Fiscal 2007 Project consigned
by the Ministry of Environment

Fiscal 2007 CDM/JI Project Study

STUDY INTO UTILIZATION OF METHANE GAS AT AL AKIDAR LANDFILL SITE IN JORDAN

Report - Summary Version

MARCH, 2008

SHIMIZU CORPORATION

Summary

1. Background of the Project

The Study entailed implementation of a feasibility study on a project to collect and combust landfill gas (LFG) comprising mainly methane gas generated from Al Akidar Landfill Site in Irbid, Jordan, and to link this to realization of a CDM project in the future.

Irbid is located in the north of Jordan near the border with Syria and it has a population of around 250,000. The project site of Al Akidar Landfill Site is located approximately 15 km east of the center of Irbid in the middle of the desert, and there are no residential districts nearby. The landfill site has an overall area of approximately 60 ha and it started operation in 1990. Within this, the site where the project will be implemented is scheduled to become filled up by 2010. The project target area is approximately 12 ha, where the depth of landfill varies between 8~15 m. In the 14 years between 1990~2003, the site receives approximately 55,000 tons of waste per year, however, this increased to approximately 220,000 tons from 2004. Due to the proximity of the site to the border with Syria, the operators are conscious of environmental impacts and implement wastewater treatment and earth covering on the site.

In the Study, a plan for introducing gas collection pipes, gas treatment equipment and gas engine power generating equipment, etc. to the project site of Al Akidar Landfill Site was compiled, and feasibility as a private sector project was assessed from the viewpoints of project effect and profitability, etc. In order to increase the feasibility of realization as a CDM project, the Study was conducted on the assumption that flare stack treatment is carried out.

Since the project will contribute to prevention of global warming and improvement of the global environment, Irbid Municipality is very keen to see its advancement. Moreover, since Jordan has hardly any experience of technology utilizing renewable energy, the project technology will contribute to the sustainable development of Jordan.

Jordan joined the Kyoto Protocol in 2003. Its DNA is the Ministry of the Environment and the approval procedures and scheme for CDM projects are already in place.

2. Contents of the Project Plan

The project proposes to install landfill gas (LFG) collection pipes at Al Akidar Landfill Site, and to collect and treat LFG. The collected LFG will be combusted/destroyed in a flare stack.

Since methane will be converted to carbon dioxide as a result of combustion and destruction in the flare stack, even though this will not directly lead to energy conservation, it will create a greenhouse gas reduction effect.

Figure 1 shows a schematic of the overall project system.

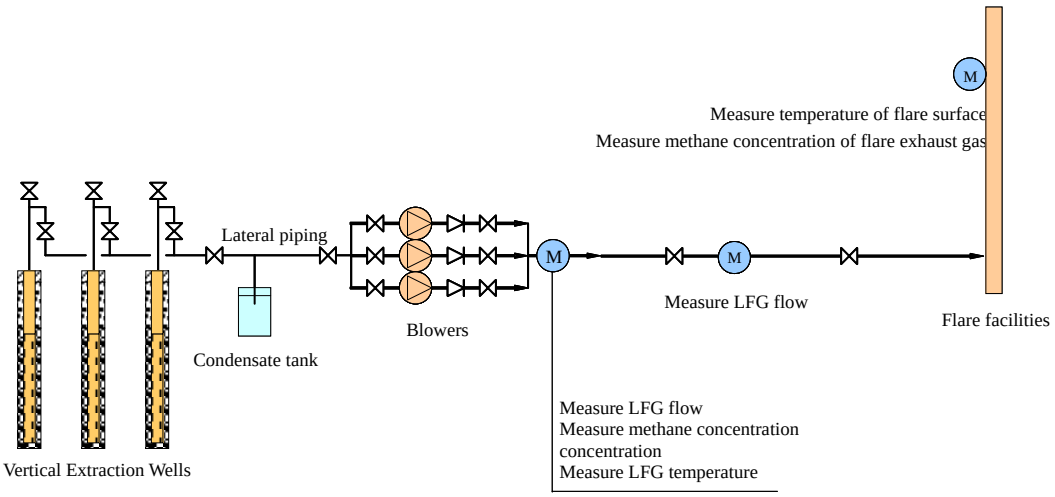

Figure 1 Schematic of the Overall System

As the method for calculating the generated amount of methane gas on the landfill site, the *"Tool to determine methane emissions avoided from dumping waste at a solid waste disposal site"* will be used. According to this, the generated amount of methane gas ($BE_{CH4,SWDS,y}$) is calculated as follows:

$$BE_{CH4,SWDS,y} = 0.9 \times (1 - f) \times GWP_{CH4} \times (1 - OX) \times 16 / 12 \times F \times DOC_f \times MCF \times \sum_{(x=1 \sim y)} \sum_j W_{j,x} \times DOC_j \times e^{-k\,(y-x)} \times (1 - e^{-kj})$$

