METHANE EMISSION IN THAILAND AND THE UTILIZATION OF METHANE EMISSION FROM SANITARY LANDFILL AS ENERGY SOURCES

Sirintornthep Towprayoon
Jittimaporn Sukpinij

Division of Environmental Technology
School of Energy and Materials
King Mongkut's Institute of Technology Thonburi

ABSTRACT

Methane is a significant 'green house gas' mostly produced by anthropogenic sources such as rice paddy field, waste treatment, oil and gas combustion and sanitary landfill. It is suggested that methane flux rate in the atmosphere is increased 1.0-1.9 percent each year. Methane emission in Thailand is mainly from rice paddy field approximately at 3.2 Tg/year. As municipal solid waste(MSW) is increasingly produced each year and 60 percent of this MSW is disposed by sanitary landfill, methane emission from landfill is calculated by using IPCC (The Intergovernmental Panel on Climate Change) model and anticipated to be 2.9 Tg/year in 1994 and 3.3 Tg/year in 2004. The estimate of methane from landfill is at proximity to rice paddy field. This paper deals with the estimate of methane emission from sanitary landfill in term of total MSW and Bangkok MSW by using IPCC model. The possibility to use methane gas as energy sources is reviewed.

INTRODUCTION

Methane is a significant 'green house gas' mostly produced by anthropogenic sources such as rice paddy field, waste treatment, oil and gas combustion and sanitary landfill. It is suggested that methane flux rate in the atmosphere is increased 1.0-1.9 percent each year[1]. Unsimilar to carbondioxide and other green house gases, methane is one of the producer gases that can be used as energy sources. The utilization of methane was via the biogas produced by microbial anaerobic digestion. Biogas from anaerobic waste water treatment plant(both in industrial and agricultural sector) was accepted to use in the boiler system and in the electric generation. There are the numerous limitation of methane utilization from other emission sources like rice paddy field and wet land. The methane emission from municipal solid waste (MSW) sanitary landfill in term of landfill gas has shown the possibility to use as energy source in many countries[2]. The available of methane utilization is depended on the amount of methane

production, emission, collection and the technology implementation. This paper deals with the amount of methane emission in the sanitary landfill of MSW in Thailand and the potential to use in the energy aspect.

METHANE EMISSION IN THAILAND

At present, there is no consensus figure of the total amount of methane emission from dominant sources in Thailand. The emission of methane from animal husbandary and waste management was report in 1993 [3] by Thailand Development Research Institute (TDRI) and Thailand Environmental Institute (TEI) as shown in table 1. The main emission was from rice paddy field which was approximately 2.53-6.87 Tg CH_4/year by TDRI and 3.2 TgCH_4/year studied by King Mongkut's Institute of Technology Thonburi (KMITT)[4]. There was no report of the methane emission from the transportation sector and Industrial sector. At this moment, the emission from wetland is now under investigating at KMITT and there is no available data of methane emission from MSW landfill. However The Office of Environmental Planning and Policy under the Ministry of Science, Technology and Environment is now preparing the national Green House Gases inventories under The Intergovernmental panel of Climate Change (IPCC) approach and aims to issue in early 1996.

Table 1. The methane emission from various sources in Thailand

	Methane Emission	
	TDRI&TEI	KMITT
Animal husbandary(Tg/y)	0.48	0.54
Waste management(Gg/y)	39.48	-
Rice paddy field (Tg/y)	2.53-6.87	3.25

METHANE EMISSION FROM LANDFILL

Methane from landfill contributed a significant proportion of annual global methane emission although the estimate was subjected to be the massive of uncertainties[5]. The estimate of the gas generation from landfill trend to be the dominant source of methane emission in the future as the amount of waste is annually increased. Various factors were involved in the emission of methane such as the volume and composition of municipal solid waste , the attenuated temperature, the technology approach, the collection system etc. The better understanding of these factors can reduce the uncertainties related with emission estimate[5].

MUNICIPAL SOLID WASTE IN THAILAND

The waste generation in Thailand is 0.925 kg/capita/day [6] which is at the upper range of the waste generation from developing countries. The composition of MSW showed the high content of moisture (60 percent) and degradable organic carbon (40 percent)[7]. In Bangkok, waste generation was 6,000 tonne per day and 60 percent of these MSW was removed to landfill at the vicinity site. The disposal of MSW by using sanitary landfill become more interesting in the regional main provinces. Thus it is anticipated that landfill will be the main source of methane emission instead of rice paddy field in the near future as the rice cultivation area is reduced each year. This reduction will lead to 0.04-0.11 $TgCH_4$/year decreased in methane emission [3].

