International Journal of Advanced Research in Engineering and Technology (IJARET) Volume 13, Issue 2, February 2022, pp. 10-17, Article ID: IJARET_13_02_002 Available online at https://iaeme.com/Home/issue/IJARET?Volume=13&Issue=2 ISSN Print: 0976-6480 and ISSN Online: 0976-6499 DOI: https://doi.org/10.17605/OSF.IO/4QVPN

© IAEME Publication

Scopus Indexed

Scopus

ECO-EFFICIENCY FACTOR IN GREEN CONSTRUCTION PROJECT MANAGEMENT

Wasu Pittayasoponkij¹, Dr. Waranon Kongsong² and Dr. Chaiwat Pooworakulchai³

¹Ph.D. Student in Engineering Law and Inspection, Faculty of Engineering, Ramkhamhaeng University, Humark, Bangkok 10240 Thailand

²Assistant Professor in the Engineering Law and Inspection, Faculty of Engineering, Ramkhamhaeng University, Humark, Bangkok 10240 Thailand, Orcid: 0000-0003-2651-8476

³Lecturer in the Engineering Law and Inspection, Faculty of Engineering, Ramkhamhaeng University, Humark, Bangkok 10240 Thailand

ABSTRACT

The objectives of this research were (1) to study eco-efficiency factors in green construction project management and (2) to study the relationship of eco-efficiency factors in green construction project management. is a study of factors and the relationship of each factor affecting the development towards efficient green construction project management. Let's start with the study of the cause. and problems in the past have arisen in the management of green construction projects Along with studying the factors of eco-efficiency In this research, data were collected by in-depth interview and questionnaire data collected from representatives of groups involved in the management of green construction projects, including environmental personnel. Construction personnel group Legal Personnel Group The results were analyzed and prioritized eco-efficiency factors in green construction project management by using the Relative Importance Index (RII). The relative importance index represents the factors affecting the management of green construction projects. The results of the interviews were then studied. and analyze issues to lead to a way that helps to create support and develop green construction project management By analyzing the hierarchical data using the Analytic Hierarchy Process (AHP) and checking the consistency Ratio (CR). The 1st-3rd group of representatives had CR = 0.044, 0.025and 0.051, respectively, and the order of eco-efficiency factors in green construction project management, the 1st - 3rd order, consisted of enhancing the potential for reuse of materials. reduce resource consumption and promote the use of renewable resources

Key words: Factor, eco-efficiency, green construction.

Cite this Article: Wasu Pittayasoponkij, Waranon Kongsong and Chaiwat Pooworakulchai, Eco-Efficiency Factor in Green Construction Project Management, *International Journal of Advanced Research in Engineering and Technology (IJARET)*. 13(2), 2022, pp. 10-17. https://iaeme.com/Home/issue/IJARET?Volume=13&Issue=2

1. INTRODUCTION

1.1. Background and importance of the Problem

construction project management It is the starting point for development in various fields and supports the growing demand of people continuously. When there is an increase in development The environmental impact in various fields has also increased, whether it is a pollution problem environmental destruction depletion of natural resources and the reduction of energy available today The events mentioned above are driving people to have increased awareness including protection Continue to care for natural resources and the environment. Green construction project management is another option that helps the development of construction projects along with environmental conservation. The problems encountered in the development of green construction project management contracts are project management costs. Quality control of both personnel and materials and efficient materials and equipment for green construction projects [1]

Environment plays a huge role nowadays. One of the development options Along with ecofriendly growth is eco-efficiency. It is one of the country's key development strategies in Thailand's 12th National Economic and Social Development Plan, which outlines "Environmentally Friendly Growth for Sustainable Development" based on the concept of growth along with conservation. natural resources and the environment found

