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Reliability Index of Wind-Solar Hybrid Power Plants using the Expected Energy Not Supplied Method

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Abstract: This paper proposes the reliability index of wind-solar hybrid power plants using the expected energy not supplied method. The location of this research is wind-solar hybrid power plants Pantai Baru, Bantul, Special Region of Yogyakarta, Indonesia. The method to determine the reliability of the power plant is the expected energy not supplied (EENS) method. This analysis used hybrid plant operational data in 2018. The results of the analysis have been done on the Pantai Baru hybrid power plant about reliability for electric power systems with EENS. The results of this study can be concluded that based on the load duration curve, loads have a load more than the operating kW of the system that is 99 kW. In contrast, the total power contained in the Pantai Baru hybrid power plant is 90 kW. This fact makes the system forced to release the load. The reliability index of the power system in the initial conditions, it produces an EENS value in 2018, resulting in a total value of 2,512% or 449 kW. The EENS value still does not meet the standards set by the National Electricity Market (NEM), which is <0.002% per year. Based on this data, it can be said that the reliability of the New Coast hybrid power generation system in 2018 is in the unreliable category.

Index Terms: Renewable energy, hybrid system, wind energy.

I. INTRODUCTION

Wind and solar based hybrid power plants are electricity generation systems using renewable energy [1]-[4]. The power plant in this study is a power plant that has been built in Ngentak Hamlet, Poncosari, Srandakan, Bantul Regency, Yogyakarta, Indonesia, in 2011. This power plant has provided a solution to meet the supply of electrical energy. The Pantai Baru Pandansimo hybrid generating system is integrated by two power plants, namely solar power plants (photovoltaic arrays) and wind power plants. The Pantai Baru Pandansimo hybrid generating system has 238 units of solar panels and 34 units of wind turbines that can generate electrical power of 90 kW. However, the Pandansimo Pantai Baru hybrid generating system is no longer functioning optimally to supply electricity to the community. That is caused by wind problems to generate wind power plants that are less effective and problems with damaged equipment such as inverters that function to move electrical energy from solar panels to batteries. Besides, the batteries in the Pandansimo Pantai Baru hybrid generating system must also be replaced because they no longer function optimally [5]-[6].

As a result of these problems can cause harm to people who use the hybrid generator system, where the New Pantai Pandansimo hybrid generating system is actively managed by the community and is a reference for renewable energy management in Indonesia in terms of its energy independence. Therefore it is essential to maintain the reliability of the generating system for the continuity of the distribution of electricity [7]-[9].

To meet and serve the needs of electricity for consumers, the reliability of the generating system is critical. A right level of reliability will determine the continuity in the distribution of electricity to the power system, and this can be calculated using the Expected Energy Not Supplied (EENS) index. EENS is a calculation or possible energy that cannot be supplied by a generator. The value of EENS is very dependent on the variation of the generator operating on the system in a particular time [10]-[11].

The purpose of this study is to determine the value of EENS in determining the reliability of the Pandansimo New Coast hybrid plant, analyze the relationship between the load time curve in the calculation of EENS, and know the value of EENS in the Pandansimo New Hybrid Power Plant following PLN standards. The benefits of this research are expected to be input for Pandansimo New Coast Hybrid Power Plant in developing and increasing the quality of the company and to find out how much the reliability level of the Pandansimo New Hybrid Power Plant.

II. LITERATURE REVIEW

Hybrid Power Plants

A hybrid power plant is a generator that has a sound generation system to serve stand-alone areas as well as areas not covered by the grid.

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For the primary energy source, the hybrid power plant uses renewable energy, and the backup energy source uses the Diesel-Generator Set [12]-[13]. In hybrid power plants, solar, wind, and others as renewable energy that can be combined with the Diesel-Generator Set so that it can become an efficient, effective, and reliable generator for supplying the electrical energy needs of the community or customers. The burden that can meet electricity needs by utilizing hybrid power plants is only in the form of home lighting or the need for electrical equipment and the needs of small industries in the area [14]. In other cases, solar cell energy can only be obtained during the day when the weather is sunny, while wind energy can be obtained during the day or night. Overcoming this solution is to use batteries to store energy that has been collected from solar cell energy and wind energy [15]-[16].

