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A Review: Design of Smart Home Electrical Management System Based on IoT

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Abstract—**This paper will explain the benefits and optimal use of smart home energy management systems viewed in various aspects. The background of this paper is many problems in Indonesia regarding the consumption of electricity and the depletion of natural resources. Although the government has applied for an energy-saving program, the implementation program is still not optimal and has not been able to overcome the existing problems. In this paper, the idea of applying the SHEMS (Smart Home Electrical Management System) will be divided into three parts including IoT control, manual / automation control, and monitoring of real-time electrical energy. This research will also analyze the effectiveness of SHEMS in controlling energy use from several sources of journal literature. There are several points related to journal analysis including the effectiveness of the existing method, multi-objective scheduling, SHEMS design implementation and comparison of the results of After and before using SHEMS. From the results of the journal literature analysis, it is expected to help find the right SHEMS design method for each different case and suggests a framework for future systems.**

Keywords: Smart Home, IoT, Sensor, Electrical management system, Control System, Real-time Monitoring System.

I INTRODUCTION

Limited energy resources unable to overcome the demand of energy consumption which increases every time. Most of the problems faced in Indonesia is a continuous increase of consumers of electrical energy of year. Based on the statistical data the number of electricity use by consumers increases every year. The electrification ratio in Indonesia has reached 91.16% in 2016 and the used of oil energy for the country's power plant is 132.41 million BOE [1]. Based on this data the importance of energy savings by each community is an effective step which needs to be implemented.

IoT implementation on smart home energy management systems (SHEMS) has grown rapidly and answered many problems about energy savings in a smart home or smart city [2]. SHEMS is used to control various energy such us electrical energy, water, and gas. In the previous research, the implementation of SHEMS was carried out using various methods and different frameworks to obtain optimal energy savings results, such as the application of ZigBee sensors, automatic systems, manual controls and others, which can be seen in table 3. In this paper will be focus on efficiency electrical energy saving in smart home based IoT. Several functions of SHEMS that can be used is electrical energy monitoring [3], automatic energy controlling [4], manual controlling and electricity energy optimization.

This paper purpose to implement the most relevant SHEMS method through automatic and manual electrical energy control techniques using various sensors, real-time monitoring of electrical energy in smart home based on IoT, and its success rate.

II CURRENT STUDIES

In the process of developing SHEMS, the selection of devices such as sensors and microcontrollers, architecture and proper implementation methods must be considered properly.

A. Internet of Things

The implementation of IoT architecture be required in the development of SHEMS. One of them is being able to guarantee security in the process of data communication management based on TCP / IP in SHEMS. In figure 1 is a six-layer architecture of IoT.

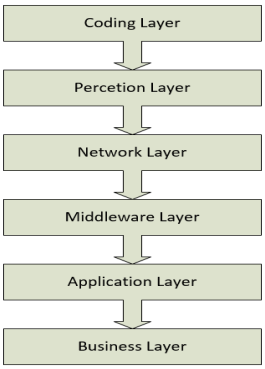

Figure 1: Six-Layer of IoT

Figure 1 shows that IoT are composed of several layers Layers such as Perception Layer, Network Layer, Middleware Layer, Application Layer, and Business Layer for transmitted data through. IoT must have Radio Frequency Identification RFID [5], Wireless Sensor Network (WSN) [6] dan Claud computing IoT can be implemented in various sectors including, smart home, smart Trafic-System, Smart Grid and many more [5].

A. The Effectiveness of SHEMS Devices controlling

In this study, the SHEMS function is seen from how to control and monitor electrical energy through house device appliances that use electricity, including air conditioner (AC), lamp, television, and another device. From monitoring system, every home that applies SHEMS can monitor electrical energy consumption that used every day. Electrical data consumption can receive from anywhere using a smartphone. In terms of control, SHEMS can be controlled manually and automatically. Manually controlling can be done through Smartphone, where users can turn on / off the devices at home through an electric control panel application, and automatic controls will using sensor for each device. Example: use a motion sensor (PIR) on the lamp. The light will turn on automatically when there is movement captured by the sensor and will turn off automatically if there is no movement captured. Existing research on SHEMS, SHEMS based on IoT [7], Automatic Control [4], multi-sensor control [3], SHEMS from the consumer behavior [10], Real-time monitoring and Electrical Energy control [11] and real-time energy consumption information [12].

