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Implementation of Energy Diversification Policy to Fulfill Electricity Needs and its Impact in Environmental Quality Improvement on Sumba Island East Nusa Tenggara

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Abstract: ***Sumba Island covering East Sumba, West Sumba, Central Sumba and Southwest Sumba districts has become Indonesia's national program as Renewable Energy Iconic and targets by 2025, one of the goal is electricity needs on that island will be fulfilled by utilizing renewable energy sources (non-fuel). Implementation of energy diversification policies in Sumba aims to by utilizing local energy sources for electricity generation to meet the electricity energy needs of the Sumba people, and have an impact on improving environmental quality. For that it is needed requires analysis and mapping of electricity demand per user sector, mapping of renewable energy sources and plans for its use, can provide an overview of the demand and availability of electricity in the community of Sumba Island 2017-2025. Modeling of energy mix is needed and then illustrated that if there is no change in demand patterns and availability of electricity (moderate scenarios), then compare with energy diversification scenario (optimization of renewable energy potential) if the mix energy is changed, fossil energy power plants (Diesel Power Plants) are gradually reduced and no longer functioned in 2025 and how that policy impacts to environmental quality in Sumba.***

Keywords: Electrical energy needs, renewable energy, diversification policy, environment quality impacts

1. Introduction

Since 2010, Sumba Island has been proclaimed nationally to become the Renewable Energy Iconic Island and become a pilot project in Indonesia, how to meet the electricity needs of the community no longer using Conventional Power Plants, but utilizing Local Renewable Energy (RE) sources. Sumba Island, which covers West Sumba, East Sumba, Central Sumba and Southwest Sumba Regencies, was chosen to be pilot project because Sumba has low Electrification Ratio [15], 85% of electricity demand in Sumba still supplied using Diesel Power Plants (DPP) but on the other hand, Sumba has potential of renewable energy (water, wind, solar, biomass), 20% of the population of Sumba is still classified as poor [1]. Referring to the Indonesian Government Regulation Number 79 of 2014, regarding the National Energy Policy which targets the achievement of Electrification Ratio in Indonesia in 2020 will reach 100% and the role of the Renewable Energy (RE) for energy and electricity utilization must reach 23% by 2025[2]. The government needs to regulate and make policies that facilitate investment for the public and private sectors in the utilization and development of RE, [3],[4]. The Law of the Republic of Indonesia, Number 30 of 2009, concerning electricity gives regional government full authority to develop plans and policies both between regions and regions and regions with the center [5]. For the Program and Development of Sumba Island as a Renewable Energy Iconic Island it is necessary to plan and make use of the electricity sector through of diversification policy. Thus, it is able to ensure the availability of sustainable electrical energy on Sumba Island. Implementing energy diversification policy in Sumba requires analysis and mapping of electricity demand per user sector, mapping of renewable energy sources and planning of its use for electricity generation and then can provide an overview of the demand and availability of electricity in the community of Sumba Island 2017-2025. For this reason, modeling energy mix is needed and then simulated using with three scenarios, namely the moderate scenario, illustrating that there is no change in demand patterns and availability of electricity, high and low scenarios show an increase and fall in electricity consumption intensity per customer by 1% with assumed is influenced by the rise and fall regional economic growth rate, and energy diversification scenario (optimization of renewable energy potential) if the mix energy is changed, Diesel Power Plants are gradually reduced and off in 2025 and how the application of these diversification policies impacts the environment. Scenarios and modeling are done by LEAP (Long-Range Energy Alternative Planning System).

2. Material and Methods

2.1 LEAP Review

LEAP is modeling software that is widely used in several countries as the main tool for analyzing both forecasting energy demand and supply scenarios focusing on energy, electrical energy systems. Some works can be mentioned as Emodi et al. (2017) in Nigeria; Lind and Espegren (2017) in Oslo; Dayana et al. (2016) in Brunei Darussalam; Nojedehi et al. (2016) in Tehran; De et al. (2015) in Brazil; Ates (2015) in Turkey; McPherson and Karney (2014) in Panama; Bautista (2012) in Venezuela; Xu et al. (2012) in Henan Province; Liu et al. (2011) in Beijing; Wang and Zhang (2011) in China; Liu et al. (2011) in Jiangxi; Dagher and Ruble (2011) in Lebanon; Huang et al. (2011) in Taiwan; Phdungsilp (2010) in Bangkok; Jun et al. (2010) in Korea and Shabbir and Ahmad (2010) in Rawalpindi e Islamabad.

Mining and Energy Foundation, Department of Energy and Mineral Resources (2012) uses LEAP as a tool for analyzing energy demand-supply planning in Indonesia from 2000 - 2010.

2.2 Modeling with LEAP

To determine the method and model of analysis, the previous base year has been set, namely 2016, while projections or forecasts are carried out over the coming 2017-2025 period. After all the necessary data is grouped, then modeled, simulated and processed using LEAP software

2.2.1 Drive Variable Module

In the Drive Variable Module, the general parameters used in the projection of electricity supply in Sumba are population, number of households, number of electricity customers, electrical energy consumption, Regional Revenue, population growth, GRDP (Gross Regional Domestic Product).

