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An Effort to Lower Electricity Bill in University Building by Automatic Lighting Switches Application

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ABSTRACT

There is a high demand for electricity in Indonesia which results in spiralling cost of electricity. This is compounded by the fact that many power generators in Indonesia still use fossil fuels. *Universitas Budi Luhur* aims to be a green campus. One way to reduce demand for energy s to use the electricity efficiently and sparingly, such as turning off the lights in the rooms when they are not in use though this is difficult to be implemented in public spaces such as toilets. Automatic light switches were installed in sample toilet rooms from August 1, 2016 to August 6, 2016. The energy saving was quite substantial, and translated into a cost saving of IDR 52.157,40 per week (about 63% of total weekly usage) or IDR 207.628,50 per month or IDR 2.503.555,20 per year. With the assumption of similar usage in all six toilets, annual saving in the electricity bill is estimated to be IDR 15.021.331,20.

Keywords: Annual saving, automatic light switch, electricity bill, energy efficiency, motion sensor, room lighting

INTRODUCTION

Electricity is important for modern life. High electricity consumption means higher cost. Additionally, the majority of Indonesian power plants are dependent on fossil fuel. A change in oil price affects fuel price which in turn determines the base electricity fare. One effort to lower electricity cost is to

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increase the efficiency of electricity usage, such as by using energy-efficient equipment and deactivating electrical equipment when not in use.

Universitas Budi Luhur depends greatly on electricity supply for the smooth running of its campus, but its energy use is not efficient. Supply of electricity to the classroom is controlled from the main panel. So, when there is no lecture scheduled in a classroom, the electricity supply there can be remotely deactivated. Lights in the office and lecturer rooms can be manually switched off when not in use, but it does not work for public facilities such as toilets and enclosed corridors. Therefore, the proposed method in this pilot project is to use automatic switches which detect the presence of a human in a particular room. Aside from its practical use, there is no need for any contact with a human. This application also helps to lower electricity consumption and prolong the lifetime of the light bulbs, which in turn leads to cost saving.

The objective of this pilot project is to measure the level of reduction in electricity consumption by reducing its usage. The expected benefit is energy efficiency and cost saving at the Universitas Budi Luhur's campus. The pilot project experiment was performed in selected man's public toilets located on the 1st floor of Building 4.

LITERATURE REVIEW

Aliyu (2015) examined the relationship between energy consumption and development. The greenhouse gas effect of the resource re-allocation process in a domestic economy will, for example, depend on the sectors in which a country claims comparative advantage. The composition effect will result in more greenhouse gas emissions if the expanding sectors are more energy-intensive relative to the contracting sectors, and vice-versa. The scale effect refers the effect on greenhouse gas emissions from increased economic activity and/or output (Aliyu, 2015). The overall presumption is that increase in economic activity correlates with the increase in energy use. All things being equal, this increase in the scale of energy use and economic activity will lead to higher levels of greenhouse gas emissions. This implies that higher income increases pollution due to greater energy consumption. Advanced techniques can reduce pollution, for example, based on the Porter Hypothesis. This hypothesis suggests that stringent environmental regulation in advanced nations would likely encourage innovation and replacement of pollution-generating production process with more efficient and environmentally-friendly technology, which would be ultimately transferred to less developed countries via FDI flows, and thus reducing damages to the environment.

Maji, Habibullah and Yusof-Saari (2016) reported that most economies will desire to strive for environmentally sustainable financial activities. Growth in activities will lead to increase in energy consumption, which in return foster the combustion of

fossil fuel and subsequently increase carbon dioxide (CO_2) emissions, a toxic substance that increases greenhouse gas and global warming. The danger and the consequences of global warming and climate change have led to the establishment of environmental friendly advocacy organisations. These organizations and relevant treaties, which include Kyoto Protocol, Environmental Protection Agency, Greenpeace and Nature Conservancy have contributed greatly to the global green movement by facilitating the conditions under which human and natural environment can come together to satisfy the economic and environmental needs of societies.

