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Exploring Critical Success Factors of Energy Management for Sustainable Building in Malaysian University

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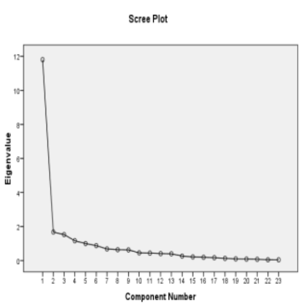
Graphical abstract



Abstract

Universities are increasingly consuming energy due to its population with various activities. Thus, Malaysian Higher Education Ministry insisted all parties involved to take the initiatives in reducing the energy consumption. Focusing on the importance of practicing energy management (EM) effectively, this paper discusses the Critical Success Factors (CSFs) towards sustainable university. Structured interviews, pilot study and a questionnaire survey were conducted. The findings disclose the relative importance of the 23 number of identified CSFs. In order to explore the underlying relationship among the identified CSFs, factor analysis method was adopted, which leads to grouping the 23 identified CSFs into four groups.

Keywords: Critical Success Factors (CSFs); energy management (EM); sustainable university

Abstrak

Penggunaan tenaga elektrik yang tinggi di bangunan universiti adalah disebabkan oleh populasi dengan pelbagai aktiviti. Oleh itu, Kementerian Pengajian Tinggi Malaysia mendesak semua pihak yang terlibat untuk mengambil inisiatif dalam mengurangkan penggunaan tenaga elektrik ini. Dengan memberi tumpuan kepada kepentingan mempraktis pengurusan tenaga (EM) secara berkesan, kertas kerja ini membincangkan Faktor Kejayaan Kritikal (CSFs) ke arah universiti yang lestari. Temu bual berstruktur, kajian rintis dan soal selidik telah dijalankan. Hasil kajian telah mengenal pasti kepentingan relatif 23 CSFs. Dalam usaha untuk meneroka hubungan asas antara CSFs yang dikenal pasti, kaedah analisis faktor telah diterima, yang membawa kepada kumpulan 23 CSFs tadi kepada empat kelompok.

Kata kunci: Faktor Kejayaan Kritikal (CSFs); pengurusan tenaga; kelestarian universiti

■1.0 INTRODUCTION

Buildings are important contributors to a large energy consumption which represent 40% of energy usage[1] and has led to environmental problems[2-3]. Energy consumption in Malaysia is relatively high compared to other middle income developing countries.[4] Malaysian university buildings are not exempted from the issue of high energy consumption.

University buildings are high consumers of energy in the category of commercial buildings due to its activities and population.[5-6] A survey done has shown the energy consumption in Universiti Teknologi Malaysia and International Islamic University Malaysia has led to more than ten million ringgit annually due to increment of students' population almost every year,[4] and this has received a serious attention from many parties.

The statistic of Malaysia Ministry of Higher Education (MOHE) shows the building users are more than 1 million people at any given time which include the public and private universities, colleges and polytechnics. Table 1 shows total of students and academic staff for year 2010 (MOHE, 2011). The energy consumption due to the population and various activities has given the impact on the environment either directly or indirectly.[5] In spite of this, many universities have been forced to anticipate and propose a comprehensive approach to reduce the energy consumption.[4] In line with the efforts, many plans towards sustainable university have been organized by MOHE to ensure the usage of energy in university can be well-managed.

The study of EM becomes crucial in developing countries. It can be proven by many studies have been done previously. For example of the previous studies relate to EM are energy conservation program in government building,[7] energy efficient design of office buildings in Malaysia,[8] conceptual framework of energy awareness development process,[9] energy efficiency award system in Malaysia for sustainable energy,[10] implementation of EM key practices for Malaysia universities,[4] sustainable EM and its effect on energy efficiency index in university buildings.[6] Yet, study on the CSFs for EM has not been explored.

