The Development of Participatory Energy Conservation Promotion in Designated Chemical Industrial Factories

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Abstract
The objectives of this study were 1) to analyze the key components of the participatory energy conservation promotion in designated chemical industrial factories and 2) to develop a model of participatory energy conservation promotion in designated chemical industrial factories. The population was comprised of the executives and employees in designated chemical industrial factories. The mixed-method research approach integrating quantitative and qualitative methods was adopted in the present research. The research instruments were the semi-structured interview sheet and questionnaire. The data were analyzed using the content analysis technique, the statistical analysis of frequency, percentage, mean, and standard deviation, and the exploratory factor analysis method. The results from the exploratory factor analysis were used to develop the model of participatory energy conservation promotion. The developed model was reviewed through the focus group discussion with 12 experts in order to confirm its validity and completeness. The results suggested that the model of participatory energy conservation promotion in designated chemical industrial factories consisted of 9 components of internal factors, called SENSATIONS^2: 1) Synergy, 2) Encouraging leadership, 3) Know, 4) Strategy, 5) Attribute, 6) Technique, 7) Improvement, 8) Organization, and 9) Numerical chemistry, and 2 components of external factors: 1) Standardization and 2) Stakeholders.
Keywords: Development, Participatory Energy Conservation, Promotion, Designated Chemical Industrial Factories

Introduction
Energy is an important factor in meeting the basic human needs or livelihood requirements. It is also a key factor in the business and industrial sectors. Thus, it has a direct impact on the overall economy and competitiveness.
Thailand's energy consumption has a tendency to increase, due to various supportive factors, including the government expenditure and investment, household consumption, and private investment. The national energy consumption was reported to increase by 0.8%, 2.7%, and

2.6% in 2014, 2015 and 2016 respectively (Department of Alternative Energy Development and Efficiency, 2016).

Thailand has the law about energy conservation, which is called the Energy Conservation Promotion Act B.E. 2535 that aims to promote energy efficiency in designated buildings and factories through the application of energy conservation techniques. The trend of energy conservation has consequently changed and tends to focus more on the dimensions of management and participation (Department of Alternative Energy Development and Efficiency, 2009). In order to achieve a more concrete result, the government has established participatory energy conservation programs in designated factories enrolling in the pilot plant scheme since 2002 with the aim to increase employees' participation in energy conservation and enhance rapid and effective outcomes. Later, the Energy Conservation Promotion Act (No. 2) B.E. 2550 was introduced. This new law aims to systematically and sustainably develop and promote employees' participation in energy management and efficiency activities and to encourage the use of energy management standards as a basis for energy conservation.

Chemical industry is important to the national energy consumption because it is considered one of the energy intensive industries. As energy consumption is mostly related to production process, employees' cooperation is required to obtain good energy conservation results. In terms of energy efficiency, the report on Thailand's energy conservation 2016 revealed that the energy efficiency of designated factories did not meet the target specified in the Energy Efficiency Plan 2015-2036 determined by the Ministry of Energy. In addition, there has been only a limited number of training courses or research studies on energy conservation in the chemical industry. All of these are the significance and background of the present study.

Research Objectives

The objectives of this study were 1) to analyze the key components of the participatory energy conservation promotion in designated chemical industrial factories and 2) to develop a model of participatory energy conservation promotion in designated chemical industrial factories.

Literature Review

Energy Conservation: Energy conservation can be done in several ways. Technology-based energy conservation is one approach that has been initially applied. As this approach focuses on replacing machinery and equipment and changing production processes (Wai, Mohammed, & Alias, 2006), it requires a high investment budget, resulting in a higher risk of losses. Moreover, it may cause inefficient use of technology, if involved persons are careless.

Behavior-based energy conservation places emphasis on saving energy through changing user behaviors. It is considered the best energy conservation approach (Jones, 2015; Ting, Mohammed & Wai, 2011) that requires cooperation in order to obtain long-term benefits (Chaiburee, 2013). Behavioral changes can result from attitude changes, which are associated with motivation, awareness, adequate skills and competencies. (Morvay & Gvozdenac, 2008).

Participatory energy conservation is another energy conservation approach, where everyone in an organization participate in energy conservation activities. It consists of 3 main components: 1) an organizational policy that focuses on providing financial support and encouraging leaders to act as a role model for employees, 2) an energy conservation committee comprising representatives of various departments that work together to implement the organizational policy, develop operational plan, and facilitate understanding and cooperation between the top management and lower-level employees, and 3) operational

employees that play the most important role because they are closely related to the production process and have the most energy-related information. Energy conservation measures can be developed through employees' cooperation and suggestion (Department of Alternative Energy Development and Efficiency, 2007).

