Energy Planning in West Java using Software LEAP (Long-range Energy Alternatives Planning)

Dindin Syarief Nurwahyudin[1*], *Nanik* Trihastuti[2], and *Nuki* Agya Utama[1,3]

[1]Master Program of Energy, School of Postgraduate Studies, Universitas Diponegoro, Semarang 50275, Indonesia
[2]Departement Law of Energy, Faculty of Law, Universitas Diponegoro, Semarang 50275, Indonesia
[3]ASEAN Centre for Energy, Faculty of Law, Kuningan Daerah Khusus Ibukota Jakarta 12950, Indonesia

Abstract. The increase in global energy consumption is increasing every year. The increasing need for energy also in fact collides with the human need to create a clean and pollution-free environment. This condition requires us to look for alternative and renewable energy sources to support our daily lives. With the preparation of the General Provincial Energy Plan (GPEP) in the future, it is expected to strengthen the competitiveness of the West Java economy, fulfill basic needs in the energy sector and strengthen the sustainability of West Java development based on the environment and local wisdom. Preparation of the West Java Regional Energy General Plan (REGP). Data processing to predict the level of planning for electrical energy needs in West Java is processed using LEAP (Long-range Energy Alternatives Planning System) software. Demand is calculated based on the amount of electrical energy consumption activity and the amount of electrical energy consumption per activity (energy intensity). The year 2019 is the base year for the calculation. The results obtained from the prediction of electrical energy demand in 2019-2030 show a positive trend, namely an increase from 111.7 million Giga Joules to 147.9 million Giga Joules. The energy transformation in the fuel output of each power plant in West Java for the baseline scenario, in 2030 will reach 95.3 million Giga Joules. Meanwhile, energy generation in the Demand Side Management (DSM) scenario in 2019 is 6 (Thousand MW), with a capacity of 3,600 MW. Then there is an increase every year, until in 2030 it will reach 26.6 (Thousand MW), with a capacity of 5,800 MW. From this paper, the procedures and data results from calculations using the LEAP tool are expected to provide an overview and input for readers in making policy in the energy sector in particular and regional development planning in general.

1 Introduction

Positioning of West Java in the dynamics of national and global development, especially those related to energy policy. Approach in the preparation of a general regional energy plan is not only about supply, demand, and price issues, but also considers global warming,

* Corresponding author: driefnor@gmail.com

sustainable development and national development policies and directions Energy is not positioned only as an economic commodity, but as an instrument in increasing economic growth and welfare. The population of West Java in 2015 was around 46 million people, of which 65% live in urban areas, which is the province with the largest population in Indonesia. West Java is one of the 3 (three) provinces in Indonesia that provides the largest contribution to the national economy, especially in the manufacturing industry sector and the national food supply. With the above conditions, the preparation of the draft General Provincial Energy Plan (GPEP) in the future is expected to strengthen the competitiveness of the West Java economy, fulfill basic needs in the energy sector and strengthen the sustainability of West Java development based on the environment and local wisdom.

Problems in West Java Limited fossil energy potential Dependence and consumption of fossil energy is very high (Transportation and industry volume), Energy infrastructure is generally owned by the state with very limited control accessibility (Jamali Network, Pipe & Gas etc.) Energy commodity prices are not controlled by the provincial government Impact environmental damage without an environment recovery cost The authority to manage the largest energy potential (geothermal) is not carried out by the provincial government [1]. Where, currently electricity consumption in West Java is 1231 KWA per capita and is expected to be 1,503 KWA per capita in 2023. Energy occupies a vital position in West Java, considering that this sector concerns the basic needs of the wider community. Covering households, industry, government, and institutions [2].

This paper aims to identify and understand energy planning in the West Java region based on Regional Energy General Plan (REGP) and National Energy Policy (NEP). By processing data using LEAP software. The scope/limitation of this paper is that it only focuses on energy policy in the province of West Java and uses several assumptions used by the author, namely: The total population of West Java as of 2019 is 49,023,200 people who occupy around 13,231 million households; The percentage of urban households is 33.3%; The percentage of rural households is 33.3%; and Assumption data for Current Accounts, Baseline scenarios, and Demand Side Management scenarios are described in the results and discussion sections.

2 Materials and Methods

2.1 Energy Potential in West Java

The potential for fossil energy in West Java comes from Oil and Gas for crude oil with reserves reaching 378.9 million barrels, with a production of 14.5 million barrels per year and is expected to last for the next 26 years if no new reserves are found. Then the natural gas reserves in West Java reached 2,976.7 BCF with an annual production of 190.7 BCF and is estimated to be able to last for the next 15 years. The potential of renewable energy in West Java has not been fully utilized, such as geothermal energy from its potential of 5,294 MW which has only been utilized for 1,164 MW. West Java has strong potential in contributing to making Indonesia the largest geothermal user in the world. Utilization of geothermal energy for power generation in fields that are already in production can be said to be optimal. However, there are still several other geothermal resource locations that can still be developed and utilized. Other new renewable energy potentials are Mini and Micro Hydro potential of 647 MW and new exploitation of 18.3 MW, Solar Energy with a potential of 9,099 MW but has only been utilized up to 0.3 MW, and Bioenergy from a potential of 2,551 MW has only been utilized for 109.3 MW and several other new renewable energy potentials that are still in the development stage such as Wind Energy and Ocean Energy (Figure 1) [3].

 https://doi.org/10.1051/e3sconf/202235901001

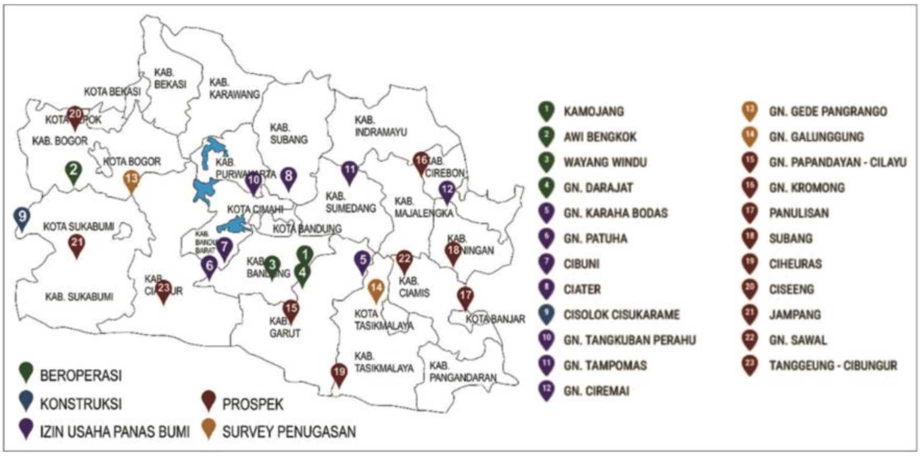


Fig. 1. Active Oil and Gas Working Area in West Java
(Source: Energy and Mineral Resources Offices; [3]**)**

2.2 Directions for Energy Policy in West Java

Based on sources quoted from the Department of Energy and Mineral Resources (DSDM) of West Java Province which was incorporated into West Java governor regulation number 15 of 2019 referring to Minister of Home Affairs Regulations Number 86 of 2017, that the formulation of the strategy statement and policy direction of Regional Apparatus in the next five years must be able to demonstrate relevance and consistency between the vision and mission statements of the Regional Medium-Term Development Plan (RMTDP) for the period with regard to the objectives, targets, strategies, and policy directions of the Regional Apparatus. In order to achieve the vision of 'The Realization of West Java, an Inner and Outer Champion with Innovation and Collaboration', the mission related to government affairs in energy and mineral resources is the mission of 'Accelerating growth and equitable distribution of sustainable development', with the target of 'Improvement of electrical energy infrastructure that supports economic growth and access to electricity for households to remote areas' and the target of 'Improving the quality of the environment and controlling the impact of climate change for the welfare of the community'.

