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Environmentally Friendly Electric Energy Development Model

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Abstract

The increased production of electrical energy will lead to an increase on the use of fossil fuels which ultimately raise the Greenhouse Gas (GHG) emissions. The use of fossil fuels (non-renewable fuels) for large-scaled generation of electrical energy will certainly cause problems considering oil and coal reserves as the main source for PLTU will shrink and run out over time. In addition, several environmental problems need to be considered and studied regarding this condition. Thus, it is very important to efficiently use electrical energy according to Presidential Instruction No. 6 of 2014 concerning energy development which focused on sub-sectors electricity development and minimization of fossil energy use as well as development of new, renewable, and converted energies. Based on this, a system which can support energy saving is needed. A system used for regulating energy needs is called the Energy Management System (EMS). The study was conducted in the Malang State Polytechnic Campus which is located on Jalan Soekarno Hatta no. 9, Jatimulyo, Lowokwaru Sub-district, Malang City. The sample used in this study consists of 230 people, including 150 students, 30 lecturers and 50 academics. This study is purposed to examine the correlation of the four variables to the energy management system and the use of environmentally friendly energy. Thus, the most appropriate model to accommodate this requirement is Structural Equation Modeling (SEM). The results of SEM analysis showed that the model of an environmentally friendly electric energy management is said to be feasible to be developed, thus it can be collectively adapted in all aspects for creating a green campus.

Keywords: *Energy Management System (EMS); Energy Saving Culture; Environmentally Friendly Electrical Energy Use; SEM (Structural Equation Modeling)*

Introduction

Nowadays, the use of electrical energy has grown rapidly in all aspects of life, along with that the energy generated by the Electric Power Plant is increased. However, along with the industry development and the increasing investment created, the electricity demand is continued to increase. The increase in the

production of electrical energy will increase the use of fossil fuels which leads to an increase in greenhouse gas (GHG) emissions. Electrical activity has the largest share in the contribution of GHG emitters in the energy sector in 2014, which reached 34,6% of the total GHG inventory in the energy sector.

The fossil fuels (non-renewable fuels) utilization for large-scaled electricity generation will certainly cause problems over time, considering oil and coal reserves as the main source for PLTU will shrink and run out over time. Besides that, environmental problems generated also need to be considered and studied considering that a PLTU with a capacity of 600 MW can consume approximately 5000 tons of coal per day. Thus, it is very important to efficiently use electrical energy according to Presidential Instruction No. 6 of 2014 concerning energy development which focused on sub-sectors electricity development and minimization of fossil energy use as well as development of new, renewable, and converted energies. Through energy efficiency, minimization of energy consumption is pursued by maintaining the same energy use, namely without suppressing the production levels or reducing the comfort levels, ensuring supply, promoting sustainability and conserving the environment.

A system that can support energy saving is very crucial. The system used in regulating energy use is called an energy management system. Energy Management System is a system used for regulating energy which includes planning and operating of energy production and consumption which aimed to conserve the resources, climate protection, and cost savings; while users have permanent access to the energy they need. According to Vilnis, *"Energy management is all about reducing the cost of energy used by an organization"* (Vilnis, 2009).

Energy-saving has not become a culture in the Malang State Polytechnic campus. The use of electrical equipments in the campus area such as in the lecture buildings, laboratory and workshop buldings, public buildings as well as the use of other electricity supporting equipments (AC, elevator, etc.) and inappropriate use of generators will raise the energy consumption. In addition, it is indicated that the increased consumption of electrical energy in the Malang State Polytechnic Campus is due to the increase in space and equipment, regarding the electronic and digital-based services in the campus. Several problems found are that there has never been an audit on comprehensive electrical energy, still using inefficient energy equipment, shared working tools (forget to turn off the equipment when working hours end), Full day (24 hours) lighting for the supporting room. Regarding these conditions, there is an opportunity to conduct electrical energy conservation, especially on consumer side (employee behavior) which is reflected in the equipment operation. Based on the above background, the researcher intends to design a model of electrical energy saving from a sustainable model of energy use in Vocational University, especially in the Malang State Polytechnic. The energy saving model is designed to use a new and renewable energy that is environmentally friendly, namely solar energy, which is always available and does not pollute so that CO_2 emissions can be reduced.

Literature Review

Energy Saving Culture

Every citizen with a good awareness will support a systematic, planned, and integrated effort to conserve domestic energy resources and increase its efficient use through energy-saving measures which becomes a part of energy conservation in the educational world (Perdana, 2017). The study results conducted by the ESDM Ministry showed that through energy conservation, there are up to 35 percent potential savings made. We realize that changing the behavior is the easiest and cheapest way, but it is very difficult to do. Changing the behavior requires serious effort. We have to do it repeatedly and

continuously so that the behavior becomes a habit and eventually becomes our culture. Although it is difficult to do, surely, we can make this behavior changed.

