Understanding the Barriers in Implementing Waste-to-Energy Technologies in the Philippines using Analytic Hierarchy Process

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Abstract

Solid waste management is still a major challenge in the Philippines despite the passage of the Ecological Solid Waste Management Act of 2000. The local government units (LGUs) are responsible in devising their own solid waste management plan. However, as the waste generated have been increasing due to rapid industrialization and population growth, large portion of collected wastes that are not disposed to sanitary landfills are either end up in a controlled disposal facilities or open dumpsites. Several efforts have been made by LGUs and national government agencies to explore other alternatives such as waste-to-energy technologies specifically waste incineration to cope with the growing waste problem in the Philippines. Incineration is one of the widely used alternatives across the globe yet resistance to the technology is strong because of several barriers concerning its financial affordability, implementability, social acceptability, and environment effectiveness. This study therefore seeks to identify and prioritize these barriers by incorporating the value judgment of key stakeholders. The Analytic Hierarchy Process (AHP) was used to structure the problem and quantify the relative importance of these barriers. Results indicate that implementability is the most important criterion. Thus, the overall ranking of the barriers imply that lack of policy support and the perceived large amount of emitted heavy metals and dioxins/furans are the most critical barriers to be considered for the successful implementation of incineration in the Philippines.

Keywords: Waste-to-Energy, AHP, incineration, solid waste management

Introduction

Solid waste management is a major environmental challenge in the Philippines. According to the National Solid Waste Management Commission (NSWMC), the country generated a total of 37,427.47 tons per day in 2012 which gradually increased to around 40,000 tons per day after four years. The National Capital Region contributed about 9,200 tons per day or almost 23 percent of the country's total waste generation in 2016. Region 4A with 4,440 tons per day, Region 3 with 3,890 tons per day, and Region 6 with 2,890 tons per day provided additional volume of wastes at 11%, 10%, and 7% respectively. The World Bank (2012) estimated that waste generation in Philippine cities will grow by 165% as a consequence of a projected 47 % increased number of urban population by 2025.

The Republic Act No. 9003 or the Ecological Solid Waste Management Act of 2000 was approved and took effect in 2001. The law established the creation of the NSWMC and mandated the Commission to oversee the implementation of solid waste management plans in the Philippines as well as prescribe policies, strategies and activities to achieve the objectives of the Act. Despite the seventeen years of the existence of the Act, poor waste management is still prevalent in the Philippines. In the study described in [1], 83% of Philippine wastes are mismanaged. This entails that large percentage of the total wastes are littered or inadequately disposed. As of June 2018, there are only 10,052 Material Recovery Facilities (MRFs) or the facilities that receive, sort, process, and store compostable and recyclable material efficiently and in environmentally sound manner, out of the 42,035 total barangays in the Philippines. Further, only 18% or 293 local government units (LGUs) have accessed to a total of 135 sanitary landfills in 2017. All collected wastes that are not disposed to SLFs either end up in a controlled disposal facilities or open dumpsites. Moreover, the country has still 423 operating illegal dumpsites despite the provision of the RA 9003 that no open dumps shall be established or operated after the effectivity of the said Act.

The growing problem in solid wastes has forced the local government units to explore other alternatives such as waste-to-energy (WtE). Waste-to-energy (WtE) is a sensitive issue in the Philippines because of the misconception that it is merely a euphemism for incineration and because of some concerns that incineration of solid wastes is absolutely prohibited under the Ecological Solid Waste Management Act and the Clean Air Act. There have been efforts from local government units, lawmakers, and even government agencies such as the Department of Environment and Natural Resources (DENR) and Department of Energy (DOE) to promote waste-to-energy. However, many civil society organizations (CSOs), lawmakers, and some experts are against incineration.

Given the strong resistance to incineration, this study seeks to (1) identify the critical barriers to the implementation of incineration in the Philippines and (2) prioritize these barriers using Analytic Hierarchy Process. The results of the study will provide information on the reasons or factors that would explain the opposition to the said technology. It will further aid decision-makers, policy-makers, key stakeholders, operators, technology developers among others to consider the identified critical barriers in their future decisions and planning enable to ensure successful implementation of the technology.

