Evaluation Analysis of Generator Capacity As An Electrical Power Back-Up System In The Pln Ulp Lambaro Building

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Abstract

Genset is one of the important equipment that must be available in public places as a backup power source, in the event of a power outage from the main power source. This research analyzes the capacity evaluation of generators in the regional secretariat building of the Pln Ulp Lambaro Building in May 2025. This building has a total load of 677 kW supplied by PLN medium voltage 20 kV and lowered by a step down transformer of 630 kVA. Current observations were made at Non-Peak Load Time at 12:30-14:30 and Peak Load Time at 17:15-19:15. From the results of this experiment it can be concluded that in May 2025 the highest peak load usage was 568.67 kW or 710.83 kVA. After the calculation, the generator power capacity in the building is 651.61 kW, while the generators used are two units with a power capacity of 1280 kW. Thus, the generator set has met the building's electrical energy needs. The generator efficiency when the generator works for 60 minutes in the building is still relatively low, which is 26.25%. The ACB safety rating value used in the generator set that exits to the Low Voltage Main Distribution Panel (LVMDP) has a rating of 2000 A for one generator unit and 4000 A for two synchronous generator units, which is in accordance with the calculation of the safety capability value of the PUIL 2000, 2011 and 2020 references

Keywords: ***Generator Capacity, Electrical Power Back-Up System***

Introduction

Electrical energy is the main energy source for operational sustainability in a building. At certain times, disruptions to the electrical system either due to planned or unexpected outages can occur. This can disrupt the continuity of operational activities. Generator sets are one solution as a backup source of electrical energy, so that operational activities are not disrupted during a power outage. Therefore, the evaluation of generators as a back-up electrical energy system is important to do. One of the problems that occurs in the PLN ULP Lambaro Building area is unplanned power outages. The tasks of the PLN ULP Lambaro Building are related to policy making and administrative services, especially for customers. Thus, the supply of electrical energy is important for the continuity of activities in order to remain able to serve the community or customers. This building uses two generators with a capacity of 1000 kVA each as a source of backup electrical energy. From the above problems, in this study a study was conducted to evaluate the capacity of generators and test the reliability of the electrical energy back-up system at the PLN ULP Lambaro Building.

This research discusses a more comprehensive evaluation of generator capacity for data collection in the field, then calculates the power capacity, efficiency, performance rating, and generator safety rating. This research is expected to provide a more measurable and effective solution in evaluating the capacity of generators in the regional secretariat building. The main objective of this research is to evaluate the capacity of the generator as a back-up system of electrical energy in the PLN ULP Lambaro Building. This research measures the total building load and generator output power, calculating efficiency. The results of this study are expected to optimize the use of generator sets as an electrical energy back-up system, so that operational activities are not disrupted.

Literature Review

2.1 Generator Set

Generator Set is a device that functions to produce electrical power. Generator set with understanding is a set of combined equipment from two different devices, namely the engine and generator or alternator. Engine as a rotating device, while the generator or alternator as a generating device. In a generator system, the drive or engine has a major influence on the generator operating system. This is because stable generator rotation can maximize generator output.

Generators are basically a type of induction motor that functions as a power plant. Generators work on the principle of converting mechanical energy into electrical energy. When the generator rotor is rotated by a mechanical power source, a rotating magnetic field is generated. This magnetic field then cuts the conductor windings inside the stator, producing an electric curren.

2.2 Generator Set Working System

The generator set consists of an Engine (Motor Drive) and also a Generator / Alternator. This one Engine Engine uses fuel in the form of diesel (diesel engine) or can also use gasoline, while the generator itself is a coil of wire made of copper which consists of a static coil or stator and is also equipped with a rotating coil or rotor. The working principle of a generator is a combustion engine (diesel engine or gasoline engine) that moves by converting fossil fuel energy into mechanical energy, then the mechanical energy is converted by a generator to produce electrical power. Therefore, this generator can be categorized as a Diesel Power Plant (PLTD) with a small scale.

