THE FEASIBILITY STUDY OF THE CONSTRUCTION WASTE RECYCLING PROGRAM IN THAILAND

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Abstract
The construction industry is growing rapidly as a result of construction, renovation, and demolition. The flourish in the construction industry is generating an increasingly massive amount of waste, called construction and demolition (C&D) waste. This includes materials, such as concrete, brick, gypsum, and timber used in the construction activities. Good management of the C&D waste could assist the industry in enhancing a green environment, and achieving a better reputation. This study aims in examining the feasibility study of the recycling program in the construction industry in Bangkok, Thailand. The internal rate of return is used to decide on the decision to implement the recycling program. The results reveal the internal rate of return of 24.77%, confirming the benefit of the program to the industry.

Keywords: Benefit, Construction waste, Cost, Feasibility study, Recycling program

1. INTRODUCTION

Construction industry is the producer of house, apartment, factory, office, school, road, and bridge (Beirut 2007). According to Jupiter Infomedia (2008), the construction industry is divided into 3 major segments, including 1) general contractors 2) heavy and civil engineering construction contractors, and 3) specialty trade contractors. All of these major segments generate high amount of construction and demolition (C&D) waste. According to Hao et al. (2008), one reason for the big upsurge of C&D waste is a high population growth. A growing population does not only boost the demand for the housing, but also push the public infrastructures (The Government of British Columbia 2011).

In Thailand, the major types of the C&D waste are: 1) concrete (46%), 2) wood (14%), 3) gypsum (6%), 4) plastic (5%), and 5) others (29%) (Kofoworola and Gheewala 2008). Almost all of these wastes are disposed of either in landfill sites or vacant; this is due to no

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effective waste management program is implemented.

This paper, therefore, aims to conduct a feasibility study of the C&D waste recycling program in Thailand to determine the worthiness of establishing the recycle program based on a number of benefits and costs. The internal rate of return (IRR) is also calculated to verify the benefits of the recycled program implementation. It is expected that the study results provide a guideline for the construction industry to plan for its recycling program.

2. BENEFIT AND COST FACTORS OF THE RECYCLING PROGRAM

Base on the construction-related literatures, the benefit and cost factors affecting the recycling program are as follows.

2.1 Benefit Factor

Benefit factor consists of five attributes, namely 1) electricity saving, 2) saving in virgin materials, 3) landfill charge reduction, 4) tax reduction, and 5) saving in transportation cost. Details of the attributes are as below.

- *Electricity saving*: According to Collins (1997), the use of recycled concrete or recycled aggregate concrete helps reducing the energy consumption, and lowering the environmental impact. This particular energy, when used, can supply 18,600 households in U.S. in the year of 1997. This is equivalent to the saving of 2,060 TJ in Thailand in 2005 or approximately more than 180,000 baht in 2005 (current exchange rate: 1 US dollar = 30 baht) (Department of Alternative Energy Development and Efficiency 2010, Provincial Electricity Authority 2011).
- *Saving in virgin materials*: According to Kofoworola and Gheewala (2008), waste minimization using recycling strategy results in 90% reduction of virgin materials required in the construction site.
- *Landfill charge reduction*: The implementation of the recycling program assists in lowering the landfill charge.
- *Tax reduction*: One of an incentive action to promote recycling is to provide the investment tax credit (Alig 1993).
- *Saving in transportation cost to landfill*: The recycling program helps reduce the amount of wastes transported to landfill sites.

2.2 Cost Factor

Cost factor consists of four attributes, namely 1) sorting cost, 2) storage cost, 3) transportation cost, and 4) processing cost. Details of the attributes are as below.

- *Sorting cost*: Labor is required to sort C&D waste before the relocation to the next process. Based on Luanratana (2003) and Manomaivibool (2005), a single labor is able to sort the waste with a capacity of 0.246 ton/person/day.

- *Storage cost*: Since storage space on site is limited, the construction company might require extra storage space for sorting process. This particular rental space stores the recycled C&D waste before transporting to the recycle shops.
- *Transportation cost to the recycled shop*: To recycle C&D waste the company saves transportation cost to landfill, but incurs transport cost to the recycled shop. This depends on the distance from site to the shop, the fuel price, and the capacity of truck.
- *Processing cost*: Apart from selling the recycled wastes to the recycle shop, the company could consider operating its own recycled facility. This, as a result, incurs the processing cost, which mainly includes the machine and labor costs (Srour et al. 2012).

3. FEASIBILITY STUDY OF THE RECYCLING PROGRAM

The above benefit and cost factors are used to calculate the benefit over cost ratio (BCR) to investigate the initiative of the recycling program in Bangkok, Thailand. The internal rate of return (IRR) is used as a key measure of this feasibility study. According to World Bank (2005), the minimum bound of IRR is set at 12%. The recycling program is considered feasible if it achieves the IRR of higher than 12%.

In this study, the recycling program is set to last for 10 years, with the same amount of total C&D waste per year. This is based on a constant number of populations in the last five years (The Office of the Federal Register, 2012).

