CRITICAL SUCCESS FACTORS FOR DEVELOPMENT OF SOLID WASTE INCINERATOR

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Abstract

The solid waste problem has long plagued the human life since the waste is not managed well and have been polluting and disrupting human comfort and health. Prior studies have found methods of waste disposal which in practiced such as open burning and landfill is irrelevant nowadays since it increased the uncontrolled population growth and as long as an increase in the industrial sector development. Therefore, many studies found the incinerators is helpful and the best method to overcome the solid waste problem. However, the development of incinerator is still unpopular among the developing countries especially in ASEAN countries. Thus, this study wish to identify the critical success factors for development of solid waste incinerators in Malaysia. The objective of this study is to determine the critical success factors for the development of solid waste incinerators. The objective was achieved through content analysis and the result had been the input to further studies using the Interpretive Structural Modeling (ISM) in order to determine critical success factors. Analysis ISM found that effective operations management, strong financial resources, and good maintenance management is the critical success factors for development of the incinerators. Surprisingly, this study reveal that the financial aspects also a main critical success factor of private involvement in the development of incinerators for solid waste management in Malaysia.

Keywords: *Critical Success Factor, Incinerators Infrastructure, Interpretive Structural Modeling, Financial Resource*

1.0 INTRODUCTION

The problem of solid waste management has long faced not only in Malaysia but throughout the world. each country confront similar problems related to solid waste management and the most critical problem is the disposal of solid waste. According to Cointreau (2007), solid waste problem becomes more critical when the population is growing and increasing active in the industrial sector. The increases in both of these factors had resulted increased in the number and composition of solid waste consequently in waste management is becoming increasingly complex.

Solid waste management need to be progressively increased over time, the increase in population, increase in industry and current demand. The demand for waste management will continue to increase over time because people gradually knowledgeable and want to live in a clean and healthy environment (Cointreau, 2007). A study by Syafiul and Syed (2006), they stated that the quality of waste management must be improved so as to achieve the main objectives of solid waste management which is to protect the environment and human life.

Problems encountered in the disposal of solid waste is about disposing technique that capable of disposing waste more quickly and effectively and more environmental friendly. Disposal of solid waste on this day we see still use traditional methods (Nasir dan Kamil, 1997). The increasing amount of waste that occurs, in future waste collection centre will not be able to

accommodate the amount of waste and the disposal of waste in a traditional way seen as impractical to implement anymore (Cointreau, 2007).

Incinerator plant can be highlighted as an effective and ideal waste disposal technique at this moment. This is because according to Brunner and Helmut (2015), incineration technique is capable to dispose various amount of composition and type of waste in large quantities at one time. It is also supported by Rootes (2015), in his studies found that the incineration technique could solve the problem of waste disposal because the incinerator's ability to dispose various of types of waste including toxic waste and electronic waste. Waste disposal by using incinerators is seen very practical at this time because it is capable to generate electricity while disposing waste process and this technique also did not affect the quality of the environment. Incinerators are seen bring many benefits and advantages to the environment and human life.

The Malaysian government in collaboration with solid waste management experts have proposed the development of a centralized and high-scale incineration system since 2000 to assist in reducing the amount of solid waste in urban areas (Sharifah *et.al.*, 2013). However, this proposal faces many challenges such as the incompatibility of existing technologies, protest by local residents, and pressure from various non-governmental organizations has led this project had to be repealed (Sharifah *et.al.*, 2013). For example, high-profile case regarding solid waste management in Malaysia is the proposed of the Broga incinerator project. In the planning process, this project is for the development of incinerators with 1500 tons capacity and if it is successfully developed will be one of the largest incinerators in Asia (Sangaralingam, 2005). It was to be develop by a foreign contractor and a local industrial partnership and the proposed site was located near a university and water catchment area surrounded by vegetable farms, palm oil and fruit plantations (Oh *et al.*, 2010). Nevertheless there is protest by public as well as high capital expenditure approximately USD 400 million and high maintenance cost, this project subsequently scrapped (Sangaralingam, 2005).

The objective of this study is to identify the factors that influence the development of solid waste incinerators and determine the critical success factors for the development of solid waste incinerators by using Interpretive Structural Model approach.

