LONG TERM PROJECTION OF ELECTRICITY GENERATION SECTOR IN WEST PAPUA PROVINCE: LEAP MODEL APPLICATION

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Abstract

Electricity is one of the crucial infrastructures in economic development. The number of registered customers electricity increases every year based on data from the State Electricity Company (PLN) Manokwari branch office data. Electricity increase because it has become an essential part of everyday life. Therefore, in West Papua, it is necessary to fix this electricity problem where the most significant source is still from fossils. By looking at potential sources in West Papua that are more sustainable and renewable to meet public electricity demand in West Papua.

In this study, LEAP software will simulate several scenarios, namely based on data from the RUPTL (Electricity Supply Business Plan) and further digging based on the potential literature in West Papua. There will be three scenarios; scenario 1 uses BAU (Business as Usual) as available in RUPTL. Scenario 2 uses BAU data and adds potential renewable energy. Scenario 3 is not using fossil energy but using renewable energy. The result is West Papua can be 100% electrified in 2025 if using scenario 2. The potential for renewable energy in West Papua is wind and sun. However, it does not rule out other sources, such as hydropower.

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1. Introduction

Indonesia's households have used electricity as the primary source of lighting, but 3-4 out of 10 of households in Papua still use non-electric light. Electricity distribution in Indonesia is shown in Figure 1. This data is the main idea for this paper wants to look for the potential source in West Papua and want to see if that can fulfill the public demand for electricity in West Papua.

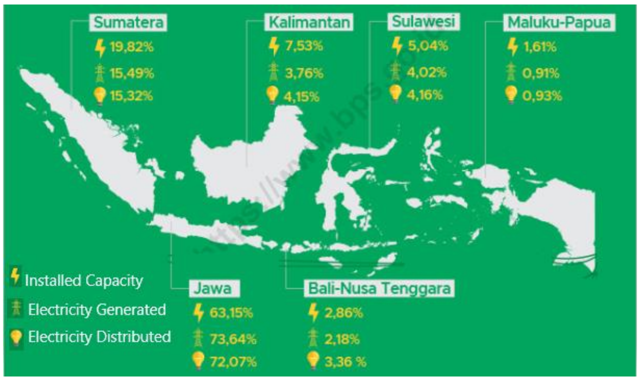


Figure 1. Electricity in Indonesia

Based on Figure 1, the electricity there is still lacking compared to other regions such as java and others, especially West Papua (BPS-Statistics Indonesia, 2019). The most significant energy used in West Papua is a diesel power plant around 83.69 MW. Recently, another developed country also makes a new resolution to find and explore new technology or energy that can replace petroleum as an energy source. Because non-renewable energy cannot sustain and the amount is limited. In Indonesia, the energy mix's target in 2025 includes coal 54.5%, renewable energy 23%, natural gas 22%, fuel oil 0.4% (PT.PLN (Persero) , 2019-2028).

To realize an optimum primary energy consumption in 2025, with shares as follows: petroleum becomes less than 20%, natural gas becomes more than 30%, coal becomes more than 33%, biofuel becomes more than 5%, geothermal become more than 5%. Other new and renewable energy specifically, biomass, nuclear, small-scale hydropower, and wind power become more than 5%, other fuels derived from coal liquefaction to more than 2%. Indonesia needs renewable energy is to encourage the reduction of carbon emission and increased utilization of environmentally friendly resources because the climate is now uncertain due to our less responsible actions and the events of global warming.

