

The Development of Criteria and Indicators for Energy Management of Educational Institutions with the Energy Management System

Chuntisa Kessmanee¹, Hathaithip Sintuya¹, Surachai Narrat Jansri¹, Nuttiya Tantranont^{2,*}

¹Asian Development College for Community Economy and Technology, Chiang Mai Rajabhat University, Chiang Mai 50300, Thailand

²Faculty of Education, Chiang Mai Rajabhat University, Chiang Mai 50300, Thailand

***Corresponding author's email:** nuttiya18@g.cmru.ac.th

Received: 27/04/2021, Accepted: 02/06/2021

Abstract

Improving energy efficiency in school buildings provides environmental, economical, and educational benefits. It is therefore important for school administrators to achieve energy efficiency through effective energy management. The objectives of this research were to develop the criteria and indicators used as the guidelines for school administrators in energy management and conservation, and to assess their energy performances. In doing so, 12 experts were surveyed for opinions in energy management and the results were applied to develop the criteria and indicators. A training course was then specifically conducted for the representatives of small, medium and large-sized schools in order to build awareness and improve their energy performances. After the training, the assessment was conducted by energy auditors from the ISO 50001 accredited agencies. The results were composed of 9 criteria and 25 indicators. The assessment results on efficiency of quality management by the auditors revealed that the energy management efficiency of the 3 institutions was at a high level and could be incorporated in other projects and their electricity consumption was reduced of 35.40%, 24.17% and 6.05% in large, medium and small schools respectively. The satisfaction assessment results of the schools on the implementation of the criteria and indicators were at high level. The findings illustrated that school administrators are the key success for implementing and improving energy efficiency in the schools. They need to work collaboratively with the others according to the PDCA cycle for the continuous energy performance improvements.

Keywords:

School Energy Management, Criteria and Indicator, Energy Audit, Energy Efficiency

1. Introduction

Global energy consumption is an important issue today due to continuous economic growth and rising energy cost. A worrying trend is that fossil fuels, which is currently the major energy source, may be depleted. This will bring energy shortages that can have huge adverse economic impacts on the global population.

In Thailand, electricity consumption in educational buildings as of 2014 was continuously rising [1]. As projected by the Ministry of Energy 20-year energy conservation plan (2011-2030) [2], if the economic structure and energy needs remained unchanged, the electricity demand of educational institutions is projected to increase to a maximum of 12,947 gigawatt per hour in 2030 [3].

Thailand has defined economic strategies under "Thailand 4.0", which consider the impacts of rising energy consumption. Thailand 4.0 is a vision of economic development wherein the government aims to change the conventional economy to innovation-driven economy based on a vision of stability, wealth and sustainability. Its mission is to push reforms that will change, reorganize, streamline various national aspects, and pave the way for a better national development that is prepared for new opportunities and threats, under the rapid and serious changes brought by the 21st century.

The Ministry of Energy has thus set the energy objectives of Thailand 4.0. It aims to incorporate green and environmentally friendly energy uses that have minimal negative environmental impacts to attain a better quality of life for the people. For electrical energy, one of the focus of Thailand 4.0 energy policy is energy efficiency [4]. Additionally, the ministry has formulated the 2018-2037 renewable and alternative energy development plan. The goal is to increase the 30% ratio of renewable and alternative energy in the forms of electrical, thermal and bio-mass energy per the final energy consumption in 2037. The ministry has also formulated the plan to cultivate better understanding and awareness on renewable energy by improving potential of personnel on producing renewable energy and by creating collaboration at the community level. These attempts will reduce imported energy, secure community energy, create new knowledge, and lead to technological development and research on energy. They will also reduce global warming and conserve the environment sustainably [5].

The building sector, consisting of public and commercial buildings, is considered the biggest global energy consuming sector, consuming 40% of the total global energy consumption and as such, also the biggest source of greenhouse gas emissions [6]. Large public and commercial buildings, like school buildings, consume more energy than residential buildings. Consequently, the educational sector, having large public buildings, also have a high energy consumption.

Some schools in Thailand have already emphasized energy saving in buildings by conducting energy conservation programs, using energy efficient equipment, changing to energy saving light bulbs, promoting awareness on energy conservation among students and administrators, and integrating energy conservation subjects into the education curriculum. Nonetheless, most schools have not done regular inspections, monitoring and assessment of their activities aiming to achieve energy consumption towards sustainable energy.

In response to Thailand 4.0, the Ministry of Education has now formulated its own energy management policy. The Ministry of Education has six educational strategies, and Section 5 targets the betterment of quality of life through environmental friendly strategies, such as energy conservation. The ministry has already issued its energy conservation policy which include measures and practices for schools to implement. Some schools have also created additional measures for promoting and supporting better energy efficiency strategies, including installation of energy efficient and saving technologies. However, energy efficiency and energy saving in educational buildings and other related structures remain low [7].

It is therefore recommended that energy management guidelines with simple, efficient, and measurable criteria and indicators be implemented to monitor and manage energy consumption in educational buildings. The problem of wasteful expenditure from energy consumption should be analyzed and behavior of school personnel and students should be changed for optimal energy consumption efficiency. Energy management in educational buildings can be a good demonstration model for others to understand and learn about efficient energy consumption, as well as to raise awareness among students and school personnel on reasonable electricity saving strategies. There is now a collaboration between the Ministry of Energy and the Ministry of Education in implementing classroom training on energy saving through the “Energy in Educational Institution Course” [8].

