Journal of Physics: Conference Series

PAPER • **OPEN ACCESS**

Redesign The Electricity System of PT Barata Indonesia To Reduce Annual Power Loss

Redesign The Electricity System of PT Barata Indonesia To Reduce Annual Power Loss

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Abstract. PT Barata is one of Indonesia's leading turbine component manufacturers, requiring a large amount of electricity for production. Along with the increase in production and factory expansion, the need for electricity continues to increase so that it continues to add power to reach 3780 KVA. One of the weaknesses of the electric power system at PT Barata is using six (6) 20kV/400 V, 630 kVA transformer units. This system produces a no-load or core loss of 8150 Watts. In one year, the power loss reached 71.394 kWh at the cost of IDR 118,514,040.00. Power loss is permanent and lasts all the time during the use of the Transformer. This article aims to redesign the electrical system at PT Barata using a single 4000 kVA transformer. The redesign of the electric power system at PT Barata was carried out by 1. Observing and measuring the electric power system at PT Barata, 2. calculating the resulting losses, 3. conducting studies and designs, 4 comparing the ratio of the total power loss of the electric power system currently with a new design, 5. Propose a redesign to management for implementation. Calculation and analysis of the new design with a 4000 kVA transformer obtained a core loss of 4450 Watt at the cost of Rp. 64,905.030.00, resulting in a savings of IDR. 53,965,980.00 per year. The new design will save 45% in operating costs compared to the previous six transformer units.

Keywords: electrical technician, adaptive, test, competency

1. Introduction

PT Barata is one of the leading Turbine Component factories in Indonesia, previously known as PT Siemens Indonesia Cilegon Factory. Along with the development of world demand for generator components, the company gradually increased its production capacity. This condition forced the company to increase its investment in the form of large-scale production machines. The consequence of growing production machines is the addition of electrical power with the appropriate capacity. Initially, the electricity demand plan did not pay attention to the need for investment in devices in the future, which must be supplied with electrical energy with adequate transformer infrastructure. The existing condition is that every new machine investment must install a new transformer. Until now, there were 6 (six) distribution transformer units (6x630 kVA) powerhouses operating.

As an electrical power supply, six transformer units impact operational costs due to transformer core losses of 71.394 kWh per year. For that, the company has to pay for electricity of IDR 118,514,040.00 per year. Core losses are permanent and will last throughout the life of the transformer [1], [2]. The cost of this power loss is invisible because it has been counted as an integral part of the electricity bill [2], [3].

Currently, the turbine component factory of PT Barata Indonesia receives electrical energy from PT KDL with a capacity of 3558 kVA. The company's energy user list notes that if all loads operate, the power required is 2819 kVA. The factory only consumes a maximum of 79% of the existing capacity. With the use of a 4000 kVA power transformer with the same load, the Transformer only bears an electrical burden of 70% of its total capacity. In reality, it has never happened that all electrical loads operate simultaneously.

