CDM: A Mechanism to Promote Solid Waste Management Efficiency and GHG Reductions in Thailand

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Abstract

The main objective of this study is to evaluate total amounts of GHG emissions from landfills and potential carbon credits from electricity generation projects of solid wastes from Bangkok Metropolitan Areas (BMA). Total amounts of GHG released to the atmosphere from two landfills which receive wastes from BMA are estimated under different management scenarios. The results show that methane released from Phanomsarakam and Kampangsan Landfill during 2005-2028 is approximately 1.94 and 4.28 million tons carbon dioxide equivalent if nothing is implemented to collect and utilize landfill gases. If methane gases are collected and then flared, it can reduce amounts of GHG emissions by 65 percent. If methane gases are used for electricity generation, it can lessen amounts of carbon dioxide emission by 69 percent. Moreover, electricity generation using landfill gas will displace electricity generation by grids which mainly use coals and natural gases. This project could help reducing GHG approximately 2.37 million tons of carbon dioxide which therefore can be claimed for certified emission reductions under a CDM project. The internal rates of return from the two projects are between 13 -38%. The results show that the project without CDM will provide less amounts net returns and take longer time to break even. Key factors affected rates of CDM project implementation and performance in Thailand mainly include high costs for implementation, stringency and very long period of approval procedure, limited financial and technical supports, and organization capacity. In conclusion, based on our case study, additional incomes from the CDM project create a great incentive for green investment and promote a better solid waste management and global warming mitigation for the future.

Keywords: Landfill Gases, Waste to Energy, Certified Emission Reduction, Carbon Trading, Clean Development Mechanism

1. Introduction

1.1 Landfills in Thailand

As being part of globalization, Thailand has increased in rates of consumption and production which eventually result in significant amounts of wastes that the country needs to deal with. Moreover, increasing future population can intensify this solid waste crisis. Solid waste management in Thailand is mainly done by landfills because it is the least-cost approach comparing with incineration. Municipal solid wastes under anaerobic condition in landfill will generate methane which is a potent GHG (23 times CO_2e). Without methane collection and utilization, landfills become important sources of GHG.

Total numbers of landfills in Thailand which actively operate are ninety (90) while total incinerators are three (3). There are more than three hundreds (300) opened-disposal sites in the country. Despite large numbers of landfills, only a few of them properly operate and maintain (with methane gas collection) because no regulation mandates for methane collection. Consequently, there is very little incentive to collect methane from landfill to generate electricity and increase waste collection efficiency. A large amount of investment needed is one of major barriers. Currently, governmental capability in providing financial supports to start up this kind of project is very little and insufficient.

Several studies have been estimated amount of methane generation from solid wastes in Thailand. Currently, opened-dump is highest implementing method in Thailand. Rates of methane emission from 142 landfills and opened-disposal sites were estimated to be average at 22.89 $g/m^2/day$ from landfills and at 1.98 $g/m^2/day$ from opened-disposal sites. Total amounts of methane emission are 64.3 Gg/year (Chiemchisri C., et al., 2004). Within 15 years with population increases at 1.5% and waste generation rate constant, if the opened-dumped areas are converted to become landfills, the methane emission will increase from 120 to 340 Gg/year (Kornbunraksa T., et al., 2005). In addition, Chiemchisri C. and Visvanathan, C. (2008) estimated potential amount of methane emission from 95 landfills and 330 opened-disposal sites in Thailand. The researchers suggested that total amount of methane will increase and can be useful if solid wastes are managed and put into closed landfills. Landfill gas could be a high potential source of renewable energy. Wannapruk et at., 2007, studied the feasibility of using community wastes for electricity generation and suggested that amount of wastes should be greater than 100 tons/day and will have biogas approximately 9-12 m^3/day or 1,800 – 2,400 $m^3/year$ which can generate about 350-500 M watts of electricity. Potential amount of electricity generation depend very much on ratio of organic compounds in wastes which should be more than 60% in weight of wastes. Jaramillo P. and Mattews H.S. (2005) studied social and economic benefits from potential uses for electricity generation from landfill gases. Evidently, the researchers found that it is difficult to make profits and recover the cost in the short term due to much higher cost of investment than income from selling electricity. Government should provide supporting policy and other financial supports.