2.3 Regional Energy General Plan (REGP) of West Java Province

In general, the implementation of the energy sub-sector in West Java is based on Law 30 of 2007 concerning Energy where energy development is divided into two priorities, namely the development of new and renewable energy (NRE) and increasing conservation efforts through energy savings [4]. In addition to this, the direction of energy development in West Java also refers to the General National Energy Plan (GNEP) based on Presidential Decree No. 22 of 2017, where the national NRE target in 2025 is 23% and in 2050 it is 31%. The national target is then translated into the West Java Regional Energy General Plan (REGP) through Regional Regulation Number 2 of 2019, where the target for the NRE mix in West Java is 20% in 2025 and 28% in 2050 [5].

2.4 LEAP (Long-range Energy Alternative Planning) Software

LEAP is a very comprehensive tool for energy planning. Many variables can be input variables such as income (GRDP), population, technology, to projected demand [6]. LEAP supports projections of final energy demand and demand for energy currently in use in detail including energy reserves, transportation, and so on. On the supply side, LEAP supports various simulation methods for modeling both capacity expansion and delivery processes from the plant. LEAP contains the Technology and Environment Database (TED) containing data on the costs, performance and emission factors of more than 1000 energy technologies. LEAP can be used to calculate emission profiles and can also be used to create emission scenarios from the non-energy sector (eg from cement production, land use change, solid waste, etc.) [6]. LEAP has features designed to create and create scenarios, manage and document data and assumptions, and view results reports easily and flexibly. LEAP consists of 4 main modules, namely the Variable Driver Module which in the new version is also called Key Assumptions, Demand Module, Transformation Module and Energy Resources Module.

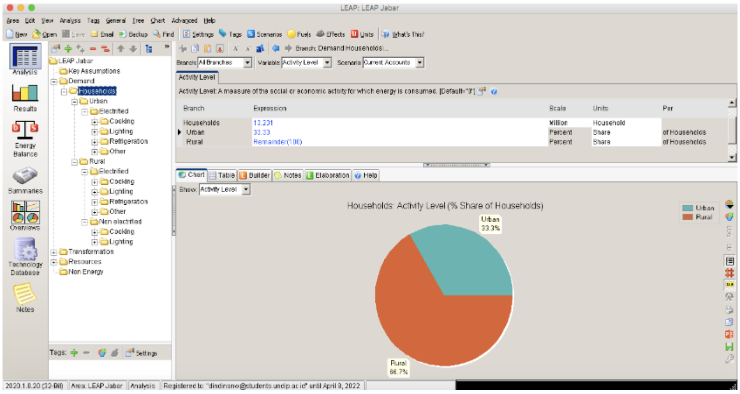


Fig. 2. Active Oil and Gas Working Area in West Java

LEAP, the Long-range Energy Alternatives Planning, a long-range energy planning system program, and how this program can be used in energy and environmental analysis. Freedonia (an example of a data structure in an independent country) reflects the characteristics found in industrialized or developed countries and in developing countries. In simple terms, the urban population is described as having fully enjoyed electricity and has a lifestyle in accordance with developed country societies, while the rural population has limited access to energy and is dependent on energy supply from biomass. In the discussion of this paper, it only covers a few sections in the household sector; energy applications in urban households, and cooking utensils and electricity in rural households [7].

3 Results and Discussion

3.1 Energy Demand

Analysis of energy demand in Freedonia only considers the household sector. Starting from setting up the “Current Accounts” data set that describes energy use in the sector in 2019. Next, creating a “Reference” scenario that analyzes how forms of energy consumption may change in the coming years, without the implementation of new policies. In the final analysis, we will develop a “Policy” scenario that analyzes how energy consumption growth can be reduced through energy efficiency policy measures [7].

3.1.1 Current Accounts

The LEAP work is carried out based on the assumption that the population of West Java as of 2019 is 49,023,200 people as shown in Figure 3 which occupies approximately 13,231 million households.

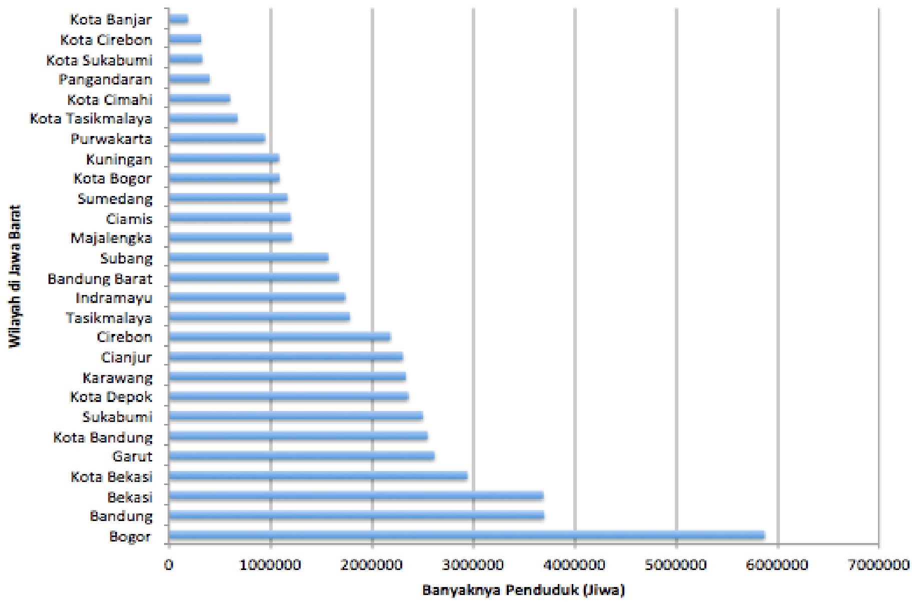


Fig. 3. Total population in West Java as of 2019

The percentage of households in West Java, for urban areas it is assumed by calculating the number of cities per number of areas in West Java, namely $(9/28) \times 100\% \approx 33{,}3\%$. Thus, 33.3% of the total population lives in urban areas, and the number of households in rural areas is calculated from the number of districts per area in West Java, namely $(19/28) \times 100\% \approx 66{,}7\%$. Thus, 66.7% of the total population lives in rural areas.
The main data from the Current Accounts are as follows:

1. Urban Area
   a. All residents in urban areas have enjoyed electricity and used electricity for lighting and other household appliances, with a total percentage of electricity needs, namely 100% Cooking, 100% Lighting, 95% Refrigeration, and 100% Other.
   b. 95% of urban households own a refrigerator with an average electricity consumption of 500 KWh per year.
   c. The average household in urban areas consumes 400 KWh of electricity for lighting each year.
   d. Other equipment such as video cassette players, televisions and fans consume 800 KWh of electricity per household annually.
   e. 30% of the urban population uses electric stoves for cooking, the rest uses gas stoves. All households have only one type of cooking utensil.
   f. The annual energy intensity from electric stoves is 400 KWh per household, while gas stoves require 60 cubic meters of natural gas for fuel per household.
2. Rural Area
   a. A recent survey of households in rural areas, whether electrified or not, indicates the type of cooking utensils (stoves) used, as tabulated in Table 1 below.

Table 1. Types of cooking utensils in rural areas in West Java

Cooking Technology	Fuel Consumed	% Rural Area Division	Energy Intensity per Household
Charcoal stove	Charcoal	30%	166 Kg
Gas stove	LPG	15%	59 Kg
Firewood	Wood	55%	525 Kg

b. Only 25% of households in rural areas have access to the electricity grid.
c. 20% of electrified households have refrigerators, with an average consumption of 500 KWh per year.
d. All electrified households use it for lighting, with a consumption of 335 KWh per household. Some 20% of these households also use kerosene lamps as additional lighting with a consumption of about 10 liters of kerosene per year.
e. Other electrical equipment (such as TV, radio, fan, etc.) consumes 111 KWh of electricity per household in a year.
f. Households that do not have electricity, rely entirely on kerosene for lighting, consuming an average of 69 liters per household per year.

3.1.2 Viewing Results

At this stage the visible results are only for one base year: 2019. Results can be seen in graphic format in Figure 4 or Table 2.
The number of levels in the table is adjusted to calculate subtotals of categories, increasing Levels to display the total fuel demand for each end use for the categories “Rural” and “Urban”, “Electrified”, and “Non-Electrified” [8].

Table 2. Current accounts energy demand in 2019 (Million GJ)

Branch	Charcoal	Wood	LPG	Kerosene	Natural Gas	Electricity	Total
Urban	-	-	-	-	6.3	28.5	34.8
Electrified	-	-	-	-	6.3	28.5	34.8
Cooking	-	-	-	-	6.3	1.9	8.2
Lighting	-	-	-	-	-	6.4	6.4
Refrigeration	-	-	-	-	-	7.5	7.5
Other	-	-	-	-	-	12.7	12.7
Rural	12.7	39.5	3.7	16.7	-	4.3	76.9
Electrified	3.2	9.9	0.9	0.2	-	4.3	18.5
Cooking	3.2	9.9	0.9	-	-	-	14.0
Lighting	-	-	-	0.2	-	2.7	2.8
Refrigeration	-	-	-	-	-	0.8	0.8
Other	-	-	-	-	-	0.9	0.9
Non electrified	9.5	29.6	2.8	16.5	-	-	58.4
Cooking	9.5	29.6	2.8	-	-	-	41.9
Lighting	-	-	-	16.5	-	-	16.5
Total	12.7	39.5	3.7	16.7	6.3	32.8	111.7

Based on the data in Table 2 above, it can be concluded that the total energy demand in West Java in 2019 was 111.7 million Giga Joules.

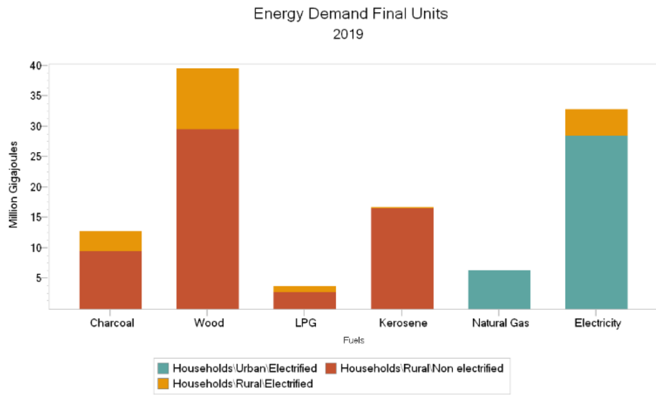


Fig. 4. Current accounts energy demand in 2019 (Million GJ)

3.1.3 Baseline Scenario

The next stage is to create forward-looking scenarios for the period 2020 to 2030. This stage will analyze how household energy demand is likely to develop over time under current policy conditions. This baseline scenario is described as "business as usual development; official GDP and population projections; no new policy measures" [8].
First enter the basic demographic changes that are expected to occur in West Java. The number of households is expected to grow from 13,231 million in 2019 at 3% per year.

1. Urban Household
   a. By 2030, 45% of West Java households will be in urban areas.
   b. Increased preference for electric stoves generate 55% market share by 2030.
   c. The energy intensity of electric and gas stoves is estimated to decrease by 0.5% annually due to the penetration of more energy efficient technologies.
   d. As incomes increase and people buy larger appliances, the annual cooling intensity increases to 600 kWh per household by 2030.
   e. Similarly, annual lighting intensity increases to 500 kWh per household by 2030.
   f. The use of other equipment that uses electricity is growing rapidly, at a rate of 2.5% per year.
2. Rural Household
   a. The ongoing rural electrification program is expected to increase the percentage of rural households with electricity to 28% by 2024 and 50% by 2030.
   b. With the increase in income, the intensity of electric lighting energy is estimated to increase by 1% per year.
   c. The number of grid-connected rural houses using refrigerators is expected to increase to 40% by 2024, and 66% by 2030.
   d. Due to rural development activities, the share of various cooking utensils in all households (both electrified and non-electric) has changed so that by 2030, LPG stoves are used by 55% of households, and charcoal stoves by 25%. The remaining rural households use wood stoves.

3.1.4 Baseline Results

The results of the baseline scenario based on fuel can be seen in Figure 5 (area chart type), Figure 6 (bar chart type) to view development data per 2 years, and Figure 7 (bar chart type) for annual development data. Meanwhile, the details of energy demand in the baseline scenario based on fuel are shown in Table 3 below.

