

A Guideline of Fuel Oil Saving in Manufacturing Sector of Thailand

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Abstract

Fuel oil is the primary fuel used in Thailand's manufacturing sector. Currently, the use of fuel oil is steadily increasing, and the world's oil reserves are slowly depleting. Therefore, the Thai manufacturing sector needs to adapt to this situation. The purpose of this research is to investigate possible strategies for fuel oil savings in the manufacturing sector of Thailand by looking at different types of factory sizes. Qualitative research was conducted through in-depth interviews with nine experts to create tools for quantitative research. A focus group discussion of 11 experts was conducted to reach a consensus on the model of this research, and qualitative research methods were used when analyzing five-hundred factories. The results showed that a strategy for fuel oil saving in the manufacturing sector of Thailand aimed to achieve sustainability encompassing four factors. 1) Innovation and Technology ($\bar{X}$ = 4.65); an essential item was "Using Smart Plant technology to control fuel oil properly. 2) Organization System ($\bar{X}$ = 4.64); the most important item was "Annual budget allocation for investment expenses for energy conservation and oil energy management. 3) Eco-efficiency ($\bar{X}$ = 4.61): The most important item was the installation of a solar rooftop on the factory roof for lighting systems. 4) Mindset ($\bar{X}$ = 4.60). The most important item was encouraging personnel to participate in the formulation of fuel-oil-saving measures. The hypothesis testing revealed that differences in the number of personnel in the organization between "less than 200 people" and "greater than or equal to 200 people" revealed overall aspects significantly different at the level of 0.05. An analysis of the structural equation model showed that the results passed the assessment criteria using empirical data. The Chi-square Probability Level (CMIN-p) was 0.064, and the relative chi-square (CMIN/DF) was 1.134. The Goodness of Fit Index (GFI) was

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0.954. The Root Mean Square Error of Approximation (RMSEA) was 0.016.

Keywords: A Guideline of Energy Saving, Fuel Oil, Manufacturing Sector of Thailand

Introduction

Energy is an essential foundation for economic and social development in the country. The energy was used at every activity step—transportation, agriculture, and other industries (Kim et al., 2021). Energy drives everything endlessly to spin. Humans still have an unlimited demand for resources. With the prosperity that occurs simultaneously in all aspects nowadays, natural resources such as fuel and natural gas, which are limited, have begun to diminish (Manganelli et al., 2021). They are using each other without saving or realizing the benefits. In the future, there may be conditions of global variability that will cause humans to make significant adjustments owing to the exhaustion of energy sources. Therefore, many countries, including Thailand, must cope with the energy situation to maintain the balance of nature. (EPPO, 2021)

The manufacturing sector is one of the fundamental mechanisms that will lead Thailand to develop and strengthen competitiveness strongly and sustainably (Cai et al., 2019). Fuel oil is a crucial component of the manufacturing industry and national development. The demand for fuel is currently increasing. Strong economic growth worldwide has encouraged a steady increase in fuel oil consumption. With the projected energy consumption from various sources up to 2050, it has been found that oil remains the most used energy source (EIA, 2022). Energy consumption increases with economic growth. The gross domestic product (GDP) in the 4th quarter of 2021 grew by 1.9 percent. Refined oil accounts for 55% of final energy consumption (Tran, 2020). The manufacturing sector uses the most fuel, accounting for 40 percent of all fuel consumption, followed by residential homes, commercial businesses, and agriculture. Other sectors, such as electricity and construction, have low fuel consumption (DEDE, 2021).

The exploration of crude oil reserves in Thailand has been steadily decreasing. (DMF, 2022) As a result, most of Thailand's energy needs to be imported from abroad. More than 60 percent of imports come from primary commercial energy demand. Thailand has a fuel import rate as high as 80 percent of domestic fuel consumption. It also tends to increase because Thailand is unable to increase petroleum production to keep up with the demand.

As mentioned above, it can be seen that the amount of fuel oil reserves in the country is about to run out. This will have a significant impact on Thailand's manufacturing sector and economy. From all the essential issues and problems, it is vital to find ways to save fuel oil energy in the manufacturing sector of Thailand.