The Ministry of Energy has also initiated a project to promote and encourage energy efficiency in educational institutions by organizing “the energy volunteers doing good deeds with heart” activities. This is to promote energy conservation and renewable energy consumption in schools, as well as to encourage students to learn about energy and expand what they learned to their homes and communities, where mostly, energy consumption efficiency is relatively low due to old and poorly maintained electrical appliances. The project includes a campaign on energy saving by the Bureau of Energy Policy and Planning, providing schools and communities knowledge on safe use of cooking gas, efficient use of electricity, and environmental conservation.

The Ministry of Energy has already provided a budget for installing energy-efficient equipment, resulting in energy saving of over 7.7 hundred thousand units/year or 3.24 million baht/year. Additionally, the ministry has allocated some budget for schools to change to and install energy-efficient equipment. By now, 5,751 LED bulbs, 144 inverter air conditioners, 19 VRF air conditioner systems,

and 270.08-kilowatt solar cell systems have been installed. The Internet-of-Things (IOT) energy management system has also been installed in various schools. These efforts have reduced energy consumption and expenditure by over 40% [9].

School administrators have played a significant role in implementing and translating the national energy policies into practice. Important responsibilities of the school administrators include academic, budget, personnel, and general administration. As specified in the 1999 National Education Act and in subsequent amendments [10], education administration and management has been decentralized, enabling educational institutions to become more flexible and independent. To cultivate excellence and express their visions in the implementation of administrative strategies, school administrators try to optimize their budget allocation for quality education management. If they can reduce energy expenditure, they will be able to have more disposable budget for academic and other administration work, which will be beneficial to educational administration [11].

Without correct and practical energy management guidelines, due to lack of clear energy management goals and policies, shortages of specialized personnel to oversee the energy management system, or lack of personnel training on proper energy management, it would be difficult to cultivate awareness on optimal and efficient energy consumption. Additionally, without regular inspections and/or efficient monitoring of energy management, the school energy management plan may result to negative impacts on the quality of school administration. To formulate and implement a school energy management plan for the improvement of efficiency and conservation of energy use, schools need to improve their energy competencies on a regular basis. This includes the issuance of practical guidelines for the inspection and reporting on the purchase and use of appliances, systems and processes relating to energy consumption [12].

For a successful and sustainable energy management, it is also imperative to establish practical and efficient criteria and indicators as guidelines for schools in establishing and monitoring the efficiency and effectiveness of the energy efficiency and conservation plans. To achieve this, firstly, schools are required to understand about energy management and how to develop their cooperation in its planning and implementation. School administrators particularly are required to understand the need for defining clear goals, policies, and plans in energy management for buildings. With full financial support and proper personnel, they will be able to achieve these goals and plans and thus, bring about energy conservation and efficient energy uses, reduce energy costs, and contribute to reducing the negative environmental impacts of energy consumption.

2. Objectives

The objectives of this research study were to develop the criteria and indicators for energy management, and to evaluate and suggest actions for the continuous improvement of energy management system in schools.

3. Methodology

Both quantitative and qualitative approaches were used to pursue the research objectives. The five steps of the research process include the following:

(1) Examining and developing the criteria and indicators to use as guideline for good quality energy management to promote energy conservation in educational institutions. This involved documentary research on energy management criteria and related concepts. The findings were applied to formulate the questionnaire used in the survey for developing the criteria and indicators.

(2) Compilation and analysis of the opinions from 12 experts collected through an iterative survey (for three times) to find consensus of thinking and opinions on energy management criteria and indicators. The experts consisted of three representatives each from the ISO 50001 agencies, the Ministry of Energy, and the three schools that have participated in the Energy Mind Awards Contest. These experts have more than five years of experience in energy management. The Index of Item Objective Congruence (IOC) was used to find the content validity from the three experts prior to the conduct of the survey. The acceptable value of IOC for each questionnaire question was between

0.67 – 1.00. The questionnaire designed to collect the opinions and consensus of the 12 experts on the criteria and indicators, used a 5-point rating scale. The survey results were analyzed for mean, median, and standard deviation. For a consensus to be acceptable, the mean must be more than 3.50, the median must be ≥ 4 , and the standard deviation must be ≤ 1.25 .

(3) Interviewing three energy auditors with over five years of experience from the ISO 50001 agencies. They were required to develop performance evaluation methods of implementing the energy management based on criteria and indicators, and the appropriate scoring methods for evaluating the schools' energy efficiency management. Additionally, the energy auditors were interviewed for their suggestions for an effective implementation of an energy management system.

(4) Conducting a training course for 18 energy management committees from 3 secondary schools in the Bangkok Metropolitan area under the Office of the Basic Education Commission. These energy management committees included 3 school administrators, 6 teachers, 3 staff and 6 students (6 people per school). The objective of the training was to educate the energy management committees to understand the criteria and indicators to ensure their correct implementation. The energy management committees were expected to transfer the knowledge they learned to other relevant people in their school for effective energy management. The three schools included in this training course were the following: Rithiyawanalai 2, a large-sized school, Kunnontheerutharam Withayakhom, a medium-sized school, and Watnoinophakhun, a small-sized school. The schools were purposively selected to obtain results for three types of school sizes, with their corresponding physical environment, community aspects, and energy management operations, such as, budget, readiness of personnel, and building designs. The trainers were energy auditors with over five years of experience.