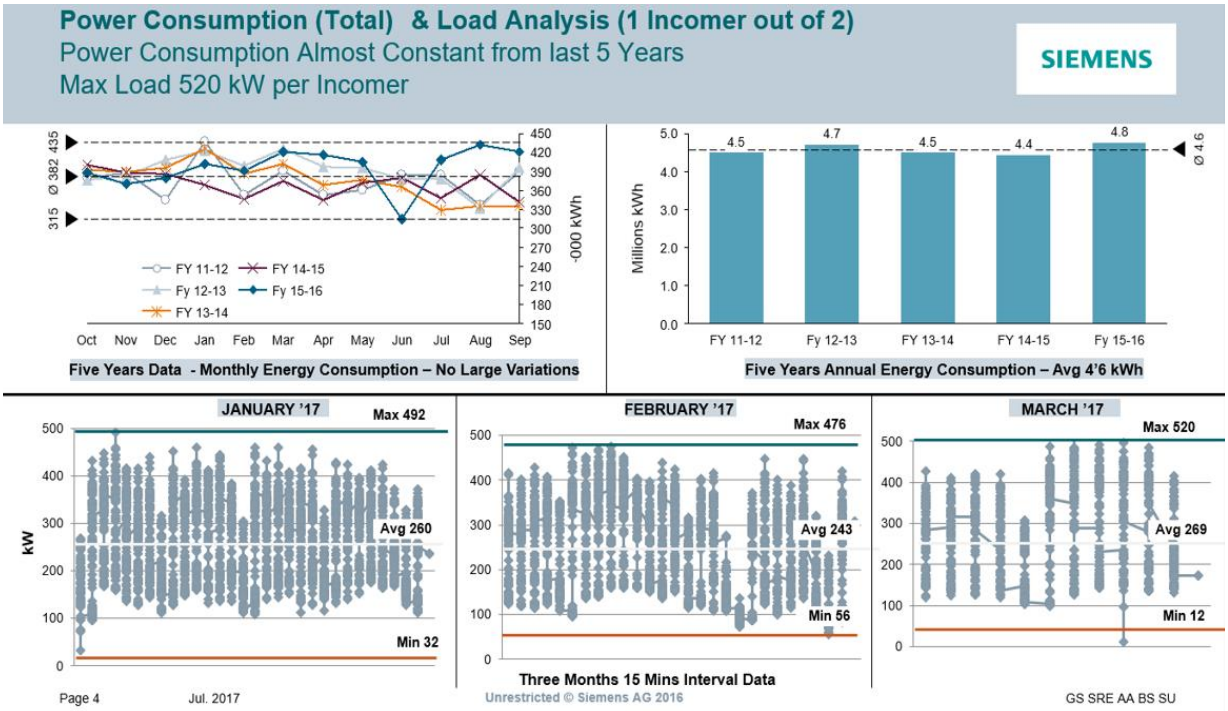

Figure 1. Loading Profile of PT Barata Indonesia

Until now, there has not been found a transformer that can work without loss. In general, the transformer core material is made of 0.27 mm Grain Oriented Silicon Steel M4, designed so that iron losses are low. The losses in the Transformer are divided into two parts, namely losses when the Transformer works without load (P-Fe) and losses when the Transformer works with loading (P-Cu). No-load losses arise because the primary circuit is given a voltage, and the secondary circuit is open [2], [4].

One of the efforts to reduce power loss is to choose the type of Transformer with the lowest possible core loss characteristics. Transformer losses relate to core and copper losses directly proportional to loading [4, 6]. Based on the technical specification data of the Transformer, the greater the power capacity of the Transformer, the greater the power consumption [5]. The total capacity of six 630 kVA transformer units is equal to 3780kVA, equivalent to a single transformer produced by a 4000 kVA manufacturer.

The amount of power consumption in using a 6-unit transformer is still more significant than a transformer with equivalent power. The 630 kVA transformer losses core PFe = 1300 Watt per Transformer, the total core loss is 6 x 1300 Watt or 7800 Watt, while the 3500 kVA transformer losses 3700 Watt, and the 4000 kVA transformer loses its core 4450 Watt.

In order not to deviate from the subject matter that has been determined, it is necessary to convey that what is meant by power loss in this article is core loss, and then we will limit the problems and objectives as follows:

- Identify the amount of power loss in the operation of a 6x630 kVA power transformer with a voltage of 20 kV/0.4 kV.
- Propose a redesign of the powerhouse electrical system using a single transformer to minimize power losses.

2. Method

The solution to the problem of how to minimize annual power losses in the powerhouse system of PT Barata Indonesia is to redesign the powerhouse system, namely by replacing the operation of six 6 x 630 kVA transformer units with a single transformer with an equivalent power of 4000 kVA, with the following stages.

2.1. Analyze and study the current (existing) condition of the Power House

There are six distribution transformers installed in the powerhouse of PT Barata Indonesia (Persero) (6x630 kVA) with a total installed capacity of 3780 kVA. The primary source of medium voltage is supplied through two feeders with two meters. The location occupies three powerhouse rooms, Power House 1, Powerhouse 2, and Powerhouse 3. Each Transformer is distributed through a low voltage panel (LVMDB), and each Transformer is equipped with an LVMDB panel so that in the powerhouse, six units, LVMDB 1 to LVMDB, are installed. LVMDB 6.