$BE_{CH4,SWDS,y}$	tCO_2e	Methane emissions potential of landfill site (SWDS)
f	-	Fraction of methane captured at the landfill site (SWDS)
OX	-	Oxidation factor
F	-	Fraction of methane in the LFG (SWDS gas)
DOC_f	-	Fraction of DOC that can decompose
MCF	-	Methane correction factor
$W_{j,x}$	t	Mass of waste type j deposited in the year x
DOC_j	-	Fraction of DOC in the waste type j
k_j	-	Decay rate for the waste type j
j	-	Waste type category

f: Fraction of methane captured at SWDS

On the project site, since landfill gas (methane) is not collected for purposes other than the project, neither is it scheduled to be in future, $f = 0$ shall be assumed.

OX: Oxidation factor

Since the project site is a managed landfill site, according to the *"IPCC 2006 Guidelines," OX* = 0.1 shall be assumed.

F: Fraction of methane in the SWDS gas

$F = 0.5$ shall be adopted as recommended in the *"IPCC 2006 Guidelines."*

DOC_f: Fraction of DOC that can decompose

$DOC_f = 0.5$ shall be adopted as recommended in the *"IPCC 2006 Guidelines."*

MCF: Methane correction factor

Since the project site is a managed landfill site, $MCF = 1.0$ shall be assumed.

$W_{j,x}$: Mass of waste type j deposited in the year x

The landfill amount and composition of solid waste on the project implementation site are as indicated in the following table. The amount of solid waste type j can be calculated through seeking the product of a) the landfill amount of solid waste and b) the composition of solid waste.

The results of estimating the generating amount of methane gas are as indicated in Table 1.

Table 1 Results of Estimating the Generated Amount of Methane Gas

Year	Generated Amount of Methane Gas (Nm^3CH_4)	Year	Generated Amount of Methane Gas (Nm^3CH_4)
2009	3,432,301	2016	3,043,953
2010	3,780,750	2017	2,866,687
2011	4,108,907	2018	2,699,744
2012	3,869,622	2019	2,542,523
2013	3,644,273	2020	2,394,458
2014	3,432,047	2021	2,255,016
2015	3,232,180	2022	2,123,694

3. Project Implementation Plan

The participants on the Japan side will conduct the initial project investment (ordering of construction works), while Irbid Public Services Committee will be responsible for all other aspects of project operation (monitoring, operation and maintenance of instruments, accounting work, CER management, subcontracting, personnel affairs, reporting, etc.).

When considered from the viewpoint of CO_2 credit acquisition, it may be better to adopt the pay-on-delivery approach for averting project risk. However, since the counterpart agency is a public utilities operator, it may require a fair amount of time in order to put budget measures into place. Accordingly, even in the case of fundraising based on advance payment, a large amount of initial investment will be required.

For this reason, in this case, in order to realize the project at an early point, it is better to implement it based on direct investment for the total necessary funds (without specifying the method of fund raising in particular).

Project profitability is greatly affected by the economic value of CERs. If CERs have no economic value, project profitability is low even before funds are raised and realization becomes near impossible. On the other hand, if it is assumed that CERs do have economic value, assuming that the project period is 14 years and price of CER is US$10/t-$CO_2$, the IRR (after tax) will be 8.27%, indicating that sufficient profits can be secured. Advertisement for Japanese participants other than Shimizu Corporation will take place from now, but it is thought that numerous corporations will be willing to invest in such a project.

It is planned to advance procedures to register with the CDM Executive Board during the first half of fiscal 2008. Then it is scheduled to install the SPC, conduct detailed design and start the construction works in the second half of 2008 and commence the project from January 2009. The Project implementation period is scheduled for 14 years.

Table 2 Project Implementation Schedule

Work item	2007	2008	2009	2010	2011		2022
FS implementation	●———						
PDD preparation		March ●					
Validation of DOE decision		●— May-June					
Approval of both governments		● July					
UN approval		● September					
SPC establishment and start of detailed design		● September ···					
Start of construction works		● ···					
Start of credit period			● January ··· Credit period: 14 years ··· ▶				

4. Baseline Setting

"ACM0001/Version 8 "Consolidated baseline and monitoring methodology for landfill gas project activities" shall be applied to the project.

