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Energy Audit and Conservation Opportunities in an Indonesian LPG Terminal: A Case Study of PT XYZ

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ABSTRACT: This study presents an energy audit and analysis of energy-saving opportunities at PT XYZ. The objective was to determine the existing energy consumption patterns, identify conservation opportunities, and propose potential energy-saving measures. Data collection was conducted through field observations, interviews, and documentation, supported by measuring instruments such as power quality analyzers, thermal imagers, and lux meters. The average monthly electricity consumption was recorded at 43,950.77 kWh, with 80.4% used for production activities and 19.6% for supporting facilities. The Energy Consumption Intensity (IKE) analysis indicated a decreasing trend, reflecting improved energy efficiency over the period of 2020–2022. Identified conservation opportunities included the implementation of solar tube lighting and the adoption of SKEM 4 air conditioning systems. Recommended energy-saving measures involved load balancing in electrical systems, upgrading pump motors from IE1 to IE2, improving motor and pump maintenance, adjusting lighting intensity, optimizing air conditioning capacity, and promoting efficient use of electronic devices. The findings provide actionable strategies for PT XYZ to enhance operational efficiency, reduce operational costs, and support sustainable energy management.

KEYWORDS: Energy audit, energy efficiency, energy conservation, energy-saving opportunities, industrial facility, Indonesia

I. INTRODUCTION

Energy plays a vital role in human civilization and industrial activities. However, the excessive reliance on fossil fuels poses a significant challenge due to their limited availability and environmental impact. In the current industrial landscape, companies are required to optimize operations and increase efficiency, particularly in production, which constitutes the highest operational cost. Energy conservation, defined as the systematic and planned effort to optimize energy use, not only reduces costs but also improves productivity and competitiveness.

An energy audit is a fundamental approach to assessing current energy consumption, identifying inefficiencies, and developing strategies for improvement. PT XYZ routinely conducts energy audits, yet the LPG Terminal area has not been included in previous assessments. This study aims to fill that gap by analyzing energy usage patterns, identifying conservation opportunities, and recommending energy-saving measures for the depot.

The objectives of this research are: (1) to evaluate the existing energy consumption patterns at the depot, (2) to identify potential energy conservation measures, and (3) to propose practical strategies to improve energy efficiency.

II. LITERATURE REVIEW

A. Energy and Its Types

Energy is defined as the capacity to perform work or cause change, and it exists in various forms such as mechanical, electrical, chemical, nuclear, and thermal energy. Mechanical energy comprises kinetic and potential energy, while electrical energy involves the movement of electrons through a conductor. Chemical energy is stored in molecular bonds and released through reactions, typically combustion. Nuclear energy is derived from atomic nucleus reactions, and thermal energy is related to heat transfer. The efficient utilization of energy resources is fundamental to sustaining industrial and economic growth.

B. Energy Conservation

Energy conservation refers to systematic, planned, and integrated efforts to preserve domestic energy resources and improve their utilization efficiency. According to Indonesia's Government Regulation No. 70/2009, energy conservation covers the stages of energy provision, exploitation, utilization, and resource preservation. In industrial settings, energy conservation can enhance productivity, competitiveness, and profitability, while reducing environmental impact.

C. Energy Audit

An energy audit is a process of evaluating a facility's energy use to identify inefficiencies and propose corrective measures. It typically involves data collection, observation, measurement, and analysis of energy consumption patterns. Audits can be categorized into:

1. Walk-through audit – a preliminary assessment without detailed calculations.
2. Preliminary audit – focusing on key energy-consuming systems with basic analysis.
3. Detailed audit – a comprehensive evaluation covering all energy-consuming systems, often conducted by professional auditors.
4. Energy management plan – a long-term, continuous audit integrated into the organization's management system.

D. Energy Consumption Intensity (IKE)

The Energy Consumption Intensity (IKE) is an indicator used to evaluate the efficiency of energy use in facilities. It is calculated as the ratio of total energy consumption (kWh) to the total output (e.g., metric tons of product). Lower IKE values indicate higher energy efficiency. In Indonesia, benchmarks for IKE are regulated under Minister of Energy and Mineral Resources Regulation No. 13/2012 for buildings and industrial facilities.

III. METHODOLOGY

A. Research Location and Period

The study was conducted at PT XYZ, located at Jl. Nilam Barat No. 37, Perak Utara, Surabaya, East Java, Indonesia. The facility operates as part of the company's integrated terminal network, distributing LPG across East Java and surrounding areas. The research activities, including data collection and measurement, were carried out in 2022.