Literature Review

To manage the energy to achieve profound results and a sustainable effect, it is necessary to place the system for proper and continuous operation. Researchers have studied research related to guidelines for fuel oil saving in the manufacturing sector of Thailand as follows. The impact of technological innovation on energy savings, reducing carbon emissions, and the role of energy consumption in influencing processes were examined using linear regression models, mediated effects models, and exemplary regression. The results show that technological innovation has effectively promoted energy savings and carbon emission reductions in China and reduced the environmental impact (Meili et al., 2020). Based on the analysis of the current situation in the machinery industry, this article describes production technology and equipment for sustainable development in the machinery industry. It considers eight factors, including the following. 1) Digital technology; 2) new materials; 3) network-forming technology; 4) clean production; 5) short process technology; 6) waste-free production technology; 7) automatic control technology; and 8) reproduction and recycling technology. Important things to consider as a power-producing country Technology and equipment should be developed to protect resources and promote sustainable environmental development. Thus, technical support can be provided while building a resource-conserving and environmentally friendly society. Currently, the manufacturing sector is interested in using innovation and technology to help increase production efficiency and preserve the environment (Zhongde et al., 2019).

The eco-industrial concept leads to sustainable development by reducing waste and avoiding pollution, particularly in cities with resources. Methods have been studied to analyze the environmental and economic impacts of eco-industrial systems by simulating long-term trends. This study focused on Huinong, western China, where industrial coal is used. The analysis results indicate the eco-industrial system's progressive environmental and economic benefits coupled with future economic growth. Sustainable industrial growth should focus on the concept of eco-industry to preserve the environment, and limited resources that can be used in the future (Huili et al., 2019). Replacing fossil fuels with renewable energy sources is an effective way to reduce carbon emissions at an industrial scale. However,

individual companies still face technical and financial hurdles that hinder their deployment of renewable energy. The eco-industrial park approach aims to create synergies between companies that enable them to share and use natural and economic resources efficiently, creating a suitable model to promote the industry's use of renewable energy sources. Synergy between eco-industrial parks and adjacent urban areas can lead to the development of suitable energy production facilities. To provide energy to meet some of the energy needs of neighboring cities. This study aims to explore the energy dependency options within an eco-industrial park. It focuses on the interconnection between energy and industry in a city (Butturi M. A. et al, 2019).

Energy conservation is a crucial factor in reducing greenhouse gas emissions. However, most experts have focused only on energy. Improving efficiency through technology or equipment replacement is often costly. It presents a significant obstacle for operators in improving energy efficiency in their industries—careful consideration of the behavior of employees in the industry. There needs to be more public attitude or awareness of environmental conservation. Thus, an engineering management tool is value engineering (VE), which is often focused on functional analysis to minimize losses due to the 5Ms (Human, Machine, Material, Method, Management) used to conserve energy (Dawan W. & Prateep C.,2018). Promoting environmental awareness, or public awareness of environmental conservation among employees, is a much easier and more cost-effective way to do this. A mindset of preserving the environment is a key factor in promoting economic and industrial growth in a low-carbon society in Thailand. Scott et al. (2022) demonstrated the importance of instilling energy conservation awareness in schoolchildren. By educating people about global climate change as a low resource. Energy consumption and financial costs associated with energy use continue to increase. They are improving the country's overall environmental and energy sustainability. To create awareness and become a habit from childhood using energy savings. The energy value that will run out in the future is also known. Results: The students learned and practiced continuously at home and school until they became a habit.

Charles A. S. et al., 2018 presented a research study on structured operations to reduce energy consumption. By issuing policies and setting goals to reduce employee energy consumption, corporate executives can find ways to reduce energy consumption. Incentives are created, and rewards are given to agencies that achieve energy-saving goals. It was found that the organization could effectively achieve energy-saving goals. Researchers have identified a rapidly growing energy consumption problem in China. Building energy conservation policies are an essential solution to this problem.

Management institutions have clear, specific responsibilities. Improving regulations and standard systems of organization management by setting a clear policy for corporate executives is an appropriate guideline for the concrete practice of employees in the organization. Such policies must originate from a thorough and analytical thinking process. to achieve effective practices and results (Xueliang Y. et al, 2017).

This research summarizes the guidelines for fuel oil saving in the manufacturing sector of Thailand into four components: 1) Innovation & Technology, 2) eco-efficiency, 3) mindset, and 4) organizational system.

Theoretical Framework

Innovation and Technology: A critical component of creating an organization's success is the organization's ability to induce innovation. This includes introducing new processes, products, or ideas into the organization. The ability to innovate is the most important factor influencing innovation—corporate Performance (Hurly & Hult (2018). Innovation ability refers to an organization's ability to generate ideas. New processes and products have been successfully implemented (Burns & Stalker, 2015). These are practical and significantly benefit the organization or society (West & Farr, 2020).