2.2.2 Request Module

Electricity customers in Sumba are divided into customer tariff groups, namely the Household tariff Sector, Industrial tariff Sector, Public and Social tariff Sector, Commercial tariff Sector. By using LEAP software the demand for electrical energy is calculated based on the amount of energy consumption activity and the amount of energy consumption per activity or energy use intensity. Energy use activities are related to the level of the economy and population [6].

a. Household Sector

The use of electricity in the Household Sector is obtained from the number of electricity customers and the use of electricity. Historical data from 2011 to 2016 are the number of customers and the use of electrical energy in the Household Sector obtained from the PLN in East Nusa Tenggara. Energy consumption intensity is defined as the energy used (KWH) divided by the number of electricity customers. Demand or energy consumption of household sector will continue to increase in coming years, along with increasing economic growth, economic activities, population growth, and price and availability of electronic goods (appliances) to be more affordable by the community. Later, household energy consumption is influenced by various factors, such as economic factors, electrical equipments, household characteristics and demographic characteristics as well as other factors [7]

b. Industrial Sector

Historical data from 2011 to 2016 are the number of customers and the use of electrical energy in the industrial sector obtained from the PLN in East Nusa Tenggara. Energy consumption intensity is defined as the energy used (kWH) divided by the number of electricity customers. The industrial sector consumes a lot of energy. Energy intensity is inversely proportional to efficiency. Less energy use to produce products is an indicator of energy use efficiency [8]. Industrial growth has an important role in the economy. The faster industrial growth, the lower the poverty level of a region

c. Government and Social Sector

The Public and Social sectors studied are social and government institutions. Data on public and social sector energy use activity is obtained from PLN in East Nusa Tenggara from 2011 to 2016. Energy intensity data is defined as the number of KWH consumed per year.

d. Commercial Sector

The use of electricity in the Commercial Sector is obtained from the number of electricity customers and the use of electricity. Energy consumption intensity is defined as the energy used (KWH) divided by the number of electricity customers.

2.2.3 Transformation Module

This module is used to calculate electricity supply. The electricity supply consists of primary energy and secondary energy production. The structure of the branches in the Transformation Module has been determined by LEAP, and each energy transformation activity consists of processes and outputs. The process shows the technology used for energy conversion, transmission or distribution. Output is a form of electrical energy generated from the process. Calculation is done in bottom-up. Starting from the amount of energy demand, calculated up to the primary energy source. The branches in the Resources Module will appear by themselves according to the types of energy modeled in the Transformation Module.

3. General Description of Sumba Island

The Sumba Island ids a part of East Nusa Tenggara Province and has area 10.710 km² and the highest point is Mount of Wanggameti (1.225 m). Sumba Island borders Sumbawa in the Northwest, Flores Island in the Northeast, Timor Island in the East, and Australia in the South and Southeast. The Sumba Strait is located north of the island. In the east lies the Savu Sea and the Indian Ocean located to the south. Sumba Island consists of 4 (four) districts namely West Sumba Regency, Southwest Sumba Regency, Central Sumba Regency and East Sumba Regency.

3.1 Climate Conditions

As in other parts of Indonesia, in the districts of East Sumba, Central Sumba, West Sumba and Southwest Sumba, only 2 (two) seasons are known, namely the dry season and the rainy season. The climatic conditions of the 4 (four) regencies located on Sumba Island are relatively similar, ie from June to September, the wind currents come from Australia and do not contain much moisture, resulting in a dry season. On the contrary, in December to March the wind flow contains a lot of water vapor that comes from Asia and the Pacific Ocean, resulting in a rainy season. This situation changes every half year after passing the transition period in April-May and October-November. However, considering that Sumba Island and NTT are generally close to the Australian Territory, wind currents that contain lots of water vapor from Asia and the Pacific Ocean reach the Sumba region, the moisture content has decreased which results in less rainy days on Sumba Island compared to the region who are closer to Asia. This makes Sumba Island classified as a dry region.

3.2 Demographic Conditions

Total population of Sumba Island in 2015 was 755.849 people. The largest population is in Southwest Sumba District with 319.119 people, and Central Sumba Regency is the district with the smallest population of 68.515 people. When viewed and sorted by area, East Sumba Regency has the largest area compared to other regencies in Sumba, namely 7.005 kM2 (63.65%), followed by Central Sumba Regency 1.817,88 kM2 (16.52%), Southwest Sumba Regency with an area of 1.445,32 kM2 (13.13%) and West Sumba Regency with an area of 737.42 kM2 (6.7%).

3.3 GRDP (Gross Regional Domestic Product)

GRDP based on constant 2010 prices, the period 2010-2016 on Sumba region generally shows an increase every year. When viewed from the average GRDP growth rate, the highest GRDP growth was found in East Sumba Regency, which was 5.08% per year, followed by Southwest Sumba Regency 5.06% per year, West Sumba Regency 4.92% per year and Central Sumba Regency 4.34% per year. If it is stated with the rate of GRDP growth on Sumba Island during on that period it reaches 4.85% per year. Figure 1. Show average growth rate of GRDP by Regency in Sumba 2011-2016 [10] [11] [12] [13].

