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The Optimization of Chillers Air-Conditioning in Thailand Supermarkets using a Retail Energy Management System (REMS)

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ABSTRACT

Supermarkets in Thailand continue to grow and there will be more than 1500 branches by 2023 open 18-24 hours a day. In this research, we will present how to increase energy efficiency in retail stores by reducing the energy consumption of compressors of chiller air conditioning systems by using energy management systems in retail stores. Retail energy management systems in retail stores use the Internet of Things to connect to a device to store data and analyze and process from big data, then Artificial Intelligence controls and commands to make the air conditioning system energy efficient. Controlling 10 AHUs using central sensors at the sales area instead of return sensors allows us to save 25% of energy or 12,886 kWh/Year. As for the cold-water pump, it is controlled by an inverter. By using sensors to measure the water flow rate, we save 33% of energy or 19,755 kWh/Year. When controlling the water pump and AHU, the chiller compressor will save energy because when the air handling unit and the water pump have reduced work, the work of the compressor to cool water is reduced as well, resulting in energy savings of 12% or 25,211 kWh/Day. Using such a system reduces the overall energy consumption of the chiller air conditioning system. 17% or 57,852 per year has a payback period of 3 years and can also be extended to other systems within the store or other stores.

1. Introduction

The retail business continues to grow every year. In Thailand by 2023, there will be more than 1,500 supermarkets [1]. Some supermarkets are open 24 hours and consume a lot of energy. Most of the energy consumption is refrigeration, while the air conditioning and lighting systems consume energy respectively. Although energy efficiency has been developed in each system, to achieve the integration of each system [2]. The energy management system (EMS) therefore helps to save energy [3]. The system can monitor the power consumption of the operation as well as save important parameters for processing and display by IOT. In this research, there is an idea from an energy management system that has been accomplished, which are home energy management system [4]. The home energy management system is created to control energy consumption and manage the

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system for the most benefit [5]. As shown in Figure 1, the devices in the house are connected to the IOT system to enable monitoring and control. The use of home energy is also consistent with the power reserved in the battery from the solar power supply [6]. During times of high power consumption, the system will be able to effectively control the reserve power consumption, such as during the peak time of the vehicle battery charge or has high power consumption from home appliances. All energy consumption is recorded in the meter [7]. This makes it possible to know the energy consumption behavior of residents and create new solutions to reduce energy consumption by controlling the operation of the equipment. And can also reduce the cost of energy consumption to be stable as well [8]. When the housing is larger and with more equipment, and rooms that are proportional to large buildings, the energy management system developed for use in the building is called the building energy management system (BEMS). Although there are different operating controls, the main devices and their functionality remain the same [9]. The operation of large air conditioners such as chillers is controlled to suit multiple rooms and various types of power reserves [10]. Likewise, cold water production can be controlled by producing cold water stored in it with heat recovery during off-peak or night, it can reduce peak power consumption during the day or on peak, as shown in Figure 2.

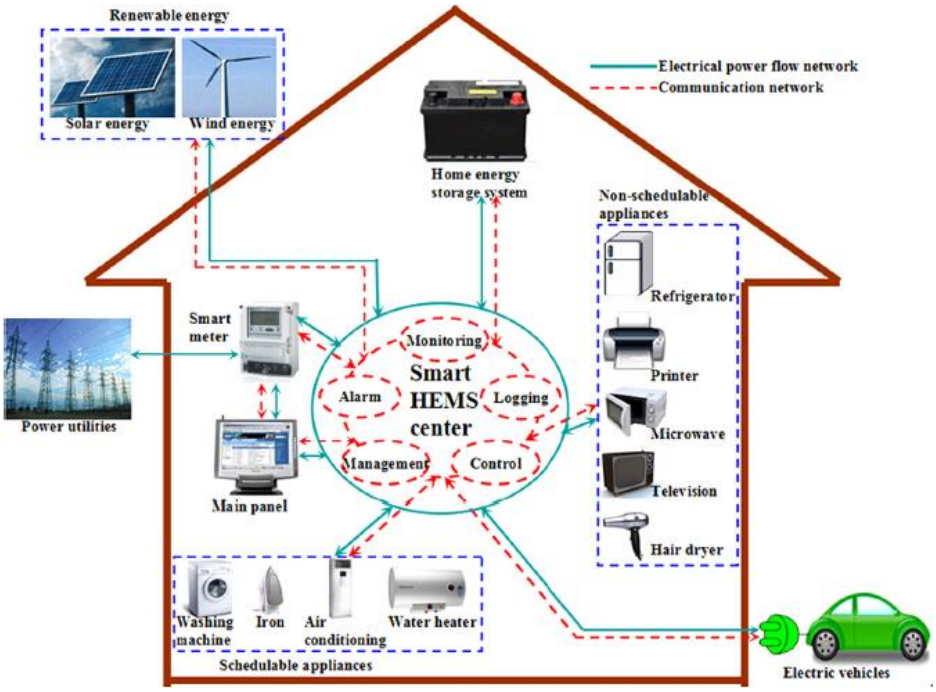

Fig. 1. Home energy management system (HEMS)

