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Analysis of Hydroelectric Power Plants in East Kalimantan, Indonesia

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ABSTRACT

This study aims to determine the amount of potential renewable energy sources of hydroelectric power plants that have been used to meet the electrical energy needs in East Kalimantan at this time, the amount of potential renewable energy sources of hydroelectric power plants that have not been used for electrical energy needs in East Kalimantan at this time, and the planning of electrical energy to provide electrical energy in the province of East Kalimantan in order to In this study, energy supply and demand in the province of East Kalimantan were analyzed using LEAP (Long-range Energy Alternative Planning system) models. Analyze the energy supply and demand over the next thirteen years using 2012 as the starting point. The linear regression methodology used to project energy demand interpolates historical data, activity, and energy intensity. According to the study's findings, just 1,509 MW of the province of East Kalimantan's potential hydropower sources—6976.14 MW—have been used up to this point. In 2025, the population is expected to rise by 6,167,359 people, increasing the demand for electricity from 17,546,970 MWh to 20,643,495 MWh. According to the national energy management's blueprint for the goal composition of the energy mix, hydropower capacity in 2025 would have been 23,961,414 MWh or 55.56% of the overall producing capacity of 43,129,583 MWh.

Keyword: renewable energy, hydroelectric power plants, electrical energy.

INTRODUCTION

East Kalimantan Province has abundant natural resource wealth, including energy resources, both non-renewable energy resources and renewable energy resources. However, its utilization to produce energy that can produce the final energy ready to use so far is still very dependent on non-renewable energy resources, especially fossil energy resources (oil, gas, and coal). (Kåberger, 2018; Mufutau Opeyemi, 2021; Overland et al., 2022; Solarin & Bello, 2021) This is because the fossil energy supply is increasingly limited and decreasing. (Bhan et al., 2020; Ediger, 2019; Kataria & Khan, 2021)

At present, nationally, the amount of domestic fuel oil production is less than the need for using fuel oil for domestic purposes. This result has resulted in the government continuing to subsidize fuel oil for various domestic needs so that the rate of growth of the Indonesian economy can continue to grow and develop. Fossil energy, especially petroleum, is the primary energy source, but the reality shows that fossil energy reserves worldwide are limited. Meanwhile, energy consumption continues to increase in line with the rate of economic growth and population growth. (Baz et al., 2021; Ikram, 2021)

Many still need to utilize the potential of renewable energy, such as biomass, geothermal, solar energy, water energy, wind energy, and ocean energy. The use of renewable energy is very urgent, along with the issue of global warming due to the carbon dioxide crisis due to the use of oil and coal as the primary fuel for electricity generation. The opportunity to use renewable energy is enormous and environmentally friendly. (Kataria & Khan, 2021; Mufutau Opeyemi, 2021; Solarin & Bello, 2021)

By government policy to utilize new and renewable energy in Presidential Decree No. 5 of 2006 regarding the National Energy Policy, which prioritizes energy development from hydropower. Estimating the use of electric power will continually increase every year. This condition is due to the growing needs of society. Many factors influence the level of demand for electric power, such as economic factors, population, region, and others. (Baz et al., 2021; Erdogan et al., 2020; Maqin & Sidharta, 2017; Rodríguez-Lozano & Cifuentes-Yate, 2021; Wang et al., 2022)

Electricity is a basic human need; more than 60% of household appliances use electricity. However, most of us think the State can only provide electricity. However, we can supply our electricity by utilizing the river water flow and waterfalls we often encounter in villages or mountainous areas. (Singh & Singal, 2017; Yah et al., 2017)

Utilizing the flow of river water can save electricity supply from the State, but indeed, the power delivered is smaller than the electrical energy by the State. Such power plants are called hydroelectric power plants and micro-hydro power plants. (Álvarez et al., 2020)

Micro-hydro or micro power plants because the power from micro hydropower plants is on a small scale (still in the hundreds of kilowatts). In addition, it uses relatively simple equipment and a small area of land for micro-hydro operations. This condition is one of the advantages of Micro Hydro Power Plants. The utilization of water energy is also environmentally friendly because its utilization can minimize environmental damage. Water is a renewable energy, so its supply is abundant. This hydropower can come from river channels, irrigation canals, natural waterfalls, or even a ditch if the water is continuous. The working principle is to take advantage of the height of the waterfall and the amount of water discharged. (Mufutau Opeyemi, 2021; Singh & Singal, 2017; Yah et al., 2017)

There needs to be a Document on the Potential for New Renewable Energy sourced from hydropower as a reference for planning documents and how vital new renewable energy is as an option in efforts to improve the community's economy and sustainable development in East Kalimantan.

METHOD

We are conducting research in East Kalimantan Province with a total of 140 sub-districts and 1,420 villages by collecting primary and secondary data originating from the 2013 inventory of electricity demand throughout East Kalimantan. The initial stage of this research was in the form of preparation for research activities, then making a functional design for the implementation of the research. Implementation of activities begins with an inventory of data that includes data on the use and potential of primary and secondary energy in the province of East Kalimantan. The data consists of primary data and secondary data.

Primary data and detailed design engineering results for Micro Hydro Power Plants are available, as well as interviews with relevant officials in districts/cities in East Kalimantan Province to obtain information about water energy resources in their working areas. Energy sector policies contribute to energy resources to improve people's welfare and regional economic development, investment climate, socio-political conditions, and the implications of regional autonomy related to plans to utilize the potential of local energy resources. Secondary data from various sources, both Provincial Government agencies and Regency/City Regional Government agencies. The data in this study is historical data for ten years. Researchers need to visit the Central Bureau of Statistics, the State Electricity Company, and the Mining and Energy Office of the Province of East Kalimantan.