(5) Evaluating the performance according to the quality management guidelines for energy management in educational institutions. After the training, the energy management criteria and indicators were implemented in the respective schools for nine months. Data were recorded and the following evaluation tools were used:

(5.1) An evaluation checklist on energy management in educational institutions containing assessment items using a 5-rating scale. The evaluators assessed the performances of the three participating schools using documentary evidence, interviews, and direct observations of what happened actually.

(5.2) Electricity consumption data of the schools before and after the implementation of the criteria and indicators.

(5.3) A satisfaction evaluation of the trainees regarding to *satisfaction, feasibility, and utility* of the criteria and indicators developed from this study.

4. Results

4.1. Results of developing the criteria and indicators on energy management and conservation in the schools

Table 1 Opinions of the experts on the criteria and indicators.

Criteria and indicators	Mean	Median	SD
<i>Administrators</i>			
1) Formulating energy management policies or directions suitable for the school	4.33	4	0.49
2) Designating responsibilities of personnel for monitoring energy management in the school	4.2	4	0.62
3) Providing resources for energy management in the school	4.3	4.5	0.78

Criteria and indicators	Mean	Median	SD
4) Formulating follow-up measures or methods and evaluation on the implementation of the energy management policies	4.2	4	0.72
5) Considering restrictions on energy management operations	4.2	2.5	0.78
6) Supervising the operations systematically and developing other related programs	4.2	4.5	0.67
<i>Personnel</i>			
7) Being knowledgeable and understanding the energy management quality system in order to implement the policies	4.17	4	0.72
8) Those supervising or carrying out the energy management are required to understand their roles and responsibilities	2.67	3	0.65
<i>Management</i>			
9) An energy management training plan should be formulated in order to provide relevant knowledge to school personnel	4.67	5	0.62
10) The school database on buildings, facilities, equipment, electrical appliances and system should be constructed	4.58	5	0.51
11) Energy management documents and their filing system should be systematic	3	3	0.95
12) Assessment on energy consumption problems is conducted	4.67	5	0.49
13) There are energy management plans/projects with clear goals and objectives	4.75	5	0.45
14) Energy management controlling guidelines and operation measures are formulated	4.75	5	0.45
15) There are evaluation and guidelines in response to possible emergencies in school	4.23	4	0.62
16) There are practical guidelines for maintaining school equipment, appliances, and electrical system	4.42	4.5	0.67
17) Energy management knowledge and projects are incorporated in classroom instruction and learning process	4.67	5	0.49
<i>Purchase, provision, and procurement</i>			
18) There are surveys on conditions of electrical equipment, appliances, and consumption system in order to incorporate into the annual purchase, provision and procurement plan	4.33	4	0.98
19) There is coordination with internal and external agencies and communities	4.33	4	0.96

Criteria and indicators	Mean	Median	SD
<i>Communication</i>			
20) Communication methods are specified	3.83	4	0.71
21) Prepare for a communication and communication media	3.25	3.5	0.87
22) There is coordination with internal and external agencies and communities	3.92	4	0.79
<i>Inspection, testing, evaluation, and follow up</i>			
23) A guideline for inspecting the conditions of electrical equipment, appliances and system is designated	4.33	4	0.65
24) There is operational follow up of energy-related plans or projects	4.25	4	0.65
25) There is consumption follow up after the school has had an energy management system	4.42	4	0.51
<i>Correction and prevention</i>			
26) There are correction guidelines for aberrant policies, plans, projects, objectives, or aberration or damage to electrical equipment, appliances and system. There are preventive measures to prevent those problems from happening again	4.42	4	0.51
<i>Community/social responsibility</i>			
27) Community/social voices are listened to on the impacts of school operations	3.33	3.5	0.75
28) Community/social collaboration or problem solving is sought	3.75	4	0.97
<i>Participation</i>			
29) There is activity participation within and outside of the school	4.08	4	0.67
30) An opportunity is provided to external individuals to participate in analyzing and revising the congruence between project performances and policies of the school and of the Ministry of Energy	4.08	4	0.52

Table 1 shows the opinions of 12 experts regarding the proposed 9 criteria and 30 indicators for energy management of educational institutions. These criteria and indicators were developed based on the literature review. However, an expert consensus was not achieved for 5 indicators i.e., indicator numbers 5, 8, 10, 21, and 27. Therefore, the 9 criteria were included but only 25 indicators were retained.

Table 2 Details of energy management criteria, indicators, and performance evaluation methods.

Criteria	Indicators	Performance Evaluation Methods
Administrators	Defining energy management policies or directions suitable for the school	Having policies and their concrete implementation
	Specifying roles and responsibilities of personnel in charge of energy management in the school	Convening meetings with the energy management working committee to inform them about the policies and appoint those in charge of energy management
	Providing resources for school energy management and considering limitations of energy management operations	Considering the feasibility of the projects and plans in order to approve operational budgets
	Designating measures or monitoring methods and evaluation of the implementation of energy management policies systematically	Formulating the meeting agenda to monitor the operations
	Supervising and developing other programs as well as implementing on a regular basis	Participating in activities or being a part of the projects to ensure that the activities or projects are actually carried out
Personnel	Those involved in energy management supervision or operation must understand their roles and responsibilities. They must be trained to have knowledge and skills about energy management	Being evaluated from correct operations and achieving objectives and goals of each project with evidence supporting involved individuals to get training
Management	There is an energy management training plan for school personnel	There is an annual plan for energy management training
	There is a filing system/database about buildings, equipment, appliances, electrical system, and energy consumption	There is a printed and electronic filing system
	There is an assessment on energy consumption problems of the school	There are results of energy problem evaluation
	There is an energy management plan/project with clear practical guidelines, objectives, and goals	There are plans or projects to correct or eliminate energy-related problems with clear practical guidelines
	There are guidelines and measures to monitor energy management	There is an operation report and manual or operation methods
	There are an assessment and guidelines in response to possible emergencies in the school	There are emergency assessment results and plans in response to emergencies

