



Efficiency, acceptance, and SWOT analysis of IoT Electrical switchboards: A TAM perspective

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Abstract: Management of electrical switchboards is conventionally performed by a person, and inspections may sometimes encounter problems with the switchboard when severe damage has occurred. To solve such problems, this investigation was to apply the Internet of Things (IoT) to increase communication channels through smart devices to control the operation of electrical switchboards via the Internet and applications to access data to monitor device operation remotely for more security, credibility, stability, and efficiency. These capacities will increase business competitive advantages in an application of electrical switchboard production. The findings indicated that users are satisfied with its efficiency in reducing errors and service time, and remotely fixing problems which are defects of the original system operation.

Keywords: Internet of things, Electrical switchboard, Energy efficiency, IoT Sensor

1. INTRODUCTION

Electrical systems can not only be used to control all electrical systems in a building but can also be designed to receive information, display the data, and bring the information into the organization's policy. Therefore, the design and development of electrical systems that are safe, reliable, stable, and efficient will build up confidence in the organization and create a competitive advantage in business.

However, existing electrical control systems, or electrical switchboards, in buildings suffer from incompatibility of existing equipment and modern technology, leading to enormous losses of electrical power due to system management of tools. In addition, the existing systems still lack accuracy and reliability, and personnel are lacking in skills in the use of future automation systems. Environmental concerns and satisfaction of the users or customers with the systems and information to support decision-making in the future operations of the organization also need to be taken into consideration.

2. REVIEW OF RELATED LITERATURE

A. Integration of the Internet of Things (IoT) to electrical control systems or electrical switchboards in buildings

One way to solve the problem is an integration of the Internet of Things (IoT) to electrical control systems or electrical switchboards in buildings. In addition, the integration can reduce the cost of producing superfluous power

systems and reduce human errors which can also increase organizational reliability. The reliability of the organization is drawn from several elements such as the design of the electrical system, selection of electrical equipment, inspection and maintenance [1]. Improvement and optimization of electrical switchboard control equipment [2] can also build organizational credibility and acceptance. Currently electrical switchboard control devices are available in both low-voltage and high-voltage systems. Most of them are prefabricated and manufactured in Thailand for a variety of applications such as small industrial plants, large industrial factories, condominiums, buildings, hotels, shopping malls and medical facilities, etc. [3]. For this reason, the devices may not be applicable for all types of organizations.

B. Methods for optimizing electrical control systems

Prior study (e.g., [4] [5] [6] [7] [8]) proposes a variety of methods for optimizing electrical control systems to meet the needs and scale of the organization to conserve energy and maintain the environment within the organization. For example, [4] has invented a more efficient way to inspect the electrical system, using a semi-automatic electric control system, which depends on the installation of electrical control equipment working with a person. Such an approach reduces the number of people and times to inspect the electrical system and the severe damage caused by a power failure. However, such an approach still requires an in-person and on-site inspection. Then, [5] have created a

method for controlling electrical power using an in-depth assessment method of Statistical Assessment for Identifying Changes in Consumption Methodology (SAICC) using historical databases to determine the operating time of electrical equipment in advance. Its modeling or forecasting may be inaccurate due to in-depth calculations or inaccurate analysis. [6], [7] have proposed methods for connecting to the Internet from a distance. Remote to control home electrical equipment to automatically monitor the operating status and control of the device through the use of Android applications and radio technology based on the Laura protocol (Long Range Wide Area). Network; LoRa designed to support the connection of low-power devices across a Wide Area Network (WAN). The proposed method can be applied to precisely monitor the operating and control status of the equipment automatically. Lastly, [8] has applied building automation control and proposed methods to improve efficiency. The use of energy in smart buildings to analyze and find energy-saving solutions in the building can also support decision-making in choosing the right electrical equipment for the building, such as lighting and ventilation systems.

Heating systems and air conditioning systems also play a vital role to this research area. The systems have been applied in smart home energy control by several studies e.g., [9], [10], [11], [12] Subsequently, the application of MQTT technology was proposed by [10], [13] to monitor energy consumption and demand to power the home at low costs. Lastly, [14] has proposed Home Energy Management System (HEMS) as a management system approach to connect to electrical equipment and systems incorporate electricity in homes or commercial buildings together under a central control system by applying automation to optimize energy control and other forms of energy such as thermal energy (namely the price of electricity at different times and the use of energy to suit the weather conditions, etc.).