B. Data Collection Methods

Data collection was performed using three main techniques:

1. Observation – Direct on-site inspection to record operational conditions and energy use patterns.
2. Interviews – Structured interviews with management and technical staff to gather information on operational schedules, equipment specifications, and historical changes to the facility.
3. Documentation – Compilation of facility diagrams, equipment specifications, operational logs, and photographs during the audit process.

C. Instruments and Equipment

Several instruments were employed to measure and monitor energy parameters. The instruments used in this study are listed in Table I, along with their respective functions in measuring electrical parameters, environmental conditions, and equipment performance.

Table I. Research Instruments

No.	Instrument	Function
1	Power Quality Analyzer	Measures and records electrical parameters (voltage, current, power factor, harmonics) in real time
2	Digital Clamp Meter	Measures voltage, current, and power factor for spot checks
3	Thermal Imager	Detects surface temperature anomalies in electrical and mechanical equipment
4	Vibration Meter	Measures vibration levels of rotating machinery such as pumps and motors
5	Luxmeter	Measures lighting intensity in work areas
6	Temperature & Humidity Meter	Measures ambient temperature and humidity
7	Laser Distance Meter	Measures distances for layout and lighting analysis

D. Variables

The main variables of the study were:

1. Energy usage pattern – Input sources and consumption by facility type.
2. Energy conservation opportunities – Identified within electrical systems, production processes, lighting, air conditioning, and electronic equipment.
3. Potential energy savings – Quantified for each facility type based on technical and operational improvements.

E. Research Procedure

The procedure consisted of:

1. Preparation – Obtaining research permits and preparing measurement tools.
2. Energy Audit Implementation – Identifying conservation opportunities, conducting field measurements, and analyzing energy use patterns.
3. Data Analysis – Evaluating energy performance, calculating IKE, and estimating potential savings.
4. Reporting – Summarizing findings, recommendations, and strategies for energy optimization.

The research procedure, from preparation to reporting, is summarized in Table II.

Table II. Research Procedure

No	Stage	Activities (Purpose)
1.	Preparation	1) Research permits 2) Preparation of measurement instruments
2.	Energy Audit Implementation	
	1) Identify conservation opportunities	To identify existing conservation opportunities
	2) on-site observation, testing, and measurements	To understand existing energy usage patterns
	3) conservation analysis	To understand potential energy savings opportunities
3.	Reporting	1) Data analysis (energy pattern, IKE, saving estimates) 2) Report and recommendations

IV. RESULTS AND DISCUSSION

A. Energy Consumption Pattern

The average monthly electricity consumption at PT XYZ was recorded at 43,950.77 kWh. Of this total, 80.4% (35,323.26 kWh) was used for production activities, mainly to operate pumps and compressors for LPG transfer, while 19.6% (8,627.51 kWh) was consumed by supporting facilities. Supporting consumption included interior lighting (0.7%), exterior lighting (9.4%), and cooling and electronic devices (9.5%). This distribution indicates that production processes dominate energy use, suggesting a primary focus area for energy efficiency measures. Table III presents the average monthly electricity consumption, product throughput, and calculated IKE values for each year during the study period.

Table III. Energy Consumption Pattern

Category	Energy Input (kWh)	Category	Subcategory	Energy Output (kWh)
Electrical Energy	43,950.77	Production	Product Distribution (Pump Motors and Compressors)	35,323.26
		Support	Interior Lighting	329.32
			Exterior Lighting	4,131.36
			Cooling and Electronic Facilities	4,166.83

B. Energy Consumption Intensity (IKE) Analysis

The IKE values for 2020, 2021, and the first half of 2022 were 0.85 kWh/MT, 0.86 kWh/MT, and 0.82 kWh/MT, respectively. The overall trend shows a slight decrease in IKE, indicating improved energy efficiency over time. This improvement correlates with increased product throughput while maintaining or slightly reducing total energy consumption. The breakdown of electricity usage by category is presented in Table IV, showing that production activities account for the majority of consumption.

Table IV. Average Energy Use, Product Throughput, And Ike Per Month

Year / Period	Electricity Use (kWh/mo)	Product Throughput (MT/mo)	IKE (kWh/MT)
2020	49,327.80	58,173.11	0.85
2021	51,850.20	60,427.25	0.86
2022	49,476.00	60,273.08	0.82
Average (2020 – 2022)	50,366.40	59,494.76	0.85

C. Power Quality Analysis

In addition to the energy efficiency assessment, power quality parameters were evaluated to determine their impact on operational performance. The results of power quality measurements showed that the facility's average power factor during the observation period was 0.84, which does not meet the Indonesian National Standard (SNI) minimum requirement of 0.85. A low power factor indicates inefficient use of electrical power and may lead to higher electricity costs due to increased reactive power demand.

