

Case Study on Energy Consumption and Electrical Systems in the Provincial Government Building of ABC

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ABSTRACT

The increasing demand for electrical energy is driven by the growth in office activities, particularly in government buildings that operate nearly all day. The ABC Provincial Government Building, as a hub for administration and public services, experiences high electricity consumption, leading to energy waste, higher operational costs, and environmental impacts through carbon emissions. Additionally, the electrical systems in such buildings are often not periodically assessed for efficiency, reliability, and compliance with energy conservation standards. This research aims to analyze energy consumption levels in the ABC Provincial Government Building using a qualitative descriptive research method with a case study approach. Data collection was conducted through literature reviews, document studies, and observations. The data were analyzed in three stages: data reduction, data presentation, and conclusion drawing. Results from an energy audit at the ABC Building, with 6,600 VA of installed electrical power, show an Energy Consumption Intensity (IKE) of 50 kWh/m²/year by 2024. Although energy consumption is measurable, energy management and conservation policies have not been fully optimized. Significant energy savings are possible through better management of air conditioning, lighting, and office equipment, along with the installation of a 50 kWp rooftop solar power system. If all recommendations are implemented, energy consumption could be reduced by up to 77%, leading to considerable energy cost savings and a notable reduction in carbon emissions.

Keywords: Energy Consumption; Electrical System; Government Building

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INTRODUCTION

Electrical energy is a vital need to support local government office activities (Lambey et al., 2021). Excessive energy use can certainly lead to waste, so to prevent it, energy efficiency measures are necessary—namely, using energy rationally without reducing comfort, safety, or productivity (Biantoro & Permana, 2017).

Global building energy use is expected to grow by more than 40% in the next 20 years (Mediastika, 2021). Several studies indicate that the growth of building area in Indonesia is very high and aligns with energy consumption growth, estimated to double in the next 20 years (Widyawati, 2019; Utami, 2021). Office buildings are key energy consumers in the building sector. Building efficiency levels are expressed as Energy Consumption Intensity (*Intensitas Konsumsi Energi*, IKE) in units of kWh/m²/year (Kartika, 2018).

Energy conservation involves systematic, planned, and integrated efforts to preserve domestic energy resources and enhance utilization efficiency (Aniekan et al., 2024; Jan & Asif, 2025; Mishra & Singh, 2023). It is a method to address energy shortages and offers an environmentally friendly solution amid rising electrical energy use (Biantoro & Permana, 2017). According to Government Regulation Number 33 of 2023 on Energy Conservation, an energy audit evaluates energy use, identifies saving opportunities, and provides efficiency

recommendations for users of energy and sources in the context of conservation (Nugraha, 2024). Based on the specific energy consumption survey (MEMR-UNDP), office buildings rank third in energy use after shopping malls and hotels, with most energy sourced from electricity supply (Wahyuzi, 2024).

Previous studies in this field provide a foundation for understanding energy consumption patterns and audit methodologies (John et al., 2025; Lawal et al., 2024; Mohamed et al., 2021). Research by Biantoro and Permana (2017) demonstrated that energy audits in government offices can identify significant efficiency potentials, particularly in lighting and HVAC systems. Similarly, Lambey et al. (2021) emphasized behavioral and operational adjustments to reduce energy costs in public buildings. Kartika (2018) and Widyawati (2019) highlighted benchmarking energy use via IKE as a tool for monitoring and improving building performance. More recently, Nugraha (2024) and Pujianto et al. (2025) underscored integrating renewable energy solutions, such as solar PV, into building energy management for long-term sustainability.

To use energy economically and efficiently, implementing energy audits in government buildings is essential as an initial step in energy management, helping reduce overall costs (Pujianto et al., 2025). Energy audits identify utilization patterns and influencing factors, such as building conditions, equipment performance, and power grid status. They determine suitable energy-saving categories for the building and provide recommendations to optimize energy management (Al-Ghaili et al., 2021; Iqbal & Kim, 2022; Khafiso et al., 2025; Mischos et al., 2023).

