Design of Smart System to Control Energy in Idle Time

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Abstract. This study aims to control energy consumption at idle time or outside working hours in office buildings both government and private so that there is not waste in the use of energy. To control the use of energy, an energy smart control system is developed by applying Wireless Sensor Network (WSN) and Internet of Thing (IoT) technology in order to realize energy efficient to support Smart Campus in Industrial Era 4.0. The Prototype of smart system to control energy testing was conducted at the Politeknik Negeri Medan building. The process of controlling energy consumption at idle time can be done. By controlling energy consumption at idle time office activities have an effect on saving energy.

1. Introduction

Idle Time is an unproductive period that occurs in an institution both government and private institutions such as during recess or office hours. At idle time electronic equipment often occurs, such as central air conditioning, remain on standby, computers, printers, lighting and others that are no longer in use, keep burning, so that electrical energy consumption continues to run.

Research Results of Energy Management Indonesia (EMI) shows the percentage of energy waste at idle time, namely government offices 25-30%, private offices 20%, industries 25%, households 10%, shops and markets 25%. From the results of these studies the government office provides the highest contribution in the waste of electrical energy at idle time compared to other offices.

To reduce waste of consumption, especially in multi-storey buildings, it takes a lot of manpower and takes a long time to turn off electronic equipment and lighting in rooms on every floor of the building that is not used.

Research on energy consumption has been carried out such as building tools to measure electrical energy consumption using ATmega 328P-PU microcontroller [1], built electronics remote control system [2], the concept of a Home Energy Management System (HEMS) for regulating electricity consumption and combination with renewable energy [3][4][5], the strategy for electricity consumption and renewable energy in order to realize a smart city [6]. From the research that has been done, it has not controlled the use of energy at idle time (outside office hours or learning activities in educational institutions).

Based on studies that have been conducted by researcher above, we propose a smart system to control energy at the idle time of learning or offices by applying WSN and IoT technology using a microcontroller ESP8266-EX base of wemos D1 implemented on the Arduino platform used to retrieve data from the cloud.
2. Related Work

2.1 Internet of Things

Internet of Things (IoT) is a new paradigm in global network technology. On this network the machine and all devices that are around us can interact with each other. IoT is recognized as one of the most important fields of future technology that receives wide attention from various fields of industry [7].

The IoT concept provides broader benefits for devices that are connected to the internet network continuously, for example electronic devices or other objects that are implanted sensors and are prepared to be actively connected extensively both locally and globally [8].

2.2 Wireless Sensor Networks

A type of sensor that is used to detect an object or environment by using sensor nodes that are distributed separately at a particular location as shown in figure 1. Wireless Sensor Networks (WSNs) have emerged as very flexible and dynamic aspects that can be used in almost every field of implementation such as agriculture, defense, environment and others [9].

![Figure 1. WSNs](image)

2.3 System on Chip

A System on a chip (SoC) with Micro Controller Unit (MCU) specifications and Wi-Fi transceivers such as NodeMCU ESP8266. Consists of 11 GPIO (General Purpose Input Output) pins, and analog inputs. So it can be programmed like arduino or microcontroller in general. This board is also equipped with Wi-Fi communication features. Several components can connect to SoC.

Gateway is a server that is used to store data and process data and convey information through the internet to the user's computer or Smartphone [5]. One of the gateways that can be used to store data from WSNs is 'Thingspeak', which is a cloud-based web service.

Relay is a piece of equipment that functions as a switch using electromagnets to control electrical switches. The relay consists of a coil of lead wire wrapped around an iron core.

2.4 Electrical Energy

Electrical energy is energy stored in electric current in one ampere (A), an electric voltage in volts (V) and Watts (W) for a unit of electrical power consumption. Electrical energy is used to drive lighting / lights, motors, cool / heat or move another mechanical device to produce other energy [6].

The state of the art of this research is to implement one component to realize Smart Vocational Education from the previous author's research on Analysis of Factors Affecting Vocational Education Quality Based on Dynamic Models, one of which is an organizational component that functions to regulate the organization's internal resources including in it efficiency of electrical energy resources.
3. Smart System to Control Energy Design
The first thing to do is set the RTC in the program to set the time or date, then connect the 12 V adapter to the NodeMCU which functions to regulate or control electrical loads such as lights, fans, other electronic equipment. Then it is connected to the Perusahaan Listrik Negara (PLN) current source to turn on the AC current. The equipment can be controlled as automatically and can turn on/off automatically. Smart system can send information to smartphone. Figure 2 describes the overall smart system works.