In addition, the average voltage imbalance was recorded at 1.60%, exceeding the SNI threshold of 1%. Voltage imbalance can cause overheating in motors, reduced equipment lifespan, and increased energy losses. To address these issues, corrective measures such as the installation of capacitor banks to improve the power factor and balancing the load across phases are recommended. These improvements would enhance overall electrical system efficiency, reduce operational costs, and extend equipment service life.

D. Identified Energy Conservation Opportunities

Several conservation opportunities were identified during the audit:

1. Lighting Systems – Installation of solar tube systems to utilize natural daylight and reduce dependency on electric lighting.
2. Air Conditioning – Replacement of conventional AC units with high-efficiency SKEM 4-rated systems.

As shown in Figure 1, the installation of solar tubes allows daylight to illuminate indoor areas, reducing dependence on electric lighting during daytime hours.

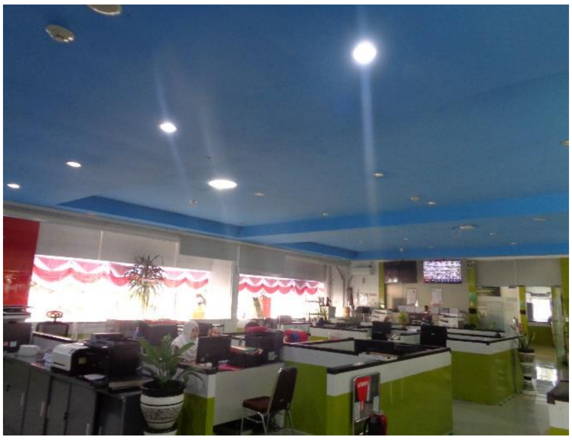

Figure 1. Solar tube for daylight indoor lighting

E. Proposed Energy-Saving Measures

Potential energy-saving measures were classified by facility type:

1. Electrical Systems – Load balancing across phases to improve power quality and reduce losses; implementing routine maintenance for electrical panels and wiring.
2. Production Equipment – Upgrading pump motors from IE1 to IE2 efficiency class; implementing a preventive maintenance schedule for motors and pumps to avoid overheating and efficiency loss.
3. Lighting – Adjusting illumination levels to match functional requirements, avoiding over-lighting.
4. Air Conditioning – Matching AC capacity with actual cooling loads; performing regular cleaning and servicing of units to maintain performance.
5. Electronic Devices – Encouraging behavioral changes through campaigns promoting the efficient use of computers, printers, and other office equipment.

Table V summarizes the estimated cost, implementation duration, and effort required for each proposed energy-saving program.

Table V. Program Cost, Durasi, Effort

Potensi Penghematan	Cost	Durasi	Effort	Potensi penghematan/tahun
Penggantian Motor Pompa dari type 1E ke 2E	>1 M	>2 tahun	High Effort High Impact	12,442,103.63
Peningkatan Perawatan Motor Pompa	< 1 M	< 1 tahun	High Effort Low Impact	9,682,033.00
Penyesuaian Kapasitas dengan Beban Pendinginan	< 1 M	< 1 tahun	High Effort High Impact	55,841,931.00
Perawatan AC	< 1M	< 1 tahun	Low Effort Low Impact	14,151,724.00

As shown in Figure 2, replacing IE1 with IE2 motors can significantly improve energy efficiency by reducing power losses, which in turn lowers electricity consumption and operational costs. Cost is estimated in IDR; ">1M" and "<1M" denote more or less than one million IDR.

Skenario/Asumsi:			
Persentase Penghematan Energi	=	2	persen
Penggunaan Energi untuk Proses Produksi Motor Pompa Pertamina	=	46.506,00	kWh/bulan
Harga listrik	=	1.114,74	rupiah/kWh
Potensi Penghematan Energi			
Potensi Penghematan Energi Per Bulan	=	Persentase Penghematan Energi x Penggunaan Energi untuk Proses Produksi Motor Pompa	
Potensi Penghematan Energi Per Bulan	=	930,12	kWh
Potensi Penghematan Energi Per Tahun	=	11161,44	kWh
Potensi Penghematan Anggaran			
Potensi Penghematan Anggaran Per Bulan	=	Potensi Penghematan Energi Per Bulan x Harga Listrik	
Potensi Penghematan Anggaran Per Bulan	=	1.036.842	rupiah
Potensi Penghematan Anggaran Per Tahun	=	12.442.103,63	rupiah

Figure 2. Estimated energy saving from replacing IE1 with IE2 motors

Figure 3 illustrates the energy-saving potential that can be achieved through regular preventive maintenance of motors and pumps, which helps maintain optimal operating efficiency.