Moreover, the following tools that are recommended for referral shall be used:

- "Tool for the demonstration and assessment of additionality" (Version 04)
- "Tool to determine project emissions from flaring gases containing methane" (Version 01)
- "Tool to calculate project emissions from electricity consumption" (Version 01)
- "Tool to determine methane emissions avoided from dumping waste at a solid waste disposal site" (Version 01)

ACM0001 states the following concerning its applicability: "This methodology is applicable to LFG collection projects where all or part of gas in the baseline scenario is discharged into the atmosphere and the following conditions are satisfied:

a) The recovered gas is flared,

b) The recovered gas is used in the production of energy (e.g. electric power and heat), and

c) The recovered gas is supplied to consumers via the natural gas supply network. If transfer of natural gas is included in the emission reductions, AM0053 can be utilized.

In addition, the conditions of applicability included in the above tools must be satisfied."

Meanwhile, the project is as described below.

① Currently, LFG collection is not carried out on the landfill site and all LFG is released into the atmosphere. (Baseline)

② The project proposes to collect LFG on the existing landfill disposal site and to flare the captured gas.

Therefore, since the project falls under applicability of (a) under ACM0001, this methodology can be applied.

Also, according to ACM0001, the Tool for Demonstration of Additionality is used to demonstrate the fact that the project is additional to the baseline, which is set as maintenance of the status quo.

The baseline emissions, project emissions and emission reductions in the project were calculated based on ACM0001. In the project, formulae were arranged assuming that there will be no power generation, production of thermal energy or supply to the natural gas pipeline in the project.

Tables 3 and 4 show the calculation results. However, it should be noted that these are trial calculations and do not represent emission reductions in reality.

Table 3 Outline of Emissions and Emission Reductions

Year	Project Emissions	Baseline Emissions	Leakage	Emission Reductions
	t-CO_2e	t-CO_2e	t-CO_2e	t-CO_2e
2009	8,555	51,666	0	43,111
2010	16,328	56,911	0	40,583
2011	23,648	61,851	0	38,202
2012	301	58,249	0	57,948
2013	301	54,857	0	54,556
2014	301	51,662	0	51,361
2015	301	48,653	0	48,353
2016	301	45,820	0	45,519
2017	301	43,152	0	42,851
2018	301	40,639	0	40,338
2019	301	38,272	0	37,971
2020	301	36,043	0	35,743
2021	301	33,944	0	33,644
2022	301	31,968	0	31,667
Total	51,838	653,685	0	601,847

Table 4 Results of Estimating Emission Reductions

				2009	2010	2011	2012	2013	2014	2015	2016
ex-ante	$BE_{CH4,SWDS,y}$		tCO_2e	51,666	56,911	61,851	58,249	54,857	51,662	48,653	45,820
	collected LFG		tCO_2e	43,412	40,884	38,503	58,249	54,857	51,662	48,653	45,820
		EqC	-	0.84	0.72	0.62	1.00	1.00	1.00	1.00	1.00
	BE_y		tCO_2e	51,666	56,911	61,851	58,249	54,857	51,662	48,653	45,820
		$MD_{project,y}$	tCH_4	2,460	2,710	2,945	2,774	2,612	2,460	2,317	2,182
		$MD_{reg,y}$	tCH_4	0	0	0	0	0	0	0	0
			AF	-	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	PE_y		tCO_2e	8,555	16,328	23,648	301	301	301	301	301
		$PE_{EC,y}$	tCO_2e	301	301	301	301	301	301	301	301
			$EC_{PJ,y}$	MWh	193	193	193	193	193	193	193	193
			$EF_{grid,y}$	tCO_2e/MWh	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3
			TDL_y	-	0.200	0.200	0.200	0.200	0.200	0.200	0.200	0.200
		not collected LFG		tCO_2e	8,254	16,027	23,348	0	0	0	0	0
	ER_y			tCO_2e	43,111	40,583	38,202	57,948	54,556	51,361	48,353	45,519

