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An improved electricity efficiency method based on microcontroller and IoT with infrared sensor

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ABSTRACT

This paper proposes an improved electricity efficiency method using an infrared sensor and internet of things (IoT). Almost all field of human work require electrical energy, especially for household needs. The averages household has many lamps in each room, so if it is not controlled, it will be wasteful of energy. However, this work is carried out to gain a better understanding of a new method for saving energy. The main advantage of this work is the simplification of the sensor used, in which only the infrared sensor required. Although the proposed approach faces numerous challenges, it successfully provides result as parameters that it can be processed rapidly using low-cost microcontrollers. The idea is based on the microcontroller and internet implementation with infrared sensor to monitor the number of people in home to control the lamp light intensity. The idea is proven in two ways: design and experiment. In this paper, the implementation of Raspberry Pi and Arduino is created to monitor the number of people in room and control the lamp intensity through internet or web. Arduino uses for the sensor processing and Raspberry Pi as server. The web is used to display the monitoring result by retrieving data from database that created using MySQL. The result indicates that the electricity bill decreased between 7.7-8.2% over 2 months implementation. The conclusion of this study suggests that the research in this area could be directed toward to be used in saving electricity usage in human life, especially for household.

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1. INTRODUCTION

Indonesia is currenly included in the category of countries that are quite wasteful in energy use. Recorded energy use in Indonesia currenly reaches 1,131 million tons or equivalent of a barrel of oil. Some of the causes of high energy consumpsion are the use of electronic devices that are quite old and behavioral factors in energy use. The average waste of energy use are for household lighting and duration of use (hours) [1]. In the phenomenon that occurs in the electricity production carried out everyday by the State Electricity Company (PLN ~Ind.), is distributed to all circles of society. The use of households has the second highest ranking of electricity users as seen in the average selling price (IDR/kWh) as much as 557.76 with the number of customers is 31,095 thousands. Also, there are others that can cause the same dangerous things at home, for example, forgetting to turn off the lamp equipment in the house which can

cause the electrical short circuit/electric current, and then can cause fire, thus a system is needed to control the lamp from long distance or automatically controlled. Light application using internet for home automation is proposed in [2-4]. Technological advances continue to grow more rapidly following the times. Until now internet connection is one requirement that must be owned by almost everyone. Even, the public often not maximize the use of internet in the completion work. Application development tools, both on the hardware and software technologies to develop an automatic light relay application in the room are already widely used [5].

On the other hand, the internet of things (IoT) is ushering a set of novel applications and services to many vertical domains. Among them home automation represent an important market segment for smart home domain [6]. The smart home employs IoT technologies to equip home dwellers with increased comfort, energy effieciency, security and interaction with its appliance even when there is no one at home. Intelligence and communication modules embedded into these devices allow them to (i) exchange data with a data processing and storage unit, (ii) be controlled remotely through the internet, (iii) report their maintenance needs, (iv) manage themselves automatically and (v) optimize energy and resource usage [7]. Based on these discussion, it is clear that the use of the IoT and infrared sensor can be implemented as a technology for saving electricity. The key benefit of this paper are simplicity and low cost application.

2. RESEARCH METHOD

The research methodology is the stages that must be defined before carrying out the research, so it can be done with focused, clear, efficient and effective. The block diagram was design of three parts which are the input, process, and output. In Figure 1, the circuit was constructed using infrared sensor and will be processed separately by Arduino and Raspberry. During data processing, Arduino and Raspberry will communicate using serial communication. After all data was accomplished and processed, it will be implemented on the output in the form of Lamp or Web Page. The Arduino and Raspberry will be used as the controller and data processing device. The database was processed by Raspberry Pi because it has a Linux operating system that can manage the database easily and sensor processing will be controlled by the Arduino.

In Figure 2, when the system was turned on, Raspberry opened a serial port to get or transmit serial data. It obtained by Raspberry is later processed and used as input for the database. The data in the database will be displayed on the website as an indicator that the lamp are on or off. Every data changes or update in database, Raspberry will directly send data through serial communication to Arduino and it will process in reltime.

2.1. Internet of things

IoT can be explained as a set of things that are connected to each other via the internet. Things here can be tags, sensors, humans, etc. IoT functions to collect data and information from the physical environment, these data will be processed so the meaning can be understood [8]. It describes a vision where everyday object become part of the Network where Intelligence added to them with other things in Network or Network itself, which has impact on our personal, professional and social environment [9, 10, 11] as shown in Figure 3.