Methodological framework

Analytic Hierarchy Process

The Analytic Hierarchy Process (AHP) is a multi-criteria decision analysis (MCDA) tool that allows decision-makers dealing with complex problem to develop a hierarchical structure of alternatives or factors according to priority or importance. It was developed by Thomas L. Saaty in the 1970s and the tool has been extensively applied, studied, and refined since its introduction. Several studies across the globe have used AHP to discuss waste management issue, for example in the development of waste management systems [2], selection of waste-to-energy (WtE) conversion technology [3], analysis of waste treatment options [4,5]. One salient feature of AHP is that it provides effective means of measuring tangibles or intangibles, carefully measured or roughly estimated, well or poorly understood, and quantitative or qualitative factors [6].

The method was designed for decision-makers or key stakeholders to evaluate systematically the elements of the hierarchy by comparing them to one another with two elements at a time. Prioritization of participants depends on concrete data about the elements or their judgments about the elements' relative meaning or importance. A score or numerical values based on fundamental scale will be used to derive numerical weight or priority weight for every element of the hierarchy. The priority vector will represent the criteria, sub criteria, or alternatives' relative ability to achieve the goal, which can be obtained through eigenvector method.

Problem structure

Literature review and key informant interview (KII) were conducted to structure the problem and determine the critical barriers to the implementation of incineration in the country. Technical experts and representative/s from the government sector and the civil society organization (CSO) participated in the study to provide their value judgment on the topic. A total of six participants with at least 10 years of experience on their field of expertise and with profound knowledge on waste-to-energy and incineration issues in the country were selected and involved in the study. The barriers identified by all experts were listed and finalized using literature review, and categorized into four (4) main criteria namely financial affordability, implementability, social acceptability and environmental effectiveness. Figure 1 shows the problem structure of the study while Table 1 describes the definition of the specific barriers for each criteria or category.

A structured questionnaire survey was used in the study to derive the value judgment of the experts. The set of questions and the sequence are the same for all respondents. An explanation of the purpose of the study, pairwise comparison method, and the measure of the intensity of responses are all part of the survey form prior to the questions. All respondents received similar questionnaires. The experts were asked to explain their answers per item of the survey form. The values from the pairwise comparison represent the relative priorities of criteria and sub-criteria. The fundamental 9-scale was used in the study as described in Table 2.

Table 1. Definition of the subcriteria described in the problem structure

Code	Barrier	Description
FA1	High capital costs	Capital costs consist of direct and indirect expenses involved in the establishment of the technology. Direct costs include expenditures for the equipment, labor, and material necessary for installation. Indirect costs include expenditures for engineering, financial and other services that are not part of the actual installation activities.
FA2	High costs involved in the purchase and installation of monitoring equipment of the government	The monitoring equipment and laboratory services of the government are lacking due to high cost involved in the purchase and installation.
IM1	Undefined and/or overlapping role of key persons/ agencies/ stakeholders involved	Undefined and overlapping functions create ambiguity, conflict, and less ownership of responsibilities between and among key stakeholders.
IM2	Lack of policy to support the implementation of incineration	Incineration is banned under the Philippine Clean Air Act and the Ecological Solid Waste Management Act
IM3	Variation in the amount of generated waste and high fraction of food and organic waste	The form and operation depends on the delivered quantities and types of waste to be treated. A country with unsorted municipal solid waste is often below the lower calorific value due to dominant organic content with high moisture and significant level of inert waste fraction
IM4	Absence of monitoring mechanism	Without a mechanism for monitoring, sectors that do not comply will not be penalized
IM5	Lack of experts for planning, operation and monitoring of incineration plants	New technology requires experts who will handle technical components during planning, operation, and monitoring of plants
SA1	Lack of knowledge or information on incineration	Low level of information and knowledge about incineration
SA2	Perceived threat or danger	The perception on physical and psycho-sociological implications of the technology based on acquired, interpreted, selected, and organized sensory information
SA3	Lack of public participation in decision-making process	Public engagement across the range of resource management and waste issues is important as people have a democratic right to be involved in decisions that affect them
EE1	Large amount of heavy metals and dioxin/furans	Incinerators are main sources of airborne metal pollution. Its emissions also contain dioxins and furans
EE2	Contribution to climate change	The incineration of wastes most especially plastics, paper/cardboard contribute to climate change