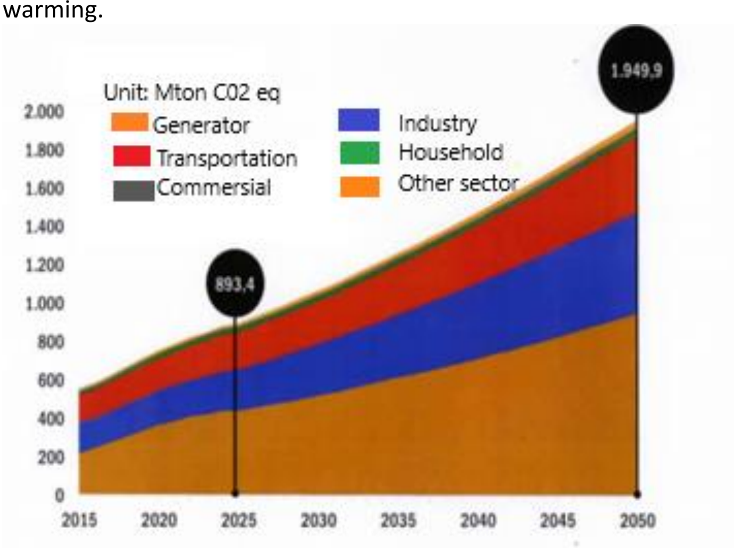


Figure 2. Greenhouse gas emission 2015-2050

Renewable energy is an energy source produced from sustainable energy resources when well-managed, such as geothermal, wind, bioenergy, sunlight, water flow and waterfall, and hydrokinetic ocean and ocean thermal engine. According to "Presidential Regulation Number 22, 2017" the central government issued a plan and national energy policy or RUEN (National Energy Plan) (Kemenkumham, 2014). This RUEN is used as a guideline for preparing RUPTL (Electricity Supply Business Plan) and others.

Previous research on renewable energy in West Papua has been done by (Bawan, 2009) about renewable energy potential analysis in Kaimana district West Papua Province. Renewable energy in Kaimana's regency can be developed, such as micro-hydro, solar power, wind power, and biomass energy. Moreover, the most significant potential is solar energy, wind power, and other energy is bioethanol from sweet potato.

Research on renewable energy projections in other regions has also been carried out by (Kresnawan et al., 2018) about long-term electricity generation sector projection in east Borneo province using LEAP model application (Kresnawan et al., 2018). Other research on energy demand forecast with LEAP model based on scenario analysis Shandong Province (Wang et al., 2010) (Massaga et al., 2019).

In this paper, there are three scenarios to simulated condition demand and source for electricity. Scenario 1 or BAU uses available data from RUPTL or electricity supply business plan. Scenario 2 or diesel scenario from BAU and adds other sources according to potential sources can be improved. Scenario 3 or non-diesel reduce fossil provides an overview of how West Papua has energy demand. It discovers the potential of renewable energy that can be sustainable and environmentally friendly that is suitable, and can be improved.

2. Methodology

LEAP model is developed using an end-user approach after a systematic review of different vital assumptions and variables (Hussain et al., 2018) (Shahinzadeh et al., 2016). LEAP provides a range of accounting, simulation, and optimization methodologies powerful enough for modeling electric and energy sector generation and capacity expansion planning (Ejaz et al., 2018). The modeling approach is sufficiently flexible and transparent, and it is easy to incorporate data and results from other more specialized models. Both BAU and EE scenarios were considered and compared in the analysis (Dayana et al., 2016).

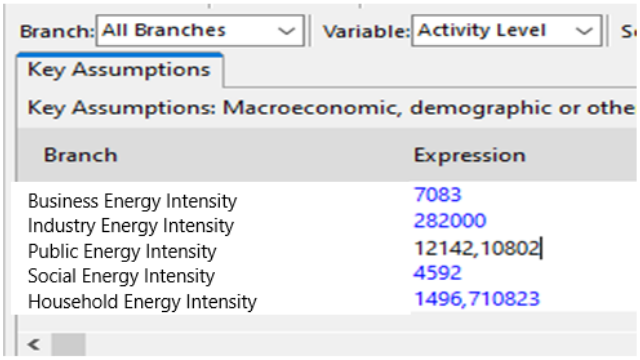
This paper explains the projection electricity consumption and resource potential in West Papua using long-range energy alternatives projection using LEAP software from 2018 until 2044. Population growth determines the LEAP assumption (Rehman et al., 2017). The research collects West Papua statistics data, including electrification statistics existing demand and resource and potential energy from the Ministry of Energy and Mineral Resources (ESDM) and State Electricity Enterprise (PLN).