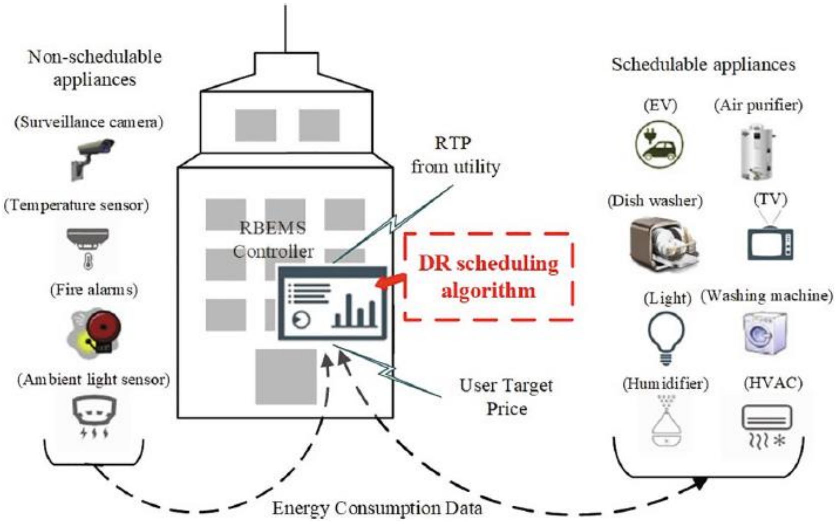

Fig. 2. Building energy management system (BEMS)

Likewise, there is a factory energy management system (FEMS), as shown in Figure 3. but it differs from HEMS and BEMS because in a factory there are many types of high-powered machines such as foam injection machines, injection molding machines, boilers, machines [11]. Energy intensive can be managed accordingly and in accordance with production, reducing unnecessary energy losses and can do the same as cold water production by moving the energy-intensive production process to the range.at night to avoid excessive power consumption during peak. From the past energy management systems in a larger overview, there are energy management systems that help manage energy in different parts or areas that consist of residences, buildings, and factories [12]. It is a community energy management system (CEMS), as shown in Figure 4 The CEMS system comes in to help a lot in management when the system can be controlled and managed in a large area because it can track and know the behavior of each community [13]. The backup power in each community is important because the national power generation must be carefully planned, large fuel costs have a significant impact on the cost of electricity generation, and the planning of backup power from renewable energy and initial refueling from various fuels allows accurate predictions from the CMES system [14].

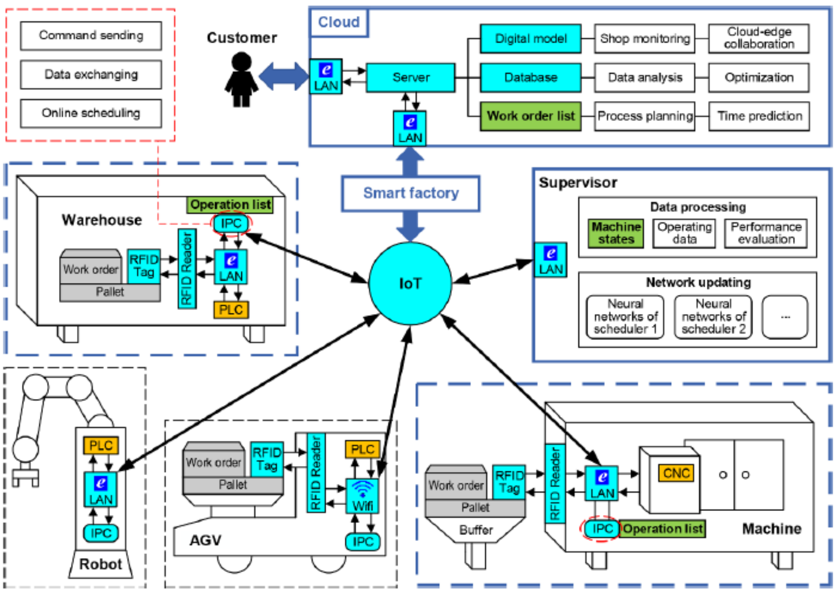

Fig. 3. Factory energy management system (FEMS)