This study analyzes energy consumption levels and evaluates electrical systems in the ABC Provincial Government Building, while identifying efficiency opportunities and actionable improvement recommendations in the ABC Provincial Government Building. Specifically, it calculates the building's Energy Consumption Intensity (IKE), analyzes daily usage patterns, assesses electrical system quality (including voltage and current imbalances), and examines savings potential through operational adjustments and rooftop solar power systems (PLTS). Benefits include data-driven recommendations for building management to implement conservation measures, reducing electricity costs, improving system efficiency, and supporting government goals for carbon emission reduction and sustainable development. Furthermore, the findings serve as a reference and model for energy audits in other government buildings.

METHOD

This study employed descriptive qualitative research with a case study approach. The case study approach allowed examination of the problem specifically and contextually, focusing on energy consumption and electrical systems in the ABC Provincial Government Building (Sugiyono, 2017).

Data collection involved literature studies, document studies, and observations. Literature studies provided theoretical foundations through books, journals, laws, and regulations. Document studies examined official reports, archives, statistical data, and policy documents. Observations captured factual conditions in the field.

Data analysis proceeded in three stages: reduction, presentation, and conclusion drawing. Data reduction selected, focused, and simplified relevant information. Data presentation

organized findings into narratives, tables, or matrices. Conclusions formulated key meanings and findings from the analysis.

RESULTS AND DISCUSSION

Building Utilization

The (ABC) Building is used as a training office with information on the use of the building as follows:

Table 1. Building Operating Hours Information

Regional Productivity Development Center Building	
Office Space	Monday - Thursday
	07.30 - 16.00
	Friday
	07.30 – 16.30

Source: Building Management Report, 2025

Information on the use of buildings on each floor is as follows:

Table 2. Building Utilization Information for Each Floor

UTILIZATION		
1st Floor	2nd Floor	3rd Floor
1. Lobby	1. Lobby Meetings	1. Exhibition
2. Class 1.01	2. ABC Officer	2. R. Pondcast
3. Class 1.02	3. Latches	3. Warehouse 1
4. Class 1.03	4. Reporting Office	4. Men's Toilet
5. Class 1.04	5. Head Office Room	5. Female Toilet
6. Class 1.05	6. Mosques	6. Warehouse 2
7. Class 1.06	7. Pulau Seribu	7. Kitchen
8. Class 1.07	8. Head office Pulau Seribu Room	8. Janitor
9. Men's Toilet	9. Supervision Room	9. Warehouse 3
10. Women's Toilet	10. Kitchen	
11. Disabled Toilet	11. Men's Toilet	
12. Lataksi Room	12. Women's Toilet	
13. Control Panel Room	13. Janitor	
14. Janitor	14. Lobby	
15. Garden	15. Archives	
16. Terrace		
17. Janitor 2		

Source: Building Layout Document, ABC Provincial Government, 2025

The source of electrical energy used by the ABC Building comes from PLN with a connected power of 66,000 VA without any backup or backup electricity from the generator.

Historical Data on Energy Consumption

The electrical energy consumption of the ABC Building in 2022 to 2024 with an average annual energy consumption of 89,902 kWh/year or 7492 kWh/month as described in the following table:

Table 3. Electricity Consumption Data 2022, 2023 and 2024

Moon	Energy Consumption (kWh)			Energy Cost (Rp)		
	2021	2022	2023	2021	2022	2023
Jan	5.940	7.974	6.900	8.581.229	13.552.052	11.727.097
Feb	6.363	7.862	7.651	9.192.626	13.361.365	13.003.444

Mar	5.100	8.010	6.866	7.368.259	13.613.915	11.669.313
Apr	7.588	9.168	6.158	10.962.095	15.580.611	10.466.046
May	6.863	7.187	5.678	9.914.398	12.214.862	9.649.252
Jun	6.285	10.066	7.923	9.080.228	17.107.129	13.466.056
Jul	9.176	8.002	8.632	13.255.989	13.598.959	14.670.683
Agst	8.798	6.929	8.010	14.952.805	11.776.383	13.612.555
Sep	7.944	7.976	7.566	13.501.746	13.555.111	12.858.304
Oct	8.546	7.586	6.904	14.523.843	12.893.314	11.733.555
Nov	7.604	8.321	6.416	12.922.886	14.142.469	10.904.864
Of the	7.987	8.392	5.334	13.573.466	14.262.456	9.064.613

Source: PLN Electricity Bills, 2022-2024

The intensity of energy consumption in a building is a value/amount that can be used as an indicator to measure the level of savings (optimization) in energy utilization in a building. The intensity of energy consumption in buildings/buildings is defined in the amount of energy (only electricity) as a union of the area in the building served by energy (KWh/m²/year or KWh/m²/month).