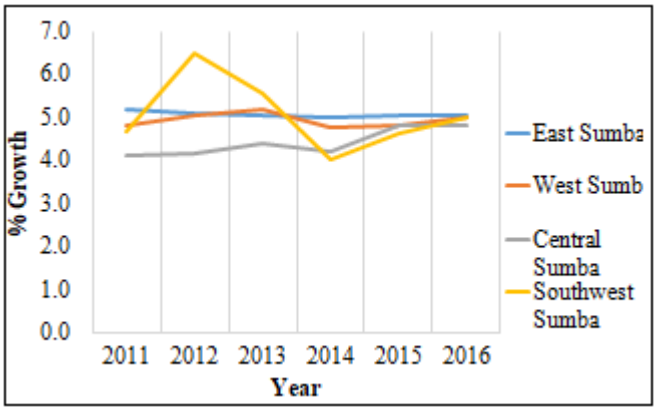

Figure 1: Average Growth Rate of GRDP by Regency in Sumba 2011 - 2016

3.4 Income per capita

The average per capita income of the population of Sumba year of 2013-2015 is Rp.6.59 million per year, with an average growth rate of 2.82% per year. Income per capita of residents in East Sumba Regency on average Rp.12.35 million per year, with an average rate of revenue growth of 3.51% per year. West Sumba Regency averages Rp.9.28 million per year, with a growth rate of 3.01% per year and Southwest Sumba District of Rp.5.74 Million per year with a growth rate of income during the 2013-2015 period of 2.72 % per year.4. Existing Conditions and Electrical System Planning in Sumba

4. Electrical System on Sumba

4.1 Electric Service Administration Areas

Administratively, the PLN in the NTT region divides Sumba Island into three parts of customer service area namely branch of East Sumba, branch of West and Central Sumba Rayon, and branch of Sumba Jaya (Southwest Sumba). Electric power system in Sumba Island is generally isolated and the distribution of electricity to the customer is supplied through a 20 kV distribution network. Until the end of 2015, Electric power capacity in region Sumba area reaches 15.83 MW and nighttime peak load 12.9 MW.

4.2 Electricity Customers Based on Tariff Groups

Electricity Customers Based on the Tariff Group and the general electricity customers based on tariffs are household tariff customers, business / commercial tariff customers, government and social tariff customers, and industrial tariff customers.

4.3 Number of Electricity Customers in Sumba 2011-2016, based on tariff groups

The number of electricity customers in Sumba based on tariff groups throughout 2011-2016 can be found in Figure 2, below.

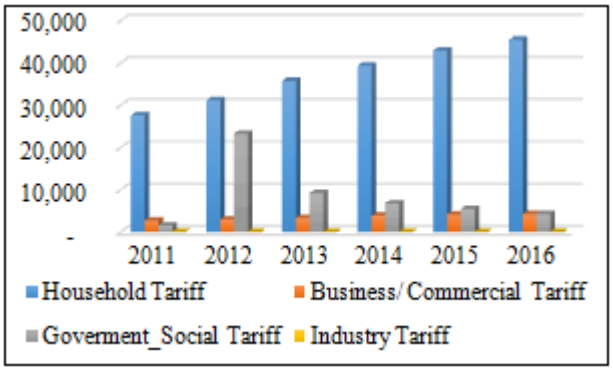

Figure 2: The Number of Electricity Customers In Sumba Based on Tariff Groups

Electricity customers at Sumba are the highest number of electricity customers. Until 2016, electricity customers had household tariffs of 45.501 customers, followed by electricity customers and government tariffs of 4.291 customers, business tariff customers with a total of 4.233 customers and industry customers totaling 13 customers.If divided by service area and per customer tariff group, during period of 2011-2016, on East Sumba area, Household tariffs customers dominate with an average percentage 80.69%, Government and Social tariff customer groups 11.7%, Business/ Commercial tariff customer groups 7.58% and Industrial tariff customer groups 0.03%. On West and Central Sumba region, household customers still dominate with an average percentage 71.13%, Government and Social tariff customer groups 17.72%, Business / Commercial tariff customer groups 11.12% and customer tariff of Industrial 0.03%. Average percentage of electricity customer composition in Sumba Barat Daya also shows the same dominance pattern, household customers still dominate with average percentages 74.95%, Government and Social tariff customer group 21.23%, customer group Business / Commercial rates 3.81% and Industrial tariff customer groups 0.01%. **See Figure 3.**