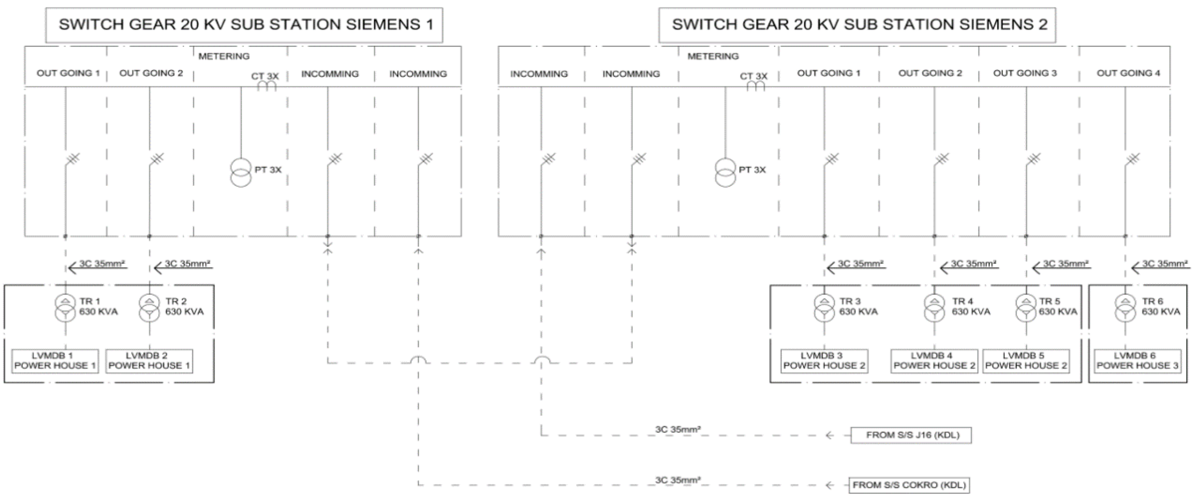

Figure 2. Single Line Diagram of Existing Powerhouse

Technical specifications of dry type transformer with Cast-Resin insulation Geafol brand with a power of 630 kVA. Core power dissipation (core loss) 1650-Watt, copper loss 6800-Watt, and a total of 8450-Watt at full load [7], [12].

Table 1. Dry Type Transformer Technical Specification Data

Rated power	**Rated primary voltage1**	**Rated secondary voltage**	**Insulation level HV**	**Insulation level LV**	**Impedance voltage**	**No-load losses**	**Load losses at 120 °C**	**Noise level**	**Total weight**
kVA	Ur HV kV	Ur LV kV	kV	kV	uzr %	Po W	Pk120 W	LWA dB	kg
630	20	0.4	50/ 95	3/–	6	1650	6800	70	1750

The technical specifications for transformers 2 to 6 are identical, transformer type Oil Immersed Transformer, oil-cooled transformer Trafindo with a power of 630 kVA, core power dissipation (core loss) 1300-Watt, copper loss 6500-Watt and a total of 7800-Watt at full load [8], [11], [12].

Table 2. Oil Immersed Transformer Technical Specification Data

Capacity	**Dimension**			**No Load Losses**	**Load Losses (70°)**	**Total Losses**	**The Impedance at (70°)**	**Exciting Current**	**Oil Volume**	**Total Weight**
kVA	Length	Width	Height	Watt	Watt	Watt	%	%	Liters	kgs
630	1680	960	1365	1300	6500	7800	4	1.8	510	2150

