

## Development of Audit Energy Application for Residential Sector

Rihartanto<sup>1\*</sup>, Wawan Kustiawan<sup>2</sup>, Lambang Subagiyo<sup>2</sup>

<sup>1</sup>Department of Information Technology, State Polytechnic of Samarinda, Indonesia

<sup>2</sup>Magister Program of Environmental Science, Mulawarman University, Indonesia

\*Corresponding author: rihart.c@gmail.com

### Abstract

The residential sector is the biggest electric energy user in Indonesia. In this sector, there is a potential electricity saving of up to 30%. This savings can be obtained by implementing energy conservation. Energy use intensity (EUI) is a measure in assessing the efficiency of a building. From the EUI value can then be determined the efficiency criteria of a residential building, is it very efficient, efficient, moderately efficient or wasteful. An energy audit application was developed to facilitate in assessing the efficiency of a residential building in consuming electricity. The efficiency assessment in the model building shows that there is a significant electricity saving after the conservation efforts conducted, even though the model building is included efficient in the use of electrical energy.

### Keywords

efficiency, conservation, energy audit, EUI

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## 1. INTRODUCTION

Electricity is the most used energy in today's activities. It is secondary energy that obtained from conversion of other energies, both renewable and non-renewable. Electricity was used in many sectors such as industrial, commercial and residential. Not only used for lighting but also for a productive purpose.

The increase of electricity needs are caused by many factors, some of it is population growth (Fithri et al., 2014), the uplift of quality of life, lifestyle (Laicane et al., 2015; Sukarno et al., 2015), family members (Laicane et al., 2015), and so on, including rapid advances in technology, which increased the number of devices and it used intensity that needs more electricity.

The increasing demand for electrical energy directly leads to increased use of fossil fuels (Sukarno et al., 2015) such as fuel, gas, and coal. Besides its nature that is not renewable, the use of fossil fuels also causes pollution on the environment. Therefore, the energy-saving movement that has been proclaimed by the government needs to be supported and implemented consistently. This support can start on a small scale, such as the efficiency of household energy consumption.

Households are electricity users with relatively low amounts of power, but collectively the largest electricity user in Indonesia, it is 42.34% in 2014 increased to 43.72% in 2015 (Directorate General of Electricity, 2016). A study conducted by the Ministry of Energy and Mineral Resources in 2014 shows that the potential for national energy savings in the household sec-

tor is 15-30 percent (EBTKE-ESDM, 2014). Therefore, some steps should be taken so that the efficiency of electricity usage in the household sector can be implemented and monitored continuously.

The effort to save electricity as well as its efficiency monitoring in a household should be carried out by the owner or user of the residential building. What is needed is a tool used to assess how efficient the use of electricity in the building. To facilitate the assessment and monitoring, an energy audit application was developed to assess the efficiency of electricity usage (Handani et al., 2014; Safti, 2015) in a residential building. The output of this application is the energy use intensity (EUI) value and the efficiency criteria of the assessed building.

## 2. EXPERIMENTAL SECTION

### 2.1 Energy Conservation

Energy conservation is the efficient and rational use of energy without reducing the energy usage that is absolutely necessary. Energy conservation is the act of reducing the amount of energy use or the optimal use of energy in accordance with the needs so that it can lower the energy costs incurred (Hidayat, 2008; Untoro et al., 2014). Energy conservation efforts are applied at all stages of utilization, using efficient technology, and cultivating an energy-efficient lifestyle (Mukarom et al., 2014). The purpose of energy conservation is to preserve the natural resources in the form of energy sources through technology selection policy and energy utilization efficiently, rationally, to

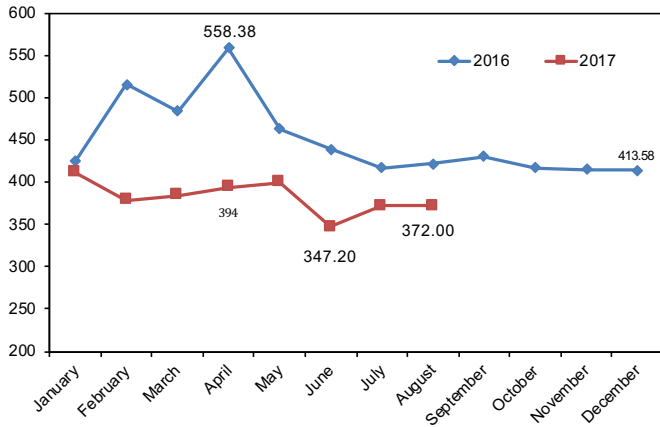


Figure 1. Comparison of Electrical Consumption in 2016 and 2017

realize the ability of energy supply.

Energy conservation is an important element in an energy policy. Energy savings reduce energy consumption and energy demand per capita, so it can offset the increasing energy demand due to population growth. Reduced energy demand can provide flexibility in choosing energy production methods. Some important goals underlying the importance of energy efficiency are to (1) lower energy costs; (2) lowering production costs; (3) lower energy consumption; (4) reducing emissions of greenhouse gases and other gases (SO<sub>x</sub>, NO<sub>x</sub>); (5) improving product quality; (6) improve overall environmental function; (7) enhance reputation/recognition; and (8) improving occupational health and safety.