Criteria	Indicators	Performance Evaluation Methods
	There are practical guidelines to maintain the electrical equipment, appliances, and system of the school	There are maintenance plans and their execution
	There is incorporation of energy management knowledge and projects into the learning process in classroom	There are lesson plans with an incorporation of energy management contents, e.g., academic contents, activities, or projects
Purchase, provision, and procurement	There is a survey on the suitability of electrical equipment, appliances, and electricity consumption system to incorporate the data into the annual purchase, provision, and procurement plan	There is a purchase, provision and procurement plan for budget allocation
	There is a systematic guideline for purchase, provision, and procurement	Price comparison and seller evaluation must be conducted prior to the purchase and procurement
Communication	Defining communication methods, what to communicate, and media production	Records or evidence of media production
	Coordinating with internal and external agencies, as well as surrounding communities	Evidence of reception or message reception internally and externally
Inspection, testing, evaluation, and follow up	There are corrective guidelines for things not in accordance with policies, plans, projects, or objectives, as well as irregularities or damage to equipment, appliances, and electrical system of the school. There are also guidelines to prevent problems from happening again	Operation reports and summary of electrical equipment and appliances in good condition
	There is a follow up of the plan or project operations on energy of the school	Operation results of projects in line with objectives and goals
	There is a follow up of expenditure after having the energy management system	Declining expenditure compared with the data in the same period of the previous year
Correction and prevention	There are corrective guidelines for things not in accordance with policies, plans, projects, or objectives, as well as irregularities or damage to equipment, appliances, and electrical system of the school. There are also guidelines to prevent problems from happening again	Problems solved, with regular meetings of the working committee to monitor performances. Irregularities are recorded in meeting reports and follow up is conducted
Community/social responsibilities	Listening to the problems of community/society regarding to the impacts from the operations of the school. Collaboration or problem solving is conducted with community/society	There is no complaint from communities

Criteria	Indicators	Performance Evaluation Methods
Participation	Participating in activities in school and with external agencies	Acceptance of activity participation
	Providing school personnel an opportunity to take part in analyzing and revising the congruence of project operation results with school policies and policies of the Ministry of Energy	Meeting reports of administrators and working committee

Table 2 shows the details of the energy management criteria, indicators, and performance evaluation methods. In the second and third survey, the respondents insisted on maintaining the 9 criteria and 25 indicators. Afterwards, the performance evaluation methods were developed from interviewing three energy auditors.

Table 3 Success indicator assessment criteria in the implementation of the energy management criteria and indicators.

Score range	Level	Interpretation
4.51- 5.00	Highest	School has high potential to implement the criteria and indicators and should receive budgetary and technological support for continuous development
3.51 - 4.50	High	School has potential to implement the criteria and indicators and should receive budgetary and technological support to improve its performance
2.51 - 3.50	Moderate	School has potential to implement the criteria and indicators but should focus more on the missing indicators
2.5 and lower	Poor	School does not have sufficient potential to implement the criteria and indicators. However, it required support for the missing indicators to start implementing the criteria and indicators to formulate the practical guidelines

Table 3 shows the scoring methods in evaluating the success of the implementation of the energy management criteria and indicators from interviewing three energy auditors. The assessment criteria are divided into 4 levels, including highest, high, moderate and poor.

4.2. Results of operation assessment of the management quality of the school energy management

The assessment conducted by the three energy auditors was done through review of documents, interviews, observations, and collection of evidence of actual implementation. Each criterion and indicator were scored from 1 to 5. The results showed that the performance of the three schools was all at high levels with mean scores of 4.4, 4.0, and 4.2 for Rithiyawanalai 2, Kunnontheerutharam Withayakhom, and Watnoinophakhun school, respectively. The implementation of the criteria and indicators was acceptable and reflected its success. Nevertheless, each school had its own limitations and different facilitating factors, as shown in Table 4.

Table 4 Assessment results on the implementation of the energy management criteria and indicators for the three schools.

Criteria	Rithiyawanalai 2	Kunnontheerutharam	Watnoinophakhun
Administrators	5	4	4
Personnel	4	4	4
Administration	4	3	4
Purchase and procurement	5	5	5
Communication	5	4	5
Inspection	4	4	3
Correction and prevention	4	3	3
Community/social responsibility	5	5	5
Participation	4	4	5
Mean	4.4	4.0	4.2

4.3. Electricity consumption data of the schools before and after the implementation of the criteria and indicators

Thai educational institutes operate on a two-semester basis. The first semester starts from May to October and the second semester from November to March. The data for this investigation were collected in 2019. The 2019 data were compared with data from the 2017 and 2018 academic years, which were the times before the implementation of the energy management criteria and indicators (see Figs. 1-3).

