Effect of Load Growth on PLTH Baron Techno Park Performance

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***Abstract*--The reliability of stand-alone and hybrid power plant systems was dependent on electrical loads that the system must supply. For example, on renewable energy sources (RES), Reviews of those systems needs to be calculated well before the development process. One of the most important processes in the initial calculation is the electrical load that must be supplied by the system. The electrical load has a major influence on the amount of power generating capacity. A power plant that has higher electricity production than the load to be fulfilled was considered capable of meeting the system electrical load requirements. However, in terms of the reliability, it is considered as a loss because it will affect the life of the components and the high cost of operating from the system. Therefore, this research discusses the effect of load growth on hybrid power plant system performance of Baron Techno Park. The result of the research shows that the total electricity production of Baron Techno Park hybrid power plant system is 319.695 kWh/year with Net Present Cost (NPC) is $560.077 and the cost of energy (COE) is $0.64/kWh. Total electricity consumption of the PLTH Baron Techno Park is 67.413 kWh/year with total excess electrical energy is 245,547 kWh/year. Load growth of 5%, 10%, 15%, and 20% of the total current load affect the consumption of electric energy, excess electrical energy, and COE. The higher the load growth will affect the total electricity consumption that is increasingly higher so that the total excess electrical energy is lower. This research found that the performance of the system is not influenced by load growth. The highest performance of the system is resulted by the wind turbine of 72.62%, followed by solar panels of 18.82%, and biodiesel of 8.56%.**

***Keywords*--Load, Load Growth, Electricity Production, Power Consumption, Performance, NPC, COE.**

I. INTRODUCTION

No doubt that the demand for electricity in the modern era is a requirement that may be synchronized with the primary human needs. Electrical energy need is in line with the era of modernization. Unfortunately, the availability of the electrical energy cannot meet human needs. This is because the human need for electricity increases every time. The impact of the imbalance of energy provided by the electrical needs has been experienced by people living in remote areas.

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Data recorded from the Ministry of Finance in 2017, Indonesia recorded 74,954 villages spread over 33 provinces [1]. From this data, there are 17% or 12,659 remote villages that do not have access to electricity from State Electricity Company (PLN). From 12,659 villages, nearly 20% or 2,519 villages have no electricity at all [2]. This will greatly affect the economic growth and people's lives. In terms of potential, Indonesia has a lot of potential renewable sources of electric energy, among which are solar energy, wind energy, geothermal, hydro, marine and biomass. If it can be fully utilized, the shortage of supply of the electrical energy as mentioned earlier can be solved.

In order to maximize the electrical energy generated from renewable energy sources, the hybrid system is an alternative way that can be applied to optimize renewable energy sources. Hybrid Model of Renewable Optimalization (HOMER) is one of the software applications that can be used to design and analyze the power generation system, either stand-alone or hybrid systems. Research on the analysis of a hybrid power plant with the help of the HOMER software has been carried out in several countries, including Indonesia, among which are studies on the performance analysis of power generation hybrid system (wind and solar) in Pantai Baru Pandansimo Bantul, Yogyakarta [3]. In the study, the performance and economic value hybrid power system in Bantul Yogyakarta Pandansimo beach was analyzed. The analysis was performed using the HOMER software of PLTH conditions of Pandansimo Off-Grid and On-Grid. The result of the analysis is the data of PLTH Pandansimo system performance and enhanced system performance of PLTH Pandansimo in the production of electrical energy either from an economic point of value Net Present Cost (NPC) and the Cost of Energy (COE). In addition, research conducted using the HOMER software has also been done in locations in Tuba island Langkawi Malaysia [4]. The research and analysis aimed at optimizing the mini-grid solar power plants with storage systems such as batteries and inverters. The economic analysis in the study includes consideration of the initial investment cost (Initial Capital), NPC (Total Net Present Cost), COE/cost of electricity produced per kWh, and the payback period/SPBT (Simple Payback Time).