Concepts of Participation: Participation is essential to the success of each activity and program. The achievement of consumer-based energy conservation in industrial factories relies on cooperation of operational employees in every process of production.

Cohen & Uphoff (1980) categorized participation into 4 dimensions: 1) participation in decision-making, which is the initial stage of participation associated with communicating and providing clear information about a collaborative activity or program in order to develop understanding, encourage sharing of opinions, prioritize problems, determine options, and evaluate solutions and decisions; 2) participation in implementation, which is concerned with participating in a program through providing various forms of cooperation such as labor, raw material, and relevant information and participating in management and coordination process in a voluntary and continuous manner. At this stage, training may be provided or recommendations may be made; 3) participation in benefits, which is involved with material benefits, social benefits, personal benefits, 4) participation in evaluation, which is associated with sharing opinions that reflect levels of satisfaction and providing suggestions in order to monitor and control all related activities.

Concepts of Motivation: Motivation refers to forces that drive each individual to do some activities in order to achieve what he or she wants (Moorhead & Griffin, 2010 cited in Rurkkhum, 2014). The end-results of each motivation is reward or compensation. There are two types of reward (Tiyao, 2000): 1) extrinsic reward, which is a reward given by other people such as salary, promotion, special assignment, and certificate and 2) intrinsic reward, which is a reward or pleasure an individual directly gets from performing an activity such as gaining more abilities, expertise, knowledge and feeling proud of his or her tasks or social works (Kaewchuay, 2015). When extrinsic and intrinsic rewards are appropriately used, it can make executives succeed in tasks that rely on motivation (Tiyao, 2000).

Concepts of Transformational Leadership: Transformational leadership is a leadership approach that causes changes and transformations of things. It consists of 4 main components (Bass & Avolio, 1994): 1) idealized influence, which emphasizes that leaders should act as a role model with ethics, morality, and public dedication, 2) inspirational motivation, which is associated with leaders' use of positive communication style to build engagement in terms of organizational goals, enhance cooperation in exchanging ideas, and create the power to drive an organization forward, 3) intellectual stimulation, which focuses that leaders should encourage employees to have self-confidence, develop problem-solving abilities, and generate creative ideas necessary for changes, and 4) individualized consideration, which concentrates on leaders' role in mentoring, coaching, supporting, and accepting the ability of each employee in order to promote teamwork, build internal motivation, and achieve success at work.

Research Methodology

The present research adopted the mixed-method research approach, consisting of qualitative method and Quantitative method.

The qualitative method used was the in-depth interview with 7 executives of designated chemical industrial factories that were selected through a purposive sampling technique, requiring five to thirty participants (Nastasi & Schensul 2005 cited in Sutheewasinnon & Pasunon, 2016). The obtained data were analyzed using the content analysis method in order to find out the key components of a model. As for the quantitative research design, the questionnaire was developed based on the theoretical framework derived from the literature

review and the data obtained from the in-depth interview. The respondents were 68,610 employees in 373 designated chemical industrial factories (National Statistical Office, 2011), which were comprised of petroleum products sectors and chemical products sectors. The sample size of 382 was defined using the table of Krejcie and Morgan (Krejcie & Morgan, 1970) with a confidence level of 95% and an allowable error of.05. Multi-stage cluster sampling was implemented in this study. Regarding the quantitative analysis, the data obtained through the questionnaire were analyzed with the descriptive statistical analysis and exploratory factor analysis methods. The results were used to develop a model of participatory energy conservation promotion in the designated chemical industrial factories. The developed model was reviewed by the experts with the use of the focus group technique, requiring five to ten participants (Nastasi & Schensul 2005 cited in Sutheewasinnon & Pasunon, 2016). The obtained comments and suggestions were used to revise the model in order to ensure its completeness.

Research Results

The Key Components of the Participatory Energy Conservation Promotion in Designated Chemical Industrial Factories

Results from the in-depth interview: The key informants were asked to rate the importance of participatory energy conservation in designated chemical industrial factories, ranging from low-level to high-level. The results indicated that all key informants thought that the importance of participatory energy conservation was at the high level. They explained that if the employees especially who work with machinery and equipment understand the concept of energy conservation and comply with the energy efficiency measures, it will lead to organizational success and sustainability. However, the participatory energy conservation should be increasingly developed and supported in terms of the implementation of energy management system standards such as ISO 50001 and the promotion of voluntary participation through Kaizen or QCC activities.