2.2. Microcontroller serial communication

Raspberry Pi can be used to do many things like a personal computer [12, 13]. It's requires to store operating system and program files [14, 15]. In this research, the Raspberry Pi will be used as web and database server by connecting the infrared sensor in the room through the internet.In this research Arduino will process the data from infrared. The Arduino advantages are independent platform, construction robust and low price [16, 17]. The serial communication between Arduino and Raspberry used the serial communication with asynchronous type. This serial communication uses the (COM) port on the computer. The Raspberry Pi requires the installation of the package to communicate serially through Arduino [19]. The receiving node synthesizes the split message sent from the sending node. The split message include important information for reconstituting the original data frame [20] as shown in Figure 4.

Raspberry Pi program will read serial, the command ser.read() is used, and in order to make the program easier, then the command variable data=ser.read() is needed. For the serial program on the Arduino, uses almost the same program command of Serial.read() as shown in Table 1. The data of the character sent via the serial communication.

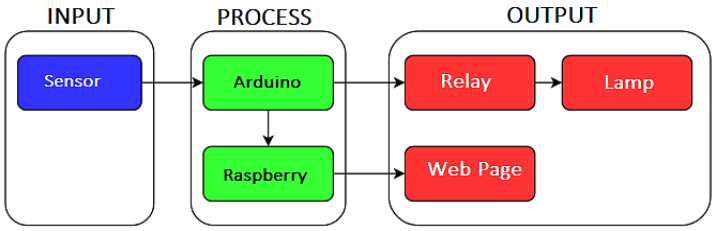

Figure 1. The system diagram block

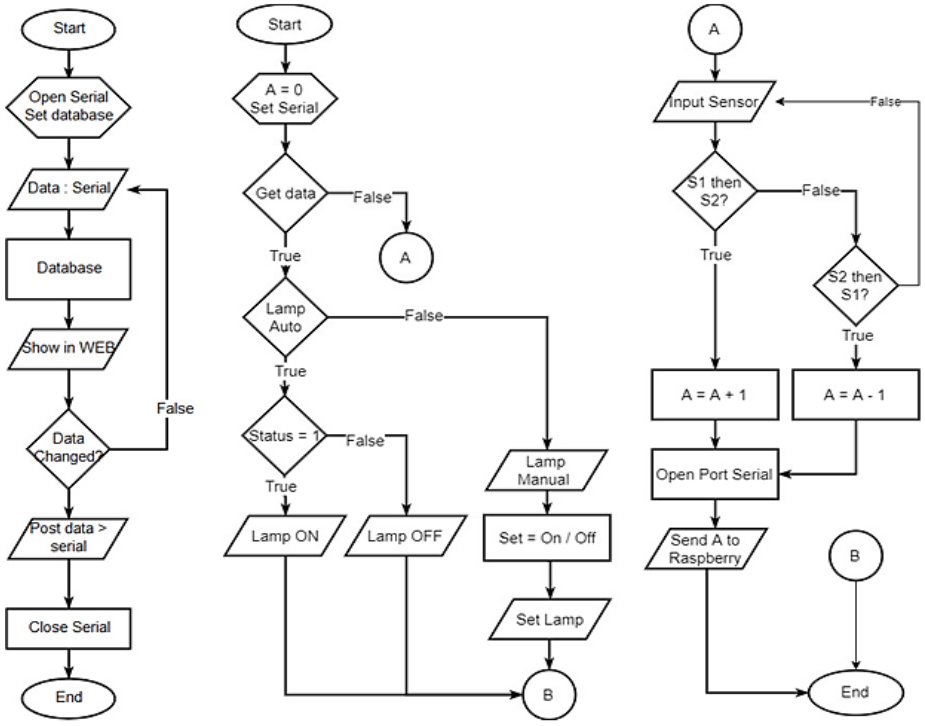

Figure 2. Flow chart system in arduino and raspberry

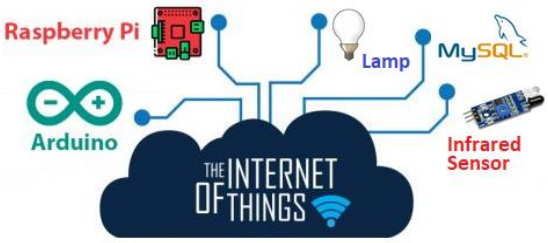

Figure 3. System proposed

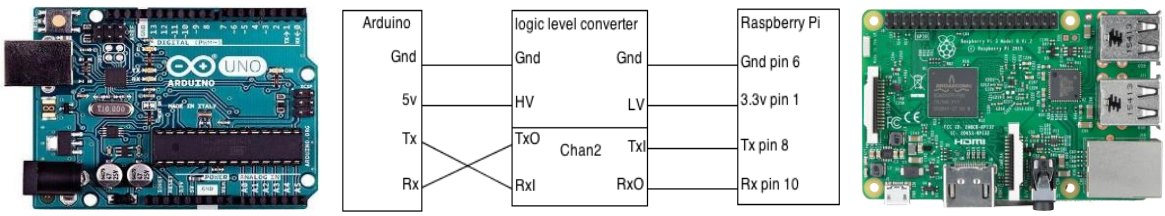

Figure 4. Microcontroller communication

Table 1. The data of the character sent via the serial communication

Data transmission from			
Arduino to Raspberry		Raspberry to Arduino	
Character	Function	Character	Function
A	Entering the Living Room	0	Lamp 1 On
B	Exiting the Living Room	1	Lamp 1 Off
C	Entering the Family Room	2	Lamp 2 On
D	Exiting the Family Room	3	Lamp 2 Off
E	Entering Room	4	Lamp 3 On
F	Exiting Room	5	Lamp 3 Off
G	Entering Kitchen	6	Lamp 4 On
H	Exiting Kitchen	7	Lamp 4 Off

2.3. Web hierarchical process structure