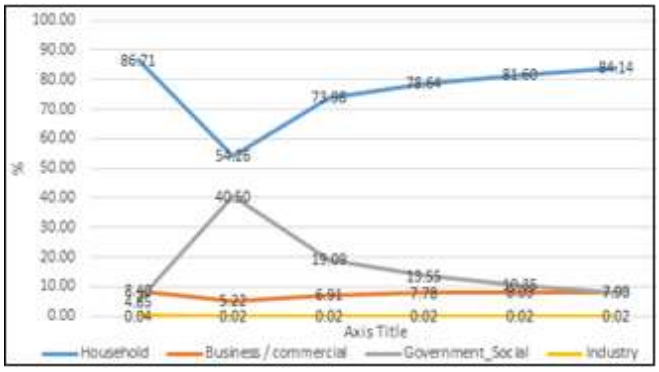

Figure 3: Percentage of dominance of electricity customer groups in Sumba in 2011-2016

4.4 Electric Energy Consumption

Viewed based on the service area, electricity consumption on Sumba Island in 2016 reached 78.47 GWH / year. East Sumba region consumes electricity of 35,007 GWH / year (44.61%), West and Central Sumba 18.38 GWH / Year (23.42%) and Southwest Sumba 25,079 GWH / Year (31.96%). Electricity Consumption in Sumba 2011-2016 can be seen in Figure 4.

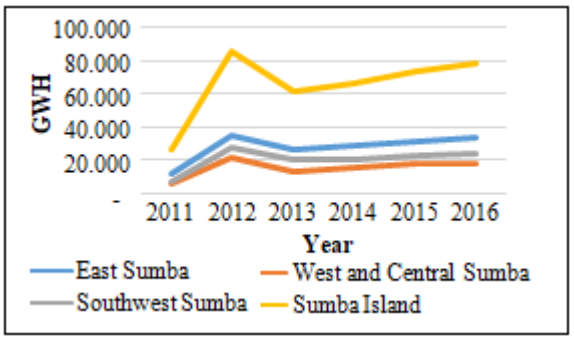

Figure 4: Electricity Consumption in Sumba 2011-2016

5. Electricity System Development Plan in Sumba

The Electricity System Development Plan in Sumba is adjusted to the development prospects and local electricity load requirements. To meet the electricity needs of the people on Sumba Island, including the districts of East Sumba, Central Sumba, West Sumba and Southwest Sumba until the next 2025, the PLN plans to develop the electricity system in Sumba with the addition of new power plants and the construction of 70 kV High Voltage Air Channels from Southwest Sumba, namely Tambolaka to Waingapu, in East West Sumba. Figure 5 below shows the development plan of the Electrical System in Sumba.

Figure 5: Map of Electrical System Development on Sumba Island

From Figure 6 above, the plan to develop the electrical system on Sumba Island includes the addition of Waingapu Gas Engine Power Plant (GPP), in East Sumba, with a capacity of 10 MW in 2019/2020 and 2021/2022 Gas Engine Power Plant (GPP) Waitabula, Southwest Sumba, with a capacity of 20 MW. The addition of Biomass Power Plant (PLTBM) in 2018 is 1 MW in Waikabubak, West Sumba [16].

5.1 Potential of Renewable Energy (Water, Solar, Wind and Biomass)

Sumba Island does not have fossil energy sources such as petroleum, coal and natural gas. So far, the need for final energy derived from petroleum, coal and natural gas is supplied from other regions on Indonesia. To meet electricity needs in Sumba until 2016, 85% supplied using Diesel Power Plants (PLTD) and the rest use of Micro Hydro Power Plants (PLTMH), Solar Power Plants (SPP), wind Power Plants (PLTB) and Biomass Power Plants (PLTBM). The potential of renewable energy in Sumba is spread almost evenly throughout the region. PLN on East Nusa Tenggara Region plans to optimize the use of renewable energy in Sumba and gradually reduce the electricity supply of DPP and the target to be achieved in accordance with the direction of national energy policy namely the use of renewable energy at least 23%. The following is outlined utilization of renewable energy for electricity generation in Sumba.

5.2 Water Energy

Potential sources of water energy in Sumba are scattered in four districts. Some of the water energy potential that has been used for Mini Power and Microhydro Power Plants, among others in Southwest Sumba Regency has been operated Mini Hydro Power Plant, Lokomboro I with an installed capacity of 800 kW, Lokomboro II and III, 1000 kW, and Lokomboro IV and V amounting to 400 kW, Lokomboro 6 with an installed capacity of 200 kW, Lokomboro VII with an installed capacity of 200 kW. The development plans for Lokomboro VIII and IX are 200 kW each. Development plan and operation of mini and micro hydro power plants in 4 (four) districts in Sumba in 2017-2025 with a total installed capacity of 8.5 MW. The map of the distribution of potential and plans for the development of

mini-power plants and the micro-hydro of Sumba can be seen in the following Figure 6.