Eco-efficiency is an industrial management tool to enhance business competitiveness along with environmentally friendly production. Eco-efficiency It is an idea initiated by The World Business Council for Sustainable Development (WBCSD). Eco-efficiency can be implemented along the entire value chain of a product or service, not just within the physical boundaries of the plant. For some companies, the main harmful effects on the environment with which they are associated actually occur outside their fences - either upstream in the raw material generation and supplier processing phases, or downstream in the product use or disposal phases. In light of this, eco-efficiency can be achieved through seven. key approaches: (1) Reduce material intensity (2) Energy intensity minimized (3) Dispersion of toxic substances is reduced (4) Undertake recycling (5) Capitalize on use of renewables (6) Extend product durability (7) Service intensity is increased [2] In Thailand, the NSTDA defines the term eco efficiency (Eco-Efficiency) is a management philosophy (Management Philosophy) that is consistent with the goals of the government, that is, it is important to both add value (Value Creation) and reduce the impact on the environment. (Environmental Impact) [3] Eco-efficiency It is also an important tool for sustainable development. There are 3 main concepts which are (1) increasing the value (value) of the product or service (2) reducing the use of resources (resource) and (3) reducing the emission or impact on the environment. Examples of factors affecting green construction project management include good attitude towards the project. understanding of the project Material efficiency, material cost, increased cost construction changes Related documents approval process and government benefits for project participants [4]

Environmental advocates maintain that waste minimization, recycling, remanufacturing and other environmental practices will greatly enhance the ``bottom-line" for organizations) [5], in line with [6] that considers two methods of environmental protection, "recycled harmful substances. to the environment (Rec)" and "other methods to control pollution (Other)," positively impact future financial performance. This improvement reflects the results of the company at different levels. both in terms of efficiency product quality or the relationship of stakeholders and confirming situations that are beneficial to both the environment and the company [7]

2. OBJECTIVES

To study the factors of eco-efficiency in the management of green construction projects and to study the relationship of eco-efficiency factors in green construction project management

3. RESEARCH METHODOLOGY

This research is a research by collecting data from documents, textbooks, books, articles, related research. To define issues related to eco-efficiency in green construction project management As a variable for creating interview forms and questionnaires by collecting data from 3 groups of stakeholders, namely environmental personnel representatives; Representative of the construction personnel group Representatives of the legal personnel group consisting of employers, designers, project consultants, contractors, supervisors, contractors

The importance of each factor in the management of green construction projects affecting eco-efficiency by comparing the significance weight of each pair of factors and weigh the importance of the degree of difference between these factors. The importance level is divided into 9 levels as shown in Table 1.

level of meaning	meaning	Description		
1	equal importance	Both factors are equally important.		
3	more important than medium	One factor is more important than a moderate		
		factor.		
5	noticeably more important	One factor is clearly more important than the		
		other.		
7	more important than most	One factor is most important than the other.		
9	It's even more important.	One factor is significantly more important		
		than a factor.		
2,4,6,8	It is the middle priority of the	The relative significance value is considered		
	values mentioned above.	to be the middle of the above-mentioned		
		values.		

Table 1 The level of importance of each factor in the management of green construction projects affecting eco-efficiency

The data from the in-depth interview were analyzed by hierarchical data using the Analytic Hierarchy Process (AHP) and the Consistency Ratio (CR) was examined. interviewee which is used to calculate the Eigenvector that is reasonable or not In which case the CR value is less than or equal to 0.10 is considered acceptable. by finding the consistency of reason It can be obtained from equation (1) and equation (2) as follows:

$$CI = \frac{(L-n)}{(n-1)}$$
(1)

$$CR = \frac{CI}{RI}$$
(2)

CI	=	Consistency Index
RI	=	Random Consistency Index (Table 2)
n	=	number of factors being compared
L	=	Sum(consistency vector) n
Sum(consistency vector)	_	Sum (Weight gain from experts * Eiganvector)
Sum(consistency vector)	_	Eiganvector

Table 2 Random Consistency index (R)									
Ν	1	2	3	4	5	6	7	8	9
R.I.	0.00	0.00	0.58	0.90	1.12	1.24	1.32	1.41	1.51

