A study of the present status, minimum requirements and expectation conditions that affect the peak demand of electrical energy at Thai vocational education institutes affiliated to the Office of Technology and Vocational Education Commission

Kalayanee Jitgarun, Apichit Therdyothin & Anuvat Tongsakul

King Mongut's University of Technology Thonburi
Bangkok, Thailand

ABSTRACT: The purposes of this research were to analyse and describe the major factors that affected peak demand electrical energy at vocational education institutes affiliated to the Office of Technology and Vocational Education Commission. The sample chosen for this study were 511 electrical power instructors engaged at vocational education institutes. The instrument used for data collection was a seven-rating scale. The reliability of the instrument calculated by the Cronbach Alpha coefficient was 0.9859. The data was analysed by utilising means (X), Standard Deviation (SD), an analysis of factors by Principal Component Analysis technique (PCA), orthogonal rotation axis using the Varimax method, and the Zone of Tolerance. The results of the study showed that there were five major factors that affected the peak demand of electrical energy as follows: the motor system, the lighting system, the electrical appliance system, the air-conditioning system, and other systems. When the present status, minimum requirements and expectation conditions were compared, it was found that the use of low quality ballasts, such as magnetic ballasts, or general lamp selection, such as non-reflective lamps, and irons left unplugged after use would generate peak demands for electrical energy.

INTRODUCTION

Electrical energy is considered one of the important basic needs of people, as well as for the production of business and industry [1]. Indeed, business and industry requirements in Thailand have been increasing economically each day. According to economic statistics from the past to the present, it was found that the trend of electrical power usage has been increasing; for example, it was 6.7% in 2003 and 7% in 2004 [2].

This increase may relate to the economic profile of Thailand and the rise in demand for electrical appliances, such as electric fans, refrigerators, boiler pots and rice cookers, which was 2.8% higher during 2003-2004 than the previous year [3]. Furthermore, most Thai people prefer light from electrical lamps for their convenience, while machine tools, electric welding and electrical motors are being utilised more in industry.

Forecasts for high peak demand of electrical energy in Thailand indicate that they will continue to rise, as identified in the Ninth (2002-2006), the Tenth (2007-2011) and the Eleventh (2012-2016) Economy and Social Development Plans, citing 1,104, 1,906 and 1,535 megawatts per year, respectively. Moreover, at the end of the Ninth (2002-2006), the Tenth (2007-2011), and the Eleventh (2012-2013) Economy and Social Development Plans, the levels are expected to be 21,648, 29,321 and 38,851 megawatts, respectively [4].

However, causes of high peak demands for electrical energy at vocational education institutes might come from the following wasteful behaviour of electricity consumption:

- Lighting, such as unnecessarily switching on electric lamps or electrical appliances during lunch breaks and excessive lighting outside buildings or working spaces;
- Electrical appliance systems, such as turning on electric fans without having any work done, turning on videos or televisions without anybody watching them, and unplugging electric appliances after use;
- Air-conditioning systems, such as turning on air-conditioning units while the room is already cool or when there is nobody in the room, or cooking with electrical appliances that generate heat in an air-conditioned room;
- Motor systems, such as forgetting to turn off the breaker causing the motor to run without the system being properly used, improper or mismatch of electrical motor utilisation, and lack of proper maintenance;
- Other systems, such as using electrical materials that do not conserve energy, and utilising electrical systems until there is an overload.

Thus, it is the researchers' intention to analyse the major factors, as well as to describe the present status, minimum requirements and expectations of behaviours that affected the peak level of demand for electrical energy at Thai vocational education institutes affiliated to the Office of Technology and the Vocational Education Commission. It is hoped that the results should generate changes in the behaviour of vocational education administrators, instructors, support staff and students. What is more, there is a need to establish rules and regulations, or undertake campaigns for vocational education institutes to conserve energy in a right and more economical manner, as well as utilising standard electrical materials and appliances with higher efficiency, such as reducing one degree of temperature in air-conditioning units will help save electricity by 10% or about 5,000 million Baht per year [5].

OBJECTIVE

The objective of this research is to analyse and to describe the major factors that affect peak demand electrical energy at Thai

vocational education institutes affiliated to the Office of Technology and Vocational Education Commission.