Based on the Regulation of the Minister of Energy and Mineral Resources of the Republic of Indonesia Number 3 of 2025, Energy Conservation by the Government and Regional Governments has been explained about the intensity of energy consumption for the supervision of the implementation of energy conservation. The IKE standard used as a reference for the level of building energy use can vary, influenced by the analysis approach and building samples taken in the process of formulating the standard. The value of IKE is also dynamic and can change at any time (based on the results of the latest research) following the development of energy-saving equipment technology and following the level of energy saving awareness of employees (building users). The following are the results of the Energy Consumption Intensity survey (average) for Office and Commercial Buildings from various study results conducted by several institutions and funded by several international donors with IKE Benchmarking can be seen in Table 4 above.

The Energy Consumption Intensity (IKE) value for the ABC Building is based on annual energy consumption, then divided by the area of the air-conditioned building or conditioned with an air-conditioned building area of around 1673.54 m², the IKE value of 53 kWh/m²/year in 2022, 58 kWh/m²/year in 2023 and 50 kWh/m²/year in 2024. From the IKE value, the DKI ABC Building in 2022, 2023 and 2024 has an IKE value below the maximum value in the Office Building of 135 kWh/m²/year and can be said to be very efficient.

Electrical System

Electrical systems are all systems in buildings related to electronic equipment (computers, LCDs, printers, etc.), transformers, electric motors, cable systems, building transportation and energy use monitoring devices. For the electrical system in the ABC Building, there is only the use of electronic equipment, the use of pumps without an energy monitoring system. The proper design and arrangement and maintenance of the electrical system can affect the consistency of total energy efficiency. A good electrical system is one of

the main factors that affect the amount of electrical energy use. By using the same electrical equipment, the amount of electricity bill becomes relatively smaller if the electrical system in the building is properly designed or repaired. And vice versa. In addition to the initial design of the electrical system, a good system can continue to be managed through good management. The main source of electrical energy used in the ABC Building comes from PLN.

The ABC Building subscribes to electricity from PLN with 544204564729 Customer ID with a Government tariff/power (P1) of 66,000 VA. The ABC Building has not used the generator as a backup power source and only uses PLN as the main source of electricity. PQA equipment is installed on the main source power panel of the ABC 1st floor.