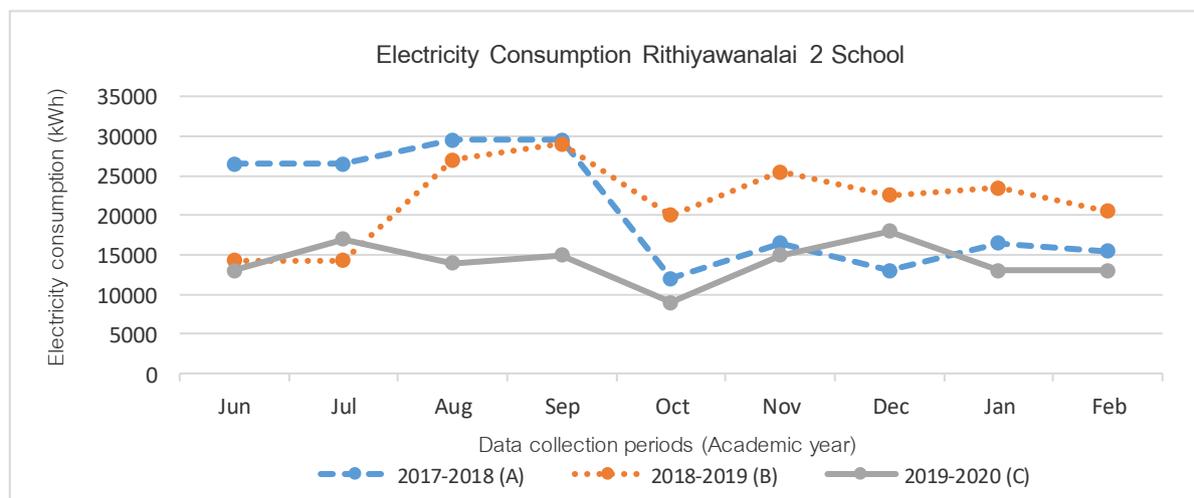


Fig. 1 Comparison of electricity consumption of Rithiyawanalai 2 school in the same period of 2017, 2018 and 2019 academic years.

Fig. 1 shows the electricity consumption of Rithiyawanalai 2 School in Sai Mai district in Bangkok. It is a large-sized school in a large area with many buildings and classrooms. It has a big number of personnel carrying out activities such as: a language student exchange program, a scientific innovation and invention contest program, and an energy conservation and saving program. The comparison of electricity consumption in the three academic years revealed that the average annual electricity consumption was 20,611.11 kW/h in 2017 and 21,851.78 kW/h in 2018. These were relatively high due to the construction of a new building in those years. In 2019, it was 14,116.67 kW/h. When comparing back the two previous academic years to the energy consumption for 2019, the consumption was less by 31.31% compared to 2017, and less by 35.40% compared to 2018. This was because the school had implemented plans to change electrical equipment, to experiment solar cell installation, and to launch a campaign to raise personnel awareness on saving electricity. Furthermore, the school had participated in the energy conservation program of the Ministry of Energy, using the criteria and indicators as a practical guideline.

Fig. 2 shows the electricity consumption of the medium-sized Kunnontheerutharam Withayakhom School in Din Daeng district in Bangkok. It used to be a large-sized school, but due to out migration in the surrounding communities resulting to lower number of students, there were personnel reduction, partial closing down of buildings, and reduction of school activities. The electricity consumption in the three academic years showed that the average annual consumption was 18,577.78 kW/h in 2017, 14,530.11 kW/h in 2018, and 11,018.22 kW/h in 2019. Comparison showed that the 2019 consumption was 40.78% less compared to 2017, and 24.17% less compared with 2018. This was because the school had implemented plans to change electrical equipment, to reduce the use of air-conditioners, and to launch a campaign to raise personnel awareness on saving electricity. Moreover, the school had initiated an internal energy conservation program using already the criteria and indicators as a guideline to create more activities.

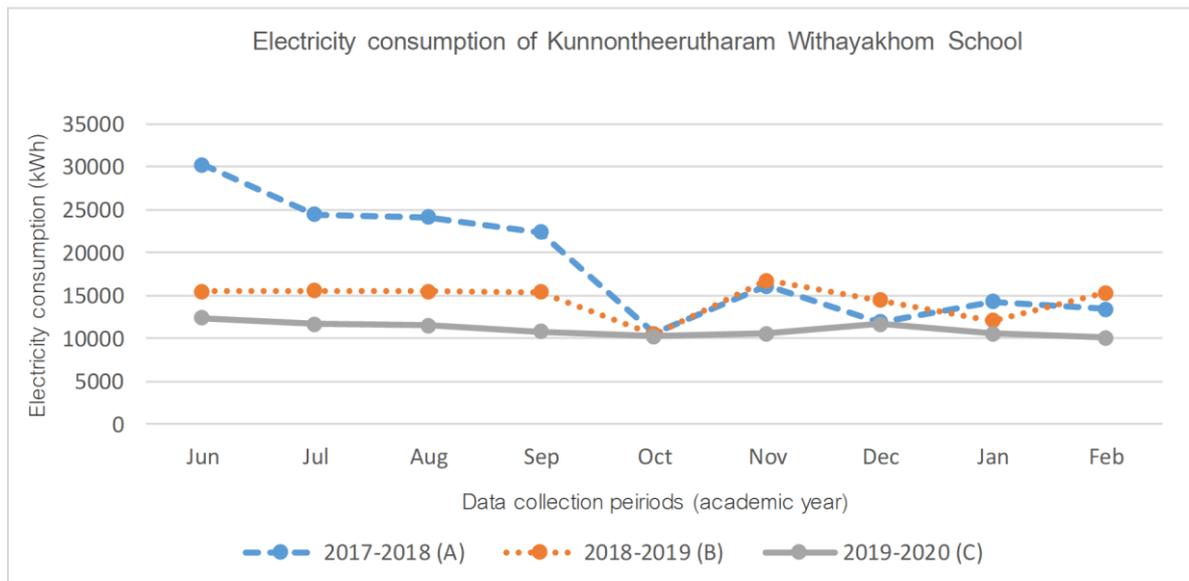


Fig. 2 Comparison of electricity consumption of Kunnontheerutharam Withayakhom school in the same period of 2017, 2018 and 2019 academic years.