They are collecting data on related government and private agencies in each sub-district/village using the tracing method. Researchers make data tabulations in the data information system format. The second stage of the implementation of this research includes data processing and analysis. In analyzing, it is necessary to pay attention to the geographical conditions of areas with potential local energy resources, especially renewable energy, economic conditions, population, and the environment. At the same time, the third stage is reporting research results, including designs and recommendations.

The tools in this study are a set of computers and their equipment that are useful for processing and analyzing data. For field measurements, use the following equipment: current meter (water speed meter), compass, GPS, altimeter (measuring height above sea level) and distance meter (distance measuring device), and tape measure. The data in this study, both primary data and secondary data, were analyzed descriptively and qualitatively. Furthermore, energy planning methods can use the help of various models to produce various alternative optimal solutions for energy procurement. (Directorate General of Energy and Mineral Resources, 2003).

In carrying out this research, using The Long-range Energy Alternatives Planning software, later abbreviated as LEAP, is software to aid energy-environmental planning/modeling. (Adeyemi-Kayode et al., 2022; Hanif et al., 2019) LEAP works based on the assumption of the scenario that the user wants; the scenario on calculations from the process of converting fuel into energy until the energy process reaches the community. (Dos Anjos et al., 2021; Emodi et al., 2017) LEAP is a model that considers the end-use of energy to include various energy-use technologies. LEAP's advantage over other energy-environmental planning/modeling software is the availability of an attractive interface system that provides ease of use and is accessible to people in developing countries. LEAP can perform analysis quickly from an energy policy idea to an analysis of the policy results, and this is because LEAP can function as a database, forecasting tool (forecasting tool), and analysis tool for energy policy. Functioning as a database, LEAP provides comprehensive energy information. As a forecasting tool, LEAP can make projections of the demand and supply of energy within a specific time according to the user's wishes. (Handayani et al., 2019; Shahid et al., 2021) As an analysis tool for energy policy, LEAP provides a view of the effects of energy policy ideas from the perspective of energy supply and demand, the economy, and the environment. (Aeknarajindat et al., 2020; Alberto Alvarez et al., 2021)

First, in the base year, namely 2012, projections or forecasts for the next 13 (thirteen) years with a projection period of 1 (one) year. 2012 is the base year because the most recent data is data for 2013, and in that year, no extraordinary events affected the economy of East Kalimantan Province. After grouping all the data, the next step is to enter the secondary data into each module in LEAP.

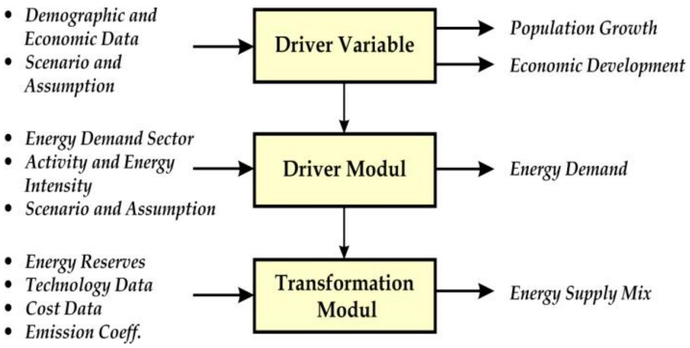

Figure 1. Model Arrangement in LEAP

There are four modules in LEAP by default: the Driving Variable Module, Demand Module, Transformation Module, and Energy Resources Module. The figure above shows calculating energy demand and supply in LEAP. (Stockholm Environment Institute – Boston, 2012) The Driver Variable Module accommodates general parameters that will later be included in the energy demand and supply projection, including population, number of households, Gross Regional Income, per capita income, population growth, GRDP growth, and others. In LEAP, energy demand forecasting is calculated based on the amount of energy consumption activity, the amount of energy used per activity, or the intensity of energy use. Energy consumption activity is closely related to the level of the economy and population. Energy consumption activities are grouped into five sectors: Household, Industry, Social, Government, and Captive Power.

This module is for calculating energy supply. The energy supply can consist of primary energy production (natural gas, oil, and coal) and secondary energy (electricity, fuel oil, and LPG). First, determine the structure of the branch arrangement in the Transformation Module, where each energy transformation activity consists of processes and outputs. Processes denote a technology for converting, transmitting, or distributing energy. Output is the energy form of the processes.

RESULTS AND DISCUSSION

In terms of water potential, East Kalimantan has considerable potential. There are 210 rivers totaling approximately 12,083 km (East Kalimantan in Figures 2013). Good water potential for hydroelectric power plants is generally located in mountainous border areas and forest areas with relatively low population density. However, the area upstream of the rivers in East Kalimantan has a large water discharge and a potential height of water falling if it becomes a reservoir.

The potential of Micro Hydro Power Plant (PLTMH) East Kalimantan

In general, potential water resources for electricity are outside the city center or inland locations. In the western region of East Kalimantan Province, the morphology is wavy/wavy from weak to strong in the form of hills and mountains. Because of its morphological shape, much water flows between the hills and mountains to form grooves and small rivers which empties into large rivers. In addition, because there are many height differences at relatively close distances, especially in areas passed by small rivers or streams, the water flows in these small rivers and streams flows relatively quickly. What is more, if the water flows through an area where the rocks are broken, then the water flow forms a waterfall that flows even faster.