![Smart System Design to Control Energy](image1)

Figure 2. Smart System Design to Control Energy

3.1 Schematic Design
The overall design of smart system to control energy hardware like figure 3. It can be seen that each series connected by the respective pins of the series.

![Schematic Design](image2)

Figure 3. Schematic Design

3.2 Smart System Works
The systematic work of smart system can be seen in figure 4. The system works start from initialization components, Then the program will display a page to input data time from the RTC and
Smartphone. After the main menu page appears, the user is provided with several menu options to choose. Each menu is represented by a decision symbol, whose function is to describe a decision or action that must be performed under certain conditions. If the user chooses activation and deactivation based on the schedule, the program will run a command based on RTC whose function is to connect a symbol with others symbol on the same page. If the user chooses activation and deactivation based on the choices on the Smartphone, the program will run the command chosen by the user which function to connect a symbol with others symbol on the same page.

![Diagram](image.png)

**Figure 4.** Smart System Works

### 4. Experiment

Implementation of smart system hardware and software. These components consist of input and outputs. Smart system components have been tested. This tool has worked in accordance with the workflow system. When the system is activated and then set the time to turn off switch electronic devices at 18.00 pm and turn on the switch at 7.29 am. The result of the system is able to work by sending information to the smartphone that the condition of the switch device has been turned off at the specified idle time. Example information in smartphone can be seen in figure 5.
Energy smart control has been tested with data collection as in Table 1. The measurement results show that the equipment tested consumes electrical energy nearly 50% at idle time. When the smart control energy automatically disconnects, the energy is flowing only for the control device.

Table 1. Measurement Results

| No | Date            | Operational Time (7.30 - 17.59) | Idle Time (18.00 - 7.29) | Load                      |
|----|----------------|---------------------------------|--------------------------|---------------------------|
| 1  | 10/08/19(Operational), 8 - 9 (Idle) | 3.210                           | 5.760                    | 10 Computer + 1 Exhaust Fan |
| 2  | 10/09/19(Operational), 9 - 10 (Idle) | 780                             | 940                      | 1 Exhaust Fan 10 Computer + 1 Exhaust Fan |
| 3  | 10/10/19(Operational), 10 - 11 (Idle) | 3.770                           | 6.600                    | Exhaust Fan 10 Computer + 1 |
| 4  | 10/11/19(Operational), 11 - 12 (Idle) | 2.760                           | 5.530                    | 10 Computer |
| 5  | 10/12/19(Operational), 12 - 13 (Idle) | 3.110                           |                          |                           |
| 6  | 10/13/19(Operational), 13 - 14 (Idle) |                  |                          |                           |
| 7  | 10/14/19(Operational), 14 - 15 (Idle) | 620                             | 6.010                    | 10 Computer + 1 Exhaust Fan |
| 8  | 10/15/19(Operational), 15 - 16 (Idle) | 3.710                           | 5.990                    | 10 Computer + 1 Exhaust Fan |
| 9  | 10/16/19(Operational), 16 - 17 (Idle) | 1.130                           | 6.030                    | 10 Computer + 1 Exhaust Fan |
| 10 | 10/17/19(Operational), 17 - 18 (Idle) | 3.340                           | 6.090                    | 10 Computer + 1 Exhaust Fan |
| 11 | 10/18/19(Operational), 18 - 19 (Idle) | 2.690                           | 5.940                    | 10 Computer + 1 Exhaust Fan |
|    | Total           | 25.120                          | 48.890                   |                           |
|    | Average energy consumption per day (KWH) | 2.28                            | 4.44                     |                           |

Figure 5. Information in smartphone
5. Conclusion

Based on the results of the system design and all tests that have been carried out for all conditions that might occur in smart switch control system based IoT. The system that has been made, the system can remotely control by a smartphone, the system can set the schedule automatically, the system can find out the efficiency of electricity consumption

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