Table 2 Random Consistency Index (RI)

The data from the questionnaire was used to analyze the ranking of factors affecting the management of green construction projects by group of variables in each aspect as well. Relative Importance Index (RII) [8]

$$RII = \frac{\sum_{i=1}^{5} W_i X_i}{AN} \times 100\%$$
(3)

$$W_i = Criteria to measure the level of impact, ranging from 1-5.$$

$$X_i = The number of responses in each criterion$$

$$A = The highest measurement criterion is 5.$$

$$N = Total number of questionnaires$$

4. RESULTS AND DISCUSSION

Research results of eco-efficiency factors in green construction project management By categorizing factors in each aspect affecting the management of green construction projects. and to determine the relationship of eco-efficiency factors in the management of green construction projects divided into main factors and sub-factors with details as follows:

The main factors are cost, project management, quality and benefits.

The sub-factors are:

(1) Cost factors consist of personnel, materials/equipment Location/project area and procedure

(2) Project management factors consist of planning/operation procedures, timing, control/audit/assessment. and related documents

(3) Quality factors consist of personnel, materials/equipment. and environment

(4) Sub-factors in terms of benefits, comprising an increase in market value Government benefits increased utilization corporate image

4.1. Interview Data

Data were collected by in-depth interviews from 3 groups of stakeholders, namely environmental personnel representatives. Representative of the construction personnel group Representatives of the legal personnel group consisting of employers, designers, project consultants, contractors, supervisors

The results of this study were used to analyze and find the relationship of eco-efficiency factors in the management of green construction projects using the Analytic Hierarchy Process (AHP) and examine the Consistency Ratio (CR). Found

The results of the analysis and finding the importance of eco-efficiency factors in green construction project management using the Analytic Hierarchy Process (AHP) and checking the Consistency Ratio (CR) according to Equation (2) from the inquiry. Opinion of the sample as shown in Table 3 - 5

Wasu Pittayasoponkij, Waranon Kongsong and Chaiwat Pooworakulchai

Table 3 Importance of main Factors in Green Construction Project Management Affecting Ecoefficiency from the first group of representatives

Main Factors	Eigenvector
1. Cost	0.272
2. Project Management	0.540
3. Quality	0.057
4. Benefits	0.131

The results of the analysis of opinions of The first group of representatives had CR = 0.044, which is less than 0.10, indicating that the factors from group 1 were consistent. The Eigenvector could be used as a weight value. For the importance of factors in the management of green construction projects that affect eco-efficiency. of the first group of representatives, namely project management The priority is 0.540, which is the first priority, the cost is 0.272, which is the second priority. Benefits The importance is 0.131, which is the 3rd priority, the quality is 0.057, which is the 4th priority.

Table 4 Importance of main factors in green construction project management affecting eco-efficiency from representatives of the 2nd group

Main Factors	Eigenvector
1. Cost	0.477
2. Project Management	0.290
3. Quality	0.100
4. Benefits	0.133

The results of the analysis of the opinions of the representatives of group 2 revealed that CR = 0.025, which was less than 0.10, indicating that the factor values from the representatives of group 2 were consistent. Eigenvector could be used as a weight value. For the importance of factors in the management of green construction projects that affect eco-efficiency. Of the 2nd group of representatives, namely cost, with a value of 0.477, which is the first priority in project management. The priority is 0.290, which is the second priority. The importance is 0.133, which is the 3rd priority, the quality is 0.100, which is the 4th priority.

