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Assessing Applicability of Technologies for Waste to Energy in Developing Asian Cities

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Abstract

High economic growth in developing Asian countries (DACs) has evoked pressure on natural resource utilization and generated excessive amount of waste. Parallel with changes in waste generation and continuing dependency on landfill as final waste treatment option, has increased potential of methane release which caused direct impact on greenhouse gases (GHGs) emission density. There is an emerging need in DACs to have an alternative waste treatment option that can provide two fold benefits of wise use of biomass waste and reduce GHG emissions. This study tends to assess the applicability of waste to energy technologies from Japan to be introduced for implementation in DACs. Commercialization interest was observed earlier to see the tendency of Japan's involvement in technology transfer. Eventhough there was a high rate in transferring biogas technology, but only 10% of it was a converted energy from animal biomass and none utilizing municipal solid waste (MSW). Furthermore, available technologies were evaluated based on cost, technology level and resource recovery indication. Based on collected qualitative data, result had shown that biogas technology was most applicable and commercially available than others. To reduce the implementation barrier, the most suitable approach was proposed. It was suggested that decentralized, networked but top-down approach will be the best option to enhance technology transfer from Japan.

Keywords: Biomass waste, Climate change mitigation, Resource recovery, Technology transfer

1. Introduction

In recent years, rapid urbanization in developing Asian countries (DACs) has driven urban population to increase, consume vast amount of resources, generate excessive amount of waste and caused natural ecosystem under pressure. Urban area in Asia generated approximately 0.76 million tons of municipal solid waste(MSW) per day and expected to increase up to 1.8 million tons of waste per day by 2025 (World Bank,1999).This increasing trend of waste generation and continuing dependency on landfill as final treatment option have direct impact on greenhouse gases (GHGs) emission density. Adhikari et al, (2006) estimated that by the year 2025, landfill share of global anthropogenic emission has possibility to increase to 10% from 8% in 1995. This is resulted by methane (CH_4) that is generated from urban food waste generation in Asia which is expected to have 13 million tons of increase in the 30 years period of time. Unfortunately, dependency on landfill as final waste treatment is still widely being practice in most DACs. Controlled landfilling practice are implemented in large scale, and this will lead to increasing of landfill (CH_4) emission. Alternative waste treatment methods need to be introduced to recover biomass waste and to avoid the release of GHGs to atmosphere.

Minimum emission can be achieved if disposal technology is properly chosen (Calabro, 2009). Ruth (1998) declared that utilizing MSW as an alternative energy resource can mitigate the MSW disposal problem, conserve more valuable fuels, and reduce emissions of GHGs associated with global climate change. However, emission savings for energy generated from waste technologies depends substantially on recycling, as well as on recovering energy from waste (Papageorgiou et al, 2009). Transferring waste to energy technology has been expended to DACs through utilizing flexible mechanism of Clean Development Mechanism (CDM) offered under Kyoto Protocol. Commercialization of waste to energy under CDM has also acted as an important mean for DACs to obtain benefit in improving local sustainable development and at the same time mitigating GHGs emission as co-benefit.

This study will examine the applicable technology to recover energy from biomass waste as one of the option in mitigating GHGs emission in Asian developing countries. Tuck and Watsa (2009) declared that developing countries can shift to lower carbon paths while promoting development if receiving financial and technical assistance from high-income countries. Thus, we have observed possibilities of technology transfer from Japan towards DACs. To Effectiveness of available technologies in Japan was reviewed to evaluate most possible technology to be transferred. Commercialization interest was also accessed by focusing on investment trend of Japan in CDM towards Asian developing countries. To reduce implementation barrier and increase emission mitigation capacity, the best approach were summarized and proposed.

2. Methodology

Qualitative methods were applied to collect relevant information. Analysis on registered CDM projects was then conducted to find commercialization interest of Japan to transfer the technology to DACs. Registered project hosted by DACs and invested by Japan that has been approved until October 31 2009 was extracted. From that, trend of technology transfer which was approved under Sector 13 Waste and Disposal was also ranked. Furthermore, in order to evaluate efficiency of available technologies, literatures from various sources were reviewed and interviews with Japanese experts were also conducted. Literatures from published journals, conference proceedings, reports and internet online information were reviewed to gain information on the advantage and disadvantage of each technology. An expert opinion was also observed through an interview session. A semi-structured interview was divided into five sections consisted of 18 elaborated check items of open ended question. The outcomes of interview were expected to be applicable to evaluate the effectiveness based on cost, technology level and resource recovery indication. The result were then weighted with scale 'proven to be effective' as 3, 'described as effective' as 2, 'predictably effective' as 1 and 'ineffective so far' as -1.