In hybrid power plants needed backup or emergency energy due to energy shortages that might occur if they only rely on solar cell energy and wind energy [17]. Cloudy or rainy weather conditions will only produce less energy from solar energy, and the absence of wind can make wind power plants not produce energy. Therefore a backup energy source is needed to overcome the problem of energy shortages in hybrid power plants [18]-[19].

The hybrid power system consists of two energy sources, namely the sun, with the help of PV modules and wind with the help of wind turbines and generators as backup energy. The working principle of hybrid power plants for the utilization of solar energy, solar panels capture sunlight, which then turns into electrical energy [20]. There are photovoltaic cells in a solar panel made of two layers of silicon. When the solar panel is exposed to sunlight, positive and negative ions will be generated in the silicon layer, and will then produce electrical energy [21]-[22].

To utilize wind energy at the same time, that is, when the wind blows, the turbine wheels move and rotate the rotor on the diesel-set generator, which then generates electrical energy. The electrical energy is then distributed to the batteries to be stored [23].

Electrical energy from windmills and solar cells is in the form of direct current, whereas electronic equipment such as TVs, water pumps, electric irons, and other needs use alternating current. For this reason, a current converter from DC to AC is needed, i.e., an inverter. Figure 1 shows the typical hybrid power plants [24]-[25].

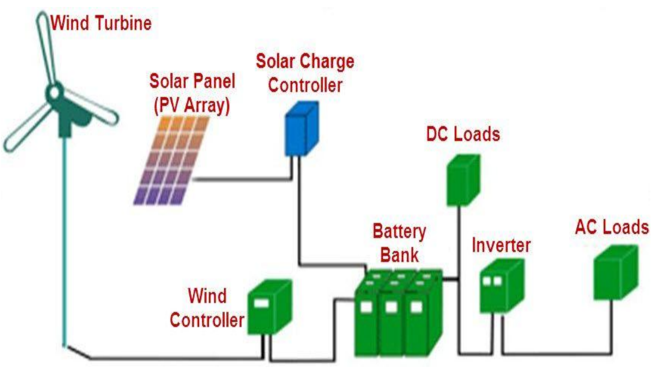

Figure 1. The typical hybrid power plants

The Pantai Baru hybrid power plant is a combination of the Solar Power Plant and the Wind Power Plant. In Solar Power Plants use solar panels arranged in series to produce voltage and arranged in parallel to get a large current [26]. In the Wind Power Plant using windmills or low-speed wind turbines, with an average wind turbine specifications with a capacity of 1 kW [27].

In the Pantai Baru Hybrid Power Plant, there are three electricity generation groups, namely the western group, the eastern group, and the KKP group. In the western group, there is a wind turbine system of 240 V and a solar panel system of 120 V with a total capacity of 36 kW. In the east group, there are 48 V, 120 V, and 240 V generation systems consisting of solar panels and wind turbines with a total capacity of 44 kW. In the CTF group, there are only solar panels with a 48 V system with a total capacity of 10 kW. In wind turbine systems often used dummy load devices. Dummy Load is a dumping ground for the overvoltage generated by the generator. If the voltage generated is up to 260 V, the voltage will be transferred to the dummy load.

Wind energy is a renewable energy that contributes significantly in meeting the needs of electricity, especially remote areas [28]-[29]. Figure 2 shows one of the wind power plants on Pantai Baru.

Figure 2. Wind power plant in Pantai Baru hybrid systems

Table 1. Wind turbine specifications in Pantai Baru hybrid power plants

Specifications of wind turbine	
Type	1 kW/240 V
Pmax	1 kW
Vmax	240 V
Wind speed (Cut In)	3,5 m/s < *v* < 25 m/s
Wind speed (Cut Off)	*v*<3,5 m/s, *v*<25 m/s
Rotation speed	375 rpm
Generator 3 Phase	1500 watt
Magnetizing Generator	Permanent magnet
Tower height	15 mm
Blades number	3 pieces
Blade length	1450 mm
Blade weight	2,45 kg
Blade materials	Fiber Reinforced
Blade pointer	Tail plate

The specifications of the wind turbine found in the Pantai Baru hybrid power plant for the type of lattice and tri angel can be seen in Table 1.