Figure 6: Map of the Development Plan for Mini and Micro Hydro Power Plants in Sumba 2017-2025

5.3 Solar Energy

Solar potential in the province of East Nusa Tenggara (NTT) generally and in the Sumba region in particular is very potential to be used for electricity generation, because of the high intensity conditions of solar irradiation radiation, and the short rainy season. Thus the Sumba region tends to get abundant sun exposure throughout the year. this condition provides enormous benefits, let alone associated with geographical conditions and the hilly and mountainous topographical area of Sumba with communities lived spreading, the use of sunlight for solar power plants (SPP) off/on grid and Solar Home Systems (SHS) can be utilized to fulfill the electricity needs of the people in the Sumba Region. Existing condition of the Solar Power Plant (SPP) which has been operating in Sumba namely SPP Bilacenge I with an installed capacity of 500 kWP in Southwest Sumba Regency and SPP Salura 150 kWP in East Sumba Regency. SPP development and development plans in Sumba in 2017-2025 by the PLN on East Nusa tenggara Region and spread in 4 (four) regencies in Sumba, with a total installed capacity of 10.75 MWP. Figure 7 shows the planned use of solar energy for electricity generation (SPP) which is spread in 4 (four) regencies in Sumba.

Figure 7: Map of the Development Plan and Development of Solar Power Plants (SPP), in Sumba 2017-2025

5.4 Wind Energy

The minimum speed wind for turbine can produce electrical energy is 3 m / s. There are also several areas in Sumba where wind energy has the potential to be used for electricity generation. There are 2 (two) potential areas in Sumba that are suitable for wind energy utilization, namely in Haharu Subdistrict, East Sumba, potential wind speeds of 4.6 m / seconds and in Paberiwai District, West Sumba, with a wind speed of 4.01 meters /second.

5.5 Biomass Energy

State of Electricity Company, East Nusa Tenggara Region, has planned one area in Sumba for the utilization of biomass for Biomass Energy Power Plant, with a capacity of 1 MW, in West Sumba Regency, using Kaliandra Plant, utilizing an area of 200 Ha.See Figure 5.

6. Implementation of Energy Diversification Policies

Most of the electricity needs in Sumba which include the districts of East Sumba, Central Sumba, West Sumba and Southwest Sumba are still supplied with use of fossil power plants, (Diesel Power Plants). The power capacity is capable of Diesel Power Plants in each district, 5.56 MW in East Sumba, 2.6 MW to serve the electricity needs in West and Central Sumba District and 2.37 MW to serve the electricity needs in Southwest Sumba Regency. It is assumed, the intensity of electrical energy consumption is influenced by economic growth and population on Sumba Island. If the rate of economic growth and population increase will affect the increase in electricity consumption by 1% (high scenario) and if the economic growth and population on Sumba Island decreases it will have an impact on reducing electricity consumption by 1% (low scenario) and if the economic growth of Sumba does not experience increase and or decrease, electricity consumption in Sumba remains (moderate scenario).The application of diversification policies to meet the demand for electricity customers in Sumba is carried out by optimizing the use of renewable energy sources. Electricity generation is carried out as efficiently as possible, using a merit order scheme, that generation electricity with the lowest cost will be prioritized to operate, compared to the more expensive ones, until the electricity load is sufficient. It is assumed that the margin of electricity reserves in Sumba is 35%. Modeling and simulation is done using the help of LEAP (Long Range Energy Alternatives Planning).

6.1 Electricity Consumption per Regency in Sumba

Electricity Demand for Sumba Island in the next 2025 will reach 155.55 GWH (moderate scenario), 154.56 GWH (low scenario) and 157.68 GWH (high scenario). The rate of growth of electricity consumption in Sumba during the period 2017-2025 averaged 7.82% per year for the low scenario, 7.9% per year for the moderate scenario and 8.06% for the high scenario. When viewed from the percentage of electricity consumption growth per area during 2017-2025, the consumption electricity rate on Southwest Sumba district shows a trend of higher electricity consumption growth with an average growth of 8.26% per year, followed by East Sumba 7.95% per year and West and Central Sumba 7.38 % per year.

1) East Sumba Regency

The demand for electricity in East Sumba dominance by the Household Tariff Group with the amount of electricity demand in 2025 will reach 62.28 GWH, with the average rate of demand growth throughout 2017 - 2025 of 7.9% per year, followed by the customer business with 7.15 GWH with the average demand rate electricity per year 8.18%, customer social and government rates 5.71 GWH with an average annual electricity demand rate of 8.35%, and industrial customers of 0.05 GWH with an average annual growth rate of demand showing a downward trend of -0.84%. Electricity demand per customer group in East Sumba Regency 2017-2025 can be seen in Table 1, below.

Table 1: Demand for Electricity in East Sumba

Customer Tariff Group	2017	2018	2019	2020	2021	2022	2023	2024	2025	Avr
Household	33.87	36.54	39.42	42.53	45.89	49.52	53.45	57.69	62.28	37.31
Growth (%)	7.86	7.87	7.88	7.89	7.90	7.91	7.93	7.94	7.95	7.90
Business / commercial	3.81	4.12	4.46	4.82	5.22	5.64	6.11	6.60	7.15	4.26
Growth (%)	8.17	8.17	8.17	8.18	8.18	8.18	8.18	8.18	8.18	8.18
Goverment and Social	3.00	3.25	3.52	3.82	4.14	4.48	4.86	5.27	5.71	4.55
Growth (%)	8.25	8.27	8.30	8.33	8.35	8.38	8.41	8.44	8.46	8.35
Industry	0.06	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05
Growth (%)	-0.85	-0.85	-0.84	-0.84	-0.84	-0.83	-0.83	-0.83	-0.82	-0.84
East Sumba (GWh)	40.75	43.97	47.46	51.22	55.30	59.70	64.47	69.62	75.19	54.54
Growth (%)	7.90	7.92	7.93	7.94	7.95	7.97	7.98	7.99	8.00	7.95