This paper made three different scenarios, BAU, diesel-endogenous, and non-diesel endogenous. Explanation about three scenarios; scenario 1 for the business as usual scenario, this research using existing data and renewable energy in the planning or progress built. The diesel scenario used BAU data and added other sources using renewable energy potentially there but not yet developed. Scenario 3, non-diesel scenario, decrees the amount not put fossil in the scenario. For solar power plant and hydropower that potential in West Papua put in the endogenous capacity item. Data used in this simulation are:

A. Key Assumption

Conversion GWh to KWh = 10^6 x KWh (1)

For energy intensity (in KWh/customers) in the current account, this primary data in 2018 according to an existing condition.


Branch: All Branches | Variable: Activity Level

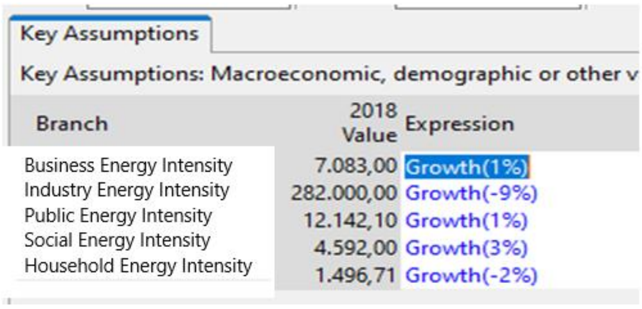
Key Assumptions

Key Assumptions: Macroeconomic, demographic or othe

Branch	Expression
Business Energy Intensity	7083
Industry Energy Intensity	282000
Public Energy Intensity	12142,10802
Social Energy Intensity	4592
Household Energy Intensity	1496,710823

Figure 3. Current account for energy intensity

Intensitas energy in BAU, diesel, and non-diesel scenario.


Key Assumptions

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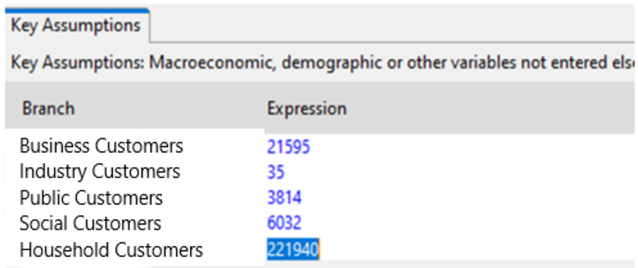
Branch	2018 Value	Expression
Business Energy Intensity	7.083,00	Growth(1%)
Industry Energy Intensity	282.000,00	Growth(-9%)
Public Energy Intensity	12.142,10	Growth(1%)
Social Energy Intensity	4.592,00	Growth(3%)
Household Energy Intensity	1.496,71	Growth(-2%)

Figure 4. BAU, diesel, non-diesel scenario for IE

To get the results of growth from IE on average 2013-2018.

B. "User"


Key Assumptions

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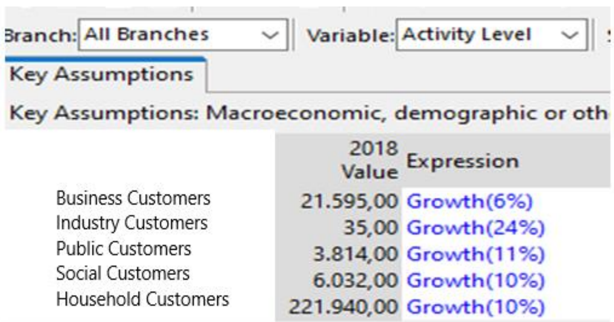
Branch	Expression
Business Customers	21595
Industry Customers	35
Public Customers	3814
Social Customers	6032
Household Customers	221940

Figure 5. Current account for customers

Moreover, demand with BAU, diesel, non-diesel scenario, from customers' growth on average 2013-2018.