Based on the results of a literature review, success rate electrical energy consumption obtained in table 1.

Table 1. Literature Review of Success Rate Electrical Consumption

Success Rate cost & kWh Energy consumption	**Ref**
18% kWh/day	[13]
61.36% kWh/Month	[4]
80% success rate	[14]
10% kWh/day	[10]

Table 1 shows the success rate of implementing SHEMS. The success rate is based on the amount of energy consumption before and after the implementation of SHEMS. From the results of the percentage amount of electrical energy consumption in table 1 success depends on the type of framework used.

B. Sensor Appliances

A sensor is the part of IoT Perception Layer which can be used to changing information from connected devices to analog signals. In implementation of SHEMS there are several studies that combine more than one sensor for smart home energy management system such like, temperature and humidity sensor for controlling air conditioner [15], temperature and humidity sensor using for different region [16], temperature and humidity sensor for controlling fan [17], PIR sensor for control lights by detecting the heat from occupants moving [4], Light Sensor [17], Meters Sensor [18], Sound sensor [19], Infrared sensor [14].

C. Smart Home Appliances

To build an electricity management system the main thing to consider is what kind of smart home appliances should be implemented using IoT. the determination of the type of smart home equipment results in a large amount of electrical energy consumption that can be optimized SHEMS through IoT.

Table 2. Several Types of Devices

Smart Home Appliances	**Journals References**
Lamp	[20],[13], [10], [15], [7], [16]
Fan	[15], [16]
AC	[20], [13], [15], [7], [16]
Phone Charger	[13], [16]
Refrigerator	[13], [16]
Boiler	[13], [16]
TV	[13], [14], [16]
Cameras for security, Electric Clothes Dryer, Coffee Machine, Microwave, Blender, LCD Monitor, Well Pump (1/3-1 HP), Clothes Dryer, Washing machine, Vacum cleaner	[16]

Table 2 shows about several types of home appliances that are monitored and controlled using smartphone and various sensor via SHEMS.

The application of sensors to each home appliances must be in accordance with their respective functions. Sensor fault determination will result in the waste of energy. Example: if the motion sensor is placed on the fan, the fan will keep ON whenever the sensor reads the movement. For, the most appropriate sensor used is a temperature sensor. The fan will be ON only if the temperature of room is too hot.

D. Existing Framework

Determining the right framework is an important thing that can affect the success rate of reducing the amount of energy consumption. The framework used should be low in cost and must be in accordance with the conditions in which it is implemented.

Table 3: Existing Framework

Framework	Ref.
Real-time monitoring temperature and humidity monitoring system based on IoT with Multi-sensor Implementation.	[3]
IoT-based real-time monitoring system with multi-sensor implementation to compare the accuracy of data received from each sensor.	[21]
The recommended system for an energy control on a smart home based on occupants activities or habits.	[10]
Automat system with multi-sensor and monitoring system uses local home network.	[4]
Manually controlling system via a smartphone using Infra Red (IR).	[14]
Two manual control systems using Wifi for indoor controllers and using GSM modules for control from outside the home.	[13]
Automat control system and monitor energy based on the amount of costs to be paid.	[15]
The application of the ZigBee sensor, the system can be monitored and controlled manually via a Smartphone.	[11]
distributed optimization algorithm for scheduling the energy consumption of multiple smart homes using a smart meter.	[22]
Home appliances controlling using ZigBee and IR remote control.	[23]
Electrical consumption optimization, residential appliances control, smart plugs, and Conservation Voltage Reduction (CVR)	[24]
Electrical appliances using wireless smart socket.	[25]
Manual and Automatic control light based on IoT.	[7]

Table 3 describes some of the frameworks used in existing studies. Determining the right framework can support the effectiveness of SHEMS. The determination of the framework must be adjusted to the problems faced, the application environment, and costs.

