Journal of Information Systems Engineering and Management
2025, 10(48s)
e-ISSN: 2468-4376
https://www.jisem-journal.com/

Research Article

Energy Management with Energy Saving Technology Innovation and BCG Model Policy Influencing Gas Fuel Energy Saving Efficiency: Case Study of Industrial Plants in the Eastern Region of Thailand

Thakon Sawatdikumthon[1], Rungraditt Kongyoungyune[2],Wannee Benjawatanapon[3]

[1]*Faculty of Liberal Arts, Krirk University, Thailand, Email: thakono@gmail.com*

[2]*Chaopraya University, Nakhon Sawan, Thailand, Email: rungradit.k@cpu.ac.th*

[3]*Faculty of Liberal Arts, Krirk University, Thailand, Email: dr.wannee1949@gmail.com*

ARTICLE INFO

Received: 25 March 2025

Revised: 20 April 2025

Accepted: 20 May 2025

ABSTRACT

This research aims to study energy management factors (Energy Management), innovation management factors (Innovation Management), factors of using the BCG Model (Bio-Circular-Green Economy) policy that influence the effectiveness of gas energy saving of industrial plants in the eastern region of Thailand. It emphasizes the important role of integration between Energy Management, Innovation Management and the application of the BCG (Bio-Circular-Green Economy) economic model to promote efficient energy use, reduce energy loss and reduce greenhouse gas emissions. This study used path analysis to analyze the structural relationships among the aforementioned factors. The data were collected from 223 industrial plants that use gas fuel. Statistics used in data analysis include percentage, mean, standard deviation, Pearson Product Moment Correlation Coefficient and Path Analysis. The results of the study revealed that Energy management factors Innovation management and the use of the BCG Model policy have a significant positive influence on the effectiveness of energy saving. The analysis results indicate that Energy management and innovation management have both direct and indirect effects on using the BCG Model policy, which is the factor that has the greatest influence on the effectiveness of gas energy saving of industrial plants in the eastern region of Thailand. In addition, using the concepts of the Circular Economy (Circular Economy) and the Green Economy (Green Economy) will help reduce environmental impacts and increase competitiveness at the international level. This study recommends the development of policies that support the use of technological innovations, changing energy consumption behavior and promoting cooperation between the public and private sectors to create sustainability in the industrial sector.

Keywords: Energy management, innovation management, BCG economic model, energy saving effectiveness, greenhouse gas reduction

BACKGROUND AND IMPORTANCE OF THE PROBLEM

The BCG (Bio-Circular-Green Economy) economic model is an important guideline for Thailand in reviving the economy after the COVID-19 crisis with the goal of sustainable development through the use of science, technology and innovation to increase economic value along with conserving natural resources and the environment (Phutrakul, 2022, Channuwong & Ruksat, 2022). The government has announced BCG as a national agenda since 2021 and has integrated this approach into the 13th National Economic and Social Development Plan (Office of the National Economic and Social Development Council, 2021). Thailand's past economic growth relied too much on natural resources, resulting in the degradation of the ecosystem. Inefficient use of energy and an economic growth rate of less than 3 percent per year is not enough to bring the country out of the middle-income trap. BCG is therefore a holistic development approach. with emphasis on the bioeconomy circular economy and green economy to reduce waste emissions Increase the use of resources wisely and create sustainability in all sectors (UNDP, 2021). Targeted industries such as agriculture and food, energy, automotive, and manufacturing have the potential to apply BCG to

increase efficiency, reduce costs, and reduce greenhouse gas emissions, such as the development of renewable energy technology. Innovative energy saving technology Recycling in the manufacturing industry and the shift to electric vehicles (World Bank, 2021)

The energy sector still faces challenges in reducing production costs. and increasing energy efficiency, especially in industrial factories. which must be adjusted to be consistent with the goals of the National Energy Strategy 2022–2036, which requires efficient use of energy. and continuously reducing energy intensity (Energy Intensity) (Office of the Permanent Secretary, Ministry of Energy, 2022)

However, Thailand still faces limitations in many areas, including an insufficient technological infrastructure. Limitations in knowledge in SMEs, reliance on foreign technology and the legal system are not yet conducive to investment in the circular economy. (Office of the Science Promotion Commission) Research and Innovation, 2022) so that the BCG Model can be driven sustainably. It is necessary to promote the development of technology in the country. Upgrading personnel in the industrial sector to be able to use AI, Big Data and digital technology. Including creating cooperation between the public, private and educational institutions. To develop knowledge and a green innovation ecosystem suitable for the Thai context. An integrated policy-making approach between BCG and the energy and environment plan is therefore necessary. So that all sectors, especially the private sector, can truly conduct environmentally friendly businesses, such as providing tax benefits for investing in innovations that reduce carbon emissions. or carbon credit system (TGO, 2023)