The UI (User Interface) that use has several pages that properly arranged and configured using the PHP programming language. In this part, Raspberry Pi is used for web server. When the user will access the device, the address is 192.168.43.3/login.php as shown in Figure 5. The web hierarchical structure.

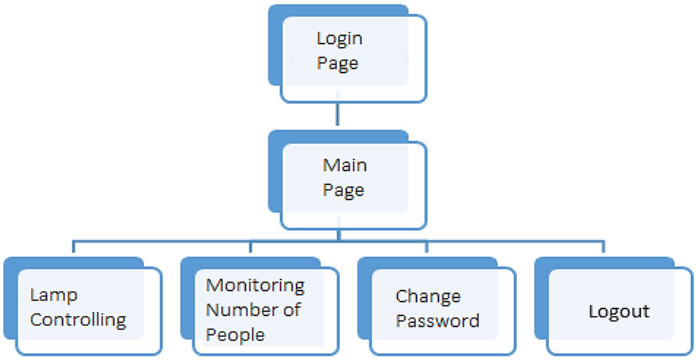

Figure 5. The web hierarchical structure

The in order to pass through the login page, then user needs to enter the username and password. The input spaces are required for the username and password, and are created using HTML.

<input id="name" name="username" placeholder="username" type="text">

The script above is the command to provide the input spaces for the username which is labeled id "name" with the type text as the input.

*<input id="password" name="password" placeholder="**********" type="password">*

In Figure 6, the web process was designed using MDS5 to process incoming information, and each group was divided into 16 seat groups of 32 bit, after a series of processing, the algorithm output consists of four block of 32 bit, the four block of 32 bit packet cascade will generate a 128 bit hash value [21, 22]. It means that before obtaining the access to the lamps and the number of people monitoring in the room, we need to login first. The algorithm to compare inputs between login page with database is added to ensure that the username and password are registered. In the other hand, the process to compare this inputs were started from the username and password because every action taken, the status canged to true or false. The user will return to login.php if password s not same and continue to idex.php page if password correct.

In addition to use MD5 to secure the password, adding an option to change the password is added to avoid piracy or illegal access by using the password that has been created. The steps to change the password can be seen in Figure 7, As a system security protocol, the old password must be entered to avoid it illegal replacement by others when the account is logged in. The user will be directed to the login.php page after clicking the text "here".