Eco-efficiency: Balancing economic growth with increasing resource efficiency and reducing environmental emissions or eco-efficiency as a management tool for the sector. The industry can compete in business and produce environmentally friendly products (Jennifer, 2020). There are seven guidelines: 1) Reduce the use of resources or raw materials in production and services. 2) Reduce energy consumption in production and service; 3) Reduce the release of toxic substances into the environment. 4) Strengthening the material recycling potential 5) Promote the use of renewable resources 6) Increase the product's shelf life. 7) Increasing the level of service for products and strengthening service business (Allen et al., 2019).

Mindset: aising awareness in resource management consists of 1) Creating an understanding of the importance of resources, 2) Inspiring and motivating, 3) Influencing acceptance, 4) Inducing action, 5) Reinforcing continuity, 6) Praising (Ketsripongsa, 2017). Promoting environmental awareness contributes to the success of economic and industrial growth (Dawan W. & Prateep C., 2018).

Organization System: The process of achieving the organization's objectives by performing four main functions (Bartol & Martin, 2015).

It includes 1) planning, setting goals, and determining operating methods according to the objectives or goals. 2) Organization, personnel arrangement, work departments, and appropriate allocation of various resources following the work plan. 3) Leading consists of two essential components: self and motivation, which involve persuading others to work to the fullest based on their abilities. 4) Control is the ability of an organization to operate according to the plan.

Research hypothesis

Based on the research objectives and literature related to the topic, we formulated research hypotheses according to the theory. The six hypotheses of this study can be summarized into six hypotheses of research as follows:

H1: Organizational systems directly influence Innovation & Technology. Kahn, K. B. (2018); Kimberly, J. R., and Evanisko, M., (2020).

H2: Organization System Direct influence on Eco-efficiency (Jennifer M. B., 2020); Beise, M., and Rennings, K., 2019).

H3: The organizational system directly influences mindset (Olga B. et al., 2020; John J. B., 2018).

H4: Mindset directly influences Innovation & Technology (Aurelia et al., 2021; W. and Asnan; F., 2018).

H5: Mindset Direct influence on Eco-efficiency (Federica S. et al., 2022; Zhengge T., Tianyang H. and Renjun S., 2019).

H6: Direct influence of innovation and technology on Eco-efficiency (Luis, E. V., and Mauricio; C. V., 2021; Yanjie L., Hari P. V. and Praveen L., 2018).

Research Methodology

This research was conducted to create a new body of knowledge using mixed research.

1. An in-depth interview with three entrepreneurs and executives in the industrial business sector, three executives from the government and related organizations, three academics, and three executives from energy in industrial business establishments was conducted as part of the qualitative research. The researcher has set interview guidelines for four components, Innovation & Technology, Eco-efficiency, Mindset, and Organization System. The Index of Item Objective Congruence (IOC) was between 0.60-1.00 (accepted at > 0.5). The

standard deviation was in the range of 0.51–1.69. Corrected Item–Total Correlation, estimated the questionnaire with a scale, and it was in the range of 0.31–0.79. The reliability of the entire questionnaire was analyzed using Cronbach's Alpha Coefficient, which was 0.97.

2. Quantitative Research was conducted by sending a questionnaire to the people in charge of energy in the manufacturing industry in large and small designated factories. The sample size comprised 500, 250 from large designated factories and 250 from small designated factories. The questionnaire was designed to have a checklist and a rating scale. The criterion for the weight value was defined as five levels, according to the Likert method. The data analysis was performed using descriptive statistics. Statistical analyses were performed using the SPSS software package. A structural equation model (SEM) was developed using the AMOS software. Thus, four criteria were used to evaluate data-model fit. 1) Chi-square probability greater than 0.05, 2) relative chi-squared less than 2.00, 3) conformity index greater than 0.90, and 4) root mean squared index of estimation error less than 0.08.

3. Qualitative Research using Focus Group Discussion Techniques was conducted to validate the model. The population used in this study comprised 11 experts.

Result and Discussion

Table 1: Mean and standard deviation of the importance of the components of the guidelines for fuel oil saving in the manufacturing sector in Thailand.