Generator Set (Genset) is usually used by several industries and institutions as a backup power producer if the main power supply from PLN is experiencing blackouts due to interference or is under maintenance, and can be used as the main producer of electric power in a place that is not reached by electric power by PLN, and can be used as an additional power producer if needed

2.3 Building Electrical System

The electricity distribution system at PLN ULP Lambaro Building uses a medium voltage system. The main source of electricity comes from PT PLN with a power capacity of 1250 kVA, equipped with backup power from two generator units, each with a capacity of 1000 kVA to meet electricity needs in the event of a blackout by PLN. The electricity supply from PLN is channeled to the Medium Voltage Connecting Panel (PHBTM), then flowed to a voltage reducing transformer with a capacity of 630 kVA which functions to reduce the voltage from 20 kV to 380 V. After being lowered, the electricity is channeled to the Low Voltage Sharing Panel (PHBTR) and then distributed to various electrical loads throughout the PLN ULP Lambaro Building.

Research Methodology

3.1 Generator Power Capacity

Demand factor (DF) is required to find the capacity of electrical equipment, such as generators to be installed based on the size of the connected load. The value of DF is usually expressed in percent or decimal. In addition, DF plays a role in determining the required generator power capacity to match the installed load

$$Demand\ Factor(DF) = \frac{\text{Rated maximum load}}{\text{Total installed load}} x100\% \quad (1)$$

The power capacity of the generator can be obtained from the following equation:

$$\text{Power Capacity} = DF\ x\ \text{Total installed load}\ x\ \text{Genset safety factor} \quad (2)$$

3.2 Genset Efficiency

Efficiency is the ratio between the output power to the input power of a generator set, it can be calculated with the following equation:

$$\eta = \frac{P_{Out}}{P_{In}} x100\% \quad (3)$$

Where:

η = Efficiency (%)

P_{Output} = Generator output power (W)

P_{Input} = Generator input power (W)

3.3 Genset Output Panel Safety Capacity

The overcurrent protection system on the generator set is determined at 150% of the nominal current value (In) of the generator set, with reference to the PUIL 2020 standard. The type of safety used is Air Circuit Breaker (ACB), because it is able to handle large electric currents and can be adjusted to operational needs. ACB serves as protection against overload conditions and short circuit interference. The calculation of the safety rating for the cubicle outgoing and incoming genset and the calculation of the safety current is described in the equation referring to the following equation:

$$I_n Generator\ Set = \frac{P}{\sqrt{3} x V_{L-L} x \cos\varphi} \quad (4)$$

$$I_{Pengaman} = 150\% x I_{Genset} \quad (5)$$

Where:

In Generator Set = Current on generator set (A)

$VL-L$ = Line to Line Voltage (V)

3.4 Determination of the conductor for the generator set

In calculating the capacity of the generator, supporting equipment is needed, one of which is a conductor that functions to flow electric current. Therefore, the calculation in the selection of the conductor is very necessary. Based on the provisions in PUIL 2011 regarding the calculation of cable size, the equation as below is used as a reference in determining the size of the generator conductor

$$KHA = I_n Generatorset\, x 115\% \quad (6)$$

Where
KHA = Current-carrying capability (A)

Results

PLN ULP Lambaro Office Building has a total electrical load of 677 kW supplied by PLN through a medium voltage network of 20 kV. The voltage is then lowered by a step-down transformer with a capacity of 630 kVA. To find out the amount of daily load consumption, data is needed from the measurement of electric current carried out at the Low Voltage Sharing Panel (PHBTR). The measurements were carried out in May 2025, both under conditions Outside Peak Load Time (LWBP) and Peak Load Time (WBP), with the measurement results presented in the following Table:

Table 1. PDTR Ampere Meter Control Data May Period 2025

Installed Power	**1400 A/865 kVA**			
Day/Date	**Time**		**AMax**	**AMax**
	LWBP	**WBP**	**LWBP**	**WBP**
Thursday /1	12.30-14.30	17.15-19.15	985	925
Friday /2	12.30-14.30	17.15-19.15	1005	980
Saturday /3	12.30-14.30	17.15-19.15	982	992
Sunday /4	12.30-14.30	17.15-19.15	980	956
Monday /5	12.30-14.30	17.15-19.15	960	930
Tuesday /6	12.30-14.30	17.15-19.15	982	895
Wednesday /7	12.30-14.30	17.15-19.15	970	890
Thursday /8	12.30-14.30	17.15-19.15	976	900
Friday /9	12.30-14.30	17.15-19.15	1030	940
Saturday /10	12.30-14.30	17.15-19.15	990	975
Sunday /11	12.30-14.30	17.15-19.15	954	956
Monday /12	12.30-14.30	17.15-19.15	1036	991
Tuesday /13	12.30-14.30	17.15-19.15	1008	955
Wednesdayg/14	12.30-14.30	17.15-19.15	1025	995
Thursday /15	12.30-14.30	17.15-19.15	1065	982

