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# Smart metering tools for energy reduction in Thailand's 4-star hotel rooms

*Herramientas de medición inteligente para la reducción de energía de las habitaciones de los hoteles 4 estrellas de Tailandia*

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***ABSTRACT***

This research aimed to develop smart meter tools for energy reduction of the 4-star hotel guest rooms in Thailand. The Smart Meter Hotel (HSM) was designed to measure electricity usage and transmit data via the "Internet of Things" to the cloud network. The data was also sent to the hotel front office department to inform the actual amount and cost of electricity consumption from the guests. Thus, the applied tool provided electricity usage in real-time to reduce the electrical peak load and to manage the energy efficiency.

**Keywords:** Hotel Smart meter, Smart Meter, Energy Management, Energy Reduction, Energy

***RESUMEN***

Esta investigación tiene como objetivo desarrollar herramientas de medición inteligente para la reducción de energía de las habitaciones de los hoteles 4 estrellas en Tailandia. El Hotel Smart Meter (HSM) fue diseñado para medir el uso de electricidad y transmitir datos a través del "Internet de las cosas" a la red en la nube. Los datos también se enviaron al departamento de recepción del hotel para informar la cantidad real y el costo del consumo de electricidad de los huéspedes. Por lo tanto, la herramienta aplicada proporcionó el uso de electricidad en tiempo real para reducir el pico de la carga eléctrica y administrar la eficiencia energética.

**Palabras clave:** Hotel Smart Meter, Smart Meter, Gestión de energía, Reducción de energía, Energía

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## *INTRODUCTION*

Nowadays, Four-star hotels have the highest number of guests due to the reasonable price and the ability to stay for many days. The first priority of a hotel business is to fulfill guest's satisfaction (Geetha et al.: 2017, pp. 43-54) by delivering a high standard of service (Sheng et al.: 2018, pp. 286-292). To provide a comfortable stay (Chen et al.: 2019, pp. 326-335), the hotel mostly offered two key cards to the hotel guest to keep the air condition on and maintain the temperature (Navratil et al.: 2019, pp. 1065-1077) while the guests were not in the room. Therefore, the condition of the room would be similar to when the guests are occupying the room with the operation of the air conditioning and lighting system. Thus, the electricity consumption is at 24 hours per day. This is the main reason that causes the waste of energy by providing the guests with maximum comfortability (Wang et al.: 2008, pp. 1952-1958).

Thailand Power Development Plan 2021 (PDP) required the business to be environmentally conscious, creating energy usage awareness and having energy efficiency measures. The hotel industry is considered a business with high energy consumption. So, the hotelier in Thailand is focusing more on the CSR program, including the use of natural resources to create higher environmental benefits (Mey et al.: 2006, pp. 144-160). The hotels in Thailand use electric power to provide the guests from 3 major sources, which are: electricity, liquid petroleum gas, and diesel.

The electricity consumptions of each hotel are different (Farrou et al.: 2016, pp. 553-562). It depends on the level of the hotel, such as five stars hotels, four stars hotels, or three stars hotels, which are classified according to the quality of service, in-room amenities, use area, and etc. For each hotel level, there are different electricity usage according to room type, size, and appliances in the room (Deng & Burnett: 2002, pp. 57-66). For the 4 Star hotel in Thailand, the percentage of electricity consumption occurred from air conditioning, lighting, elevator, water heat, and fan pump as 57%, 18%, 9%, 8%, and 8%, respectively (Tangon et al.: 2018). The air conditioning system consumed the most power and was used 24 hours a day to serve the hotel guests (Kresteniti: 2007, pp. 290-297) and staff. The electricity consumption will also vary depending on the temperature used, size, and type of the room, such as hotel tell room, lobby, or meeting rooms (Yao et al.: 2015, pp. 1977-1982). In addition, the hotel industry is one of the nine industries that must comply with the Building Energy Code (BEC). BEC enforced the design of the building to be rebuilt or modify for an area of more than 2,000 square meters. The hotel must be within the BEC design criteria, which consisted of 1. Air conditioning, 2. Lighting System, 3. Building envelope system, 4. Hot water production, 5. Renewable and combined energy systems to reduce the Specific Energy Consumption (SEC). The SEC is the whole energy consumption per square meter of living space area.