Table 3. Energy demand in baseline scenario based on fuel (Million GJ)

Fuel	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Electricity	32.8	35.8	38.9	42.2	45.8	49.6	54.4	59.5	65.0	70.9	77.2	83.8
Natural Gas	6.3	6.5	6.6	6.7	6.9	7.0	7.0	7.1	7.2	7.2	7.2	7.2
Kerosene	16.7	16.8	16.9	17.0	17.1	17.1	16.5	15.8	15.2	14.4	13.7	13.0
LPG	3.7	4.7	5.6	6.6	7.7	8.7	9.8	10.9	12.0	13.1	14.3	15.5
Wood	39.5	37.7	35.9	34.0	32.0	29.9	27.8	25.7	23.4	21.2	18.8	16.4
Charcoal	12.7	12.7	12.6	12.6	12.6	12.5	12.5	12.4	12.3	12.2	12.2	12.1
Total	111.7	114.1	116.5	119.1	121.9	124.9	128.0	131.4	135.1	139.1	143.4	147.9

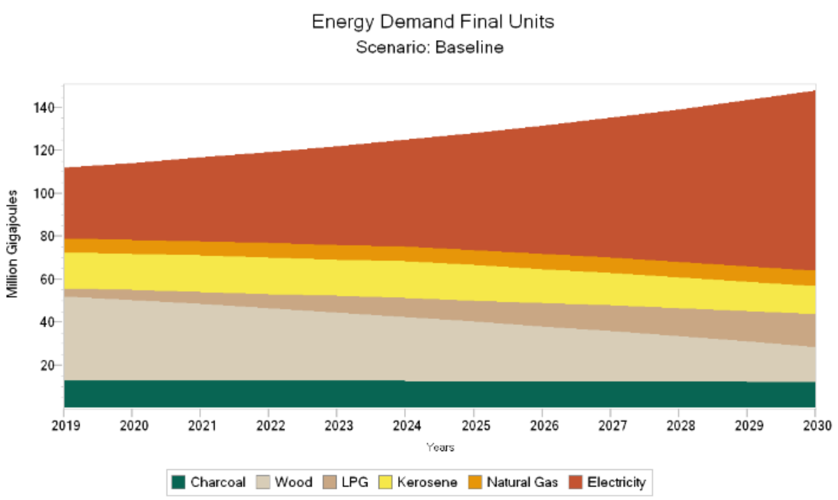


Fig. 5. Energy demand by fuel in the baseline scenario every 2 years (Million GJ)

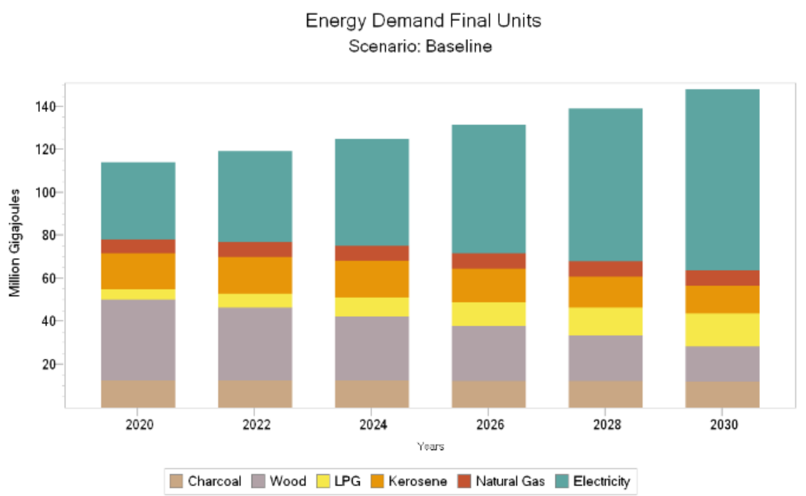


Fig. 6. Energy demand by fuel in the baseline scenario every 2 years (Million GJ)

The details of energy demand in the baseline scenario based on the energy branch are shown in Table 4 below.

Table 4. Energy demand in the baseline scenario by energy branch (Million GJ)

Branch	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Households	111.7	114.1	116.5	119.1	121.9	124.9	128.0	131.4	135.1	139.1	143.4	147.9
Urban	34.8	37.5	40.4	43.5	46.8	50.3	54.0	57.9	62.1	66.5	71.3	76.3
Electrified	34.8	37.5	40.4	43.5	46.8	50.3	54.0	57.9	62.1	66.5	71.3	76.3
Cooking	8.2	8.6	9.1	9.5	9.9	10.4	10.9	11.3	11.8	12.3	12.9	13.4
Lighting	6.4	6.9	7.5	8.1	8.8	9.5	10.3	11.1	11.9	12.8	13.8	14.8
Refrigeration	7.5	8.2	8.8	9.5	10.3	11.1	11.9	12.8	13.7	14.7	15.8	16.9
Other	12.7	13.8	15.1	16.4	17.8	19.3	20.9	22.7	24.6	26.6	28.8	31.1
Rural	76.9	76.5	76.1	75.6	75.1	74.6	74.1	73.5	73.0	72.6	72.1	71.7
Electrified	18.5	18.9	19.4	19.9	20.4	20.8	23.6	26.3	29.0	31.7	34.4	37.1
Cooking	14.0	14.1	14.2	14.3	14.3	14.3	15.9	17.3	18.6	19.9	21.0	22.0
Lighting	2.8	3.0	3.1	3.2	3.4	3.5	4.1	4.7	5.2	5.9	6.5	7.1
Refrigeration	0.8	1.0	1.2	1.4	1.7	1.9	2.4	3.0	3.6	4.3	5.1	6.0
Other	0.9	0.9	0.9	1.0	1.0	1.1	1.2	1.4	1.5	1.7	1.8	2.0
Non electrified	58.4	57.6	56.7	55.7	54.8	53.8	50.5	47.2	44.0	40.8	37.7	34.6
Cooking	41.9	40.9	39.9	38.9	37.9	36.8	34.2	31.7	29.1	26.7	24.3	22.0
Lighting	16.5	16.6	16.7	16.8	16.9	16.9	16.3	15.6	14.9	14.1	13.4	12.6
Total	111.7	114.1	116.5	119.1	121.9	124.9	128.0	131.4	135.1	139.1	143.4	147.9

Based on the data from Tables 3 and Tables 4, energy demand planning in the baseline scenario based on fuel and its energy branches is increasing every year until by 2030, energy demand in West Java reaches 147.9 million Giga Joules.