The BCG (Bio-Circular-Green Economy) economic model is an important guideline for Thailand in reviving the economy after the COVID-19 crisis. with the goal of sustainable development Through the use of science, technology and innovation to increase economic value. along with conserving natural resources and the environment (Phutrakul, 2022). The government has announced BCG as a national agenda since 2021 and has integrated this approach into the 13th National Economic and Social Development Plan (Office of the National Economic and Social Development Council, 2021). Thailand's past economic growth relied too much on natural resources. Resulting in the degradation of the ecosystem. Inefficient use of energy and an economic growth rate of less than 3 percent per year is not enough to bring the country out of the middle-income trap. BCG is therefore a holistic development approach. with emphasis on the bioeconomy circular economy and green economy to reduce waste emissions Increase the use of resources wisely and create sustainability in all sectors (UNDP, 2021). Targeted industries such as agriculture and food, energy, automotive, and manufacturing have the potential to apply BCG to increase efficiency, reduce costs, and reduce greenhouse gas emissions, such as the development of renewable energy technology. Innovative energy saving technology Recycling in the manufacturing industry and the shift to electric vehicles (World Bank, 2021

The energy sector still faces challenges in reducing production costs. and increasing energy efficiency, especially in industrial factories. which must be adjusted to be consistent with the goals of the National Energy Strategy 2022–2036, which requires efficient use of energy. and continuously reducing energy intensity (Energy Intensity) (Office of the Permanent Secretary, Ministry of Energy, 2022)

However, Thailand still faces limitations in many areas, including an insufficient technological infrastructure. Limitations in knowledge in SMEs, reliance on foreign technology and the legal system are not yet conducive to investment in the circular economy. (Office of the Science Promotion Commission) Research and Innovation, 2022) so that the BCG Model can be driven sustainably. It is necessary to promote the development of technology in the country. Upgrading personnel in the industrial sector to be able to use AI, Big Data and digital technology. Including creating cooperation between the public, private and educational institutions. To develop knowledge and a green innovation ecosystem suitable for the Thai context. An integrated policy-making approach between BCG and the energy and environment plan is therefore necessary. So that all sectors, especially the private sector, can truly conduct environmentally friendly businesses, such as providing tax benefits for investing in innovations that reduce carbon emissions. or carbon credit system (TGO, 2023)

Therefore, the researcher is interested in studying the use of innovations in saving fuel energy in the production sector for industrial plants that use gas fuels, both NG and LPG, due to the result of the use of fuel in the production sector being high in each production cycle. Therefore, it is part of the overall production costs that are of enormous value in the industrial sector throughout the country. The study of “Energy Management Innovative energy saving technology

Journal of Information Systems Engineering and Management
2025, 10(48s)
e-ISSN: 2468-4376
https://www.jisem-journal.com/

Research Article

and the use of BCG MODEL that influence the effectiveness of gas fuel saving in modern industrial plants. in the Eastern Region" this time therefore follows the economic development model BCG Model (Bio-Circular-Green Economy) as mentioned above

Research objectives

1. To study energy management factors Innovation management factors, BCG Model use factors, and energy saving effectiveness factors

2. To study the structural relationship between energy management factors, Innovation management factors, BCG Model use factors, and energy saving effectiveness factors.

3. To study the direct and indirect influence of energy management factors, Innovation management factors and factors using the BCG Model on energy saving effectiveness factors

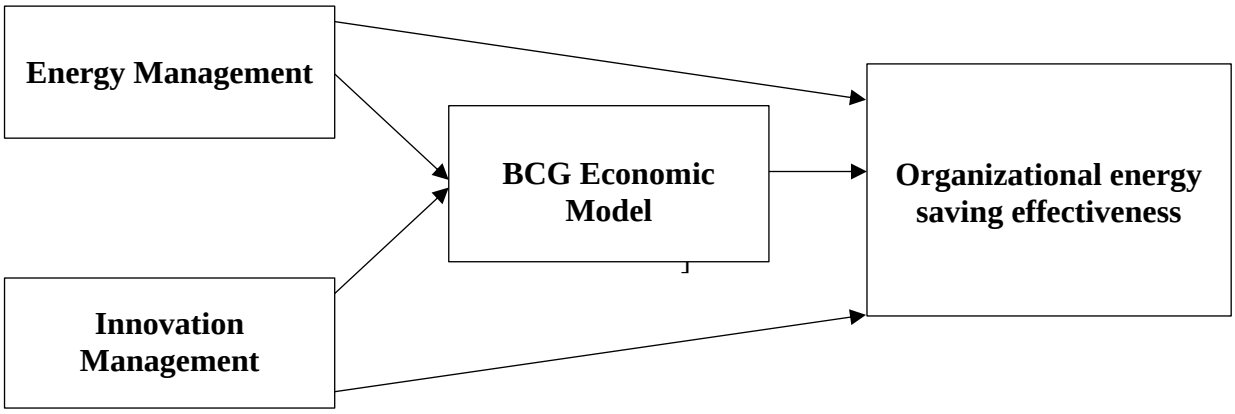
Research hypothesis

Ha1: There is a relationship between Energy management factors Innovation management factors, BCG Model use factors, and energy saving effectiveness factors

Ha2: Energy management factors, Innovation management factors and BCG Model use factors have both direct and indirect influence on energy saving innovation factors in industrial factories in the Eastern region

Research Conceptual Framework

Figure 1: Research conceptual framework



LITERATURE REVIEW

1. Total Energy Management (TEM) of Lyle Harris (1974) The concept of Total Energy Management (TEM) of Lyle Harris (1974) is a framework that has been accepted internationally and has been applied in various industries around the world, such as the Industrial Energy Efficiency Project in the United States and the ISO 50001 standard in Europe. This concept focuses on Systematic energy management To increase energy efficiency, reduce costs, and promote organizational sustainability, the TEM concept can be applied to systematically increase the efficiency of energy management in organizations based on 3 basic principles: 1) Analysis and planning of efficient energy use 2) Linking energy management with efficient energy management business objectives and strategies 3) Using technology and tools to analyze and manage energy.