1.2 Clean Development Mechanism (CDM)

Trading of Certified Emission Reductions (CERs) from CDM projects can help Annex I countries to offset their GHG obligation in a cost-effective manner while providing financial supports to help developing countries to be part of global GHG reductions and adopt clean technology. Therefore, CDM is an excellent market-based mechanism which could help increasing efficiency of environmental management in GHG reduction and sustainable development. Thailand has ratified Kyoto Protocol in August 2002 as Non-Annex I parties, which means that the country does not have the commitment to reduce the GHG emissions but still can perform the voluntary emission reduction project. Evidently, Thailand will receive significant benefits from the CDM if it was implemented widely.

CDM had been introduced in Thailand since 2005. Thailand Green House Gases Management Organization (TGO) as Designated National Authority (DNA) was established in 2008 to manage GHG in Thailand, coordinate CDM operation, develop database about CDM projects. Currently, seventeen (17) CDM projects have already certified by UNFCCC Executive Board. There are forty-one projects already received letter of approval from TGO. However, Thailand only has 1 approved CDM project from landfill gas to energy category. Despite, total waste handling and disposal type projects around the world are 321 projects (UNFCCC CDM projects statistics, February 2009). During 1998 – 2020, with rate of GDP growth 4-5% per year, GHG emission forecast in Thailand will increase, with increases of carbon dioxide 2.9% per year and methane 1.2% per year (JGSEE, 2008). Energy sector emits the highest amount of GHG. More production and use of renewable energy from wastes can potentially help reducing sources of global warming impact. Despite high potentials and benefits from this CDM type of project, the causes hindering CDM projects implementation in Thailand have not been fully understood.

1.3 Objective

This challenge becomes a main focus of our research by using Bangkok as a case study. Bangkok as a capital of Thailand has a waste generation rate approximately 9,300 – 11,000 tons/day in the past 10 years (BMA, 2008). However, only about 40% of these wastes are collected and then transferred to put into 2 active landfills, Panomsarakam and Kampangsan Landfill which started to operate since 2005. Due to lack of sufficient financial and administrative capacity, BMA will soon face serious problems if solid wastes still remain inefficiently managed. Finding solutions to promote CDM projects will create a great incentive for investment to improve this situation.

The main purposes of our investigation are: (1) To estimate total amount of GHG generation from solid wastes and evaluate potential carbon credits from BMA landfills to energy generation (2) To evaluate the economic benefits/investment returns from various management scenarios and (3) To identify factors hindering the CDM implementation of landfill gas to energy type project and recommend solutions to promote efficient wastes management and GHG reduction in Thailand.

2. Methodology

2.1 Data Collection

Data in this study was collected from 3 major wastes transfer sites of Bangkok Metropolitan Administration (BMA). Data collected, during the period of the past 10 years, includes number of populations, quantity and characteristics of wastes generation, related prices and costs of construction, management system of BMA. The collected data is used to forecast number of future population, amount of future wastes and methane generation. Amount of methane emission and reductions is calculated by following UNFCCC methodology (ACM001 Version 8): Tool to determine methane emission avoided from dumping solid waste disposal site (UNFCCC, 2008). Policy and regulation and performance related to CDM implementation in Thailand is also studied and collected by interview TGO, consultants, and relevant stakeholders.

2.2 Data Analysis

The study examined amount of methane emission in a short term (10 years) and a long term (20 years). The implementation time for reduction methane emission of the project will be considered into 2 phases: short-term from 2009-2018 and long-term from 2009-2028. The CDM project implementation will be considered for 10 years period with no renewal. The analyses are divided into 4 cases, baseline, scenario A, scenario B and scenario C, as summarized in table 1. Baseline scenario is considered if there is no management for methane emission. In scenario A, methane is collected and then flared. In scenario B, electricity will be generated from methane and the excess amount is then flared. Scenario C is to implement a CDM project. The feasibility study of electricity generation project from landfill gases, with and without CDM, is also estimated by calculating costs, benefits, net present value, internal rate of return, and payback period from an investment.

3. Results and Discussion

Sources of solid wastes in Bangkok Areas are from residential, commercial, institutions, construction sites and demolition, public areas, industrial estates, and agricultural activities. Rate of solid wastes generation in Bangkok is approximately 0.9 – 1.0 kg/capita/day. Currently, amount of solid wastes collected is approximately 8,500 – 9,300 ton/day. The process of solid wastes management in Bangkok is to collect and separate at the transfer sites, then transport to landfills. There are 3 collection and transfer sites for solid wastes, Onnut, Nongkam and Saimai.