Wind Power Plant can be one of the solutions to environmental problems and the availability of energy sources because wind energy is energy available at all times and, most importantly, free from pollution. The wind turbines used in the Pantai Baru hybrid power plant are types of lattice wind turbines [30].

Solar panels and windmills help each other in supplying electrical energy. When it is blazing hot while the wind speed is low, the solar panel is in charge of supplying electrical energy and then storing it into the battery. Vice versa, when the weather is raining while the wind speed is stable, then the windmill will take over as an energy supplier. Figure 3 shows solar panels in Pantai Baru hybrid power plants while the specifications is shown in Table 2.

Figure 3. Solar panels in Pantai Baru hybrid power plants

Table 2. Solar panel specifications in Pantai Baru hybrid power plants

Specifications of solar panels	
Company	Skytec Solar
Model No.	SIP-220
Standard Test Conditional AM	1,5 E : 1000 W/m^2
Temp.	25^{o}C
Rated Power (Pmax)	220 V
Open Circuit Voltage (Voc)	36,24 V
Short Circuit Current (Isc)	7,93 A
Maximum Power Voltage (Vpm)	29,82 V
Maximum Power Current (Ipm)	7,39 A
System Voltage	12 V
Maximum System Voltage	1000 V
Weight	19 kg
Dimension	987 x 1637 x 45 mm

Solar power generation is electricity generation that converts solar energy into electrical energy by using solar panels as its primary tool [31]-[32]. In the Pantai Baru hybrid generator, solar panels (PV) are arranged in series to produce voltage and arranged in parallel to produce large currents. The material contained in the solar panel is polycrystalline silicon with a tilt angle setting of 15 degrees to the ground. The electrical energy obtained by solar panels depends on the amount of power from the system when the battery reaches its maximum voltage.Solar panels are an essential component in solar power plants. Solar panels are electronic devices that convert solar energy into electrical energy [33].

Expected Energy Not Supplied Method

Expected Energy Not Supplied Method (EENS) is a calculation or the possibility of energy that cannot be supplied by a generator. The value of EENS is very dependent on the variation of the generator operating on the system in a specific time. The reliability standard for EENS is based on the National Electricity Market (NEM) that energy that is not available every year is not more than 0.002% of the total energy consumption in the area. The EENS value is obtained by multiplying the energy value curtailed by the probability of the generator being in service. Energy curtailed is obtained from the area under the old load curve that is formed, the parts of that area are determined by the value of the generator that is operating or in service.

A load curve with its curve equation is for example defined as $f(x) = -0.1033x^2 + 0.6082x + 76.057$. The line equation is used to find the value of energy curtailed that does not form a flat figure. The following is the formula used to find the energy value curtailed.

$$EC = \int_{x_n}^{x_{n+1}} f(x)dx \quad (1)$$

where EC is Energy Curtailed, f (x) is the equation of the load curve, and x_n, x_{n+1} is the upper and lower limits of the integral, which is the value of the point of intersection between the old load curve and the magnitude of the generator in operation or service.

The calculation used to calculate the value of energy curtailed that does not form a flat figure is by introducing the equation of the old curve of the load with the integral limit corresponding to the formed cutoff. Energy curtailed values can be found using the flat wake formula if the area formed by the intersection between the in-service generator value and the old load curve creates a two-dimensional figure. So it can be said that energy curtailed is equal to the area or area formed under the old curve of the load formed.

The EENS value can be found by multiplying the energy value curtailed by the probability of the generator is in service, how to calculate the EENS value can be seen in the following formula:

$$EENS = EC \text{ x } P \quad (2)$$

where EENS is Expected Energy Not Supplied, EC is Energy Curtailed, and P is In-Service Power Probability.