Table 5 Importance of Main Factors in Green Construction Project Management Affecting Ecoefficiency from representatives of the 3rd group

Main Factors	Eigenvector
1. Cost	0.347
2. Project Management	0.469
3. Quality	0.056
4. Benefits	0.128

The results of the analysis of the opinions of the representatives of group 3 showed that CR = 0.051, which was less than 0.10, indicating that the factor values from the representatives of group 3 were consistent. Eigenvector could be used as a weight value. For the importance of factors in the management of green construction projects that affect eco-efficiency. of the 3rd group of representatives, namely project management The priority is 0.469, which is the first priority, the cost is 0.347, which is the second priority. The importance is 0.128, which is the 3rd priority, the quality is 0.056, which is the 4th priority.

to prove the importance of factors Summary of the importance of factors in the preparation of the environmental impact assessment process of steel factories located in industrial estates as shown in Table 6.

Factors	Group 1 Representative		(Ren	Group 2 resentative	Group 3 Representative		
Factors	order	Significance	order	Significance	order	Significance	
Main factor		5					
1. Cost	2	0.272	1	0.477	2	0.347	
2. Project Management	1	0.540	2	0.290	1	0.469	
3. Quality	4	0.057	4	0.100	4	0.056	
4. Benefits	3	0.131	3	0.133	3	0.128	
Sub-factor							
1. Cost							
1.1 Personnel	4	0.066	3	0.125	3	0.127	
1.2 Materials/							
Equipment	1	0.507	2	0.308	2	0.297	
1.3 Location/ project							
area	2	0.332	4	0.052	1	0.525	
1.4 Process	3	0.095	1	0.515	4	0.052	
2. Project Management							
2.1 Planning/ Operation							
Procedures	1	0.576	1	0.587	1	0.556	
2.2 period	4	0.057	2	0.256	3	0.119	
2.3 control/audit/							
assessment	2	0.251	3	0.099	2	0.280	
2.4 Related documents	3	0.116	4	0.058	4	0.045	
3. Quality							
3.1 Personnel	3	0.082	1	0.648	1	0.690	
3.2 material/ equipment	1	0.602	3	0.122	3	0.149	
3.3 environment	2	0.315	2	0.230	2	0.161	
4. Benefits							
4.1 Adding Market							
Value	2	0.264	1	0.503	4	0.081	

Table 6 Summary of the importance of factors in the preparation of the management of green construction projects affecting eco-efficiency.

Factors	Group 1 Representative		(Rep	Froup 2 resentative	Group 3 Representative	
	order	Significance	order	Significance	order	Significance
4.2 Government	3	0.092	2	0.321	3	0.170
benefits						
4.3 increased utilization	1	0.598	3	0.128	1	0.525
4.4 corporate image	4	0.047	4	0.048	2	0.224

4.2. Questionnaire Information

Results of the study by categorizing eco-efficiency factors affecting green construction project management. A total of 25 factors were collected by questionnaire. The total number of samples was 85. A minimum determination of 72 samples showed 18.06% more data than the initial sample count for reliability testing. (Reliability) by determining Cronbach's alpha coefficient of 0.95 from the analysis and ranking of factors affecting the management of green construction

projects in terms of eco-efficiency by Relative Importance. Index (RII), where the relative importance index represents the eco-efficiency factor in the management of green construction projects. The results of the analysis and ranking of factors according to equation (3) from the questionnaire of the sample group. as shown in Table 7.

 Table 7 Results of the sequence analysis of factors affecting the management of green construction projects in terms of eco-efficiency

	Factors Affecting Green Construction Project Management	RII (%)	Ranking
1.	reduce water use	67.3	21
2.	reduce energy consumption	80.7	4
3.	reduce resource consumption	81.4	2
4.	Reduce the release of toxic substances into the environment	79.5	5
5.	Strengthening material reuse potential	83.1	1
6.	Promote the use of renewable resources	81.2	3
7.	increase the shelf life of the product	73.9	9
8.	Increase the service level of the products and strengthen the	71.5	14
	service business.		
9.	climate change	75.5	7
10.	ozone depletion	64.2	25
11.	Ecotoxicity	73.4	11
12.	air pollution emissions	76.2	6
13.	water pollution emissions	73.6	10
14.	soil emissions	72.7	12
15.	Emissions in the form of solid waste / waste	69.4	18
16.	Emissions in the form of hazardous materials	70.6	15
17.	noise pollution	68.7	20
18.	raw material acquisition process	70.4	16
19.	transport procedure	68.9	19
20.	The process of bringing raw materials to use in production	69.9	17
21.	Carcass/waste disposal procedures	72.0	13
22.	goal setting and clear boundaries Product revenue	74.8	8
23.	Product revenue	65.2	24
24.	Amount of products produced	65.9	23
25.	Environmental Impact Assessment	67.1	22

