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# Fostering Energy Saving Potential Through Preliminary Energy Audit in Fuel Terminal: A Case Study

**Oktasio Fahlevi*, Todo Hotma T Simarmata, Ginanjar Indra Maulana**
Kementerian Energi dan Sumber Daya Mineral, Indonesia
Email: oktasio@esdm.go.id* , todo.simarmata@esdm.go.id, ginanjar.maulana@esdm.go.id

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*Energy Audit; Energy Performance Indicators; Enenrgy Conservation Opportunities*

**ABSTRACT**

*The energy audit is a method for analyzing energy use patterns in a facility and identifying potential efficiency improvement opportunities. In this study, level 2 of the energy audit was conducted at one of Indonesia's fuel terminals. The energy performance indicator (ENPI) was calculated over three years. The ENPI of the fuel terminal increased from 2022 to 2024, indicating that energy consumption per unit of production (kL) rose year by year. The increase from 2022 to 2023 was 27%, while that from 2023 to 2024 was 14%. A higher ENPI value indicates greater energy consumption to produce each kiloliter of product. The implementation of energy conservation opportunities is expected to reduce energy consumption by an average of 5–10% per month, equivalent to approximately 35,784–48,585 kWh per month, and can also reduce $CO_2$ emissions by 298.14 Ton$CO_2$Eq using an emission factor of 0.83. In order to implement an energy management system, the organization must establish a supporting system, particularly an energy policy that defines the company's general energy-related policies.*

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## INTRODUCTION

Energy audit activities involve evaluating energy utilization, identifying energy-saving opportunities, and providing recommendations to improve efficiency for energy source users and consumers in the context of energy conservation. The government targets potential energy savings of 10–30% in the industrial sector (HEESI, 2020, Ministry of Energy and Mineral Resources). Most energy in this sector comes from electrical sources. Enhancing performance in the industrial sector—particularly in the downstream oil and gas industry, such as fuel terminals—can be achieved through efficiency improvements in both energy utilization and cost-effectiveness (de Almeida et al., 2014; Fuchs & Masoum, 2015; Giacone & Mancò, 2012; Goyal & Garg, 2016). From an energy efficiency perspective, fuel consumption at fuel terminals can be optimized by operating high-efficiency units, thereby minimizing energy losses and waste. In parallel, implementing a real-time monitoring system to measure and report energy consumption supports better control and decision-making by providing up-to-date information on energy use during daily operations (Benedetti et al., 2016; Bollen & Das, 2011; Bunse et al., 2011; Cagno et al., 2015). To achieve efficient energy use in the fuel distribution process, energy audit activities are vital as a first step to identify daily energy use patterns and energy-saving opportunities. A study investigated the optimization of national fuel oil (BBM) supply and distribution systems, emphasizing the determination of optimal fuel delivery routes from supply points to end destinations within the distribution network to reduce overall transportation costs (Abdelaziz et al., 2011; Adaramola, 2014; Akagi et al., 2017; Arun Shankar et al., 2016).

The purpose of an energy audit is to identify operational problems, improve occupant comfort, and optimize energy use in existing facilities (Sterling, 1994). The individual responsible for carrying out this activity is referred to as an energy auditor. In Indonesia, energy audits are regulated under SNI ISO 50002:2014, while the certification and implementation of energy auditors are governed by SKKNI Energy Auditor No. 53 of 2018. Energy audits are generally classified into several levels: Type 1 (known as a walkthrough audit), Type 2 (a preliminary audit), and Type 3 (a detailed audit).

The objective of this study is to analyze the energy consumption profile of an existing fuel terminal and identify potential energy conservation opportunities. An energy audit serves as the main tool to examine the energy consumption profile, including on-site measurements of equipment to obtain primary data and interviews with the energy manager to collect secondary data. In addition, a simple techno-economic analysis ensures that the proposed recommendations are feasible for implementation. The results also provide an energy baseline that can serve as a reference for minimum standard energy usage.