To enhance implementation of waste to energy application in DACs, this study proposed the criteria of approach which best match the local condition that need to be considered for mutual beneficial among parties involve. For this purpose, an interview session was carried out with two Japanese companies which directly involved in implementing technology transfer. It was expected that interviews would probe into the outcomes of implemented project and demonstrated the gap in current practice of technology transfer between Japan and developing countries in Asia. In each interview session, field notes were taken and highlighted as key significance.

3. Results

3.1 Commercialization interest of Japan towards transferring waste to energy technology

Transferring waste to energy technology has expended to DACs through utilizing flexible mechanism of Clean Development Mechanism (CDM) offered under Kyoto Protocol. Until October 31, 2009 there were 1382 registered projects hosted by Asia and the Pacific. Under CDM, Japan has expanded investment towards non-Annex 1 countries through 297 registered projects with 73% of the projects were hosted by DACs. As summarized in Figure 1, Japan has shown tendency to invest and commercialize technology related to Sector 1 Energy Industries and Sector 13 Waste Handling and Disposal with 143 and 25 registered projects respectively. China, India, Indonesia, Malaysia and Thailand are among the highest collaborators. On the other hand, no commercialization interest is shown in energy distribution sectors, construction sectors, metal production sector, solvent used sector as well as afforestration and reforestration sector in DACs.

Commercialization of waste to energy under CDM has also acted as an important mean for DACs to obtain benefit in improving local sustainable development and at the same time mitigating GHGs emission as co-benefit. In industrialized countries, thermal treatment of incineration with energy recovery, is the most commercial option for waste management (Malkow, 2003; Rylander,1997; Akehata, 1998; Price, 1996; Hjelmar, 1996; Vehlow, 1996). Further analysis on projects registered under Waste Handling and Disposal has shown that Japan has interests to utilize biomass from agriculture waste through combustion technology, and recovering biomass from animal husbandry through biogas technology (Table 1). Eventhough commercialization rates are higher in biogas treatment, 90% of it is converted energy from landfill gas and wastewater, yet, there is still no approved CDM project in DACs to recover MSW as feedstock and produce energy.

3.2 Waste to energy technologies in Japan

After oil shock crisis in 1973, Japan interest towards bioenergy usage has increased and related research has been conducted actively (Oomori et al, 2001) Renewable energy generated from biomass resources has similar ability to fossil fuel, in converting into liquid fuel with advantage in transporting and storage; a characteristic which not provided by other renewable energy. In Japan, biomass from waste is converted to thermal power by biochemical treatment, thermo-chemical treatment or combustion treatment.

Biochemical treatment referred to biogas and bio-ethanol technology. Biogas technology produced flammable gas from fermentation of organic matter in anaerobic process. This renewable fuel can be compressed for vehicle fuel, but in DACs it's usually used for heating purpose. Bio-ethanol is fuel that utilized starch from agriculture residues as a feedstock to convert it to sugar. It was then fermented to ethanol and distilled in pure form. However, there is still no verification utilizing MSW. Gasification is technology which applied thermo-chemical treatment by converting a heterogeneous feedstock at high temperatures to produce synthesis gas. This mixed gas can be utilized as fuel and for electricity generation. Meanwhile, combustion treatment can be classified to RDF and direct combustion. RDF described fuel that being produced by mechanical processing of screens, shredding, separating and dehydrating MSW. This can recover high calorific fraction of organic component such as plastics and biodegradable waste to produce a combustible fuel. On the other hand, direct combustion did not require pre-processing. The collection truck will directly unload their truck into bunker and burning fuel with excess air to produce steam. The steam is captured by turbine and converted to energy.

Implementation effectiveness of each technology was assessed and summarized in Figure 2.Result illustrated that biogas, RDF and direct combustion are the most applicable and commercially available to be implemented in DACs. Main advantages of these technologies are it have been fully developed and can be affordable among countries with system simplification. Implementation history of traditional biogas treatment also one of major merits to improve existing practice in local site. Meanwhile, considering available local resource input, bioethanol was evaluated as ineffective technology for commercialization in DACs which have insufficient sugar production, except for Indonesia or Thailand. High technology level of gasification have only be implemented in Europe and Japan, therefore it is predicted that less effective to transfer to DACs.

3.3 Best approach to increase applicability of waste to energy implementation

From above findings, in spite of emerging need in DACs to recover biomass waste, there is still a gap in technology transfer. Thus, to reduce implementation barrier of waste to energy in DACs, it is important to validate the best approach that is able to respond to local demand and mutually benefit investor with maximum advantage. We had observed practical experience of two Japanese companies, Takuma Co., Ltd. and Kajima Corporation, which have successfully generated energy from MSW. Takuma Co., Ltd has introduced direct combustion technology in Taiwan. From 4 operating plants, 4650 ton/day has been recovered, which accounted 21% of all MSW in Taiwan. Meanwhile, Kajima Corporation has verified that RDF would be an appropriate technology to be introduced in Indonesia and Vietnam. The company had conducted preliminary study to access local needs and the best option of Intermediate Waste Treatment Facility (IWTF), a combination of combustion with biogas and/or RDF, was proposed.