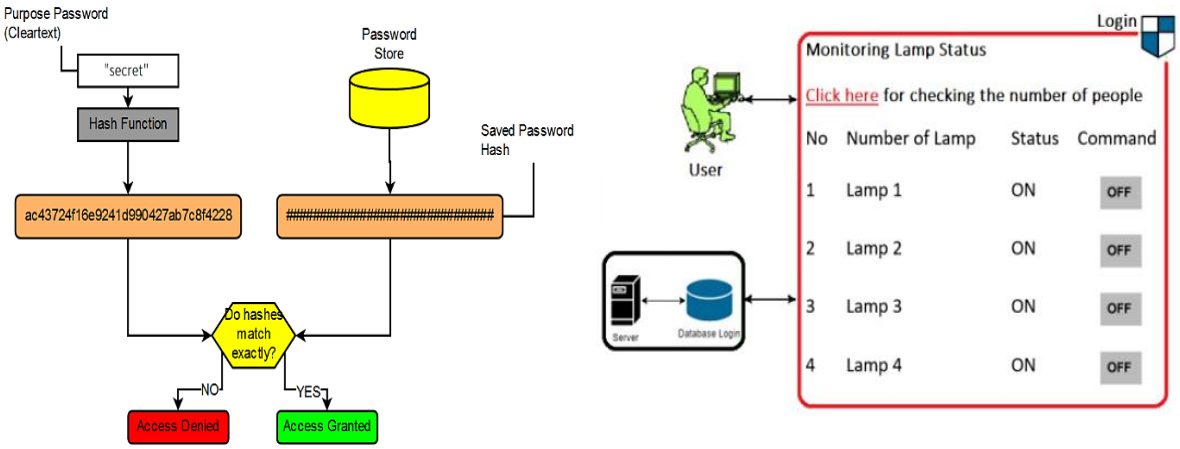

Figure 6. The MDS5 process design

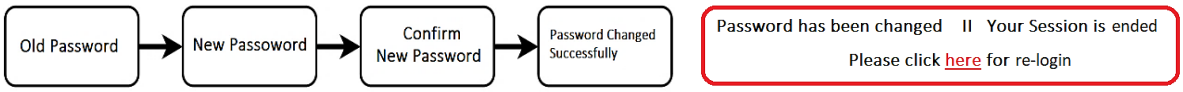

Figure 7. Step for changing the password

2.4. Database

The database was designed using MySQL. It provided large-scale data sharing in the network environment and allows many different users to access data, it greatly improves the efficiency of the work [23]. Many of the most popular and highly-trafficked websites in the world are built on MySQL [24]. In earlier work [25], we looked at how often dynamic features are used across of 19 popular open-source PHP systems. In order to get the data from the database, we need to enter the database name on the script to be executed by the program when the script is running.

In Figure 8, the function of "mysql_connect($host, $user, $pass)" on the script is used to execute the connection command with the host, user, and password, which were declared previously. Meanwhile, the function of "mysql_select_db($db_name)" is used to select the database will be used next. In this IoT application provides continuous flow of data. Data is stored in MySQL and will communicate with Arduino to update the data [26].


```
$host = "localhost";
$user = "root";
$pass = "xxxyyy";
$db_name = "smarthome";
mysql_connect ($host, $user, $pass) or die
(mysql_error());
mysql_select_db($db_name) or die (mysql_error());
?
```

Figure 8. The connection.php as the database

3. RESULT AND ANALYSIS

3.1. Infrared sensor testing for movement reading

In Figure 9, the experiment was conducted to prove the sensor function, when someone passed the sensor, it will reflect light from infrared to photodiode, so the sensor will provide digital voltage output data and proceesed by Arduino. Sensor placement will affect the sensor readings. Each sensor is placed in two different parts, inside and outside of the roomi order to avoid the light reflection on other sensors that can affect the sensor reading conditions. Experimental studies of the possibility of detecting the motion showed

that the active infrared sensor is capable of recording the movement object at a distance of 2 to 5 meters [18] as shown in Table 2.