2) West Sumba and Central Sumba Regencies

Demand for electricity in West and Central Sumba is still dominated by the Household tariff customer group, with the amount of electricity demand until 2025 reaching 30.16 GWH, with the average rate of demand growth throughout 2017 - 2025 of 7.32% per year, followed by customer business rates amounting to 3.49 GWH, with an average rate of electricity demand per year of 7.69%, customers of social and government tariffs of 3.03 GWH with an average rate of electricity demand per year of 7.88%, and electricity tariffs of industrial customers of 0.02 GWH, with an average rate of demand growth per year shows a downward trend of -1.48%. Electricity demand per customer group in West and Central Sumba Districts 2017-2025 can be seen in Table 2.

Table 2: Demand for Electricity in West and Central Sumba

Customer Tariff Group	2017	2018	2019	2020	2021	2022	2023	2024	2025	Avr
Household	17.14	18.39	19.73	21.16	22.71	24.38	26.16	28.09	30.16	23.10
Growth (%)		7.27	7.28	7.29	7.31	7.32	7.34	7.35	7.37	7.32
Business_commercial	1.93	2.08	2.24	2.41	2.60	2.79	3.01	3.24	3.49	2.64
Growth (%)		7.68	7.68	7.68	7.69	7.69	7.69	7.69	7.70	7.69
Goverment_Social	1.65	1.78	1.92	2.07	2.23	2.41	2.60	2.81	3.03	2.28
Growth (%)		7.77	7.80	7.83	7.86	7.89	7.92	7.95	7.98	7.88
Industry	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.02	0.03
Growth (%)		-1.49	-1.49	-1.49	-1.48	-1.48	-1.48	-1.47	-1.47	-1.48
West and Central Sumba	20.75	22.28	23.91	25.67	27.57	29.61	31.80	34.16	36.70	28.05
Growth (%)		7.33	7.35	7.36	7.38	7.40	7.41	7.43	7.44	7.39

3) Southwest Sumba Regency

The demand for electricity in Southwest Sumba is also dominated by the Household Tariff Group, with the amount of electricity demand until 2025 reaching for 36.32 GWH, with the average rate of demand growth in throughout 2017 - 2025 of 8.26% per year, followed by the demand for business rates 4.09 GWH with an average annual electricity demand rate of 8.33%, social and government tariff customers 3.22 GWH with an average annual electricity demand rate of 8.32%, and industrial customers of 0.03 GWH with an average annual growth rate of demand showing a downward of -0.98%. Electricity demand per customer group in Southwest Sumba District 2017-2025 can be seen in Table 3, below.

Table 3: Demand for Electricity in Southwest Sumba

Customer Tariff Group	2017	2018	2019	2020	2021	2022	2023	2024	2025	Avr
Household	19.23	20.82	22.53	24.39	26.40	28.59	30.96	33.53	36.32	21.68
Growth (%)	8.21	8.22	8.24	8.25	8.26	8.28	8.29	8.30	8.32	8.26
Business / commercial	2.15	2.33	2.53	2.74	2.97	3.21	3.48	3.77	4.09	2.45
Growth (%)	8.31	8.32	8.32	8.33	8.33	8.33	8.34	8.34	8.35	8.33
Goverment and Social	1.70	1.84	1.99	2.16	2.34	2.53	2.74	2.97	3.22	2.73
Growth (%)	8.20	8.23	8.26	8.28	8.31	8.34	8.37	8.41	8.44	8.32
Industry	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03
Growth (%)	-0.99	-0.99	-0.98	-0.98	-0.98	-0.97	-0.97	-0.96	-0.96	-0.98
Southwest Sumba	23.12	25.02	27.08	29.31	31.74	34.36	37.21	40.30	43.66	26.90
Growth (%)	8.20	8.22	8.23	8.25	8.26	8.28	8.29	8.31	8.32	8.26

7. Moderate Policy and Energy Diversification Policy in Sumba in 2017-2025

Scenario of moderate policy describe that all electricity needs in Sumba will still be supplied using existing power plants, existing plant of Micro Hydro Power Plants (MHPP), Solar Power Plants (SPP) and Biomass Power Plant (BPP), wind Power Plant (WPP) and Gas Power Plant (GPP) come into the Sumba system of 30 MW supplied from Waingapu GPP in 2019/2020 located on East Sumba Regency and Waitabula GPP in 2021/2022 on Southwest Sumba Regency. The operation of the Renewable Energy Power Plant existing conditions also continue to be operated. Scenario of diversification policy describe that all electrical energy needs in Sumba still supplied using the DPP, but supply from DPP is gradually reduced and by the end of 2025, the DPP is off (no longer operated). The Waingapu Gas Power Plant (GPP) with a capacity of 10 MW and the Waitabula Gas Power Plant (GPP), 20 MW entered into the Sumba system in 2019/2020 and 2021/2022, but the electricity supply from GPP will be reduce gradually 1% per year. Power plants sourced from renewable energy will be upgraded and adapted to development plan of Electricity Company Nation, East Nusa Tenggara Region

7.1 Application of moderate scenario Energy Policy

The results of simulating the implementation policy of the moderate scenario in Sumba 2017-2025 can be seen in Figure 8 below.