THE ESTIMATE OF METHANE EMISSION

There are numbers of methods to estimate methane emission from sanitary landfill. These methods varied widely not only in the assumptions, but also in their complexity[5,8,9]. The IPCC has set up the guideline to determine the amount of methane emission from landfill in 1995. The method is simplicity and can be applied to the total waste of the country. It is based on the mass balance approach, and does not incorporate any time factors into the methodology. The method assumes that an instantaneous release of methane takes place from refuse during the year the refuse is landfilled. The calculation is based on the amount of waste generation and landfill, the fraction of degradable organic carbon (DOC), the fraction of DOC that actually degrades to biogas and the fraction of biogas that releases as methane. The figure used for calculation is shown in table 2. The estimated methane emission from landfill for the whole country of Thailand and for the metropolitan of Bangkok are illustrated in table 3.

Table 2. The parameter used for calculation

waste generation(kg/capita/day)	0.925
fraction MSW landfill	0.60
fraction DOC in MSW (DOC_{land})	0.43
fraction DOC actually degrade (DOC_{deg})	0.77
fraction C in biogas released as CH4	0.55

Although Bangkok faced the problem of rapid increment of population and the problem of migration citizen. The calculated amount of methane from landfill (based on number of populations) was far beyond the figure of the whole country. In practical, The data from the Bangkok Metropolitan Administration (BMA) at 1994 showed that the daily collection of MSW was 6,000 tonne which can converted to 650 tonne of biogas/day or 812,000 m^3 of biogas per day. The anticipation of the methane emission from sanitary landfill (whole country) in the next decade was shown in

figure 1. The amount of methane in 2004 is 3.3 Tg/year which is at close proximity to the amount emitted by rice field.

Table 3. The methane estimation from landfill in 1994

	W (kg/y)	WT (Tg/y)	CH_4 (Tg/y)
whole country	20.05	12.03	2.921
Bangkok	2.19	1.314	0.319

W = Total solid waste (waste generation x population x 365)
WT = landfill waste (W x fraction landfill)
CH_4 = The annual amount of methane emission (WT x DOC_{land} x DOC_{deg} x fraction of C as CH_4)

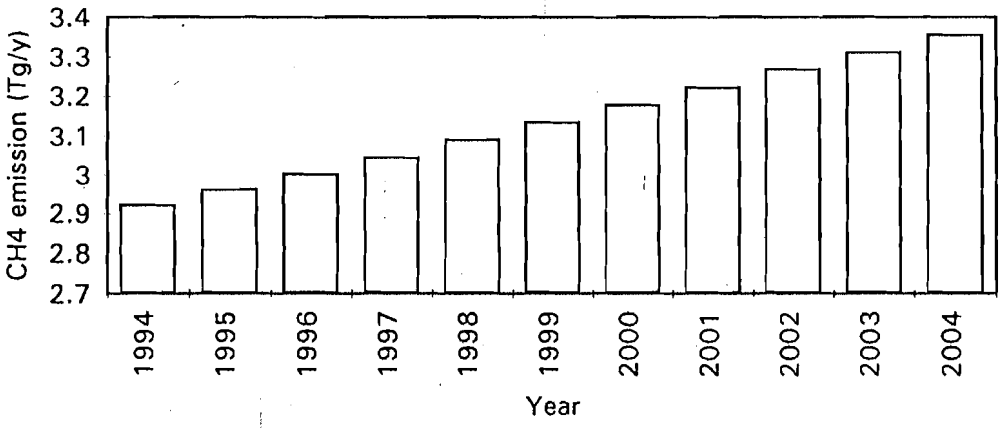

Figure 1. The anticipation of the methane emission from landfill from 1994-2004

LANDFILL GAS AS ENERGY SOURCE

Biogas from landfill site composed of CH_4 and CO_2 as main gases and the small amount of inert gas. The quality of the gas depend on the ratio of CH_4 and CO_2 (mostly by half). The purification is needed when more advanced purposes are expected. The use of landfill gas can be classified into 2 categories

1. To use directly as the biogas in the combustion for electricity production or use as fuel in boiler /kiln. The gas can also be applied for thermal energy in the sludge drying system. In Europe,there were more than 58 landfill gas projects for boiler/kiln and 78 projects for engine end-uses [2].

2. To upgrade as purified methane and use as vehicular methane in substitute of diesel and alcohol[10]. This process is complicated and need more advanced technology on purification and compression.

