-km or litre/ton-km)} = \sum_{i,j} \frac{1}{EFi,j,t} VOR_{i,t} \;\ldots\ldots\ldots\ldots (4)$$

Calculation of energy demand of transportation sector ($ED_{i,t}$) in the following step, will detailed in equation (5), while GHG emission ($EF_{j,k,t}$) is calculated in equation (6), reflecting emission factor of pollutant type *k* for fuel category *j* in year *t*.

$$EI_{i,t} \text{ (litre)} = \sum_{i,j} TD_{i,t} EI_{i,j,t} \;..\;\ldots\ldots\ldots\ldots\ldots\ldots\ldots (5)$$

$$Emission_t\ (CO_2\ E_q) = \sum_i \sum_k \sum_j ED_{i,t}\ EF_{j,k,t} \;\ldots\ldots\ldots\ldots\ldots\ldots\ldots (6)$$

2.3. Data and data sources

Data is an important part in the preparation of the model, so that accurate results will be obtained. For LEAP modeling, data are collected from various sources. Data on GRDP, population, and number of vehicles were obtained from the Indonesia Statistics Central Bureau (BPS). Data relating to primary energy supply is sourced from Pertamina, the national oil company in Indonesia, while electricity data is supported by PLN, the national electricity company in Indonesia. GRDP and economic growth of Yogyakarta served in Table. 1 below.

Table 1. Gross Regional Domestic Product (GRDP) and Economic Growth Of Yogyakarta 2019, Based on Constant Price 2010

No	Economic Sectors	2019		
		GRDP (IDR. million)	Growth	Share
1	Agriculture, forestry, fishing	8,184,692.0	1,03	10.19
2	Mining and quarrying	557,653.5	3.04	0.49
3	Manufacturing	13,201,887.1	5.73	12.83
4	Electricity and gas	165,217.4	5,43	0,14
5	Water supply, waste processing, waste and recycling	103,372.6	8.90	0.10
6	Construction	11,421,140.	14.39	9.63
7	Wholesale and retail, car, and motorcycle repair	8,643,437.9	5,16	8,41
8	Transportation and storage	5,493,402.2	3.55	4.57
9	Accommodation and food service activities	10,217,676.9	8.39	8.84
10	Information and communication	11,695,491.8	7,45	9,72

https://doi.org/10.1051/e3sconf/202450802009

No	Economic Sectors	2019		
		GRDP (IDR. million)	Growth	Share
11	Financial and insurance activities	3,805,395.9	8.52	4.03
12	Real estate	7,499,627.4	5.93	7.39
13	Business activities	1,224,235.0	6,75	
14	Public administration and defense; compulsory social security	7,477,921.5	3.30	8.44
15	Education	9,146,783.8	6.57	8.87
16	Human health and social work activities	2,764,571.4	6,61	3,18
17	Other services activities	2,887,199.8	6.25	2.27
Total and Regional Economic Growth		104,489,706.4	6.60	100.00

Source: Yogyakarta's BPS,2020

Based on the 2010 constant market prices, GRDP of Yogyakarta increase from 98.02 trillion rupiah in 2018, to 104.49 trillion rupiah in 2019. In other words, economic growth reached 6.60%. This economic growth rate is higher than the previous year which amounted to 6.20%, even higher than the national economic growth of 5.02%. The increase in GRDP based on constant prices is surely caused by increased production in all categories, without the effect of inflation. The biggest role in GRDP of Yogyakarta was generated by Manufacturing industry, which reached 12.85%. The second stage was a construction sector of 11.11%, furthermore the Accommodation and Food Service Activities, amounted to 10.35%.

As a small province in Indonesia, Yogyakarta only has four districts and one city, with a total population of 3,842,932 people with a population growth of 1.18%, while population density per sq km reached 1,206 people. Population is the main actor in regional economic development. The existence of the population is a factor that supports or hinders development, depending on its quality.

Table 3. Population, Population Growth Rate, by Regency/Municipality in Yogyakarta Province, 2019

No	Region	Population	Population Growth Rate	Population Density per sq.km
1	Kulonprogo	430,220	1.13	734
2	Bantul	1,018,402	1.24	2,009
3	Gunungkidul	742,731	1.06	500
4	Sleman	1,219,640	1.22	2,122
5	Yogyakarta City	431,939	1.18	13,290
Yogyakarta Province		**3,842,932**	**1.18**	**1,206**

Population growth has implications for meeting the basic needs of the people, including energy needs. As a province that have no energy sources, both electricity and fossil energy, the fulfillment of energy needs in Yogyakarta was supported from outside the region, especially from Central Java Province. Therefore, integrating the potential of renewable energy in regional energy planning is considered very important, in addition to achieve energy independence, as well as an effort to reduce the effect of greenhouse gases as a result of the people activities.