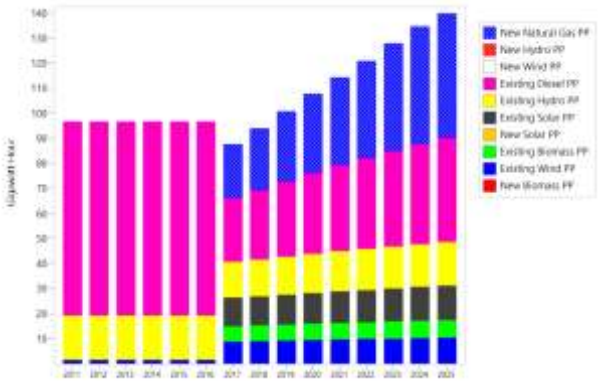

Figure 8: Fulfillment of electrical energy needs on Sumba 2017-2025 (Moderate scenario Policy)

From figure 8 above, if implementing a moderate scenario policy for meeting the electricity needs in Sumba in 2017 - 2025, then the electricity supply to the Sumba System in 2017 is 84.62 GWH and increase to 155.5GWh in 2025. The fulfillment of electricity needs in Sumba during this period was obtained from the supply of Gas Engine Power Plant (GPP) 21.3 GWH in 2017 and in year 2025 it will increase to 49.5 GWH (35.4%). GPP operations must be accelerated from the time previously planned to anticipate the demand for electricity in Sumba. The electricity supply from the existing DPP (Diesel Power Plant) to the Sumba system also increased by 25.6 GWH in 2017 to 41.6 GWH (48.8%) in 2025. Additional electricity supply to the Sumba system was also obtained from existing HPP, electricity generation capacity needs to be increased, because contribution HPP to the system expected on year 2025, amounting to 17.3 GWH (18.5%).The same thing like the existing of SPP is 13.7 GWH (9.8%), the existing BPP is 7.1 GWH (5.1%) and the existing WPP 10.4 GWH (7.5%). Percentage of contribution from Renewable Power Plant for existing conditions (HPP, SPP, WPP and BPP) to the Sumba System throughout 2017-2025 continues to decline and the role of electricity contribution to the Sumba system is taken over by the GPP and DPP, which at the end of 2025 supplied the Sumba system with 91.1 GWH (84.2%).

7.2 Application of Diversification Scenario Energy Policy

The simulation results of the implementation of the Diversification Policy on Sumba 2017-2025 can be seen in figure 9.

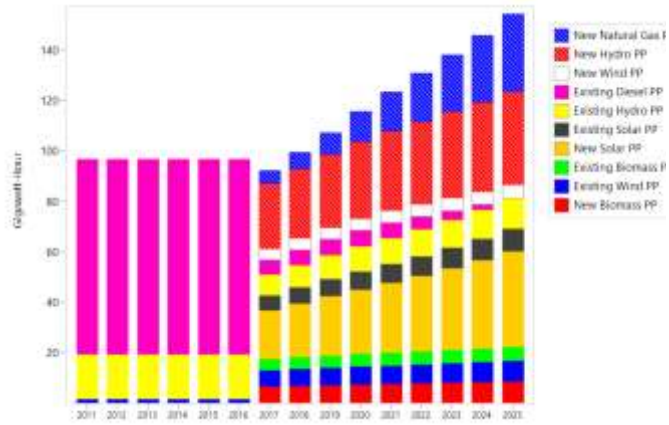

Figure 9: Implementation of the Diversification Policy on Sumba 2017-2025

From Figure 9 above, implementation of the diversification policy to meet Sumba's electricity needs during 2017-2025, the total electricity production in 2017 reached 84.62 GWH and then increased to 155.5 GWH in 2025. The contribution of electricity supply from GPP in 2017 was 5 GWH, then increased to 30.7 GWH (19.88%) at the end of 2025. GPP also had to operate in 2017 or faster than the planned time. The electricity supply from the existing DPP, will decreases gradually. In 2017, DPP supply amounting to 5.6 GWH and decreases gradually and is "off" or no longer operated (0%) in 2025. the end of 2025, electricity supply taken over by renewable energy power plants like existing HPP, existing SPP, existing WPP, existing BPP with a total supply of 34.5 GWH (22.36%). If the plan to develop and operate a new of renewable energy power plant by the PLN goes according to plan, then new HPP, new WPP, new SPP and new BPP will supply electricity to the Sumba system in year of 2025 amounting to 89.1 GWH (57.8 %).80.12% Electricity needs in Sumba at the end of year 2025 supplied by Renewable Energy Power Plants and the remainder by GPP