2. Social innovation management theory Jürgen Howaldt, Christoph Kaletka, Antonius Schröder, Marthe Zirngiebl (2018) Howaldt et al.'s (2018) social innovation management theory presents a comprehensive framework for evaluating and developing social innovation in organizations. that reflects the process and important elements of social innovation which can be applied to drive change at both the organizational and social level, covering 5 main dimensions as follows: 1) Review of the main concepts of social innovation. Social innovation is a process that aims

Journal of Information Systems Engineering and Management
2025, 10(48s)
e-ISSN: 2468-4376
https://www.jisem-journal.com/

Research Article

to solve social problems through creativity and efficient use of resources. 2) The link between social innovation and organizations. Social innovation has a significant influence on the design and operation of organizations. 3) Development of new organizational models. Organizations that focus on developing new organizational models are more likely to adapt to social changes. 4) Incorporating social innovation into business activities. Social innovation can effectively create added value in the business sector. 5) Impact of introducing knowledge into organizations and society Organizations that can apply knowledge and social innovation have the potential to create sustainable impacts on both the organization and society.

3. Concept of using the BCG MODEL policy in organizations. The concept of BCG economy (Bio-Circular-Green Economy) is a policy framework that has been developed to drive economic growth along with conserving natural resources and reducing environmental impacts (NSTDA, 2021). The concept of Bio-economy-circular-green (Bio- Circular-Green Economy: BCG Model) has been recognized as an important guideline for sustainable economic development. It focuses on efficient use of resources, reducing waste, and adding value through innovation and environmentally friendly technology (World Economic Forum, 2020). The BCG Model is a framework that combines the Bio Economy, Circular Economy, and Green Economy to foster sustainable development in businesses and organizations (Ellen MacArthur Foundation, 2019). Organizations' use of the BCG Model reflects their ability to put sustainable development principles into practice through bioeconomy policies. Circular economy and green economy Applying these concepts helps organizations reduce their impact on the environment. Increase competitiveness and strengthen long-term sustainability.

4. Theoretical concept of organizational energy saving effectiveness (Energy Efficiency) Energy saving effectiveness of an organization is an important concept that helps the organization to operate efficiently. Reduce energy costs and reduce environmental impact The researcher has applied five approaches from the research of academics: 1) Organizational energy management. (Organizational Energy Management) Vieira (2015) 2) Energy Efficiency Management (Energy Efficiency Management) Debnath et al. (2019) 3) Measurement and monitoring of the efficiency of energy saving (Energy Performance Measurement and Monitoring) 4) Use of technological innovation (Technology Innovation) Klewitz et al. (2017) 5) Behavioral Change of employees (Behavioral Change) Choudhary et al. (2018) The above 5 guidelines are important components of the organization's energy saving effectiveness. This is in line with the concept of sustainable development. Good energy management will reduce environmental impacts, reduce costs, and increase the organization's competitiveness. Integrating innovation and changing employee behavior are important factors that help organizations truly develop towards sustainability.

METHODOLOGY

This research is quantitative research. which consists of the following research processes

Population and sample

The population and samples used in this research include 483 industrial plants that use NG and LPG gas. A sample of 219 plants was calculated using the formula of Yamane Taro (1973, p.127) and a margin of error of 5 percent was used. Multi-stage sampling was used to select groups. The person who will answer the questionnaire is Top management consists of the general manager, Deputy General Manager Assistant General Manager or middle level executives, consisting of deputy heads of departments, directors, managers or those assigned by the establishment. Those who answer the questionnaire are considered representatives of that agency. By giving questionnaires to sample establishments, 5 sets per establishment. The schedule for collecting at least 3 questionnaires per establishment is counted as the unit of analysis.

Variables used in the study

The independent variable is

Energy management in the organization According to the conceptual framework of Lyle Harris (1974), it was found that there are confidence values as follows: Energy analysis and planning and strategy (= 0.92) in terms of linking management with management strategies (= 0.97) in the use of technology in energy management and planning (= 0.95)

Journal of Information Systems Engineering and Management
2025, 10(48s)
e-ISSN: 2468-4376
https://www.jisem-journal.com/

Research Article

Social innovation management It was found that there was also a high level of confidence, including the review of social innovation concepts (= 0.94) in terms of linking innovation with the organization (= 0.97) Development of new organizational models (= 0.89) in terms of importing social innovation into business models (= 0.96) on the impact of bringing knowledge into the organization and creating a transparent organizational society (= 0.96)

Using economic policy, BCG found that using bioeconomy policy (Bio Economy) (= 0.98), Using circular economy policies (Circular Economy) (= 0.95) Using green economic policies (Green Economy) (= 0.94)

The dependent variable is Organizational energy saving effectiveness factors It was found that there was a very high level of confidence around organizational energy management (= 0.96) Energy well-being management (= 0.96) Measuring and monitoring the efficiency of energy saving (= 0.97) Use of innovative technology (= 0.97) and changes in employee behavior (= 0.96)

Tools used to collect data

The tool used to collect data in this research is a questionnaire (Research Questionnaire), which is a tool used for collecting quantitative data. (Quantitative Research) by creating questionnaires. The researcher has studied various concepts and theories from related documents and research. to be used as a questionnaire (Questionnaire) with closed- ended questions. The structure of the questionnaire is divided into 4 parts as follows.