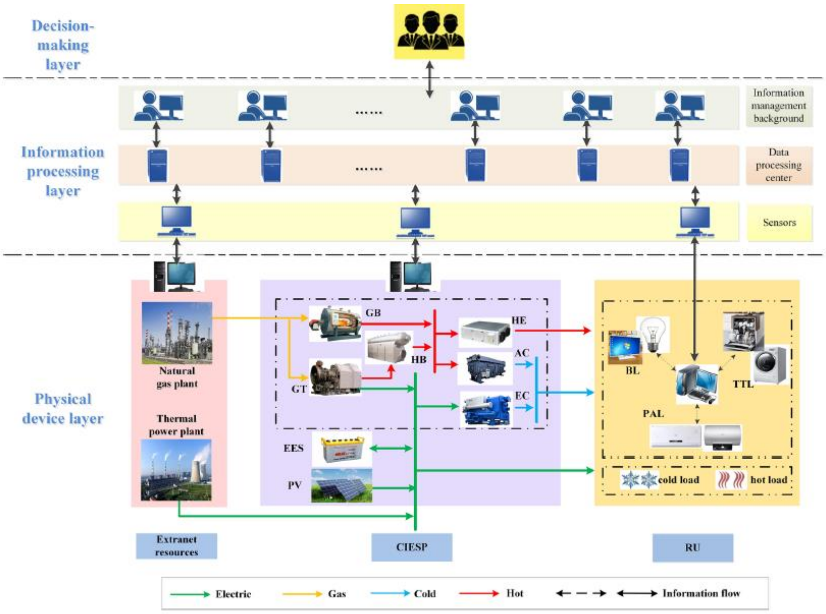

Fig. 4. Community Energy Management System (CEMS)

2. Methodology

The air conditioning system in this research uses air-cooled chillers. Package air-cooled chillers 3 systems with scroll compressors 6 HP 3 unit per systems control with water temperature at setpoint 9 degrees. The water pump for the chiller system uses a centrifugal pump 8Hp 4-unit control by operating hour 6 open. The 10-unit air handling unit and independent control with air temperature sensors at the return position at a setpoint 25 degrees of the air conditioner, as shown in Figure 5.

Fig. 5. Air condition system

2.1 Air Handling Unit

The operation of the air conditioning system is controlled by a sensor at the return position of the air conditioner. The installation location of the air conditioner is high, causing problems with the temperature inside the store being colder than usual. and overworking because the temperature inside the branch affects the power of the AHU pump and Chiller. The solution to this problem is to install sensors in the sales area to provide a temperature suitable for the customer. The REMS for control AHU are shown in Figure 6 and Figure 7.

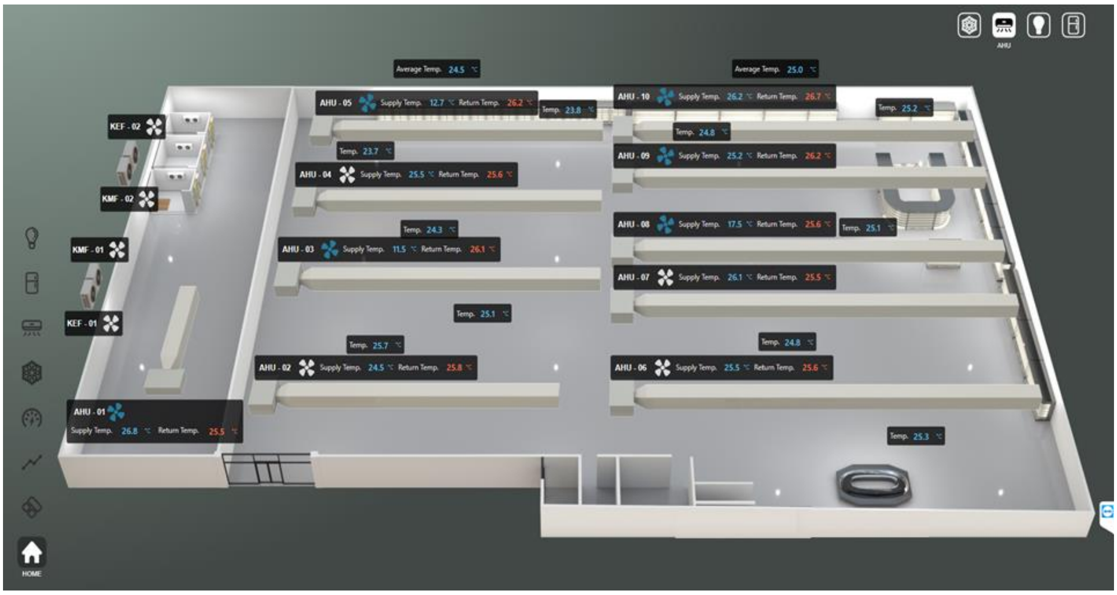

Fig. 6. The REMS for the AHU air-conditioning system

Fig. 7. The REMS for the AHU air-conditioning system

2.2 Water Pump

The water pump for the chiller system uses a centrifugal pump 8Hp 4-unit control by operating hour 6 open. The water pump will work together in pairs and alternately working. The work will result in work that is more than necessary due to the unequal load of chillers in each period. But the water pump is still working steadily all the time. Water pumps can save energy by controlling the amount of water from the water flow rate supplied to each AHU so that when the AHU is stopped, the water valve will stop working resulting in a measurable decrease in water demand. Installing a water flow meter to send data to the inverter reduces the cycle time of the pump resulting in energy savings because it is based on actual load conditions. The flow rate must not be less than 60% of the normal system and the water pump must operate at least 35% to prevent equipment damage. The REMS for the control water pump are shown in Figure 8.