Guidelines of fuel oil saving in manufacturing sector of Thailand	Small Designated Factory			Large Designated Factory		
	$\bar{X}$	S.D.	priority	$\bar{X}$	S.D.	priority
Overview	4.61	0.12	Most	4.65	0.11	Most
1. Innovation & Technology	4.63	0.15	Most	4.67	0.13	Most
2. Eco-efficiency	4.59	0.14	Most	4.63	0.15	Most
3. Mindset	4.59	0.18	Most	4.62	0.17	Most
4. Organization System	4.62	0.15	Most	4.67	0.14	Most

Table 1 shows the overall importance level and the four components of the structural model, the approach to fuel oil saving in the manufacturing sector of Thailand. The small designated factory found that overall, it was at the highest level. The mean was 4.61, and when

considering each aspect, it was found that all aspects were of the highest level. In terms of Innovation & Technology, the highest mean ($\bar{X}$ = 4.6), followed by Organization System ($\bar{X}$ = 4.62), Eco-efficiency ($\bar{X}$ = 4.59, S.D. = 0.14), and Mindset ($\bar{X}$ = 4.59, S.D. = 0.18), respectively.

The large designated factory found it overall at the highest level. The mean was 4.65, and when considering each aspect, it was found that all aspects were of the highest level. In terms of Innovation & Technology, the highest mean ($\bar{X}$ = 4.67, S.D. = 0.13), followed by Organization System ($\bar{X}$ = 4.67, S.D. = 0.14), Eco-efficiency ($\bar{X}$ = 4.63), and Mindset ($\bar{X}$ = 4.62), respectively.

The results of the comparison are of the importance level of the guidelines of fuel oil saving in the manufacturing sector of Thailand. Overall, when classified by the size of the designated factory, it was found that there was a statistically significant difference at the 0.05 level.

Table 2: Criteria for conformity assessment of the Structural Equation Model (SEM) before and after improvement.

Evaluating the Data-Model Fit		Criteria	Before Improvement	After Improvement.
CMIN-p	(Chi-square Probability Level)	Value > 0.05	0.000	0.064
CMIN/DF	(Relative Chi-square)	Value < 2.00	1.173	1.134
GFI	(Goodness of Fit Index)	Value > 0.90	0.824	0.954
RMSEA	(Root Mean Square Error of Approximation)	Value < 0.08	0.019	0.016

Table 2 shows the results of the model before improvement. It was found that passes only two criteria; the Relative Chi-square is 1.173, which is less than 2.00. The root Mean Square Error of Approximation was 0.019, which was less than 0.08. Therefore, the researcher improved the model in accordance with Arbuckle's (2011) recommendation, which considers the value of the resulting program to eliminate some improper observational variables individually. Upon updating the model, the Chi-square Probability Level was found to be 0.064, which is greater than 0.05. The Relative Chi-square is 1.134, which is less than 2.00, and the goodness-of-fit index is 0.954, which is greater than 0.954. The Root Mean Square Error of Approximation was 0.016, which is less than 0.08. It was concluded that the model passed the assessment criteria and aligned with the empirical data.

Figure 1: Guidelines of fuel oil saving in the manufacturing sector of Thailand in Standardized Estimate model