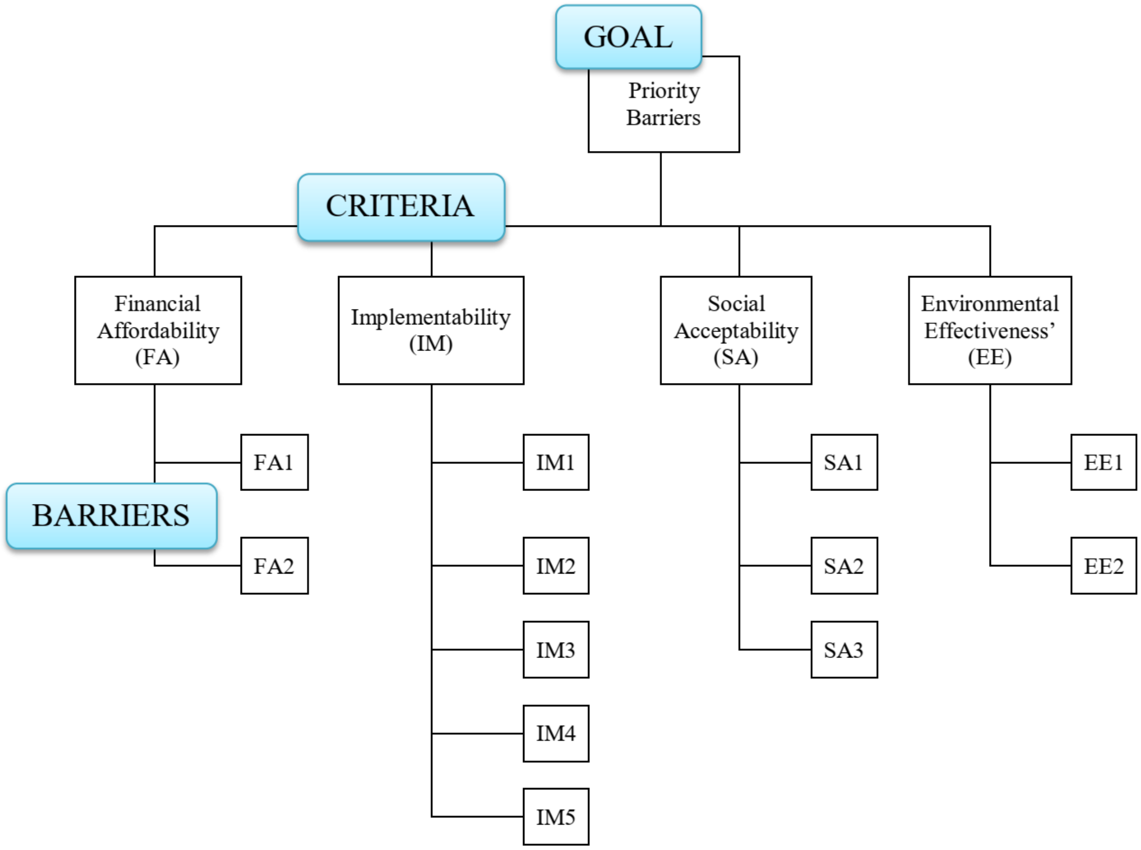

Figure 1. Hierarchy of the barriers in implementing Waste-to-Energy in the Philippines

The priority vector obtained through Eigenvector method represents the criteria, sub criteria, or alternatives' relative ability to achieve the goal, which was. A consistency check was done to ensure that values derived are consistent or near consistent matrices. All consistency ratios (CR) are less than 10% [7]. Provided that the judgments were derived from different sectors or stakeholders: the government sector, civil society organization, and technical experts; the geometric mean of individual evaluations was used as elements in the pairwise matrices and then priorities were computed. The geometric mean was adopted to preserve the reciprocal property of individual evaluations. Priority weights derived from the three sectors were synthesized using arithmetic mean. The global weights or the overall priority weights were computed by multiplying the aggregated weights of the criteria and the barrier.