2.2. System design using 4000 kVA Transformer

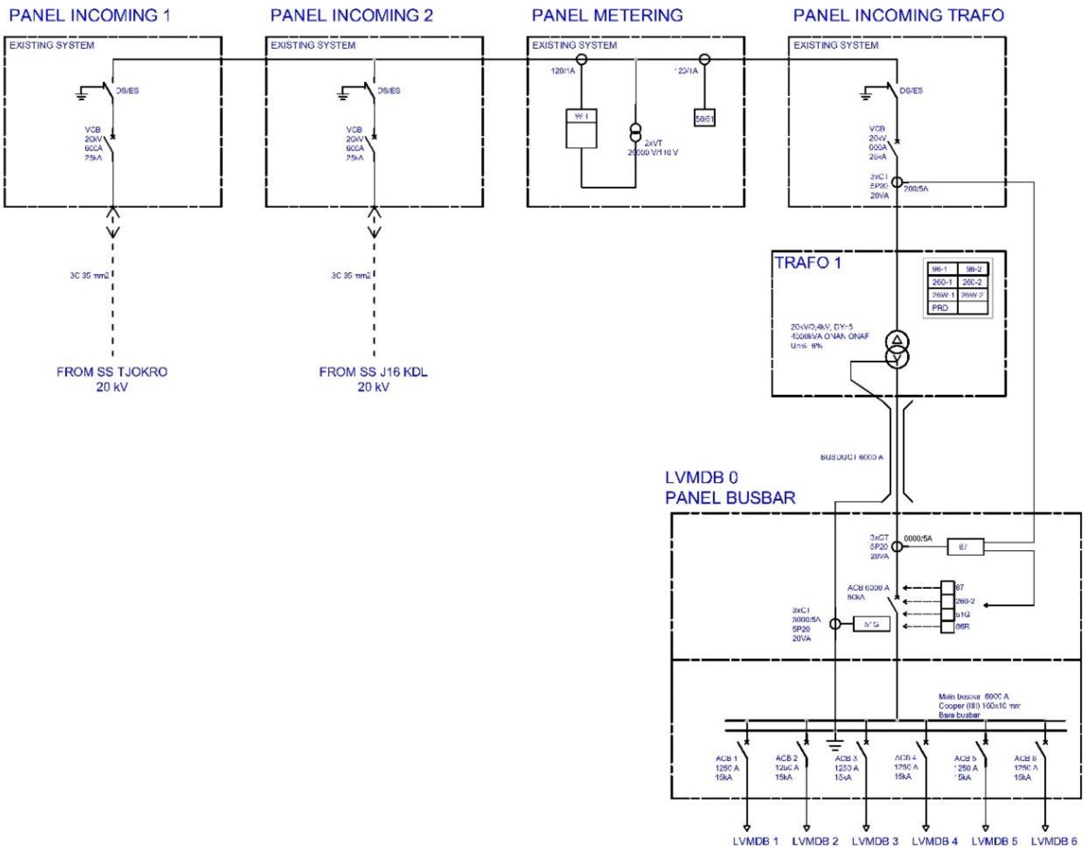

Figure 3. Powerhouse System Design using a Single Transformer

The design of PT Barata's electric power system with a single 4000 kVA transformer requires changes to the layout and low voltage distribution system on the secondary side of the Transformer so that not all existing systems have to be changed. LVMDB 1 to LVMDB 6 and all MDBs do not require changes. All LVMDB panels are repositioned. On the medium voltage side, it is still supplied from two feeders and a consumption metering system (energy metering) into one metering system. Changes were only made to the transformer control system, which used six units to become one unit. The addition of one LVMDB 0 busbar panel unit is needed because it functions as a low voltage distribution control panel to serve each LVMDB

3. Results and Discussion

3.1. Technical Analysis

The calculation and analysis results compare the power loss due to annual core loss from a six-unit 630 kVA transformer, with an equivalent power transformer of 3500 kVA and 4000 kVA.

Table 3. Comparison of Loss Calculation Results on Three Transformer Systems

Transformers Operation	Core Losses (kWH)	Power Losses Cost	Saving
6 Unit x 630 kVA	71,394.00	IDR 118,514,040	0%
1 Unit x 4000 kVA	38,982.00	IDR 64,710,120	45%

The results of the redesign of the supply system from medium voltage to low voltage of 400 Volts and their distribution in a single line diagram of the redesign are as follows.