One of the areas in Indonesia which has a huge potential for renewable energy is the Special Region of Yogyakarta, precisely in the southern coast of Gunung Kidul. This is the reason of the Agency for the Assessment and Application of Technology (BPPT) to develop some renewable energy which one of them is a hybrid power generation (wind, solar, PLT diesel, and biodiesel) located in Baron Beach (Baron Techo Park). PLTH system development of the Baron Techno Park was funded by a NORAH grant from Norway in 2009 in collaboration with the government of the province of Yogyakarta. PLTH system installed in Baron Techno Park has a capacity of 36 kW solar power, thermal power station of 15 kW, 25 kW PLT diesel, and biodiesel 25 kW. In addition, the power plant of the Baron Techno Park also has a battery bank with a capacity of 228 kVAh (120 cells, 1,200 Ah), Hybrid Power Controller with a total capacity of 25 kVA, and system data acquisition [5]. Because of several obstacles when this research conducted, PLTH Baron Techno Park system operates only with a solar power capacity of 24 kW and 5 kW thermal power station.

Research on performance analysis of hybrid power plants of the Baron Techno Park has been done before. Results of a study comparing the performance of a system that operates (PLTS 24 kW, 5 kW thermal power station) with the installed system (PLTS 36 kW, 15 kW thermal power station). From the analysis of identification of both solar systems and operating thermal power station and the installed electrical load PLTH is able to meet Baron Techno Park. In addition, the system connected to the electricity grid (on-grid) have a higher economic improvement compared to system off-grid [6].

In contrast to previous research, this paper discusses the power generation system performance of the Baron Techno Park in the future when all generation sources installed to work optimally, both for the solar thermal power station, PLT diesel or biodiesel. In addition to differences in generation capacity, the total load in this study is also higher than previous studies. It can be seen from the data of the PLTH Baron Techno Park that operates. With the addition of generating capacity and load, the system's ability to serve burden as well as the growing influence of the burden of the cost, the total electricity production, performance, and reliability of future systems analyzed. Recommendations from this study can be used as a reference for system development of the PLTH Baron Techno Park in the future, both to increase generating capacity and load capacity.

II. METHODOLOGY

This study used the HOMER software to analyze the performance of the PLTH Baron Techno Park. The analysis of this study is based on two categories of load, the real burden that is regarded as a burden that must be met in the current system and the burden in the future, which is regarded as the electric load growth of the PLTH Baron Techno Park. The real burden in this study is considered as the growing burden of 0% (constant). The growing burden used as the sensitivity analysis is increased from 5%, 10%, 15% and 20%, of the total real burden. The analysis of the current load is intended to determine whether the system is viable and able to meet the load demand for the PLTH Baron Techno Park. Additionally, the presence of load growth analyzed the total production of electricity and the excess electrical power generated by the system. Furthermore, analyzed the influence of the growing burden of the costs and performance of the system. Parameters for the economic improvement of the system of the PLTH Baron Techno Park in terms of total cost of the current (Net Present Cost) and electricity production costs per kWh (Cost of Energy). In the last stage, the performance calculation is performed to determine the percentage of the performance of solar panels, wind turbines, and biodiesel.

A. *Calculation of HOMER Method*

HOMER performs energy balance calculations for each system configuration that will be considered and then determines the proper configuration, whether it can meet the electricity needs with the conditions specified and estimated operating costs and installation costs during the project period. Calculation of system costs of which are capital costs, replacement costs, operating and maintenance costs, fuel, and interest rates. The software works by three steps, namely simulation, optimization, and sensitivity analysis [7]. In this study, the method of calculation used is as follows.

1) Net Cost Total: Calculation of annualized cost on HOMER done by calculating the net present cost, then it is multiplied by a factor of capital determination, as shown in (1) [8].

$$C_{aan} = \text{CRF}(i,R_{proj}) \,.\, C_{NPC} \quad (1)$$

C_{aan} is the total annualized cost ($/year), CRF is a factor determining the capital stock, i is the interest rate (%), R_{proj} is long a project operates, and C_{NPC} is the present total cost.

