The Development of an Appropriate Energy Management System for a NGV Station According to ISO 50001: 2011

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Abstract

This study aimed to develop an appropriate energy management system(EMS) for a NGV station according to the Energy Conservation Promotion Act (ECPA), B.E.2535 (1992) (including as amended in B.E.2550[2007]) and also consistent with the ISO 50001: 2011, as a case study of a NGV station regarded as a controlled building. It was therefore conducted through comparing the 8-stage-procedure of the energy management system according to the ECPA with the requirements specified by the ISO 50001: 2011. Both systems were similar and based on the quality cycle of PDCA. Even if there was still a little difference in required details and there were some more contents and requirements in the ISO 50001: 2011, totally, they were more flexible. There were some principles, however, of significance to be done: identification of areas and volume of the energy use, and goals of the energy conservation. In this study, the Statistical Process Control (SPC) was used as a key instrument to find measures taken to conserve the energy, to monitor and to review the energy management system. The result shows that the total energy can be saved 0.56%, which over the saved energy target 0.48%.

Keywords*:* energy management system, controlled building, ISO 50001-2011

1. Introduction

Final energy consumption of Thailand in each sector is likely to rise each year. Particularly in industrial sector, it became the first rank or about 43 % in 2015 [1]. Even though in public sector, a campaign of various actions has been continuously conducted to promote energy saving in the industrial sector, the consumption has not yet been reduced. This may result from the continuous economic expansion in our country where the impacts of the consumption are on global warming and climate change. Accordingly energy conservation is not just of significance locally in Thailand but also globally across countries. On June 15, 2011, the International Organization for Standardization: ISO, proclaimed the ISO 50001:2011 which can be applied to various types of factories and industries. Those factories which need to consume more energy than that specified in the law or are regarded as those to be under control are required to adopt the energy management system (EMS) according to the Energy Conservation Promotion Act (ECPA), B.E.2535 (1992) (including as amended in B.E.2550 [2007]) and not quite so hard to develop further to meet the ISO 50001. To be certified by the ISO 50001 is to upgrade the EMS to be so efficient and effective that it can be internationally recognized. In order to be effective in the EMS, energy consumption must be continuously, systematically and sustainably efficient.

As for this case study of the natural gas station for automobiles, it is also based on the global concern about energy conservation; the energy must be efficiently used through the EMS. The first to be done is to set the EMS consisting of complete 8 stages of implementation. According to the improving guidelines for energy management, it is to improve the station in compliance with the energy management according to the law through publicizing energy policy, collecting data about energy using, selecting major actions to save the energy and adopting the measurement and evaluation system of energy using. Organizations that have good energy management systems can reduce energy costs by 5-20 percent of total energy consumption [2]. Moreover, it has also been found that such factors as qualifications of those responsible for energy using, executive concern about energy conservation, employee collaboration to conserve the energy and percentage of electricity using for lighting system have significantly affect the potential of a controlled factory to conserve the energy [3]. The actions which are according to the objectives and goals will enable the EMS effective [4]. In addition, it is also discovered

that works by industrial, energy and environmental engineers are inevitably interrelated. Thus, an engineer must understand both the efficiency of energy using and the economic and ecological efficiency necessary in industrial production. The published work [5] has found that when applying ISO 50001:2011 to the EMS plant, such as reducing the number of machines, managing the proper loading of the machine and using natural daylight in plant, it can reduce power consumption. The objective of this study is to apply ISO 50001:2011 to the EMS plant in order to reduce energy consumption.

2. Review of Related Literature

2.1 Developmental Stages of the Energy Management System according to the Energy Conservation Promotion Act (ECPA), B.E.2535 (1992) (including as amended in B.E.2550 [2007])

According to the ECPA, any factories which have one or more electricity meters of 1,000 kilowatts or more or have a transformer of more than 1,175 kilovolts-amperes or yearly use electric energy / heated steam energy or any forms of energy more than 20 million mega-joules are regarded as those required to be controlled, thus, to comply with the 8 developmental stages of the energy management system according to this ECPA as shown in Fig. 1 [6]. Especially, the stages: 4,5,6,7 and 8 must be in compliance with the criteria and methods as specified in the announcement of criteria and methods on energy management for the controlled factories and buildings, B.E.2552 (2009), by the Ministry of Energy.