Part 1 of the questionnaire is a rating scale. It is a question about Factors of energy management in organizations by Lyle Harris (1974) developed from "Total Energy Management" has 3 aspects: 1) analyzing and planning efficient energy use, 2) linking energy management with business objectives and strategies, 3) using technology and tools for analysis and management. Consists of 15 questions.

The second part of the questionnaire is a rating scale, asking about innovation management factors in organizations by Jürgen Howaldt, Christoph Kaletka, Antonius Schröder, and Marthe Zirngiebl (2018). There are 5 areas: 1) reviewing the main concepts of social innovation, 2) linking social innovation and organizations, 3) developing new organizational models, 4) integrating social innovation into business activities, 5) The impact of bringing knowledge into organizations and society. Organizations have open and transparent communication. It consists of 19 questions.

Part 3 of the questionnaire is a rating scale. It is a question about Factors for using policies in organizations. Factors in the BCG Model, an economic model for sustainable development, has 3 aspects: 1) using bioeconomy policies in organizations, 2) using circular economy policies in organizations, 3) levels of using green economy policies in organizations. Consists of 15 questions.

Part 4 of the questionnaire is a rating scale. It is a question about energy saving effectiveness factors of applied organizations from research by academics in 5 approaches: 1) organizational energy management, 2) energy well-being management, 3) measurement and monitoring of energy saving efficiency, 4) use of innovative technology, and 5) changes in employee behavior. Consists of 24 questions.

Creation and development of tools used in education

The researcher checked the accuracy of the content and determined the reliability of the questionnaire as follows.

1. Check the accuracy of the content (Content Validity) by 10 experts by considering the consistency between the questions and the intended study objectives using the S-CVI (Scale Content Validity Index) average CVI = 9.49 S-CVI value = 0.95

2. find confidence (Reliability) of the questionnaire by testing the questionnaire with employees. which is not the sample group used in this study, numbering 30 people, the confidence for the whole version was 0.95.

Data collection

The researchers distributed questionnaires and collected data by preparing a book with questionnaires and sending them to the population through the Google form system by coding in the sample questionnaire set. along with explaining details of the purpose of the research By collecting population data from industrial plants that use gas fuel. that were returned via Google form from actual data collection. To increase the accuracy of the results and reduce

Journal of Information Systems Engineering and Management
2025, 10(48s)
e-ISSN: 2468-4376
https://www.jisem-journal.com/

Research Article

errors that may result from low response rates, Yamane (1973) sent questionnaires beyond the calculated sample size. You can collect data from a sample group. and received 821 questionnaire responses from 223 factories, which is more than specified. Using samples larger than the recommended values therefore helps to increase accuracy. Larger sample size will help reduce sampling error (sampling error) and increase the accuracy of research results (Creswell & Creswell, 2018). When you receive the questionnaire back, check the accuracy and completeness of the questionnaire to process the questionnaire and analyze the data.

Statistics used to analyze data

The researcher used descriptive statistics. and inferential statistics for analyzing data and testing hypotheses. The details are as follows: 1) Find the average of the variables in the energy management factors in the organization. Innovation management factors in organizations Factors in the use of policies in the organization BCG Model, factors in the effectiveness of energy saving in the organization 2) Using mean and standard deviation (Standard Deviation) 3) Using correlation coefficient analysis (Pearson Correlation) to analyze the relationship between variables 4) Using path analysis (Path Analysis) to study relationships and influences according to the overall conceptual framework presented in Figure 1 and including calculating the values of direct influence (Direct Effect) and indirect influence (Indirect Effect) and total effect (Total Effect) to understand the influence of energy management factors in the organization. Innovation management factors in organizations Factors in using policies in the BCG Model organization that affect the organization's energy saving effectiveness factors.

Research results

Results of factor analysis

Table 3 Results of factor analysis

Factor	M	(S.D.)	The side with the highest score	The side with the lowest score
Energy management in the organization	3.51	1.13	Energy use analysis and planning (= 3.74)	Use of technology and analytical tools (= 3.15)
Innovation management in the organization	3.51	1.24	Review of the main concepts of social innovation (= 3.55)	Development of a new organizational model (= 3.49)
Using the policy BCG MODEL	3.48	1.18	Using green economy policies (= 3.69)	Using bioeconomy policies (= 3.21)
Effectiveness of energy saving in the organization	3.63	1.24	Changes in employee behavior (Choudhary et al., 2018 (= 3.70)	Measuring and monitoring the efficiency of energy saving (= 3.53)

Table 4 Results of factor ranking analysis

Factor	Mean ($\bar{x}$)	Standard deviation (S.D.)	Ranking
Energy saving effectiveness of the organization	3.63	1.24	1
Energy management in the organization	3.51	1.13	2
Innovation management in organizations	3.51	1.24	3
Using the BCG economic model	3.48	1.18	4

Journal of Information Systems Engineering and Management
2025, 10(48s)
e-ISSN: 2468-4376
https://www.jisem-journal.com/

Research Article

From the analysis of data on four factors: energy management in the organization; Innovation management in the organization, use of the BCG Model policy and the effectiveness of energy saving in the organization were found.