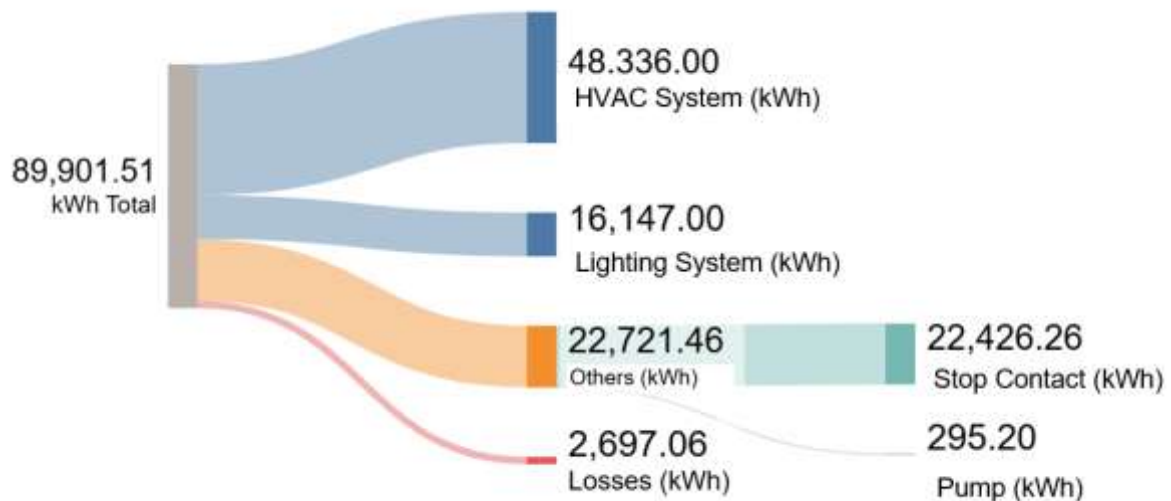


Figure 1. Energy Distribution of the Building

Source: Field Observation and Electrical System Documentation, 2025

The value of voltage and current imbalance is an important parameter in the electrical system (quality) of both transmission and power distribution systems. Voltage imbalance is the percentage of voltage difference between phases (R/S/T). Voltage imbalance occurs when the voltage of each phase has a large and non-standard voltage angle, so that the voltage between phases is not the same. The standard for voltage imbalance values refers to the ANSI C84 Standard. 1 – 2016. According to the regulation, the maximum limit value for voltage imbalance in the distribution system must not exceed (\leq) 3%. For Standard load imbalance values are regulated in ANSI C84. 1-1995 and IEEE (Institute of electrical and electronics engineers) Std 446 – 1980 which must not exceed (\leq) 20%. The consequences that arise when the value of the imbalance exceeds the standard, will interfere with the equipment. When it comes to equipment with a voltage of 3 phases (such as a 3 phase motor), the performance/performance of the equipment will decrease, so that the motor will become wasteful and experience overheating. The operating conditions of the equipment become abnormal and will reduce the life-time of the equipment, as the equipment quickly deteriorates prematurely. The figures below show the relationship between voltage imbalance and increased motor temperature, energy loss and reduced horsepower derating. Voltage Unbalance based on IEC 61000-2-2 and IEEE 1159-2019 Standards indicates that the allowable voltage and current imbalance is a maximum of 2% and 15% for distribution systems. The data obtained based on

the results of measurements at the ABC Building, namely the average voltage and current imbalance was 0.24% and 13.1%. Voltage and current imbalances can cause damage to equipment and low efficiency in electric power systems.

Daily energy consumption is the multiplication of power and usage time. The results of the measurements at the ABC Building which were carried out on June 13 - 24, 2025, recorded the results of the energy profile as shown in the graph below.

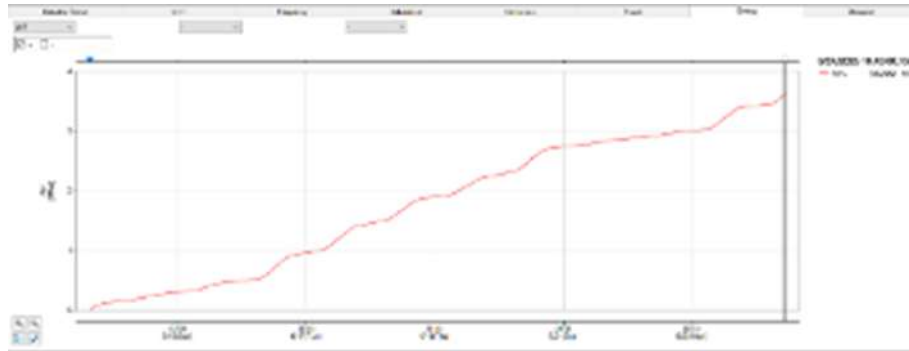


Figure 2. Cumulative Energy Profile Graph by PQA in Main Panel
Source: PQA Measurement Data, June 2025

Changing Operating Patterns

The purpose of this energy conservation implementation is to get energy consumption savings by regulating the initial operating pattern of office equipment, computers, lights and air conditioning. From the results of the data obtained in the assessment, it was found that energy consumption on weekdays began to rise at 06.30 WIB and began to decrease at 19.00 WIB. If possible, the operating pattern can be carried out using the air conditioning system, lighting system and computer in the original office room at 06.30 WIB to 19.00 WIB to 06.30 WIB to 17.00 WIB. The potential energy savings from this activity is 3,936 kWh/year. The potential energy cost savings are Rp. 6,689,193 per year.