C. Innovative method to optimize the management of electrical equipment and electrical switchboards by using Internet Of Things (IoT)

From the aforementioned prior study, numerous researchers have proposed a wide variety of methods for effective remote control of electrical equipment. However, those methods primarily control the use of electrical equipment from the end and do not address the accuracy and efficiency of controlling the equipment under different environmental conditions. Elaborating on the legacy systems, this research has two features distinctive from those systems. On one distinctive feature, this study has proposed an innovative method to optimize the management of electrical equipment and electrical switchboards by using IoT to suit different environments. This proposed method is a combination of system equipment and the addition of the sensor being installed in an electrical switchboard with the purpose to facilitate remote monitoring of electrical equipment operation and to reduce severe wastage due to equipment failure through the addition of the sensor can be controlled

through an application that controls the main functions of the devices. On the other distinctive feature, this study included the assessment of users' satisfaction and acceptance of the system. This study therefore adopted and applied the Technology Acceptance Model (TAM) to illustrate the customers' satisfaction and acceptance of the innovative technology efficiency. TAM was built upon the theory of rational action (TRA) [15] which states that a person generally behaves as he or she intended. On the other hand, his or her behavioral intentions are determined by personal opinions and norms. TAM adjusts the rational action of TRA to illustrate a person's acceptance behavior [16] suggesting that a user's beliefs determine his or her opinions on something or someone. In other words, the opinions on a system determine his or her behavioral intention to use the system. If the opinions are positive, they ultimately lead to the practical use of the system.

D. Technology Acceptance Model (TAM)

Since its initiation, TAM has received ample attention [17]. This indicates that TAM is a powerful model for technology evaluation and comparison among user groups of specific technologies. Several studies e.g., [18], [19], [20], [21] have shown that both TAM elements, perceived ease of use (PEOU) and perceived ease of use (PEOU), are determinants of adoption and use. Several studies e.g., [22], [23], [24], [25] revealed that PEOU influences one's behavioral intentions through PU. Specifically, prior study using TAM for IoT evaluation investigated the acceptance of mobile library applications [21], the acceptance of smart meter with a focus on the electricity-saving knowledge and environmental awareness effect [26], users' intention in developing IoT [27], assessing customer's satisfaction of the products [28], TAM/ISS model and PLS-SEM approach evaluating the continuous usage of voice enabled IoT systems [29], understanding the acceptance of IoT through an integrative theoretical approach. [30], consumer acceptance of IoT in smart home context [31], and the usage of the IoT in smart farming (UTAUT) [32]. To gain insights of the user/customer perception of IoT application use and their perceived ease of use, SWOT analysis has been applied in this study. The analysis has been applied in various technology business areas such as cloud adoption [33], real estate technology [34], sustainable industry 4.0 wireless networks, real-time big data analytics, and IoT-based decision support systems [35], and industry 4.0 adoption for sustainability [36]. Drawing upon the aforementioned prior study, theory, and rationale for the study, we therefore formulated the following five research questions (RQs).

RQ 1: What are major characteristics of a conventional switchboard and an innovative one?

RQ 2: How are existing users/customers satisfied with its efficiency?

RQ 3: How do new users/ customers accept of the innovative product?

RQ 4: What does the element analysis of its efficiency and acceptance indicate?

RQ 5: What are strengths, weaknesses, opportunities and threats (SWOT) of the switchboards with regard to TAM?

3. METHODOLOGY

A. Design

This exploratory research design was based on a mixed method. The data collection followed these procedures. First, relevant documents were analyzed. Next, a focus group of 15 experts was conducted. Then, two questionnaires – one focusing on efficiency of the product while the other focusing on its acceptance – were administered. The data were collected during February – March 2021.

B. Samples

Samples in this study were engineering experts and technicians. These personnel have high experience in the applications of IoT technology to control electrical devices in various fields such as electric control systems in smart home, remote traffic signal control systems, anti-theft system inside the building, and electric power control systems in smart industrial estates and so on. They were chosen by purposive sampling. The participants were 15 experts and 300 technicians who control and operate electrical switchboards of 3 companies (namely Acifa Public Company Limited, WHA Bangna Business Complex and WHA's group and Carabao Group PCL). All were existing users or customers of the product and new customers of the product.