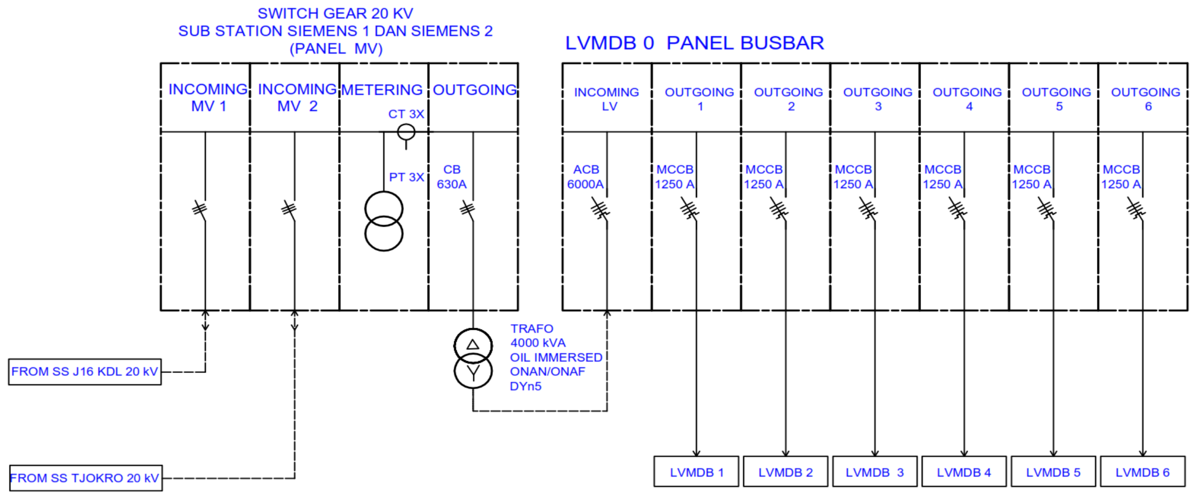

Figure 4. Redesign of Single Line Diagram Power House

The redesign of the powerhouse electrical system does not change the existing system as a whole. The low-voltage distribution panels (LVMDB 1 to LVMDB 6) and the entire MDB require no alterations. This panel is only being relocated according to the layout plan. The medium voltage panel is supplied by two feeders, a change to the discharging system to a single meter will limit power consumption to 3550 kVA (replacing two 2520 kVA and 1038 kVA metering). The transformer control system underwent a change from initially using six breaker units in two MV cubicles (Switchgear 20 kV) to one MV cubicle unit. The redesign requires adding one LVMDB busbar panel unit that functions as a 400-volt low voltage main divider panel output from the Transformer to be distributed to each LVMDB 1 to LVMDB 6. The topology of the powerhouse electrical system using a single 4000 kVA transformer is described in the following.

The technical advantage of using a single 4000 kVA transformer is that the fault localization system can be carried out with only one branch circuit breaker termination. Transformer maintenance work becomes lighter with fewer equipment requirements. The only drawback is that there is no backup. The new system only relies on one transformer unit as the primary source of electrical energy so that in the event of a transformer failure, blackouts in all load locations will occur. For that, we need a reliable protection system and limiting the Transformer's operation to 80% of its nominal power so that the Transformer works in a safe loading area. The operating limit of PT Barata Indonesia's turbine component generator transformer is 80%. The operating conditions of 80% of the transformers can meet the electrical power needs of all the equipment used. The company only uses less than 50% of the existing capacity based on the loading profile data. The Transformer only works at 0.5 x 80% of the nominal power or operates at 40% of the transformer power. These operating conditions can increase the lifetime of the Transformer.