Table 4. Total Number of registered Vehicles and Related Variables

Type of Vehicles	Fuel Share (%)	Total Registered Vehicles	Mileage (km)	Load Factor	Fuel Economy (km/l)
Passenger Car		374,118	20,100	1.8	
- Gasoline	94.30				11.0
- Diesel	0.70				14.0
- Biodiesel	5.00				14.0
Bus		48,713	31,000	42.0	
- Diesel	95.0				6.0
- Bio-Diesel	5.00				6.0
Truck		158,994	31,000	8.3	
- Diesel	93.00				5.0
- Bio-Diesel	7.00				5.0
Motor Cycle		3,4238,740	8,000	1.3	
- Gasoline	100.00				35.0

Source: Traffic service

Table 5. Activities of the Non-road Transportation Sector

Type o Modes	Fuel Share (%)	Activity	Unit
Passenger Train		831.40	Million Pass-km
- Diesel	100.00		
Cargo Train	100.00	127.56	Million Ton-km
- Diesel			
Passenger Airplane		986.77	Million Pass-km
- Avgas	0.03		
- Jet Oil	99.97		
Cargo Airplane		94.92	Million Ton-km
- Jet Oil	100.00		

Source: Traffic service

3 Scenario Development

In this study, two scenarios are used to analyze energy demand and supply. The first scenario is the baseline scenario. This scenario is a scenario without any new policy interventions in energy planning. Energy intensity and fuel use in each sector do not change during the planning period. In addition, does not accommodate fuel substitution in every equipment used in the household sector. In the transportation sector, the vehicle technology used and the mode of transportation have not changed.

The second scenario is the mitigation scenario. Mitigation scenarios consist of fuel substitution, energy efficiency, and changing modes in the transportation sector. Fuel substitution is implemented in every sector with the aim of replacing some of the energy sources from fossil energy with renewable energy. Therefore, the emission factor of 0.86 kg CO2/kWh has been added to this scenario [19]. The use of more efficient technology is implemented by changing the energy intensity in each sector. Meanwhile, changes in transportation modes are used to analyze the impact of using public transportation which is more than the use of private transportation.

Mitigation Scenario is a combination of Energy Efficiency (EE) scenario, Fuel Substitution (FS), mode change scenario (MC), and efficient vehicle (EV) scenario and is used to analyze their impact on energy demand and GHG emissions. The EE scenario is a representation of the use of equipment with a better level of efficiency and this is represented by a decrease in energy intensity changes. The FS scenario describes a change in the type of fuel used to support the same activity. These two scenarios, namely EE and FS, are applied in all sectors. The MC scenario is a scenario that represents a change in modes in the transportation sector. In this scenario, the use of private vehicles will be shifted to the use of public transportation. In addition, for the transportation sector, the EV scenario is also applied. This scenario represents a more efficient use of vehicles including electric vehicles.

4 Results and Discussion

This section discusses in detail and briefly the results of the LEAP model simulation. The discussion is divided in two sections. The first section discusses the projection of energy demand in all sectors based on the scenario developed during the projection year. GHG emissions as a result of the fuel used in all sectors are discussed in the second section. Each pollutant that contributes to global warming is briefly described.

Two scenarios have been developed to calculate the projected energy demand. The scenarios are (1) baseline scenario and (2) mitigation scenario. The baseline scenario describes the calculation of the projected energy demand based on the parameter values that occur in the base year and these parameters do not change throughout the projection calculation period. Mitigation scenarios consist of fuel substitution and energy efficiency scenarios. The fuel substitution scenario describes changes in the pattern of use of the fuel type in each sector and activity. Energy efficiency scenario describes a change in the pattern of energy users by using more efficient equipment. In the transportation sector, the energy efficiency scenario is described as a change in the mode of transportation and a change in the type of vehicle from the existing one to a vehicle that is more energy efficient, including a vehicle with electric energy as the primary energy.