Table 1 Number of students and academic staff in higher education institute for year 2010

Energy users in higher education institute for year 2010	IPTA	IPTS	Poly-technics	Community Colleges
Student	437,420	509,556	86,471	17,279
Academic Staff	28,571	33,613	6,741	2,259
Total	**465,991**	**517,369**	**93,212**	**19,538**
Grand Total of student and academic staff in IPTA, IPTS, Polytechnics and Community Colleges	**1,096,110**			

*Note: IPTA - Institut Pengajian Tinggi Awam (Public Institute of Higher Learning); IPTS - Institut Pengajian Tinggi Swasta (Private Instutute of Higher Learning)

In view of sustainability, the progress is very slow and disappointing with various obstacles[11-14] such as lack of policy framework, inadequate data and information, lack of awareness, lack of financial support, lack of teamwork and commitment, lack of experience in technology and management, lack of manpower and education and many more. In addition, there are still many of university leaders and academicians are unaware of sustainability principles.[15-16] Therefore, there is an urgent need to develop a practicable and efficient guideline for improving the implementation of EM towards Malaysian sustainable university. This paper aims to develop a set of CSFs for implementing EM in universities buildings with prominence on sustainability. In this study, a systematic approach is adopted to combine several research exercises to analyze the CSFs.

2.0 LITERATURE REVIEW

2.1 EM towards Malaysian Sustainable University

In Malaysia, the Ministry of Higher Education (MOHE) spends more than ten million ringgit annually on the expensive electricity bills.[4] Figure 1 shows the percentage of energy used in educational building. The major electricity used in Malaysian universities building was HVAC (45%), followed by lighting system (42%), water heating (3%) and others (10%). Consequently, university is a place which well-suited for strategic EM where it involves people at all levels to achieve energy policies and objectives.[4] In fact, an energy cost savings of 5-15 percent is usually obtained when EM is implemented.[17]

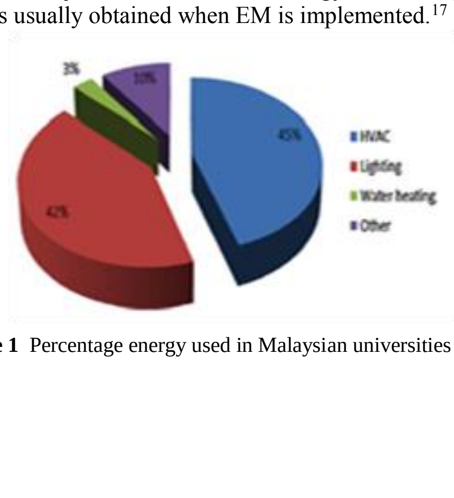


Figure 1 Percentage energy used in Malaysian universities building

A building does not have to be new to be efficient where it can be applied by converting existing buildings into models of sustainability.[18] The concept of sustainability has been widely recognized, promoted, integrated and considered in many sectors, including education sector.[19-21] Sustainability is "a process that aims at meeting the needs of the present generation without harming the ability of future generations to meet their needs".[22]

While ULSF describes sustainability by stating: *"Sustainability implies that the critical activities of a higher education are at a minimum ecologically sound, socially just and economically viable, and that they will continue to be so for future generations. A truly university would emphasize these concepts in its curriculum and research, preparing students to contribute as working citizens to an environmentally sound and socially just society"*. From this perspective, the main challenge towards sustainable university is through simultaneous environmental, social, and economic improvement. It is also known as "Triple Bottom Line" (TBL) which is often used in any organizations to achieve sustainability as hown in Figure 2.[28]