Electricity is the most important expense of doing a business, especially for the hotel industry( (Lai: 2016, pp. 33-43). If the electricity cost could be reduced, it would increase direct profits for the entrepreneurs. Therefore, the entrepreneurs should have plans for energy conservation management in the hotel business (Norazah & Norbayah: 2015, pp. 103-117). This energy conservation management will lead to the planning and controlling for efficient usage of electrical and lighting equipment to save energy and reduce energy costs (Cingoski & Petrevska: 2018, pp. 87-101). Understanding the principles of calculating electricity costs is important to plan for the reduction of electrical energy from the Electrical Charge Breakdown. There are some parts that can be controlled, such as electric power, peak load, and power factor load. The parts that cannot be controlled are the costs for Ft, service fees, and VAT which depend on the total electricity cost in each month. Therefore, it is important to consider the part that can be controlled by using it carefully and efficiently (Chan: 2005).

This research focused on the development of a device called Hotel Smart Meter or "HSM." The HSM will collect electricity usage data from the hotel room and analyze the electricity usage profile of the hotel guests. The information on electricity usage will be feedback to the hotel and guests. The main goal is to reduce the energy waste from the use of air conditioning while there are no guests in the room through creating awareness of the value for energy usage and energy waste. In addition, this will contribute to the reduction of hotel energy usage and electricity expenses.

## *METHODOLOGY*

The research assesses the usage of energy for hotel room by 1. Design Hotel Smart Meter (HSM) for measuring real electrical energy consumption in the hotel room, and 2. Analyze the factors that affect the guest's energy usage guidelines. The HSM collected the power usage of the lighting system, air condition system, and power outlet. The data from the power usage are then analyzed for the behavior of using the energy. The protocol to reduce energy usage and build awareness of energy savings was then developed.

### Hotel Smart Meter Concept

Electrical management means efficient management and control of electrical equipment and reduces the amount of electrical energy usage. The HSM was designed to be a tool for measuring actual electrical energy usage data (Beccali et al.: 2018, pp. 106-114) in the hotel room for air conditioning, lighting, and outlet system (Said et al.: 2017, pp. 99-103). The data was then transmitted via IoT and stored in the Cloud system. The energy usage data could automatically be shown as kWh and electricity expenses in the guest room's TV and HSM mobile application. The guest will be aware and understand the actual amount of electricity used and the load profiles of air conditioning, lighting, and electrical outlet in the room during the 24 hours stay. The amount of electricity usage was calculated into the actual electricity cost of the guest (Zhao et al.: 2012, pp. 1523-1527). The HSM was installed in the guest room to manage and reduce electricity usage during the period with the highest electricity consumption demand and to show the guest real electricity usage for air conditioning and lighting. The results could be used to motivate in reducing the wasteful energy consumption from the guest who came from the behavior of turning on the air conditioner during the day. In addition, the hotel can also manage electricity usage during low peak and low demand times, such as turning on the water pump at night to stable average load usage (Mey et al.: 2006, pp. 144-160). This is part of the measures for electrical energy conservation. The information is very important and will be used to create strategies to reduce electricity consumption, reduce operating costs, and conserve the environment.

### Hotel Smart Meter Design

Figure 1 showed the schematic of HSM Control Box Hardware and Connection. The HSM consisted of MicroController (Node MCU), a sensor for measuring electrical energy PZEM-004Tv3, system data communication for internet (Protocol), AWG 26 mm cable, and Power supply 12 VDC. The HSM was installed to measure the electricity usage from the breakers. There are operation system steps by measuring energy comparing between 2 types of energy meters. Protocol Config RS485 and PZEM-004T power measurement modules were integrated with Node MCU. There is no common platform to display energy values in most industries. The data must be transmitted per the specifications of the company that produced the devices; for the convenience of applying data to create a dashboard platform, the researcher designed and built an intelligent energy meter in conjunction with the energy config Protocol RS4875 to measure energy usage and display the data.

### Hotel Smart Meter Data Collection Protocol and Display

Figure 2 displayed the flow diagram of the HSM data measurement, data analysis, and display. The HSM system will start receiving the energy usage from the smart meter "protocol config RS485" together with the energy detector sensor PZEM-004T and analyzing the error together. It will calculate the tolerances and the index correction value so that the data to be used is accurate. The energy data will be sent from the protocol config RS485 energy meter via the TTL communication channel, RX, and TX ports (Figure 1). After that, the measurement index will be calculated and refunded to motivate guests. The measurement data will also be sent to the Cloud Server using the Blynk Server Cloud and Thingspeak Cloud.