4.1. Energy Demand Projection

Efforts to reduce carbon emissions and achieving energy independence are carried out through the development of renewable energy in all sectors and utilizing energy efficiency potentials into scenario simulations, namely baseline scenarios and mitigation scenarios. There is no intervention in the baseline scenarios throughout the energy projection. Mitigation scenarios consist of fuel substitution and energy efficiency scenarios in all sectors.

Based on the baseline scenario, the demand for electrical energy up to 2050 is shown in Figure 1. In 2050, the overall energy demand will reach 147.15 x 103 TJ. When compared to the demand for electrical energy in 2019, energy demand in 2050 grew by 174.14% with an average annual growth of 3.31%. Based on the baseline scenario, energy demand in the transportation sector dominates the energy demand structure throughout the projection period. In 2019, the transportation sector requires energy of 31.38 x 103 TJ or 59.36% of the total energy demand in 2019. In 2050, energy demand in the transportation sector will reach 62.68 x 103 TJ or 42.59% of overall energy demand by 2050.

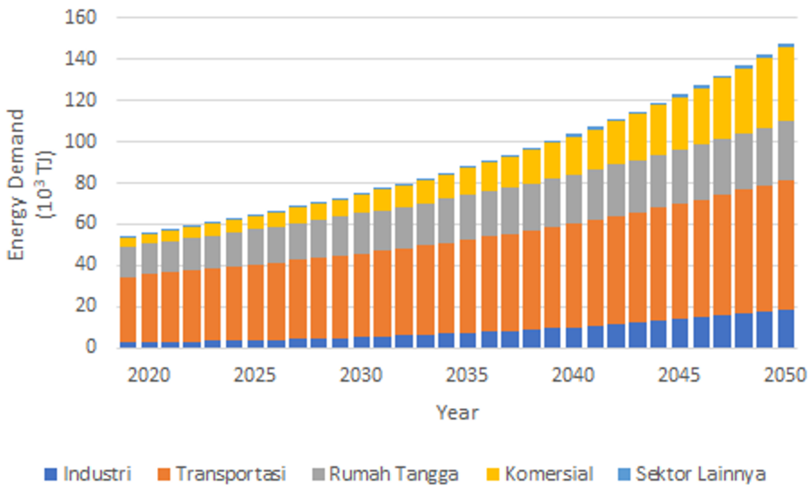

Fig. 1. Energy demand by sector for the baseline scenario.

Based on the mitigation scenario, energy demand in each sector is shown in Figure 2. When compared to the baseline scenario, the calculation result of energy demand based on the mitigation scenario will decrease by 22.89% in 2050. This decrease in energy demand is caused by the energy efficiency scenario which is part of the energy efficiency scenario. of the mitigation scenario. When compared to energy demand in 2019, energy demand in 2050 based on the mitigation scenario grew by 111.48% with an average annual growth of 2.56%. Similar to the results of the projection calculation based on the baseline scenario, the transportation sector dominates energy demand throughout the projection period. In 2050, the transportation sector requires 49.86 x 103 TJ of energy or 33.88% of the total energy demand in 2050.

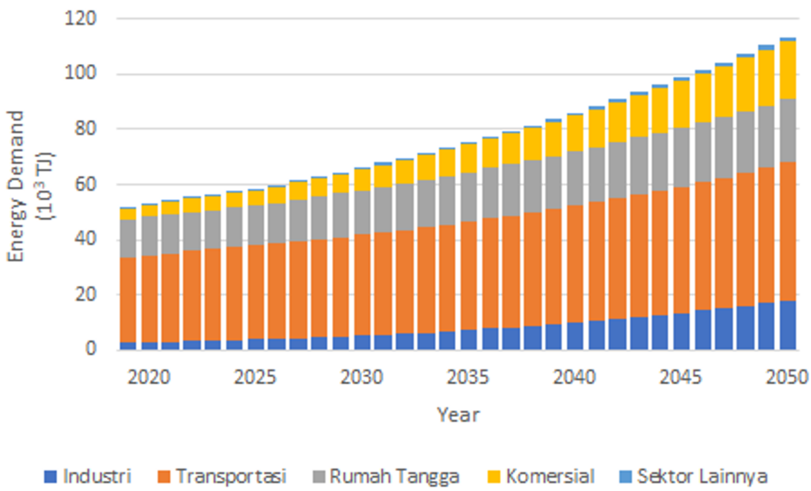

Fig. 2. Energy demand by sector for mitigation scenarios.