Based on the theoretical framework derived from the literature review and the data obtained from the in-depth interview with the executives of the designated factories, which was carried out to investigate the key factors of participatory energy conservation promotion in designated chemical industrial factories, it was found that there were 59 internal factors variables and 2 external factors variables. The obtained data were used to develop the questionnaire with a 5-point rating scale. The questionnaire was examined by 5 experts using the item objective congruence (IOC) (Rovinelli & Hambleton, 1977) in order to ensure the content validity. After being revised according to the experts' suggestions, the questionnaire was tried out on 30 employees in other designated chemical industrial factories in order to examine the reliability of the research instrument with the Cronbach's alpha coefficient method (Cronbach, 1951 cited in Karnreungsiri & Praditsuwan, 2017). The results indicated that the reliability value of the participation was 0.942, the strategy was 0.907, the leadership was 0.949, the technique or skill was 0.889, the attribute was 0.914, the knowledge was 0.801, the external factors was 0.858. These value were higher than 0.70 which means that the scale measurements in this questionnaire have an acceptable level of reliability (Hair et al., 2010).

Results from the questionnaire: Regarding the basic information of the respondents, it was found that most of them were male (77.5%), aged less than 30 years old (25.5%), held a bachelor degree (38.6%), and had worked in the current factory for 5-10 years (26.0%).

The means of the factors of the participatory energy conservation promotion were between 3.08 and 4.23. The importance values of the factors were at the moderate to highest level. Most of the factors were found to have a high level of importance. The factor with the highest

level of importance was "an energy conservation committee comprising representatives of various departments" (Mean = 4.23, SD =.90).

Analysis of the internal factors: Considering the analysis results of the internal factors, the Bartlett's Test of Sphericity was used to examine the overall significance of correlations among variables ($p < .05$) and the Kaiser-Meyer-Olkin Measure of Sampling Adequacy was used to examine the relationship between the 59 internal factors variables. The results revealed that the examined data were presence of correlation among variable with the significance of Bartlett's Test of Sphericity ($p < .05$) and were most adequate for factor analysis with the KMO value of.901 (Kaiser & Rice, 1974). Then the variables were analyzed using the principal component analysis and varimax orthogonal rotation techniques. The results showed that there were 9 components with eigenvalues greater than 1. The cumulative percentage of variance was reported at 71.25.

The maximum factor loading of each variable was used to decide whether it would fall under which component. In order to confirm the practical significance of the variable classification, the factor loading had to be greater than.50 (Hair et al., 2010). By adhering to this criterion, three variables were removed. There were only 56 variables left.

Analysis of the external factors: Regarding the results of the external factor analysis, the 9 external factors variables were also examined with the same method that was used for the internal factor analysis. The results indicated that the data were presence of correlation among variable with the significance of Bartlett's Test of Sphericity ($p<.05$) and were highly adequate for factor analysis with the KMO value of.813 (Kaiser & Rice, 1974). There were 2 components with eigenvalues greater than 1. The cumulative percentage of variance of the two components was 65.00.

Based on the factor analysis, it was found that the internal factors were comprised of 9 components and 56 variables. The external risk factors were composed of 2 components and 9 variables.

The Development of a Model of Participatory Energy Conservation Promotion in Designated Chemical Industrial Factories

The analysis results were used to develop a model of participatory energy conservation promotion in designated chemical industrial factories. The focus group discussion was carried out in order to review the developed model. The 12 experts participating in the focus group discussion were comprised of 6 scholars and 6 executives and engineers of designated chemical industrial factories. The model was approved by the experts. The obtained feedback and suggestions were used to modify the model until it was completed.

A model of participatory energy conservation promotion in designated chemical industrial factories, which was called SENSATIONS^2, was presented in a mind-map form as shown in Figure 1.