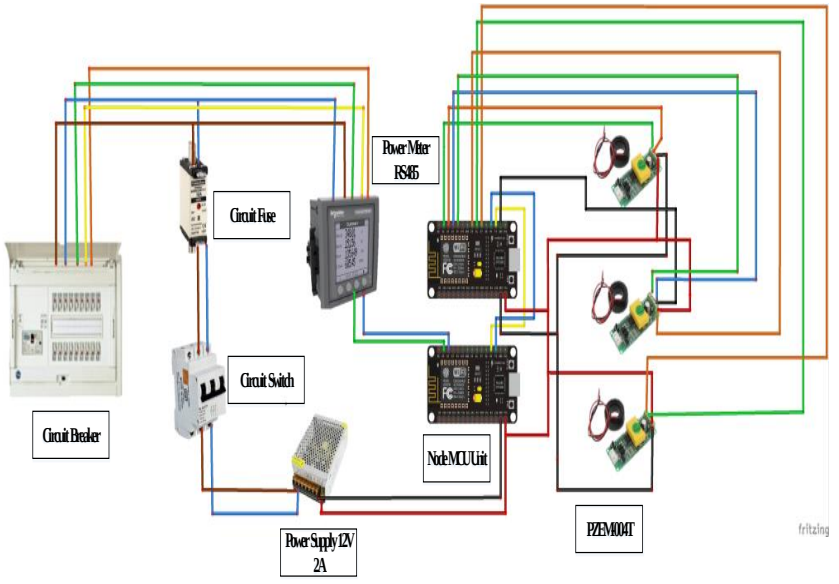


**Figure 1:** Schematic of IoT Smart Meter Control Box Hardware and Connection

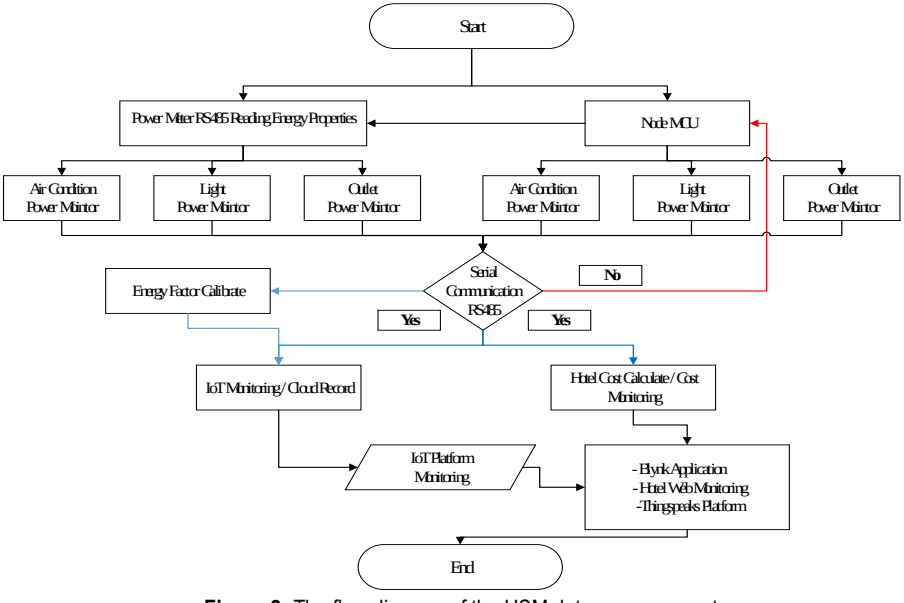


**Figure 2:** The flow diagram of the HSM data measurement

And research design Hotel Energy Monitor Website was designed to show guests' individual energy usage and individual savings. The guests could see their energy usage behavior for air conditioning, lighting, and electrical appliances via iPad. For the energy conservation promotion, the guest could also see the savings in the amount that the hotel would return to the guests when checking out. Additional login would be

used for hotel staff in order to monitor the electricity costs of guests with different habits and create a discount on the next stay. The users' information such as nationality, duration of stay, and energy usage profile could be collectively analyzed to find ways to motivate the guests to stay by offering promotions or discounts for guests of different nationalities. The analysis of foreign tourist behavior, including calculating refunds, could create incentives for guests, resulting in an awareness of energy conservation by implementing the following system. Therefore, the hotel can also control guest access to manage energy usage and reduce energy costs (Dalton et al.: 2009, pp. 955-964; Wang: 2012, pp. 268-275).

**The guidelines to create predication to reduce energy consumption**

1. Hotel Smart Meter records the data of energy used by air conditioning, lighting system, and power outlet during the guest stay.
2. The hotel guest can check the data of energy used by using the guest room's TV and HSM mobile application.
3. The guest participation in the program will be evaluated for behavior toward energy reduction from the benefit of the program.
4. The results from observes test and all customer suggestions will be separated into groups consist of age, the purpose of stay, duration, and nationality to evaluate and formulate guidelines for creating a participation energy reducing model.