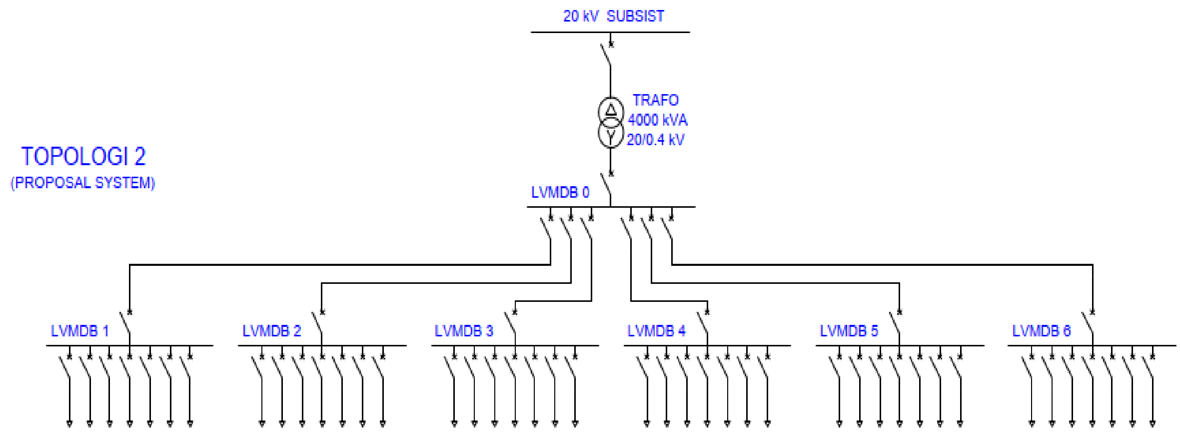

Figure 5. Topology of the Redesigned Powerhouse System

The technical constraint is that the redesign of the powerhouse uses a 4000 kVA transformer when the maximum loading on the low voltage side (secondary) will flow 5774 Amperes, so that the distribution line must use a busbar or bus duct with a capacity of 6000 A. The use of a busbar or bus duct requires that the busbar panel (LVMDB 0) be in a position adjacent to the Transformer. This condition can be overcome by placing the LVMDB 0 busbar panel close to the Transformer's low voltage (secondary) side so that the bus duct installation is more efficient than the old design. The redesigned powerhouse layout can be seen in Figure 6.

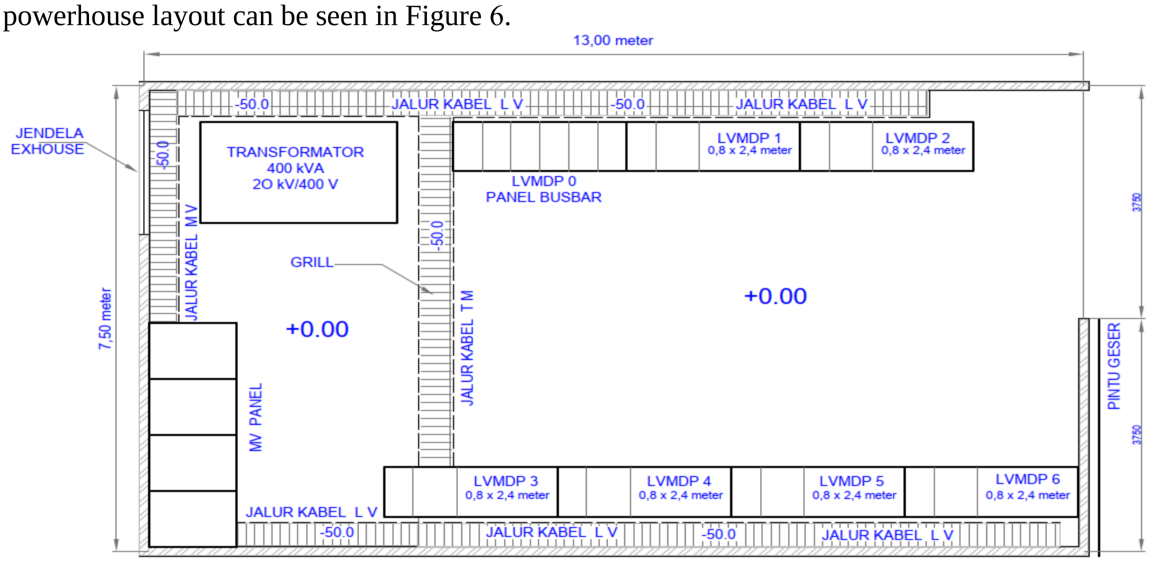

Figure 6. Layout Plan of the Redesigned Power House

Two alternatives are using a single transformer in the redesign of the powerhouse of PT Barata Indonesia, namely the use of a single 3500 kVA or 4000 kVA transformer. The Calculation of losses and savings is as follows.