The chance to build a state defending spirit for the sustainability of future energy is realized through awareness of being economical, wise, and smart in the application of energy-saving cultural values for all educational academics, both lecturers (educators) and students as well as the application of educational syllabus in the form of excellent subjects, i.e. green education in energy conservation and saving. Lecturers in the educational sector will be given support and commitment by EECCHI in the form of training materials, workshops, guidebooks and challenges of energy-saving competition inter schools, awarding schools that have succeeded in creating academics who act wisely, smartly, save energy through energy efficient behavior, thus can apply the learning method of energy-saving cultural values in the school environment.

Form of government appreciation for putting energy-saving cultural values into realization was taken through energy-saving competition inters schools and colleges so that schools / colleges are selected to become energy-saving ambassadors and the best role models for energy saving in Indonesia. Home and School Energy Efficiency Champion (HSEEC) is an example of energy conservation socialization program that has been implemented by the Ministry of Energy and Mineral Resources (ESDM). This activity is designed in the form of competitions of energy efficiency practice through changes in energy consumption behavior in the household and school environmets.

Energy Conservation

According to the government regulation of Republic of Indonesia No. 70 of 2009, energy conservation is a systematic, well-planned, and integrated effort to conserve and increase the efficiency of its use. Energy conservation means using the energy efficiently without reducing function of the energy itself technically but trying to get the lowest economic level, being acceptable to the community and also not disturbing the environment. Thus, with energy conservation, electrical energy becomes more efficient through measures to reduce various losses of electrical energy at all processing levels, starting from its generation, delivery (transmission), to its utilization.

Many efforts can be made in conserving electrical energy both on the supply side and on the demand side. This thesis will discuss efforts made are on the consumer side (demand) and one of the techniques for conserving electrical energy is by auditing or checking the level of electrical energy use.

Sustainable Energy Management Modeling

The main legal basis is Law No. 30 of 2007 concerning energy as the legal basis for energy management by considering the limited reserves of non-renewable energy so that it is necessary to use various energy resources. Efficient management of electrical energy through energy saving is based on Presidential Instruction Number 6 of 2014 concerning energy development which focused on sub-sectors electricity development and minimization of fossil energy use as well as development of new, renewable, and converted energies.

Energy saving in the environment of Government agencies through actions and energy saving innovations within the respective agencies and within the State-Owned Corporation area according to their respective authorities based on energy saving policies includes savings on lighting and air conditioner (AC) equipments for office areas or buildings, office equipment and supplies that use electrical energy, which are managed by the Government, Local Governments, based on Presidential

Instruction of the Republic of Indonesia No. 2 of 2008 concerning Energy and Water Saving. Ministerial Regulation of Energy and Mineral Resources No. 13 of 2013 which regulating the Use of Electricity Saving specifically focuses on the regulation of electricity use in State buildings, State Company and Regional Companies Buildings and, residential areas of government officials, public street lighting, decorative lights and billboard.

Environmentally Friendly Approach for Electricity Energy Use

The use of environmentally friendly manner for sustainable availability of energy sources is very important. This can be taken by saving the electrical energy use and utilizing renewable energy sources considering that fossil energy resources will diminish and run out over time. The development of technology and industry have impacted to the increasing income and welfare of the population and followed by an increase in energy consumption. For this reason, the government has introduced a program of 10.000 MW followed by 35,000 MW to meet the energy requirements, especially for national electrical energy. In addition, energy savings must be implemented considering that the old fossil energy sources will shrink over time, according to Presidential Instruction No. 2 of 2008 about Energy and Water Savings which regulating steps and innovations to save energy and water in the respective agencies and / or in the State and Regional Companies areas according to their respective authorities which refers to the Energy and Water Saving Policy.

In line with this, the Minister of Energy and Mineral Resources has issued Ministerial Regulation of Energy and Mineral Resources No. 13 of 2012 concerning Electrical Energy Saving. The scope of this regulation includes: State Buildings, BUMN, BUMD and BHMN buildings, residential areas of government officials, public street lighting, decorative lights and billboard. Electrical use savings in the buildings are carried out for air conditioning system (AC), lighting system and supporting equipments.