Table 1 below shows that 9 Regencies and 69 Villages have the potential for electricity generation from water with a scale of less than 500 kW or commonly referred to as PLTMH and the potential of water resources in the Regency/City of East Kalimantan Province are as follows:

Table 1. Data on potential recapitulation of hydropower potential Micro Hydro Power Plant in East Kalimantan until 2013

No	Kabupaten/Kota	Potensi Sumber Daya Air (kW)
1	Balikpapan	-
2	Kutai Timur	250.00
3	Tarakan	-
4	Penajam Paser Utara	-
5	Paser	1,020.00
6	Bulungan	1,669.00
7	Samarinda	-
8	Berau	116.00
9	Tana Tidung	22.00
10	Malinau	905.00
11	Kutai Kertanegara	120.00
12	Bontang	-
13	Kutai Barat	1,500.00
14	Nunukan	940.00
	Total	**6,542.00**

No	Kabupaten/Kota	Potensi Sumber Daya Air (MWh)
1	Balikpapan	13.60
2	Kutai Timur	102.75
3	Tarakan	0
4	Penajam Paser Utara	0
5	Paser	37.92
6	Bulungan	1.67
7	Samarinda	0
8	Berau	598.72
9	Tana Tidung	0.02
10	Malinau	5,367.01
11	Kutai Kertanegara	852.02
12	Bontang	0
13	Kutai Barat	1.50
14	Nunukan	0.94
	Total	**6,976.14**

From the data above, the Tarakan, Samarinda, and Bontang cities do not have water resources for electricity. In Samarinda City, there are rivers and waterfalls such as the Mahakam River and Tanah Merah Waterfall, both of which still need to be measured for the potential of water resources for electricity. At the same time, Tarakan and Bontang City have no potential for water resources. The most significant potential for water resources is in Malinau Regency, with a power of approximately 5,367.01 Mega Watt.

Utilization of Water Energy Resources in East Kalimantan Province

Table 2 shows the Micro Hydro Power Plant currently being used consists of 33 PLTMH units spread across the East Kalimantan region.

Table 2. Amount of Water Resources for Electricity (PLTMH) Prov. East Kalimantan Utilized until 2013

No	Kabupaten/Kota	Potensi Sumber Daya Air (kW)
1	Balikpapan	0.00
2	Kutai Timur	50.00
3	Tarakan	0
4	Penajam Paser Utara	0
5	Paser	25.00
6	Bulungan	50.00
7	Samarinda	0
8	Berau	369.00
9	Tana Tidung	-
10	Malinau	695.00
11	Kutai Kertanegara	-
12	Bontang	0
13	Kutai Barat	320.00
14	Nunukan	-
	Total	**1,509.00**

For power plants in East Kutai, Paser, Bulungan, Berau, Malinau and West Kutai Regencies. While the largest is in Malinau Regency, which is 695 Kilo Watts, and the entire power plant sourced from water utilized is 1,509 Mega Watts. Meanwhile, to take advantage of hydroelectric power plants, until now, there has yet to be any. The obstacle in developing water-based electricity generation is the potential location of hydropower plants far from urban areas (maximum load). Because of its remote location, it requires a significant investment to construct a transmission network with transformers. In addition, in East Kalimantan, there is still a lot of coal and natural gas located closer to cities. Hence, the transmission network built is relatively close to the maximum load (urban).

Strategic planning of Water Energy Resources for Household Electricity in East Kalimantan Province. Based on the General Plan for Electricity (RUKTL), the state electricity company made 2025 new and renewable energy to generate electricity, reaching 4.4% of the total energy used (energy mix). Under these conditions, this study will discuss using new and renewable energy in 2025, which is 4.4%. In the strategic planning for fulfilling electricity from water resources, the base year for which the simulation is used is 2012, while the simulation period is 13 years, with a projection period from 2012 to 2025.

Some of the simulation strategic planning parameters are the results of calculations, while some are assumptions. The description of these parameters is as Economic growth. Economic growth is essential in projecting electricity demand—East Kalimantan's economic growth from GRDP and per capita income. Based on the results of processed

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Vol. 17 No. 1, April 2023, 195 - 212
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information from 2007 to.d. 2012, the GRDP of East Kalimantan experienced an average increase of 4.06% as shown in table 3.

Table 3. GRDP Growth

Tahun	PDRB (Juta Rupiah)	Pertumbuhan
2007	98.428.543	
2008	103.206.871	4,85
2009	105.564.938	2,28
2010	110.886.682	5,04
2011	115.244.165	3,93
2012	120.067.296	4,19
Rata-rata		4,06

(Kalimantan Timur Dalam Angka, 2013)

Population growth. In addition to economic growth, population growth is a helpful parameter in projecting energy needs. Based on BPS information on "East Kalimantan in Figures, 2013", from 2002 to.d. In 2010 the population of East Kalimantan experienced an average increase of 3.82%, while the average growth rate from 2002 to 2012 was 3.75% as shown in table 4.

Table 4. Population Growth in East Kalimantan Province

Jumlah Penduduk		Laju Pertumbuhan (persen)
2002	2.443.334,00	
2010	3.553.143,00	3,82
2011	3.690.520,00	3,87
2012	3.821.676,00	3,55
Rata-rata		3,75

(Kalimantan Timur Dalam Angka, 2013)

In modeling the demand for electrical energy in this study, calculating projected needs at the household scale, not at the individual scale. Therefore, projecting is the number of households. Assumes the growth of the number of households with the population growth.