Branch: All Branches | Variable: Activity Level

Key Assumptions

Key Assumptions: Macroeconomic, demographic or oth

	2018 Value	Expression
Business Customers	21.595,00	Growth(6%)
Industry Customers	35,00	Growth(24%)
Public Customers	3.814,00	Growth(11%)
Social Customers	6.032,00	Growth(10%)
Household Customers	221.940,00	Growth(10%)

Figure 6. Some customers for BAU, diesel, non-diesel scenario

C. Demand Electricity

The demand electricity formulation is:

$$Q = Ie \times A \qquad (2)$$

Where, Q= Demand (KWh) Ie= Energy Intensity A= user industry, commercial, household, and public.

D. Data Transformation

Reserve margin; 25%, system peak load; 58.36. It is for current accounts, in GWh for Historical production.

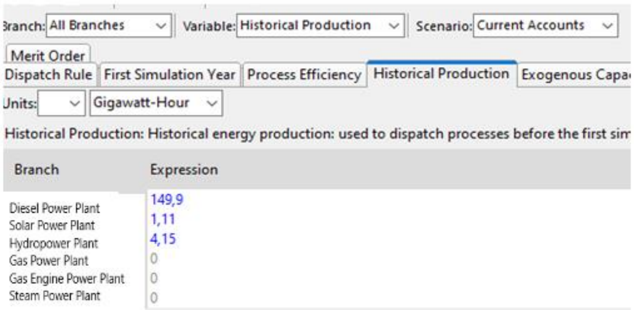


Figure 7. Historical production for current account

In MW, for exogenous capacity,

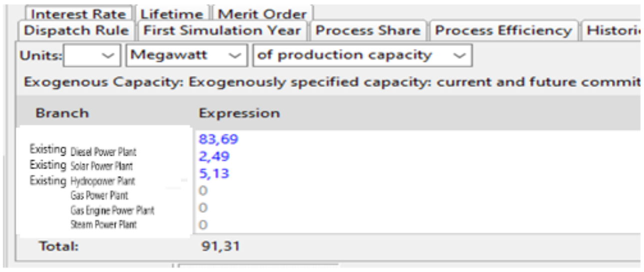


Figure 8. Exogenous capacity for current account

Scenario and design for Scenario 1; BAU scenario adds some data. For scenario 2, diesel has a potential source, hydropower in Warsamson 20MW, PLTS Dombok 0,075 MW, and interpolation.

Table 1. Data our scenario

Diesel	MW	2019	2037	2038	2039	2040	2042	2043	2044	2045
Step	Solar			10	12					
Interpolasi	Hydro	20	75							
Interpolasi	Solar	0,075		5			40	35	65	90
Interpolasi	Wind	0,415		6			22	22	22	46
Step	waste		50	80		100		150	170	180
	Sum	20,49	125	101	12	100	62	207	257	316

For Scenario 3 or non-diesel scenarios, this research uses hydropower and solar potential energy in endogenous capacity and the other like scenario two but in exogenous capacity.

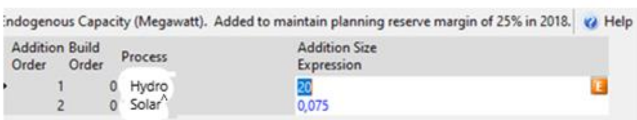


Figure 9. Data for endogenous

3. Results & Discussion

A. Existing Condition

In West Papua, look at Table 2 the energy supply is still dominated by fossil base. The existing condition in West Papua for diesel is 149.9 MW, and from data RUPTL Table 3 source of energy increases in 2023 and 2019. The state electricity company is developing to provide electricity with several plans for some areas with varying sources. This paper will analyze if that scenario is enough to fulfill the demand or create other scenarios to see other alternatives.

Table 2. Existing condition

Own Production			Rent		
Hydro	Diesel	Solar	Diesel	Diesel Total	Total
4.15	113.92	1.11	35.98	149.9	155.16

From basis data in 2018, the most significant demand in "Household."