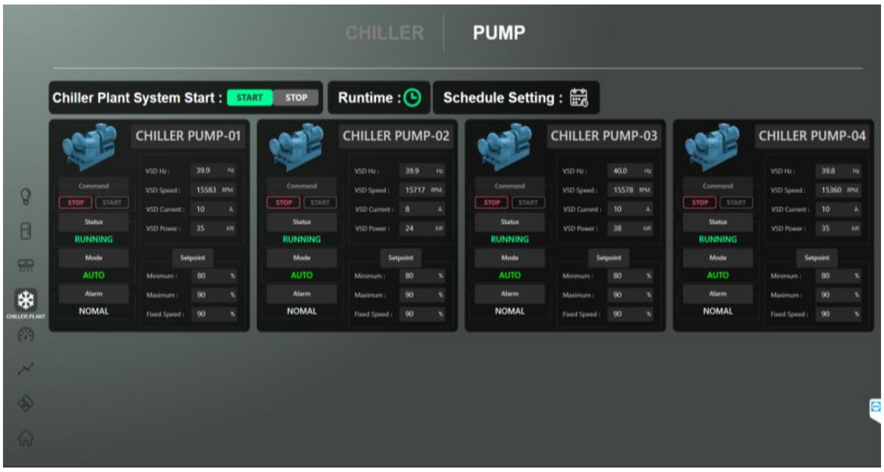

Fig. 8. The REMS for the water pump

2.3 Chiller System

The package air-cooled chillers 3 systems with scroll compressors 6 HP 3 unit will be energy saving. Because The systems can be operated more efficiently, resulting in less chiller operation when the AHU is controlled by temperature. The water pump is controlled by the flow rate. Chillers are the same as the chiller capacity increases with load, resulting in more chillers operating under load conditions, resulting in energy savings. The REMS for the chiller system are shown in Figure 9.

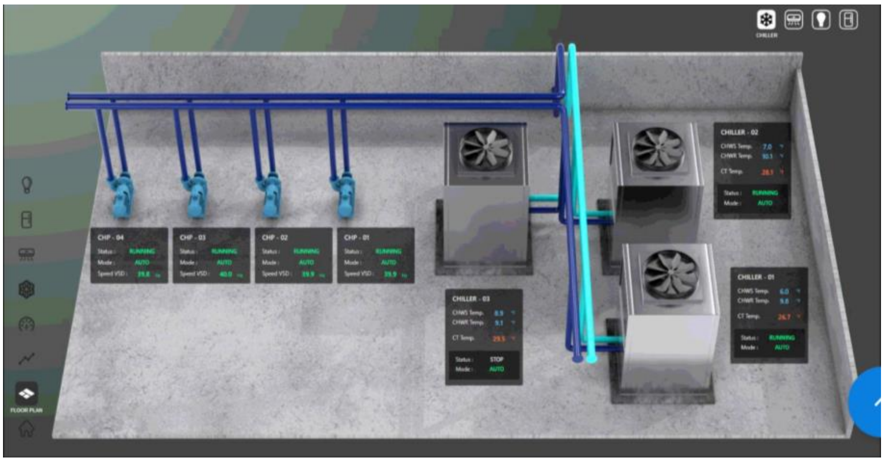

Fig. 9. The REMS for the chiller system

3. Results

3.1 Air Handling Unit

The results show the room temperature before and after installation of REMS and the setting temperature at room temperature of 26 Degrees. The before-condition temperature will swing because the condition is split to operate 10 units at the return sensor of air conditions. Normally, the room temperature in the sales area will be lower than the return temperature of 2-3 degrees. that means the AHU will over-operate because the specification needs a temperature of 26 Degrees in the sales areas. For the after-condition use the centralized sensor 2 location at the sales area by splitting to sensor no.1-5 used for control AHU no.2-4 then AVG. room temperature equals 26 degrees, the AHU will close, and if AVG. room temperature of more than 26 degrees, the AHU will be on. The second location that splits the sensor to no.6-1- is used for control AHU no.5-10 then AVG.

room temperature equals 26 degrees, the AHU will close, and if AVG. room temperature of more than 26 degrees, the AHU will be on. The room temperature measured by sensor no.1-10 and control of the temperature by on-off AHU are shown in Figure 10 and Figure 11.