8. Implementation Impact of Moderate Policy and Diversification Policy to living Environment in Sumba

8.1 Moderate Policy

Implementation impact of operating the power plant in Sumba 2017-2025 to the living environment using Moderate Policy can be seen in Table 4, below

Table 4: Operation of Power Plants in Sumba in 2017-2025 and Their Impact to the Environment (Thousand Metric Tonne) according to Moderate Policy

Dampak	2017	2018	2019	2020	2021	2022	2023	2024	2025
Carbon Dioxide Biogenic	3.417	3.489	3.566	3.648	3.727	3.787	3.852	3.920	3.975
Carbon Dioxide	31.348	34.688	38.326	42.140	45.853	49.205	53.036	56.608	59.442
Carbon Monoxide	0.003	0.004	0.004	0.005	0.005	0.006	0.007	0.007	0.008
Methane	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.002
Non Methane Volatile Organic Compounds	0.001	0.001	0.001	0.002	0.002	0.002	0.002	0.002	0.003
Nitrogen Oxides	0.044	0.050	0.057	0.065	0.072	0.080	0.088	0.096	0.102
Nitrous Oxide	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Sulfur Dioxide	0.001	0.001	0.001	0.001	0.001	0.002	0.002	0.002	0.002
Total	34.807	38.234	41.957	45.861	49.462	53.083	56.988	60.638	63.533

In the end of year 2025, total amount of electricity need is 155.5 GWH. According to moderate policy, 35.4% of total amount electricity needs will supplied using Gas Engine Power Plants (GPP), 48.8% supplied from the operation of the Diesel Power Plant (DPP) and 5.1% of the Biomass Power Plant (BPP) or from the total amount of electricity production in Sumba to fullfill electricity needs, 89.3% of the electricity production produced was obtained from the process of burning diesel fuel, nature gas and biomass. Combustion process in these power plant produces gas emissions and pollute the air in form of CO2 Biogenic, CO2, CO, and NO2 with a total of 34.8 Thousand Metric Tonne in 2017 and increased to 63.5 Thousand Metric Tonne in year of 2025.

8.2 Diversification Policy

Implementation impact of operating the power plant in Sumba 2017-2025 to the living environment according to Diversification Policy can be seen in Table 5, below.

Table 5: Operation of Power Plants in Sumba in 2017-2025 and Their Impact to Environment (Thousand Metric Tonne) according toDiversification Policy

Impact	2017	2018	2019	2020	2021	2022	2023	2024	2025
Carbon Dioxide Biogenic	2.925	3.025	3.131	3.224	3.310	3.402	3.500	3.605	3.717
Carbon Dioxide	7.261	8.238	9.436	11.555	13.123	14.563	15.488	16.480	17.588
Carbon Monoxide	0.001	0.001	0.001	0.002	0.002	0.003	0.003	0.004	0.005
Methane	0.000	0.000	0.000	0.000	0.000	0.001	0.001	0.001	0.001
Non Methane Volatile Organic Compounds	0.000	0.000	0.000	0.001	0.001	0.001	0.001	0.001	0.002
Nitrogen Oxides	0.010	0.013	0.017	0.025	0.032	0.039	0.046	0.054	0.063
Nitrous Oxide	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Sulfur Dioxide	0.000	0.000	0.000	0.001	0.001	0.001	0.001	0.001	0.001
Total	10.198	11.278	12.586	14.806	16.469	18.009	19.041	20.147	21.377

In the end of year 2025, total amount of electricity need is 155.5 GWH. According diversification policy, DPPmust not operate anymore, biggest contribution to producing electricity to fullfill electricity needs in Sumba, 80.12% taken over by renewable energy power plants (HPP, SPP, WPP and BPP) and the remaining of 19.88% will contributed from the operation of the GPP and BPP. The operation process of GPP and BPP will produce CO biogenic, CO2 and NO2 gas emissions as many as 21.4 Thousand Metric Tonne.

9. Conclusions

The demand for electrical energy on Sumba Island in 2025 reached 155.5 GWH (moderate scenario). The electricity consumption of customers in East Sumba Region is the largest, followed by electricity customers from Southwest Sumba, and West and Central Sumba. Household electricity tariff customer group dominates electricity consumption in Sumba, followed by business / commercial customers, Government and Social customers and Industrial customers. The dominance of the number of household customers indicates that electricity consumption in Sumba is used for consumptive activities. The decline in the number of Industrial customers in Sumba indicate a warning that regional governments must think of policies / regulations and incentives that can attract investors to invest in their regions.

With Implementation of energy diversification policies, 80.12% electricity needs in Sumba will supplied by Renewable Energy Power Plants and this exceed the government's target set forth in Government Regulation Number 79 of 2014, regarding the National Energy Policy, states that role of the Renewable Energy (RE) using for energy utilization and electricity utilization must reach 23%, by 2025

With the implementation of energy diversification policies in Sumba, it will be impact to reducing the total amount of gas emissions (CO_2, CO, NOx, SOx,)

10. Acknowledgments

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