C. Instrument for data elicitation

The instruments for data elicitation included a document analysis, a focus group, and two questionnaires. First, the document analysis aimed to understand the two applications (i.e., a conventional system and a IoT-integrated one) and TAM. Next, a focus group aimed at drawing information on the experts' opinions regarding the two applications. What did you think of the conventional switchboard? What did you think of the electrical switchboard control system with IoT technology? Lastly, the questionnaire comprised the efficiency and the acceptance of the management. The users' opinions were assessed 5-rating scale questionnaire in these areas: efficiency (namely benefit, practicality, feasibility, effectiveness, confidence and safety), acceptance (namely relative advantage, compatibility with the original system, complexity in use, trainability and observability), element analysis of efficiency and acceptance of the product (namely performance beneficial for facilitating the services management and building confidence in the power system, system implementation and management, and integration and application).

D. Theoretical framework of the study

TAM, a theoretical framework to understand potential customers' behavioral intentions, contained two key factors, PEOU, or the degree to which a potential customer perceives that the use of a product will be effortless, and

PU, or the degree to which a potential customer perceives that the use of a product will increase productivity. As the product was innovative, a SWOT analysis was applied to shed light to prepare for marketing strategic planning and decision-making. The relationship of these factors in the theoretical framework could be photographically presented below.

E. Data analysis

Descriptive statistics were means, standard deviation, variance, and percentage. The data from all instruments and SWOT analysis were qualitatively and quantitatively analyzed to draw the conclusion of the study.

F. Reliability and validity check

The questionnaires were constructed in response to the purposes of the study and then sent to the five reviewers for contents validity check and the Item-Objective Congruence (IOC) evaluation. The reliability check of the questionnaire was tested by the Alpha Cronbach's Coefficient test. The value was 0.76, indicating moderate value.

Figure 1 illustrates a theoretical framework of the study. In this framework, an innovative product (i.e., IoT-integrated switchboard) was examined whether its efficiency and acceptance met business objectives which aimed to retain loyalty of existing customers and attract new customers. The objectives were verified by two factors of TAM, PEOU and PU, and SWOT analysis.

4. RESULTS

A. RQ 1: What are the major characteristics of a conventional switchboard and an innovative one?

The results of the study were drawn from the document analysis and the focus group of experts. The details of the results were below.

- Features of a conventional switchboard The switchboards use personnel to check the status of the electrical system once a week so the personnel must have expertise and high work experience. Their responsibilities focused on taking note of the electrical system operation (e.g., busbar thermal, thermal temperature measurement of electrical equipment installed inside the switchboard, electric bill, and measurement of current and voltage, etc.). Then, the collected data were analyzed with a package of ready-made programs to display the results in weekly, monthly, and annual report formats. The monitoring could be illustrated in Figure 2.

Figure 2 illustrates how the switchboard was managed. There are several critical limitations (e.g., personnel, the use of modern temperature measuring instruments and personal temperature readings) which leads to high cost for checking the power system status.

Note: Green area represents low temperature area and red area shows high temperature.

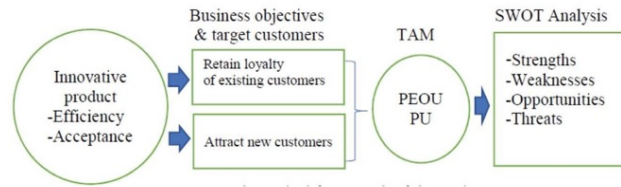


Figure 1. Theoretical framework of the study

TABLE I. USER'S SATISFACTION OF SWITCHBOARD EFFICIENCY

Efficiency of IoT	mean	S.D	L. efficiency
1. Beneficial to the business owner	4.13	0.800	high
2. Practical to support work and decision making in work	4.17	0.784	high
3. Feasible to manage materials and equipment	4.09	0.847	high
4. More efficient than conventional systems	4.12	0.827	high
5. Effective for data implementation design, work, and fast	4.09	0.867	high
6. Able to store various operating values of equipment	4.21	0.830	high
7. send messages to notify work through the application efficiently	4.17	0.831	high
8. Reliable, efficient for operation on the electrical switchboard	4.05	0.816	high
9. Able to build confidence and safety of electrical systems	4.15	0.841	high
Total	4.13	0.696	high