## *RESULTS*

**Energy Profile**

For the 4 Star Hotel, the overall energy usage profile was measured and shown in Figure 3. The energy usage behavior in the hotels between 10:30 and 12:00 is high due to the opening of air conditioners, lighting, and other systems, including water, pumps to do activities for both the employees and customer services. The period before 12:00 and during 12:00 – 14:00 will be for using electrical appliances such as a vacuum. After 14:00, the energy usage was higher than before 12:00 because of the energy consumption from customers after the check-in. According to Figure 3, the period of 14:00 – 18:00 shown that the total energy consumption is 20 – 24 kW. The energy usage, therefore, reached the peak point, which causes the electric power price in the hotel to hit the peak point, and the electricity bill would be higher. The behavior of guests using the air conditioner at the same time makes the electricity cost rise to the peak point. Therefore, the data of energy consumption profile from the HSM would allow the hotel to make predictions about the use of electrical equipment within the hotel.

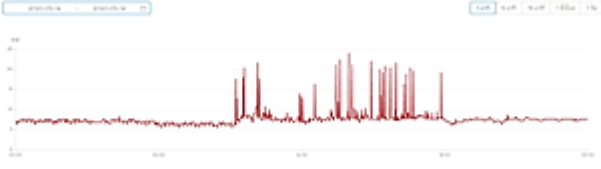

**Figure 3:** Real-time overall electrical consumption of the 4 Star Hotel

For the real-time measurement in a hotel room of 35 sq.m., Figure 4 showed the data for the period of 2 days for air conditioning, lighting, and outlet system power consumption. The power consumption is mainly used in the afternoon and at night. The air conditioner started to operate and consumed energy until it reached a constant setting of 25 °C, and then the air conditioner would work less. The 1,800 BTU air conditioner maximum operating condition was 1,500 W.


**Figure 4:** Example of a hotel room (35 sq.m.)
energy consumption profile (W)
of air conditioner, lighting, and an outlet for two days period

The HSM could measure the real-time power consumption for the unit of seconds. Figure 5 showed an example of the detailed measurement data from a hotel room during the cycling air conditioning operation. Figure 5(field one a) showed the overall room voltage, which was about 229-230 V. Figure 5(field 2 b), (field 3 c), and field 4d displayed the real-time power consumption of the Air Condition Power Unit, another appliance unit from the outlet, and Lighting Unit, respectively. At the start of air condition (Figure 5(b)), the blower and fan coil unit consumed approximately 0.05-0.06 kW at about 5 – 6 minutes.

The smart meter was able to display electrical usage and could control the device that was installed on the smart meter. The smart meter could control the electricity consumption during the time specified by the hotel. If the key card was not inserted, the system would cut the electricity. The system would automatically cut the electricity during 12:00 – 14:00, but if the key card is inserted, the system will keep operating. So, the guest could use the room as usual. Figure 6 showed the comparison of energy savings when implemented the measures of turning off the air conditioner when the guest vacated their room. Therefore, using a smart meter help guests to be aware of the energy usage. It could be seen that the energy-saving rate of air condition was reduced guest room costs by about 50-75 baht per day per room. There were significant savings from just changing part of the guest energy consumption behavior.


**Figure 5:** Real time power consumption of
(a) Hotel Voltage (V); (b) Air conditioner power unit (W); (c) Power outlets (W); and (d) Lighting Systems (W)

The comparative of Comparison of energy saving by development Hotel Smart Meter to create understand the data electrical usage and implementing energy conservation measures of turning off the air conditioner in the hotel room while the guest vacates the hotel room in 24 hr.

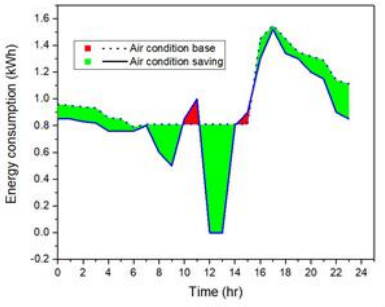


**Figure 6:** Comparison of energy saving by implementing energy conservation measures of turning off the air conditioner while the guest vacates the hotel room

**Energy Consumption Behavior**

According to the analysis of energy usage, it was found that the guests used the electricity from air condition at high proportion and left the air condition operated at all-time which resulting in overworked motor and consuming power. Comparing to different guest nationalities, the energy usage behavior on the first day was mostly the same, which was keeping the air conditioner operate while the guests were not in the room causing energy waste. Each hotel had a different policy. The hotel that provided two key cards had a higher tendency for the guest to leave one of the key cards in the slot to keep the room condition to their liking. The change of humidity in the room depended on the individual's physical condition. From the research, it was founded that males set the air condition at a lower temperature than females and have more opportunity to leave the air condition operated throughout their stay. Age was not the factor affecting the air-conditioner temperature setting but depending on the individual thermal comfort. The tendency of the air condition in Thailand to be open at low temperature would cause the air condition.