III. METHODOLOGY

This research was conducted at the Hybrid Power Plant, which is an electric energy generation system using renewable energy. The research location at the Hybrid Power Plant is located in Ngentak Hamlet, Poncosari, Srandakan, Bantul Regency, Special Region of Yogyakarta, Indonesia.

The tool used in this study is a laptop unit with Windows 10.1 64 bit operating system as a media for designing and testing the simulation to be performed. Microsoft Word and Microsoft Excel software as the leading software used to do the design and calculation in this study. Daily, weekly, monthly, and yearly load data that is used and supplied by the Pantai Baru hybrid generating system is used in the analysis of hybrid plant performance. The steps of this study are stated in the form of a flow chart, as shown in Figure 4.

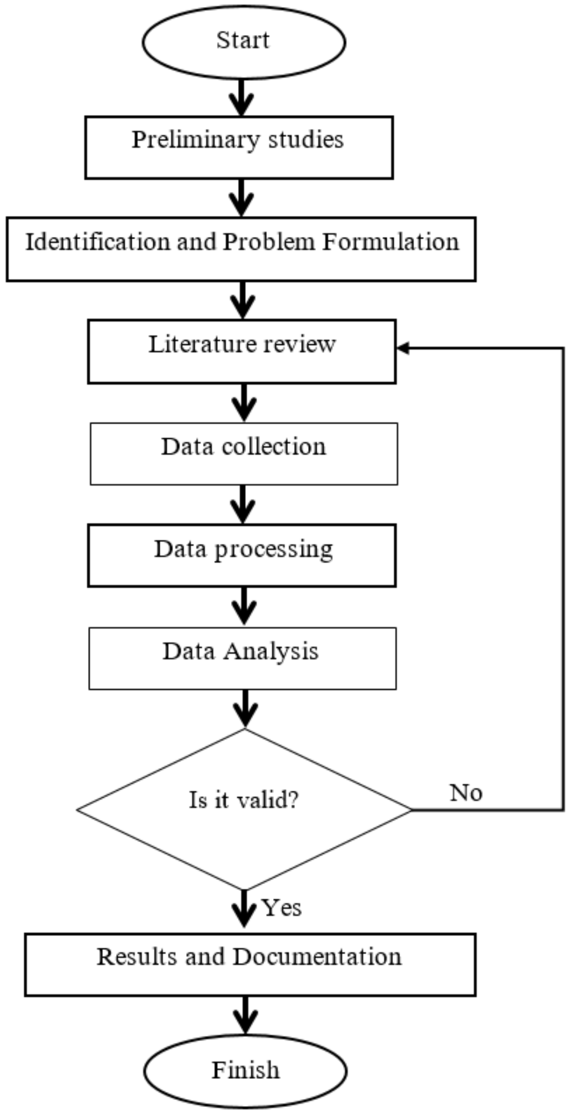

Figure 4. The steps of this study

IV. RESULTS AND DISCUSSION

Forced Outage Rate (FOR) of Hybrid Power plants

Hybrid power plants in the Pantai Baru system, electric power generation units are divided into three units. There are two types of generation in this generation system, namely solar panels and wind turbines (triangle and lattice), each of which has an installed power capacity. In the Pantai Baru hybrid power plant, the total installed capacity is 90 KW, which consists of the east group is 44 kW, the west group is 36 kW, and the KKP group is 10 kW, with 238 solar panel units and 34 wind turbine units.

After knowing the number of units in the Pantai Baru hybrid power plant which has three groups of generating units, a combination that might occur in the operation of the system can be found in terms of power supply. In this calculation, the value of n is the number of generating units contained in the system. With the number of generating units is 3, the combination of wind power plants is 8.

Individual probabilities or likelihood of each combination can be calculated using the FOR (Forced Outage Rate). FOR calculation is done by knowing the duration of disturbance from each unit in the Pantai Baru hybrid power plant. FOR calculations are also carried out before calculating individual probabilities or probability of occurring.