Development of Electricity Customers from the State Electricity Company. At the end of 2013, the number of electricity customers at the State Electricity Company for the East Kalimantan Region was 938,610 customers, consisting of 881,080 household customers, 358 industrial customers, 35,808 business customers, 15,292 social customers, and 6,072 public customers. Connected power to these customers is 1,221,672 MVA consisting of 752,369 MVA for household customers, 163,155 MVA for industrial customers, 202,243 MVA for business customers, 43,296 MVA for social customers, and 60,610 MVA for public customers. Energy consumption for these customers is 2,462,300 GWh consisting of 1,374,840 GWh for household customers, 542,533 GWh for industrial customers, 322,944 GWh for business customers, 74,652 GWh for social customers and 147,330 GWh for public customers. The following table shows the development of the number of

Jurnal Ekonomi, Bisnis & Entrepreneurship
Vol. 17 No. 1, April 2023, 195 - 212
ISSN: 2443-0633, E ISSN: 2443-2121

electricity customers of PT. PLN (Persero) East Kalimantan Region from 2009 to the end of 2013 as shown in table 6.

Table 6. Development of Number of Customers per Tariff Sector

Pelanggan	Tahun				
	2009	2010	2011	2012	2013
Rumah Tangga	406.143	408.307	434.060	553.975	605.084
Industri	244	244	242	246	283
Bisnis	25.847	28.456	31.808	51.805	54.399
Sosial	9.636	9.977	10.371	18.791	21.967
Publik	4.146	4.346	4.483	10.226	10.472
Jumlah	**446.016**	**451.330**	**480.964**	**635.043**	**692.205**

(PT. PLN (Persero) Wilayah Kalimantan Timur)

Table 6 above shows that household customers dominate (91.35%), followed by business customers (5.82%). The following is a pie chart of the percentage of customers per tariff sector. Development of Non-PLN Power Plants (Captive Power). Captive power is a generator the private sector uses to provide electricity for their business, and the generator uses diesel fuel. The current captive power generation capacity development is as follows:

Table 7. Development of Power Plants Non-PLN (Captive Power)

Jumlah Captive Power		Laju Pertumbuhan (persen)
2007	683,17	
2008	728,97	6,70
2009	827,72	13,55
2010	906,47	9,51
2012	954,22	5,27
2013	1.102,00	15,49
Rata-rata		10,10

(PT. PLN (Persero) Wilayah Kalimantan Timur)

The following shows energy consumption per tariff sector for several electricity customers at PT. PLN (Persero) East Kalimantan Region.

Table 8. Development of Energy Consumption (MWh) per Tariff Sector 2009 – 2013 and Development of Energy Consumption Captive Power (MWh)

Pelanggan	Tahun				
	2009	2010	2011	2012	2013
Rumah Tangga	1.417.198	1.279.241	1.179.357	1.311.181	1.483.455
Industri	855	56.523	142.989	144.774	147.172
Bisnis	92.383	272.067	543.740	588.428	626.898
Umum	46.283	113.124	250.800	232.834	244.992
Jumlah	**1.556.720**	**1.720.955**	**2.116.886**	**2.277.217**	**2.502.517**

Jumlah Captive Power (MWh)		Laju Pertumbuhan (persen)
2008	3.551.584,32	
2009	3.744.164,16	5,42
2010	4.159.388,16	11,09
2011	4.490.516,16	7,96
2012	4.691.295,36	4,47
2013	5.312.680,70	13,25
Rata-rata		8,44

The relationship between increased energy consumption and economic growth as a parameter of energy elasticity. Determine the projected customer growth and electricity demand growth with the help of the energy elasticity parameter. Using the equation in determining the projection parameters as follows:

Jurnal Ekonomi, Bisnis & Entrepreneurship
Vol. 17 No. 1, April 2023, 195 - 212
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$$\epsilon = \frac{\left(\frac{\Delta listrik\ \ terjual}{listrik\ \ terjual\ \ _{n-1}}\right)}{\left(\frac{\Delta PDRB}{PDRB\ \ _{n-1}}\right)} \quad \text{...(1)}$$

Dengan :

ϵ = elastisitas energi
Δ listrik terjual = perubahan listrik terjual antara tahun ini dengan tahun sebelumnya
listrik terjual$_{n-1}$ = listrik terjual pada tahun sebelumnya
Δ PDRB = perubahan PDRB antara tahun ini dengan tahun sebelumnya
PDRB$_{n-1}$ = PDRB pada tahun sebelumnya

Calculating parameters for projected customer growth based on population growth and the number of household customers. Using a numerical base on the number of household subscribers because customers directly related to the population are household customers. Calculating the parameters of customer growth projection and elasticity using the following equation:

$$PP = \frac{Elastisitas\ \ pelanggan\ \ sektor\ \ x}{Elastisitas\ \ pelanggan\ \ sektor\ \ ruma\ h\ tangga} x\ pertumbuhan\ penduduk$$

Dengan :

PP = Proyeksi Pelanggan
Sektor x = Sektor yang akan diproyeksikan jumlah pelanggannya

$$PK = \frac{Elastisitas\ \ pelanggan\ \ sektor\ \ x}{Elastisitas\ \ pelanggan\ \ sektor\ \ ruma\ h\ tangga} x\ pertumbuhan\ ekonomi$$