## METHOD

Figure 1 illustrates the research methodology applied in this study. The research was conducted in accordance with SNI ISO 50002:2014 on Energy Audits—Requirements with Guidance for Use. A Type 2 (preliminary) energy audit was selected, with reference also made to SNI 6196:2011 concerning building energy audit procedures. The process began with energy audit planning, a critical stage for defining the scope of work and audit objectives. This was followed by an opening meeting with key stakeholders or the building energy manager to communicate the objectives, boundaries, and audit method. Data collection was carried out in parallel during this phase. The energy auditor ensured the availability of secondary data; if such data were incomplete or unavailable, on-site measurements were performed. During the site visit, data loggers were installed on selected utility systems. The two main tools used were a power quality analyzer to measure power quality and an ultrasonic flow meter to measure fluid flow. Once the measurement phase was completed, the collected data were analyzed. The audit results were then used to identify Energy Conservation Opportunities (ECOs), followed by discussions and agreements with stakeholders regarding their implementation, and finally a closing meeting.

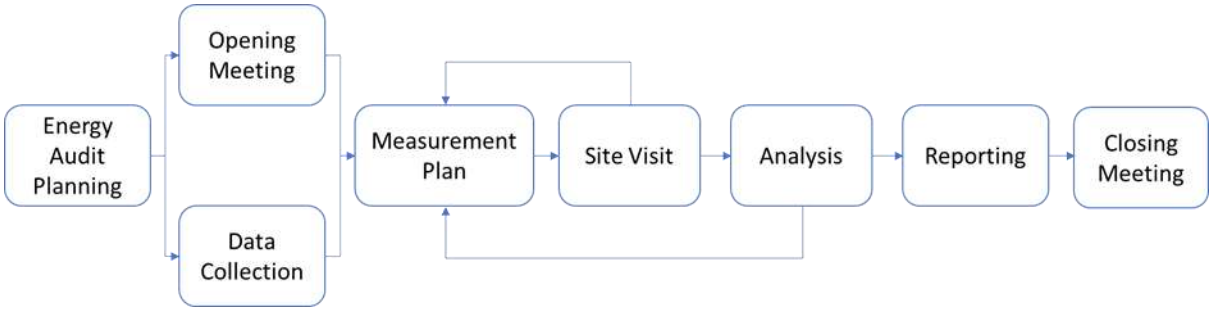



**Fig.1. Energy audit methodology based on SNI ISO 50002 : 2014**

In this study, the initial step involved defining the scope of the energy audit, including the specific areas to be evaluated. Type 2 or preliminary energy audit was chosen. The systems assessed included the electrical system, cooling system, lighting system, and energy

management system. The preparation phase began with coordination with the building energy manager, followed by a detailed field survey. These steps are essential for comparing existing conditions with applicable standards in order to formulate appropriate ECOs recommendations.

## RESULTS AND DISCUSSION

This research was conducted at one of fuel terminal in Indonesia and high level of complexity among fuel terminal in Indonesia. The electricity supplied by the national grid (PLN) B2 members through the transformer has a capacity of 197 kVA with the help of backups from 2 electrical generator units with a total capacity of 2x 250 kVa. There is a simple single line diagram as a figure 2.