2.0 FACTORS THAT INFLUENCE THE SUCCESS OF DEVELOPMENT OF SOLID WASTE INCINERATORS: LITERATURE REVIEW

2.1 Establishment of policies and legislation

Solid waste management requires the establishment of policies and legislation that led to the achievement of the main goal of solid waste management in Malaysia (Sharifah *et.al.* 2013 and Shekdar, 2009). The formulation of the national policy should be made by measuring the targets to be achieved within a certain period of time and need to be revised and updated from time to time in accordance with feedback and the current situation (Rootes, 2015; Sharifah *et.al.* 2013; and Shekdar, 2009).

Rules and regulations can help improve the effectiveness of solid waste management should be fully enforced, for example, prohibition the mixing of hazardous industrial waste with non-hazardous solid waste (Shekdar, 2009). He further highlighted that the enforcement of legislation must use a simple and transparent mechanism.

According to Sharifah *et.al.* (2013) and Li *et.al.* (2015), in the implementation of legislation must be accompanied by a system of compound or financial penalties for offenders who violate the law and regulations. For example, industrial or any factory that mixing hazardous waste with non-hazardous solid waste will be penalized in monetary terms. This will increase theirs cost and reduce their profits and indirectly it will make them not to repeat the mistake again.

2.2 Responsible institutional structures

Solid waste management also requires the involvement of institutional such as government, state government, contractors, consultants,

private sector, non-government organization and others (Rootes, 2015; and Shekdar, 2009). These institutions have a role and responsibility in various angle especially in raising funds to cover the costs of solid waste incineration's development (Shekdar, 2009). In addition, the establishment of stakeholders in waste management should be more open which includes the professionals, academics, politicians and others (Rootes, 2015).

Involvement of various professional bodies will open a lot of positive impacts that can improve the quality of solid waste management, especially for incineration project (Shekdar, 2009). This is because they have a different point of view and have relationships with many other parties that can help to ensure the success of a project. For example, academics at universities who are capable and skillful conducting studies can investigate any issue in the incinerator. In addition, the ministry and professionals like entrepreneurs can help in terms of finance. Collaboration with each member are important in the design, provide a long-term strategic plan and audit mechanisms work performed (Rootes, 2015 and Shekdar, 2009).

2.3 Sophistication of technology and progress

The incinerator is a high-tech waste disposal plant (Shekdar, 2009; and Basargekar, 1985). Incinerator technology development should be compatible with the type of waste and the environmental conditions. This advanced technology can improve the quality of waste management and indirectly helps to achieve solid waste management objectives which is to protect environment and human life (Sovacool and Drupady, 2011; Shekdar, 2009; and Dunn, 1975).

In addition, the use of the latest technologies such as maximizing the use of electronic administrative or so-called "paperless administration" where all data information, forms, and so on are created and stored digitally. This will reduce the production of waste, especially paper and indirectly will reduce deforestation for the purposes of paper production. In general, the technology available now makes it easier for the works of man and capable of preserving the environment. Incinerator is also a well-known technology that capable to turning waste into electricity or so called waste to energy (Song *et.al.*, 2015).

2.4 Effective operations management

Strategic operation management is important and it is one of the main pillars of solid waste management (Sovacool and Drupady, 2011; Shekdar, 2009). Operation managements of incinerator should ensure the efficiency of collection, transportation, recycling, and disposal of non-recyclable waste. In addition, operating incinerators requires the design of control mechanisms and monitoring over time to improve its effectiveness and to address issues that arise such as systems failure (Sovacool and Drupady, 2011; Shekdar, 2009).

Solid waste disposal process can be enhanced by the use of computerized technology, communications, and system database online so that anyone directly involved with operations management can analyzed current information at any time and everywhere.(A. Imam, *et.al.*, 2008).

2.5 Strong financial resources

Incineration is a very expensive waste disposal technology in term of capital and maintenance costs (Permana *et.al.*, 2015;Rootes, 2015; Shekdar, 2009). The allocation of funds to finance the incinerator project requires the cooperation of various parties, including local and foreign investors. The financial aspect is the most important thing that should be emphasized in be success in the incinerator project because the technology used, the operations and maintenance are costly (Permana *et.al.*, 2015; Rootes, 2015; Sovacool and Drupady, 2011; and Shekdar, 2009).

Generally, Shekdar (2009) insists that the development of the incinerator must developed based on "no profit no loss" tariff. This is because the development of incinerator is intended to improve the solid waste management that can help improve the quality of the natural environment and human life.

2.6 Awareness and active involvement of the public

According to Shekdar (2009) in his study, solid waste management, need support from the public especially for incineration. In the early stages of the implementation of the incinerator indeed there was an outcry from the public because they have not exposed the advantages and capabilities of the technology of incinerators. Consequently, awareness campaigns and continuing education using a variety of media that exist today, such as network television, newspapers, radio, internet, facebook, and so on. Programs such as advertising on television should highlight the advantages and capabilities of incineration in the disposal of solid waste which led to a positive impact on the environment and human life.