Dengan :

PK = Proyeksi Konsumsi
Sektor x = Sektor yang akan diproyeksikan jumlah pelanggannya

By using equations, the results of determining the elasticity value, customer projection parameters and electricity consumption projection parameters are shown in the following table 9:

Table 9. Growth assumptions and Strategic Planning Projection of Electricity Needs up to 2025 (MWh)

	Rumah Tangga	Industri	Bisnis	Sosial	Publik
Elastisitas	1,18%	1,42%	0,18%	0,39%	1,88%
Proyeksi Pertumbuhan pelanggan	3,82%	3,67%	0,48%	3,23%	2,30%
Proyeksi pertumbuhan konsumsi	7,00%	8,43%	1,06%	2,35%	11,19%

Pelanggan	Tahun						
	2013	2015	2017	2019	2021	2023	2025
Rumah Tangga	1,147,679	1,522,485	2,010,374	2,643,870	3,464,551	4,525,523	5,894,536
Industri	163,650	202,347	250,194	309,356	382,507	472,955	584,791
Komersial	697,088	861,922	1,065,734	1,317,740	1,629,335	2,014,612	2,490,991
Sosial	54,223	68,710	87,068	110,330	139,807	177,159	224,491
Pemerintah	77,479	98,179	124,410	157,649	199,768	253,140	320,772
Captive Power	5,484,280	5,844,286	6,227,924	6,636,745	7,072,403	7,536,659	8,031,390
Total	7,624,398	8,597,929	9,765,704	11,175,689	12,888,371	14,980,048	17,546,971

If it is averaged for all sectors, electricity demand is projected to increase by 12.2% per year. Table 10 shows the number of household customers can be projected by targeting an electrification ratio in 2012 of 61.60%. We are projecting the number of household customers by targeting an electrification ratio of 100% in 2025.

Table 10. Results of Strategic Planning Prediction of Power Generation Capacity (MWh) 2012 to 2025

Jenis Pembangkit	Tahun						
	2013	2015	2017	2019	2021	2023	2025
PLTD Samarinda	65,359	67,488	63,732	63,103	-	-	-
PLTD Balikpapan	138,802	143,323	135,346	134,011	-	-	-
PLTMG Balikpapan	16,627	17,356	16,510	16,310	7,747	8,855	10,373
PLTD Berau	209,813	216,647	204,589	202,571	-	-	-
PLTU Berau	76,742	80,105	76,199	75,279	35,756	40,870	47,873
PLTD Bontang	163,935	169,274	159,853	158,277	-	-	-
PLTMG Bontang	59,688	62,304	59,266	58,550	27,810	31,788	37,235
PLTU Mahakam	315,188	329,002	312,958	309,181	146,853	167,859	196,623
PLTG Mahakam	184,395	190,401	179,804	178,031	-	-	-
PLTGU Mahakam	328,892	343,307	326,565	322,623	153,238	175,157	205,172
PLTD Mahakam	666,790	688,509	650,189	643,777	-	-	-
PLTMG Mahakam	43,852	45,774	43,542	43,016	20,432	23,354	27,356
New_PLTG01_KaltimFTP2	-	163,015	153,942	152,424	-	-	-
New_PLTG02_KaltimFTP2	-	163,015	153,942	152,424	-	-	-
New_PLTU01_Berau	-	-	38,099	37,639	17,878	20,435	23,937
New_PLTU01_TjSelor	-	-	38,099	37,639	17,878	20,435	23,937
New_PLTU02_TjSelor	-	-	38,099	37,639	17,878	20,435	23,937
New_PLTU02_Berau	-	-	38,099	37,639	17,878	20,435	23,937
New_PLTU01_Malinau	-	-	16,328	16,131	7,662	8,758	10,259
New_PLTU02_Malinau	-	-	16,328	16,131	7,662	8,758	10,259
New_PLTG01_MahakamSenipa	-	130,412	123,154	121,939	-	-	-
New_PLTG02_MahakamSenipa	-	130,412	123,154	121,939	-	-	-
New_PLTU01_KaltimMT	-	-	149,676	147,869	70,234	80,280	94,037
New_PLTU02_KaltimMT	-	-	149,676	147,869	70,234	80,280	94,037
New_PLTU01_MuaraJawa	-	-	544,275	537,705	255,397	291,929	341,953
New_PLTU02_MuaraJawa	-	-	544,275	537,705	255,397	291,929	341,953
New_PLTU01_TanahGrogot	-	-	38,099	37,639	17,878	20,435	23,937
New_PLTU02_TanahGrogot	-	-	38,099	37,639	17,878	20,435	23,937
New_PLTU01_MelakFTP2	-	-	38,099	37,639	17,878	20,435	23,937
New_PLTU01_NunukanFTP2	-	-	38,099	37,639	17,878	20,435	23,937
New_PLTU02_NunukanFTP2	-	-	38,099	37,639	17,878	20,435	23,937
New_PLTU01_Kaltim2FTP2	-	-	-	537,705	255,397	291,929	341,953
New_PLTU02_Kaltim2FTP2	-	-	-	537,705	255,397	291,929	341,953
New_PLTU01_Embalut	-	-	-	268,853	127,699	145,964	170,976
New_PLTU02_MelakFTP2	-	-	-	37,639	17,878	20,435	23,937
New_PLTU01_KaltimInfrastrukt	-	-	-	-	255,397	291,929	341,953
New_PLTD01_Berau	-	-	-	9,145	-	-	-
New_PLTD01_Nunukan	-	-	-	3,049	-	-	-
New_PLTA01_Kelai	-	-	-	-	-	-	-
New_PLTD01_KotaBangun	-	-	-	-	-	-	-
New_PLTG01_Kaltim	-	-	-	-	-	-	-
New_PLTU02_KaltimInfrastrukt	-	-	-	-	-	291,929	341,953
New_PLTD02_Berau	-	-	-	-	-	-	-
New_PLTD01_Melak	-	-	-	-	-	-	-
New_PLTD02_Nunukan	-	-	-	-	-	-	-
New_PLTA02_Kelai	-	-	-	-	-	-	-
New_PLTD02_KotaBangun	-	-	-	-	-	-	-
New_PLTD03_Berau	-	-	-	-	-	-	-
New_PLTD03_Nunukan	-	-	-	-	-	-	-
New_PLTD02_Melak	-	-	-	-	-	-	-
PLTS	2,229	2,326	2,213	2,186	1,038	1,187	1,390
PLTMH	5,514	5,756	5,475	5,409	2,569	2,937	3,440
PLTA Kayan	-	-	-	-	10,266,964	11,735,539	13,746,496
PLTA Tabang	-	-	-	-	340,530	389,238	455,937
PLTA Kelai	-	-	-	-	127,699	145,964	170,976
Captive Power	4,921,200	5,136,887	4,886,382	4,827,399	2,292,899	2,620,872	3,069,975
Total	7,199,025	8,085,312	9,440,266	10,724,710	15,162,789	17,623,585	20,643,495