There are two major landfills, Panomsarakam landfill receives 38.2% of total amount of wastes generated while Kampangsan landfill receives about 61.8%. Characteristics of wastes are important for monitoring changes of waste composition. Physical composition of BMA wastes from year 1994 – 2005 has organic 94% and inorganic 6% and more detail is summarized in table 2. Chemical composition of wastes is humidity 51.7%, volatile solid 37.8%, ash 10.4%, and heating value 1,705.8 kcal/kg, as summarized in table 3.

3.1 Amount of GHG Emission Evaluation

In the past 10 years, population in Bangkok continuously increases. Though, registered population is rather constant but hidden/transit population significantly increase, accounted for about 40% of the total population. Relationship between population and actual amount of waste generation is shown in figure 1. With the rate of waste generation at 1 kg/cap/day, amount of wastes will put in landfill each year is summarized in table 4. Based on population forecast and the current rate of waste generation, the amount of methane generation each year from 2005-2028 within the 2 landfills can be showed in, figure 2. Total amount of methane in 20 years will be 6.22 million ton carbon dioxide equivalent (tCO_2e), generating from Panomsarakam and Kampangsan landfill approximately 1.94 and 4.28 million tCO_2e, respectively. This amount is considered as baseline for comparison with other management approach.

Scenario A supposed that methane gases are collected and then flared (at 50% efficiency) without electricity generation. Methane will be converted to carbon dioxide and reduced global warming potential. In 10 years, amount of total GHG emission from this scenario for the two landfills is 1.79 M tCO_2e. This emission is from Panomsarakam 0.56 M tCO_2e and Kampangsan 1.23 M tCO_2e. In 20 years, amount of total GHG emission from this scenario is 2.17 M tCO_2e. This emission is from Panomsarakam 0.68 M tCO_2e and Kampangsan 1.49 M tCO_2e. This approach can reduce methane emission about 65% from baseline scenario.

Scenario B assumed that methane gases are collected and used to produce electricity for selling and using in the project. In 10 years, amount of total GHG emission from this scenario is 1.59 M tCO_2e. This emission is from Panomsarakam 0.50 M tCO_2e and Kampangsan 1.09 M tCO_2e. In 20 years, amount of total GHG emission from this scenario is 1.94 M tCO_2e. This emission is from Panomsarakam 0.61 M tCO_2e and Kampangsan 1.33 M tCO_2e. Amount of methane emission in this scenario will be reduced about 69% from baseline scenario. The analysis of GHG emissions for each scenario from 2 currently active landfills in Bangkok can be summarized in figure 3.

Alternatively for scenario C, if the CDM project be implemented from 2009 – 2018 (for 10 year crediting period), the potential emission reductions will be approximately 2.37 M tCO_2e, from Panomsarakam 0.84 M tCO_2e and Kampangsan 1.53 M tCO_2e. The CDM project will help generate additional income from selling electricity and certified emission reduction. The current price of carbon credits is approximately in range between 14 – 34 $US/ton carbon credits. These amounts of carbon credits can generate significant revenues in the first 10 years of implementing the project and become an important financial incentive for the investors to decide to implement this type of project.

From 2009 – 2014, total amount of methane gases can generate energy for about 141.4 Gwatts of electricity, from Panomsarakam 67,850 Mwatts and Kampangsan 73,584 Mwatts. This electricity generated from methane gases can reduce amount of non-renewable energy produced from coals and natural gases. In the estimation, the electricity generator is assumed based on manufacture specification to have efficiency 45.5%. The efficiency of gas collection is assumed at 70 percent, as recommended by UNFCCC methodology. Therefore, sensitivity analysis of gas collection at 60 – 80 percent was analyzed. It was found that amounts of carbon dioxide reduction from electricity generation and flare vary within the range of 5 - 15 percent. Efficiency of gases collection affected amount of electricity generation from Panomsarakam landfill between 3 - 7 percent but do not affected amount of electricity generation from Kampangsan landfill due to excess amounts of gases from the landfill for electricity production.