Interview responses from both companies representatives were summarized and it can be concluded that decentralized, networked but top-down approach will be the best option in commercializing waste to energy technology in DACs. For technical and administrative reason, small scale plant would be better. This is because, compared to centralized large scale plant, in small scale plant is easier to construct system simplification and ensure sufficient feedstock input in term of collection, coverage area and recovery rate. For the purpose of marketing the generated output, networked structure will give more access of area, and marketing gas or RDF will be much simpler than for selling electricity to the general grid. Moreover, top-down approach through municipality involvement has been described as more effective compared to bottom-up approach. Initiative taken by municipality is needed to raise interest on waste to energy among community. On the other hand, introducing simplification technology and optimizing local human capacity were described to be more cost-effective.

4. Discussion

Recovering waste by utilizing it as an energy resource has potential to directly mitigate GHGs emission from waste sector through wisely use of abundant biomass waste and indirectly by declining usage demand of fossil fuel - coal, oil or natural gas. There are varieties of available waste to energy technologies range from traditional method that has been practised decades ago to the latest high level technologies. The present study is trying to prove the transferred waste to energy as an alternative option for DACs to improve MSW management issue by optimizing biomass waste utilization. Relatively, investment from developed countries to transfer technology is needed to get DACs involve in mitigating climate change impact. Thus, we tried to access commercialization interest of Japan by analyzing current technology transfer tendency registered under CDM mechanism. Result illustrated that relatively there are high registered projects that utilize biogas technology, yet none of them recovering MSW to generate energy, besides recovering landfill gases. To reduce this gap, and also in introducing renewable energy through wisely use of abundant biomass waste in DACs, there is a need in making some progress to define recovering and mitigation rate that is achievable.

To evaluate effectiveness of available technologies, the advantages and disadvantages of practical experience implemented in Japan was summarized. Japan, which depends on 94% of fossil fuel as energy supply in 1973, has put some efforts to reduce the dependency by introducing renewable energy as one of the alternative options. Qualitative analysis has identified biogas, RDF and direct combustion as the most applicable waste to energy technologies to be transferred from Japan.

As proposed in Bali Action Plan, measurable, reportable and verifiable (MRV) is important for developing countries as a benchmark or standard for nationally appropriate mitigation action. Moving towards post-2012 climate regime, we intend to observe what will be the best approach for DACs. Qualitative analysis has drawn a result that a decentralized, networked and top-down approach is significant approach to introduce waste to energy in DACs. It is also proposed that combination of those high applicability technologies, such as combustion and biogas and/or RDF, will increase biomass waste recovery rate and mitigate greater amount of GHGs emission.

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Attachments: Figures and Table

Table 1: Commercialization interest of waste to energy technology invested by Japan in DACs

Treatment	Registered Project	Host Country	Methodology Number		Methodology	Methodology Title
Landfill Gas (LFG)	2	Malaysia	ACM0001	-	Consolidated	Consolidated baseline and monitoring methodology for landfill gas project activities
	4	China	ACM0001	AMS-ID & ACM0004		
	1	Indonesia	ACM0001	AM0025		
	1	Thai	ACM0001	-		
Biogas	1	China	ACM0010	-	Consolidated	Consolidated methodology for GHG emission reductions from manure management systems
	1	Indonesia	ACM0010	-		
Biogas	1	Philippines	ACM0014	-	Consolidated	Mitigation of greenhouse gas emissions from treatment of industrial wastewater
	1	Indonesia	ACM0014	-		
	2	Thailand	ACM0014	AMS-I.C.		
Biogas	1	Malaysia	AMS-III.H.	-	Simplified	Methane recovery in wastewater treatment
	1	Malaysia	AMS-III.H	AMS-I.D.	Simplified	
	1	Indonesia	AMS-III.H.	AMS-III.O	Simplified	
	1	Indonesia	AMS-III.H.	AMS-I.D.		
	1	China	AMS-III.H.	AMS-I.C.	Simplified	
	2	Thailand	AMS-III.H.	AMS-I.D.		
Combustion	1	Cambodia	AMS-III.E.	AMS-I.A.	Simplified	Avoidance of methane production from decay of biomass through controlled combustion
Combustion	2	Malaysia	AMS-III.E.	AMS-I.D.	Simplified	
Composting	1	Malaysia	AMS-III.F.	-	Simplified	Avoidance of methane emissions through controlled biological treatment of biomass