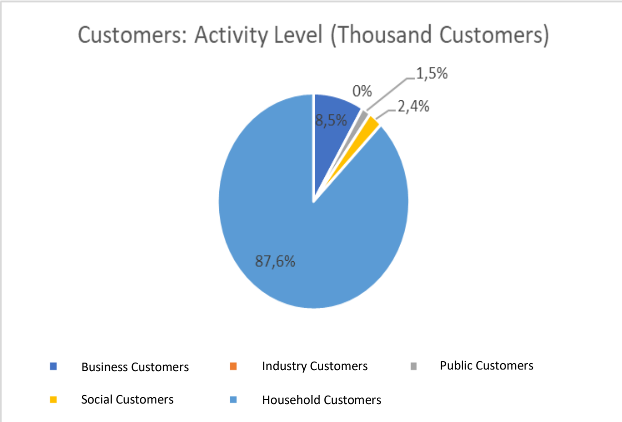


Figure 10. Costumers activity level (thousand costumers)

Figure 10, demand is always growing every year following the GDRP and population growth. Population growth caused the escalation of household demand. GDRP growth caused the escalation of business, industry, and public demand. So, if West Papua only used this existing condition for energy, it will not be enough.

B. Optimization

The result for capacity in Figure 11 for Scenario 1—BAU, scenario diesel in Figure 12, and scenario non-diesel in 13 and 14 that capacity for scenario 2 or when use BAU scenario and adding some renewable energy is higher than that of around 600 MW in 2044. For non-diesel scenario or not using fossil-based when using endogenous having a high value. It is calculated internally by LEAP to maintain a minimum planning reserve margin peak power that requirement every year. Capacity will be increasing in each scenario because It considers and fulfilled demand and adapted to the potential that can be used as an alternative. The most significant demand is households.

Table 3. RUPTL for BAU scenario

No	System	Type	Location/ generator name	KAP (MW)	Target COD	Status	Dev.
1.	Sorong	Gas/ Engine Gas	Sorong	50	2019	Procurement	PLN
2.	Isolated Spread	Diesel	Lisdes	5,38	2019	Plan	PLN
3.	Isolated Spread	Solar	Lisdes	2.92	2019	Plan	PLN
4.	Kaimana	Engine Gas	Kaimana	10	2020	Procurement	PLN
5.	Manokwari	Engine Gas	Manokwari 2	20	2020	Procurement	PLN
6.	Fak-Fak	Gas/ Engine Gas	MPP Fak Fak	10	2020	Procurement	PLN
7.	Bintuni	Engine Gas	Biintuni	10	2021	Plan	PLN
8.	Manokwari	Gas/ Engine Gas	MPP Manokwari	20	2021	Procurement	PLN
9.	Raja Ampat	Engine Gas	Raja Ampat	10	2021	Procurement	PLN
10.	Sorong	Gas/Engine Gas/Gas Steam	Sorong 2	50	2021	Plan	PLN
11.	Fak-Fak	Engine GAs	Fak-fak	10	2022	Plan	PLN
12.	Isolated Spread	Diesel	Lisdes	8.3	2023	Plan	PLN
13.	Sorong	Steam	Sorong 3	50	2024	Plan	PLN
14.	Sorong	Microhydro	Waigo	1.3	2024	Plan	PLN
15.	Manokwari	Engine Gas	Manokwari 3	20	2025	Plan	PLN
16.	Sorong	Engine Gas	Sorong	20	2022	Plan	IPP