1. Organizational energy saving effectiveness factors have the highest mean value of 3.63 and standard deviation of 1.24, indicating that the organization has implemented energy saving operations at a relatively good level. Especially in the field of Change employee behavior which is the side with the highest score (M = 3.70) and the side with the lowest score is Measuring and monitoring the efficiency of energy saving (M = 3.53)

2. Energy management factors in organizations have a mean of 3.51 and a standard deviation of 1.13. The side with the highest mean is Analysis and planning of efficient energy use (M = 3.74) The side with the lowest average is Using technology and tools for analysis and management (M = 3.15)

3. Innovation management factors in organizations the average value was 3.51, the same as the energy management factor in the organization. But it has a slightly larger standard deviation of 1.24. The side with the highest means is Review of the main concepts of social innovation (M = 3.55) The side with the lowest average is Development of a new organizational model (M = 3.31)

4. Factors in using the BCG economic model It has the lowest mean value among all factors, which is 3.48 with a standard deviation of 1.18. The aspect with the highest mean score is Green Economy Policy (Green Economy) (M = 3.69) and the side with the lowest average is Circular Economy Policy (Circular Economy) (M = 3.21)

Relationship analysis results (Correlation coefficient) between variables

Analysis of the correlation coefficient between variables for use in answering research questions and study objectives No. 2 and testing research hypothesis No. 1 is a study of the structural relationship between energy management. Innovation management in using the BCG Model and efficiency in energy saving of industrial groups that use gas fuel in the Eastern Region There will be a statistically significant relationship.

Table 5 Correlation Coefficients (Correlation) between variables

Variable	Energy Management	Innovation management	Usage BCG Model	Energy saving effectiveness
Energy Management	1	.870**	.854**	.854**
Innovation management		1	.908**	.832**
Usage BCG Model			1	944**
Energy saving effectiveness				1

** means that it is statistically significant at the 99 percent confidence level or has a P-Value less than 0.01.

From the analysis of the correlation coefficient table It was found that the four main variables were energy management; Innovation management in organizations BCG economic policy and energy saving effectiveness There is a high level of relationship for every pair of variables. It is statistically significant at the .01 level (2-tailed), indicating a stable and supportive relationship structure, as follows:

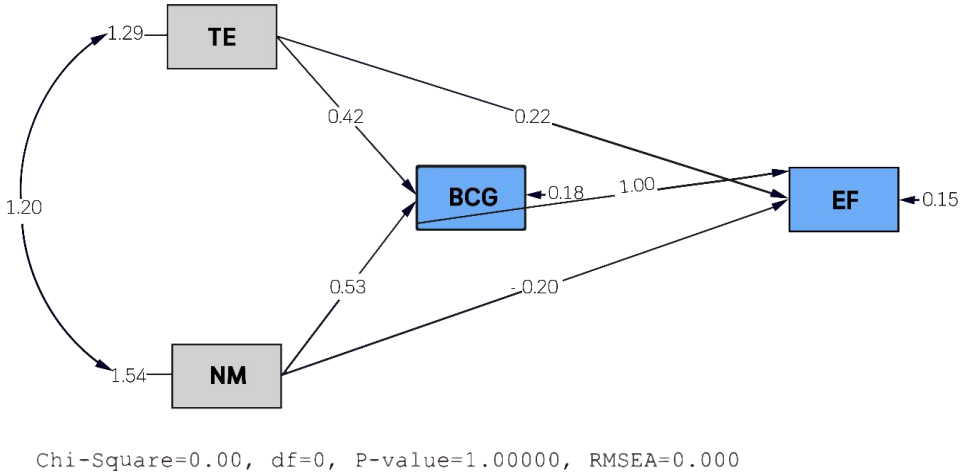
Energy management is closely related to innovation management in the organization (r = .870) and the application of BCG economic policy (r = .854). It is also related to energy saving effectiveness (r = .854) at a very high level. In addition, innovation management in the organization has the highest relationship with the application of BCG economic policy (r =.908) and is significantly related to energy saving effectiveness (r = .832). While the relationship between the adoption of BCG economic policy and the effectiveness of energy saving was the highest (r = .944), indicating that the integration of the bioeconomy concept circular economy and the green economy plays an important role in increasing sustainable energy efficiency. The results of the analysis support the hypothesis that all four variables had a highly positive and significant relationship.

Journal of Information Systems Engineering and Management
2025, 10(48s)
e-ISSN: 2468-4376
https://www.jisem-journal.com/

Research Article

Results of analysis of influence values between variables

Diagram 2 shows influence values (Path Analysis) and relationships between variables.



TE = Energy management in the organization; NM = Innovation management in the organization; BCG = Using the BCG economic model in the organization; EF = Effectiveness of energy saving in the organization

Table 6 shows the total influence (TE), direct influence (DE), and indirect influence (IE).