Uncertainty related to amount of electricity estimation depends on the efficiency of waste separation before putting into landfills, the design and efficiency of electricity generator, and efficiency of landfill gas collection system. Currently, in several landfills in Thailand, landfill gas pipeline system can not collect all gases or function at low efficiency. With vertical layout of collecting pipes, leachates sometimes flow into collecting pipelines which possibly block biogas flow. Therefore, amount of gases collection is less than expected. Horizontal layout of collecting pipes can improve efficiency of gases collection. However, with the non-uniform settlement of the solid wastes, it could cause damage to the pipes and create gas leakages. Study of new design and materials of piping system with flexibility, high pressure resistant, and low cost will help improving the gases collecting efficiency.

3.2 Financial Analysis

The study analyzed the feasibility of implementing the electricity generation from landfill gases, with and without the CDM project. In term of investment cost, fixed costs include generator system, piping system, air pollution treatment system, while operation and maintenance costs consist of labor cost, O&M for instrument, interests, and taxes. If implementing CDM, the addition costs include fee for application, for inspection and certified letter of approval, costs of project design document (PDD), verification, monitoring, validation, registration, taxes and other related transaction costs. Costs of CDM implementation varied depending on project size and type of potential reduction activities. For the fee, TGO charges from CDM project which reduces GHG less than 15,000 tCO_2e at 75,000 baht (~2,143 $US)[1]/project. For CDM project reducing

[1] For exchange rate 1 dollar is approximately 35 baht (April, 2009).

GHG more than 15,000 tCO_2e, it will be charged at 10 baht (0.28 $US)/$tCO_2e$ but not over than 900,000 baht (~25,714 $US). From the survey, average cost for developing the PDD is about 1.5 - 2.0 million baht (42,857 – 57,142 $US). The monitoring cost by DOE is approximately 150,000 – 300,000 baht (4,286 - 8,571 $US). Registration fee by UNFCCC EB is approximately 0.1 $US/CER for the CDM project with less than 15,000 tCO_2e, and 0.2 $US/CER (no more than 350,000 $US) for the CDM project with more than 15,000 tCO_2e. Recently, Thai Government promotes the development of renewable energy project by providing low interest loans at 4% per year. Moreover, the Government gives financial incentive (adder) for the amount of electricity selling to government grid at 2.5 baht/kwatt, addition to regular price of 1.7 baht/kwatt for 7 years periods after the selling commitment.

From the financial analysis summarized in table 5, for Panomsarakam landfill, cost of investment for CDM with energy generation (1 Mwatt) project from landfill gases is approximately 357 – 388 MBaht which is higher than that without CDM project (about 242 – 260 MBaht). But total returns of investment from the CDM project is about 420 Mbaht which is much higher than without CDM. Moreover, the net present value for investment is at 31-62 Mbaht. Implementing CDM project creates opportunity to break even from the investment. Panomsarakam landfill project has internal rate of return at 13-23%. The project will break even in 4 years after investment.

While Kampangsan landfill, cost of investment for energy generation (1 Mwatt) project from landfill gases is approximately 248 - 266 MBaht which is less than that with CDM project (about 429 -460 MBaht). However, total return of investment from the CDM project is about 642 Mbaht which is much higher than without CDM (163 Mbaht). The net present value for CDM project investment is at 183 - 214 Mbaht. Kampangsan landfill project has internal rate of return at 27-38% and will break even in 3 years after investment. Therefore, implementing CDM project from Kampansan landfill creates higher opportunity to break even from the investment compared to Panomsarakam landfill.

To improve efficiency of MSW management with energy generation, benefits over costs from both projects are greater than 1. However, with CDM implementation, the project offers positive net present value and break even within the shorter period. This financial factor is important for decision making for the owners to invest in the green project.

3.3 Implementation Barriers

In Thailand, the regulation and policy on GHG reduction is still in developing process and based on voluntary basis. There are several issues affecting the implementation of CDM projects in Thailand. First, many project developers in the country still lack of full understanding on their potentials in CDM project implementation, CDM application procedure and documentation requirement. Therefore, significant amount of time is spent on developing background, project design document and revision process to meet requirements from TGO.