The landfill site that have the potential to utilize methane gas should produce over 100,000 m^3/day at least 10 year[10].

LANDFILL GAS FROM BANGKOK MSW

Kessler (1990) reported that the preliminary estimates based on construction and generating equipment costs, indicate a pay-back period from less than 2 years for the landfill site that produced biogas over 50,000 m^3/day and pay-back period over 4 years for the landfill of 10,000 m^3/day gas production. The estimate of 812,000 m^3 /day was calculated from the collection of daily Bangkok MSW which showed the high economical potential to utilize gases as energy source. However the 6,000 tonne /day of MSW collection was difficult to landfill at the same site. Thus, the local management to 4-5 landfill sites is recommended. As the methane estimated model from IPCC does not take time phase in to account, this may lead to over estimate of the biogas. Design of the landfill site capacity should be carefully considered to produce significant amount of gas for commercial use.

THE USE OF LANDFILL GAS

At present, BMA remove one sixth of the collected MSW out of the city and landfill at the vicinity area by some private company. Unfortunately methane production are not taken into account. There are at least two possibilities that the methane utilization from Bangkok MSW landfill site can be achieved. The first is the electric power generation and the later is sludge drying system. To use methane in the power plant could produce 1000-3000 kW of electricity depend on the quality and quantity of the landfill gas. As Thailand meet the increasing demand of electricity, the small private electric generating plant to distribute electricity for surrounding area is one of the decentralized policy of the government. This utilization will intensively serve the need of the country. As for heating aspect, the study of landfill gas from Bangkok MSW landfill site (unpublished data) showed that the gas was the low-grade fuel (580 BTU/ft^3) which could be used to raise steam or produce heat for drying proposed particularly the sludge drying system in the waste water treatment plant or MSW treatment plant nearby. Thus, it is recommended that the landfill site designed to use landfill gas as heating purposed should attach to the waste treatment plant. The gas can also be transfered to the end user by pipelines installation. However, in practical, many problems are raised among the experts. These are the design of proper landfill and its gas abstraction system to collect most of the gas production, the benefit of purification and compression of the gas for specific utilization, the environmental health hazard from the toxic gases produced with methane and the leachate control of the landfill disposal site.

CONCLUSION

Influenced by the population growth and the waste generation, the preliminary estimates (based on the IPCC assumption) of Bangkok MSW landfill has shown the tendency to produce high amount of methane gas that is significant to use as energy source. To use direct landfill gas for small electric power generation which is encourage for the local power supply demand by the government policy and to use as heat generating fuel in the sludge drying system are the most considering alternative. However, much is to be considered and done on the environmental basis of waste disposal treatment and the benefit returned in term of economic and energy aspects.

REFERENCES

[1] Holzapfel Pschorn, A. and Seil, W., "Methane Emission During a Cultivation Period from an Italian Rice Paddy ", Journal of Geophysical Research, Vol. 91, No.11 pp 8.3-814, 1986 .

[2] Fabry, M.R. and Ferrero, G.L. " Landfill gas : EEC perspective on use as a fuel", Landfill gas Energy and Environment'90 Harwell Laboratories , Oxfordshire. 1991

[3] Thailand Development Research Institute and Thailand Environment Institute, " Preparation of a National Strategy on global Climate Change , Submitted to The Government of Kingdom of Thailand. 1993

[4] Towprayoon S., Asawapisit,S. and Wanichapongpan, P. "Methane emission from rice paddy field in Thailand" Proceeding International Conference on Regional Environment and Climate Changes in East Asia. 1993.

[5] Intergevernmental Panel on Climate Change "Greenhouse Gas Inventory Reference Manual " 1995.

[6] Wilson, D. and Nair, C., "Solid Waste Management in Developing Countries : The Need to Adapt Western Technologies and Management Systems". ASEP Newsletter, vol.8 No.1 1992.

[7] Japan International Cooperative Agency "The Bangkok Solid Waste Management Study in Thailand " Report to Bangkok Metropolitan Administration.1985 .

[8] Gardner, N. and Probert, S.D. " Forcasting Landfill-Gas Yields" Applied Energy 44, 131-163, 1993

[9] Lee, J.J.,Jung, I.H., Lee, W.B. and Kim, J.O. " Computer and Experimental Simulations of the Production of Methane Gas from Municipal Solid Waste " Wat. Sci. Tech. vol 27, No.2 pp. 225-234, 1993.

[10] Kessler, K. "Brazillian Trends in Landfill Gas Exploitation" Landfill gas Energy and Environment'90 Harwell Laboratories , Oxfordshire. 1991