Predictor variables	**(TE) Energy Management in the organization**			**(NM) Innovation management in the organization**			**(BCG) Using economics Models BCG in the organization**			**R^2**
The variable is predicted	***TE***	**DE**	***IE***	***TE***	**DE**	***IE***	***TE***	**DE**	***IE***	
(BCG) Using the BCG economic Model in the organization	0.42**	0.42**	-	0.53**	0.53**	-				0.87**
(EF) Effectiveness of energy saving in the organization	0.64**	0.22**	0.42**	0.33**	-0.20**	0.53**	1**	1**	-	0.90**

TE = Total Effect, DE = Direct Effect IE = Indirect Effect, R^2 = Structural Equations, ** = p<0.01

Direct Effects (DE) Energy management in the organization (TE) has a direct influence on the BCG economic model (BCG) equal to (b = 0.42) and has a direct influence on the organization's energy saving effectiveness (EF) equal to (b = 0.22) Organizational innovation management (NM) has a direct influence on the BCG economic model (BCG) equal to (b = 0.53) and has a direct influence on the organization's energy saving effectiveness (EF) equal to (b = -0.20) The BCG economic model (BCG) has a direct influence on the organization's energy saving effectiveness (EF) with statistical significance at the 0.01 level (b = 1.00)

Indirect Effects (IE) Energy management in the organization (TE) has an indirect influence on the organization's energy saving effectiveness (EF) through the BCG economic model (BCG) (b = 0.42) Innovation management in the organization (NM) has an indirect influence on the organization's energy saving effectiveness (EF) through the BCG economic model (BCG) (b = 0.53) Both TE and NM have no indirect influence on BCG because BCG is a variable that

Journal of Information Systems Engineering and Management
2025, 10(48s)
e-ISSN: 2468-4376
https://www.jisem-journal.com/

Research Article

is directly influenced.

Total Effects (TE) Energy management in an organization (TE) has a total influence on the BCG economic model (BCG) (b= 0.42) and has an overall influence on the organization's energy saving effectiveness (EF) (b = 0.64) Organizational innovation management (NM) has an overall influence on the BCG economic model (BCG) (b = 0.53) and has an overall influence on the organization's energy saving effectiveness (EF) (b = 0.33) The BCG economic model (BCG) has an overall influence on the organization's energy saving effectiveness (EF) (b = 1.00)

The BCG Economic Model (BCG) variable was able to explain 87% of the variance (R^2 = 0.87). The Enterprise Energy Effectiveness (EF) variable was able to explain 90% of the variance (R^2 = 0.90). The model was able to accurately explain the results and was in very good agreement with the empirical data.

DISCUSSION

This study concludes that "Energy saving effectiveness" is the number one important factor (M = 3.63), especially the change in employee behavior (M = 3.70), which supports the concept of Choudhary et al. (2018) Hongjinda (2017), and Channuwong & Ruksat (2022) who stated that raising awareness and participation of employees has a sustainable effect on efficient energy use. However, the measurement and monitoring of energy saving still needs to be further developed (M = 3.53) according to the proposal of Kemp and Foxon (2017) in the field of "organizational energy management" (M = 3.51) The strength is planning energy use systematically (= 3.74), which is consistent with the concept Total Energy Management and strategic energy management guidelines of Harris (1974), but there are still limitations in the use of analytical technology (M = 3.15) according to the findings of Chen and That (2021) and Kamron (2019) for "Innovation management in organizations" (M = 3.51) found that reviewing social innovation concepts is a strong point (M = 3.55) according to the concept of Howald et al. (2018) and Jirawat Homnan (2020) who pointed out that social innovation can strengthen organizational adaptability. However, the development of new organizational models still needs additional support (M = 3.31) Finally, "Using the policy BCG Model" (M = 3.48) found that the development of green economy (Green Economy) has been promoted (M = 3.69) consistent with the concept of World Economic Forum (2020) and national strategy But the bioeconomy (Bio Economy) There is still a lack of concrete integration (M = 3.21), which is consistent with the findings of Naksombat (2021) and Wongmajarapinya et al. 2024) who found that energy saving in the industrial sector requires the integration of many factors. Both personnel behavior Energy planning Promoting innovation and driving policy BCG Model To create competitiveness and long-term sustainable development

Discuss the results of the relationship between variables.

The results of the analysis of the relationship between the four factors include energy management. Innovation management, policy implementation BCG Model and efficiency in saving energy in industrial plants that use gas fuel in the eastern region of Thailand It was found that every pair of variables had a high level of positive relationship with statistical significance at the .01 level, which can be summarized as follows.

Using the policy BCG Model has the highest relationship with energy saving effectiveness (r = .944) points out that the integration of the bio-, circular and green economy has a direct effect on reducing energy consumption and increasing production efficiency (Geissdoerfer et al. 2017; Creative Economy Promotion Agency, 2565) Innovation management is strongly related to the use of BCG Model (r = .908) shows that innovation is an important mechanism for driving the economy. BCG Especially in the field Bio Economy and Green Technology (Howaldt et al., 2018; Chen & Li, 2021) Energy management is related to innovation management (r = .870) and uses BCG Model (r = .854) points out that organizations with good energy management systems tend to create innovations and integrate ideas. BCG effectively (Smith et al., 2019; Prasertsan et al. 2019; Geissdoerfer et al. 2017) Energy management also has a high relationship with energy saving effectiveness (r = .854) supports that systematic energy planning and management can actually reduce energy use (Vieira, 2015; IEA, 2020; Prasertsan et al. 2019) In terms of innovative management and energy saving effectiveness (r = .832) even though it has the lowest value in the group But it also shows that innovation plays a role in promoting efficient energy use (Choudhary et al., 2018; Smith et al., 2019)

The study results confirmed research hypothesis number 1 and clearly answered research question number 2. Integrating energy management, innovation and economic policy BCG Support each other in raising the efficiency of

energy saving of the organization with statistical significance. and is an important guideline for sustainable industrial development in the future.