In addition, approval time for each project for letter of approval at domestic level, and registration at international level require a long time before the project owners can receive benefits from investment. The approval time depends on numbers of project application and the completeness of information in the submitted document. If the project developer provides incorrect or insufficient information, document re-submission can be resulted in longer approval time. This factor becomes a disincentive for investment. Since, the project owners have to provide in advance high investment for consultation, implementation and other fees, whereas the income from CDM project may not guarantee or recover in a shorter time. Furthermore, ability to negotiate for the credits price for small investor is difficult due to limited access to carbon market. This issue can also prolong decision to implement the project to sell carbon credits.

To get approval for domestic license for electricity generation in Thailand is also a complicated process. Application process is required an approval from several related agencies including Ministry of Industry, Ministry of Energy, Ministry of Natural Resource and Environment and the Local Government. Some agency especially local government did not have sufficient knowledge about CDM and require more information and longer time for inspection and review process. Longer approval time creates more lost of benefits for CDM implementation. Moreover, CDM is quite a new area for investment for banking sectors. Due to uncertainty of investment return and CDM additionality requirement, many banks and financial sectors in Thailand hardly approve loans for the CDM project.

Thai government can help improving performance of the CDM projects by simplifying of rules and data requirements for PDD and by providing clear guidance, information network, database and training programs for accessing CDM consultants, carbon reduction technology and carbon market to potential developers and relevant stakeholders. Ministry of Finance can help providing subsidy or tax exempt for the clean technology system. Local government can promote CDM for environmental management and GHG reduction by educating governmental staffs and helping citizens to identify potential project within the areas to improve environmental quality management. It is important to promote CDM projects continually with suitable financial support programs and policy from both government and private banking sectors, and thoroughly with public education.

4. Summary

Bangkok Metropolitan, with high economic growth and population increase, currently generate significant amount of solid wastes and urgently need an effective waste management system. Landfill is major approach to dispose of the wastes of Bangkok city which generate considerable amount of landfill gases. Landfill biogases, as a potent source of GHG, can be used as a valuable resource to produce renewable energy coupling with GHG reduction. The study found that wastes from Bangkok Metropolitan have high potential to generate large amount of electricity 141 Gwatt and reduce up to 2.37 Mt CO_2e (CERs). With CDM project, the electricity generation and carbon credits can help generating enough incomes for the waste management project and shortening the payback period for the investment. However, the CDM project in Thailand is still at a learning stage and need to improve implementation performance compared with other developing countries. Major factors affect the achievement of CDM projects in Thailand including complexity of CDM application process and domestic license for electricity generation, cost of CDM implementation, high costs related consulting fee, long implementation time and turn-over rate for project approval, and uncertainty of investment return. The government and private sectors (including Banking) need to provide more helps in developing supporting policy, finance and information for CDM investment and for public education. In the near future, wastes-to-energy project could be implemented more widely and will greatly help improving environmental quality management, solving energy demand and reducing GHG for Thailand.