3.1 Benefit Factor Calculation

3.1.1 Electricity Saving

According to Kofoworola and Gheewala (2008), saving of 2,060 TJ (or 3,301,849 million kilowatt-hours) of electricity in the U.S. residential buildings reduces around 180,000 baht/year. Adjusting this information to suit with Bangkok condition (in terms of population and electricity consumption), it is found that the electricity cost is reduced by 13,000 and 59,000 baht in the first and the last year of the recycling program, respectively (see Table 1) (Department of Alternative Energy Development and Efficiency 2010, Provincial Electricity Authority 2011).

Table 1: Benefit factor results.

Year	Electricity saving	Saving in virgin material	Landfill charge reduction	Tax reduction	Saving in transportation cost to landfill	Total benefit
1	13,680.6	13,596,509.5	18,154,800	-	86,350.7	31,851,340.8
2	15,449.4	26,807,899.1	36,309,600	-	172,701.3	63,305,649.8
3	17,743.4	40,211,848.6	54,464,400	-	259,052.0	94,953,043.9
4	20,837.4	53,615,798.1	72,619,200	-	345,402.6	126,601,238.2
5	25,238.4	67,019,747.7	90,774,000	-	431,753.3	158,250,739.4
6	31,996.3	80,423,697.9	108,928,800	-	518,104.0	189,902,597.4
7	43,696.5	93,827,646.7	127,083,600	-	604,454.6	221,559,397.9
8	59,747.9	93,006,099.8	125,970,867	-	599,162.1	219,635,876.7
9	59,747.9	58,539,585.8	79,288,158	-	377,122.6	138,264,614.7
10	59,747.9	58,539,585.8	79,288,158	-	377,122.6	138,264,614.7

3.1.2 Saving in Virgin Material

Saving in virgin material will be calculated material by material. In this study, the four top types of C&D waste, including concrete, wood, gypsum, and plastic, are considered (Kofoworola and Gheewala 2008). The amount of total recyclable C&D waste in Bangkok is also considered constant at 79,288.16 tons/year (Padungsirikul 2003, Hao et al. 2008, The Office of the Federal Register 2012). However, the amount of sorted recycled waste varies, depending mainly on the sorting capacity each year. This based on the number of labors available to perform the sorting activity each year.

In concrete, the saving cost is calculated based on the amount of concrete recycled per year, the amount of trucks used to carry those concrete amounts, and the market price of concrete per truck of 10,000 baht (see equation 1) (Bureau of Trade and Economic Indices 2012).

Number of truck = Sorted concrete per year/12 tons per truck (1)

Wood could directly be used in another site. Equation 2 illustrates the saving from the recycled wood. It is noted that the amount of wood is converted from ton unit to cubic foot unit to match with the wood price listed in the Bureau of Trade and Economic Indices (2012).

Saving from the recycled wood = (Sorted recyclable amount per year x Proportion of wood x Price per unit)/(0.7 x 35.32) (2)

According to Gypsum Recycling International (2012), 94% of gypsum can be recycled, leading to the saving from the recycled gypsum, as shown in equation 3.

Saving from the recycled gypsum = Sorted recyclable amount per year x Proportion of gypsum x 0.8 x Price per unit x Recyclable percentage of gypsum (3)

Only 8% of the plastic in the construction industry can be recycled (EPA 2012). This is illustrated in equation 4 below. It is noted that the amount of plastic is converted from ton unit to kilogram unit to match with the plastic price listed in the Bureau of Trade and Economic Indices (2012).

Saving from the recycled plastic = Sorted recyclable amount per year x Proportion of plastic x 1,000 x Price per unit x Recyclable percentage of plastic (4)

A summary of the saving in virgin material is shown in Table 1.

3.1.3 Landfill Charge Reduction

Landfill charges can be determined by multiplying the amount of wastes disposing of in landfill (which will be reduced when the recycling program proceeds) with the landfill charge of 1,000 baht per ton. The results are as shown in Table 1. It is clear that the landfill charge reduction is increased, explaining the increased recycling amount, and decreased wastes disposed of in landfill.

3.1.4 Tax Reduction

In many developed countries, tax reduction is used as an incentive to encourage companies with the recycling program. For example, Kentucky and New Jersey states offered 10 – 50 percent tax reduction for the companies implementing the recycling program (Alig 1993). In Thailand, however, the tax incentive for recycling program is still in the early stage of implementation. Hence, it is not considered in this study.

3.1.5 Saving in Transportation Cost to Landfill

The amount of sorted recycled waste saves the transportation cost to landfill. In this study, the average distance to landfills (Kampaengsan and Rachadewa landfills) is 15.66 kilometers, and the fuel cost is 3.50 baht/kilometer, leading to the transportation cost of 54.81 baht/truck/trip (EPPO 2012). This cost must be multiplied by two trips to complete a round trip; the total transportation cost per truck is then 109.62 baht.

The number of trucks used depends on the amount of sorted recyclable amount per year.