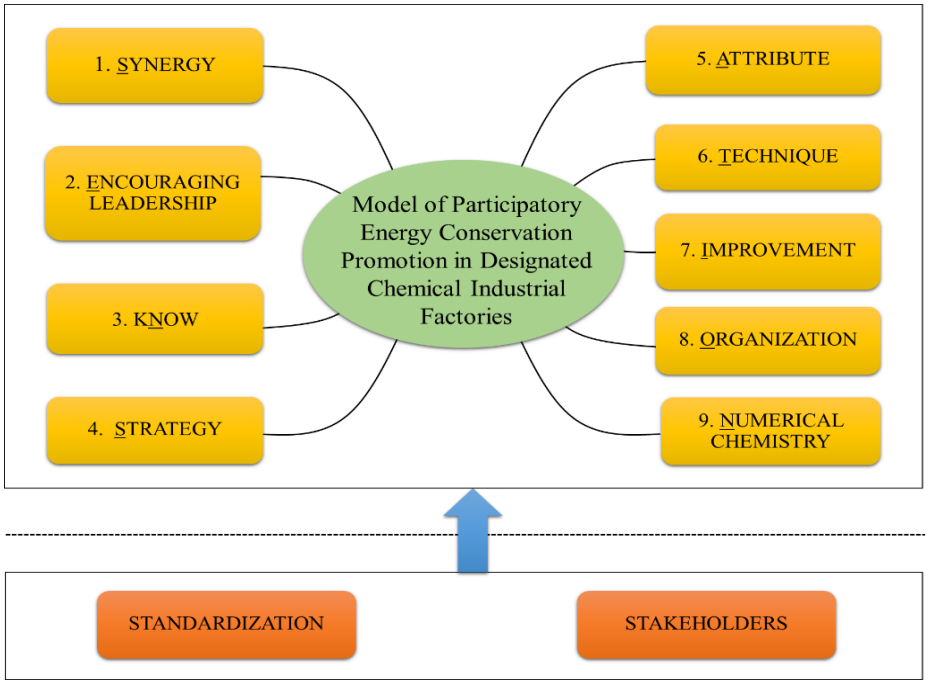

Figure 1 A conceptual model of participatory energy conservation promotion in designated chemical industrial factories (SENSATIONS^2)

Based on the research results, it could be summarized that the model of participatory energy conservation promotion in designated chemical industrial factories consisted of 9 components of internal factors and 2 components of external factors which was called SENSATIONS^2.
The internal factors consisted of the following components. 1) Synergy or participation in implementation, participation in benefits and participation in evaluation, 2) Encouraging leadership, 3) Know or participation in decision-making, 4) Strategy, 5) Attribute, 6) Technique, 7) Improvement, 8) Organization, and 9) Numerical chemistry or Stoichiometry knowledge. The external factors were composed of the following components. 1) Standardization and 2) Stakeholders.

Discussion and Conclusion

According to the research results, the executives of the designated chemical industrial factories thought that employee participation was highly important. The employee participation significantly contributed to the success of energy conservation. If the employees at all levels participate in energy conservation, it will result in sustainable success. The energy management should be carried out using a top-down approach by adopting the energy management standards such as ISO 50001 to enhance participation within an organization. A bottom-up approach should also be applied through conducting Kaizen or QCC activities so that employees can initiate and practically take part in the energy conservation process. This is considered a management style that integrates western and eastern cultures to promote participatory energy conservation throughout the organization in a sustainable way.
Components and patterns of participatory energy conservation promotion in designated chemical industrial factories: Building participation is a process of encouraging employees to voluntarily participate in energy conservation activities and cooperate in group activities, including suggestion system and Kaizen activities. This is in line with the study of Kardkarnklai (2006), which suggested that Kaizen activities enable employees to develop creative ideas and energy conservation approaches in a factory. Kaizen activities are considered guidelines for team management that focus on improving overall work practice of

employees at all levels and seeking new approaches to improve operational practice in a continuous way. Executives and engineers should play an important role in providing advice and support (Imai, 2012) in order to make employees motivated and willing to achieve energy conservation goals. In this process, motivation building is required. Energy conservation project contests should be carried out so that those who initiate energy conservation innovations can showcase their talents and receive rewards and compliments from executives. Once they get recognized, they will be proud and motivated to continue working. In addition, providing employees opportunities to share experience with colleagues makes them proud of themselves and their team. This will also inspire other employees to follow their actions (Copying Effect), which leads to a continuous participation in energy conservation (Rowenstrunk & Mutze-Niewohner, 2010). The component about participation building is consistent with the participation concept of Cohen & Uphoff (1980) in terms of participation in implementation, participation in benefits, and participation in evaluation.