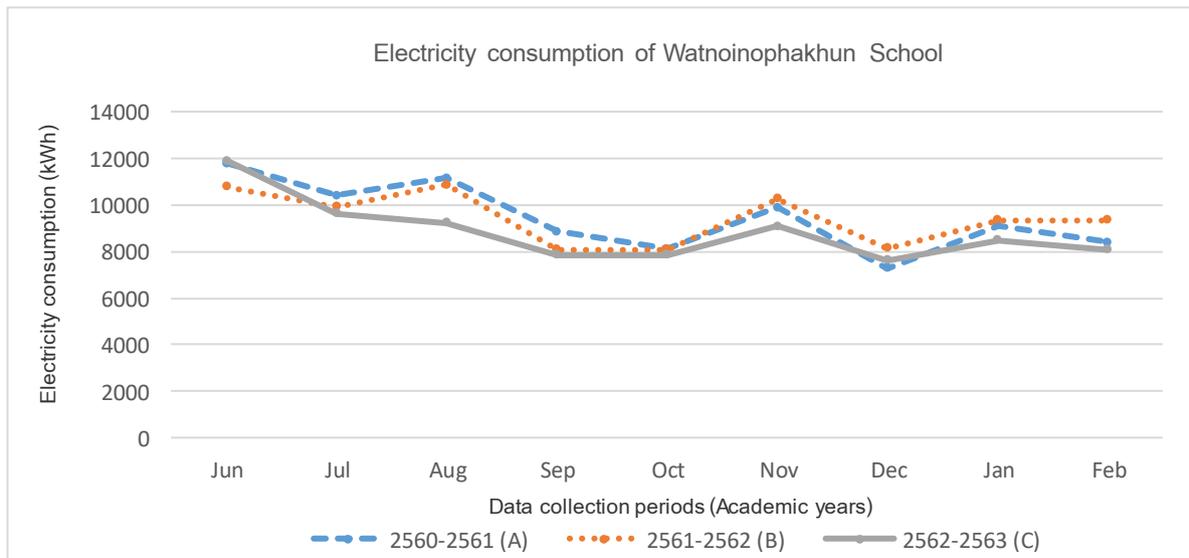


Fig. 3 Comparison of electricity consumption of Watnoinophakhun school in the same period of 2017, 2018 and 2019 academic years

Fig. 3 shows the electricity consumption of the small-sized Watnoinophakhun School in Dusit district in Bangkok. It used to be a medium-sized school, but due to out migration in the surrounding communities resulting to lower number of students, there were personnel reduction, partial closing down of buildings, and reduction of school activities. The school has received good collaboration from surrounding communities. The comparison of electricity consumption in the three academic years showed that the annual average consumption was 9,449.33 kW/h in 2017, 9,443.89 kW/h in 2018, and 8,861.56kW/h in 2019. Comparison showed that the 2019 consumption was 6.22% less compared to 2017 consumption, and 6.05% less compared with 2018. The difference was not significant because it was a small school, and so the budget for changing electrical equipment was not much. However, the school had regularly organized energy conservation programs and the activities with good collaboration from communities and external agencies. Additionally, the school had launched campaigns to raise awareness on electricity saving in cooperation with its personnel and families of students. It had established an internal energy conservation program by using the energy management criteria and indicators to create a practical guideline to construct a quality control system for the plan.

4.4. Results assessment of opinion from the school representatives on the criteria and indicators

The 18 representatives or members of the energy management committees from the three secondary schools were asked to rate their opinions on the criteria and indicators based on three aspects: satisfaction, feasibility, and utility.

On the aspect of “satisfaction” of the energy management criteria and indicators, the mean value of the overall average rating given by the members was 3.77, a high level rating. The highest level of rating for satisfaction was given for “the specific energy management policies are suitable for schools to implement”, for which the mean value of the ratings was 4.67. The rest items got the same mean value of the rating at 3.56, which was still considered high level. Details of the ratings are shown on Table 5.

Table 5 Opinion levels on the aspect of “satisfaction” of energy management criteria and indicators.

Satisfaction	Mean	SD	Level
The specific energy management policies are suitable for schools to implement	4.67	.50	Highest
Communication methods of the energy management committee about energy management are interesting	3.56	.52	High
Electricity equipment and appliances are in good condition	3.56	.52	High
School administrators are open to problems and solutions related to energy management from the committee or personnel	3.56	.52	High
School is satisfied with the energy management criteria and indicators, and implement them in order to realize energy conservation in practical terms, e.g., reduction of electricity consumption or awareness of personnel on the issue	3.56	.52	High
Total	3.77	.50	High

On the aspect of “feasibility” of the energy management criteria and indicators, the results showed that the rating level given by the members for this aspect were at the highest level, with a rating mean value at 4.55. When each item was taken into consideration, the highest rating level for feasibility include “the school mandating the times for turning on the air-conditioners”, and “the school encouraging students and personnel to exercise by walking up and down the stairs instead of using the lift”, with a rating mean value of 5.00. Two other items such as “the school encouraging the facilities division to clean up air conditioners once a year and maintain them on a regular basis” and “the school encouraging students and personnel to participate in informing the facilities division about damaged appliances and not using them until they are repaired”, were also given high rating levels, with both having the same mean value of 4.56. The item “the school encouraging students and personnel to strictly save electricity in buildings” received too a high rating level, but with the lowest mean value of 3.67. Details of the ratings are shown on Table 6.