Equation 5 shows the saving in the transportation cost to landfill; the results are illustrated in Table 1.

Saving in transportation cost to landfill = (Sorted recyclable amount per year/truck capacity of 22 tons) x transportation cost per truck (5)

3.2 Cost Factor Calculation

3.2.1 Sorting Cost

According to Luanratana (2003) and Manomaivibool (2005), one labor can sort 0.246 ton of wastes per day. In this study, it is assumed that all the construction companies located in Bangkok participate in the recycling process, and contribute one full-time labor to perform the recycling activity. This leads to 300 labors to sort the C&D waste in the first year. This number is assumed to be increased by 300 labors every year, leading to 600, 900, and so on to perform the sorting activity.

Based on the minimum wage of 300 baht per person per day, with 246 days in a year, the sorting cost is calculated, as shown in equation 6 and Table 2.

Sorting cost = (Number of labor each year) x (Minimum wage) x (Working days/year) (6)

3.2.2 Storage Cost

According to the Treasury Department (2012), the storage (or rental) cost used in this study is 48,363.33 baht per square wah, where 1 square wah equals to 4 square meters. This storage cost depends mainly on the amount of C&D wastes to be sorted each year.

Table 2: Cost factor results.

Year	Sorting cost	Storage cost	Transportation cost to the recycled shop	Processing cost	Total cost
1	22,140,000	1,246,015.4	54,867.1	-	23,440,882.5
2	44,280,000	2,492,030.8	109,734.2	-	46,881,765
3	66,420,000	3,738,046.2	164,601.3	-	70,322,647.5
4	88,560,000	4,984,061.6	219,468.4	-	93,763,530
5	110,700,000	6,230077.0	274,335.5	-	117,204,412.5
6	132,840,000	7,476,092.4	329,202.6	-	140,645,295
7	154,980,000	8,722,107.8	384,069.7	-	164,086,177.5
8	177,120,000	8,645,737.8	380,706.8	-	186,146,444.6
9	177,120,000	5,441,771.1	239,623.2	-	182,801,394.3
10	177,120,000	5,441,771.1	239,623.2	-	182,801,394.3

3.2.3 Transportation Cost to the Recycled Shop

The sorted C&D wastes will be transferred to a number of recycled shops around Bangkok, with the average distance of 11 kilometers. With the fuel price of 3.50 baht/kilometer, the transportation cost to the recycled shop is 38.50 baht/truck/trip or 77 baht/truck/round (EPPO 2012). The number of trucks used depends on the amount of wastes to be delivered to the recycled shops per year. The equation of the transportation cost to the recycled shop is as shown below.

Transportation cost = (Amount of wastes to recycled shop per year/truck capacity of 22 tons) x transportation cost per truck (7)

3.2.4 Processing Cost

In this study, the company considers selling the sorted wastes to the recycle shops. In this case, the processing cost is considered as zero.

3.3 The Feasibility Study Results

The benefit and cost factors above are used to determine the internal rate of return of the recycling program over 10 years period. Cash flows, by subtracting the benefit with the cost each year, and the net present value (NPV) are calculated to achieve the IRR of the project (see equation 8).

$$NPV = \sum_{n=0}^{n} \frac{C_n}{(1+R)^n} \quad (8)$$

The results, as shown in Table 3, detail the benefit over cost ratio of more than one, representing the good investment of the recycling program. This is also confirmed by the IRR of 24.77% (higher than the minimum bound of 12%).

Table 3: The feasibility study results.

Year	Total benefit	Total cost	Cash flow	NPV
0	-	23,440,882.50	-23,440,882.50	-23,440,882.50
1	31,851,340.75	46,881,765.01	-15,030,424.25	-14,663,828.54
2	63,305,649.75	70,322,647.51	-7,016,997.76	-6,678,879.49
3	94,953,043.94	93,763,530.01	1,189,513.93	1,104,581.93
4	126,601,238.18	117,204,412.51	9,396,825.66	8,513,060.27
5	158,250,739.39	140,645,295.02	17,605,444.37	15,560,647.49
6	189,902,597.44	164,086,177.52	25,816,419.92	22,261,417.99
7	221,559,397.85	186,146,444.61	35,412,953.24	29,791,686.43
8	219,635,876.65	182,801,394.34	36,834,482.32	30,231,775.05
9	138,264,614.69	182,801,394.34	-44,536,779.65	-35,661,862.61
10	138,264,614.69	-	138,264,614.69	108,012,096.01
Benefit over cost ratio				**1.51**
IRR				**24.77%**

4. CONCLUSION

This study performs the feasibility study of initiating the recycling program for the construction companies in Bangkok, Thailand. Five benefits and four costs are considered in the calculation, with the project life of 10 years. The analysis results reveal the benefit over cost ratio of more than one, with the IRR of more than 12%. This confirms the setting up the program to benefit the industry in long term.

Some of the data used in this study, though, derive from the average values based in Bangkok area. The adjustment might be necessary for other areas to achieve the accurate results.

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