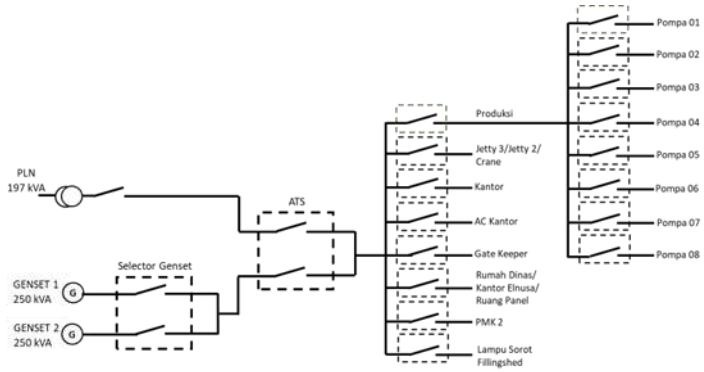
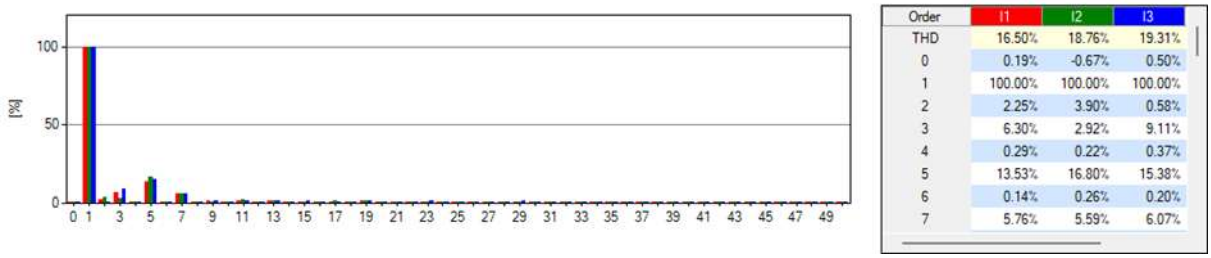



**Fig.2. Simple Single Line Diagram of Fuel Terminal**

Electricity measurement was conducted in main distributin panel. We found the harmonics distrotion exceeds the standard (more than 15%). One of the causes is the use of motors with Variable Frequency Drives (VFDs), which are commonly used in industrial applications to control motor speed. VFDs operate by varying the input frequency supplied to the motor, and this process often generates harmonics in the voltage and current drawn by the electric motor.




| Order | I1 | I2 | I3 |
|---|---|---|---|
| THD | 16.50% | 18.76% | 19.31% |
| 0 | 0.19% | -0.67% | 0.50% |
| 1 | 100.00% | 100.00% | 100.00% |
| 2 | 2.25% | 3.90% | 0.58% |
| 3 | 6.30% | 2.92% | 9.11% |
| 4 | 0.29% | 0.22% | 0.37% |
| 5 | 13.53% | 16.80% | 15.38% |
| 6 | 0.14% | 0.26% | 0.20% |
| 7 | 5.76% | 5.59% | 6.07% |

**Fig.3 Total Harmonics Distortions at electric current system**

High THD can have negative impacts on electrical systems such as reduced power efficiency because the supplied energy is not used optimally due to the presence of distortion. Also, the harmonic distortion increases core and winding losses in transformers, causing overheating and a reduction in efficiency and lifespan of equipment (Seddik et all).

### Energy Utilization and production

The electricity consumed is used for the operation of fuel and utility distribution machines (except generators) and office buildings. Based on the energy audit conducted, the

percentage of electrical energy consumption load per day is obtained as shown in diagram 1 below:

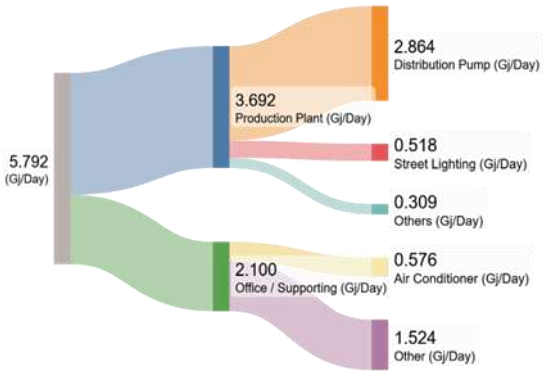



**Fig.4. Refferences of Energy System (RES) of Fuel Terminal**

From the graph above, the total energy consumption at the Fuel Terminal is 5,792 GJ per day. The energy consumption is mainly divided into two major groups: the Production Plant, which accounts for 3,692 GJ per day (approximately 64%), and Office/Supporting facilities, which consume 2.1 GJ per day (approximately 36%). The largest share of energy consumption comes from the distribution pumps, which account for more than half of the total energy use. Therefore, the Significant Energy Use (SEU) at the Fuel Terminal is identified as the distribution pumps.