Overall, the different scenarios reduce the energy demand projected. It should be noted that the projection results for energy demand are exposed to several uncertainties due to certain assumption related to some variables. For example, the load factor of the vehicle is assumed to be constant and remains the same during the projection period. This might not be the situation as the load factor is likely to change as the population growth.

4.2. GHG Emission Projection

Renewable energy integration in lower emission transitions, including energy transition, have therefore been recognized by the international community as a change process that must simultaneously reach multiple goals: greening the economy, providing clean energy access, reducing, ensuring decent jobs, while protecting the environment and mitigating climate change [17]-[20]. CO2, NO2, and CH4 are the gasses emitted by the transportation sector which directly contribute to global warming [18]. This section briefly explains every emitted gas and combine these gasses as GWP factor in all the scenarios. The impact of energy use is the generation of greenhouse gas (GHG) emissions. Based on the baseline scenario, GHG emissions generated as the impact of activities in each sector are shown in Figure 3.

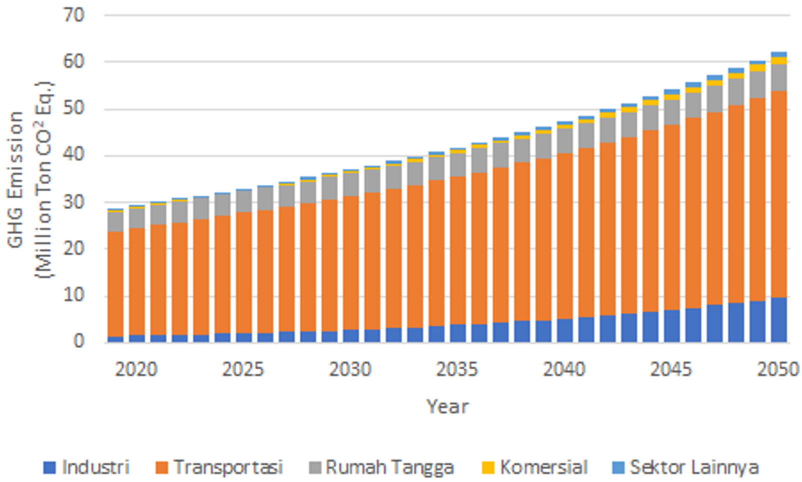

Fig. 3. GHG emissions in each sector based on the baseline scenario

Based on the baseline scenario, GHG emissions experience an average growth of 2.55% per year. The transportation sector has the largest contribution in generating GHG emissions, which is 71.29% of the total GHG emissions produced in 2050. Based on the mitigation scenario, the emissions produced during the projection period are shown in Figure 4. When compared to the baseline scenario, the average growth is The average annual GHG emission produced under the mitigation scenario is lower, which is 1.92% per year. Just as in the calculation based on the baseline scenario, the transportation sector produces the largest GHG emissions when compared to other sectors. In 2050, the transportation sector will produce GHG emissions of 33.40 x 103 Tons CO2 Equivalent or 67.00% of the total GHG emissions in 2050.