Installed Power	**1400 A/865 kVA**			
Day/Date	**Time**		**AMax**	**AMax**
	LWBP	**WBP**	**LWBP**	**WBP**
Friday /16	12.30-14.30	17.15-19.15	1030	990
Saturday /17	12.30-14.30	17.15-19.15	1030	962
Sunday /18	12.30-14.30	17.15-19.15	954	930
Monday /19	12.30-14.30	17.15-19.15	998	978
Tuesday /20	12.30-14.30	17.15-19.15	1022	994
Wednesday/21	12.30-14.30	17.15-19.15	1030	1007
Thursday /22	12.30-14.30	17.15-19.15	1038	1008
Friday /23	12.30-14.30	17.15-19.15	1080	994
Saturday /24	12.30-14.30	17.15-19.15	980	980
Sunday /25	12.30-14.30	17.15-19.15	870	882
Monday /26	12.30-14.30	17.15-19.15	998	970
Tuesday /27	12.30-14.30	17.15-19.15	995	938
Wednesday/28	12.30-14.30	17.15-19.15	990	950
Thursday /29	12.30-14.30	17.15-19.15	1001	975
Friday /30	12.30-14.30	17.15-19.15	1002	986
Saturday /31	12.30-14.30	17.15-19.15	996	958
		Max	1080	1008
		Min	870	882
		Average	999	960

When there was a power outage from PLN on May 1, 2025, the output power of the generator was recorded to meet the electricity needs of the building. The blackout lasted for 1 hour, starting at 10:30 am until 11:30 am. The amount of load borne by the generator during the blackout period is presented in the table below:

Table 2. Genset Power Data When Operating for 1 Hour

Inspection Items	**Code**	**G1**	**G2**	**G1**	**G2**	**G1**	**G2**
		10.15	**10.15**	**10.45**	**10.45**	**11.15**	**11.15**
Ampere	R	250	218	280	255	295	287
	S	220	200	240	244	255	261
	T	225	190	250	228	265	259
Voltage	R-S	380	380	380	380	380	380
	R-T	380	380	380	380	380	380
	S-T	380	380	380	380	380	380
	R-N	220	220	220	220	220	220

Inspection Items	Code	G1 10.15	G2 10.15	G1 10.45	G2 10.45	G1 11.15	G2 11.15
	S-N	220	220	220	220	220	220
	T-N	220	220	220	220	220	220
kWh		140kW	140 kW	164 kW	168kW	180 kW	200kW
Frequency		50Hz	50Hz	50Hz	50Hz	50Hz	50Hz

4.1 Generator Power Capacity Calculation

Based on Table 1 above, the highest daily maximum load at the PLN ULP Lambaro Office Building during May was recorded on Friday, May 23, 2025. The maximum current measured was 1080 A, resulting in a power value of P = 568.67 kW. Meanwhile, the total installed load in all buildings was 1400 A, which is equivalent to a power of P = 737.16 kW. In order for the generator power to be utilized to its maximum capacity (100%), the Demand Factor (DF) is calculated based on the ratio of power at maximum current conditions to installed power, resulting in a DF of 77%. Thus, the required generator power capacity is 651.61 kW.

4.2 Determination of Genset Performance Rating

The table below shows the individual and total generator power capacities. The generator set used in the building is a standby generator unit, with an engine speed of 1500 rpm. Two generator units are synchronized to work together, each with a capacity of 1000 kVA or 800 kW. To avoid too heavy a workload, it is assumed that the total power supplied is 77% of the total generator capacity. Thus, the synchronous generator set rating reaches 1600 kVA or 1260 kW, while the working capacity per generator set unit is 800 kVA or 640 kW. Meanwhile, the installed power in the building is 865 kVA or 677 kW. Based on these calculations, the generator capacity used has met the load requirements of the building. However, based on the PHBTR ampere meter control data table, the installed power in the PLN ULP Lambaro Office Building is not 100% used in its entirety.