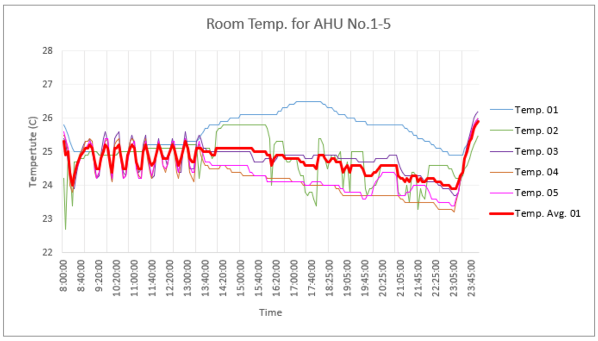

Fig. 10. The room temp from sensors No. 1-5

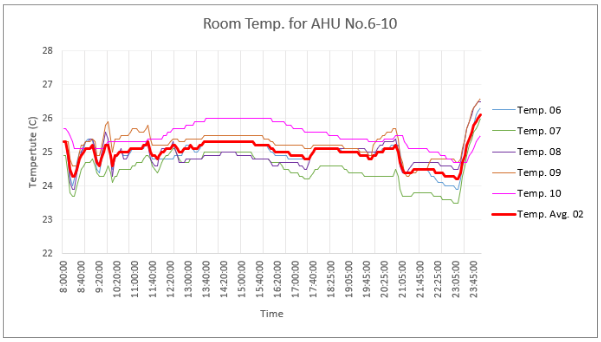

Fig. 11. The room temp from sensors No. 6-10

The result of the energy saving shows the before power consumption for AHU 10 Unit is 141.22 kWh/Day and after power consumption is 105.92 kWh/Day showing the energy saving of 35.01 kWh/day or 25%, which is the result of AHU operating by the centralized sensor the operating status of AHU for after condition will show the 7-day operating status. The AHU No.1-10 Operating every time the store opens affects power consumption and room temperature because AHU over operating. The after condition showed on and off sometimes because AHU is controlled by the centralized sensor. The AHU operating status is shown in Figure 12 to Figure 31.