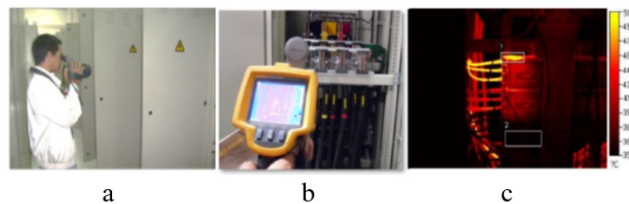


Figure 2. Electrical status monitoring: (a) Thermal Person Monitoring (b) Thermal Image Monitoring with Thermo Image Technology (c) Thermal Camera Temperature Results

Also, if the damage is not at the time of inspection, it will cause severe damage to the switchboard and cost a lot of damage. A short circuit damage in the failure to detect in time could be shown in Figure 3.

Figure 3 illustrates a short circuit damage in the failure to detect in time. When repair and maintenance of equipment within the electrical switchboard could not be planned, the failure led to loss of investment regarding the purchase of electrical equipment replacement, loss of competitive opportunities, and personnel being at risk during inspection and so on.

In order to reduce the risk, this study proposed a method to optimize efficiency by using IoT to reduce the personnel's risks during inspection and monitoring of the operation 24 hours a day.

- Electrical switchboard control system with IoT Technology Electrical engineering and design and building electrical safety inspections regarding the new system shown in Figure 4. Figure 4 illustrates the installation of IoT in an electrical switchboard which can also be illustrated in

the form of the architecture of IoT installation structure as shown in Figure 5.

Figure 4 illustrates the installation of IoT in an electrical switchboard which can also be illustrated in the form of the architecture of IoT installation structure as shown in Figure 5.

Figure 5 illustrates the architecture of IoT sensor installation structure in an electrical switchboard. After installing IoT sensor systems at various points as needed, electronic devices link or send information to each other through the Internet network.

They enable the command of various electronic devices through the Internet with various devices (e.g., smartphones and portable computers and so on), unlike in the past when electronic devices were only a medium for transmitting and displaying information. Therefore, the new system can be used to monitor and notify various statuses of the electrical switchboard system. First, the system can measure the temperature in the position of the device that has the highest current flow. When the temperature exceeds the

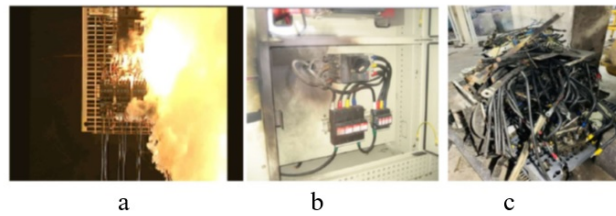


Figure 3. A short circuit damage in the failure to detect in time: (a) electrical short circuit causing a fire, (b) fire damage in a lightning protection device, and (c) fire damage in the device



Figure 4. The installation of IoT in an electrical switchboard

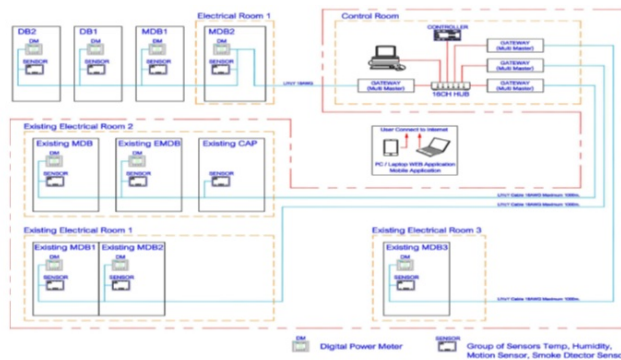


Figure 5. The architecture of IoT sensor installation structure in an electrical switchboard

specified level and the equipment is at risk, it can alert the operator’s mobile phone. Second, the system can measure the moisture content inside the electrical switchboard to prevent relative humidity more than the standard set. Third, the system can detect the amount of smoke to prevent fire inside the electrical switchboard (including an automatic alert system to the fire extinguishing equipment to automatically extinguishing the fire). Fourth, the system can detect moving objects of objects or people and alert the system operator to the system operator. Fifth, the system can measure the number of lightning strikes and display the number and frequency of lightning strikes so that the procurement plan can be planned timely. Sixth, the system can measure current power unit and display the power consumption in various forms. Seventh and lastly, the system can control the electrical switchboard remotely

through a variety of devices (e.g., smart phones, portable computers, desktop computers and so on). The results of the electrical switchboard management and control via a smart phone device could be displayed as shown in Figure 6.