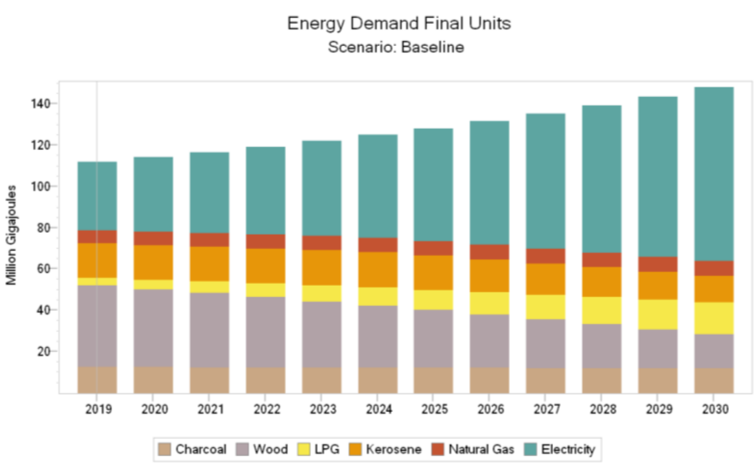


Fig. 7. Energy demand by fuel in the baseline scenario in all years (Million GJ)

3.2 Energy Transformation

The Transformation sector uses specialized branches called modules to model energy demand and conversions such as electricity generation, oil refining or charcoal production. Each module consists of one or more processes that represent each technology such as a type of power generation or oil refining, and produces one or more fuel products. The process and results of these fuels represent the energy products produced by the module [7]. In this section we will develop a simple model of electricity transmission and generation in West Java.

 https://doi.org/10.1051/e3sconf/202235901001

3.2.1 Transmission and Distribution

This section begins by adding a simple module to represent the losses of the electricity transmission and distribution (T&D) process and natural gas pipelines. In the base year, T&D losses are in the range of 15% of the electricity generated in 2019. In the baseline scenario, T&D losses are expected to decrease to 12% in 2030. Meanwhile, natural gas pipeline losses are 2% in 2019 and is planned to reduce to 1.5% by 2030.

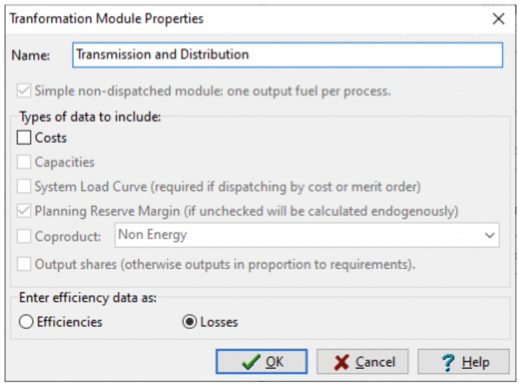


Fig. 8. Transformation module properties for transmission and distribution

3.2.2 Power Generation

Next, simulate electricity generation in West Java. The "Electricity Generation" module should already appear in the list. If not, then have to add it.
The order of the modules reflects the flow of energy sources from the basic form/extraction (bottom order) to final energy use (top order). Therefore, electricity must be generated before it is transmitted and distributed. The same is applied to the coal mining module which is the fuel for power generation, which will be placed next [7]. Make sure that you have set the appropriate properties ( ) for the Electricity Generation module. Because it will define detailed data about capacity, cost, efficiency and system load curve of the installation, it is necessary to enter the data by ticking the details of the data mentioned above [8], and are shown in Figure 9 below.

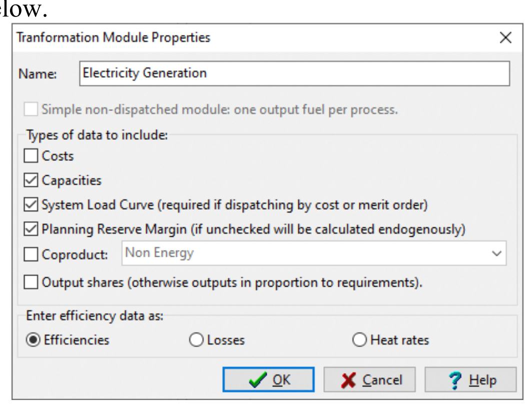


Fig. 9. Transformation module properties for power generation

In the next step, adding the assumption of three processes as a representation of various kinds of power plants in West Java. The following Table 5 provides information regarding the basic characteristics assumptions of the three power plants.

Table 5. Assumptions of the basic characteristics of power plants

Types of Power Plants	Installed Capacity (MW)	Efficiency (%)	Merit Order	Maximum Availability (%)	Historical Production (GWh)
Existing Coal Steam	1000	30	1 (base)	70	3343.2
Existing Hydro	500	100	1 (base)	70	1731.3
Existing Oil Combustion Turbine	800	25	2 (peak)	80	895.5

In this section, simulate the base year operating system in particular. This was done because that year already had historical data describing the power plant operating system. There are no operational data for subsequent years. Therefore, we will simulate different dispatched power plants by specifying dispatch rules and various parameters that allow LEAP to simulate these dispatched power plants through merit orders [7, 8].
The power generation system is assumed to operate with a minimum planning reserve margin of 35%. The data is entered in the Electricity Generation branch.

3.2.3 The Baseline Scenario

In the baseline scenario, it is possible to determine the assumption of changes to the power generation system in the future.

a. There are no plans to build a new power plant in West Java.
b. In the baseline scenario, the existing coal power plant (Existing Coal Steam) is planned to be closed. The coal power plant with a capacity of 500MW will be laid off in 2023 and the remaining 500MW will be laid off in 2027.
c. In the future, in order to meet demand and replace power plants that have stopped operating, a Coal Steam Power Plant (capacity of 500 MW with an efficiency of 35%) will be established for the base load and an Existing Oil Combustion Turbine (capacity of 300 MW with an efficiency of 30%) for medium loads. Both types of power plants have an operating life of 30 years and a maximum capacity of 80%.

Then, enter the following data in LEAP by adding two new processes "New Coal Steam" and "New Oil Combustion Turbine" under Current Accounts.

Table 6. New process assumptions for power generation

Addition Order	Build Order	Process	Addition Size Expression
1	0	New Coal Steam	500
2	0	New Oil Combustion Turbine	300

3.2.4 Viewing Results

The results of energy transformation in electricity generation in West Java are shown in Figure 10 and Figure 11. Figure 10 represents the fuel output of each power plant in West Java for the baseline scenario, where in 2030 the total fuel output from power plants will reach 95.3 million Giga Joules, as tabulated in Table 7 and Table 8. The same thing is represented in Figure 11, but there are two additional new processes, namely "New Coal Steam" and "New Oil Combustion Turbine".

 https://doi.org/10.1051/e3sconf/202235901001

Table 7. Electricity Generation in West Java: Baseline Scenario by fuel

Fuel	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Residual Fuel Oil	3.2	7.3	5.3	7.7	9.8	8.2	11.7	11.1	14.5	14.4	14.6	19.3
Coal Bituminous	12.0	28.1	33.9	35.0	36.8	42.9	44.5	50.9	53.4	60.1	66.9	69.2
Hydro	6.2	6.6	6.3	6.5	6.6	6.4	6.6	6.5	6.7	6.6	6.5	6.7
Total	21.5	41.9	45.5	49.2	53.2	57.4	62.8	68.5	74.6	81.1	88.0	95.3