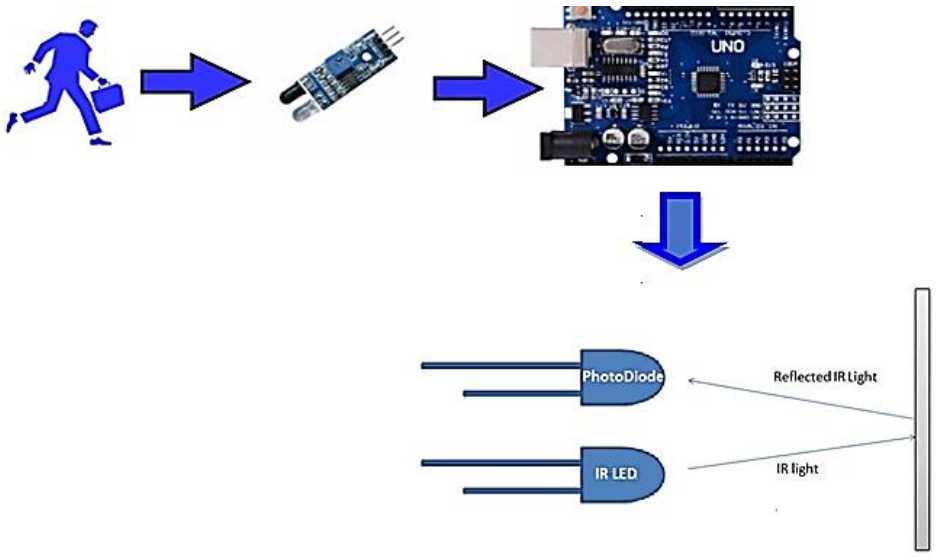

Figure 9. The diagram block of the reading sensor

Table 2. Results for movement reading testing

Sensor	Test Number				
	1	2	3	4	5
1	Read	Read	Read	Read	Error
2	Error	Read	Read	Read	Read
3	Read	Read	Read	Read	Read
4	Read	Read	Read	Read	Read
5	Read	Read	Read	Read	Read
6	Read	Read	Read	Read	Read
7	Read	Read	Read	Read	Read
8	Read	Read	Read	Read	Read

3.2. Infrared sensor testing during the day and night

In addition to testing the motion, the sensor was tested for the light effect during day and night. The test result was described that sensor was influenced of light, the infrared sensor can work properly at day. The infrared sensor is affected by the lamplight at night because its characteristic. Besides that, It can be also affected by the previously sensor voltage reference that is adjusted to the existing light, while the lamplight is brighter when it is turned on and shown in Table 3.

Table 3. Sensor testing for ambient light effect

Sensor	Sensor Position	Sensor test when the lamps are ON	
		Day	Night
1	Outside living room	Not affected	Affected
2	Inside living room	Not affected	Affected
3	Outside bedroom	Not affected	Affected
4	Inside bedroom	Not affected	Affected
5	Outside family room	Not affected	Affected
6	Inside family room	Not affected	Affected
7	Outside kitchen	Not affected	Affected
8	Inside kitchen	Not affected	Affected

3.3. Raspberry performance testing

The Raspberry performance test will be conducted in two steps, test of Raspberry response for lamp, and the Raspberry wireless range testing in the wi-fi network shown in Table 4. This testing was carried out

to get responses if there is a sequence to turn on/turn off the light in a variety of ways, because Raspberry prioritized kernel performance over the others. Besides that, the response was affected by unstable signal conditions shown in Table 5.

Table 4. The raspberry response for the order to on/off lamp

Total of order in 1 second	Test 1	2	3	4	5	6	7	8
	Response in Seconds							
1	1	2	1	1	1	1	2	1
2	1	3	1	2	1	1	2	2
3	2	2	3	2	3	3	3	1

Table 5. The raspberry range test on the connected Wi-Fi

No	Range	Status	Response
1	0 m	Stable	1 second
2	10 m	Stable	1 second
3	15 m	Low	3 second
4	25 m	Disconnected	No response

3.4. Web page access testing

This testing is designed to find out whether the web can be accessed and work properly when it is accessed through the PC. Figure 10 showed the page access result on index.php. When accessing the page directly to the URL 192.168.43.3/index.php, we will be redirected to the login page on the URL 192.168.43.3/login.php, because we didn't login to computer, but if we accessed the login page, we will be redirected to monitoring page.