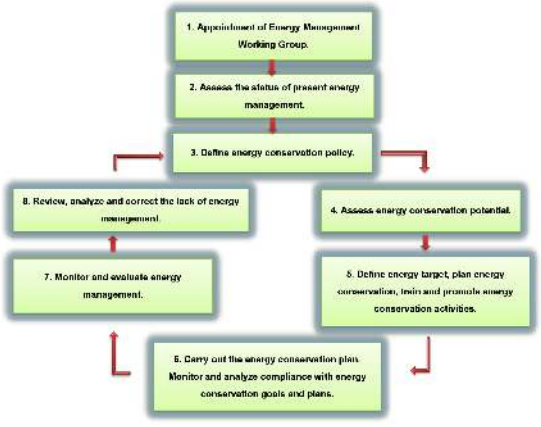

Fig. 1 shows Energy Management System according to ECPA B.E.2535 (1992) (Including as amended in B.E.2550 [2007])

2.2 Requirements by ISO 50001:2011

The ISO 50001:2011 is an international standard for energy management which is similar to ISO 9001 for quality management and ISO 14001 for environment management. It aims to enable to improve the performance, efficiency, using methods and proper using volume of the energy. It also helps to reduce the greenhouse effects, impacts on the environment and cost of the energy using. This standard can be applied to all types and sizes of factories. It consists of requirements, how to implement, and how to set objectives, goals and operational plans which are based on related legal requirements and significant data of the energy using. It is also based on the quality principle of PDCA: Plan > Do > Check > Act, as shown in figure 2[7].

According to the Fig. 2, those factories wishing to be certified are required to follow the 7 items of the requirements for the EMS which are in the Ministry of Industry's announcement, no. 4413, B.E.2555(2012) [7], and consistent with the quality cycle of PDCA. Also in the 7 items, there are systematically definite requirements, guidelines and instruments in 2 dimensions: management and methods.

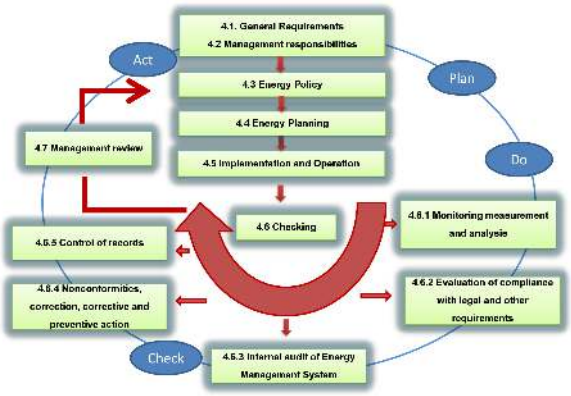

Fig. 2 shows Energy Management System according to ISO 50001:2011

In the dimension of management, a factory is required to have definite policy, objectives and goals of the energy management and to allocate all resources required to achieve these policy, objectives and goals. Training, teaching and such activities as internal communication, publicizing and information dissemination which are necessary for efficient energy conservation should also be done. Moreover, monitoring system, instrument and any

methods for energy using should set up and used. Internal monitoring and assessment should also be conducted to set up improving and preventing guidelines for the energy management. Finally, executives should play significant roles in the review for the efficient and sustainable energy management.

In the dimension of methods, a factory must have energy data management, and an analysis of the energy using for systematic planning. It must also have practical guidelines, rules and regulations, manuals and procedures for the energy management activities such as purchasing, designing, measures selecting, considering proper opportunities for improving energy performance, and organizing of energy using related activities and projects. In addition, the energy using is regularly monitored, measured and analyzed by reliable instruments and then the energy performance is improved.

2.3 The Energy Management according to the ECPA as Compared with the ISO 50001:2011

As for those factories regarded as under control, it is not so tough to set up the EMS complying with the ECPA and to develop further towards the ISO 50001:2011 despite more details to be done because both are mutually consistent with the quality cycle of PDCA. As shown in Table 1, the ECPA consists of the 8 stages whereas the ISO 50001:2011 is composed of the 7 items.