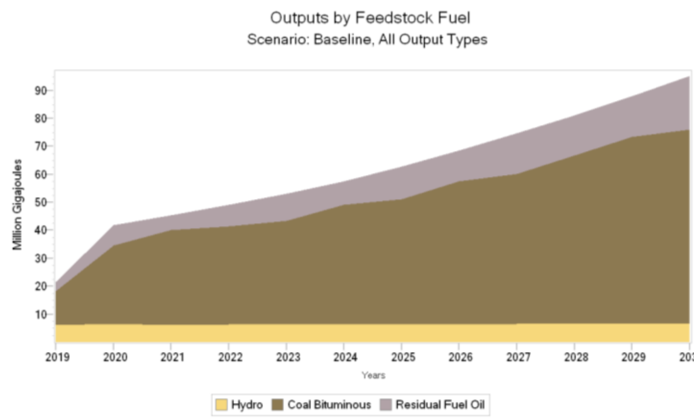


Fig. 10. Output fuel at power plants in West Java: baseline scenario

Table 8. Electricity Generation in West Java: Baseline Scenario by branch

Branch	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Existing Coal Steam	12.0	13.1	12.5	12.9	6.6	6.4	6.6	6.5	-	-	-	-
Existing Hydro	6.2	6.6	6.3	6.5	6.6	6.4	6.6	6.5	6.7	6.6	6.5	6.7
Existing Oil Combustion Turbine	3.2	4.2	3.0	4.4	4.6	3.3	4.1	3.9	4.5	4.0	3.6	4.4
New Coal Steam	-	15.0	21.4	22.1	30.2	36.5	37.9	44.5	53.4	60.1	66.9	69.2
New Oil Combustion Turbine	-	3.1	2.3	3.3	5.2	4.9	7.6	7.2	10.0	10.4	10.9	14.9
Total	21.5	41.9	45.5	49.2	53.2	57.4	62.8	68.5	74.6	81.1	88.0	95.3

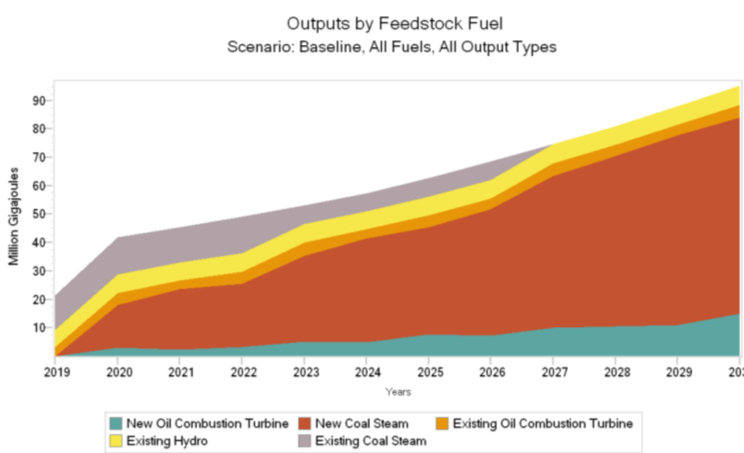


Fig. 11. Electricity generation in West Java: baseline scenario

3.3 Emission

In this section, we will take advantage of the default emission factors as suggested by the Intergovernmental Panel on Climate Change (IPCC). To create this link, click the technology branch and then select the Environment tab. Using the preferred form of TED technology (shown in Figure 12), then select the IPCC Tier 1 default technology that is appropriate for each demand-side and power generation technology [7, 8].

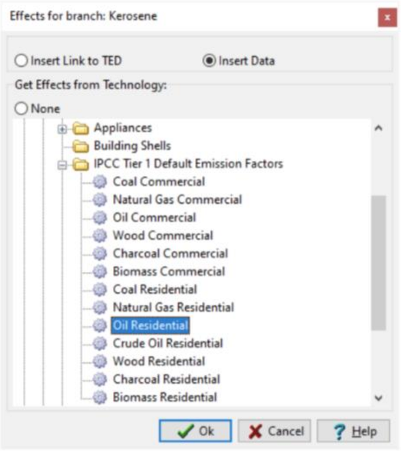


Fig. 12. Effects for the kerosene branch

Then, ensure that the input fuel for the TED technology choice is the same as the fuel used in the LEAP technology. In some situations, IPCC Tier 1 technology does not cover all fuel options. If this is the case, then the closest condition must be selected (for example: the IPP "Oil Residential" category can be linked to the "Kerosene Lighting" category from LEAP. There is no need to add environmental load data to any demand-side electrical equipment (e.g. lighting or refrigerators) because the environmental impact is going upstream (eg to power plants that are actively operating) [7, 8].

3.3.1 Viewing Results

The results for the potential 100-year global warming emissions from West Java in the baseline scenario can be seen in Figure 13 (based on the energy branch) and in Figure 14 (based on fuel), with a note that in the base year, 2019 global warming emissions are 6.9 Million Metric Tonnes CO_2-equivalent. The potential for global warming emissions continues to increase every year as shown in Table 9 and Table 10, until by 2030 the potential for global warming emissions will reach 25.8 Million Metric Tonnes CO_2-equivalent.

Table 9. One hundred year global warming potential of emissions from West Java baseline scenario by branch (all GHGs)

Branch	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Demand	2.3	2.3	2.4	2.4	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5
Transformation	4.7	10.0	11.0	12.0	12.7	13.8	15.2	16.7	17.9	19.7	21.5	23.3
Total	6.9	12.3	13.4	14.4	15.1	16.3	17.7	19.2	20.4	22.1	24.0	25.8

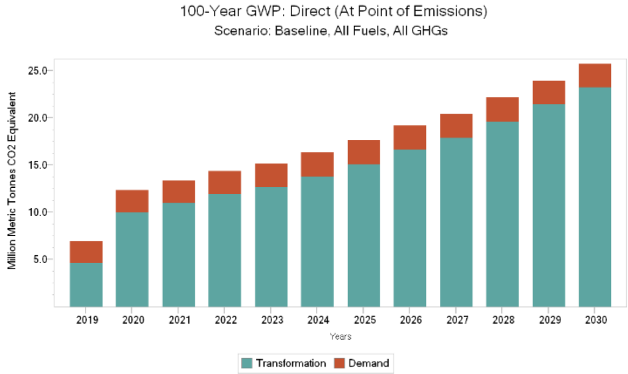


Fig. 13. One hundred year global warming potential of emissions from West Java baseline scenario by branch (all GHGs)

Table 10. One hundred year global warming potential of emissions from West Java baseline scenario by fuel (all GHGs)

Fuel	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Natural Gas	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4
Kerosene	1.2	1.2	1.2	1.2	1.2	1.3	1.2	1.2	1.1	1.1	1.0	0.9
Residual Fuel Oil	0.9	2.0	1.4	2.1	2.6	2.1	3.0	2.9	3.7	3.7	3.7	4.9
LPG	0.2	0.3	0.3	0.4	0.4	0.5	0.5	0.6	0.7	0.7	0.8	0.9
Coal Bituminous	3.7	8.0	9.6	9.9	10.1	11.7	12.1	13.8	14.2	16.0	17.8	18.4
Wood	0.4	0.4	0.4	0.3	0.3	0.3	0.3	0.3	0.2	0.2	0.2	0.2
Charcoal	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Total	6.9	12.3	13.4	14.4	15.1	16.3	17.7	19.2	20.4	22.1	24.0	25.8

