

Prototype of online expert system for electrical energy audit with benchmarking method

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Abstract. An energy audit as the primary process of an energy conservation program should be the responsibility of all parties. This should be done not only because of the government's advice but also driven by the energy crisis while alternative energy is not enough to meet energy needs. In fact, the task of energy audit has not been widely applied in the community due to the lack of popularity of this activity and the difficulty of its implementation. The aim of this research is to make efforts to succeed energy conservation by making computer applications as a tool in the implementation of the electrical energy audit. The method of drawing conclusions and recommendations of the electrical energy audit is done by benchmarking process. This application is made in two modes that are web-based and mobile. The original application is web-based to improve data storage and processing capabilities. While mobile applications as navigation and guides are made to improve the mobility of energy audit implementation. The results showed that with the development of this application the energy audit is increasingly known to the public and the audit process can be carried out more easily.

1. Introduction

Increased energy consumption due to technological and industrial developments that have continued to increase since the industrial revolution up to now and the development of population caused the crisis of energy and global warming [1]. Some research explores for new and renewable energy as an alternative [2]. At now the supply of renewable energy has not fully become alternative energy, therefore it needs the best management and energy efficiency [3]. Energy management and efficiency are believed to be a major step towards for solution the energy crisis and global warming [4, 5]. Energy conservation is the responsibility of government and society [6]. Unfortunately, the responsibility of energy management is not yet popular in Indonesia. According to official ESDM web data for new and renewable energy and energy conservation, by 2017 the number of energy managers across Indonesia will be 275 persons [7]. This shows the level of implementation of management and energy audit in Indonesia is still very low. Factors causing energy audits have not been widely implemented namely the assumption that Indonesia is endowed with abundant natural resources and lack of widespread training on energy audits [8].

Advancement of information technology is very useful as a tool and support activities because of its superiority in the collection, access, processing and data analysis [9]. Information technology has an important role in delivering the right information to the right target [10]. Good Search Engine Optimization is very influential on the success of information a web [11]. Community difficulties in



the energy audit process can be assisted by a system of energy audit experts [12]. Expert systems will guide the energy audit process until an energy audit report is generated [13].

The development of mobile computing using gadget equipment gives a powerful impact on information systems. Mobile equipment becomes the solution for jobs that require high flexibility [14]. Energy audits are conducted in two stages: initial audit and detailed audit [15, 16]. Field trips are conducted both in the initial audit and detailed audit stages and are in dire need of flexibility and mobility. This problem is solved with a mobile-based application. EBTKE Directorate General of ESDM Ministry has made a web-based application online report on energy management but has not yet covered its energy audit process [17].

The aim and state of the art of this research are to make online application server web and mobile to facilitate the sustainability energy conservation program. The audit process is slightly different from SNI 03-6196-2000 and SNI 6196-2011 that is by conducting all audits to study the relationship of the initial audit result with the detailed audit.

Hypothesis: with the development of electrical energy audit applications, the energy management can be applied more widely and users can run the audit process with more ease and more precise results.

2. Process of electrical energy audit

Energy audits as the backbone of energy management, aimed at calculating the amount of energy consumption in buildings, recognizing the savings opportunities and ways of saving. Energy audits are conducted by a mini-audit process (walk through audit) followed by preliminary and detailed audits [15, 16, 18]. Audit data is contained in a printed worksheet or using a computer application. Analysis of energy-saving opportunities can be done with the help of computer programs (computer aided) that has been recognized profession society [19].

The walk-through audit is a site visit of the building utility to visually inspect each of the energy using systems. This includes an evaluation of energy consumption data to analyze energy use quantities and patterns as well as provide comparisons for industry averages or benchmarks for similar facilities. It is a preliminary estimate and provide a list of low cost savings opportunities through improvements in operational and maintenance practices. This audit process into three components, pre-site work, site visit and post-site work. The pre-site work is collect and review at least two years of uses energy data and accuracy of the billings. The site visit will be spent inspecting actual systems and answering specific questions from pre-site review, fill out the audit data sheets, and take pictures during walk through the building [20].

Detailed energy audit for the electrical system typically includes gathering the data lighting system survey, power factor and demand, motor inventory and loads. Lighting accounts for a significant portion of electrical energy consumed in a building. Energy is saved in the lighting system by reducing illumination levels if needed, improving lighting system efficiency, curtailing operating hours and by taking advantage of available daylighting. Further, the Heating, Ventilation and Air-Conditioning (HVAC) Systems is a very important portion of the overall energy audits program [21].

3. Prototype and simulation

The energy audit flow developed on the prototype of the system is in accordance with SNI 03-6196-2000 and SNI 6196-2011. A little difference is made by performing a detailed audit both when the initial audit results are below or above the IKE benchmark standard. The purpose of this step is to know the subsequent relationship of the initial audit result with detailed audit result.