5. Acknowledgement

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7. Figures

Figure 1 Relationship between Population and Waste Generation in Bangkok

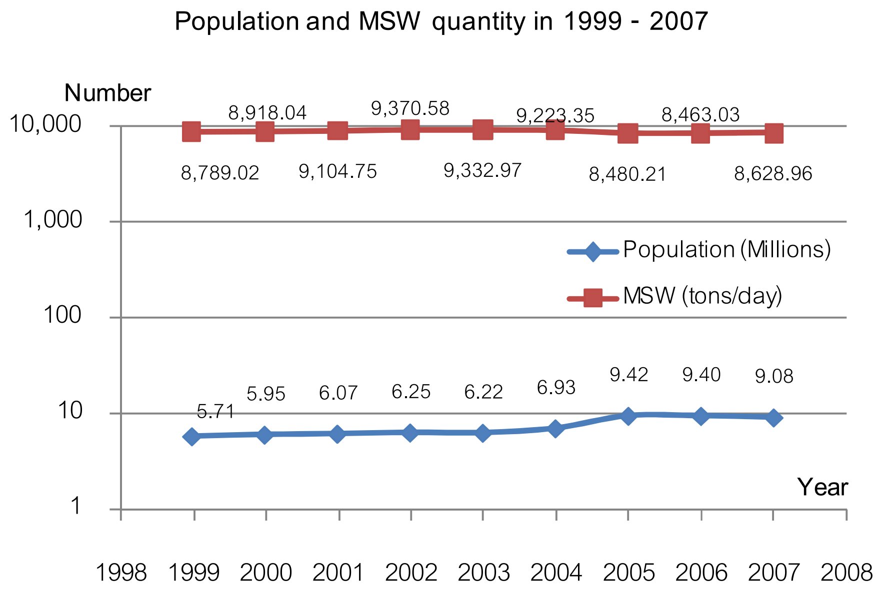


Figure 2 Methane Gases Generation from Panomsarakam and Kampangsan Landfills

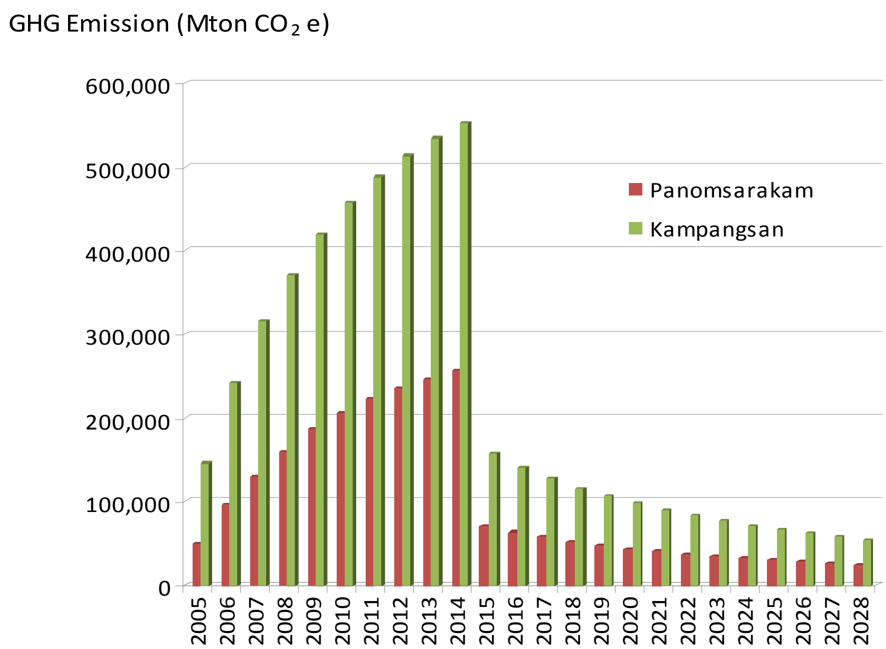


Figure 3 Amount of Methane Generation in Each Scenario

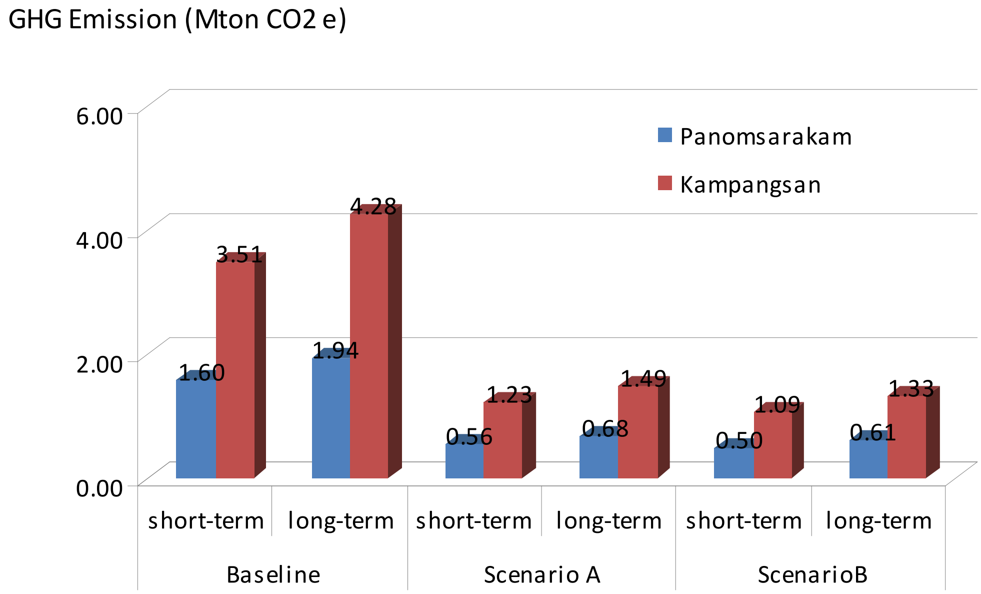
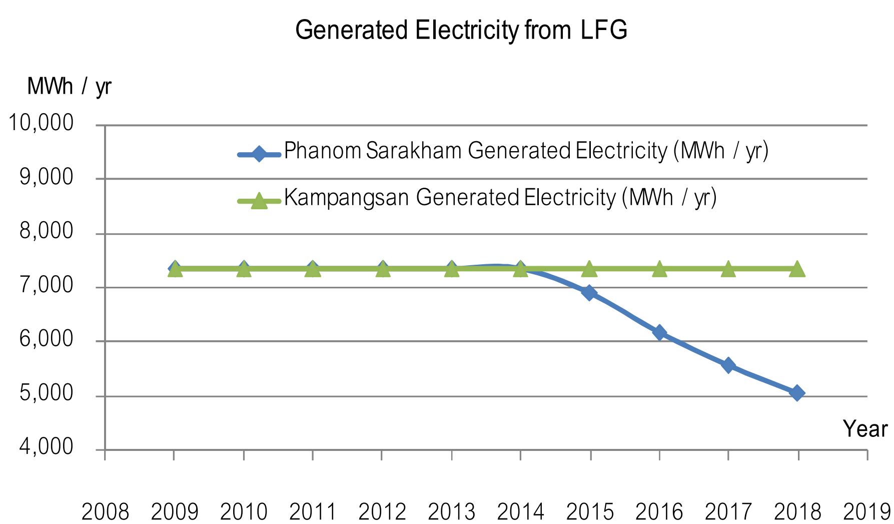