The results of the discussion of influences between variables

The results of the study answer objective number 3 and accept hypothesis number 2, which is that energy management factors Innovation management factors. Usage factors. BCG Model influence on energy saving effectiveness factors From the analysis of the relationship structure between variables using the model WHICH It was found that the efficiency of energy saving of the organization (IF) Is directly and indirectly influenced by 3 important factors: energy management in the organization (THE) Innovation management in organizations (NM) and the use of economic models BCG Especially the model BCG that directly affects the highest level (b = 1.00, $p<0.01$) reflects the role of economic models BCG

In pushing the organization towards sustainable development which is in line with Thailand's policy guidelines as planned. BCG Economy Model (NSTDA, 2021) and the international circular economy guidelines (World Economic Forum, 2020)

By managing energy in the organization (TE) IF affects both direct (b = 0.22) and indirectly through BCG (b = 0.42) with the sum of influence (TE) up to (b = 0.64) shows that systematic energy management starts from planning, measurement, and participation of personnel within the organization. It truly plays an important role in saving energy. Research by Pansombat (2019) supports this finding. It states that energy management in factories with proper evaluation and use of technology can significantly reduce energy costs. consistent with the concept Total Energy Management of Harris (1974) and Vieira (2015)

In the section on innovation management in organizations (NM) Although it has an overall influence on IF at a moderate level (b = 0.33), but found a negative direct influence (b

= -0.20), which may reflect communication problems within the organization or resistance to change by employees in some cases. However, when considering indirect influence through BCG (b = 0.53) found that NM Energy efficiency can be promoted if innovation is properly integrated into the green economy. consistent with the work of Howald et al. (2018) and Chotikarn (2020), and Channuwong et al. (2022) who emphasize that for innovation to be truly effective it must be supported structurally in terms of policy, personnel, and organizational culture.

And finally, the model variance shows high accuracy (R^2 of BCG = 0.87, IF = 0.90) indicates that this model is suitable for analyzing structural factors of energy management in the industrial sector. which is consistent with the work of Thanarak et al. (2021) in the study of energy management and innovation with title “Summary of the application of economic models BCG together with energy management and innovation management” which found that it is an important guideline that affects the effectiveness of energy saving in the organization. Specially, creating participation strategic planning and the use of new technologies should be promoted and expanded at the policy level to drive the country's sustainable development goals.

Suggestions for next research

Guidelines for expanding results towards sustainable development of Thai industry from a study that focused on gas-fueled industrial plants in the eastern region of Thailand. It was found that innovation management is consistent with the concept BCG Model It plays an important role in increasing the effectiveness of energy saving in the organization. To expand knowledge and lead to sustainable development in the Thai industrial sector. Therefore, there are suggestions for future research as follows.

1) Expand the scope of research to cover all agencies that use gas fuel. The sample should be expanded to be diverse. To compare energy saving results and find innovations that can be applied across industries. Helps formulate policy with a more comprehensive database.

2) Re-study in the same context over time. The study should be completed to assess the continuation of the results. Both in terms of saving energy Reducing greenhouse gas emissions and the impact of new technology or policy

Research Article

3) Long-term study design (Longitudinal Study) Long-term research will help track the development of organizations adopting energy-saving technologies. and clearly reflects the sustainability of this approach

4) Increase qualitative research to understand issues in depth Studying complex factors such as acceptance of new technology Organizational challenges and organizational culture through qualitative research It will help reinforce the insights more clearly.

5) Expand education in other industries. You should study industrial sectors with different production characteristics, such as agriculture, food or renewable energy factories. To compare and develop appropriate energy management models in each context.

6) Add organizational and policy factors to the analysis. Integrating new factors such as organizational culture, leadership, and government support. It will help make the analysis more comprehensive. and in line with the country's sustainable development goals Conclusion: These recommendations aim to strengthen knowledge and guidelines for efficient energy management in the Thai industrial sector. Ready to support the use of technology and innovation that concretely answers the needs of the green economy and sustainable development in the future.

CONCLUSION

The objective of this research is to study factors influencing the effectiveness of gas fuel energy saving in industrial plants in the eastern region of Thailand. Focusing on integration between energy management Innovation management and the use of policy based on the concept BCG Model (Bio-Circular-Green Economy) The results of the structural analysis found that all three factors were significantly related. and has a positive effect on the effectiveness of energy saving. Especially using the concept of green economy and circular economy. This reduces energy loss and greenhouse gas emissions. It also promotes competitiveness at the international level.