Table 4. Oil Immersed Transformer Technical Specification Data

Capacity	**Dimension**			**No Load Losses**	**Load Losses (70°)**	**Total Losses**	**The Impedance at (70°)**	**Exciting Current**	**Oil Volume**	**Total Weight**
kVA	Length	Width	Height	Watt	Watt	Watt	%	%	Liters	kgs
630	1680	960	1365	1300	6500	7800	4	1.8	510	2150
4000	2730	1635	2530	4450	44000	48450	7.5	1.8	2830	9240

The technical advantage of using a single 4000 kVA transformer is that the fault localization system can be carried out with only one branch circuit breaker termination—less maintenance of transformers and equipment. The only drawback is that there is no backup. This system only relies on one transformer unit as a source.

The electric power system must have reliable protection to overcome disturbances and avoid damage [10]. In addition, the loading on the Transformer needs to be limited to a maximum of 80% of its nominal power [10]. Transformer operations of 80% can still meet the needs of all electrical equipment in the factory. For the last two years (2019-2020), the electricity demand has been less than 50% of the existing capacity. Thus, the Transformer only works at 0.5 x 80% of its nominal power or 40% of the transformer power. The low load condition of the Transformer is very beneficial for the life of the Transformer because the Transformer does not experience excessive heat.

4. Cost Estimation

The financing structure of the design powerhouse uses a single 4000 kVA transformer in outline. It can be described as follows in table 5.

Tabel 5. Cost Struktur Redesign System Electricity Powerhouse

No.	type of work	Qty	Unit	Material (IDR)	Equipment (IDR)	Service (IDR)	Sub Total (IDR)
1.	Procurement	1	Unit	954.314.000	-	-	954.314.000
a.	Procurement of transformer 4000 kVA	1	Unit	954.314.000	-	-	954.314.000
b.	Protection	1	Unit	500.000.000	-	-	500.000.000
c.	Busbar panel, ACB, and Instrumentation	1	Unit	250.000.000	-	-	250.000.000
d.	Busduct/Busbar	1	Unit	50.000.000			50.000.000
2.	Dismantling	1	Unit	-	68.000.000		68.000.000
3.	Powerhouse repair	1	Unit	31.000.000			31.000.000
4.	Installation work	1	Unit		64.000.000		64.000.000
5.	Testing, Commissioning, and operation worthy certificate (SLO)	1	Unit			55.906.000	
	Total						1.973.220.800

5. Return Investment (ROI) and Break-Even Point (BEP)

An investment needs to be analyzed based on ROI and BEP to determine its feasibility. An investment needs to be analyzed based on ROI and BEP to determine its feasibility. An investment is worth funding if the ROI value is positive, providing profits and a fast BEP.

$$\text{Return on investment (ROI)} = \frac{(\text{Ni+PROFIT})-\text{Ni}}{\text{Ni}} \text{ x } 100 = \frac{53.97\ Milliom}{1.97\ \text{Billion}} \text{ x } 100\% = 3\%$$

$$\text{Payback Periode} = \frac{\text{Investation}}{\text{Savings}} = \frac{1.97\ \text{Billion}}{53.97\ \text{Million}} = 36{,}5 \text{ years}$$

ROI of 3% means the return on investment has a gain of 3% of the investment value for a year from power loss savings compared to the operation of the previous six transformer units. Meanwhile, the payback period of 36.5 years still seems too long. This Calculation is only carried out on the efficiency aspect of transformer core losses. The BEP value is much shorter if we consider maintenance savings, service utilization, and production loss costs due to power failures.

6. Conclusion

One of the actions that can increase the efficiency of PT Barata Indonesia powerhouse is to redesign it to replace 6 630 kVA transformer with a single transformer with an enormous power equivalent to 4000 kVA. The redesign of the powerhouse electrical system uses a single 4000 kVA transformer, making power losses due to transformer core losses decreased from 71.394 kWh to 38.982 kWh and savings of IDR 53,965,980.00 per year, 45% lower than the use of the previous 6-unit Transformer.

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