NPC cost calculation is performed to determine the total cost of the initial construction of the system. NPC cost calculation includes initial investment costs (I), the cost of turnover (R), the cost of operation and maintenance (O&M), the cost of fuel (Fuel), and a residual value (SLV). Residual value is the component that is saved at the operation time. In other words, there are no additional costs for maintenance and replacement. In the system development, it is expected to obtain a low total cost of NPC. The current cost (NPC) can be calculated using (2).

$$\text{CNPC} = (\text{Cann, tot}) / (\text{CRF (i, Rproj)}) \quad (2)$$

2) Levelized Cost of Energy (COE): It is defined as the average cost per kWh of electricity production generated by the system. Similarly, the cost of the NPC, the system design is expected to cost a small electric energy production. The COE is used to calculate costs, as shown in (3).

$$\text{COE} = \frac{C_{ann-}C_{boiler}\,H_{served}}{E_{Served}} \quad (3)$$

with C_{boiler} is a cost margin boiler ($/kWh), H_{served} is available total thermal load (kWh/year), and E_{served} is the total available electrical load (kWh/year).

3) Capital Recovery Factor: Capital recovery efforts in the operation is known as "capital recovery factor". It is the value of the results of operations of the system used to calculate the current income (a set amount of annual cash). The equation of the capital recovery factor can be written as (4).

$$\text{CRF}(i,N) = \frac{i\,(1+i)^N}{(1+i)^N-1} \quad (4)$$

where i is the interest rate (%), and N is the number of years of system operation.

4) Performance Ratio (PR): The ratio of the performance of the power plant is an indicator of performance used in the power generation system to determine the quality of the overall performance of plants installed. PR is defined as the ratio of output actual and nominal of the system. To determine PR, it uses (5) [9].

$$PR = \frac{Actual\ Plant\ Output\ (kWh)}{Calculated\ Nominal\ Plant\ Output\ (kWh)} X\ 100\% \quad (5)$$

Actual plant output is the output actual generating (kWh) and Calculated Plant Nominal output is output nominal generator calculated (kWh).

B. Profile of PLTH Baron Techno Park

The PLTH Baron Techno Park consists of several subsystems power plants, namely two wind power plants (thermal power station) with a capacity of 10 kW and 5 kW solar power plant (SPP) 36 kW are divided into three arrays with 120 modules each PV array power is 120 Wp per panel, generator biodiesel with a capacity of 25 kW, the storage system (battery bank) which is divided into two arrays with each array there are eight strings and each string there are 15 batteries. The capacity of the battery bank is 288 kVAh, 1,200 Ah. Baron PLTH Techno Park presents a diesel generator with a capacity of 25 kW, but it is not included in the simulation because the reality on the ground, the generator is only prepared to meet the demand of the load when all the plants are not in operation, and situations like this are rare. The Baron Techno Park PLTH system is shown in Fig. 1.

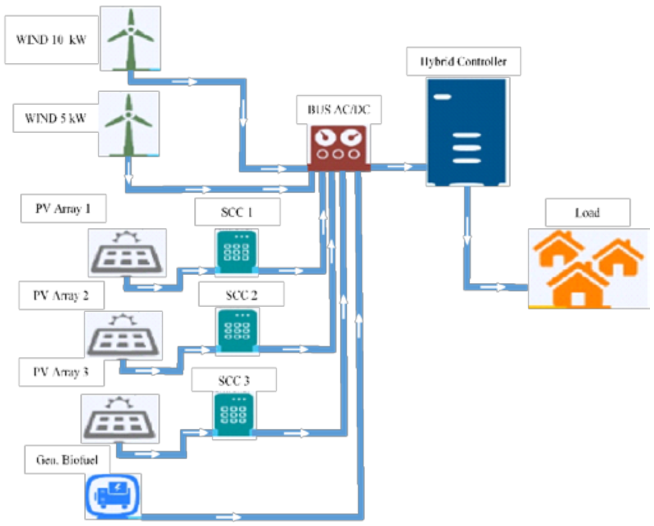

Fig. 1 PLTH Baron Techno Park system.

1) Profile Load: electric load data of the PLTH Baron Techno Park is shown in Table I. The total electrical load of the PLTH Baron Techno Park is 184.7 kW/day with an average electrical load requirements of the PLTH Baron Techno Park is 7.7 kW/h. This total electrical load is a real burden that is a reference system load growth of 5%--20%.