E. Novelty of SHEMS

The application ideas for Smart home energy management system will be different with the existing framework. Design Framework concerning SHEMS system will combine multi-sensor (temperature and humidity sensor, PIR sensor, light sensor, meters sensor, and sound sensor), multi-controlling for every single device (automatic and manual controlling), real-time energy monitoring using smartphone, Home prototype design and SHEMS implementation is adapted to the application environment.

III SHEMS IMPLEMENTATION METHODS

In smart home energy management system based on IoT there are a few main points that must be considered there are components used, different architectural designs for each building, and what type of control will be implemented to the system.

A. IoT Smart Home System Component

Smart home electrical management system is a system built from supporting components such as microcontrollers, sensor relays, and routers. Each component has its own role and function to support the energy saving process in smart homes. The following are some of the components used to build SHEMS:

1. Microcontroller will be used is a Master Controller S3C6410 [3] as the data control center of each sensor and connected device.
2. Sensors: Temperature and humidity sensor for air conditioner controlling [15] and fan controlling [17], PIR sensor for lamp controlling [4], Light Sensor for outdoor lamp controlling [17], Meters Sensor [18], and Sound sensor for lamp controlling [19]. Every sensor will get the information data from object and then converted to electrical signals. The function of sensors is as an automatic control system connected with microcontroller as a central data processing.
3. Relay plays an important role as an electrical switch that can be run with a logic function and will be connected to any home electronic device with 220V voltage [17] [18].
4. Wifi Router : in this journal Wifi Home is used to connect each device to the internet.

A. *Method for Design Smart Home energy system*

Based on a review of several existing methods in this paper, the Idea for SHEMS design method was given. The idea of developing the system includes determining the installation of SHEMS, determining the system controlling and monitoring.

1. System design is built based on the extent and function of the room for determining the use of suitable sensors, electrical installations used to determine the position of the micro-controller board and the design of the SHEMS architecture and determine the control function of each device.
2. The device control design can be run automatically by using sensors. System will receive sensor data reading and determine the condition value. When the system receives analog data sent by the sensor according to the value of the specified condition, the device will automatically ON / OFF.
3. The manual control system will use smartphone as a control panel.
4. The system is able to monitor electricity used (kWh/day) online via a smartphone from anywhere.
5. The controlling system can be selected according to the user's wishes.

IV. IMPLEMENTATION AND CONSTRUCTION

This Section will discuss the idea of the implementation and construction of the system design. Different building types affect the effectiveness of energy savings. Determination of sensor installation and IoT network installation on the smart home should be based on the area of the room, the function of the room, the installation of the electricity network used, and the range of sensors and the ability of the sensor to capture data.

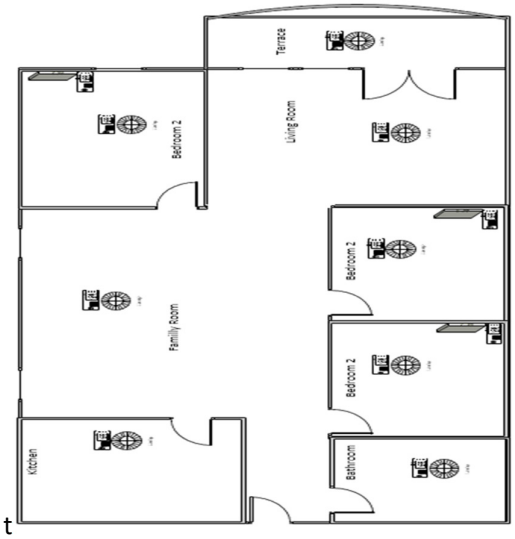

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Figure 2 : home sketch

Figure 2 is a display of an example of a house plan design where the position and placement of each sensor is adjusted to the function of the device used in each room. Sensor placement is considered from several aspects including the function of the room, activity, volume of the room, the function of electrical equipment, and the position of the placement of sensors must be able to reach the entire room.

In addition to building types, another thing that must be considered is the type of system control. Every equipment in the house must be able to control the use of electrical energy. How to control electrical energy from each equipment must be in accordance with the function of the equipment itself. The control systems used include automatic control of equipment, manual control and combine the control system. In Figure 3 shows the process of the automatic controlling system.