Skenario/Asumsi:			
Persentase Penghematan Energi	=	15,00	persen
Penggunaan Energi untuk Proses Produksi Motor Pompa	=	3.723,2	kWh/bulan
Harga listrik	=	1.444,7	rupiah/kWh
Potensi Penghematan Energi			
Potensi Penghematan Energi Per Bulan	=	Persentase Penghematan Energi x Penggunaan Energi untuk Proses Produksi Motor Pompa	
Potensi Penghematan Energi Per Bulan	=	558,48	kWh
Potensi Penghematan Energi Per Tahun	=	6.701,76	kWh
Potensi Penghematan Anggaran			
Potensi Penghematan Anggaran Per Bulan	=	Potensi Penghematan Energi Per Bulan x Harga Listrik	
Potensi Penghematan Anggaran Per Bulan	=	806.836	rupiah
Potensi Penghematan Anggaran Per Tahun	=	9.682.033	rupiah

Figure 3. Energy-saving potential from improved motor and pump maintenance

F. Estimated Impact of Proposed Measures

Implementation of the recommended measures is expected to yield both direct and indirect benefits:

- Reduction in total energy consumption and associated costs.
- Lower equipment downtime due to improved maintenance.
- Enhanced compliance with national energy efficiency regulations.
- Contribution to corporate sustainability and environmental goals

Figure 4 presents a Pareto analysis of the proposed measures, indicating that a small number of actions contribute to the largest portion of potential energy savings.

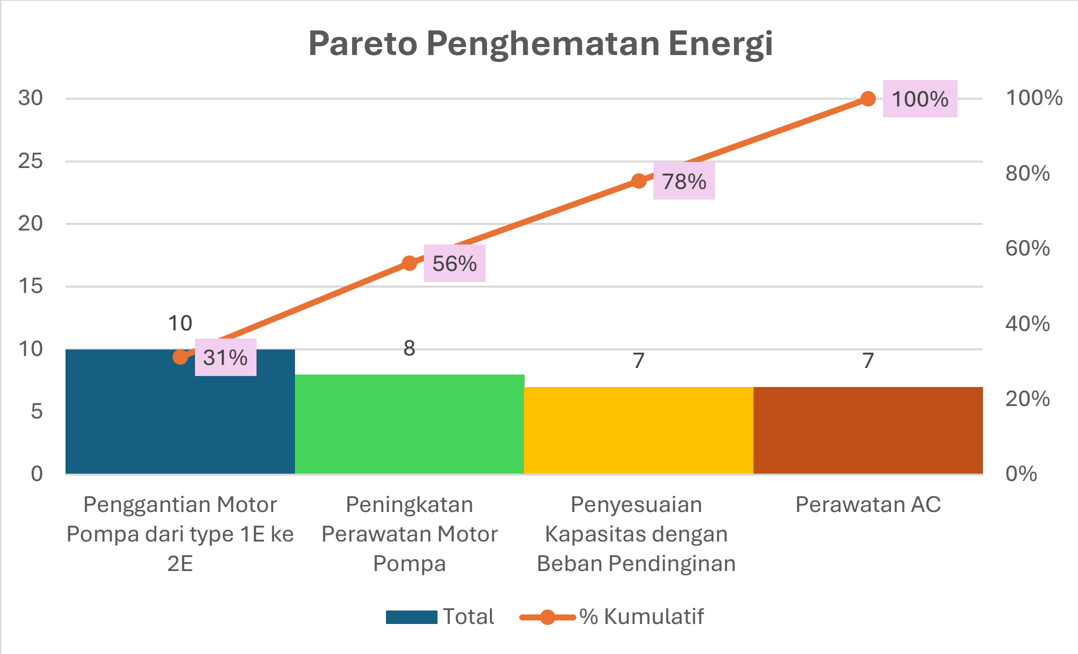

Figure 4. Energy-saving prioritization using a Pareto chart

V. CONCLUSIONS

This study conducted an energy audit at PT XYZ to assess energy usage patterns, identify conservation opportunities, and propose energy-saving measures. The findings showed that the facility's average monthly electricity consumption was 43,950.77 kWh, with the majority (80.4%) used for production processes and the remainder for supporting activities. The Energy Consumption Intensity (IKE) analysis from 2020 to 2022 revealed a slight but consistent improvement in efficiency.

Key energy conservation opportunities identified included the application of solar tube lighting systems, replacement of conventional air conditioning units with high-efficiency SKEM 4-rated systems, upgrading pump motors from IE1 to IE2, and balancing electrical loads. Additional recommendations involved optimizing lighting levels, matching AC capacity to cooling requirements, and promoting efficient use of electronic devices through awareness campaigns.

Implementing these measures would not only reduce operational costs and energy consumption but also enhance system reliability and support sustainable energy management within the facility.

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