Promoting energy conservation in organizations requires the participation of executives to cooperate with employees at all levels. This is similar to the concept of Morvay & Gvozdenac (2008), which suggested that leadership plays an important role in making changes and building cooperation in energy saving. Success in participation building depends on the determination of leaders. This is in line with the transformational leadership concept of Bass & Avolio (1994), which indicated that the characteristics of transformational leaders included being a role model, creating inspiration, focusing on creativity, and serving as a mentor and coach.

Creating awareness is a process of communicating and providing knowledge in order to build understanding through various public relations channels. Clear, accurate, and easy to understand communication will make people understand and develop energy saving ideas (Chaiburee, 2013). This is consistent with the participation concept of Cohen & Uphoff (1980) in aspect of participation in decision-making, which suggested that providing people with right and concrete information will make them interested and decide to join a program. The role model is in line with the concept of Morvay & Gvozdenac (2008), which stated that supervisors have an impact on the behaviors of subordinates so they should act as a role model for energy saving in order to make the subordinates willing to follow them. The component about training and building awareness in energy conservation is similar to the finding of Jirawatwong (2010), which indicated that training and educating will help to create employees' awareness in energy conservation. The component about seeking energy conservation opportunities through organizing workshops and experience-sharing forums is consistent with the concept of Rowenstrunk & Mutze-Niewohner (2010), which suggested that participative workshops related to energy conservation are powerful tools that enhance learning and sharing of energy conservation ideas among employees from different functions. Brainstorming is a creative technique for problem solving (Pangsranoi, 2014). Scrutiny is needed to achieve a viable project (Rossiter & Davis, 2015). Discussion is a form of participation-building process (Rowe & Frewer, 2000 cited in Penglee & Sorakraikitikul, 2017).

In terms of management strategies, in order to achieve concrete and sustainable results, it is necessary to have a good energy management system and appropriate operational planning. Senior executives must determine a clear goal and policy, intend to continuously improve energy efficiency, and be ready to allocate adequate resources in an appropriate way (Phojkrajang, 2013).

Production processes in the chemical industry are associated with using chemicals to create chemical reactions. Improving chemical reactions in unit operation is considered a way to reduce energy consumption (Rowenstrunk & Mutze-Niewohner, 2010). An important energy

conservation technique in the production process of the chemical industry is reusing heat from chemical reactions.

Knowledge about energy analysis and solutions is important to the improvement of work or production process for energy efficiency. In a more complicated process, knowledge about heat integration using pinch analysis can be used to conserve heat energy in the chemical process, which contributes to reducing energy consumption in the utility system (Jones, 2015; Rowenstrunk & Mutze-Niewohner, 2010).

Participatory organization should be established consisting of a senior executive, who act as the chairman of an energy conservation committee, and representatives from every department, who serve as the energy conservation committee members and work together using the representative participation approach. Each representative will coordinate between the senior executive and operational employees in order to create better understanding and cooperation

Components of external factors: In addition to the energy conservation law, the Energy Efficiency Plan (EEP 2015) and the Energy Efficiency Action Plan 2017-2021 were also determined by the Ministry of Energy in order to emphasize that designated factories should continue to improve their production and energy efficiency by themselves and further carry out their energy management activities according to the Thai law and international energy management system standards such as ISO 50001 (Ministry of Energy, 2015).

At present, both public and private organizations play an important role in promoting participatory energy conservation through implementing energy and environmental management systems and conducting various activities and projects related to greenhouse gas reduction such as carbon footprint and green industry programs, which require cooperation in the supply chain.

The implementation of energy conservation programs mentioned above is usually involved with participatory activities of people within and outside an organization. If an organization succeeds in carrying out its internal participatory energy conservation activities, it will be able to communicate and convince its stakeholders to participate in external energy conservation activities, especially the activities that show the organization's social responsibility towards communities and customers. This will help to create reliability and enhance sustainable coexistence between business and society.

Recommendations

1) Chemical industrial factories that adopt the ISO 50001 energy management standard to promote participation and enhance cooperation within their organization should simultaneously carry out group activities such as Kaizen and QCC activities in order to integrate management systems and achieve top-down and bottom-up cooperation.

2) Regarding energy conservation techniques used in the chemical industry, there should be further studies on the utilization of heat generated from exothermic reactions, starting from the process of design.

3) The government should design more chemical engineering training courses for those personnel responsible for energy in designated chemical industrial factories.

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