Table 3. Generator Power Capacity

Generator unit	Output	
	P	S
Genset 1	800	1000
Genset 2	800	1000
Paralel	1600kW	2000kW

From Table 3 above, the highest current recorded in the PHBTR panel occurred on Friday, May 23, 2025, amounting to 1080 A. Then the power P = 568.67 kW and S = 710.83 kVA were obtained. Thus, in May 2025, the highest load was 710.83 kVA/568.67 kW. Meanwhile, the capacity of the synchronous generator set is able to supply power up to 1600 kVA or 1280 kW. This shows that the capacity of the generator is sufficient to meet the electricity needs of the building in the event of a blackout from PLN.

4.3 Generator set Efficiency Calculation

The change in power consumed by the load over a period of time can be seen in the table below. When both gensets operate for 30 minutes, the total power absorbed by the load reaches 332 kW. After operating for 60 minutes, the power consumption increased to 380 kW. The efficiency of the generators under synchronous conditions for 30 minutes at 273 kW was 25.93%, while the efficiency of each generator during this period was 26.25%. For operating conditions for 60 minutes at 380 kW, the efficiency of the generators in synchronous conditions increased to 29.68%, while the efficiency of each generator reached 31.25%. A comparison of the efficiency values of generators operating for 30 minutes and 60 minutes with increasing power is shown in Table below. The efficiency values under synchronous conditions show that

25.93% < 26.25%, while the efficiency values under load sharing conditions show that 29.68% < 31.25%. The efficiency of the generator set during the 60-minute operating period is considered low because the load supplied is only 380 kW, even though the total building load reaches 677 kW. Therefore, in order to increase the efficiency of the generator, it is necessary to increase the load when the generator is operating.

Table 4. Genset Efficiency for 30 Minutes and 60 minutes

Generator Set	Time (Minutes)	Total Power	Efficiency When Synchronized
1 (1000 kVA)	20	332	29,68%
2 (1000 kVA)			
1 (1000 kVA)	60	380	31,25%
2 (1000 kVA)			

4.1 Determination of Generator Safety Rating

In determining the safety rating of the generator output, it is necessary to first know the nominal current in the generator of 1519 A. Due to the safe factor of the generator of 80%, the Safe Factor = 1215.2 A. The safety used is an Air Circuit Breaker (ACB) with a capacity = 150% of the Safe Factor, obtained 1822.8 A. The outgoing safety rating of two synchronous or parallel genset units is $2 \times 1822.8 = 3645.6\ A$. Incoming cubicle safety genset per unit using ACB with a rating of 2000 A and for outgoing cubicle safety genset parallel using ACB with a rating of 4000 A.

KHA calculation of each genset to the incoming cubicle is 115% of the nominal current of each genset, obtained 1746.85 A. The cable used is NYY 9 (1 x 300 mm^2) + BC 70 mm^2. For KHA synchronous genset from outgoing cubicle to PDTR busbar is 3493.7 A. Thus, the cross-sectional area of the cable used must be with KHA 3493.7 A.

Conclusion

Based on the results of the research that has been done, the total installed load in the PLN ULP Lambaro Office Building is 677 kW or 865 kVA. In May 2025, the highest peak load usage that occurred was 568.67 kW or 710.83 kVA. This shows that, in May 2025, the existing load in the building is not used in its entirety. The research shows that the generator power capacity should be 651.61 kW. There are two generator units in use with a power capacity of 1280 kW. This means that the existing power capacity is appropriate. In addition, the generators have been able to back-up the electrical energy needs at the PLN ULP Lambaro Office Building in the event of a power outage. When the generator works for 60 minutes at the PLN ULP Lambaro Office Building, the generator efficiency is still fairly low at 26.25%. This is because, when the generator works, the loading on the generator is also low, namely 32.24% of the total building load of 677 kW. In addition, the ACB safety rating used in the outgoing generator to the PDTR panel busbar for one generator unit has a rating of 2000 A and for two synchronous generator units has a rating of 4000 A. This calculation is based on the safety capability value in PUIL 2020. Improving the performance of the generator set at the PLN ULP Lambaro Office Building can be done by optimizing operations, by operating the generator set at a load of around 70%-80%.

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