2.7 Good maintenance management

The incinerator which is a high-tech waste disposal plant will necessarily involve more accurate maintenance in order to maintain the effectiveness of landfill operations (Sharifah *et.al,* 2013). Maintenance involved, such as routine maintenance, periodic, and scheduled to be implemented correctly and carefully should be undertaken by experts who are highly skilled in handling the incinerator. This maintenance management should be implemented with caution, especially when it comes to the maintenance of high-tech machines to prevent negligence and damage to other parts. Indirectly, waste disposal operations will be delayed and the cost of operation and maintenance management also will be increase.

2.8 Strategic location

Site selection for the development of the incinerator should see a few things such as not to disrupt traffic main road and is easily accessible for waste truck to delivered waste to the incinerator (Sharifah *et.al,* 2013). The selection of sites for the development of the incinerator can be done using computerized technology so that higher accuracy site selection (Sharifah *et.al,* 2013).

3.0 CRITICAL SUCCESS FACTOR FOR DEVELOPMENT OF SOLID WASTE INCINERATORS: INTERPRETIVE STRUCTURAL MODEL (ISM)

Step 1: Identify elements and factors

Elements and factors are identified through a literature review. The results of the literature review will be used to create questionnaires and distributed to the experts. The criteria for selecting respondents are viewed in terms of his experience must be at least 3 years in the management of existing incinerators in Malaysia. Six respondents selected which is the incinerator operations manager of Langkawi Island, Cameron Highlands, Pangkor Island, Tioman Island, Kajang, and Labuan. From six respondents submitted, five of them complete the questionnaire and gave full respond. So, the next step will be using the data obtained from the five expert.

Step 2: Develop SSIM

There is eight factors that influence the development of solid waste incinerators which is the establishment of policies and legislation, responsible institutional structures, sophistication of technology and progress, effective operations management, strong financial resources, awareness and active involvement of the public, good maintenance management, and strategic location. For analyzing the barriers in developing SSIM, the following four symbols have been used to denote the direction of relationship between barrier (i) and (j):

V : Barrier i will help to achieve barrier j;
A : Barrier j will help to achieve barrier i;
X : Barrier i and j will help to achieve each other; and
O : Barrier i and j are unrelated.

Step 3: Comparison of the experts' opinions

From complete SSIM that received from the expert, next step is comparison of the expert's opinion. Each factor will be compared between the experts to see what options are often selected by experts. The final results of this analysis will obtain a final SSIM (Table 1) that will be used for next step.

Step 4: Reachability Matrix

The SSIM has been converted into a binary matrix, called the initial reachablity matrix by substituting V, A, X, and O by 1 and 0 as per given case. The substituting of 1 and 0 are as following rules:

- If the (i, j) entry in the SSIM is V, the (i, j)
- entry in the reachability matrix becomes 1 and the (j, i) entry becomes 0;
- If the (i, j) entry in the SSIM is A, the (i, j) entry in the reachability matrix becomes 0 and the (j, i) entry becomes 1;
- If the (i, j) entry in the SSIM is X, the (i, j) entry in the reachability matrix becomes 1 and the (j, i) entry also becomes 1; and
- If the (i, j) entry in the SSIM is O, the (i, j) entry in the reachability matrix becomes 0 and the (j, i) entry also becomes 0.

Initial reachability matrix will be used for further calculations. The driving power and the dependence power of each barrier are shown in Table 2. The driving power and dependence power for each barrier is the total number of barriers (including itself), which it may help achieve.

Table 1: Final SSIM

	Factors	Barrier (j)							
		Establishment of policies and legislation	Responsible institutional structures	Sophistication of technology and progress	Effective operations management	Strong financial resources	Awareness and active involvement of the public	Good maintenance management	Strategic location
Barrier (i)	Establishment of policies and legislation		X	A	A	A	X	O	V
	Responsible institutional structures			X	A	X	V	A	X
	Sophistication of technology and progress				X	A	V	X	O
	Effective operations management					X	V	X	V
	Strong financial resources						V	V	O
	Awareness and active involvement of the public							O	A
	Good maintenance management								V
	Strategic location								