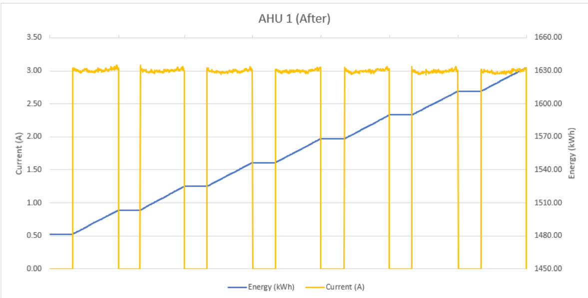

Fig. 12. Before Operating Status for AHU No.1

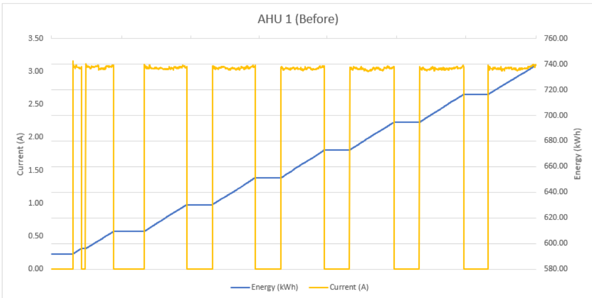

Fig. 13. After Operating Status for AHU No.1

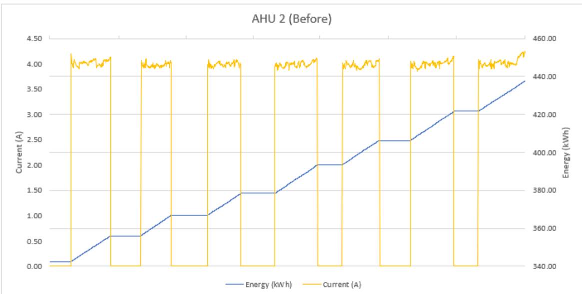

Fig. 14. Before Operating Status for AHU No.2

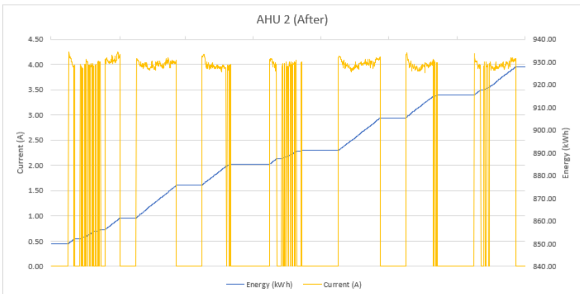

Fig. 15. After Operating Status for AHU No.2

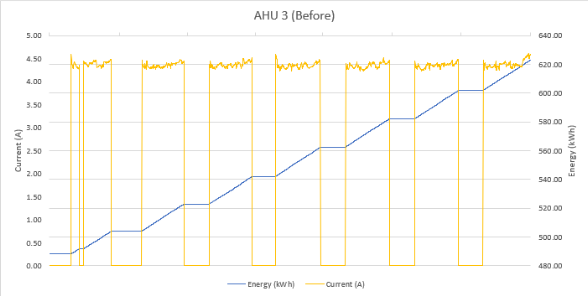

Fig. 16. Before Operating Status for AHU No.3

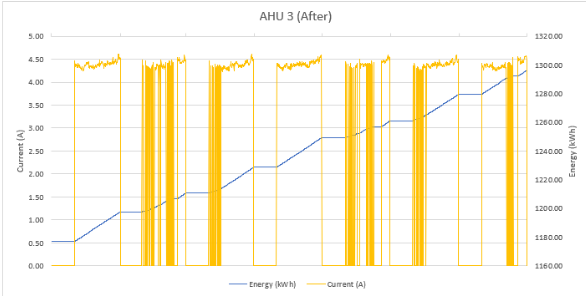

Fig. 17. After Operating Status for AHU No.3

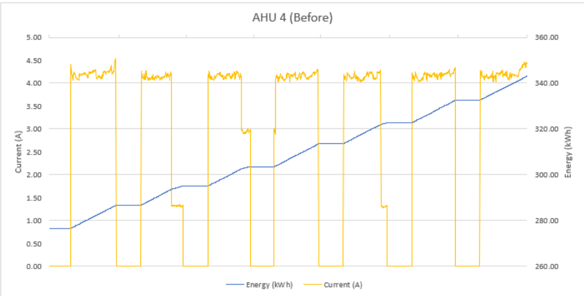

Fig. 18. Before Operating Status for AHU No.4

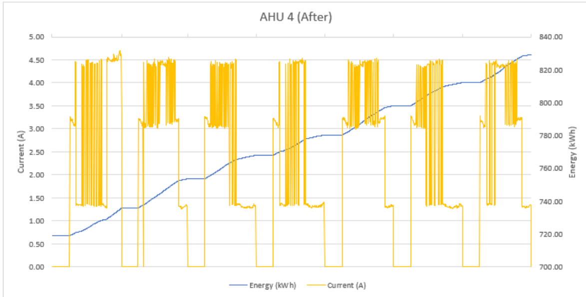

Fig. 19. After Operating Status for AHU No.4

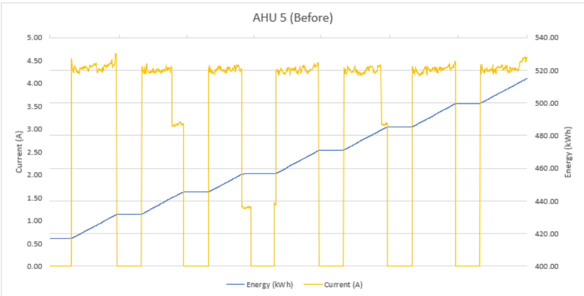

Fig. 20. Before Operating Status for AHU No.5

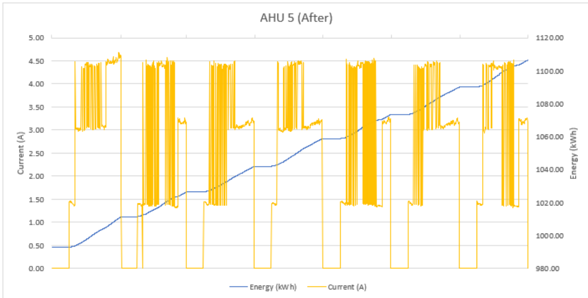

Fig. 21. After Operating Status for AHU No.5

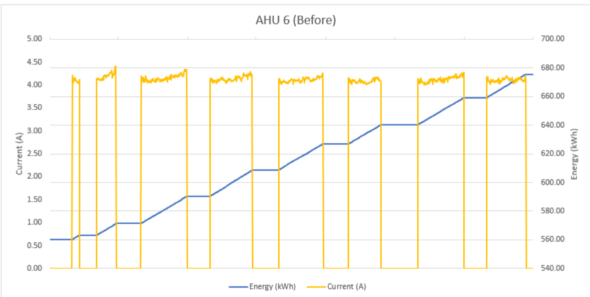

Fig. 22. Before Operating Status for AHU No.6

Fig. 23. After Operating Status for AHU No.6

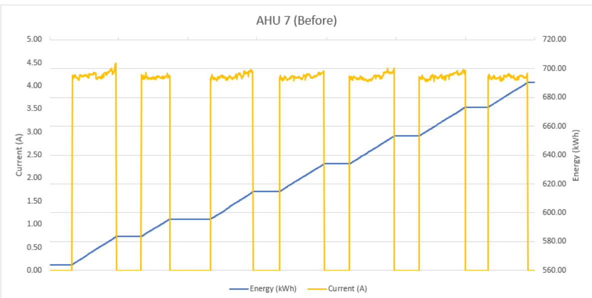

Fig. 24. Before Operating Status for AHU No.7

Fig. 25. After Operating Status for AHU No.7