Table 6 Opinion levels on the aspect of “feasibility” of energy management criteria and indicators.

Feasibility	Mean	SD	Level
The school mandating the times for turning on the air-conditioners	5	.00	Highest
The school encouraging the facilities division to clean up air conditioners once a year and maintain them on a regular basis	4.56	.52	Highest
The school encouraging students and personnel to participate in informing the facilities division about damaged appliances and not using them until they are repaired	4.56	.52	Highest
The school encouraging students and personnel to strictly save electricity in buildings	3.67	.50	High
The school encouraging students and personnel to exercise by walking up and down the stairs instead of using the lift	5.00	.00	Highest
Total	4.55	.16	Highest

On the aspect of “utility” of the energy management criteria and indicators, the results showed that the rating level given by the members for this aspect were at high level, with a rating mean value of 4.11. When each item was taken into consideration, the highest level of rating for utility was given for “the school participating in energy management activities organized by external agencies,” with a rating level mean value of 5.00, and “school administrators or teachers providing support to energy management programs” with a rating level mean value of 4.67. The items received a high level of rating include “the school having a good relationship with communities and collectively solving problems when they arise” with a rating level mean value of 4.00, and “school administrators or teachers providing students and personnel knowledge about saving electricity on a regular basis” with a rating level mean value of 3.78. However, for the item of “the energy management committee reporting the status of their operations to school personnel”, the rating level given was only at moderate level with a rating level mean value of 3.11. Details of the ratings are shown on Table 7.

Table 7 Opinion levels on the aspect of “utility” of the energy management criteria and indicators.

Utility	Mean	SD	Level
School administrators or teachers providing support to energy management programs	4.67	.50	Highest
School administrators or teachers providing students and personnel knowledge about saving electricity on a regular basis	3.78	.83	High
The energy management committee reporting the status of their operations to school personnel	3.11	.782	Moderate
The school having a good relationship with communities and collectively solving problems when they arise	4.00	.707	High
The school participating in energy management activities organized by external agencies	5.00	.00	Highest
Total	4.11	.52	High

4.5. Key actors/stakeholders for effective implementation of energy management system

To successfully adopt and implement the criteria and indicators for energy management, key actors or stakeholders need to be identified and be made aware of their duties and responsibilities in driving energy efficiency and energy conservation activities under the energy management plan. The following key actors/stakeholders and their suggested duties and responsibilities are defined below:

(1) School administrators: School administrators are probably the main key actor or stakeholder for implementing and improving energy efficiency in schools. An important mechanism for successful and sustainable energy management is that school administrators are determined to drive and support related programs with systematic practices to achieve efficient reduction of energy costs by applying the criteria and indicators systematically. For successful and continuous implementation of the criteria and indicators, school administrators are required to seriously support the implementation of an energy management plan in collaboration with the working committee, personnel, parents, and communities according to the PDCA cycle, as described below:

(1.1) Plan: School administrators formulate energy management plans or directions appropriate to school context.

(1.2) Do: School administrators assign responsibilities of personnel in charge of energy management by providing them relevant training; supporting sufficient budget, resources, and necessary technology; revising curricula in accordance with energy management needs and contents; creating the environment and learning resources conducive to knowledge inquisitiveness; and investigating operational restrictions of energy management.

(1.3) Check: School administrators issue measures, and evaluation and monitoring methods for the implementation of the energy management policies.

(1.4) Act: School administrators supervise the improvement and revision of the plans as well as drive other energy management programs to ensure their actual and continuous successful implementation.

(2) Teachers and staff: The inputs from teachers and staff are imperative for the success of energy management. They need to work together and contribute towards policy implementation. Additionally, they need to train and communicate with the students through teaching and learning process, to promote student awareness, and to motivate them to participate in energy management campaigns around the school.

(3) Students: Students must be aware and should understand the importance of energy and energy conservation. After being informed, trained and followed the plan developed by the school, the students are expected to raise awareness on the importance of energy consumption and saving in both school and their homes.

(4) Community: The responsibility for raising awareness of energy management should not rest solely with the schools. Community and parental involvement are integral part of effective energy management. Supporting each other would make a positive difference in motivating behavioral change by everyone for energy efficiency.

5. Discussion

The key findings of this study are as follows:

(1) The criteria and indicators were implemented with a complete quality control system. They were practical and suitable for the schools because they were convenient and easy to understand. The nine criteria include the following aspects: administrators as leaders in formulating policies suitable for school contexts; personnel; management; purchase and procurement; communication; inspection, testing, evaluation and follow up; correction and prevention; community and social responsibility; and participation in revisions and improvements. The criteria were consistent with existing management system standards as ISO 50001, Thailand Energy Awards, and Energy Mind Award [13-15].

(2) The results of the evaluation of the criteria and indicators in the three participating schools showed that electricity consumption decreased, which was in line with Thailand 20-year energy conservation plan, under the policy to reduce electricity consumption and promote the 30 percent use of renewable energy [16].