Table 2: Reachability Matrix

Factors		Barrier (j)								Driving Power
		Establishment of policies and legislation	Responsible institutional structures	Sophistication of technology and progress	Effective operations management	Strong financial resources	Awareness and active involvement of the public	Good maintenance management	Strategic location	
Barrier (i)	Establishment of policies and legislation	1	1	0	0	0	1	0	1	**4**
	Responsible institutional structures	1	1	1	0	1	1	0	1	**6**
	Sophistication of technology and progress	1	1	1	1	0	1	1	0	**6**
	Effective operations management	1	1	1	1	1	1	1	1	**8**
	Strong financial resources	1	1	1	1	1	1	1	0	**7**
	Awareness and active involvement of the public	1	0	0	0	0	1	0	0	**2**
	Good maintenance management	0	1	1	1	0	0	1	1	**5**
	Strategic location	0	1	0	0	0	1	0	1	**3**
Dependence Power		**6**	**7**	**5**	**4**	**3**	**7**	**4**	**5**	

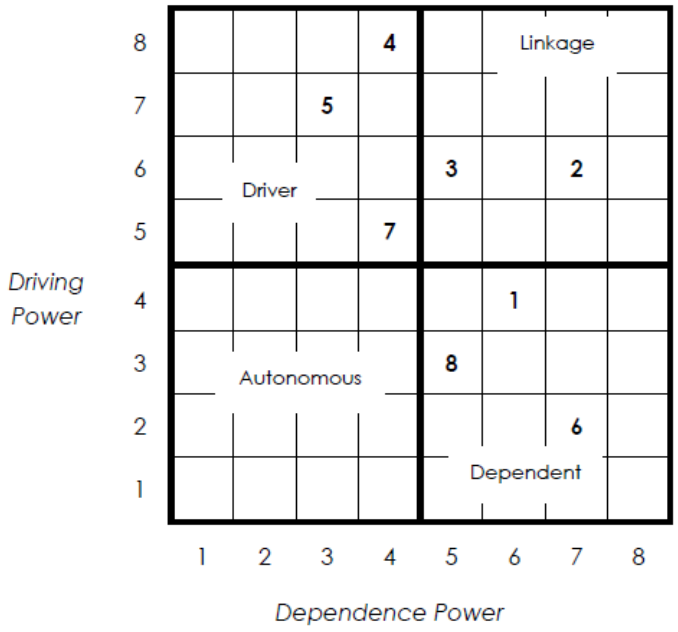

Figure 1: Cluster of CSF for development of solid waste incinerators

Step 5: Classification of factors

All factors have been classified into four categories which is autonomous, dependent, linkage, and driver based on their driving power and dependence power. These classification of factors are similar to classification used by Mandal and Deshmukh (1994). The driving power and dependence power diagram is shown in figure 1.

It is noted that the strong financial resources have a driving power of 7 and a dependence power of 3 (see Table 2). Therefore, it is positioned at a place which corresponds to a driving power of 7 and a dependence power of 3 as shown in Figure 1.

The use of advanced technology require regular maintenance to ensure the technology can lengthen its life and improve the effectiveness of its operations. Maintenance work for incinerator should be handled by expert in that particular technologies in order to ensure the appropriate maintenance is executed. Any errors will result in damage to the machine and affect the operation of the incinerator.

At the same time, to ensure that the incinerator project is successfully develop requires strong financial resources. Not only at the construction level, but also at the operational and maintenance. There are some materials to filter the smoke and dust before released into the air to ensure cleanliness of the air. These materials are include in the operating costs to be incurred over time. Similarly, the costs of maintenance of the incinerators including daily maintenance, periodic, scheduled and emergency or urgent maintenance.

All three of these factors have direct relevance and should be viewed more closely to achieve success in solid waste management system. Five other factors that policies and legislation, institutional responsibility, technology, awareness and active involvement of the public, and strategic location are the factors that help support three main factors.The fourth cluster is called independent or some other study called it driver category that has strong driving power and weak dependence power. In this case, factor effective operations management, strong financial resources, and good maintenance management are in the category of driver.

4.0 CONCLUSION

There are three critical success factors that are the driver in the development of incinerators which is effective operations management, strong financial resources, and good maintenance management. All three of these factors need to be focused more precisely and improved over time because these three factors is the key to success in development of solid waste incinerator.

Effective operations management can be implemented by arranging an orderly and systematic system for each level of management that involve. Operation of incinerator involves the use of high technology and it requires certain skills to handle these technologies. Effective operations management strategy depend on the management commitment and skill. Strategic management of operations can also reduce operating costs and maintenance costs.

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