So that planning for meeting electricity needs based on hydropower is summarized in the following table 11:

Table 11. Results of Additional Strategic Planning Generation of Water Resources and Strategic Planning Type of Power Plant (MWh)

No.	Kabupaten/Kota	Nama Sungai	Daya (MW)	Tahun Dibangun	Total Daya (MW)
1	Kukar	Belayan	200	2020	200
2	Berau	Sembakung	75	2020	75
3	Bulungan	Kayan	6030	2020	6030
	Total				6305

Jenis Sumber Pembangkit	Tahun						
	2013	2015	2017	2019	2021	2023	2025
PLTU	1,777,583	1,855,492	6,803,440	10,669,609	5,797,515	7,460,867	8,739,332
PLTD	20,552,993	21,407,092	20,333,639	20,137,770	7,642,995	8,736,240	10,233,249
PLTA + PLTMH	9,191	9,594	9,126	9,016	17,896,270	20,456,131	23,961,415
PLTG	1,009,630	3,303,024	3,121,353	3,089,908	139,972	159,993	187,409
PLTS	13,110	13,685	13,017	12,860	6,108	6,982	8,179
Total	23,362,507	26,588,885	30,280,574	33,919,163	31,482,860	36,820,213	43,129,583
% EBT (Air)	0.04	0.04	0.03	0.03	56.84	55.56	55.56

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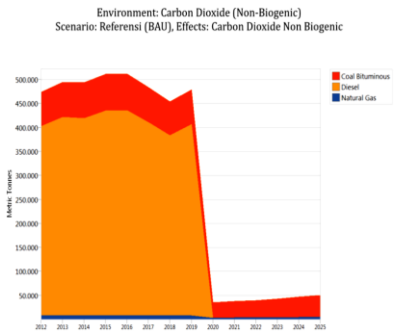
So, with the above planning, in 2025 the capacity of power plants originating from water (PLTA + PLTMH) will reach 23,961,415 MWh or 55.56% of the total generating capacity (43,129,583 MWh). This composition has exceeded the energy mix target in the national energy management Blueprint.

Carbon Dioxide Gas Emissions

Human activities produce greenhouse gas emissions, for example from motor vehicles, industrial activities, power plants that use coal and others. There are three main factors for high greenhouse gas emissions, namely forest and land destruction, use of energy that is not environmentally friendly and waste disposal. In sufficient portions, activities that produce greenhouse gases are not harmful to humans. However, if it is used excessively, the greenhouse gas emissions that arise can trigger global warming which affects the earth's temperature. If this happens, it is necessary to control greenhouse gas emissions so that these greenhouse gas emissions can be reduced. (Hanif et al., 2019) The Indonesian government through Presidential Regulation Number 61 of 2011 concerning the National Action Plan for Reducing Greenhouse Gas Emissions seeks to regulate greenhouse gas emissions. Through this regulation, the Government of Indonesia declared a voluntary commitment to reduce greenhouse gas emissions between 26% and 41% by 2020. The impact of greenhouse gas emissions from the power generation sector is mainly due to CO2 gas from fossil energy-fired power plants.

Therefore, the use of fossil fuels results in different types of emissions as tonnes of CO2 equivalent. These emissions can compare the global warming potential of the scenarios as in the previous chapter. Comparison of the global warming potential to meet the demand for electric power in the Province of East Kalimantan (tons of CO2 equivalent), as shown in the figure 2. The entry of water-based power plants in 2020 is very pressing for reducing carbon dioxide gas emissions. The generation technology in this scenario is a more environmentally friendly technology. Therefore, even though the addition of the power plant is a coal-fired power plant, the equivalent CO2 emissions produced are relatively lower compared to the BAU scenario. If running the EFF scenario, the reduction in CO2e emissions every year until 2025.