Figure 4 Amount of Electricity Generated from Landfill Gases Each Year (2009-2018)



8. Tables

Table 1 Management Scenarios

Cases	Baseline	Scenario A	Scenario B	Scenario C
Short-term	No management	Flare	Electricity Generation	CDM Implementation
Long-term	No management	Flare	Electricity Generation	

Table 2 Physical Composition of Municipal Solid Wastes (MSW) in Bangkok

Physical Composition of MSW	Percent (%)
Food Waste	39.75
Paper	11.70
Plastics	21.44
Textiles	5.42
Rubber and Leather	1.06
Yard Waste	6.67
Bone and Shell	0.68
Misc. Organics	7.28
Glass	3.60
Metal	1.79
Stone and Ceramic	0.56
Total	100.00

Table 3 Chemical Composition of Municipal Solid Wastes (MSW) in Bangkok

Chemical Composition of MSW	Percent (%)
Moisture content (%)	51.68
Volatile Solid (%)	37.78
Ash(%)	10.42
Calorific Value (kcal/kg.)	1,705.57

Table 4 Amount of Municipal Solid Waste Generation and Collected Each Year (2005 -2014)

Year	Municipal Solid Waste in Landfill (tons)	
	Phanomsarakam Landfill	**Kampangsan Landfill**
2005	702,603.10	2,020,895.50
2006	832,911.75	1,874,935.65
2007	811,402.30	1,936,288.50
2008	900,133.80	1,913,538.05
2009	934,410.95	1,986,410.30
2010	933,670.00	1,984,837.15
2011	933,367.05	1,984,187.45
2012	932,111.45	1,981,519.30
2013	930,742.70	1,978,610.25
2014	930,885.05	1,978,913.20

Table 5 Financial Analysis of Landfill Gases Management and Electricity Generation Investment with and without CDM Implementation

Case	Without CDM	CDM
Panomsarakam Landfill, Chachengsao Province		
Cost (Present Value)	242.12 to 260.11 M Baht	357.49 to 388.78 M Baht
Benefit (Present Value)	157.11 M Baht	419.57 M Baht
Net Present Value (NPV)	- 85.01 to –103.00 M Baht	30.79 to 62.08 M Baht
Internal Rate of Return (IRR)	-	13.22 to 23.27%
Payback Period (yr)	-	4
Kampangsan Landfill, Nakornpathom Province		
Cost (Present of Value)	247.54 to 265.87 M Baht	429.04 to 460.03 M Baht
Benefit (Present of Value)	162.98 M Baht	642.92 M Baht
Net Present Value (NPV)	-84.55 to –102.89 M Baht	182.89 to 213.88 M Baht
Internal Rate of Return (IRR)	-	26.84 to 37.78%
Payback Period (yr)	-	3