Table 4. Energy Saving Potential

No	DESCRIPTION	EXISTING CONDITIONS	IMPLEMENTATION PROPOSAL
1	Operating Pattern		
	Lighting, Air and Other Equipment	Active Operation 06.30 to 19.00	Active Operation Hit 06.30 to 17.00
	Energy Savings Potential/year	3,936 kWh/year	
	Potential Cost Savings/year	IDR 6,689,193 /year	

Source: Analysis of Operating Pattern Adjustment, 2025

Potential Use of Solar Power Plants in Buildings

The implementation of the use of rooftop solar power in the ABC Building aims to reduce electricity bill costs through the use of solar energy, by optimizing the available roof area and considering the minimum load limit of the building, so that all electrical energy produced is used for its own needs without exporting power to the PLN network.

The scope of implementation of solar PV installation includes the installation of a rooftop solar power plant in the ABC Building in accordance with the design drawings that have been determined, with an installed capacity of 50 kW which is planned to meet the electrical load

needs of the building through optimal utilization of the available roof area. The potential energy savings from the installation of rooftop solar power plants is 61,063 kWh/year. The potential energy cost savings are Rp.103,775,968 per year.

Table 5. Calculation of Potential Savings for Rooftop Solar Installation

NO	DESCRIPTION	UNITS	EXISTING	IMPLEMENTATION
			CONDITIONS	PROPOSAL
1	Installation of 50 kWp solar power plants			
	Capacity	kWp	-	50
	Energy Production per year	kWh	-	61.063
	Energy Saving Potential per Year	kWh	-	61.063
	Potential Cost Savings/year	Rp	-	103.775.968

Source: Solar PV System Simulation and Energy Yield Analysis, 2025

Meanwhile, the estimated total investment cost to install rooftop solar power plants is Rp. 625,000,000 with a potential annual energy cost savings of Rp. 103,775,968, the simple payback period (SPP) of the implementation of this PPE is 6.02 years.

Table 6. Rooftop Solar Installation Cost

No	Cost Component	Number of Units (kWp)	Price per Unit	Amount of Fees
			Rp	Rp
1	Solar PV System	50	15.000.000	750.000.000
TOTAL ESTIMATED INVESTMENT COSTS				750.000.000
TOTAL POTENTIAL COST SAVINGS/YEAR				103.775.968
SIMPLE PAYBACK PERIOD (YEARS)				7,23

Source: Quotation from Solar PV Provider and Economic Analysis, 2025

Based on these calculations, the implementation of rooftop solar power in the ABC Building shows good potential both from a technical and economic perspective. The use of the roof area of the building for the installation of solar power plants with a capacity of 50 kWp is able to produce significant electrical energy to support the operational needs of buildings, while reducing dependence on electricity supply from the PLN network. This is in line with the goals of energy efficiency and the use of new and renewable energy in government buildings.

From an economic aspect, investment in the installation of rooftop solar power plants is considered feasible because it is able to provide sustainable energy cost savings every year. Although it requires a relatively large initial investment cost, the period of return on investment that is in the medium term suggests that the implementation of this solar power plant can be a strategic solution in the long term, not only for operational budget savings, but also as a form of commitment to emission reduction and sustainable development.

CONCLUSION

The energy audit of the ABC Provincial Government Building revealed a 6,600 VA PLN subscription powering air conditioning, lighting, and equipment, with an Energy Consumption Intensity (IKE) of 50 kWh/m²/year in 2024. Energy management was inadequate, lacking policies, occupant engagement, and a dedicated team, though operational adjustments to air conditioning, lighting, and equipment could save 3,936 kWh/year (Rp. 6,689,193 and 3.26 tons CO₂ annually). A 50 kWp rooftop solar system offered further potential savings of 61,063 kWh/year (Rp. 103,775,968 and 50.08 tons CO₂), yielding a total 77% reduction in consumption from 84,038 kWh/year to 19,039 kWh/year if implemented. For future research, comparative audits across multiple provincial buildings could benchmark IKE regionally and evaluate long-term impacts of solar integration on grid stability.

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