According to the comparison in the Table, the ECPA's 8 stages can be completely applied to the ISO 50001:2011's 7 items even though there are more details in the latter which can be seen in the Ministry of Industry's announcement, no. 4413, B.E.2555 (2012) [7], and in the announcement of criteria and methods on energy management for the controlled factories and buildings, B.E.2552 (2009), by the Ministry of Energy [6].

Table.1 Comparison between ECPA and ISO 50001:2001

P-D-C-A	ECPA B.E.2535 (1992) (including as amended in B.E.2550 (2007))	ISO 50001:2011
Stage and management	1. Appointment Energy Management Working Group	4.1 General Requirements
	2. Access Energy Status	4.2 Management responsibilities
Plan	3. Define Energy Policy	4.3 Energy Policy
	4. Access to energy Potential	4.4 energy Planning
	5. Define energy target and plans	
Do	6. Carry out and monitoring	4.5 Implementation and Operation
Check	7. Monitor and evaluate	4.6 Checking
Action	8. Review and analyze	4.7 Management review

2.4 Statistical Process Control-SPC and the Energy Management System-EMS

Data on energy consumption and obtained products in the past are important to be analyzed to get the behavioral pattern of the energy consumption leading to the assessment whether the energy using potential is improved or not. In this case, an instrument to be used in such analysis is the Statistical Process Control / SPC. In the SPC, such numerical and tabular data on energy consumption as monthly volume of the used energy and the products monthly obtained are converted into the graphical ones in various forms. Basic techniques used in the SPC are as follows [8]:

1. Scatter plot
2. Regression analysis, and
3. Difference and Cumulative Summation of Difference Chart or DIFF and CUSUM

In order to set up goals of energy conservation in the planning stage according to the ISO 50001:2011, the analyses of previous energy using potential are of useful significance.

3. The Study Results and Data Analysis

In this study, the Thailand's EMS according to the ECPA was adjusted to become consistent with that of the ISO 50001:2011through assessment of the EMS of a case study of a natural gas station for automobiles regarded to be a controlled factory according to the ECPA, B.E.2535 (1992) (as amended in 2550[2007]) because it used 100% of electric energy in its process of production. The results are as follows:

3.1 Similarities & Differences between the ECPA's & the ISO 50001:2011's EMS

According to the Table 2, the ISO 50001:2011's EMS consists of both the adjusted EPCA's and new items.

Again in the Table 2, the first new item added was a handbook of the energy management identifying the definite scope of the EMS and appointing a representative from the factory's working group. In the case of the gas station, the vice-chairman for the factory's working group who understood the ISO 50001:2011's EMS clearly well was appointed.

As for the policy on the EMS of the natural gas station, it was the integration from both the ECPA's & the ISO 50001:2011's. Thus, it consisted of all those in the ECPA's plus supporting product acquisition, service of efficient energy and designing to improve energy performance from the ISO 50001:2011's.

Table.2 Similarities & Differences between the ECPA's & the ISO 50001:2011's EMS

As for the energy planning, it was done in a form of a document through an analysis of previous data. In this case study, the SPC consisting of the scatter plot, the regression analysis, and the DIFF and CUSUM graphs was used to the previous 2- year behavioral patterns of energy using to set up goals of energy conservation. According to the ISO 50001:2011's EMS, the energy planning could not be done unless the significant behavioral patterns and the significant volume of energy using had been identified. The author used the criteria for the assessment from a reference of a report of the EMS according to the ECPA.

In the implementation and operation, those operators whose works with machines consuming significant volume of energy were required to be trained to efficiently use energy according to the ISO 50001:2011's EMS. Therefore, the energy using which was significant to the efficiency was daily checked. In addition, in acquiring procedures of energy-related products and instrument which might significantly affect the energy using, the purchasing sections were required to notify the selling companies that the purchasing procedures were included in the performance assessment of the energy using. For example, in the case of the compressor with significant use of energy, any part of it which is required to be replaced by a new one is to be assessed using an assessment form if it has used the energy efficiently or not.