Energy Management System (EMS)

Energy management is a program that is designed and implemented systematically to utilize energy effectively and efficiently by continuous planning, recording, monitoring and evaluating without reducing the quality of production and service. Energy management includes planning and operating energy-related consumption and production units to actively manage efforts to save energy use and reduce energy costs. The objectives of energy management are saving resources, protecting climate, and saving costs. For consumers, energy management makes it easier to get access to energy according to what and when they need it. Energy management deals with environmental management, production management, logistics and other business-related functions. Energy management is an activity in an organized company with management principles and aimed to conserve energy, so that energy costs as a component of production / operating costs can be suppressed as low as possible.

According to Ministerial Regulation of the Energy and Mineral Resources of the Republic of Indonesia No. 14 of 2012, energy management is an integrated activity to control energy consumption in order to achieve effective and efficient energy utilization to produce maximum output through structured and economical technical measures to minimize consumption of raw and supporting materials. This is based on the fact that the management of electrical energy in Polinema has not yet referred to a policy so that it is not measurable and there is no standard for electrical energy use, thus increase the electricity cost. Energy saving model is designed to use new and renewable energy that is environmentally friendly, that is solar energy, which is always available and does not pollute so that CO2 emissions can be reduced

Methodology

The research method is designed to answer questions and objectives, through hypothesis testing. It is the whole process required in the planning and implementation of research (Kerlinger, 1993). This is a type of explanatory research or confirmatory research, which is a study that aims to analyze the effect of one variable to another, or to explain how a variable affects other variables (Ferdinand, 2006).

This study was conducted in Malang State Polytechnic Campus, which is located at Jalan Soekarno Hatta No. 9, Jatimulyo, Lowokwaru Sub-district, Malang City. The population of this study is the entire academic community of Malang State Polytechnic, consisting of 11.952 students, 462 educators (lecturers), and 158 educational staffs (non-lecturers), with a total of 12.572 people. The sample used in this study was 230 people, consisting of 150 students, 30 lecturers and 50 academics.

This study aims to examine the relationship of the four variables towards energy management system and the use of environmentally friendly energy. Thus, the most appropriate model to accommodate this condition is Structural Equation Modeling (SEM). Furthermore, a SWOT analysis is used to get a strategy of Environmentally Friendly Energy Use.

Results and Discussion

Results of Structural Equation Modeling (SEM) Analysis

According to Arbuckle and Wothke, in Solimun (2002), the best criteria used as an indication of the goodness of the model are the Chi Square / DF value which is less than 2 and RMSEA which is below 0.08. In this study, the CMIN / DF and RMSEA values have met the cut off value. However, some of the SEM model in this study not yet met the cut-off value, thus the model formed was considered to be marginal. The test results are presented in the Table 1.

Table 1 The Goodness of fit test results of overall model in early stage

Goodness of Fit index	***Cut off Value***	**Analysis Results**	**Model Evaluation**
χ^2*- chi quare*	< df with $\alpha = 0.05$	61.373	Good Model
Sig.	≥ 0.05	0.053	Good Model
RMSEA	≤ 0.08	0.047	Good Model
RMR	≤ 0.10	0.070	Good Model
GFI	≥ 0.90	0.941	Good Model
AGFI	≥ 0.90	0.974	Good Model
CMIN/ DF	≤ 2.00	2.416	Marginal Model
TLI	≥ 0.90	0.933	Good Model
CFI	≥ 0.90	0.929	Good Model

Source: Data Processed, 2019

Based on the results obtained, there is an illustration obtained that the influence the four variables, especially on the energy management system in the study location, depends on the two variables, namely energy saving culture and electricity policy. These results proved that the role of the campus or institution in providing policies is not fully correct yet, this is because the minim counseling and socialization to lecturers, educators, and students, making them less aware of the benefits generated and impacts that can be avoided from the existence of an energy-saving culture. Figure 1 shows the results of the obtained model by using SEM.