Units: Metric Tonnes

Jenis Sumber	Tahun 2013	2015	2017	2019	2021	2023	2025
PLTU	73,128	76,333	72,610	71,734	34,072	38,946	45,619
PLTD	413,377	426,842	403,086	399,110	-	-	-
PLTG	8,347	8,713	8,288	8,188	3,889	4,446	5,207
Total	**494,853**	**511,888**	**483,984**	**479,032**	**37,961**	**43,391**	**50,826**

Figure 2. Global Warming Potential and Strategic Planning Carbon Dioxide (Non-Biogenic)

Energy Planning Strategy and Policy

As in the previous sub-chapter, the strategy and direction of the regional energy policy for the Province of East Kalimantan is to maintain regional energy security, especially coal resources. However, apart from coal, East Kalimantan Province has various other energy resources, such as oil and natural gas, and renewable energy potential, such as wind and solar. To guarantee the sustainability of energy security, an implementation strategy is needed that can be divided into 2 (two) types of strategies: the budget development strategy and the regulation development strategy. Both types of strategies can minimize returns into various sub-strategies. For example, the budget strategy can minimize the return to funding and technology sub-strategy. Meanwhile, the regulatory strategy can be minimized into a sub-strategy of government commitment, law enforcement, pricing policy, drafting of new laws, and preparation of policy instruments in the form of presidential decrees and related ministerial decrees. In addition to the implementation strategy, East Kalimantan Province's energy planning also requires energy policy direction both from the supply and demand sides.

Strategic Budget

Carry out budget strategies for programs related to physical development, especially in the form of new infrastructure development in the energy sector. In addition to building new infrastructure, funding is also for applying new technology in existing energy infrastructure. The government or the private sector can provide funding for the private sector (through PMDN or PMA). It is implementing budget allocation policies on a priority scale to fulfill needs that can encourage increased efficiency in energy use, regional economic growth, and people's welfare. In the oil and gas sector, government funding for adding new refineries, developing distribution networks and other oil and gas infrastructure, and applying new technology can be through Pertamina, PGN, and their subsidiaries. Government funding can be through PLN and electricity BUMD in the electricity sector. In the new and renewable energy sector, the government can form BUMDs engaged explicitly in constructing new and renewable energy infrastructure. Energy-independent village funding can also increase village community energy consumption through local energy. Energy User Side Sector (Energy Efficiency and Conservation). Providing funding from the government can also provide incentives for industry or other energy-using sectors that implement energy efficiency and conservation. For this reason, an audit is needed to measure the implementation of efficiency and conservation in energy use sectors and an energy-saving labeling program.

Meanwhile, the private sector receives funding from PMDN and PMA. Theever, the main problem in funding through the private sector (especially domestic capital) is the gap between available funding options and the loan capacity of private parties providing energy infrastructure development services. As an illustration, the Philippines has made a loan pattern. Most of the Electricity Cooperatives (ECs) in the Philippines cannot obtain funding from commercial banks due to the high risk posed by lenders and the resulting high need for collateral to cover the risk. To overcome these obstacles, the Department of Energy provides a credit guarantee program for commercial loans through funding from the World Bank and a grant from the Global Environment Facility. The Department of Energy selected the Local Government Unit Guarantee Corporation (LGUGC) as the Guarantee Program Manager. LGUGC regulates and operates 2 (two) windows: the first for loans to non-ECs and the other for loans to ECs. The guarantor facility was in 2004.

Regulatory Strategy

Establish regulatory strategies for matters other than funding the physical development of energy infrastructure and the application of new technologies that are more efficient. The regulatory strategy mainly includes 4 (four) things, as well as **Government Commitment**. Implementing development programs in the energy sector requires government commitment as a form of political will that strictly supports these programs. The form of government's commitment to the oil and gas sector can be a declaration of a consistent and consistent fuel use policy for the transportation sector. This form of policy was directly followed by a reduction in supply to the cessation of fuel sales for other sectors such as industry, households, commercial and public. In the field of coal utilization, carry out the government's commitment in the form of affirming export restrictions in the form of coal and directing the use of coal in the processing of coal into secondary energy, for example, electricity, to then be exported in the form of secondary energy. The new and renewable energy and energy efficiency and conservation show the government's commitment by providing incentives for EBT users and energy efficiency and conservation actors. However, it needs to be balanced with disincentives for sectors not implementing energy efficiency and conservation.

Law Enforcement. In addition to the government's commitment, implementing the energy sector development program also requires law enforcement or compliance with regulations so that it can proceed according to the strategic direction and achieve the set targets. The impact of this strategy is the need for coordination across ministries and related institutions so that infrastructure development can be created with minimal impact on the environment. For all fields, the main form of law enforcement is control and a program for implementing such supervision. The National Energy Council can be a controlling and supervisory agency for implementing these programs. So that the energy development implementation program remains by the general national energy plan prepared by the DEN as mandated by Law No. 30 of 2007. For this reason, it is necessary to prepare strict sanctions if the implementation program is not by the direction. Thus, every coal stakeholder must comply with coal mining regulations in East Kalimantan Province. So that environmental impacts do not worsen the quality of soil, air, and air in East Kalimantan Province and can even improve the quality of the environment.