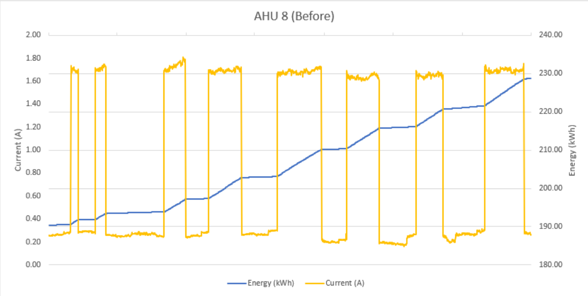

Fig 26. Before Operating Status for AHU No.8

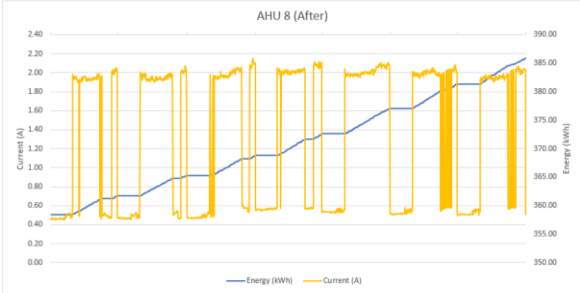

Fig 27. After Operating Status for AHU No.8

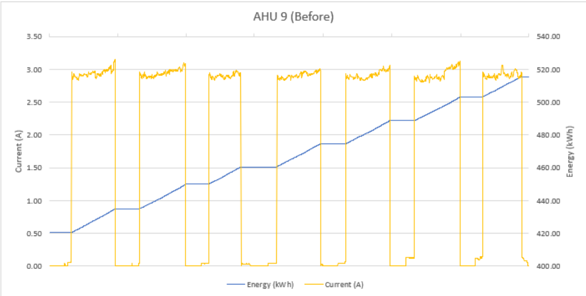

Fig. 28. Before Operating Status for AHU No.9

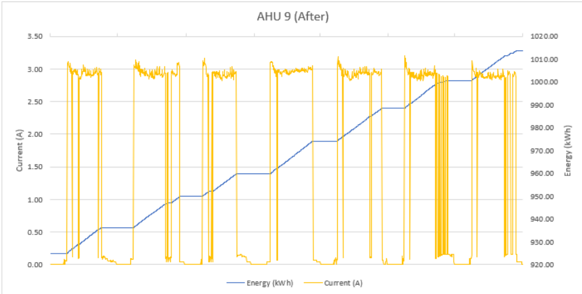

Fig. 29. After Operating Status for AHU No.9

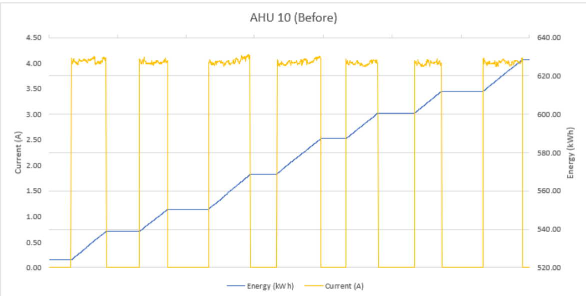

Fig. 30. Before Operating Status for AHU No.10

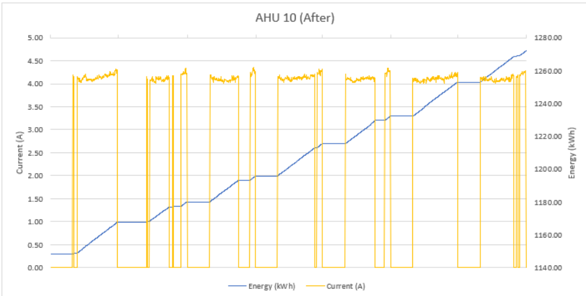

Fig. 31. After Operating Status for AHU No.10

3.2 Water Pump

The result shows that chiller pumps no.1-4 operate by reducing the speed in some time that the store opens. The flow rate must not be less than 60% of the normal system and the water pump must operate at least 35% to prevent equipment damage. The result of the energy saving shows the before power consumption for AHU 10 Unit is 164.01 kWh/Day and after power consumption is 109.89 kWh/Day showing the energy saving of 54.12 kWh/day or 33%, which is the result of chiller pumps control by flow meter. The chiller pump operates as shown in Figure 32 to Figure 35.