Figure 6 illustrates the results of the electrical switchboard management and control via a smart phone device.

The results illustrate displays of: (a) the different system notification settings, (b) the amount of electricity consumed, (c) the electrical energy and the current temperature, (d) the amount of humidity inside the switchboard, (e) the power quality and various parameters, (f) the power quality and parameters in graph form, (g) graphs showing the historical power consumption.

This new switchboard works effectively in terms of

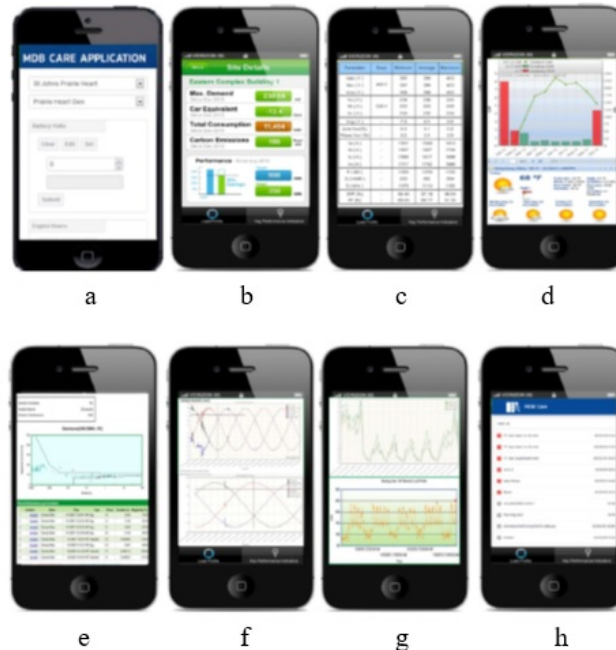


Figure 6. Electrical switchboard management and control via a smart phone device

mechanics but, in terms of marketing, it is necessary to explore the users' satisfaction of its efficiency.

B. RQ 2: How are existing users/customers satisfied with its efficiency?

The user/customer satisfaction plays a vital role in business. It is a leading differentiator that enables a business to increase its competitiveness because it can measure existing user/customer loyalty and retention.

Table 1 shows that the results of users' satisfaction of switchboard efficiency. The overall opinions of the electrical switchboard users were high (mean = 4.13, S.D. = 0.696). In details, their opinions were high also high in all items. The top three highest were: 1) its ability to store various working values of the equipment and create graphs to observe changes or to see malfunctions in the operation (mean = 4.21, SD = 0.830), 2) its ability to support work and decision-making in the work with a notification system alert via SMS and e-mail (mean = 4.17, SD = 0.784), and 3), its operations which can be captured and alerts which can be triggered through the application efficiently (mean = 4.17, SD. = 0.831) respectively. It indicated that if the producers aims to improve their users/customers' satisfactions in order to retain brand loyalty, they should focus on these efficiencies of the product: 1) its ability to store various working values of the equipment and create graphs to observe changes or to see malfunctions in the operation, 2) its ability to support work and decision-making in the work with a notification system alert via SMS and e-mail, and 3) its ability to save operations and send messages to notify work through the application efficiently. It is also essential

to understand to what extent the users/customers, especially newcomers accepted the product to increase competitive advantages as seen in the next part.

C. RQ 3: How do new users/customers accept of the innovative product?

Attracting new customers is also vital for increase in business market shares and competitiveness. Below are the results of the study.

Table 2 shows the results of new customers' application acceptance. The overall opinions were high (mean = 4.00 SD = 0.662). In details, their acceptance was ranked from the highest to the lowest as follows: 1) its relative advantage (mean = 4.13, SD = 0.703), 2) its observability (mean = 4.04, SD = 0.744), 3) its trainability (mean = 3.98, SD = 0.728), 4) its compatibility with the original system (mean = 3.98, SD = 3.98), and 5) complexity in use (mean = 3.87, SD = 0.7608) respectively. This indicated that users accept these advantages of the product: relative advantage, observability, trainability, compatibility with the original system and complexity. It could be concluded that if the producers aim to attract new customers in order to increase sales, they should focus on the aforementioned advantages.