The monitoring content according to the ISO 50001:2011's EMS is more than that of the ECPA's where only the one responsible for energy using and the working group are monitored. According to the ISO 50001: 2011's EMS all departments, where significant use of energy is found and monitored. It is important to well prepare the assessing checklist before monitoring; doing so enables the monitoring to be smoothly and completely done. Moreover, in the management review—final requirement in the ISO 50001:2011's EMS, the number of items to be reviewed is also more than that of the ECPA's.

3.2 Assessment to Determine the Patterns and Amounts of Significant Energy Use

In the EMS according to the ISO 50001:2011, the patterns and amounts of Significant Energy Use or SEU are to be identified. The SEU refers to the high proportion use of energy as compared to the overall of a factory/ a system / a machine. Criteria used to assess the SEU must also be compatible. In this case of the natural gas station, the criteria which was designed and developed by the author required the one responsible for energy using and the working group to assess using the criteria in the Appendix H attached to the report of energy management on the significant performance of the machinery [9] to determine measures for energy conservation including 3 items: (1) amount of energy using, (2) working hours, and (3) improved performance. Then, the assessed points were taken to be multiplied by one another and the result of 80 points and above was regarded as significant as shown in Table 3.

Table.3 Assessment to Determine the Patterns and Amounts of Significant Energy Use

Main Equipment			Quantity	Energy type													
Name	Capacity	Unit			1	2	3	4	5	1	2	3	4	5	1	2	3	4		
Air conditioners	[illegible]	[illegible]	5	Electric					5					5				4	100	Sty
	[illegible]	[illegible]	5	Electric					5					5				4	100	Sty
	[illegible]	[illegible]	2	Electric					5					5				4	100	Sty
	[illegible]	[illegible]	10	Electric					5					5				4	100	Sty
	[illegible]	[illegible]	4	Electric					5					5				4	100	Sty
	[illegible]	[illegible]	3	Electric					5					5				4	100	Sty
Lightings	400	W	70	Electric					5				4					4	80	Sty
	36	W	440	Electric					5				4					4	80	Sty
	11	W	100	Electric					5				4					4	80	Sty
Motor	3	kW	1	Electric					5					5		2			50	
	7.5	kW	15	Electric					5					5		2			50	
	200	kW	11	Electric					5					5		2			50	
	415	kW	2	Electric					5					5		2			50	

3.3 Goal Setting for Energy Conservation

Goal setting for energy conservation according to the requirement item 4.4, on energy planning in the EMS of the ISO 50001:2011 is critically significant because too high or low goals may be too difficult to practically achieve. Therefore, the appropriate goal setting should be based on results from the analyses and assessments through the SPC, consisting of scatter plot, regression analysis and DIFF and CUSUM, of the previous data of the energy use such as production volume and various types of the energy use. In this case of the natural gas station, data on the energy use and the production volume during the previous 2 years were collected to draw the scatter plot to be analyzed through the simple regression analysis to determine a baseline equation of the total data. The baseline equation of the total data was again analyzed to determine the DIFF and the CUSUM. Then the top 6 minus DIFF values or the differences between the actual electric energy use and the baseline one were selected to determine the baseline equation (as shown in Fig. 3) of the cited energy in previous 6 months again through the scatter-plot drawing. Later, the baseline was analyzed to determine the cited value (basic electric energy). The DIFF and the CUSUM graphs (as shown in Fig. 4) were then drawn according to all mentioned energy data. Finally, the potential volumes of the energy which have been saved can be concluded.

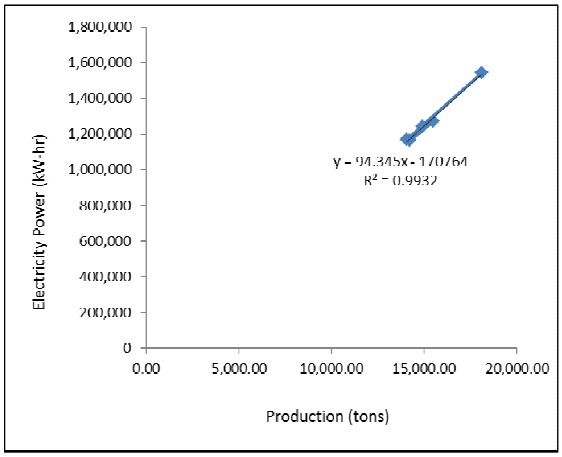

Fig. 3 shows relation between electricity power and production

As shown in Fig. 4, there were the potential volumes of the energy which could have been saved in 2 years. The total CUSUM for 1-12 months, 13-24 months and total 24 months are 11,375,574, 19,785,340 and 31,160,914, when going into details comparatively, the conservation potential volumes of energy in the 1st year (month 1 -12) and in the 2nd year (month 13 -24) were in close proximity or equal to 36.51 % and 63.49 %, respectively.