## *DISCUSSION*

**work hard, in the beginning, resulting in high electricity consumption**

Energy conservation by developing the Hotel Smart Meter (HSM) can create understand the energy data by able display electrical usage and can control the device that installed on the smart meter. The smart meter can control the electric consumption during the time specified by the hotel. If the key card is not inserted, the system will cut the electricity. The system will automatically cut the electricity during 12:00 – 14:00, but if the key card is inserted, the system will keep operating. So guest can use as usual. Therefore, using a smart meter help guests understand electrical usage and realize energy usage. It can be seen that the energy-saving rate of air condition is reduced 95% significantly and cost in 50-75 bath per day

The electrical usage data from the smart meter received can be calculated as electric consumption to reduce peak loads from guests staying at the same time. The hotel can reduce the electric charge from the peak. From taking the time-frequency, ethnicity, and purpose of stay data to analyze the way to reduce the electric cost in the hotel, which considered a high cost in the operation of 4 stars hotel. Air condition can be built to Smart Hotel Converter to reduce the energy consumption of air condition by having a monitor to know

the energy being used, compared with the normal energy usage and in order to remind the maintenance period. This can be reduced the energy consumption of air condition and reduced the cost and expenses from air condition not work well.

From the study of energy usage in hotels, it was found that energy use from the air conditioner had the highest proportion of the total hotel energy consumption. If the energy waste from the air conditioner was able to be reduced while no guest was in the room, energy cost could be reduced by 10%, and by raising awareness on energy conservation, energy usage could be reduced by 5%. By testing the Hotel Smart Meter-PZEM together with the development of the Hotel Smart meter mobile application to study the use of energy and electricity units in hotels, it could create ways to reduce energy consumption and save more electricity bills with an investment of 75,000 Baht and a payback rate of 1.25 years.

## *CONCLUSION*

This research used smart meters to measure energy usage in the guest room, send the electricity usage data into the data box and transmit the data to be processed and display via the internet of things. The electrical usage data received from the smart meter could be calculated as electric consumption to reduce peak loads from guests staying at the same time. The hotel could reduce the electric charge from the peak. Application and websites were created to display the energy consumption in real-time for the guest to see the electrical consumption. In the meantime, the data was sent to the front office staff to see the cost of electricity usage of each guest room. The electricity cost would be calculated as guest energy cost for comparing the average of usage and then create a discount in the event that the guests had turned off the air conditioner before leaving the room or open when needed. This could create awareness of energy use for the guests. By analyzing time-frequency, ethnicity, and purpose of stay with electricity usage profile, the hotel can create a promotional energy usage discount that is suitable to attract their guests. These discount measures may also help reduce the electricity cost in the hotel, which is considered a high cost in the operation of the 4 Stars hotel.

The research of Smart Meter can be used to measure the energy consumption and the cost of energy for the hotel. This can be used for a financial preparation and can also be used to forecast the demand for energy in business or hotels located on the island. So that can prepare the amount of electricity or alternative energy that will be used in the business. For example; the hotel located in Maldives, Koh Srichang, Koh Larn, hotel business in south of Thailand or in Philippine to be able to produce enough energy for guests and suitable for use in hotels that use alternative energy. It can be used to measure the amount of electricity used in hotels without sufficient electricity, to prepare backup electricity and able to prepare enough electricity to handle with a large group of tourists and able to collect the data each month.

Smart Meter can be used to create a model to design energy use to support the high seasons and low seasons in order to comply with the need of use and prevent electricity shortage and prepare backup electricity to be combined with alternative energy to reduce the occurrence of greenhouse effect.

The Smart Meter should be adapted to use with other businesses such as apartments, 5 star hotels and office building. It can be able to measure the real energy cost and bring to create guidelines for reducing energy use.

It should be design a website for user or people to understand the power unit (kWh) and create an awareness of natural resources that produce the electricity.

It can be developed the Smart Meter into mobile application for home use to measure the electrical consumption. This can lead the user understand the power unit (kWh) and resulting the right way to save the energy from air condition that has a highest electric consumption.

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