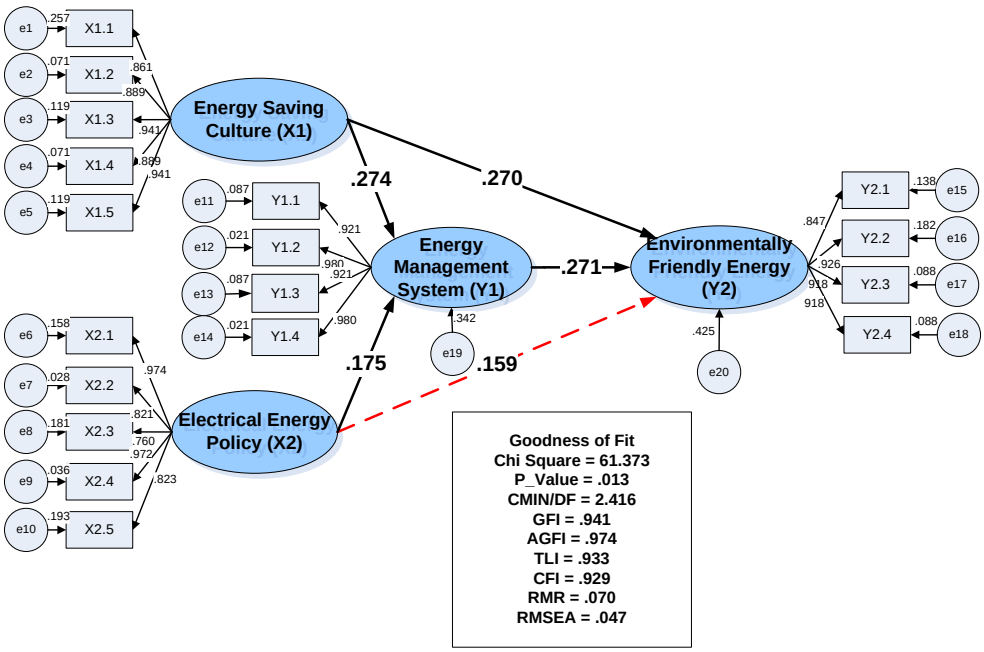

Fig 1. Path diagram of SEM analysis result

Based on the SEM analysis results, a model with a GFI value of 0,938 was obtained, which is included in a good model. Thus, based on these results, it can be concluded that an effective, efficient, and sustainable model of electrical energy management at Malang State Polytechnic is feasible to be developed.

Hypothesis Test Results

The hypothesis test was conducted by using the t test for each direct effect partially. Summary of the hypothesis test results is given in the Table 2.

Table 2 Hypothesis test results

	Independent Variables	**Dependent Variables**	**Path Coefficient** *Direct Effect*		
			Standardize	***P-value***	**Description**
H_1	Energy Saving Culture	Energy Management System	0.231	0.000	sig***
H_2	Electrical Energy Policy	Energy Management System	0.179	0.010	sig**
H_3	Energy Saving Culture	Environmentally Friendly Energy	0.035	0.013	Sig**
H_4	Electrical Energy Policy	Environmentally Friendly Energy	0.168	0.531	Non sig**
H_5	Energy Management System	Environmentally Friendly Energy	0.279	0.000	Sig***

Source: Data Processed, 2020

Based on the Table 2, the following results are obtained:

1. Hypothesis 1: Energy Saving Culture has a significant effect on the Energy Management System was accepted. Standardized path coefficient = 0,231 with p value = 0,000, the result was significant. This shows that there is a significant positive correlation between Energy Saving Culture and the Energy Management System. This illustrates that the more perceived or good the Energy Saving Culture is, the better the role of Energy Management System will be in the campus environment.

2. Hypothesis 2: Electrical Energy Policy has a significant effect on the Energy Management System was accepted. The standardized path coefficient = 0,179 with p value = 0,010 was significant. This shows the significant positive effect of the Electric Energy Policy on the Energy Management System. In other words, the higher or better the Electrical Energy Policy is, the better the Energy Management System.

3. Hypothesis 3: Energy Saving Culture has a significant effect on Environmentally Friendly Energy was accepted. The standardized path coefficient = 0,035 with p value = 0,013 was significant. This illustrates that there is a significant positive correlation between Energy Saving Culture and Environmentally Friendly Energy. This shows that whether an Energy Saving Culture is good or not does not affect Green Energy.

4. Hypothesis 4: Electrical Energy Policy has a significant effect on Environmentally Friendly Energy was rejected. Standardized path coefficient = 0,168 with p value 0,531, it was not significant. This illustrates that there is no correlation between the Electric Energy Policy and Environmentally Friendly Energy. It means that the electricity energy policy has not been able to give impact on the increase of Environmentally Friendly Energy in the campus environment.

5. Hypothesis 5: The Energy Management System has a significant effect on Environmentally Friendly Energy was accepted. The standardized path coefficient = 0,279 with p value = 0,000 was significant. This illustrates that there is a positive significant influence of Energy Management System towards Environmentally Friendly Energy. It means that the more perceived or good the Energy Management System is, the more environmentally friendly energy resulted.

Indirect effect is the effect that is measured indirectly from one variable to another through intervention. The coefficient of indirect effect is obtained from the product of the two direct effects. If both coefficients of the direct effect are significant, then the coefficient of the indirect effect is also significant. However, if one or both are non-significant, then the coefficient of the indirect effect is non-significant. There are two indirect effects tested in this study as shown in Table 3.