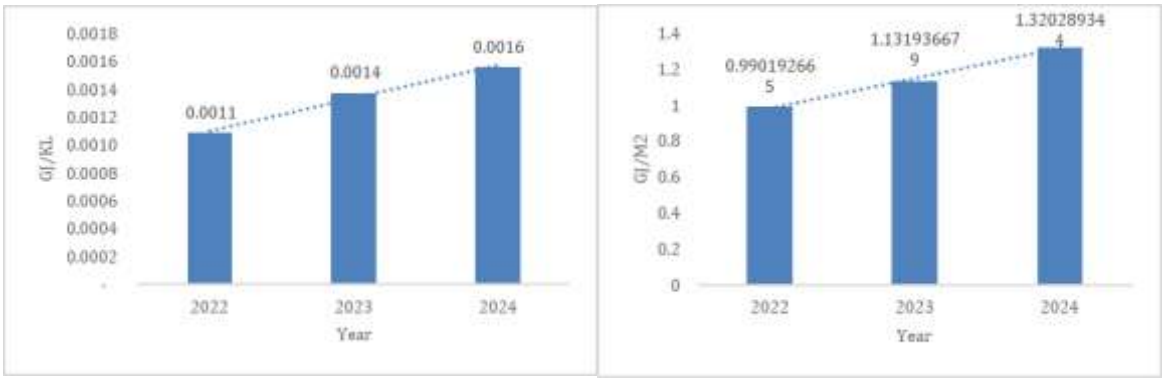
**Energy Performance Indicators (Enpi's)**

EnPIs are defined as a combination of process efficiency, energy consumption, and the management of energy sources and their end use (ISO, 2018). By integrating these aspects, EnPIs enable organizations to assess the overall "energy health" of their operations. Furthermore, , ISO 50006:2014 provides more detailed guidance on establishing suitable EnPIs for monitoring and improving energy efficiency. This standard recommends using Specific Energy Consumption (SEC) — a quantitative ratio representing the amount of energy consumed per unit of output — as a key performance metric (ISO, 2014). The SEC, frequently cited in academic and industrial studies, is commonly employed as an EnPI to measure energy efficiency performance (Gülich, 2014; Hasanbeigi et al., 2010; ISO, 2018; Jovanović & Filipović, 2016).

To determine the level of energy consumption, we use energy performance indicator (Enpi's). Enpi's is defined as the amount of energy (spesifically electricity) per unit kiloliters production served by energy.

$$Enpi's = \frac{(\Sigma\ energy\ consumption\ )}{(\Sigma\ \ Product\ )}\ per\ Year \quad (1)$$

There are 2 kind of Enpi's at fuel terminal that consist of Enpi's production (GigaJoule / Kiloliters) and Enpi's Supporting (GigaJoule / $m^2$).




A B

**Fig.5 : a: Enpi's Production , b: Enpi's Supporting**

Based on the graphs above, the Enpi's of the Fuel Terminal increased from 2022 to 2024. This indicates that energy consumption per unit of production (kL) has been rising year by year. The increase from 2022 to 2023 was 27%, while from 2023 to 2024 it rose by 14%. A higher Enpi's value indicates more energy being consumed to produce each kiloliter of product.