These also represented the energy using behavior in the 2 years. Thus, the goal of energy conservation can be evaluated through the difference between the conservation potential volumes of energy in the 1st and 2nd year or the different value in the figure 4= 1,898,356 kWh or 6.43 % of the total value of energy used in 2 years = 29,532,060 kWh. Thus, in the case study of the natural gas station, the best cited data in 6 months were taken to set up its goal of the energy conservation.

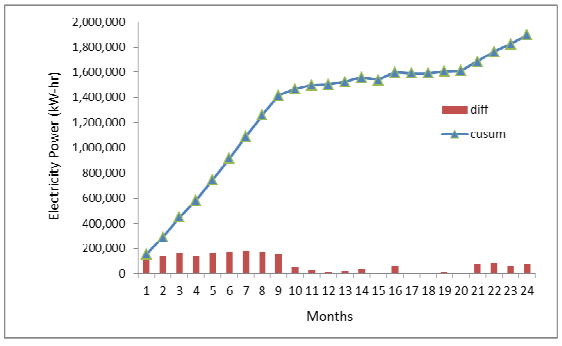

Fig. 4 shows potential of energy conservation

3.4 Measures Designated to Conserve the Energy

To designate measures to conserve the energy firstly requires a survey exploring the significant energy use by machinery, tools or any procedures from those responsible for them. However, during such surveying, other measures can be taken by some other ways based on the principle that the measures must be consistent with the factory goal of the energy conservation and that the result from saving makes the factory achieve its goal. As for the measure taken in this case study was 1) reduce using hours of Metal Halide 2) reduce using hours of light bulbs, fluorescent and essential energy saving lamps 3) reduce using hours of air conditioning.

3.5 Monitoring & Review of the EMS

Monitoring & review of the EMS need to be continuously done to audit the factory's previous performance whether it is consistent with its goals and the operational plan. It is the factory's internal audit. As for the case of the natural gas station in this case study, the monitoring of the EMS is required to be done once a year whereas the review is done by the executive board according to the last requirement in the ISO 50001 before getting into the new cycle of operation consistent with the PDCA principle of consecutive improvement. The review by the executive board must cover all previous operational affairs and meet all requirements in the ISO 50001 in the case study of the natural gas station; it is also required to be done once a year.

4. Conclusion and Recommendations

4.1Conclusion

The result from this study shows that the total energy can be saved 0.56%, which over the saved energy target 0.48%. Moreover, in the development of the EMS for those factories regarded to be under the control according to the ECPA, main missions to be done further are: (1) to identify the patterns and amounts of Significant Energy Use or SEU, (2) to design something related to the SEU to improve operational efficiency, (3) to acquire products and services related to efficient energy, and (4) to set up a documentary system for collecting documents resulting from the EMS according to the ISO 50001. Thus, those factories have systematically managed their energy using according to the PDCA principle so that their EMS's are internationally acknowledged. Their executives are well aware of the significance of the EMS and more employees take part in the energy conservation. More importantly, the goal setting for energy conservation which is tangibly done will result in that the outcomes of the energy conservation are therefore in the definite numbers leading to the EMS certified by the ISO 50001:2011.

4.2 Recommendations

The development of the EMS according to the ISO 50001 needs overall cooperation from top to bottom of a factory or else it cannot achieve the goal. To identify the patterns and amounts of Significant Energy Use or SEU, the volume and hours of energy using should be used. To set up the objective or goal, the previous data used to do so should be real and at least one year before; too few data cannot clearly suggest the behavior of energy using in last year. In addition, measures to conserve the energy should be consistent with the factory's goals. Particularly important, the factory's human resources should be developed to sufficiently learn about the energy conservation to systematically and sustainably drive the factory's EMS forward.

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