(3) The major role of school administrators is for their respective schools to conduct energy management with optimal efficiency. Thus, it is recommended that they implement the PDCA Cycle by collaboratively establishing the practical guidelines, and analyzing school needs, problems, and their causes, to formulate operational strategies; encouraging personnel to share and seek new knowledge related to their performances, and revise and improve their operations. Although operational policies and guidelines have been formulated, changes are continuous and inevitable due to annual changes in non-centralized and non-binding policies, including transfers of school administrators. The vision of each school administrator can be different, leading to policies being discontinued. Efforts need to be made such that policies be continuously implemented by schools. Personnel should have awareness of energy management and be encouraged to seek new knowledge. Furthermore, budget for necessary technologies should be allocated and provided for the sustainability of energy management programs. School administrators should promote career advancement on a performance-oriented basis, help improve job performances, and accept only qualified persons. Good awareness and values should be cultivated through activities through a routine practical guideline to create a state of continuity [17-20].

6. Conclusions

This research aimed at developing energy management criteria and indicators as well to promote and encourage the participating schools to implement their energy management plan systematically and with continuous improvement. There were 9 criteria and 25 indicators defined under this study. A

training course for the school representatives was organized for them to understand and implement the criteria and indicators. After the implementation, the scoring assessment criteria were conducted to determine the potential and readiness of each school to continue and expand further to other management programs and determine what technical support it required in order for their energy management programs to become continuous and sustainable. Other schools could also apply the criteria and indicators developed from this research in order to conserve energy, reduce costs, and provide educational opportunities for students to be involved in activities regarding to global environmental challenges and solutions.

7. Recommendations

To expand the applications of the findings of this research, schools carrying out energy management programs should fully understand the criteria and indicators to apply them efficiently and in all aspects. Additional information that the school obtained could be used to improve or revise the criteria and indicators for them to become more suitable to the school contexts.

They can be the foundation for new conservation knowledge and for promoting school energy conservation on a regular basis. They can be incorporated into the school policies in accordance with national policies and strategies about energy conservation, which would ultimately lead to energy consumption reduction, consumption of renewable energy, and the decrease of global warming.

References

- [1] Energy Policy and Planning Office. (2014). *Energy policy*. Bangkok, Energy Policy and Planning Office, Ministry of energy.
- [2] Energy Policy and Planning Office. (2011). *Thailand 20-year energy efficiency development plan*. Bangkok, Energy Policy and Planning Office, Ministry of energy.
- [3] Energy policy and planning office. (2014). *Situation of Energy and Electricity Consumption in Thailand in 2014*. Bangkok, Energy policy and planning office, Ministry of energy.
- [4] Ministry of Energy. (2017). *Energy policy Thailand 4.0*. Bangkok, Ministry of Energy.
- [5] Department of alternative energy development and efficiency. (2020). *Alternative energy development plan*. Bangkok, Department of alternative energy development and efficiency, Ministry of energy.
- [6] Salleh, M. N. M., Kandar, M. Z., & Sakip, S. R. M. (2016). Benchmarking for energy efficiency on school building design: A review. *Procedia – Social and Behavioral Sciences*, 222, 211-218.
- [7] Rittikrirkkrai, R. (2003). Energy management system organization. *Energy World Journal*, 6(18), 35-46.
- [8] Ministry of Energy, Strategy and Planning Division. (2017). *The promotion of energy teaching and learning in the basic project*. Bangkok, Ministry of Energy.
- [9] Department of alternative energy development and efficiency. (2020). *Energy volunteer project 2020*. Bangkok, Department of alternative energy development and efficiency, Ministry of Energy.
- [10] Bureau of policy and strategy, office of the permanent secretary. (2020). *Ministry of education strategic plan 2020*. Bangkok, Ministry of Education.
- [11] The Secondary Education Service Area Office 12. (2012). *Educational quality development plan 2012*. Nakhon Sri Thammarat, The Secondary Education Service Area Office 12.
- [12] Amatvanich, N., & Wirunrat, B. (2017). New model of alternative energy project indicators. *Thai journal Humanities Social Sciences and Arts*, 10(2), 2603-2606.
- [13] Metropolitan Electricity Authority. (2015). *Assessment form for the operation of energy and environment conservation in schools Academic Year 2015*. Bangkok, Metropolitan Electricity.
- [14] Department of Alternative Energy Development and Efficiency. (2018). *Documentation guide contest Thailand the energy awards 2018*. Bangkok, Department of Alternative Energy Development and Efficiency, Ministry of Energy.

- [15] International Organization for Standardization. (2018). *ISO 50001: 2018 Energy management systems: Requirements with guidance for use*. Retrieved January 27, 2021, from <https://www.iso.org>.
- [16] Energy Policy and Planning Office. (2017). *Strategic Energy Plan*. Bangkok, Energy Policy and Planning Office, Ministry of Energy.
- [17] Prashar, A. (2017). Adopting PDCA (Plan-Do-Check-Act) cycle for energy optimization in energy-intensive SMEs. *Journal of Cleaner Production*, 5(14), 77–93.
- [18] Javied, T., Rackow, T., & Franke, J. (2015). Implementing energy management system to increase energy efficiency in manufacturing companies. *Procedia CIRP*, 6(12), 56– 61.
- [19] Nallagownden, P., Elamvazuthi, I., & Ibrahim, T. (2014). A review on optimized control systems for building energy and comfort management of smart sustainable buildings. *Renewable and Sustainable Energy Reviews*, 6(34), 409-429.
- [20] Luanpasitsakul, T. (2019). *The characteristics of basic education school administrator in accordance with education goal of Thailand 4.0* (Doctoral dissertation). Bangkok, Silpakorn University.