TABLE I
DATA LOAD ELECTRICITY OF PLTH BARON TECHNO PARK

Load	Power (kW/day)	Supply Phase			Operation
		1	2	3	
Main building 1					
- AC & Lighting	12			✓	✓
- Charge BATT	10	✓			✓
- Others	25.5		✓	✓	✓
Main building 2					
- AC & lamp	67.2	✓	✓		✓
- Others	9.6	✓	✓	✓	✓
New Desalination					
- RO pump	44	✓	✓	✓	✓
- Water pump	4	✓	✓	✓	✓
- Others	18	✓	✓	✓	✓
Old Desalination					
- RO	29			✓	
Ice Maker					
- Ice Maker 1 & 2	7.3			✓	
- Cool Storage	13.68	✓			
General Light	0.96	✓	✓	✓	

2) Solar Radiation: When this study was conducted in May 2017, the PLTH Baron Techno Park became station that had operated for six months, so that the data of solar radiation, wind speed, temperature, and humidity locations PLTH accessible from the National Aeronautics and Space Administration (NASA) connected directly to the HOMER software. Besides the HOMER software, the data of solar radiation, wind speed, temperature, and humidity PLTH location are accessible via NASA surface meteorology and Solar Energy by entering latitude and longitude location of the power plant of the Baron Techno Park. The latitude of the PLTH Baron Techno Park is -8.5 and the longitude 110.5 [10]. From both data sources, solar radiation data of the PLTH Baron Techno Park are similar, with an average of solar radiation for a year was 5.66 kWh/m^2. Solar radiation data for one year are shown in Fig. 2.

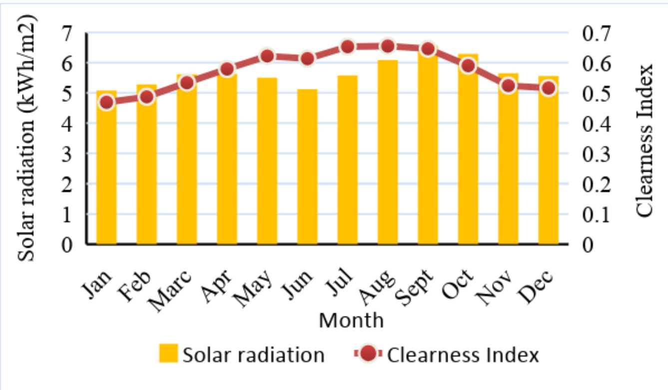

Fig. 2 Solar radiation of Baron Techno Park for one year.

The highest solar radiation is generated in September, i.e. 6.56 kWh/m^2, with a brightness index (CI) of 0.64, while the lowest solar radiation in the month of January at 5.08 kWh/m^2 with a brightness index 0.46.

3) Wind Speed: Wind speed average in the location of the PLTH Baron Techno Park is 4.42 m/s measured at a height of 50 m above ground level. The highest wind speed recorded in August, ie 6.15 m/s, while the lowest wind speed in December, which is 2.91 m/s. Monthly wind speed for a year is shown in Fig. 3.

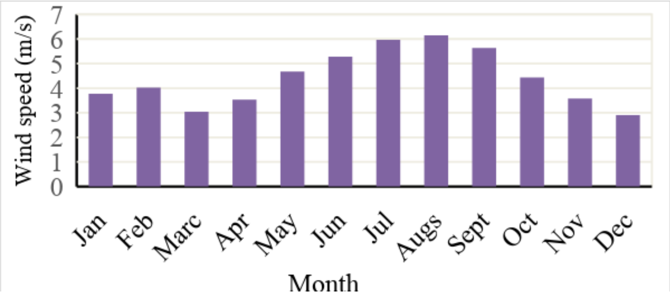

Fig. 3 The wind speed of PLTH Baron Techno Park for one year.