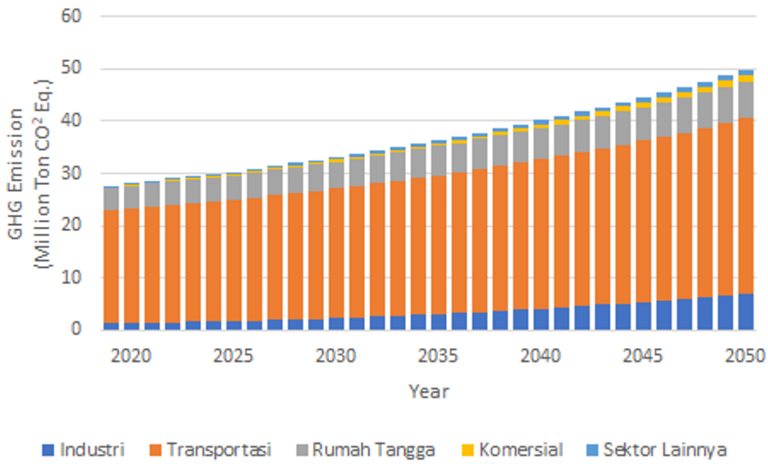

Fig. 4. GHG emissions in each sector by mitigation scenario

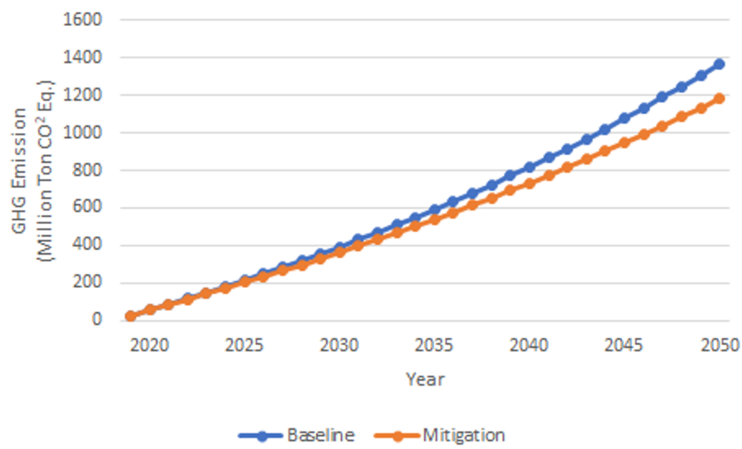

Fig. 5. Comparison of cumulative GHG emissions by scenario

Cumulatively, the GHG emissions generated for each scenario are shown in Figure 5. It can be seen that the mitigation scenario produces lower cumulative GHG emissions when compared to the baseline scenario. The mitigation scenario results in 13.54% lower cumulative GHG emissions when compared to the cumulative GHG emissions generated based on the baseline scenario. The resulting GHG emission is the impact of the emission of several gases that are taken into account in the projection calculation, namely carbon dioxide gas (CO_2), methane gas (CH_4), and Nitrogen Oxide gas (NOx). In physical units, the cumulative emissions of CO_2 gas, CH_4 gas, and NOx gas are shown in Figure 6, Figure 7, and Figure 8.

CO_2 gas is the main gas causing the greenhouse effect resulting from burning fossil fuels for transportation, cooking, power generation, industry, etc. Carbon emissions can cause major impacts such as unpredictable climate change which can lead to flooding, famine, and economic instability. In addition, if allowed to continue, carbon emissions can also cause air temperatures to increase and cause global warming. This is certainly very dangerous for the survival of living things on Earth. Therefore, it is important to prevent excessive use of carbon emissions for better survival. Mitigation scenarios consisting of fuel substitution, use of more efficient equipment, in House-Hold sectors, business, and industry sectors, also mode switching in the transportation sector resulted in a 13.5% reduction in CO_2 gas emissions when compared to CO_2 gas emissions in the baseline scenario (Figure. 6).

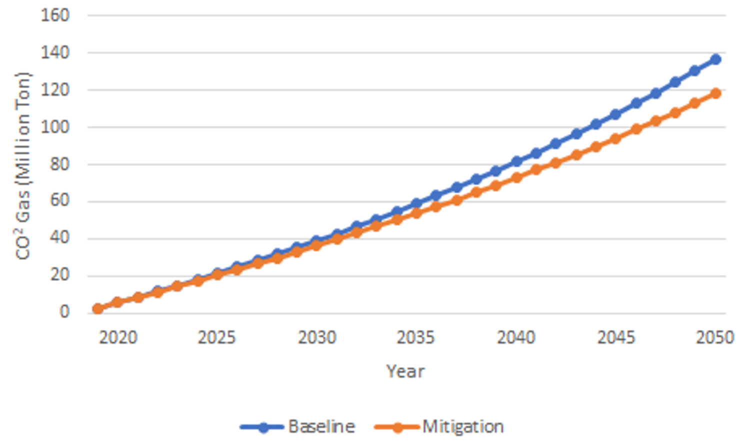

Fig. 6. Cumulative CO_2 emissions based on scenarios.

Methane (CH_4) is the main component in natural gas, which fuels industrial plants, power homes and runs air conditioner, among other applications. Methane is colorless, odorless, and highly flammable gas. It is composed of carbon and hydrogen. It is also a potent greenhouse gas, meaning it affects climate change by contributing to increased warming (US Environment Protection Agency). Methane enters the atmosphere via human-related activities and natural sources. Methane is the second most prevalent greenhouse gas, after carbon dioxide (CO_2). Approximately 80% of greenhouse gases come from carbon dioxide emissions, 10% from methane and the remaining 10% from various others source. Mitigation scenarios consisting of fuel substitution, use of more efficient equipment, in House-Hold sectors, business, and industry sectors, also mode switching in the transportation sector resulted in a 16.85%, reduction in CH_4 gas emissions when compared to CH_4 gas emissions in the baseline scenario (Figure. 7).