Pricing Policy. The price policy in implementing development programs in the energy sector is mainly related to subsidies and deregulation. In the electricity sector, implementing subsidies in Indonesia can take 3 (three) forms: Providing consumption subsidies to household consumers who have electricity connections below 450 VA. Provide subsidies also to social institutions, small businesses, and small industries. However, various studies state that only 36% of the total subsidy recipients cannot pay for their electricity consumption. Electricity Connection Subsidies, the Government and PLN, help consumers get electricity connections by providing connection funds or extending the connection fee payment period. Providing this subsidy is also to fund isolated electrification or small-scale generators. In granting these subsidies, it is necessary to stipulate criteria for selecting consumers and supervising the granting and use of these subsidy funds. Fuel Subsidies, the government provides fuel subsidies to PLN so that electricity production costs are reduced. Still, in the electricity sector, PLN as the holder of a central electricity supply business license is obliged to meet cross-provincial electricity needs, especially matters related to village electrification programs (expansion of the national network and utilization of local energy). For this reason, PLN must view electricity as a utility, not a commodity. However, PLN can apply regional electricity tariffs to gain benefits for its survival. As an illustration, regional rates already exist in Batam. At the provincial level, governors can issue business licenses to supply electricity to meet cross-district electricity needs. The district head can also issue business licenses for electricity supply to meet electricity needs at the sub-district level and across sub-districts. The holder of the electricity supply business at the regional level can view electricity as a commodity so that tariff competition can occur and encourage economic growth. As for remote areas that are not attractive to electricity investors, other ministries such as Public Welfare (Kesra), PDT (Disaster Area Management), ESDM, Transmigration, and Electrification Business Cooperatives can carry out electrification businesses.

New Policy. To accelerate the achievement of development targets in the energy sector, the government can also stipulate various new policy instruments through Governor Decrees or Regional Regulations. For example, in the oil and gas sector, the government can issue a policy of using fuel only for transportation to pursue the national energy mix target. At the same time, other sectors use other forms of energy besides fuel. For example, in the electricity sector, the government can issue a coal power plant policy that only allows the use of clean coal technology so that the production of greenhouse gases from coal combustion can decrease. In the new and renewable energy field, the government can issue incentive policies and investment assistance for using new and renewable energy. Meanwhile, in energy efficiency and conservation, the government can issue incentive policies for energy efficiency and conservation actors and disincentives for the energy sector that does not implement energy conservation.

Energy Policy on the Supply Side.

This policy is by the continuity of the supply of primary energy upstream and secondary energy downstream. This policy covers exploration activities (primary energy), exploitation (primary energy), processing (secondary energy), conservation, and export-import of energy (primary energy and secondary energy). This policy is closely related to Pertamina as a BUMN that handles fuel oil and natural gas. Energy exploration is an activity to find energy sources to increase reserves of energy sources—efforts to conduct searches, especially in areas that have never conducted a survey. As for locations already indicated, it requires efforts to increase the reserve status to something more specific.

Furthermore, considering that energy reserves are increasingly limited while energy needs continue to increase requires energy exploration activities.

Therefore, directing policies to encourage exploration activities related to creating economic and non-economic incentives. Exploiting energy as optimally as possible is an activity to produce energy in order to maintain energy availability. Therefore, it is necessary to carry out energy production efficiently in terms of technology and economics. Requires energy exploitation or production activities to exhaust the maximum possible energy reserves during production. Carry out an energy exploitation policy by shifting energy exports from primary energy to energy exports in the form of secondary energy, such as electricity.

Energy conservation is an effort to maintain the sustainability of energy resources through their wise development. Carry out conservation from the supply side by increasing the efficiency of the production of energy resources. To increase upstream conservation by wisely optimizing the production of energy resources. Strive for policies regarding conservation activities here to create a balance of interests between producers who want to get maximum benefits and the public who expect to be able to utilize energy reserves for the benefit of future generations.

Energy Policy on the Demand Side

This Policy is closely related to end consumers' primary and secondary energy needs. This Policy includes policies on diversification activities (primary and secondary energy) and energy conservation. Energy diversification is an effort to diversify energy use by end consumers to optimize the supply of energy resources. Through the energy diversification policy, the rate of depletion of energy sources can become more balanced, and this Policy will be effective in encouraging the development of new energy and updating energy sources. On the other hand, we are implementing conservation policies through energy-saving equipment and technology and educating the public about the energy-saving culture and efficient use of energy.

CONCLUSIONS

From the research results, the East Kalimantan Province has the potential to generate electricity from water, utilizing 6,976.14 MW and only 1.509 MW. However, in 2025, the population will increase by 6,167,359 people, with a need for electrical energy of 17,546,970 MWh, while the power generation capacity is 20,643,495 MWh. Therefore, if the energy mix composition target is in the national energy management Blueprint, in 2025, the hydropower capacity will reach 23,961,414 MWh or 55.56% of the total generating capacity of 43,129,583 MWh.

Based on the conclusions above, suggestions from researchers are for the Provincial Government of East Kalimantan, policies in the energy sector need to be directed at reducing the use of fuel oil (premium, diesel oil, and kerosene) for each power plant considering the number of reserves is dwindling. Can do this condition by maximizing Renewable energy, such as existing Hydroelectric Power Plants for small-scale and large-scale power plants. For further research, it is necessary to project energy demand using an econometric model so that the significance of the variables affecting the level of energy demand will be apparent. In addition, energy prices, investment costs, technology, and the environment must be examined for the overall energy demand. For further research, it is also necessary to carry out a more complete and detailed analysis of the impact of energy use on the environment and health, not only limited to CO2 emissions but also including emissions and impacts from NOx, SOx, HC, CO, lead, and others.

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