C. *Technical and Economic Data of PLTH Baron Techno Park*

Hybrid system of the PLTH Baron Techno Park is a combination of solar panels, wind turbines, biodiesel, battery, and inverter. The capital cost, the cost of replacement, the cost of the operation and maintenance (O&M), as well as the cost of fuel are required for system modeling. Economic data of the PLTH Baron Techno Park consists of the cost of the initial investment (I), the cost of turnover (R), the cost of the operation and maintenance (O&M), and the fuel cost. The cost of each component of the PLTH Techno Park Baron is adjusted for price components on the market that have been converted into US dollars by adjusting the rupiah currency and the US dollar. A value of $1 = Rp13,300 [11]. All fees are converted into the currency of the United States dollar as the exchange rate is more stable compared with Rupiah. Overall, the technical data and economic PLTH Baron Techno Park are shown in Table II.

TABLE II
TECHNICAL AND ECONOMIC DATA OF PLTH BARON TECHNO PARK

Component			Cost			
Name	**Capacity (kW)**	**L (yr)**	**I ($)**	**R ($)**	**O&M ($/yr)**	**Fuel ($/ltr)**
PV	36	25	135,338	2,706	436	0
WG	5	10	6,015	120	150	0
	10	10	9,210	184	150	0
Bio	25	2	15,631	480	0.030	0.6
BATT	-	20	120,000	2,400	270	0
INV	25	8	3,945	120	79	0

III. MODELING AND SIMULATION

Modeling of the PLTH Baron Techno Park is shown in Fig. 4. The modeling consists of several subsystems, among which is a biodiesel generator, a wind turbine (WG), solar panels (PV), battery and inverter. All systems are connected to the controller hybrid which is then converted by an inverter to serve load of the PLTH Baron Techno Park. Total load of the PLTH Baron Techno Park is 184.7 kWh/day, with an average consumption per hour is 7.7 kWh/h.

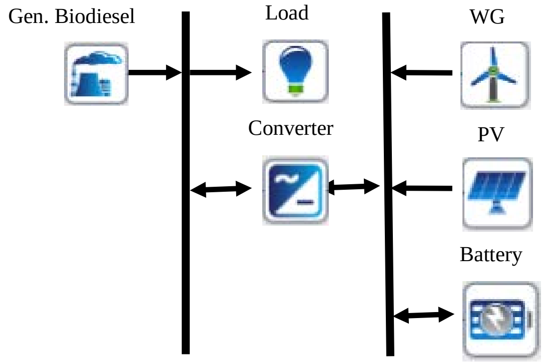

Fig. 4 Model of PLTH Baron Techno Park off-grid.

IV. RESULTS AND DISCUSSION

The results of the modeling and analysis of the PLTH Baron Techno Park include total electricity production, total demand for electricity, the system performance, cost analysts, and the growing influence of the electric load on the system.

A. *Electricity Production of PLTH Baron Techno Park*

From the results of the HOMER analysis, the total production of electricity of the PLTH Baron Techno Park which consists of a 36 kW solar panels, wind turbines of 15 kW and 25 kW biodiesel reach 319.695 kWh/year. The contribution of the electric power generated from wind turbines, ie 232.154 kWh/year, the contribution of solar panels reach 60.165 kWh/year, while the contribution of biodiesel reaches 27.375 kWh/year. Load growth of 5%, 10%, 15%, and 20% of the total load of current (184.7 kWh/day) does not affect the total electricity production of the PLTH Baron Techno Park. This is because of the absence of additional capacity generation system. Electricity production system can be increased or decreased if there is addition or subtraction of power plant components. Total productions of electric energy of the PLTH Baron Techno Park for one year are shown in Fig. 5.

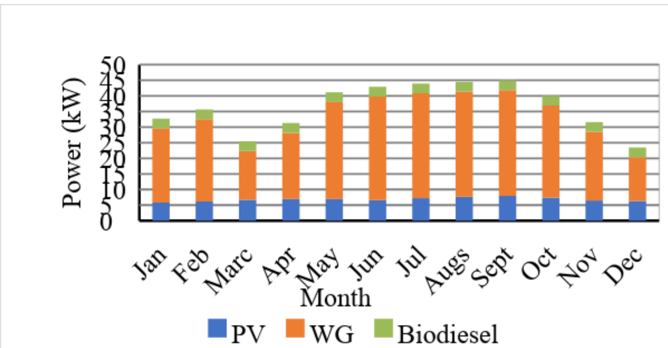

Fig. 5 Productions of electrical energy of PLTH Baron Techno Park for one year.