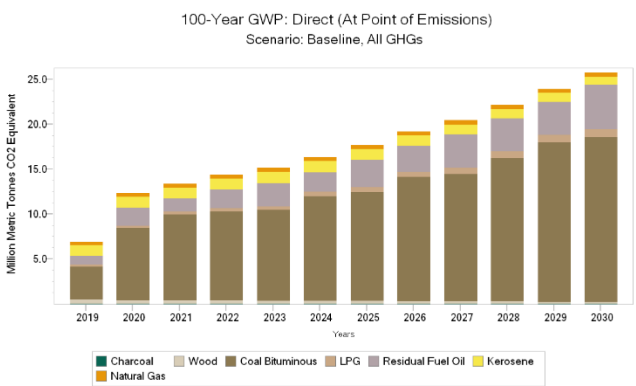


Fig. 14. One hundred year global warming potential of emissions from West Java baseline scenario by fuel (all GHGs)

3.4 Second Scenario: Demand-Side-Management

"Demand Side Management" scenario, abbreviated as "DSM" and described as "Efficient lighting, reduction of transmission and distribution losses, and improvement of electrical system load factor." [7, 8].

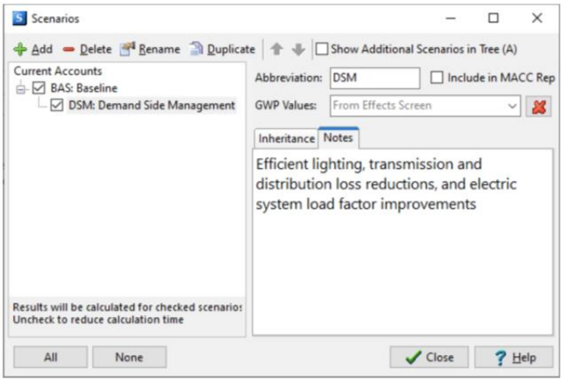


Fig. 15. Demand-Side-Management Scenario

The DSM scenario consists of four policy steps [8], namely:

1. Refrigeration: The new policy towards increasing efficiency standards on the use of refrigerators is expected to reduce energy intensity in the urban household sector by 5% in 2024 and by 20% in 2030 compared to Current Accounts. Meanwhile, in rural households, the intensity may not change.
   *Interp(2024, BaseYearValue * 0.95, 2030, BaseYearValue * 0.8)*
2. Lighting: Includes various programs including new lighting standards and the utilization of the Demand Side Management program which is expected to reduce the intensity of lighting energy from lighting electricity in urban households by up to 1% per year (-1% per year) and in rural households from 1% (baseline scenario) to 0.3% per year (+0.3% per year).
3. Transmission and Distribution: Through a planned DSM program, electricity transmission and distribution losses are expected to be reduced to 12% in 2024 and 9% in 2030.
   Interp(2024, 12, 2030, 9)

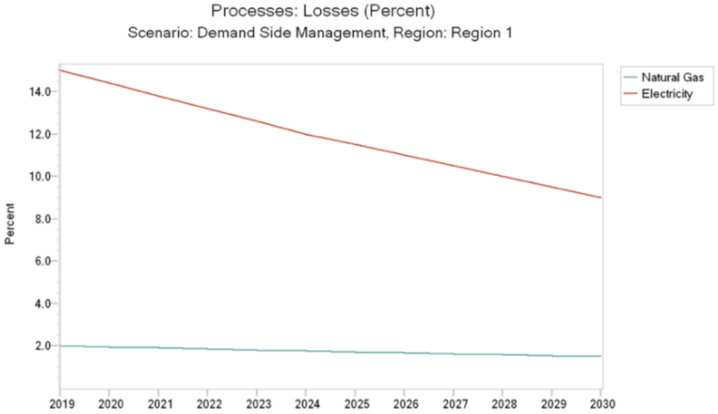
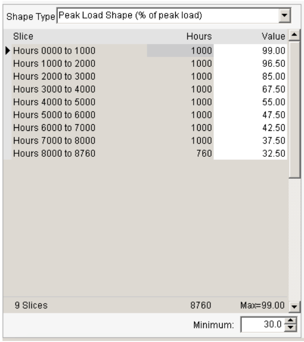


Fig. 16. Processes: Losses (%) DSM Scenario

4. Electric System Load Factor Improvements: Various load leveling programs in the DSM plan are expected to increase the system load factor by about 64% by 2030. Do not enter load factors manually in LEAP, but create one. a new yearly shape with the data listed on the right.

 https://doi.org/10.1051/e3sconf/202235901001



Shape Type: Peak Load Shape (% of peak load)

Slice	Hours	Value
Hours 0000 to 1000	1000	99.00
Hours 1000 to 2000	1000	96.50
Hours 2000 to 3000	1000	85.00
Hours 3000 to 4000	1000	67.50
Hours 4000 to 5000	1000	55.00
Hours 5000 to 6000	1000	47.50
Hours 6000 to 7000	1000	42.50
Hours 7000 to 8000	1000	37.50
Hours 8000 to 8760	760	32.50
9 Slices	8760	Max=99.00

Minimum: 30.0

Fig. 17. Yearly shapes DSM load shape

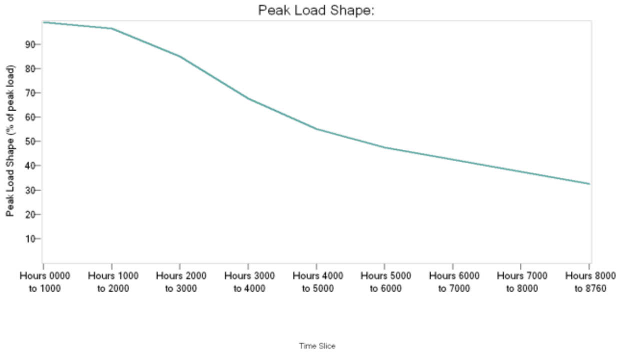


Fig. 18. Interpolation of system load curve through 2030 for DSM scenario

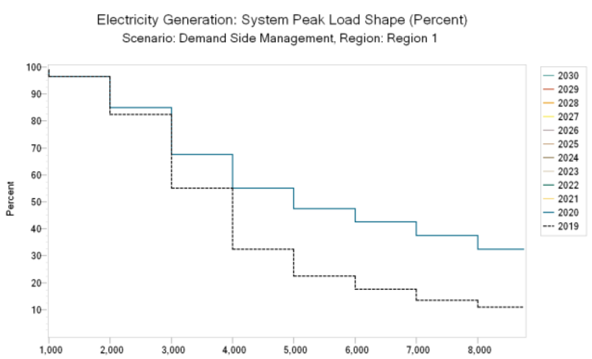


Fig. 19. Interpolation of load curves in 2019 (System load curves, marked with a dotted black line) and Electricity generation load curves: DSM scenario in 2030 (marked with blue lines)