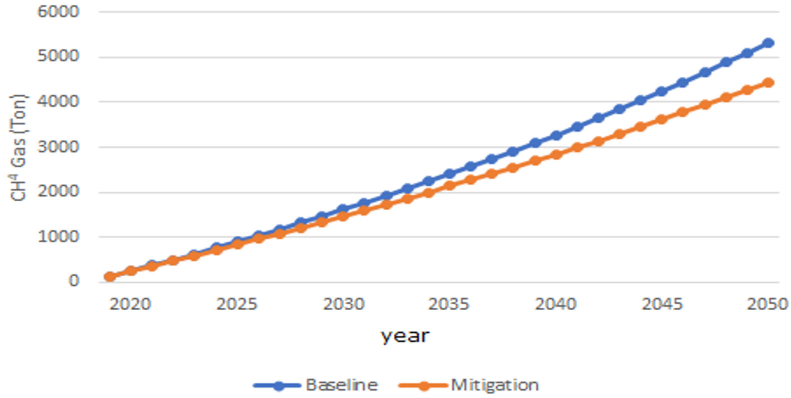

Fig. 7. Cumulative emissions of CH_4 gas based on scenarios.

NOx is composed of nitric oxide (NO), and smaller percentage of more poisonous nitrogen dioxide (NO_2). Fossil-fuel burning is by far the main man-made source: cars, trucks, tractors and boats, or industrial processes lie power generation and cement-making. Elevated levels of nitrogen dioxide can cause damage to the human respiratory tract and increase a person's vulnerability to, and the severity of, respiratory infections and asthma. By mitigation scenarios consisting of fuel substitution, use of more efficient equipment, in House-Hold sectors, business, and industry sectors, also mode switching in the transportation sector resulted in a 23.99% reduction in NOx gas emissions when compared to NOx gas emissions in the baseline scenario (Figure. 8). Thus the impact of NOx on the environment and human health can be sized with this mitigation scenario.

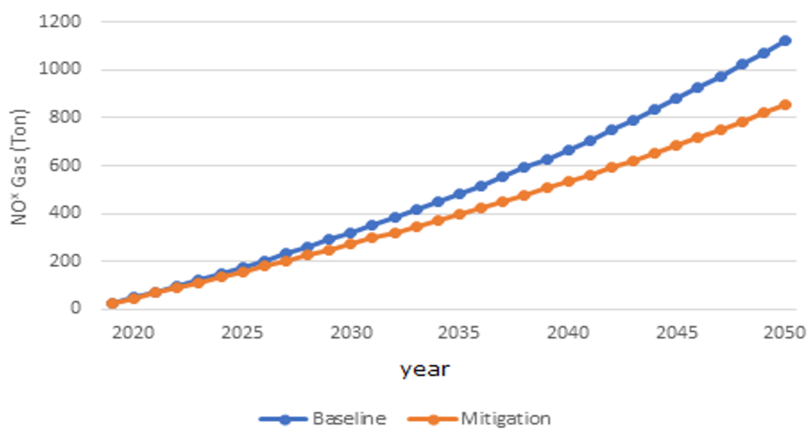

Fig. 8. Cumulative emissions of NOx gas based on scenarios.

5 Conclusion

This research contribution, we propose on the implication of renewable energy integration model for lower emission and achieving regional energy independence toward a more sustainable economic development. Related to our analysis, the main conclusions as follow:

1. Mitigation scenarios can reduce energy demand by 22.86% when compared to energy demand using the baseline scenario. In 2050, energy demand based on the mitigation scenario is 147.15 x 103 TJ. Meanwhile, based on the baseline scenario, energy demand in 2050 is 113.52 x 103 TJ. This condition confirms that the mitigation scenario makes energy use more efficient.
2. The cumulative GHG emission generated based on the baseline scenario is 1,369.37 x 103 Tons of CO2 Equivalent. Meanwhile, based on the mitigation scenario, cumulative GHG emissions can be reduced by 1,183.98 x 103 Tons of CO2 or by 13.54%. Thus, the implementation of mitigation scenarios has a better effect on the environment and human health

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