B. *Electrical Supplies of PLTH Baron Techno Park*

The electrical energy needs to meet the present load demand of the PLTH Baron Techno Park is 67.413 kWh/year. Electrical energy needs continue to increase along with the growth of the load. The higher growth in electricity load, the greater the power consumption of the PLTH Baron Techno Park. With the increasing electricity consumption of the PLTH Baron Techno Park, the lower the excess of electrical energy produced. The growing influence of the load on production, consumption, and excess electrical energy is shown in Table III.

TABLE III
EFFECT OF GROWTH CHARGES ON PRODUCTION, CONSUMPTION, AND THE ADVANTAGES OF ELECTRIC ENERGY

Load Increased (kWh/yr)	Percent (%)	Production (kWh/yr)	Comsumtion (kWh/yr)	Excess (kWh/yr)
184.7	0	319,695	67,413	245,574
193.9	5	319,695	70,754	241,841
203.2	10	319,695	74,120	238,105
212.4	15	319,695	77,429	234,432
221.6	20	319,695	80,842	231,306

From Table III, it appears that the total electricity production do not increase nor decrease, that is constant at 319.695 kWh/year, despite increasing load growth. Electricity consumption to meet current load is only 67,413 kWh/year or around 21.08% of total production. Meanwhile, with the increasing growth of 5% load, total electricity consumption increased to 22.13% or 70,754 kWh/year. If the load is increased to 10%, then the total electricity consumption is also increased by 74,120 kWh/year or 23.18%. As for the increase in the burden of 15%, total electricity consumption of the PLTH Baron Techno Park reaches 77,429 kWh/year or 24.21% of total production. For the growth of the electric load 20% of the total load current, it is seen that the electricity consumption is by 25.28% or 80.842 kWh/year. From the data above, it is seen that the total electricity consumption is very small compared to the total electricity production. Electric load growth also affects the excess of electrical energy of the PLTH Baron Techno Park. Every electric load growth is 5%, it is seen that the total excess of electrical energy decreases 9.2 kWh/year. Comparison of total electricity production, total electricity consumption, and excess electrical energy generated from the load growth are shown in Fig. 6.

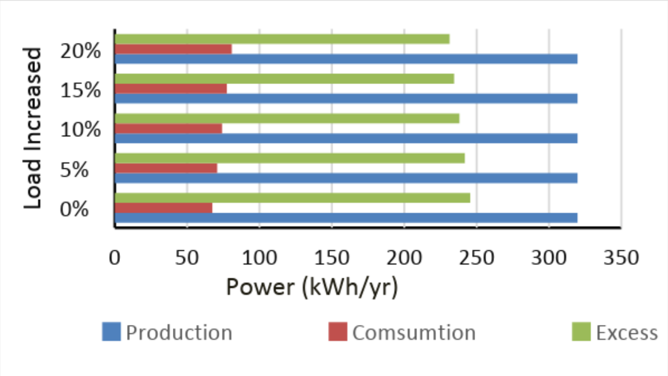

Fig. 6 Comparison of total electricity production, total electricity consumption, and excess electrical energy generated from load growth.

From Fig. 6, it can be seen that the excess electrical energy is enormous. This shows that the system performance of the PLTH Baron Techno Park from the load side is able to meet the electricity needs of the PLTH Baron Techno Park. However, in terms of reliability, it is one of the downsides. The greater the excess electrical energy generated by the system will affect the lifespan of the components, especially the lifespan of the battery will become shorter. Increasing the number of batteries is one solution to support the reliability of the system, but it has an impact on increasing investment costs, so it requires special handling to ensure the reliability of the system. One solution that can be applied is that PLTH Baron Techno Park system must be connected to the grid (on-grid) to sell excess electricity generated. If the PLTH Baron Techno Park is maintained in an off-grid, it is necessary dummy load to remove this excess electrical energy.