EXPECTED OUTCOMES OF THIS STUDY

The expected outcomes of this study are as follows:

- The administrators of vocational education institutes can adopt the results of this study to plan for reductions of the peak demand for electrical technology, or to campaign for reduced electrical consumption in a proper manner, or to utilise electrical materials and tools that have a high level of efficiency.
- These institutes can train personnel from both the public and private sectors concerning how to use electrical energy efficiently, such as lighting systems, electrical appliance systems, air-conditioning systems, motor systems and other systems. Furthermore, it is important to be aware of the design and installation as identified in specific standards of those systems established by the Engineering Council.
- This study should aid administrators and entrepreneurs to consume electricity more economically and efficiently in their workplaces.

RESEARCH METHODOLOGY

Sample

The sample chosen for this study consisted of 511 electrical power instructors, as well as instructors and support staff who had been trained in electrical conservation.

Tools for Data Collection

The instrument utilised for data collection was a 7-rating scale. The reliability of the instrument was calculated using the Cronbach's alpha coefficient, which was 0.9859.

Data Analysis

The data was analysed using means ($\overline{X}$), standard deviation (SD) and Zone of Tolerance [6]. Additional tests included an analysis of factors by Principal Component Analysis (PCA); orthogonal rotation axis was achieved by utilising the Varimax method [7].

RESULTS OF THE STUDY

Factor Analysis

The results of the study showed that there were five major factors that affected peak demand electrical energy at Thai vocational education institutes affiliated to the Office of Technology and Vocational Education Commission, as follows:

- Motor systems;
- Lighting systems;
- Electrical appliance systems;
- Air-conditioning systems;
- Other systems.

These factors explained 55.079% of the total variance. The correlation coefficient between 5 and 58 variables was 0.768-0.481, while the correlation coefficient between the five factors that affected peak demand electrical energy at vocational education institutes was 0.454-0.681, which was in the high level range. The correlation within the five internal factors was 0.037-0.148, which was in low level range. This is shown in Table 1.

Table 1: Correlation coefficient between five factors with that affected high peak demand electrical energy at vocational education institutes.

Factors	Correlation Coefficient
Motor System	0.681
Air-Conditioning System	0.641
Lighting System	0.623
Electrical Appliance System	0.454
Other Systems	0.563

The regression or prediction equation for key factors for high peak demand electrical energy at the Thai vocational education institutes was as follows:

$$Y = 0.681(M_{otor}\ S_{ystem}) + 0.623(L_{ighting}\ S_{ystem}) + 0.454(E_{lectrical}\ A_{ppliances}) + 0.641(A_{ir\text{-}condition}\ S_{ystem}) + 0.563(O_{ther}\ S_{ystems})$$

The prediction equation has the power of forecasting 40%, and the error of prediction was 20%.

Zone of Tolerance

The means of the present status, minimum requirements and expectation conditions of high peak demand for electrical energy at Thai vocational education institutes were then ranked. The results of the study are listed in Tables 2-5.

Table 2: The highest to lowest means of the variables that affect high peak demand electrical energy for the present status of vocational education institutes.

Rank	Variables	$\overline{X}$
1.	Using low quality ballasts, such as magnetic ballasts	4.722
2.	Lack of proper maintenance of lighting systems	4.544
3.	Lack of proper maintenance and cleaning of air filters of air-conditioning units every month	4.497
4.	Insufficient shade or insulation for the building, resulting in a heavy load for the air-conditioning system	4.456
5.	The number of switches do not match with the number of lamps, eg one switch connects with many lamps	4.429

Table 2 indicates that the largest problem concerning high peak demand for electrical energy for the present status of certain Thai vocational education institutes was the use of low quality ballasts, such as magnetic ballasts, while the lowest problem covered the number of switches not matching with the number of lamps, such as one switch being connected to many lamps.

Table 3: The highest to lowest means of variables that affect high peak demand electrical energy at the minimum requirements for vocational education institutes.

Rank	Variables	$\overline{X}$
1.	Selecting common globes and lamps, such as those without reflection	3.941
2.	Lack of proper maintenance of lighting systems	3.869
3.	Switching on lamps in order to increase light because of dirty walls, ceilings, floors and lamps	3.783
4.	Not closing windows properly, causing heavy loads for air-conditioning systems	3.763
5.	Using low quality ballasts, such as magnetic ballasts	3.728

Table 3 indicates that the highest problem of high peak demand electrical energy at the minimum requirements for vocational education institutes involved the selection of common globes and lamps, such as those without reflection, while the lowest problem covered the use of low quality ballasts, such as magnetic ballasts.

Table 4: The highest to lowest means of variables that affect high peak demand electrical energy as expectation conditions at vocational education institutes.