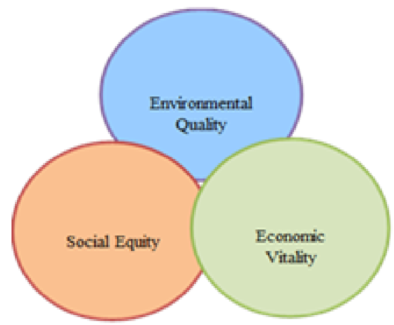


Figure 2 Integration of environmental, social and economic

Therefore, to be a sustainable university, it is important to implement EM based on the sustainability concept which integrates environmental, economic and social that will be the catalyst to the success of the university's mission in particular and the country in general. It is also known as "Triple Bottom Line" (TBL) which is often used in any organizations to achieve sustainability. There are many things to be done for universities to become true sustainable, where the concept of sustainability must be understood by people in organizations but most of them have taken it for granted.[23-24] Commitment towards these three basic elements needs to be addressed in order to guide or help universities in achieving sustainable status. "Without satisfying ecological imperatives, we poison ourselves, deplete our resources, and destroy the basic life support systems essential to the human and non-human survival. Without satisfying the economic imperative, we cannot provide the necessities of life, let alone meaningful work. Without satisfying the social imperative, our societies will collapse into chaos. Failure in any one area will result in failure in the other two" claimed.[25] However, there are still many who view sustainable development from the aspect of environmental alone.[26-27] Therefore the idea of CSFs for EM towards sustainable university is vital to improve the management of energy in university in the sense that it will indicate the progress in particular areas. The key question then ascended "How well an EM has been practiced towards sustainable universities without taking the CSFs into consideration".

2.2 CSFs for EM Towards Sustainable University

CSFs are originally defined as the limited number of areas in which results, if they are satisfactory, will ensure successful performance for the organization.[28] With the example of research exists on the CSFs, it is clear that CSFs are important and adopted by many areas. Although context-driven research may differ on the nature of focus, there are some common factors from the existing research on CSFs can be used for EM. However, the literature is still dominated by "laundry list" of CSFs rather than systematic and comprehensive by grouping the CSFs into cluster. Therefore, in this research, all variables of the CSFs identified from the international organizations and previous researchers are categorized according to cluster as shown in Table 2.

Table 2 CSFs for implementing EM from international organizations and previous researchers

CSFs	International Organizations and Researcher															
	(29)	(30)	(31)	(32)	(33)	(34)	(35)	(36)	(37)	(38)	(39)	(40)	(41)	(4)	(42)	(43)
1) Top Management Support																
Develop energy policy and guidelines	X	X				X	X			X	X	X	X	X		X
Leadership	X					X	X		X				X	X		
Create incentives by establishing an award					X										X	X
Allocation of sufficient resources	X	X	X						X				X	X		X
Training provision			X	X				X						X	X	X
2) Comprehensive Energy Management Team																
Conduct energy audit						X			X	X	X	X		X	X	X
Operations and maintenance					X	X			X					X		X
Management review and verification					X					X		X		X		X
Continuous improvement								X	X	X				X	X	
3) Stakeholders' Involvement																
Understanding of project vision and goal					X	X			X	X		X				X
Good communication among stakeholders	X		X			X			X			X		X	X	X
Knowledge and skills	X		X		X	X			X				X			X
Trust among stakeholders						X	X		X			X	X			X
4) Awareness																
Understanding the issues		X	X			X	X		X			X	X			X
Increase general energy awareness	X	X	X	X		X			X			X		X		X
Improve facility energy awareness														X		X
Education by R&D, learning and teaching		X	X	X							X	X		X		X
Community engagement and partnership	X	X	X								X	X				X
Energy information	X	X	X								X	X				X
5) Risks Management																
Identify the risks					X	X				X			X			
Assess the Risks					X	X				X			X			
Develop responses to the risks					X	X				X			X			
Develop a contingency plan for the risks					X	X				X			X			

■3.0 RESEARCH METHODOLOGY

The specific methodology of this study is based on a literature review, face-to-face interviews, a pilot study and a questionnaire survey (Figure 3). The research flow follows the procedure in the studies of[44-45].