Disturbances that occurred at the Pantai Baru hybrid power plant, including on January 21, 2019, were carried out maintenance to replace the 48 V inverter component and the transformer that burned in the western group, so maintenance time was needed for 120 minutes. On March 9, 2019, repairs were made to the eastern group unit, which performed repairs on 5 kW and 10 kW wind turbine intervals with a working time of 120 minutes. Then on March 10, 2019, for the KKP group repaired office electrical installations and public street lighting, namely the removal of electricity lines with a duration of 180 minutes.

In this calculation, the FOR value is obtained from each group. For the east group, which has a disturbance for 120 minutes, has a FOR value of 0.0769, and this value is the same as the western group, which has a disturbance for 120 minutes, then the FOR value from the western group is the same as the east group. For the FOR value of the KKP group that has a disturbance for 180 minutes, the FOR value is 0.1111.

After obtaining a FOR value on each unit, it will be known the amount of disturbance that occurs and the possibility of the unit operating within the time the unit is operated (1-FOR). Then the FOR value will be used to look for individual probabilities.

Individual Probability (IP) of Hybrid Power plants

After finding the FOR value for each unit, the next step is to calculate the individual probability (IP). The amount of power that has forced outage from the system of one unit, two units, and three units will be calculated. Each calculation will know the value of kW on an outage, starting from the value 0 (zero) equal to the largest.

In the east group system, the kW on outage value describes the amount of power that is interrupted. A value of 0 (zero) explains if there is a disturbance of 0 kW, then the individual probability is ($1-FOR_1$) ie, 1 - 0.0769 = 0.9231 meaning 0.9231 is the likelihood of the unit operating, whereas when the power has a disturbance of 44 kW or as much as the power unit group, then the individual probability is FOR_1 or the possibility of a system experiencing a breakdown of 0.0769.

In the western group system, the same as the eastern group, which is different, is only the power. The starting value at kW on outage is the same as the starting value, because each calculation starts when the system has a disturbance of 0 kW which explains if a disturbance occurs at 0 kW, then the individual probability is (1-FOR2) ie 1 - 0.0769 = 0.9231 means that 0.9231 is the likelihood of the unit operating, whereas when the power is disturbed by 36 kW or equal to the unit power of the generating group, then the individual probability is FOR2 or the possibility of the system being disturbed by 0.0769.

In the KKP group system is the same as the east and west group system, the difference is only in the magnitude of power and value of FOR. In the table above, the kW on outage value describes the amount of power that is experiencing interference.

A value of 0 (zero) explains if there is a disturbance of 0 kW, then the individual probability is (1-FOR_3) ie 1 - 0.1111 = 0.8889 meaning 0.8889 is the likelihood of an operating unit, whereas when the power has a disturbance of 10 kW or equal to the unit power of the generating group, then the individual probability is FOR_3 or the possibility of the system experiencing an error of 0.1111.

Next is calculating the probability of individual systems by combining them into two units namely the CTF group with the western group first. Individual probability calculation which consists of two units, namely the western group unit and the CTF group, where the value of 0 (zero) in the unit column describes the generating unit that is having a forced outage and the value of 1 (one) describes the generating unit in operation.

The individual probabilities of the two units, the western group, and the KKP group are operating normally, or no disturbance occurs then the amount of interference power is 0 kW with the individual probability calculation, IP (0 kW) = (1-FOR_3) (1-FOR_2) = 0.8889 x 0.9231 = 0.8205.

The next condition is when the KKP group is experiencing interference (0 kW) while the western group is in normal condition (36 kW), then the total capacity experiencing disturbance is 10 kW + 0 kW = 10 kW, so the individual probability value is ip (10 kW) = FOR_3 (1-FOR_2) = 0.1111 x 0.9231 = 0.1026.

When the next condition is the opposite condition from the second condition, which is when the KKP group is in normal condition (10 kW) while the western group is experiencing interference (0 kW), then the total capacity that is interrupted is 0 kW + 36 kW = 36 kW, so the individual probability value is IP (36 kW) = (1-FOR_3) FOR_2 = 0.8889 x 0.0769 = 0.0684.

Individual probability when both units experience interference then the amount of interference power is 10 kW + 36 kW = 46 kW, so the individual probability value is ip (46 kW) = FOR_3 x FOR_2 = 0.1111 x 0.0769 = 0.0085.