D. RQ 4: What does the element analysis of its efficiency and acceptance indicate?

It is also essential to determine what each element (Efficiency and acceptance) to prepare for SWOT analysis in the next chapter.

Table 3 shows the results of the component analysis of IoT efficiency and acceptance in electrical switchboard



TABLE II. ACCEPTANCE OF THE IOT SWITCHBOARD BY NEW CUSTOMERS

Advantages	mean	S.D	L.acceptance
1. Relative advantage	4.13	0.703	high
2. Compatibility with the original system	3.98	0.737	high
3. Complexity	3.87	0.760	high
4. Trainability	0.760	0.728	high
5. Observability	4.04	0.744	high
Total	4.00	0.662	high

management. The high percentage element was EITORA (18.327). However, the percentage elements of CPTTOT (1.683) and CT (1.050) were low. This indicated that CPTTOT and CT need improvement.

The details of each element could be illustrated in Table 4.

Table 4 illustrates the composition analysis of the efficiency and acceptance of the IOT in the electrical switchboards management. All variables yielded a weight greater than 0.30. It could therefore be concluded that all variables demonstrate efficiency and acceptance of IOT in the electrical switchboard manage. In details, the first element (EITOR) indicated the top three as follows: EITO5 (0.758), EITO4 (0.755) and EITO6 (0.749) respectively. The second element 2 (CPTTOT) indicated the top three as follows: CP3 (0.740), TT4 (0.736), and TT1 (0.730) respectively. The last element (CT) consisted of CT4 (0.726) and CT1 (0.704).

E. RQ 5: What are strengths, weaknesses, opportunities and threats (SWOT) of the switchboards with regard to TAM

In order to prepare a strategic plan as part of a marketing plan for this product, decision makers need to identify strengths and weaknesses, opportunities, and threats of any product. A SWOT analysis serves as a basis for team decision-making. With reference to the theoretical framework of the study (in Figure 1) and the results of the aforementioned four research questions, below were the results of this research question.

To retain existing users/customers, the efficiency of the product as perceived by the experts indicated the strengths of their marketing plan, including: (a) the different system notification settings, (b) the amount of electricity consumed, (c) the electrical energy and the current temperature, (d) the amount of humidity inside the switchboard, (e) the power quality and various parameters, (f) the power quality and parameters in graph form, (g) graphs showing the historical power consumption.

The opportunities of the product efficiency as perceived by the existing users or customer, determined by means score which were higher than average mean score (mean = 4.13), included 1) its ability to store various working values of the equipment and create graphs to observe changes

or to see malfunctions in the operation, 2) its ability to support work and decision-making in the work with a notification system alert via SMS and e-mail, 3) ability to save operations and send messages to notify work through the application efficiently, 4) ability to build confidence and safety of electrical systems in factories, buildings and businesses and 5) benefits to the business owner and project administrators.

However, there were some points or weaknesses of the product efficiency as perceived by existing users or customer, determined by means score which were lower than average mean score (mean = 4.13), included 1) more efficient than conventional systems that mainly rely on the experience of operators in determining problems, faults, and alarms for electrical switchboards, 2) effective for data implementation design, work, fast data processing and reporting and 3) reliable, stable and efficient for operation on the electrical switchboard.

To attract new users/customers, the opportunities of the product efficiency as accepted by the new users/customers determined by means score which were lower than average mean score (mean = 4.00), relied on its relative advantage and observability. However, there were some points or weaknesses of the product acceptance included compatibility with the original system, trainability and complexity. These weaknesses need to be improved in order to attract new users/customers.

Overall, element analysis of IoT efficiency and acceptance of electrical switchboard indicated that element analysis of IoT efficiency and acceptance of electrical switchboard was the strength (18.327) while system implementation and management (1.683) and integration and application with the electrical switchboard management plan (1.050) needed to be proved.

Table 5 show the element analysis of the efficiency and acceptance of the switchboards.