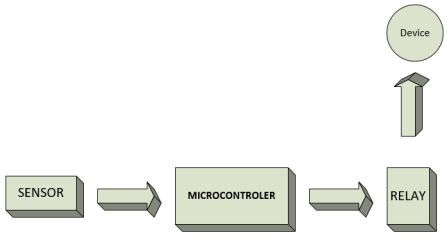

Figure 3: Automatic Control System

The sensor will send data to the microcontroller and the microcontroller will analyze the data received by the sensor according to the conditions specified in the analog data value limit. The microcontroller will forward the relay command in the form of a logic function to turn on or turn off the device.

Other system control functions are controlled manually, without involving sensor to control system. In figure 4 is the manual working principle.

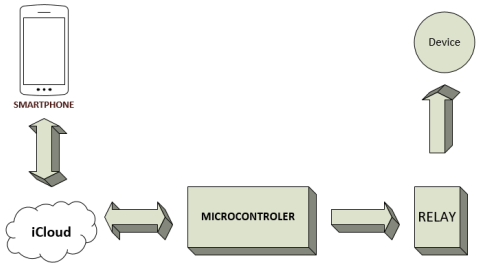

Figure 4: Manual Control System

In manual control systems, each connected device can be controlled via the control panel application installed on smartphones using the internet. Orders sent via a smartphone will be

received by the microcontroller and immediately relayed to turn on or turn off the device.

In addition to the manual and automatic control functions, the monitoring function is also needed to monitor the amount of electricity consumption. Figure 5 shows an overview of the electrical energy monitoring system.

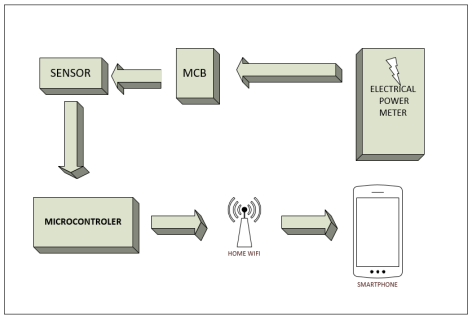

Figure 5: electrical energy monitoring system

The position of meters sensor placement is adjusted to the electrical network installation. The system electrical monitoring does not monitor each device, but the overall use of electrical energy in the house.

In this paper, one additional control function is a dual control function. Figure 6 shows an electrical multi controlling system architecture.

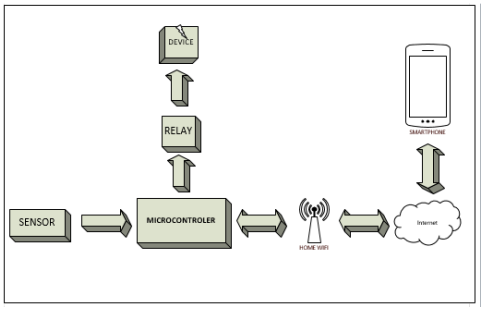

Figure 6: Multi-Controlling system

The system is able to control one device that is the same as the two control methods, namely manual and automatic control. The application of two control functions on one device uses the logic OR function on the relay.

V. CONCLUSION

This paper presents a description of the main components of SHEMS as well as various frameworks that are used to get the effectiveness of SHEMS. The strategy and implementation process are seen based on the type of device used, type of controlling, communication system used, and optimization techniques of using sensors. In this paper also given an idea about the method of implementing sensors based on the function of the room and the movement activity of the occupants of the house. The purpose of this paper is to find the appropriate framework and provide ideas about the incorporation of frameworks from various literature studies in the implementation of low-cost, efficient SHEMS and are able to answer the problem of energy waste that occurs in Indonesia. Another goal is to encourage people to understand how to use less energy at certain times and how to install electrical equipment to save electricity costs through SHEMS.

For further development, the system is expected to be able to build a smart home network where each house in the city is integrated with each other in a network, the system is also expected to be able to deliver data on the use of each household equipment not only to the homeowner but also to the state electricity company to be able to monitor the savings of electricity resources of each consumer.

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