Motion detection system is used primarily in surveillance and security systems. The system proposed by Sahu and Choubey (2013) will be useful for security in a fixed restriction area. The background of the targeted area is assumed to be non-moving and considerations of a sudden change in lightings are ignored as well. A technique called image segmentation is used to extract the foreground image from the source image and later processed to filter out noises or small image disturbance. Based on a level of acceptable percentage in human motion, the system would detect the moving objects which will be in a different colour.

A motion detection algorithm begins with the segmentation part where foreground or moving objects are segmented from the background. The simplest way to implement this is to take an image as background and take the frames obtained at the time t, denoted by I(t) to compare with the background image denoted by B. In a study (Sahu & Choubey, 2013) using simple arithmetic calculations, the researchers segmented the objects simply by using image subtraction technique of computer vision for each pixel in I(t), taking the pixel value denoted by P[I(t)] and subtracting it with the corresponding pixels at the same position on the background image denoted as P[B]. In mathematical equation, it is written as follows:

$$P[F(t)] = P[I(t)] - P[B] \quad (1)$$

Where F refers to the foreground or the resulted image after the computation at time t. To perform a point tracking algorithm, a motion detection algorithm would have to first initialise the feature points on the segmented foreground objects and track their movements.

Analysis of human motion is currently one of the most active research topics in computer vision in which the moving human body detection is the most important part of the human body motion analysis. Human body detection aims to detect the moving human body from the background image and to follow-up on treatment such as the target classification, human body tracking, and behavioural understanding. Its effective detection plays a very important role. Human motion analysis concerns with detection, tracking, and recognition of people behaviours. Rakibe and Patil (2013) presented a new algorithm for detecting

moving objects from a static background scene to detect moving objects based on background subtraction. The presence of moving objects is determined by calculating the difference between two consecutive images in the frame subtraction method. Its calculation is simple and easy to implement. For a variety of dynamic environment, it has a strong adaptability but it is generally difficult to obtain a complete outline of moving object responsible for showing the empty phenomenon. As a result, the detection of moving object is not accurate. Optical flow method is to calculate the image optical flow field and do clustering processing according to the optical flow distribution characteristics of the image. This method can provide complete movement information and is able to detect the moving object from the background. However, extensive calculation, sensitivity to noise, and poor anti-noise performance makes it not suitable for real-time demanding occasions. The background subtraction method is to use the different method of the current image and background image to detect moving objects using a simple algorithm. This method is very sensitive to the changes in the external environment and has a poor anti-interference ability. However, it can provide a complete object information in the case of the known background.

Wibowo (2004) explored the use of proximity sensor, namely human presence, in a room with the performance of the sensor working as heat detection. The idea of using automatic switch arises from the need to reduce electricity waste. In an economic viewpoint, installation of an automatic switch can control the electricity usage, for example, a 40-Watt lamp uses 200 kWh of electricity in five hours. The discussion is limited to testing the response of the fabricated sensor.

MATERIALS AND METHODS

Passive Infrared Sensor

The Passive Infrared Receiver or PIR is an infrared-based sensor. “Passive” means the device does not emit any infrared radiation. This differentiates PIR devices from other IR-based devices such as IR LED and phototransistor; the former only responds to infrared radiation emitted by other objects within its detection sphere by detecting human body temperature and/or movement since human body emits thermal radiation when moving due to energy metabolism to make muscle movement. Thus, the PIR detects a change in infrared radiation and responds by releasing output voltage.

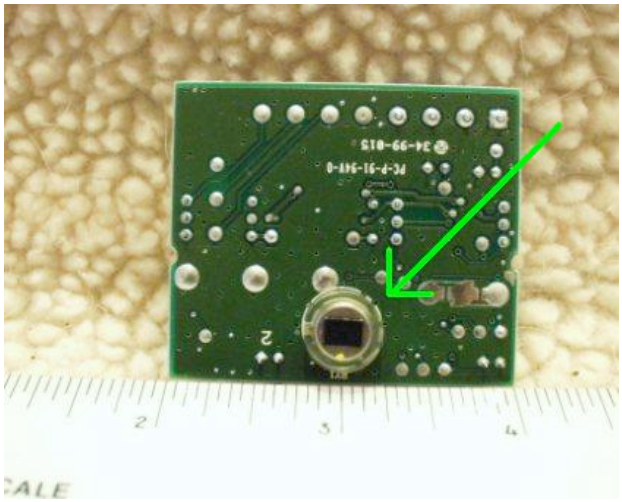

Figure 1. Pyroelectric sensor element

Figure 2. Motion sensor switch

Hypothesis

With the installation of motion sensor for lighting in the toilet used in the experiment, the expected reduction in energy consumption around 30% to 40% compared to the one without sensors.