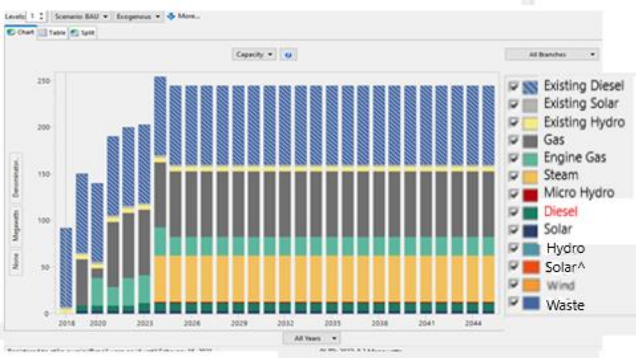


Figure 11. Result capacity in scenario BAU

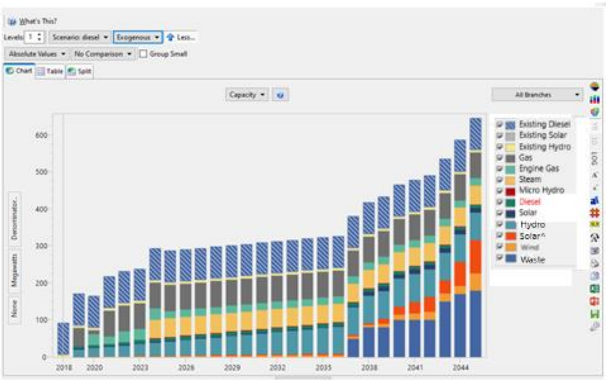


Figure 12. Result capacity in scenario diesel

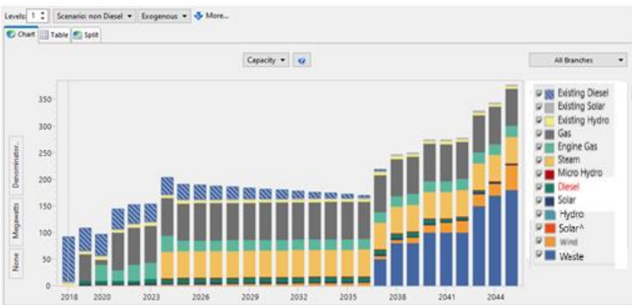


Figure 13. Result capacity in scenario non-diesel

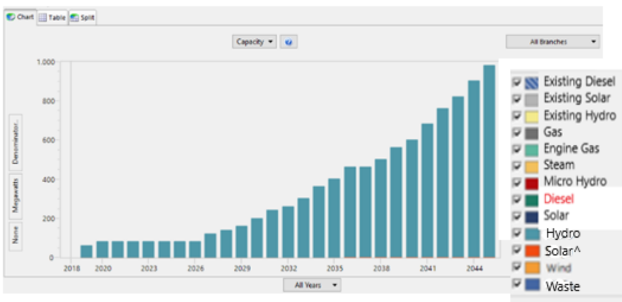


Figure 14. Result capacity in scenario non-diesel (Endo)

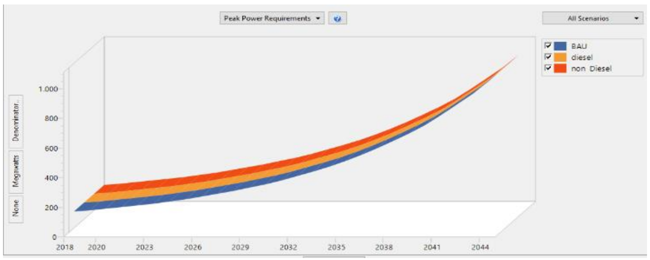


Figure 15. Peak power requirement

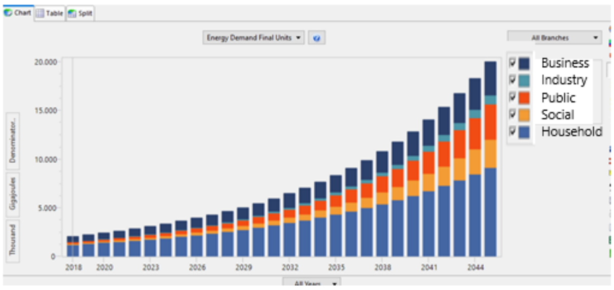


Figure 16. Demand

The result of comparing capacity and demand are shown in Figure 17, Figure 18, Figure 19, and Figure 20.