The residential sector is the largest group of electric energy users in Indonesia. In this sector, electricity is mainly used for lighting purposes, household appliances, air conditioning, and water heaters. Table 1 shows the growth of electricity usage in Indonesia from 2011 to 2015. It is seen that the electricity consumption in the residential sector continues to increase and is the largest user compared to other sectors.

Furthermore, the residential sector is divided into three classes of customers namely R1 class -small household (450VA, 900VA, 1300VA and 2200VA), R2 class -medium household (3500-5500VA) and R3 class -large/luxury household (6600VA and above).

### 2.2 Energy Use Intensity

The efficiency of a building in consuming electrical energy can be measured using the Energy Use Intensity (EUI). Electrical EUI is the division between the consumption of electrical energy in a certain period of time with the unit area of the building. EUI can be calculated using the equation (1).

$$EUI \left( \frac{kWh}{m^2} \right) = \frac{TEU}{TA} \tag{1}$$

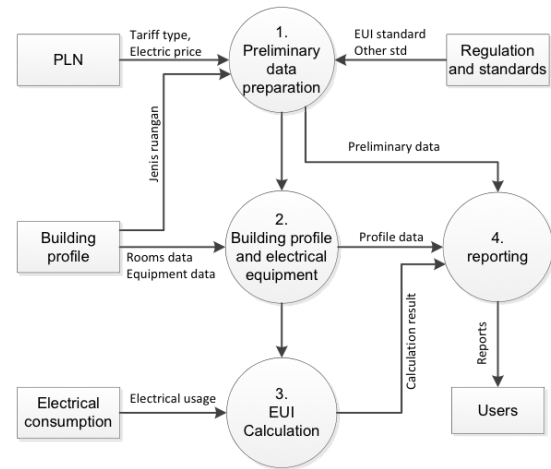


Figure 2. DFD of EUI Application for Residential Building

where TEU is the total electric usage and TA is the total area.

The regulation of the Minister of Energy and Mineral Resources of the Republic of Indonesia No. 13 of 2012 on Electricity Saving, distinguishes EUI calculations for non-air conditioned buildings, air-conditioned buildings, and buildings with a mixture of non-air conditioned and air-conditioned. The specific energy consumption per floor area is as follows:

1. If the ratio of floor area using AC to the total floor area of the building is less than 10%, then the building is included to non-air-conditioned buildings and the EUI is calculated using the equation (1).
2. If the ratio of floor area using AC to the total floor area of the building is more than 90%, then the building is included to air-conditioned buildings and the EUI is calculated using the equation (1).
3. If the ratio of floor area using AC to the total floor area of the building is between 10% to 90%, then the building is included to non-air-conditioned and air-conditioned buildings. The EUI for non-air-conditioned rooms is calculated using the equation:

$$EUI_1 \left( \frac{kWh}{m^2} \right) = \frac{TUE - EU_{of AC_{ed}rooms}}{TA} \tag{2}$$

The EUI for air-conditioned rooms is calculated using the equation:

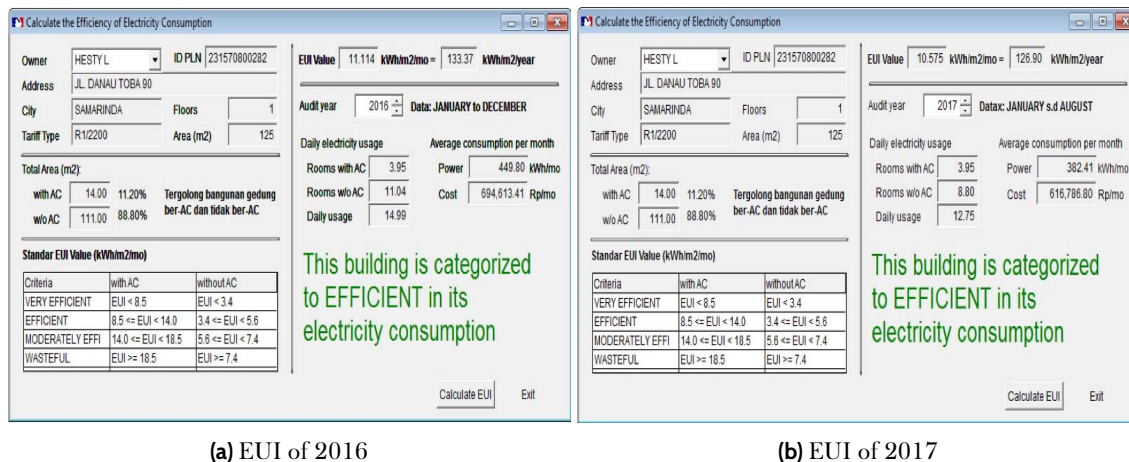
$$EUI_2 = \left( \frac{kWh}{m^2} \right) = \frac{EU_{of AC_{ed}rooms}}{AC_{ed}area} + EUI_1 \tag{3}$$