Method of Experiment

The first stage in this research involves analysing condition in the test room. The second stage is designing the sensor installed in the electrical appliances (lamps and exhaust fans). In order to obtain the

energy consumption data after performing sensor installation, an Electrical Power Consumption Meter is used to facilitate data measurement. The device can record data on daily, weekly and monthly basis. The power consumption data is then converted into electricity billing cost.

RESULTS AND DISCUSSIONS

The electric appliances installed in the experiment room consisted of eight 23W bulbs and six exhaust fans of 80W each with daily operation of 14 hours from 7am to 9pm. Total power consumption was 664 Watt-hour which translated into 0.664kWh per hour, 9.3kWh per day, 231kWh per month or 2,772 kWh per year. The measurement is recorded every 7-hour interval up to 84 hours of operation, equal to 6 days a week. During this period, total electric power consumption without the use of motion sensors amounted to 55.576 kWh and base electricity fare of IDR 1,467.28/ kWh or IDR 81,839.01 per week or IDR 327,356.04 per month.

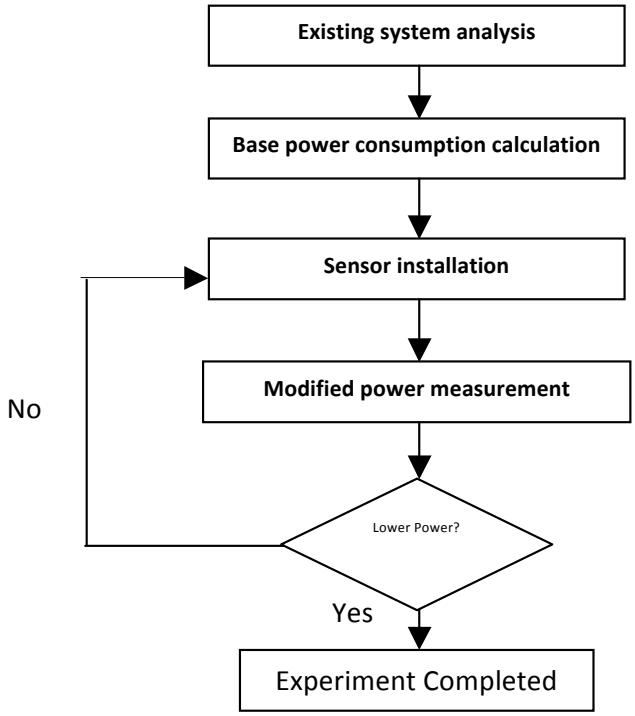

Figure 3. Experiment method flowchart

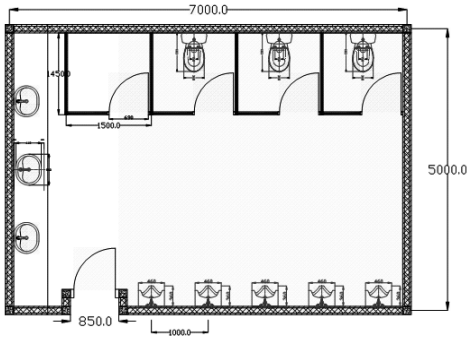

Figure 4. Room plan

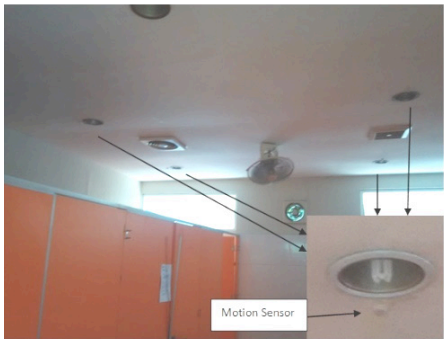

Figure 5. Sensor installation

The experiment began on Monday (August 1, 2016) at 8am. All the lights except the ones near the toilet door were switched off and only the exhaust was operating, and the meter showed 304.2W, with total consumption of 504.49 Wh. The measurement on Wednesday (August 3, 2016) at 14:30 or after 35 hours of operation, showed 10.6 kWh of consumption versus 27.9kWh in a normal operation (Figure 6).