Table 3. Calculations for the three generating groups with individual probability

Group Units			kW on outage	kW in outage	Probability	
KKP	West	East				
1	1	0	44	46	(1-FOR_3) (1-FOR_2) FOR_1	0.063
0	1	0	54	36	FOR_3 (1-FOR_2) FOR_1	0.008
1	0	0	80	10	(1-FOR_3) FOR_2 x FOR_1	0.005
0	0	0	90	0	FOR_3 x FOR_2 x FOR_1	0.001
1	1	1	0	90	(1-FOR_3) (1-FOR_2) (1-FOR_1)	0.757
0	1	1	10	80	FOR_3 (1-FOR_2) (1-FOR_1)	0.095
1	0	1	36	54	(1-FOR_3) FOR_2 (1-FOR_1)	0.063
0	0	1	46	44	FOR_3 x FOR_2 (1-FOR_1)	0.008
Total						1

The next step is to calculate the individual probabilities of 3 (three) generating units. Calculations for the three generating groups with individual probability calculations was shown in Table 3.

Table 3 is made into two parts, namely the kW on outage table, the first table is (n-1) unit + 0 and in the second table is (n-1) unit + P_n. In this case, (n -1) unit is the value of kW on outage which has been used from the previous calculation which is 0 kW and 10 kW, while Pn is the value of kW on outage which will be included in the calculation of individual probability which is 36 kW.

From the above table, the calculation of individual probabilities for groups to be added, namely:

a. For (n-1) units + 0 = individual probability in the table (n-1) unit times (1-FOR_n)
b. For (n-1) units + P_n = individual probability in the table (n-1) unit times (1-FOR_n)

Where in the calculation FOR_n = FOR_1 and (1-FOR_n) = (1-FOR_1).

Load Curve of Hybrid Power plants

The next step is to analyze the reliability of the hybrid power generation system based on the load curve. Load curves illustrate the variation in load on a generator, which is measured in KW units as a function of time. The intended time function can be daily, weekly, monthly, and yearly. However, this discussion will be limited to one day a year. The data obtained is data per day. The load curve shows the relationship between the ability to supply power (watts) with the length of time the service serves (years). The old load curve is obtained from a load curve, which is then sorted from the largest to the smallest load power with the same time function from day 1 to day 364. The electricity load curve served by the Pantai Baru hybrid power plant during 2018 is shown in Figure 5.

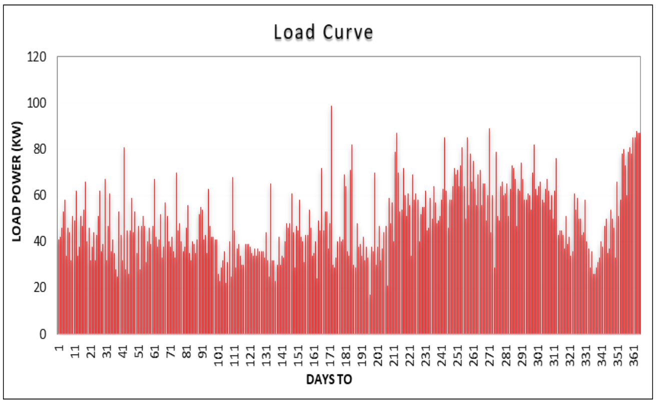

Figure 5. The electricity load curve served by the Pantai Baru hybrid power plant during 2018

Based on the electricity load curve, as shown in Figure 5, there is a load that exceeds the operating system kW of 99 kW on the 21st day of June, which causes load loss or outages. After obtaining a load curve, then make a load duration curve by sorting the load power value from the largest on the left and the smallest value on the right from the graph. Figure 5 shows the electricity load duration curve served by the Pantai Baru hybrid power plant during 2018.