3.4.1 DSM Scenario Results

The Energy generation in the DSM scenario in 2019 is 6 (Thousand MW), with a capacity = 3,600 MW. Then there is an increase every year, until in 2030 it will reach 26.6 (Thousand MW), with a capacity of 5,800 MW.

 https://doi.org/10.1051/e3sconf/202235901001

Table 11. Electricity generation: DSM scenario vs. baseline scenario

Branch	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Avoided vs. Baseline	-	0.1	0.3	0.6	0.8	1.1	1.5	1.9	2.3	2.8	3.3	3.9
Existing Coal Steam	3.4	4.3	4.5	4.6	2.7	2.4	2.5	2.6	-	-	-	-
Existing Hydro	1.7	2.1	2.2	2.3	2.7	2.4	2.5	2.6	2.7	2.5	2.6	2.5
Existing Oil Combustion Turbine	0.9	0.2	0.5	0.7	1.5	1.0	1.3	1.4	1.5	1.2	1.3	1.1
New Coal Steam	-	4.9	5.1	5.3	6.1	8.3	8.7	9.0	12.2	14.5	14.9	17.2
New Oil Combustion Turbine	-	0.1	0.2	0.3	1.1	0.7	1.0	1.6	2.2	1.7	2.4	2.0
Total	6.0	11.7	12.7	13.8	14.9	16.1	17.5	19.1	20.8	22.7	24.6	26.6

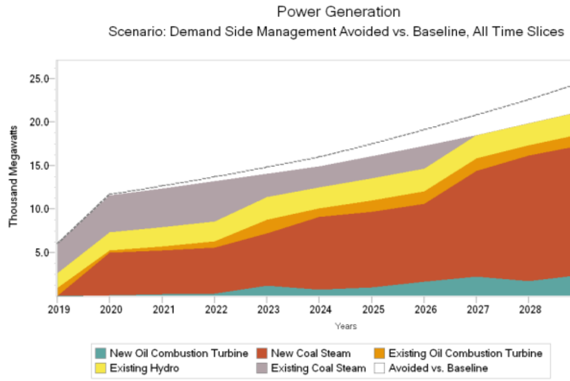


Fig. 20. Electricity generation: DSM scenario vs. baseline scenario

Table 12. Capacity: DSM scenario vs. baseline scenario

Branch	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Avoided vs. Baseline	-	300.0	800.0	800.0	1,300.0	1,600.0	1,900.0	2,100.0	2,100.0	2,400.0	2,900.0	2,700.0
Existing Coal Steam	1,000.0	1,000.0	1,000.0	1,000.0	500.0	500.0	500.0	500.0	-	-	-	-
Existing Hydro	500.0	500.0	500.0	500.0	500.0	500.0	500.0	500.0	500.0	500.0	500.0	500.0
Existing Oil Combustion Turbine	800.0	800.0	800.0	800.0	800.0	800.0	800.0	800.0	800.0	800.0	800.0	800.0
New Coal Steam	1,000.0	1,000.0	1,000.0	1,000.0	1,000.0	1,500.0	1,500.0	1,500.0	2,000.0	2,500.0	2,500.0	3,000.0
New Oil Combustion Turbine	300.0	300.0	300.0	300.0	600.0	600.0	600.0	900.0	1,200.0	1,200.0	1,500.0	1,500.0
Total	3,600.0	3,900.0	4,400.0	4,400.0	4,700.0	5,500.0	5,800.0	6,300.0	6,600.0	7,400.0	8,200.0	8,500.0

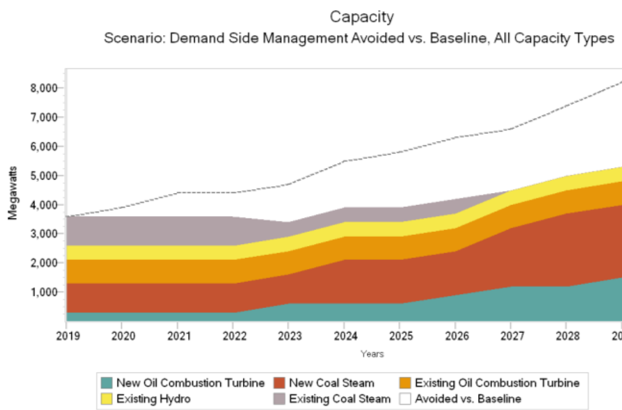


Fig. 21. Capacity: DSM scenario vs. baseline scenario

4 Conclusion

Based on the data assumptions and discussions listed in the results and discussion sections, it can be concluded that the total energy demand in West Java in 2019 was 111.7 million Giga Joule. Planning for energy demand in the baseline scenario based on fuel and its energy branches, which continues to increase every year until in 2030, energy demand in West Java reaches 147.9 million Giga Joules. The results of the energy transformation in the fuel output of each power plant in West Java for the baseline scenario, where in 2030 the total fuel output from power plants will reach 95.3 million Giga Joules. The results for the potential 100-year global warming emissions from West Java in the baseline scenario noted that in the base year, 2019 global warming emissions were 6.9 Million Metric Tonnes CO2-equivalent. The potential for global warming emissions continues to increase every year, until by 2030 the potential for global warming emissions will reach 25.8 Million Metric Tonnes of CO2-equivalent. Energy generation in the Demand Side Management (DSM) scenario in 2019 is 6 (Thousand MW), with a capacity = 3,600 MW. Then there is an increase every year, until in 2030 it will reach 26.6 (Thousand MW), with a capacity of 5,800 MW.

References

1. I. Agusalim, *Rencana Umum Energi Daerah Provinsi (RUED-P) Jawa Barat*, *docplayer.info*, (2016).
2. A. Budianto, *Rasio Elektrifikasi di Jawa Barat Capai 99,9%*, *ekbis.sindonews.com*, (2019).
3. S. Thamrin, R. Ambarwati, and S. Hidayat, *The strategies of west java's regional energy management: To support national energy security*, Int. J. Energy Econ. Policy, vol. 10, no. 6, pp. 376–382, (2020), doi: 10.32479/ijeep.10259.
4. Ministry of Energy and Mineral Resources, J*urnal Energi Media Komunikasi Kementerian Energi dan Sumber Daya Mineral*, J. Energi, vol. Edisi 02, pp. 16–19, (2016), [Online]. Available: https://www.esdm.go.id/assets/media/content/FIX2_Jurnal_Energi_Edisi_2_17112016(1).pdf.
5. West Java Regional Regulation DESDM, *Renstra Rencana Strategis Tahun 2018-2023*, (2019).
6. Suhono, *Kajian Perencanaan Permintaan dan Penyediaan Energi Listrik di Wilayah Kabupaten Sleman Menggunakan Perangkat Lunak LEAP*, Universitas Gadjah Mada, (2010).
7. M. K. Wijaya, M. E. dan Ridwan, *Modul Pelatihan Perencanaan Energi*, Exercise. USA: Stockholm Environment Institute, (2011).
8. C. Heaps, *LEAP Training Exercise English 2020*. USA: Stockholm Environment Institute, (2020).