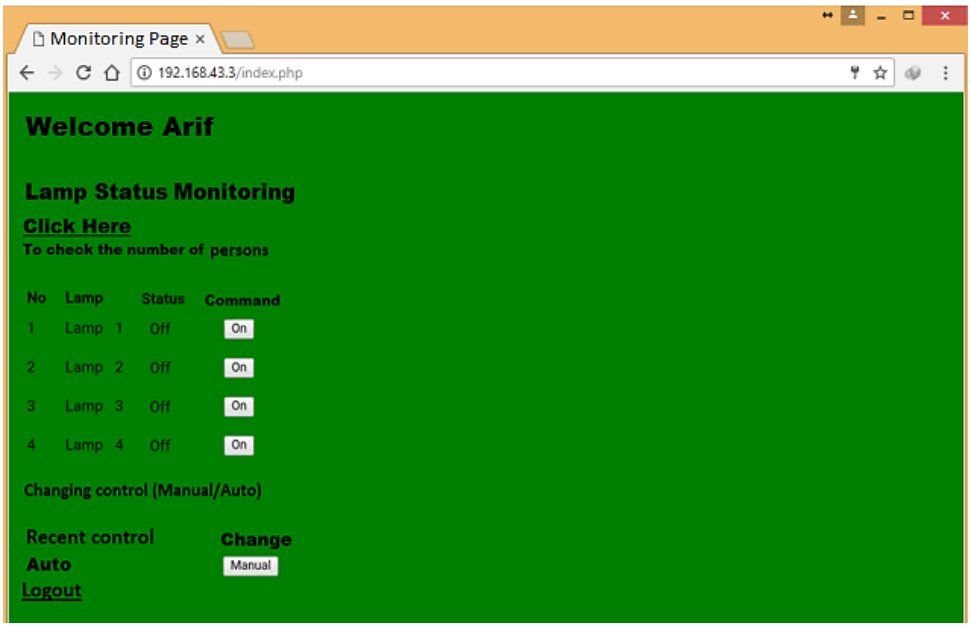

Figure 10. The page access testing using computer

3.5. Number of people inside the room testing

Testing was done to count the number of people in the room. This step was added to determine the sensor accuracy in detecting the number of people, because it will determine the size of the intensity that will controlled through the program. The method was used to count the number of people entering and leaving the room shown in Figure 11. Infrared sensor reading started from the outer sensor then the inner sensor. Arduino will process the data and send it to Raspberry as an entry detection shown in Table 6. The movement of people in and out the room was detected properly. Testing was done five times in each

room and can detect the movement of entries without error. Testing the movement of people out of the room, it can read with once error.

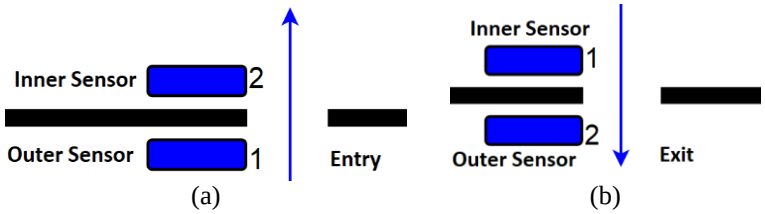

Figure 11. The Sensor Reading on, (a) entry detection, (b) exit detection

Table 6. Testing of entry sensor

No	Room	Total number of test	Error Detection		Detected	
			Entry	Exit	Entry	Exit
1	Living Room	5	0	1	5	4
2	Family Room	5	0	0	5	5
3	Bedroom	5	0	0	5	5
4	Kitchen	5	0	0	5	5

3.6. Light intensity testing

Light Intensity testing was carried out to determine changes in light intensity on the number of people in the room. Measurements were made using a light meter. By knowing the change in light intensity, it will be used as a parameter in program shown in Figure 12.

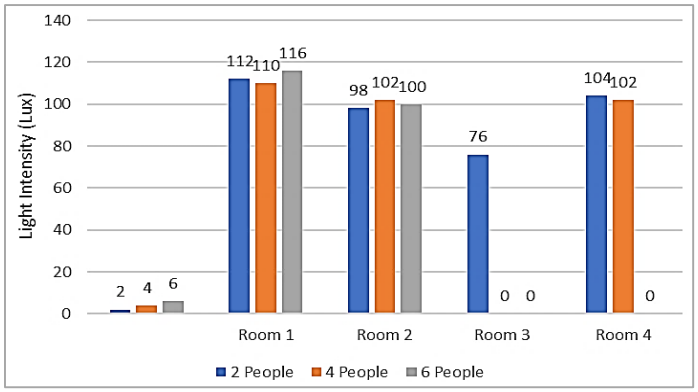

Figure 12. Light intensity experiment

3.7. Electricity bill testing

Table 7 indicates that after implementing this system, there was an efficiency in paying electricity bills using the postpaid system. For example, it applied in household electricity that uses 900-Watt electricity with 10 lamps. There is a decrease in electricity bills after compared before and after the implementation of this system. Over the past 2 months, a decrease in the range of 7.7%-8.2%, it has a positive impact on reducing electricity bills payment. This is a significant improvement, because to date,usually the ectricity bill was paid more than the result.

Table 7. Electricity bill

Month/Year	Bill of Electricity (In Rupiah)		Percentage decrease
	Before	After	
February/2019	135.650	124.526,7	8.2 %
March/2019	124.526,7	114.938,14	7.7 %

4. CONCLUSION

Returning to the question posed at the beginning of this paper, it is now possible to conclude that infrared sensor can be designed with Internet to control the intensity of light so that it impacts on electricity efficiency. This study has identified that it can develop a model for optimization the infrared sensor function. The results from this study suggest that after implementation this method, the electricity bill decresead 7.7%-8.2%. It is recommended that further research to be undertaken in the following areas like security, surveillance and medicine.

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