Based on the results obtained by using SEM, it can be concluded that after designing an appropriate model for environmentally friendly electrical energy management, it is necessary to raise awareness which focused more on the environment and energy savings so that the energy-saving character built will be better organized. The majority of lecturers, educational staffs and students from related agencies or parties have socialized energy-saving awareness, public service advertising, posters, oral and written appeals, or even regulations. It is intended that all parties have high awareness in social, economic and cultural aspects but there are still some people who deliberately use their authority to do many inaappropriate things, thus unhealthy environments still become a common thing.

Table 3 Indirect effect test results

Indirect Effects	Testing		Conclusion
	Direct Effect 1	Direct Effect 2	
Energy Saving Culture → Environmentally Friendly Energy with intermediary Energy Management System Coefficient: 0.274*0.271=0.074	Energy Saving Culture → Energy Management System Coef: 0.274 Significant	Energy Management Systems→ Environmentally Friendly Energy Coef: 0.271 Significant	Significant
Electrical Energy Policy → Environmentally Friendly Energy with intermediary Energy Management System Coeffcient: 0.175*0.271=0.047	Electrical Energy Policy → Energy Management System Coef: 0.175 Significant	Energy Management System → Environmentally Friendly Energy Coef: 0.271 Significant	Significant

Source: Data Processed, 2020

From the hypothesis results regarding indirect effect of Energy Saving Culture towards Environmentally Friendly Energy through the intermediary of Energy Management System, there were obtained a coefficient of 0,074. The test result of the indirect effect between Energy Saving Culture towards Energy Management Systems is significant. It is similar with the test result between Energy Management Systems on Environmentally Friendly Energy which is significant. Thus, the indirect effect between Energy Saving Culture and Environmentally Friendly Energy through the intermediary of Energy Management System is found to be significant. This indicated that the Energy Management System can become an intervening variable between Energy Saving Culture and Environmentally Friendly Energy. Thus, with a well-designed Energy Management System, the Energy Saving Culture will increase the Environmentally Friendly Energy.

Regarding the indirect effect of Electrical Energy Policy towatds Environmentally Friendly Energy through the intermediary of Energy Management System, there was a coefficient resulted of 0,047. The test result of indirect effect between Electrical Energy Policy and Energy Management System is significant; it is similar with the test result between the Energy Management System and Environmentally Friendly Energy which is also significant. Thus, the indirect effect of Electric Energy Policy towards Environmentally Friendly Energy through the intermediary of Energy Management System is significant. This illustrated that the Energy Management System can be an intervening variable between the Electric Energy Policy towards the Environmentally Friendly Energy. In conclusion, with a well-designed Energy Management System, the Electrical Energy Policy will increase the availability of Environmentally Friendly Energy.

This is in line with Akisawa et al., 1999 where the research aims to develop a sophisticated energy management system for energy saving and environmentally friendly society as well as providing a valuation model for zero emission (materials) and energy cascade systems. The study introduced two types of advanced energy system models: cascade energy with zero emissions by circulating materials and a super eco-friendly industrial area from complete energy use and environmental conservation perspectives. A valuation model was developed to measure the energy saving effect from a sophisticated energy cascade system consisting of four major industry groups and 12 subgroups in Japan. The results

showed that 25% energy saving can be realized from the zero emission and energy cascade system. Moreover, it was found that minimum levels of fuel and energy consumption could be obtained from the optimal area composition of the large group. The study also developed an energy cascade balance table showing the material and heat flow direction from a higher potential level to a lower potential level. The study proposed that the current energy consumption is correlated to temperature levels. The proposed energy model shows the way on how to maximize heat utilization among various industries.

Conclusion

Based on the results previously described, there are several conclusions can be drawn: (1) Based on the analysis results, periodical audits is needed to improve energy performance at Malang State Polytechnic. The audit results find that there are still many inefficiencies on laboratory room functions and become a priority for gradual and continuous improvement. In addition, the significant consumption of air conditioning, computer lighting, printers, photocopying and others electrical equipments is concerned for energy saving. The energy management plan based on ISO 50001 which refers to Law No. 14 of 2012 was implemented by making policies, energy management planning, energy saving principles, implementing energy plans, evaluating energy management with regards to audit findings and reviewing applicable energy management. (2) The SEM analysis results showed that a model of environmentally friendly electrical energy management is feasible to be developed, so that it can be collectively implemented in all aspects which ultimately lead to a green campus.

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