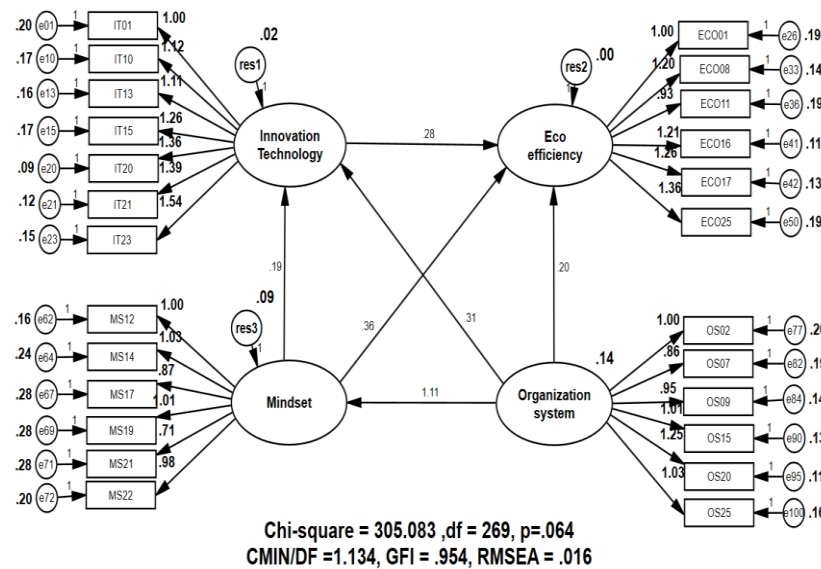


Figure 2 shows the results of the analysis of the causal influence between the variables in the guidelines of fuel oil saving in the manufacturing sector of Thailand. By applying the Standardized Estimate mode, it was found that in research hypothesis 1: the organizational system directly influences Innovation & Technology components with a statistical significance at the 0.001 level. It was weighted at 0.47. Research hypothesis 2: Organization System Direct influence on eco-efficiency components with a statistical significance at the 0.001 level was weighted equally to 0.24. Research hypothesis No.3: Organisation System Direct influence on Mindset components with a statistical significance at the 0.001 level was weighted equally to 0.82. Research hypothesis No.4: Mindset's direct influence on Innovation & Technology components with statistical significance at the 0.001 level was weighted equally to 0.39. Research hypothesis No.5: Mindset Direct influence on eco-efficiency components with statistical significance at the 0.001 level. It was weighted at 0.59. Research hypothesis No.6: Innovation and Technology Direct influence on eco-efficiency components with a statistical significance at the 0.001 level was weighted equally to 0.22.

The manufacturing sector in Thailand is a crucial component of its economy, and fuel oil is a significant cost factor for many businesses in this sector. To reduce costs and increase efficiency, finding ways to save fuel in the manufacturing sector is vital. This article outlines guidelines for fuel oil-saving measures identified through research and discussion. First, businesses should explore the possibility of using

renewable energy sources, such as solar and wind, as substitutes for fuel oil in operations. Second, businesses should consider using more efficient machinery and equipment to reduce fuel consumption. Third, businesses should consider using alternatives to reduce costs and emissions. Finally, businesses should ensure that their equipment and machinery are adequately maintained to run as efficiently as possible. These fuel oil-saving measures can help businesses reduce costs, increase efficiency, and reduce their environmental footprints. Businesses in the manufacturing sector need to consider these measures when planning the future. With appropriate strategies and investments, businesses can find ways to save fuel oil, reduce costs, and improve their performance.

Comparison of the number of personnel in the organization with less than 200 people and the number of personnel in the organization is greater than or equal to 200 people in the organization. There was a statistically significant difference at the level of 0.05, consistent with the findings of Jitrat et al. (2019). The energy-saving effect of large enterprises was higher than that of small enterprises. This was achieved owing to good operational efficiency improvements and funding to support energy-saving activities. Large energy consumer organizations, energy policy management, and full qualifications of personnel responsible for energy with medium and small enterprises (Silpcharu & Wantanakomol, 2017) Large energy consumer organizations, energy policy management, and full qualifications of personnel responsible for energy in medium and small enterprises (Silpcharu & Wantanakomol, 2017) result in additional energy savings.

The organizational System has the most significant overall influence on eco-efficiency, with the highest influence line (Standardized Regression Weight) of 0.89, consistent with Zhang et al. (2020). Empirical data show that an organization that is ready in terms of technology readiness to manage it will cause and promote environmentally friendly innovations. This leads to competitive advantage and stable organizational performance (Lamesawan et al., 2022). We are strategizing the provision and implementation of green innovations for optimum sustainability outcomes.

Guidelines for fuel oil saving in Thailand's manufacturing sector in innovation and technology have the highest average. Consistent with Liu et al. (2018), promoting innovation and technology is the country's most important measure for promoting energy saving and environmental protection. Using Smart Plant technology to control oil consumption appropriately is of the highest importance and highest individual, consistent with Rane et al. (2022). A plant using smart-plant technology can monitor and control every device. The devices were automatically controlled using their control settings. (Wantanakomol,

2021) In addition, the collected dataset can be used to interpret and predict future energy consumption, including planning for energy efficiency.

Conclusion

A guideline for fuel oil saving in the manufacturing sector of Thailand has studied textbook academic articles and related research, accompanied by in-depth interviews with experts who are corporate executives and national experts. Elements were extracted using data from 500 interrogative questionnaires and approved by consensus from qualified experts. The complete, correct, and suitable guidelines for fuel oil saving in Thailand's manufacturing sector were divided into four components: innovation and technology, eco-efficiency, mindset, and organizational system. The implementation of fuel oil saving guidelines in Thailand's manufacturing sector has the potential to help reduce fuel oil consumption and improve energy efficiency. According to these guidelines, manufacturers can reduce production costs and increase profit margins. These guidelines provide a framework for manufacturers to analyze their energy needs and identify areas where energy efficiency can be improved. By encouraging energy conservation through improved energy management, cooperatives, and the development of renewable energy sources, manufacturers can use their resources more efficiently and reduce their fuel oil consumption in the long term.

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