- In element 1 (EITORA), the strengths of the product lie in its system that was well-accepted by users at every step, managed based on the operator's skills and could store performance values of the device) and its opportunities lie in its system that practically supports work and decision making, is beneficial to every business and sector,



helps manage materials and equipment, and is beneficial to the switchboard management. However, it contained weaknesses that the system can record images and send notification messages, results in more efficient management, enables effective decision, and can build trust and safety. Also, it had some threads that the system can check the electrical switchboard efficiently, is reliable and stable, and is beneficial to the switchboard development plan.

- In element 2 (CPTTOT), the product possessed these strengths: the relevant personnel comprehending the system thoroughly, the developed system being tested individually, and being able to try before installing it. It had these opportunities: the workflow of the system not being complicated and the trial displaying the overall functioning of the system. However, it had minor weaknesses that need to be improved in terms of customer satisfaction: its design not being met the needs of users; trial errors not affecting performance; accuracy the results being obtained from the operation of the system are accurate; easiness to use and the ability to reflect overview of the switchboard management. Its thread lied in the innovative, safe, and impactful qualities of the system. The product manufacturers need to pay attention to these weaknesses and threat.

- In element 3 (CT), the product showed neither strengths nor threads. Its opportunities were that the system can be integrated with future management plans and traditional management). However, its weaknesses were that the system is able to efficiently respond to the agency policies, has no effects on and conflict in decision-making, and can be used to build on the current management, primarily based on the skills of people. This indicated weaknesses that need to be improved.

5. DISCUSSION

Specifically, prior study using TAM Model for IoT evaluation included the acceptance of mobile library applications [21], the acceptance of IoT-based smart meter with a focus on the effect of electricity-saving knowledge and environmental awareness [26], users' intention in developing IoT [27], assessing consumer's behavior toward IoT products and applications [28], integrated TAM/ISS model based PLS-SEM approach for evaluating the continuous usage of voice enabled IoT systems [29], understanding the acceptance of IoT through an integrative theoretical approach. [30], consumer acceptance of IoT in smart home context [31] and the usage of the IoT in smart farming (UTAUT) [32].

In addition, this study lends support to prior study using SWOT analysis that help identify strengths, opportunities, weaknesses and threads of various technology business areas such as cloud adoption [33], real estate technology [34] (December), sustainable industry 4.0 wireless networks, real-time big data analytics, and IoT-based decision support systems [35], and industry 4.0 adoption for sustainability [36]. However, this study yields different outcomes due to different product and contexts.

6. CONCLUSION AND FUTURE WORK

A. Five conclusions could be drawn from the study.

First, the innovative switchboard was superior to the conventional one in its displays of different system notification settings, amount of electricity consumed, electrical energy and the current temperature, amount of humidity inside the switchboard, (power quality and various parameters, power quality and parameters in graph form, graphs showing the historical power consumption.

Second, in response to the customer satisfactions to retain brand loyalty, these abilities need to be improved (namely the abilities to store various working values of the equipment and create graphs to observe changes or to see malfunctions in the operation, to support work and decision-making in the work with a notification system alert via SMS and e-mail, and to save operations and send messages to notify work through the application efficiently).

Third, to attract new customers, the producers need to improve these qualities of the product: relative advantage, observability, trainability, compatibility with the original system and complexity.

Fourth, all variables demonstrate efficiency and acceptance of IOT in the electrical switchboard manage. However, there is a need to improve the system implementation and management as well as integration and application with the electrical switchboard management plan.

Lastly, the SWOT analysis indicated that the switchboards had much more strengths and opportunities than weaknesses and threats. The strengths and opportunities were also aligned with TAM factors.

B. Suggestions

- Practical suggestions

Electrical switchboard users show a high level of opinion on the overall and individual performance of IoT. The switchboard can store various functions of the equipment and create graphs to observe changes or malfunctions in operation. It can also support work and decision making in work by sending notification system via SMS and e-mail to the owner of the business and project administrators of the industrial plants, buildings, and businesses. The system is directly useful for the management of electrical switchboards in factories, buildings, and businesses. It is the basis for decision support and can facilitate audits in order to benefit for the electrical switchboard management and development plan. In addition, the system design meets the needs of users. This results in accuracy and clarity the operation of the system, which is considered an innovative system that improves safety as well as stability and effectively affects the reliability and the electrical system management of the plants, buildings, and businesses.