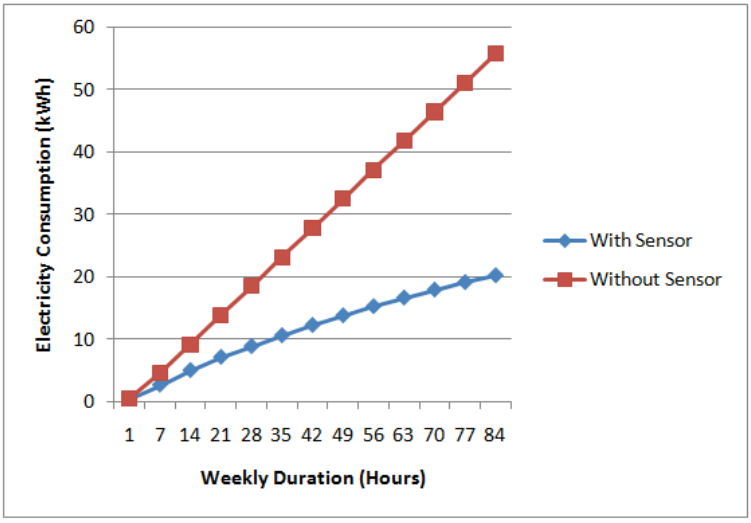

Figure 6. Power measurement comparison from 1 to 6 August 2016 stated as cumulative operating hours

From Figure 6, it can be seen that reduction amounting to half of the normal consumption is achieved after 28 hours. By the end of the week on August 6th, the reduction in consumption reached 63.73%. Table 1 shows financial saving if these figures were converted into electricity cost.

Table 1
Cost reduction due to energy efficiency

Energy (kWh)		Base fare (IDR/kWh)	Cost (IDR)		Cost saving (%)
With Sensor	Without Sensor		With Sensor	Without Sensor	
0.504	0.664	1,467.28	739.51	974.27	24.10
2.711	4.648	1,467.28	3,977.80	6,819.92	41.67
5.058	9.296	1,467.28	7,421.50	13,639.83	45.59
7.158	13.944	1,467.28	10,502.79	20,459.75	48.66
8.890	18.592	1,467.28	13,044.12	27,279.67	52.18
10.622	23.24	1,467.28	15,585.45	34,099.59	54.29
12.264	27.888	1,467.28	17,994.72	40,919.50	56.02
13.816	32.536	1,467.28	20,271.94	47,739.42	57.54
15.278	37.184	1,467.28	22,417.10	54,559.34	58.91
16.651	41.832	1,467.28	24,431.68	61,379.26	60.20
17.933	46.48	1,467.28	26,312.73	68,199.17	61.42
19.126	51.128	1,467.28	28,063.20	75,019.09	62.59
20.229	55.776	1,467.28	29,681.61	81,839.01	63.73

From Table 1, by the end of the week, it is shown that there is a cost reduction from IDR 81,839.01 to IDR 29,681.61. This is a saving of IDR 52,157.40, as a direct consequence of installing the sensors.

CONCLUSION

The results of the experiment showed the cost saving in the first hours was insignificant, but over time, it rose significantly to over 60% after one week. This figure is 1.5 times of the optimistic figure prediction of 40% and twice the least expected saving of 30%. With the projected saving of IDR 208,628.60 per month or IDR 2,503,555.20 per year, the total cost saving is significant i.e. IDR 15,021,331.20.

Future research should look at installing the same system in the other five toilets at the university in its first phase while the second phase can look at building corridors with eight 4-storied buildings. This is expected to significantly reduce expenses on electricity.

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