After making a load duration curve, then the time value t will be obtained. The requirement to determine the value of t is that the load power ≥ kW of operation or power is available. When the operating kW is 90 kW, the on outage load is 0 kW, or the system has no disruption is 0 kW. Therefore, the system operates optimally without any disturbance, which is 90 kW. The value of t when the condition is one because when the load condition is more excellent than 90 kW which is 99 kW, and the load curve that has been compiled is on the 1st day, therefore the value of t = 1. If there is a load on the old curve, the load is more than 5 kW of operation; there will be a load release.

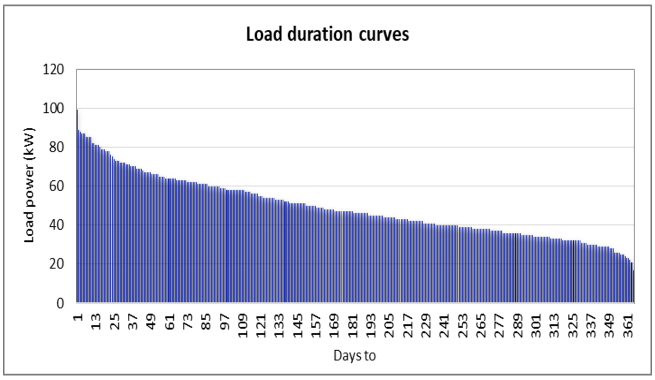

Figure 5. The electricity load duration curve served by the Pantai Baru hybrid power plant during 2018

When the operating kW is 80 kW, the on outage load is 10 kW, or the system is experiencing interference is 10 kW, from the installed power that is 90 kW. The value of t at the time of the condition is 16 because when the kW load value is 81 and on the old curve the load that has been arranged is on the 16th day, therefore the value of t = 16. When the operating kW is 54 kW, the load is on outage is 36 kW, or the system is experiencing interference is 36 kW, from the installed power that is 90 kW. The value of t at the time of the condition is 129 because at the time the kW load value is 54 and on the old curve, the load that has been compiled is on the 129th day, therefore the value of t = 129.

When the operating kW is 46 kW, the on-outage load is 44 kW, or the system that is experiencing interference is 44 kW, from the amount of installed power that is 90 kW. The value of t at the time of the condition is 190 because when the kW load value is 46 and on the old load curve that has been arranged is on the 190th day, therefore the value of t = 190. When kW operating is 44 kW, then the load is on outage is 46 kW, or the system is experiencing interference is 46 kW, from the installed power that is 90 kW. The value of t at the time of the condition is 226 because at the time the kW load value is 44 and on the old curve, the load that has been arranged is on the 226th day, therefore the value of t = 226.

When the operating kW is 36 kW, the on-outage load is 54 kW, or the system that is interrupted is 54 kW, from the amount of installed power that is 90 kW. The value of t at the time of the condition is 290 because when the kW load value is 36 and on the old curve, the load that has been arranged is on the 290th day, therefore the value of t = 290. When kW is operating at ten kW, then the load is on outage is 80 kW or the system experiencing interference is 80 kW, from the installed power that is 90 kW. The value of t at the time of the condition is 364 because when the load value of kW is 17 and on the old curve, the load that has been compiled is on the 364th day, therefore the value of t = 364. When the operating kW is 0 kW, then the load is on outage is 90 kW, or the system is experiencing interference is 90 kW, from the installed power that is 90 kW. The value of t at the time of the condition is 364 because when the load value of kW is 0 and on the old curve, the load that has been arranged is on the 364th day, therefore the value of t = 364. A summary of the results of the t time calculation is shown in Table 4.

Table 3. Calculations for time t in Pantai Baru hybrid power plant

Power of Out Service (kW)	Power of In Service (kW)	Time t
0	90	1
10	80	16
36	54	129
44	46	190
46	44	226
54	36	290
80	10	364
90	0	364

Expected Energy Not Supplied (EENS)

Expected Energy Not Supplied (EENS) is a calculation or the possibility of energy that cannot be supplied by a generator. The value of EENS is very dependent on the variation of the generator operating on the system in a specific time. The EENS value is obtained by multiplying the energy value curtailed by the probability of the generator being in service. This value can be shown in the equation EENS = EC x P. Energy curtailed is obtained from the area under the old load curve that is formed, the parts of that area are determined by the value of the generator that is operating or in service. Figure 6 shows the electricity load duration curve with its equation served by the Pantai Baru hybrid power plant during 2018