Table 2. AHP Fundamental Scale [7]

Scale	Meaning	Description
1	Equal Importance	Both contribute equally to the objective
3	Moderate Importance	Experience and judgment slightly favor one over another
5	Strong Importance	Experience and judgment strongly favor one over another
7	Very Strong or Demonstrated Importance	One is favored very strongly over another or its importance is demonstrated in practice
9	Extreme Importance	The evidence favoring one over another is one of the highest possible order of affirmation

Results and Discussion

As shown in Table 3, implementability is the top priority consideration by stakeholders when it comes to incineration projects, which accounted for 0.443. This is followed by environmental effectiveness, social acceptability, and financial affordability which represent 0.320, 0.141, and 0.096 respectively.

Table 3. Priority weights of the barriers to implement waste-to-energy projects

Criteria	Aggregated Weights	Barrier	Aggregated Weights	Overall Priority Weights	Rank
Financial Affordability (FA)	**0.096**	High capital costs	0.726	0.0698	6
		High costs involved in the purchase and installation of monitoring equipment of the government	0.274	0.0264	10
Implementability (IM)	**0.443**	Undefined and/or overlapping role of key persons/ agencies/ stakeholders involved	0.059	0.0260	11
		Lack of policy to support the implementation of incineration	0.500	0.2214	1
		Variation in the amount of generated waste and high fraction of food and organic waste	0.174	0.0771	3
		Absence of monitoring mechanism	0.098	0.0435	9
		Lack of experts for planning, operation and monitoring of incineration plants	0.169	0.0748	4
Social Acceptability (SA)	**0.141**	Lack of knowledge or information on incineration	0.372	0.0524	8
		Perceived threat or danger	0.446	0.0628	7
		Lack of public participation in decision-making process	0.182	0.0257	12
Environmental Effectiveness (EE)	**0.320**	Large amount of heavy metals and dioxin/furans	0.644	0.2061	2
		Contribution to climate change	0.220	0.0703	5

In implementability criterion, the lack of policy support (0.500) has higher weight compared to variation of generated waste in the country (0.174), lack of experts (0.169), absence of monitoring mechanism (0.098), and undefined role of key stakeholders (0.059). With respect to environmental effectiveness of incineration, the emitted heavy metals, dioxins and furans as a barrier (0.644) is a more crucial concern than the contribution of incineration to climate change (0.220). The results also show that in social acceptability criterion, the perceived threat or danger by the public is the top barrier (o.446) followed by lack of knowledge (0.372) and lack of participation (0.182). It is found that in terms of the financial affordability of incineration, the capital cost (0.726) is more important than the monitoring equipment cost (0.274).

From the overall ranking, experts view the lack of policy support (0.221) and the large amount of emitted heavy metals and dioxins/furans (0.2061) as the most critical barriers to the implementation of incineration projects in the Philippines. The experts explained that the decision made by the Supreme Court on the case of the Metro Manila Development Authority (MMDA) vs JANCOM in 2002 provided grounds for the implementation of incineration as a mode of waste disposal if it does not emit poisonous and toxic fumes which is defined by the Philippine Clean Air Act as any emissions and fumes beyond internationally-accepted standards. Despite the Supreme Court ruling, the call for amendment of the provisions of the Republic Act No. 8749 and Republic Act No. 9003 has been continuous to secure legal basis prior implementation of any incineration projects. The second top most concern about incineration is the emitted heavy metals, dioxins/furans, and other harmful substances which if not controlled, can adversely affect human health by entering the food chain after being emitted into the air. The results further imply that the variations in the amount of generated wastes (0.077), the lack of experts for planning, operation and monitoring of incineration plants (0.074), and its contribution to climate change (0.070) are other barriers to be considered. The least priority barriers according to experts are the high costs involved in the purchase and installation of monitoring equipment of the government (0.0264), the undefined and/or overlapping role of key stakeholders involved (0.0260), and the lack of public participation (0.0257).

Conclusions

Prioritization of critical barriers to the implementation of incineration in the country was performed using the Analytic Hierarchy Process (AHP). Twelve (12) critical barriers were identified by the experts' involved in the study based from four (4) criteria namely, financial affordability, implementability, social acceptability, and environmental effectiveness. Implementability or the technical and administrative feasibility of incineration is the most significant criterion with the highest priority weight of 0.636. The lack of policy support and the large amount of emitted heavy metals and dioxins/furans are the most critical barriers to the implementation of incineration projects in the Philippines with priority weight of 0.221 and 0.206 respectively.

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