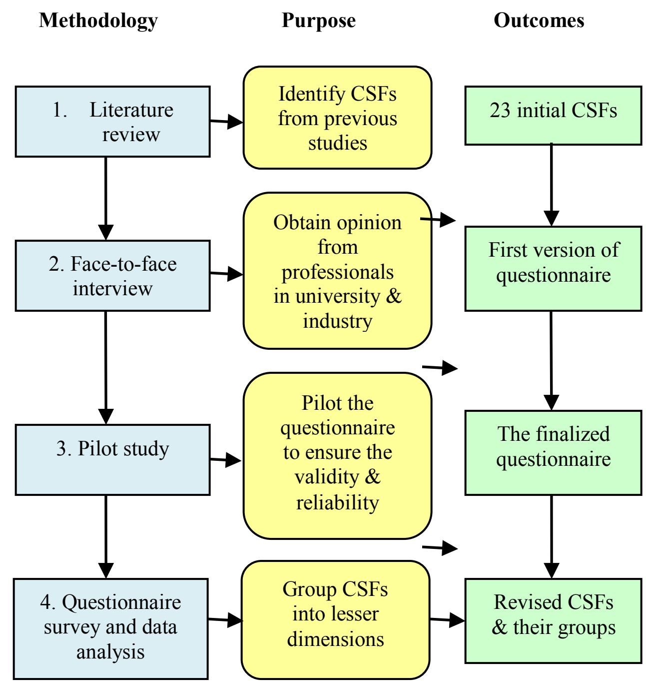


Figure 3 Research framework of this study

A thorough literature review was carried out to produce a comprehensive list of CSFs. 23 CSFs were identified in the literature review, then these CSFs were confirmed by professionals in university and industry before developing the questionnaire instrument. The preliminary list of CSFs was presented to 6 experts during face-to-face interviews. These experts were selected because they all had more than 10 years overall experience in managing energy or has conducted various research in the area of EM or sustainability. Table 3 shows the expert profile for face-to face interview. The interviews were conducted in the interviewees' office, and lasted for 0.5 to 1 hour, depending on the interviewees' available time. From the interview conducted, all interviewees agreed that the proposed 23 factors were critical and comprehensive, and meanwhile some interviewees provided valuable comments on the scope, for example the responsibilities to reduce the consumption of energy should come from all, not only selected technical person in charge.

A pilot study was also conducted to ensure the validity and reliability of items in questionnaire. One top management team, one is senior in sustainability centre, three are senior lecturers, five are energy managers and the other five are students were prompted to answer the preliminary questionnaire. There were no adverse comments proposed, so the finalized questionnaire is the same as that of the first version.

In responding to the questionnaire, respondents were requested to indicate the level of significance of each of the factors. The level of importance is measured on a 5-point Likert scale where 5=Extremely Significant; 4=Very Significant; 3=Moderately Significant; 2=Slightly Significant; 1=Not Significant. At the beginning of questionnaire comprises of respondents' background such as their position and the length of experience. At the end of questionnaire are suggestions for improving EM implementation towards sustainable university if any. The questionnaires were distributed via e-mail and personal delivery to increase the response rate. A total of 400 questionnaire were delivered to the respondents, only 280 completed questionnaires were received which generated a response rate of 70%.

Table 3 Expert profile

Expert	Organization	Position	Experience (years)
1	University	Head of Research Centre for Sustainability	23
2	University	Director of Environment & Development	18
3	University	Senior Lecturer; Research Alliance (Energy)	11
4	University	Senior Energy Manager in Facilities Management Unit	13
5	Industry	Consultant	18
6	Industry	Energy Manager	11

■4.0 DATA ANALYSIS AND FINDINGS

The Statistical Package for the Social Sciences (SPSS) 16.0 was used to analyze the data. The reliability of the 5-point Likert scale used in the survey was determined using Cronbach's coefficient alpha, to measure the internal consistency among the factors. The value of the test was 0.955, which was greater than 0.7. This indicates that the 5-point Likert scale measurement was reliable.

A long list of 23 CSFs is not very helpful to explain the success of a project. Factor analysis was used to explore and detect the underlying relationships among the identified CSFs. Factor analysis is typically known as a data reduction technique. This is a technique that tries to statistically identify a reduced number of factors from a larger number of items which are typically called the measured variables. The factors identified are called latent variables as they are not measured directly.

There are several tests required for the appropriateness of factor analysis. The tests include Kaise-Meyer-Olkin (KMO), Bartlett's Test of Sphericity, eigen values, % of variance, scree plot, and rotated component matrix. Result in Table 4 clearly shows the KMO value of 0.825 is >0.70 and the Bartlett's test which is significant ($p< 0.01$). This indicates that the data is suitable for a factor analysis.

Table 4 KMO and Bartlett's test

Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		0.825
Bartlett's Test of Sphericity	Approx.Chi-Square	675.503
	df	253
	Sig.	.000

Next is "Total Variance Explained" which is to assess how much of the variance has been explained by the extracted factors and how many factors has been extracted. From the Table 5, it shows that 4 factors can be extracted, where the initial eigen values are more than 1. The scree plot below can also be used to decide on number of factors that can be derived. From the Figure 4, based on eigen value only 4 factors will be extracted based on eigen value, but based on the scree plot it may be plausible up to 5 factors. Since initially the factors extracted are 4, so the scree plot stop at the 4 factor solution.