				2017	2018	2019	2020	2021	2022		TOTAL
ex-ante	$BE_{CH4,SWDS,y}$		tCO_2e	43,152	40,639	38,272	36,043	33,944	31,968		653,685
	collected LFG		tCO_2e	43,152	40,639	38,272	36,043	33,944	31,968		606,056
		EqC	-	1.00	1.00	1.00	1.00	1.00	1.00		
	BE_y		tCO_2e	43,152	40,639	38,272	36,043	33,944	31,968		653,685
		$MD_{project,y}$	tCH_4	2,055	1,935	1,822	1,716	1,616	1,522		31,128
		$MD_{reg,y}$	tCH_4	0	0	0	0	0	0		0
			AF	-	0.0	0.0	0.0	0.0	0.0	0.0		
	PE_y		tCO_2e	301	301	301	301	301	301		51,838
		$PE_{EC,y}$	tCO_2e	301	301	301	301	301	301		4,209
			$EC_{PJ,y}$	MWh	193	193	193	193	193	193		2,698
			$EF_{grid,y}$	tCO_2e/MWh	1.3	1.3	1.3	1.3	1.3	1.3		
			TDL_y	-	0.200	0.200	0.200	0.200	0.200	0.200		
		not collected LFG		tCO_2e	0	0	0	0	0	0		47,629
	ER_y			tCO_2e	42,851	40,338	37,971	35,743	33,644	31,667		601,847

5. Monitoring Plan, etc.

Monitoring items in the project have been decided based on ACM0001.

Figure 2 shows the monitoring plan in schematic form.

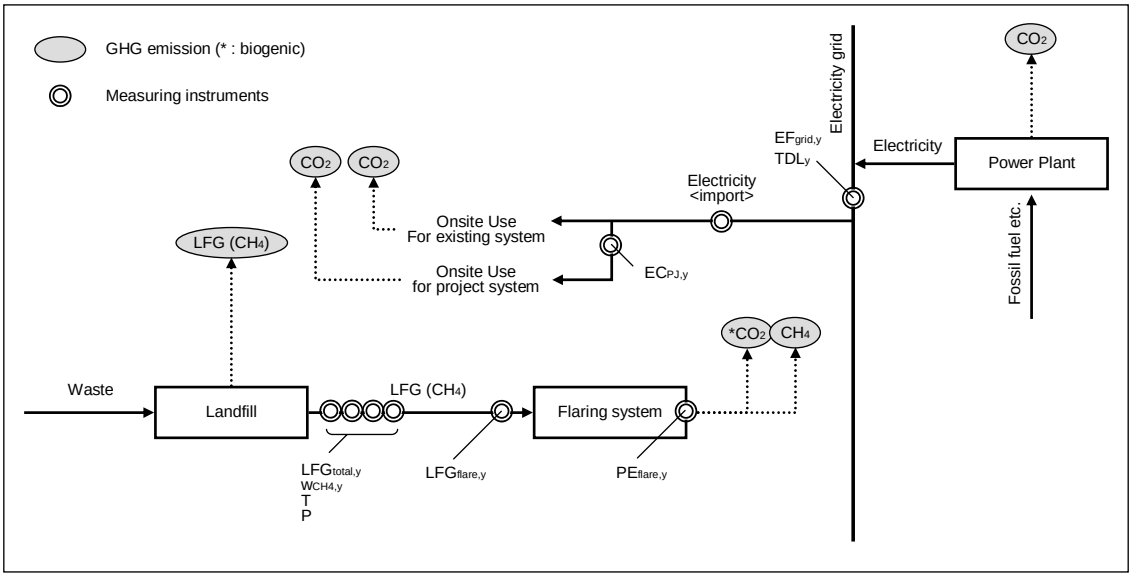

Figure 2 Monitoring Plan Schematic

6. Profitability

Project profitability is assessed according to the investment payback period and the internal rate of return (IRR). The initial cost is 2,302,476 US$, and the running cost is approximately 48,632 US$ per year. As for taxation, corporate profit tax is taken into account. According to Jordanian law, this is set at 25% of ordinary profit. Also, a 15% CER tax levied on the acquired credits is taken into account. Plant and equipment depreciation was calculated assuming a depreciation rate of 90%.

The exchange rate used in the calculations was: 1US$ = 116.00 yen.

Concerning the investment payback period, the number of years from the start of the project (start of construction) to the time when aggregate project balance enters the black was calculated for the case where CERs have no economic value and the three cases where the economic value of CERs is 5 US$/t-$CO_2$, 10 US$/t-CO_2 and 15 US$/t-$CO_2$ respectively.

Table 5　Investment Payback Period in Each Case

Economic Value of CERs		Investment Payback Period
Case where CERs have no economic value	0 US$/tCO$_2$	（Irrecoverable）
Cases where CERs have economic value	5 US$/tCO$_2$	（Irrecoverable）
	10 US$/tCO$_2$	8 years
	15 US$/tCO$_2$	6 years

As for the internal rate of return (IRR), comparative examination was carried out for four different cases, i.e. the case where CERs have no economic value and the three cases where the economic value of CERs is 5 US$/t-$CO_2$, 10 US$/t-CO_2 and 15 US$/t-$CO_2$ respectively.