Rank	Variables	$\overline{X}$
1.	Not unplugging the iron after use	5.493
2.	Putting hot things in, or on top of, the refrigerator, or covering it with a cloth	5.460
3.	Not switching off photocopy machines and not unplugging it after work hours	5.346
4.	Welding with electrical welder unintentionally, such as doing it for fun	5.344
5.	Not turning off the breaker, causing the electric motor to run without being used	5.337

Table 4 shows that the major problem for high peak demand for electrical energy as expectation conditions at vocational education institutes was not unplugging the iron after ironing clothes, while the lowest problem involved not turning off the breaker, causing the electrical motor to run without being used.

The means of the present status, minimum requirements, and expectation conditions of high peak demand for electrical energy at the Thai vocational education institutes were then compared. The results are shown in Figure 1.

Figure 1 shows that at the present high peak demand for electrical energy at vocational education institutes seems to be normal.

The differences of means between the present status, minimum requirements and expectation conditions of the factors that affect high peak demand for electrical energy at the vocational education institutes are listed in Table 5.

Table 5 shows that the present status of factors affecting high peak demand for electrical energy at vocational education institutes was between expectation conditions and minimum requirements.

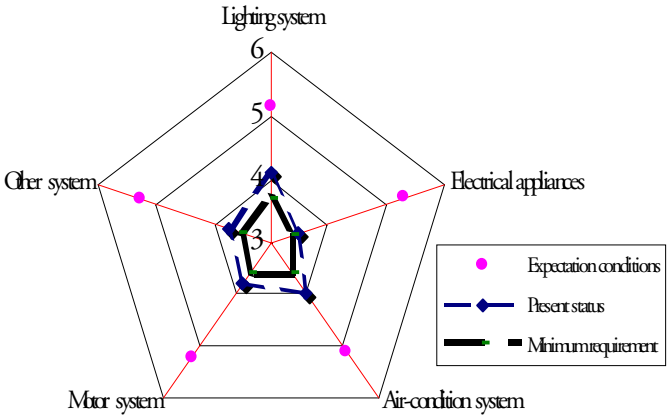

Figure 1: A comparison between the present status, minimum requirements and expectation conditions of high peak demand electrical energy at vocational education institutes.

Table 5: The differences of means between the present status, minimum requirements and expectation conditions of factors affecting high peak demand for electrical energy at vocational education institutes.

Factors	Present Status	Expectation Conditions	Minimum Requirements
	$\overline{X}$	$\overline{X}$	$\overline{X}$
Lighting systems	4.110	5.137	3.982
Electrical appliances	3.484	5.295	3.366
Air-conditioning systems	3.980	5.125	3.583
Motor systems	3.777	5.221	3.589
Other systems	3.716	5.234	3.551

DISCUSSION

The results of the study lead to the following discussion.

The same problem regarding the present status and minimum requirements concerning high peak demand for electrical energy at certain Thai vocational education institutes involved the use of low quality ballasts, such as magnetic ballasts. This problem has also been identified by the Energy Conservation Act of BE 2535 (or 1992), Part 1, Section 7, and Part 2, Section 17, which states that *To reduce electrical energy, there is a need to focus on the improvement of electrical system, electrical materials, and electrical machine*.

Moreover, there is a need to control electrical energy consumption, using it economically so that the cost of electrical energy will be reduced. In turn, this should decrease problems in the environment that have been generated by energy production resources.

Some recommendations to reduce the cost of electrical energy at vocational education institutes are as follows:

- *Lighting systems*: working space, lamp selection and connector kits, the efficiency of light, the life period of lamps, the timing of light to its potential, power and wattage [8].

- *Computer systems*: automatic turning on-and-off and standby settings for monitor screens and hard disks.
- *Electrical appliances*: the selection of appliances with improved electrical conservation or efficiency, setting up appliances so as to help conserve energy, such as the direction and position of electrical appliances, studying their respective manuals, and applying maintenance.
- *Air-conditioning systems*: opening and closing air-conditioning correctly, setting the room temperature at 25 degrees Celsius, using ventilators in air-conditioned rooms, checking electronic controllers, plus the regular cleaning of air filters, evaporators and condensers [9].

According to the Office of the National Energy Policy Commission, Thai vocational education institutes will be subsidised approximately 50% on any project that is concerned with electrical energy conservation, as mentioned in the Energy Conservation Act of BE 2535 (or 1992).

This provides a sound incentive and an excellent opportunity to establish programmes that will conserve electrical energy.

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