This study provides these implications:



TABLE III. ELEMENT ANALYSIS OF IOT EFFICIENCY AND ACCEPTANCE OF ELECTRICAL SWITCHBOARD

Elements of Items	Variance	% variance	% cumulative variance
EITORA	18.327	61.092	61.092
CPTTOT	1.683	5.609	66.700
CT	1.050	3.500	70.201

TABLE IV. ELEMENT ANALYSES OF IOT EFFICIENCY AND ACCEPTANCE OF THE ELECTRICAL SWITCHBOARD

Element	Efficiency	Weights
EITO1	The system is beneficial to every business and sector.	0.733
EITO5	The system is well-accepted by users at every step.	0.758
EITO4	The system managed based on the operator's skills.	0.755
EITO6	The system can store performance values of the device.	0.749
EITO2	The system practically supports work and decision making.	0.739
EITO3	The system helps manage materials and equipment.	0.706
RA1	The system is beneficial to the switchboard management.	0.704
EITO7	The system can record images and send notification messages.	0.698
RA2	The system results in more efficient management.	0.685
RA3	The system enables effective decision.	0.652
EITO9	The system can build trust and safety.	0.615
RA4	The system can check the electrical switchboard efficiently.	0.594
EITO8	The system is reliable and stable.	0.587
RA5	The system is beneficial to the switchboard development plan.	0.571
CP3	The relevant personnel comprehend the system thoroughly.	0.740
TT4	The developed system can be tested individually.	0.736
TT1	You can try it out before installing it.	0.730
CP2	The workflow of the system is not complicated.	0.720
TT3	The system trial shows the overall functioning of the system.	0.703
OT2	The system is designed to meet the needs of users.	0.684
TT2	Trial errors do not affect performance.	0.680
OT1	The results obtained from the operation of the system are accurate.	0.666
CP1	The system is easy to use.	0.653
OT3	The system can reflect overview of the switchboard management.	0.629
OT4	The system is innovative, safe and impactful.	0.578
CT4	The system can be integrated with future management plans.	0.726
CT1	The system can be integrated with traditional management.	0.704
CT5	The system is able to efficiently respond to the agency policies.	0.679
CT3	The system has no effects on and conflict in decision-making.	0.659
CT2	The system can be used to build on the current management, primarily based on the skills of people.	0.610

TABLE V. THE ELEMENT ANALYSIS OF THE EFFICIENCY AND ACCEPTANCE OF THE SWITCHBOARDS

Element	Strengths	Weaknesses
1.EITORA	EITO5,EITO4,EIT06	EITO7 , RA2,RA3,EITO9
2.CPTTOT	CP3,TT4,TT1	OT2,TT2 ,OT1,CP1,OT3
3. CT	-	CT3 CT2
Element	Opportunities	Threads
1.EITORA	EITO1,EITO2,EITO3,RA1	RA4,EITO8,RA5
2.CPTTOT	CP2,TT3	OT4
3. CT	CT4,CT1	-



1) information for the development and improvement of personnel management and management systems that inspect, maintains and maintains electrical switchboards.

2) a guide for information in decision making in management, a skill set for personnel and technical developments, and strategies for developing new electrical switchboard products to be reliable, stable, and efficient, and

3) information for decision making in development.

- Suggestions for future inquiry

Three suggestions for future inquiry are: first, future inquiry may need to take other essential factors (namely price and break-even point, etc.) into consideration in decision-making, especially small business and factories where this system has never been installed; second, installation of hardware systems or sensor devices must be adjusted to the electrical system of the factory, building, and plant; and lastly, control of electrical equipment through the application may encounter an unstable connection problem if the device is located where Wi-Fi signal cannot be reached so an additional router must be installed.

AUTHOR CONTRIBUTIONS

Conceptualization, S.C. and K.W.; data curation, S.C.; formal analysis, S.C. and K.W.; funding acquisition, S.C.; project administration, S.C. and K.W.; software analysis, S.C. and K.W.; supervision, S.C.; writing—original draft preparation, S.C. and K.W.; and writing—review and editing, S.C. and K.W. All authors have read and agreed to the published version of the manuscript.

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