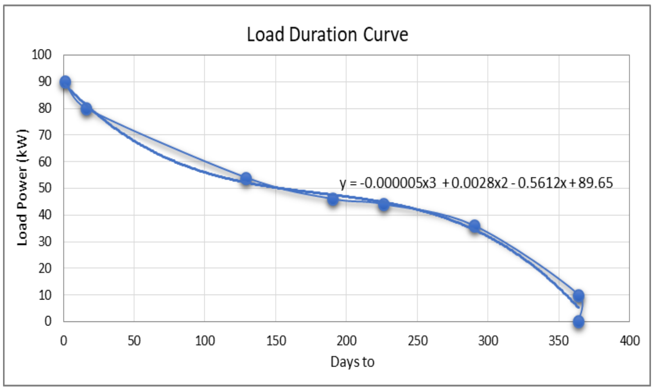

Figure 6. The electricity load duration curve with its equation served by the Pantai Baru hybrid power plant during 2018

From the load duration curve as shown in Figure 6, the curve line equation is $y = -0.000005x^3 + 0.0028x^2 - 0.5612x + 89.65$. This equation is used to find energy curtailed whose shape is not a two-dimensional figure.

The formula for getting the energy value curtailed is $EC = \int_{x_n}^{x_{n+1}} f(x)dx$.

Based on this formula, the calculation for the out of service condition is then performed based on the data, as shown in Table 3. The power values in the out of service condition are used as the basis for the x variable. The curtailed energy values are summarized in a table, as shown in Table 4.

Table 4. Calculations for curtailed energy in Pantai Baru hybrid power plant

Power of In Service (kW)	Time t	Curtailed Energy
0	364	18524
10	364	14884
36	190	4837
44	226	3498
46	190	2937
54	129	1587
80	16	86
90	1	-1

After that, the next step is to look for the EENS value by multiplying the energy value curtailed by the probability of the generator being in service. The complete EENS calculation results are shown in Table 5.

Table 5. EENS for Pantai Baru hybrid power plant

EENS for UNIT 1, 2 and 3				
Capacity Out of Service (kW)	Capacity in Service (kW)	Probability	Energy Curtailed (kWh)	Expectation (kWh)
0	90	0.757	0	0
10	80	0.095	86	8
36	54	0.063	1587	100
44	46	0.063	2937	185
46	44	0.008	3498	27
54	36	0.008	4837	38
80	10	0.005	14884	78
90	0	0.001	17876	12
$EENS_{1,2,3}$				449

Based on the results of calculations, as shown in Table 5, Expect Energy Not Supplied (EENS) in PLTH Pantai Baru with a total of 3 generating units will produce a total value of 449 kWh / year or 2,512% in 2018. If stated in a percentage, then the EENS value obtained as follows:

EENS (%) = (EENS Value) / (Total value of generator load data for 1 year) x 100%

EENS (%) = (449 kWh) / (17876 kWh) x 100%

EENS (%) = 2,512%

This value still does not meet the established National Electricity Market (NEM) standard that is <0.002% / year. From this, it can be said that the Hybrid Power Plant in Pantai Baru has a low level of reliability or in other words, is not reliable.

V. CONCLUSION

The results of the analysis have been done on the Pantai Baru hybrid power plant about reliability for electric power systems with EENS. It can be concluded that based on the load duration curve, loads have a load more than the operating kW of the system that is 99 kW. In contrast, the total power contained the Pantai Baru hybrid power plant is 90 kW. This fact makes the system forced to lose the load or release the load. In the calculation of the reliability index of the power system in the initial conditions, it produces an EENS value in 2018, resulting in a total value of 2,512% or 449 kW. The EENS value still does not meet the standards set by the National Electricity Market (NEM), which is <0.002% / year. Based on this data, it can be said that the reliability of the Pantai Baru hybrid power generation system in 2018 is in the unreliable category.

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