C. *PLTH Baron Techno Park Performance*

From the modeling and analysis of the system of the PLTH Baron Techno Park, it can be seen that the highest performance is generated from wind turbines (WG) is 72.6%, while the performance of solar panels (PV) is 18.82%, and biodiesel is 8.56%. It can be calculated using (5).

- The performance of wind turbines (WG)

  Actual output of WG = 232,154 kWh/year

  Nominal Output of PLTH = 319,695 kWh/year

  $$\text{Performance} = \frac{232{,}154}{319{,}695} \text{ x } 100\%$$

  Performance = 72.62%.

- The performance of solar panels (PV)

  Actual output of PV = 60,165 kWh/year

  Nominal output of PLTH = 319,695 kWh/year

  $$\text{Performance} = \frac{60{,}165}{319{,}695} \text{ x } 100\%$$

  Performance = 18.82%.

- Performance of Biodiesel

  Actual output of Biodiesel = 27,375 kWh/year

  Nominal output of PLTH = 319,695 kWh/year

  $$\text{Performance} = \frac{27{,}375}{319{,}695} \text{ x } 100\%$$

  Performance = 8.56%.

From the modeling results, it is known that the growing burdens of 5%--20% do not affect the performance of the PLTH Baron Techno Park. The performance of the wind turbines, solar panels, and biodiesel does not increase nor decrease despite rising load growth. This is because there is no addition or subtraction of generating capacity. The growing influence of the PLTH Baron Techno Park burden on system performance is shown in Table IV.

D. *Cost analysis of PLTH Baron Techno Park*

Results of cost analysis of the PLTH Baron Techno Park includes the calculation of the net present cost, annualized cost, and the production cost of electricity per kWh (COE). The current cost (NPC) of the real load capacity of the PLTH

Baron Techno Park is $560,077 to the cost of production of electrical energy (COE) of $0.64/kWh. While operating costs PLTH Baron Techno Park with real load capacity is $11,368.

TABLE IV
EFFECT OF GROWTH CHARGES AGAINST PERFORMANCE OF PLTH BARON TECHNO PARK

Load Increased (kWh/yr)	Percent (%)	Performance Ratio		
		WG (%)	PV (%)	Biodiesel (%)
184.7	0	72.62	18.82	8.56
193.9	5	72.62	18.82	8.56
203.2	10	72.62	18.82	8.56
212.4	15	72.62	18.82	8.56
221.6	20	72.62	18.82	8.56

Costs of NPC PLTH Baron Techno Park with a load capacity at this time are shown in Table V. The current costs include the cost of the initial investment (I) of $413,114, the cost of turnover (R) of $4,965, the cost of operation and maintenance (O&M) of $40,934, the cost of biofuel (fuel) amounted to $101.921, and the residual value of -$856.6.

TABLE V
COST CURRENT PLTH BARON TECHNO PARK

Comp	I ($)	R ($)	O&M ($)	Fuel ($)	SLV ($)	Total ($)
PV	135,188	0	5,631	0	0	141,024
WG	138,150	2,438	29,086	0	-331	169,345
Bio	15,631	1,655	1,698	101,921	-81	120,826
BATT	120,000	765	3,490	0	-431	123,824
INV	3,945	106	1,021	0	-15	5,058
System	413,114	4965	40,934	101,921	-857	560,077

The annual fee of the PLTH Baron Techno Park with a load capacity at this time is shown in Table VI. Unknown total annual cost of the system is $43,324 with capital costs (I) of $31,956, the cost of replacement (R) for $384, and the cost of operation and maintenance (O&M) of $3,166. While the cost of fuel (Fuel) for biodiesel is $7.884 and a residual value (SLV) of $-66.