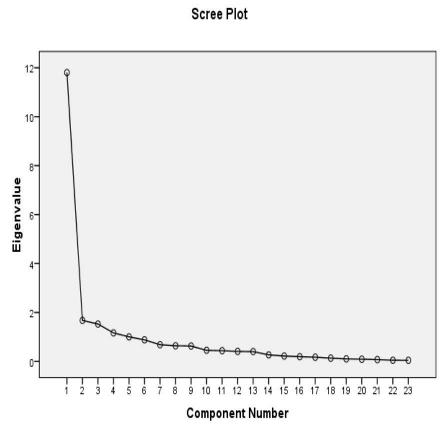


Figure 4 Scree plot

Table 5 Total variance explained

Component	Initial eigenvalues			Extraction sums of squared loadings		
	Total	% of variance	Cumulative %	Total	% of variance	Cumulative %
1	11.804	51.322	51.322	11.804	51.322	51.322
2	1.673	7.275	58.597	1.673	7.275	58.597
3	1.525	6.631	65.228	1.525	6.631	65.228
4	1.163	5.056	70.284	1.163	5.056	70.284
5	1.000	4.347	74.631			
↓	↓	↓	↓			
23	0.042	0.183	100.00			

Lastly is "Rotated Component Matrix". The significant loading factor must be >0.40 and above,[46] and the no of items for each factor must be at least 4 or 5.[47] From the Table 6, it shows that 10 items in factor 1, 5 items in factor 2, 4 items in factor 3, and lastly 4 items in factor 4. In conclusion, the factor loading and number of items obtained has fulfilled the requirement.

Table 6 Rotated component matrix

Item	Component			
	1	2	3	4
Develop energy policy and guidelines	0.658			
Implement and manage the committee of EM	0.568			
Conduct energy audit	0.708			
Operation & maintenance	0.680			
Continuous improvement	0.464			
Energy information	0.700			
Risk identification	0.813			
Risk Assessment	0.855			
Develop responses to the risk	0.779			
Develop a contingency plan for the risk	0.565			
Create incentives by establishing an award for positive contribution		0.692		
Training provisions		0.673		
Understanding of project vision and goal		0.778		
Trust among stakeholders		0.521		
Increase general energy awareness		0.732		
Allocation of sufficient resources; manpower, technology, money and time			0.566	
Good communication			0.656	
Understanding the issues			0.489	
Community engagement and partnerships			0.706	
Management review & verification of progress				0.697
Knowledge and skills				0.823
Improvement of facility energy awareness				0.673
Education by research & development, teaching and learning				0.587

A total of 23 items were analyzed and no items were removed, forming four factors as shown in Table 4. These four factors could explain 70.284% of CSFs for EM towards sustainable university to be studied. In the social sciences, this percentage is enough of the recommended value which is 60%.[47] The findings of the analysis showed that the first factor is a combination of variable items and requires an appropriate new name. Thus, the first factor containing 10 items was given the name Operation and Risks Management with eigenvalues 11.804 and accounted for 51.322% variance. The second factor containing 5 items was given the name Leadership Management with eigenvalues 1.673 and accounted for 7.275% variance. The third factor containing 4 items was given the name Partnerships and Resources with eigenvalues 1.525 and accounted for 6.631% variance. Lastly, the fourth factor containing 4 items was given the name Awareness Management with eigenvalues 1.163 and accounted for 5.056% variance. Thus, the factors or variables of CSFs in the context of EM towards sustainable university are: (1) Operations and Risks Management; (2) Leadership Management; (3) Partnerships and Resources; (4) Stakeholders' Involvement.

■5.0 CONCLUSION

Analysis in this study shows that various CSFs has important inter-relationships and can be grouped into one factor. This study stresses that if management of university is able to keep a good track of implementing EM based on four group of CSFs identified, they are likely towards achieve the success in reducing the energy consumption.

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