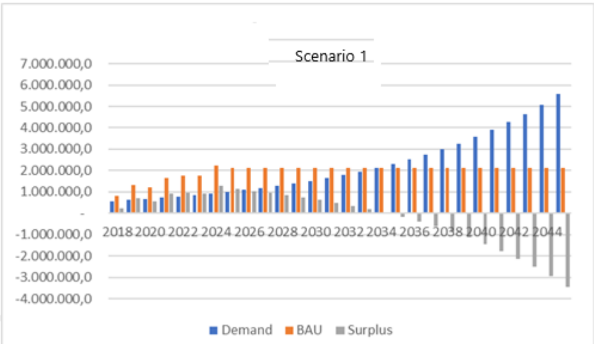


Figure 17. Scenario 1 BAU

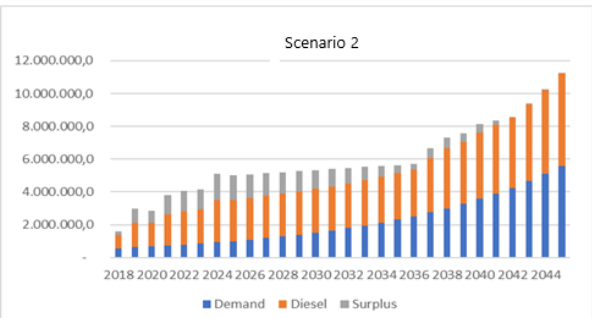


Figure 18. Scenario 2 diesel

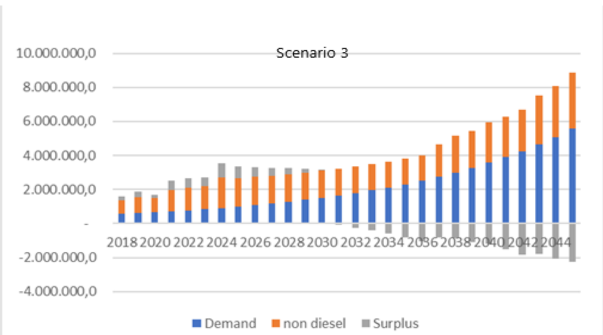


Figure 19. Scenario 3 non-diesel

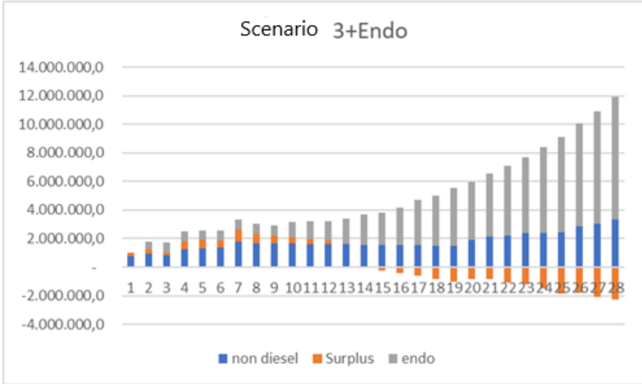


Figure 20. Scenario three mixings with endo capacity

Suppose West Papua wants to optimize, it cannot just be with the BAU scenario in Figure 17 that there is no balance between capacity and demand energy in 2035-2045. After making the diesel scenario, it needs a high energy source if it wants to be replaced. All demand is fulfilled with this scenario. When using a non-diesel scenario, it needs more energy. It is not enough if it only puts the same source as a scenario in diesel. Moreover, if resource adjusts more, it will also not be relevant to the capacity. This simulation will know the endogenous capacity for planning to fill the gap, to understand how much source is used from endo, and put solar and hydro in endogenous capacity.

4. Conclusion

To fulfill the energy and electricity of 2019-2045, West Papua can use the diesel scenario but gradually reduce diesel use and increase renewable energy. For non-diesel scenario need depth research and more investment because it requires an additional more than 20% of renewable energy available. West Papua can be used as a reference if resources want to use renewable energy sources.

BAU scenario from 2035 to 2045 from simulation, it gets a minus and between capacity and demand is not balanced. If West Papua does not add source, it will always be minus. The potential renewable energy in West Papua is wind and solar panels, but it does not close hydropower. Walsamson and Dombok area still need to be studied and coordinated correctly, not to cause social problems.

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