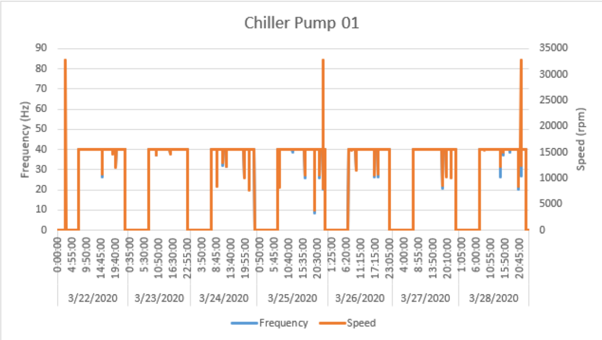

Fig. 32. Operating Status for Pump No.1

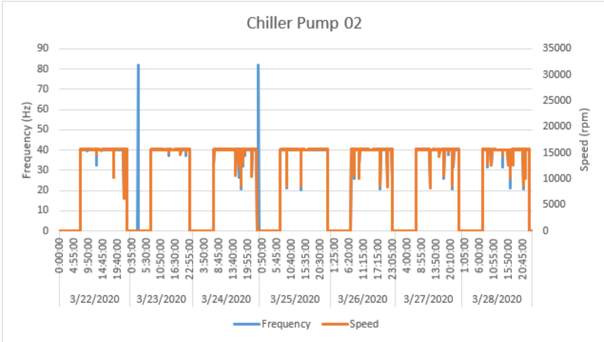

Fig. 33. Operating Status for Pump No.2

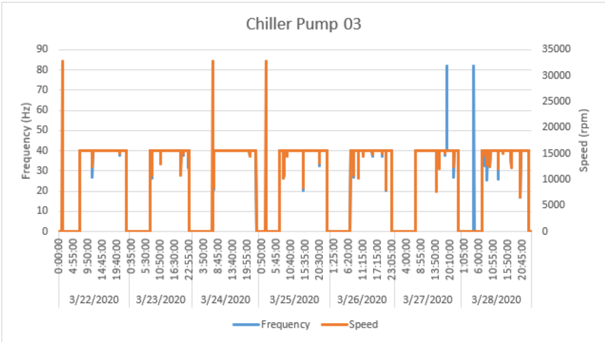

Fig. 34. Operating Status for Pump No.1

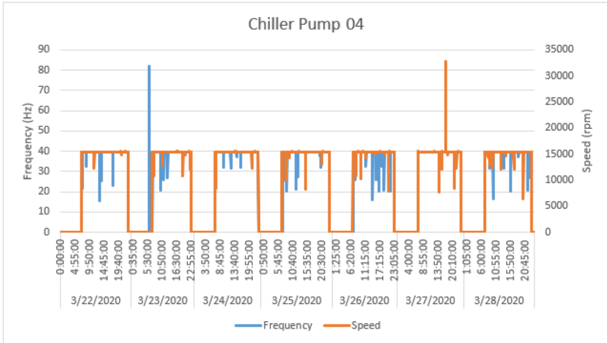

Fig. 35. Operating Status for Pump No.2

3.3 Chiller Systems

The result shows the operating status chiller before condition that the after controlling the condition of AHU and pump the chiller can achieve the setpoint of cold water and operate in unload status more the after condition. The result of the energy saving shows the before power consumption for AHU 10 Unit is 575.59 kWh/Day and after power consumption is 506.52 kWh/Day showing the energy saving of 69.07 kWh/day or 12%, which is the result of chiller pumps control by flow meter. The chiller pump operates as shown in Figure 36 and Figure 37.

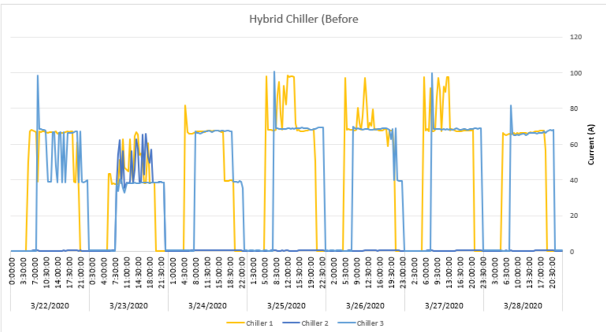

Fig. 36. Before operating Status for Chiller No.1-3

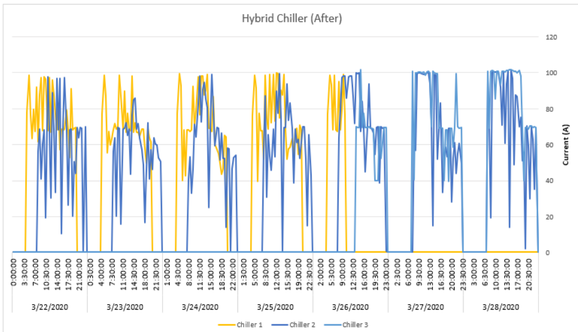

Fig. 37. After operating Status for Chiller No.1-3

4. Conclusions

The chiller air condition system in the supermarket that uses retail energy management systems in retail stores uses the Internet of Things to connect to a device to store data and analyze and process from big data, then Artificial Intelligence controls and commands to make the air conditioning system energy efficient. Controlling 10 AHUs using central sensors at the sales area instead of return sensors allows us to save 25% of energy or 12,886 kWh/Year. As for the cold-water pump, it is controlled by an inverter. Using sensors to measure the water flow rate can save 33% of energy or 19,755 kWh/Year. When controlling the water pump and AHU, the chiller compressor will save energy because when the air handling unit and the water pump have reduced work, the work of the compressor to cool water is reduced as well, resulting in energy savings of 12% or 25,211 kWh/Day. Using such a system reduces the overall energy consumption of the chiller air conditioning system. 17% or 57852 per year has a payback period of 3 years and can also be extended to other systems within the store or other stores.

Acknowledgment

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