For Enpi's supporting The graph also shows that energy consumption per square meter of supporting facilities has continued to increase each year. From 2022 to 2023, the increase was 14.4%, while from 2023 to 2024 it rose by 16.7%. A higher supporting-facility Enpi's indicates greater energy use for supporting facilities (such as offices, lighting, air conditioning, and common facilities) per unit of building area. This trend reflects a decrease in energy efficiency in the supporting facilities. Although these are not classified as Significant Energy Uses (SEU), the supporting-facility enpi's at the Fuel Terminal has shown a consistent increase, indicating rising energy consumption per building area and declining energy efficiency (Kanneganti et al., 2017; Karcher & Jochem, 2015; Kumar et al., 2019; Ma et al., 2019).

**Evaluation of SEU**

All distribution pumping equipment uses an electric-motor energy source and is equipped with VSD (Variable Speed Drive) installation.

**Table 1: Evaluating Pump Performance**

| ***Pump Unit*** | **Pum Performance** | |
|---|---|---|
| | **Power Actual (kW)** | **Efficiency %** |
| *Distribution Pump 02* | 10 | 31,7% |
| *Distribution Pump 03* | 10,7 | 27,7% |
| *Distribution Pump 04* | 17,51 | 21,7% |
| *Distribution Pump 06* | 11,2 | 26,6% |
| *Distribution Pump 07* | 11,7 | 30,6% |
| *Distribution Pump 08* | 10 | 36,0% |

Based on the simulation of pump efficiency calculations at the Fuel Terminal, the pump efficiency values are found to be below the pump design reference (>50%). This indicates that there are still opportunities for energy savings from this pump equipment through improvements on both the mechanical and electrical aspects of the pump. The solution to

increase the performance of distribution pump can be implemented by motor rewinding, adjusted the flow rate, maintenance of pump (casing, impeller, shaft balancing, etc). Besides that, the energy saving potential from solar PV could be implemented in rooftop building (May et al., 2015; Nguyen & Aiello, 2013; Paraschiv et al., 2020; Saidur et al., 2010).

## Energy Conservation Opportunity (ECO's)

The total energy saving recomendations that can be implemented will show in table.2

**Table 2. The summary of energy saving potential.**

| No. | Energy Conservation Opportunity | % Saving | Category |
|---|---|---|---|
| | **Production & Supporting facility** | | |
| **1** | Improving pump efficiency | 15% | Medium Cost |
| **2** | PV Solar Rooftop installation capacity 130 kWp | 28% | High Cost |
| **3** | Energy monitoring system installation | 5% | Medium Cost |
| **4** | Deactivating of one generator set | 2% | Willingness |
| **5** | Intallation of Fiter Harmonics | 10% | High Cost |
| **6** | Reducing electrical demand at night can be achieved through the shutdown of unused lights and air-conditioning units | 8% | Williingness |

As indicatated of the environmental aspect of energy management, we also calculated the emissions factor. By the implemented of ISO 50001:2018 Energy Management Systems, the calculation data are calculated annually (Trianni et al., 2013; Wang et al., 2016; Zhou et al., 2018). Therefore, the calculation of CO2 emission reduction has been included as a part of an effort to reducing CO2 emissions nationally. The energy management activity in this Fuel terminal can reduce CO2 emissions 298,14 TonCo2Eq with the emission factor is 0,83.

The implementation of the energy-saving measures presented in table 2 is expected to reduce energy consumption by an average of 5–10% per month, equivalent to approximately 35,784–48,585 kWh per month. Lastly, In order to implement an energy management system, the organization must establish a supporting system, particularly an energy policy that defines the company's general energy-related policies (Schulze et al., 2016; Singh et al., 2015; Smith, 2020; Thollander et al., 2013).

## CONCLUSION

The objective of this study is to identify and describe feasible energy-saving potentials. Through an energy audit, the energy consumption profile and potential improvement opportunities can be identified. This activity is also necessary for establishing and evaluating energy performance indicators. Several energy conservation measures can be implemented to reduce overall energy consumption; however, the final decision regarding the implementation of these recommendations remains with the fuel terminal. For future research, measurement and verification activities are required to quantify energy savings and assess the effectiveness of the implemented measures.

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