Since this assessment of project profitability based on IRR is sought as an indicator for determining the propriety of investment, the project IRR not taking into account interest and loan repayments was used. The calculation results of the internal rate of return (IRR, after tax) in each case are indicated below.

The project IRR is negative in the case where CERs have no economic value, however, since an IRR (after tax) of 8.27% can be expected when the economic value of CERs is 10 US$/t-$CO_2$, the project is sufficiently lucrative to merit investment.

Table 6　Internal Rate of Return (IRR) in Each Case

Economic Value of CERs		IRR
Case where CERs have no economic value	0 US$/tCO$_2$	Minus
Cases where CERs have economic value	5 US$/tCO$_2$	Minus
	10 US$/tCO$_2$	8.27
	15 US$/tCO$_2$	16.96

As was mentioned earlier, the initial cost of the project is approximately 2,302,476 US$. On the other hand, the total reduction in greenhouse gas emissions over the project credit period (2009-2022) is 601,847 t-CO_2.

The cost of reducing greenhouse gas emissions was calculated by dividing CO_2 emissions over the credit period (2009~2022) by the initial cost (converted to US$). Table 7 shows the results.

Table 7　CO_2 Reduction Cost

Item	Amount
GHG Emission Reduction（t- CO_2）	601,847
Cost（1000 US$）	2,302,476
CO_2 Reduction Cost（US$/tCO$_2$）	Approx. 3.83

7. Conclusion and Future Work

The F/S conducted examination of the project to collect and combust LFG from Al Akidar Landfill Disposal Site, and thereby reduce atmospheric emissions of methane.

In addition to collecting and utilizing methane gas from the target landfill site and thereby reducing emissions of greenhouse gases, the project is a co-benefit undertaking that will also lead to improvements in terms of the local environment, sanitary situation and disaster prevention through preventing odor, flies and pests, and fires, etc. The host country is also very hopeful that the project will be realized.

The Government of Jordan has already completed the CDM project approval scheme including the CDM project approval procedure, and there is a strong possibility that the project will be approved in the host country.

Irbid Public Services Committee, the project counterpart, welcomes implementation of this CDM project from the viewpoints of environmental improvement and acceptance of overseas investment, etc., and it gave immense cooperation in the course of the FS.

In the project plan, from the viewpoint of securing profitability, etc., it is envisaged that acquisition of carbon credits will be aimed for from 2009. As a result, it was concluded that the project can be sufficiently profitable so long as it is approved by related agencies as a CDM undertaking and the market price of carbon credits is 10 US$/t-$CO_2$ or higher.

However, the project also contains elements of risk such as uncertainty over the amount of incoming solid waste, the amount of generated LFG and setting of the project period, etc., and these risks will need to be carefully addressed when it comes to advancing the project.

The consolidated methodology can be applied to projects for the collection and combustion of methane gas from landfill sites, and since there are no elements beyond the control of the project participants such as the review and approval of new methodology, this is extremely advantageous from the viewpoint of certainly and quickly realizing the project in readiness for the initial commitment period from 2008.

Meanwhile, when it comes to forming LFG projects, unlike chlorofluorocarbon destruction and N_2O destruction projects, it is essential to conduct detailed examination in the survey stage because numerous factors such as the following have an impact:

- Weather conditions in the host country;
- Shape of the landfill site;
- Composition of solid waste depending on lifestyles; and
- Waste collection system

Based on detailed investigation of such elements, it is possible to gauge the effect and profitability of the project.

Moreover, interpretations of LFG projects differ according to the host country, and it is sometimes difficult to coordinate the opinions of central government agencies and local governments (counterparts) regarding project realization. As competition to acquire projects heats up between countries, this coordination of views is the most important theme in the project development stage. In this case, the host country is enthusiastic about realizing the project under Japanese support and it holds the FS in high regard.

Through this study, it was possible to examine a landfill gas recovery project in the Middle East region, where know-how in this field has so far been scarce. As a result, characteristics of landfill methods and conditions of LFG generation in arid areas could be gauged. Also, it was possible to understand trends and advertise policies of the Government of Japan in the Middle East, where projects have so far been rare. Nearby countries have already expressed an interest in the activity. The Middle East has so far adopted a positive attitude towards reducing emissions of greenhouse gases, and it is starting to show an interest in some countries from the viewpoint of attracting overseas investment. It will be necessary to immediately actualize the project in order to solidify Japan’s record in the region, and moreover, to continue developing projects and linking these to realizing the objectives of Japan.

Shimizu Corporation intends to work towards the prompt implementation of the project while keeping an eye on future political and economic trends in Jordan.