Based on the results of the RII analysis, prioritize factors affecting the management of green construction projects in terms of eco-efficiency. From the questionnaire for the opinions of the sample group, the first order was to enhance the reuse of materials (RII 83.1%), the second was to reduce the use of resources (RII 81.4%), and the third was to promote the use of renewable resources (RII 81.2%).

5. CONCLUSION

The results of the study of eco-efficiency factors in the management of green construction projects from asking for opinions by interview and the questionnaire of the target group by collecting data from 3 groups of stakeholders, namely representatives of the environmental personnel group; Representative of the construction personnel group Representatives of a group of legal personnel, comprising employers, designers, project consultants, contractors, and supervisors, then analyzed and determined the importance of eco-efficiency factors in the management of green construction projects using the Analytic Hierarchy Process (AHP) and checked for Consistency Ratio (CR) results from the analysis of opinions of The first group of representatives got CR = 0.044. The importance of factors in the management of green

construction projects affecting eco-efficiency are project management, cost, benefits and benefits. and quality, respectively, the second group of representatives had CR = 0.025. The priorities of the factors were cost aspect, project management aspect. benefit and quality The third group of representatives got CR = 0.051. Priority factors were project management, cost, benefits. and quality For the analysis and ranking of eco-efficiency factors in green construction project management by using the Relative Importance Index (RII), the relative importance index represents the factors affecting the management of green construction projects. RII prioritizes the highest of factors: 1st, enhancing material recycling capacity (RII 83.1%), 2nd reducing resource consumption (RII 81.4%), and 3 promoting the use of renewable resources (RII 81.2%)

REFERENCES

- [1] Wasu Pittayasoponkij, Waranon Kongsong, Chaiwat Pooworakulchai. "Green construction project contract development under construction standard : A Review", ELI. Conference 2021, Engineering Law and Inspection 15 May 2021
- [2] The World Business Council for Sustainable Development (WBCSD). eco-efficiency Learning Module [Online] https://www.wbcsd.org/Projects/Education/Resources/Eco-efficiency-Learning-Module.
- [3] National Science and Technology Development Agency (NSTDA), Office of the State Enterprise Policy Office (KOR.) (Practice Edition) January 2020
- [4] Wasu Pittayasoponkij, Waranon Kongsong, Chaiwat Pooworakulchai. Factors Affecting Green Construction Project Management. International Journal of Management (IJM)Vol 12, Issue 11: pp 65-72
- [5] Joseph Sarkis, James J. Cordeiro. An empirical evaluation of environmental efficiencies and firm performance: Pollution prevention versus end-of-pipe practice. European Journal of Operational Research 2001; 135: 102-113
- [6] Hang Song, Chunguang Zhao, Junping Zeng. Can environmental management improve financial performance: An empirical study of A-shares listed companies in China. Journal of Cleaner Production 141 (2017) 1051 1056
- [7] Pilar Rivera-Torres, Concepción Garcés-Ayerbe, Sabina Scarpellini, and Jesús Valero-Gil. Pro-Environmental Change and Short- to Mid-Term Economic Performance: The Mediating Effect of Organisational Design Change. Organization & Environment 2015, Vol. 28(3) 307–327
- [8] R. F. Aziz, "Ranking of delay factors in construction projects after Egyptian revolution, Alexandria Engineering Journal, vol. 52, no. 3 pp. 387-406, 2013.