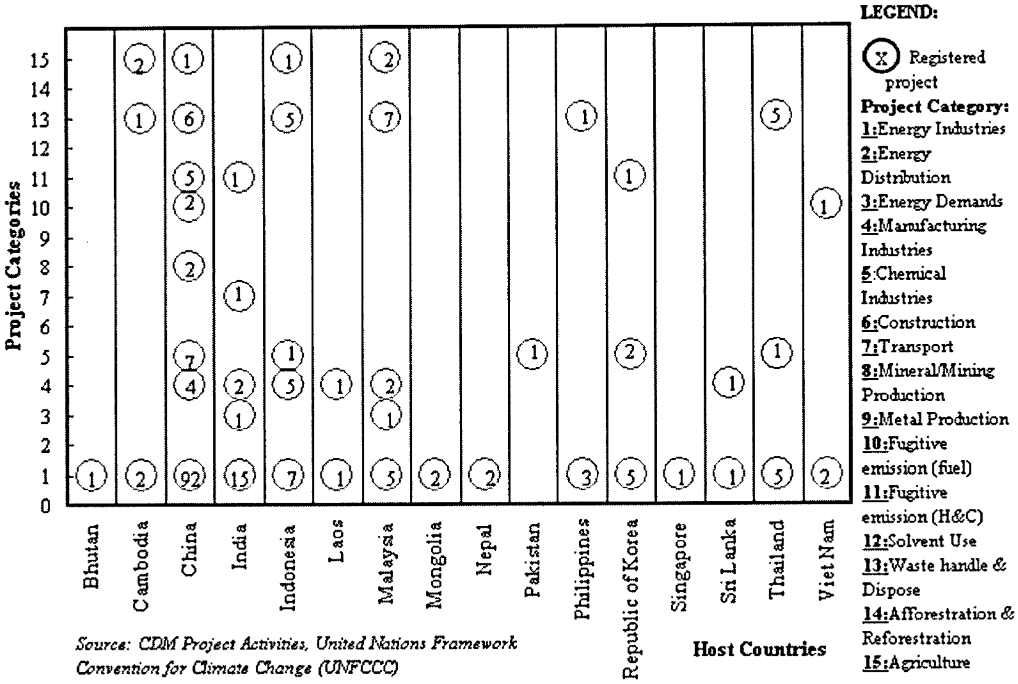

Figure 1: Registered CDM projects hosted by DACs under Japan's investment

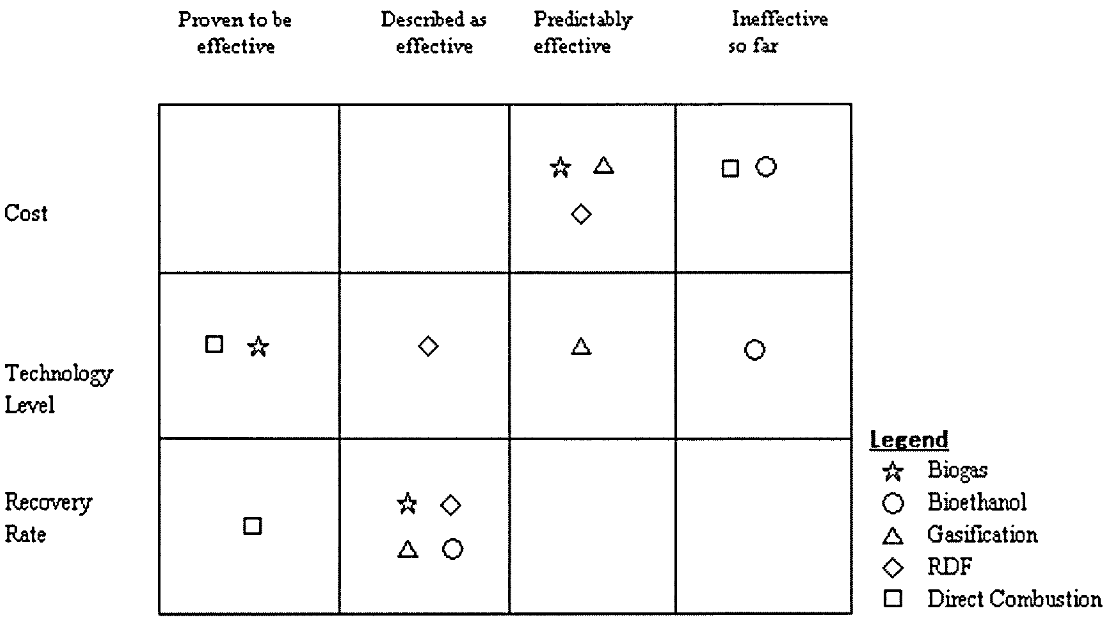

Figure 2: Effectiveness evaluation of waste to energy in Japan