The regulation also categorized the EUI of non-air-conditioned and air-conditioned buildings into four criteria of efficiency. Those are very efficient, efficient, moderately efficient and wasteful as shown in Table 2. Based on these EUI standard

**Table 1.** Sales of PLN Electricity per Customer Sector (MWh)

Year	Residential	Industry	Commercial	Public
2011	65,111,571.80	54,725,821.64	28,307,207.83	9,848,059.19
2012	72,132,538.78	60,175,960.38	30,988,636.57	10,693,609.93
2013	77,210,709.47	64,381,395.29	34,498,384.97	11,450,528.66
2014	84,086,464.74	65,908,675.67	36,282,421.51	12,324,213.70
2015	88,682,130.00	64,079,390.00	36,978,050.00	13,106,250.00

Source: PLN, 2016



(a) EUI of 2016 (b) EUI of 2017  
**Figure 3.** Electrical EUI of building model in 2016 (a) and 2017 (b)

value then Energy Saving Potential (ESP) can be calculated using the formula:

$$ESP = \frac{\Delta EUI \cdot Electricity\ tariff}{12\ months/year} \tag{4}$$

**3. Results and Discussion**

The chosen building model is a residential building that included to R1 class using 2200VA of electric power, the total building area of 125 m<sup>2</sup>. The building model has 14 m<sup>2</sup> air-conditioned room so that the EUI is calculated using equation (3). Energy consumption data in model buildings for 2016 and 2017 are shown in Table 3. Data 2016 is the data used in calculating the EUI value. EUI value obtained is used as a reference in implementing efficiency of electricity usage in the model building. The selected efficiency model is classified as a low cost/no cost model such as (1) gradually replacing incandescent/TL/CFL lamp with LED lamp; (2) changes in operating patterns of electrical equipment and (3) increased user awareness in implementing energy conservation. This energy conservation effort is implemented since early 2017. The value of EUI for 2016 is 11.11 kWh/m<sup>2</sup>/month, which means it is included in the efficient category, however, there is still energy saving potential of 2.61 kWh/m<sup>2</sup>/month.

The comparison of the amount of electrical energy consumption in the model building is shown in Figure 1. Data 2017 shows a significant decrease in electricity usage after energy conservation efforts are implemented. The average decline in electricity consumption for the same period between 2016 and 2017 is 82.90 kWh/month.

The application design of this electrical energy audit follows the Data Flow Diagram (DFD) shown in Figure 2. It is seen that this application involves a number of entities to work, including National Electrical Company (PLN), building profiles, electrical consumption profile, regulation, and standards as well as consumers of electricity itself. The process stages in the application start from initial data preparation, noting the building profile as well as the electrical equipment used, the EUI calculation and the results are displayed as reporting.

This application was developed using Visual FoxPro 9 SP2 along with its native database. Applications can work in multi-user environments and there is no limit on the number of buildings that can be evaluated. The final result given is the value of EUI as well as the criteria of efficiency in the assessed building. Figure 3 is the output of the application for 2016 (3a) and 2017 (3b) for the model building, which indicates a decline in the EUI value by 2017 even though both are under the same efficiency criteria.

The EUI in 2016 is 11.11 kWh/m<sup>2</sup>/month and decreases to 10,575 kWh/m<sup>2</sup>/month in 2017 after energy conservation

**Table 2.** EUI Standards for Office Buildings

Criteria	Air-Conditioned buildings (kWh/m <sup>2</sup> /month)	Non-Air-Conditioned buildings (kWh/m <sup>2</sup> /month)
Very efficient	EUI < 8,5	EUI < 3,4
Efficient	8,5 ≥ EUI < 14	3,4 ≥ EUI < 5,6
Moderately efficient	14 ≥ EUI < 18,5	5,6 ≥ EUI < 7,4
Spendthrift	EUI ≥ 18,5	EUI ≥ 7,4

\*Source: The Regulation No. 13/2012

**Table 3.** Electricity Usage of Building Model (kWh)

Month	2016	2017
January	425.6	411.17
February	515.58	378.89
March	483.85	384.4
April	558.38	394.04
May	462.93	399.56
June	438.48	347.2
July	416.41	372
August	421.28	372
September	429.88	-
October	416.9	-
November	414.78	-
December	413.58	-
Total	7,413.64	5,076.26

efforts.

#### 4. CONCLUSIONS

This application successfully performs an energy audit assessment in the form of EUI values as well as the efficiency criteria based on EUI value. This assessment is conducted following the existing energy audit flow in SNI 03-6196-2000 on energy audit procedures. The criteria of the efficiency of electricity consumption used in this application refer to Regulation of Minister of Energy and Mineral Resources No. 13/2012 on Electricity Power Conservation. The future work will be the development of audit energy applications for the residential sector on Android platform so that this application can be freely available to the public.

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