By developing policies that support energy-saving technologies. Changing behavior within the organization and promoting public-private sector cooperation It will be the key to driving Thai industry towards true sustainability. This research can therefore guide policy and practice in energy management of industrial organizations. to support the transition to a green economy in the future

REFERENCES

[1] Chen, Y., & Li, S. (2021). Green innovation and sustainable development: Empirical evidence from China. Journal of Cleaner Production, 278, 123–478.
[3] Chotikarn, S. (2020). Social innovation: a driving force for sustainable development.
Social Development Journal, 22(1), 87–108.
[4] Channuwong, S., & Ruksat, S. (2022). Buddhist teachings for improving mental health during the COVID-19 pandemic. The Journal of Behavioral Science, 17(2), 29-41.
[5] Channuwong, S., Siripap, P., Ladnongkun, V., & Makingrilas, J. (2022). Marketing strategies influencing customer satisfaction of supermarkets in Bangkok Areas. Journal of MCU Peace Studies, 10(2), 472-487.
[6] Choudhary, A., Mathur, S., & Jain, K. (2018). Achieving energy efficiency in industries through innovative technologies: An overview. Renewable and Sustainable Energy Reviews, 81, 1678–1697. https://doi.org/10.1016/j.rser.2017.05.282
[7] Creative Economy Agency (CEA). (2022). BCG Economy Model: Guidelines for driving Thailand with the creative economy. Bangkok: Creative Economy Promotion Agency.
[8] Debnath, K. B., Mourshed, M., & Keane, M. M. (2019). Sustainability and Resilience in Energy Systems: A Life Cycle Management Perspective. Sustainable Energy Technologies and Assessments, 35, 258–270.
[9] Ellen MacArthur Foundation. (2019). Completing the Picture: How the Circular Economy Tackles Climate Change. Cowes: Ellen MacArthur Foundation.
[10] Geissdoerfer, M., Savaget, P., Bocken, N. M. P., & Hultink, E. J. (2017). The Circular Economy – A new sustainability paradigm? Journal of Cleaner Production, 143, 757– 768. https://doi.org/10.1016/j.jclepro.2016.12.048
[11] Harris, L. (1974). Total energy management. Industrial Press.

Research Article

[12] Howaldt, J., Kaletka, C., & Schröder, A. (2018). Social innovation and its relationship to social change: Verifying existing social theories in reference to social innovation and its relationship to social change. Athens Journal of Social Sciences, 5(2), 123–144.
[13] Homnan, J. (2020). Social innovation for organizational adaptation in the era of change.
Loei Rajabhat University Research and Development Journal, 15(2), 45-58.
[14] Khamron. A. (2019). Using technology to analyze energy use in industrial plants.
Journal of Alternative Energy and Environmental Technology, 7(1), 55-68.
[15] Kemp, R., & Foxon, T. (2017). Technological transitions and system innovations. In Handbook of Sustainable Innovation (pp. 10–22). Edward Elgar Publishing.
[16] Klewitz, J., Zeyen, A., & Hansen, E. G. (2017). Intermediaries Driving Eco-innovation in SMEs: A Qualitative Investigation. European Journal of Innovation Management, 20(2), 233–257.
[17] Nakasombat, T. (2021). Bioeconomy development in Thailand: opportunities and challenges. Journal of Political Economy, 9(1), 25-40.
[18] NSTDA (National Science and Technology Development Agency). (2021). BCG Model: Bio-Economy-Circular-Green. For sustainable development. Bangkok: National Science and Technology Development Agency.
[19] Office of the Permanent Secretary, Ministry of Energy. (2022). National Energy Strategy 2022–2037. Bangkok: Ministry of Energy.
[20] Office of the National Economic and Social Development Council. (2021). National Economic and Social Development Plan No. 13 (2023–2027). Bangkok: Office of the National Economic and Social Development Council.
[21] Pansombat, P. (2019). Energy management in the industrial sector: a case study of a food factory. Mahanakorn Technology Business Administration Journal, 16(2), 1–15.
[22] Phutrakul, K. (2022). BCG Model: Thailand's new future. Bangkok: Digital Economy Promotion Agency.
[23] Prasertsan, S., Rerkkriangkrai, W., & Chaisomphob, T. (2019). Energy management for sustainable industry in Thailand. Renewable and Sustainable Energy Reviews, 101, 27–40.
[24] TGO (2023). Guidelines for using the carbon credit system in Thailand. Bangkok: Greenhouse Gas Management Organization (Public Organization).
[25] Thanarak, P., Chanthong, W., & Pimonsathean, Y. (2021). Applying Structural Equation Modeling (SEM) to assess energy management practices in the Thai manufacturing sector. Energy Reports, 7, 4990–5001.
[26] United Nations Development Programme (UNDP). (2021). Thailand's Bio-Circular-Green Economic Model: An Inclusive and Sustainable Pathway to Prosperity. Bangkok: UNDP Thailand.
[27] Vieira, E. (2015). Energy Efficiency: Towards the End of Demand Growth. Academic Press. Vieira, E. (2015). Organizational Energy Management: A Multidimensional Perspective.
Journal of Cleaner Production, 105, 163-178.
[28] World Bank. (2021). Thailand Economic Monitor: The Road to Recovery. Washington, DC: World Bank Group.
[29] World Economic Forum. (2020). The Circular Economy Imperative: How to Build Resilient, Thriving Economies. Retrieved from https://www.weforum.org
[30] Wongmajarapinya, K., Channuwong, S., & Pratoomsawat, T. (2024). The model of modern
management influencing sustainable organization development of Thai Smile Bus Company Limited. Migration Letters, 21(S2), 385-399.
[31] Yamane, T. (1973). Statistics: An introductory analysis (3rd ed.). Harper and Row.