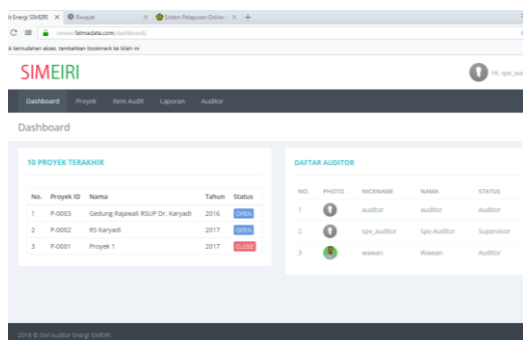
Electrical energy audit system is made gradually with waterfall model [22]. Energy audits on this prototype consist of an assessment of electrical energy consumption (IKE), illumination, watt intensity of lighting, room temperature, humidity chamber and watt intensity of AC.

The simulation is done on building Rajawali RSUP Dr. Karyadi, Semarang, Indonesia. The lighting conditions, temperature and humidity based on KEMENKES 2011 standard as benchmark. The conditions measured that out of the standard tolerances are recommended to be changed according to

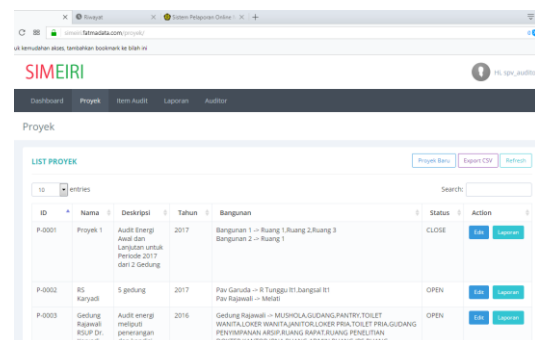
the standard. The intensity of power in lighting and air conditioners that exceeds the standard becomes an energy saving opportunity. The results are made from the assessment of energy audit as table 1.

Table 1. Relationship measurement of air condition and lighting room with energy intensity used.

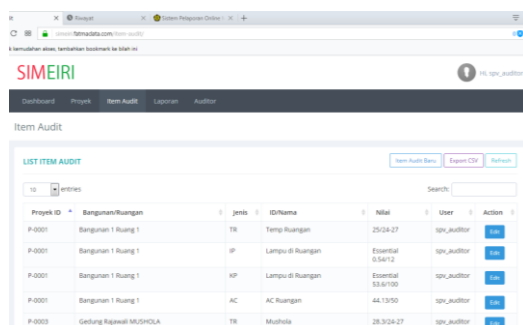
Room condition	Energy Intensity	Results	Recommendation
Under standard	Under standard	Probably Normal	Room condition and energy must be standardized
	Standard	Probably Waste	Energy-saving opportunities
	Exceed standard	Probably Waste	Energy-saving opportunities
Standard	Under standard	Efficient	Maintain
	Standard	Normal	Maintain
	Exceed standard	Waste	Energy-saving opportunities
Exceed standard	Under standard	Efficient	Energy-saving opportunities
	Standard	Probably Efficient	Energy-saving opportunities
	Exceed standard	Probably Normal	Energy-saving opportunities



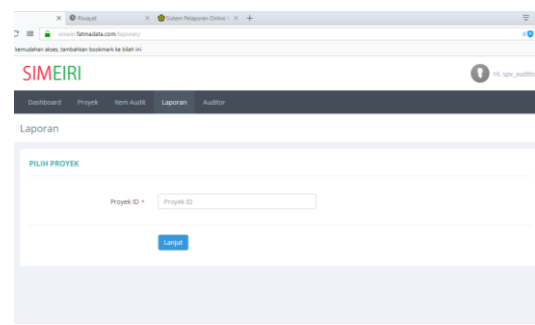
(a) Page of “Dashboard”.



(b) Page of “Project”.



(c) Page of “Audit Item”.



(d) Page of “Report”.

Figure 1. The user interface of the application.

Web-based parent application so that the data input on the client side and data storage is on the server. This system model relieves user-side storage media and facilitates teamwork. Users consist of supervisors and auditor members. To ensure the security of user data, the protection is done by using username and password login procedure and used https-protected internet communication protocol.

After logging into the system, the start page displays "Dashboards" showing the list of existing projects and auditors. The audit process is done by following the next page flow from the "Project" which contains the project identity and building data, the "Item Audit" page contains space and fills the audit data as well as the benchmark results of each item. The "Auditor" page contains auditor data. Page views are shown in figures 1(a) - (d). The last page is used to generate electrical energy audit reports.

4. Conclusions

An important note of this research is that the application of information technology is very helpful and support the energy conservation program. The applications created in this study are designed to facilitate managers and auditor members in assessing, processing and producing collaborative teamwork reports. Application alpha testing stage is done by a case study of building project of Rajawali RSUP Karyadi Semarang and got result according to audit process done manually. Further development of the website not only as an audit tool but also contains all information related to energy conservation to attract website visitors and help spread the science of energy conservation.

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