TABLE VI
ANNUAL COST PLTH BARON TECHNO PARK

Comp	I ($)	R ($)	O&M ($)	Fuel ($)	SLV ($)	Total ($)
PV	10,473	0	436	0	0	10,908
WG	10,687	187	2,250	0	-26	13,100
Bio	1,209	120	131	7,884	-6	19,346
BATT	9,283	59	270	0	-33	9,578
INV	305	8	79	0	-1	391
System	31,956	384	3,166	7,884	-66	43,324

The operating costs are the total costs of operation and maintenance (O&M) of the total annual fuel costs and the cost of annual turnover minus the cost of the rest of the year. Thus, the total cost of operating system is

Coper, tot = 3,166 + 7,884 + 384-66 = $11,368/year.

From the analysis of the known value of NPC of the PLTH Baron Techno Park is $560,077. It can be calculated using (2).

$$C_{ann,\ tot} = C_{often} + C_{arep} + C_{ann,\ of}$$

Cann, tot = 31.956 + 384 + 3.166 + 7.884 to 66 = $43.324/year

$$\mathrm{CRF}(i, N) = \frac{0.0588\ (1+0.0588)^{25}}{(1+0.0588)^{25}-1} = \frac{0.2453}{3.1720} = 0.0773369$$

$$C_{NPC} = \frac{43.324}{0.0773369} = \$560.198$$

Cost per kWh of the electricity production of the system of the PLTH Baron Techno Park can be calculated using (3).

Cann, tot = 31.956 + 384 + 3.166 + 7.884 to 66 = $43.324/year

E_{served} (the total electrical load available) = 67.413 kWh/year

hence,

$$\mathrm{COE} = \frac{43.324}{67.413}$$

COE = $ 0.64 / kWh

E. Effect of Load Growth of PLTH Baron Techno Park

Growth burden of the current load does not affect the cost of the NPC and operating costs, but the effect on the total production cost per kWh of electricity (COE). The influence of the growing burden on the cost of the PLTH Baron Techno Park is shown in Table VII.

TABLE VII
EFFECT OF LOAD GROWTH OF PLTH BARON TECHNO PARK

Load Increased (kWh/yr)	Percent (%)	Cost		
		NPC ($)	COE ($)	Operating ($)
184.7	0	560,077	0.64	11,368
193.9	5	560,077	0.61	11,368
203.2	10	560,077	0.58	11,368
212.4	15	560,077	0.56	11,368
221.6	20	560,077	0.53	11,368

From Table VII, it can be seen that the higher growth of the load, the lower the cost of COE. It is considered good for the system due to the increasingly smaller electricity production costs, there are cost savings to be incurred. Thus, we can conclude that the PLTH Baron Techno Park needs to increase the electrical load in order to minimize the expenses for the operation, and can improve the reliability of the system.

V. CONCLUSIONS

From this research, it is known total electricity production of the PLTH Baron Techno Park is 319,695 kWh/year, with total demand for electricity to meet the load demand for the PLTH Baron Techno Park is 67,413 kWh/year or only 21% of total electricity production. This shows that the system performance of the PLTH Baron Techno Park, seen from the aspect of the load, is able to meet the electricity need of the PLTH Baron Techno Park. However, in terms of reliability, it is one of the downsides. The greater the excess electrical energy generated by the system will affect the lifespan of the components, especially the life of the battery life will be shorter and have increased the costs of the system. Growth does not affect the total electrical load power production. However, the higher the electrical load, the greater the electrical consumption of the PLTH Baron Techno Park. In terms of costs, the current cost (NPC) of the PLTH Baron Techno Park is $560,077 with a production cost of electricity per kWh of $0.64/kWh. Electric load growth affects the production of the cost of electricity (COE). The higher the electrical load, the lower the cost of COE. While in terms of performance, it is known that the PLTH Baron Techno Park's highest system performance is wind turbine that is 72.62%, followed by a solar panel of 18.82%, and the lowest is biodiesel which is 8.56%. Load growth does not affect the system performance because it is affected by generation capacity, not load capacity. Thus, the Baron Techno Park system must increase the load capacity in order to reduce the excess electrical energy generated. One solution that can be used is the system must be connected to the grid electricity network (on-grid) in order to sell the excess electrical energy generated. This can reduce the system cost requirements and positively impact the reliability of the system. If the Baron Techno Park PLTH system is maintained under these conditions, a dummy load is required to dispose of the excess electrical energy generated.

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