Feasibility Study on Effective Using of Landfill Gas in Lugansk, Ukraine
Summary

4th March 2005
Shimizu Corporation

1. Basic components of project implementation

(1) Outline of the proposed project and background of the plan

The project proposes to capture landfill gas (LFG) generated on a landfill site and to reduce emissions of methane gas into the atmosphere by using it to generate power in a gas engine. Moreover, since the generated power will replace grid electricity, CO_2 emissions from thermal power plants will be reduced.

The project site is a landfill site in Lugansk City, which is situated in the eastern part of Ukraine on the border with Russia and has a population of approximately 500,000. The city's landfill site covers an area of roughly 8.4 ha with waste landfilled to a depth of between 20~35 m. Urban waste from the city has been landfilled at the site since 1978, and LFG including methane gas is currently released into the atmosphere.

The existing site is scheduled for closure in 2007, and work is already underway on constructing a new landfill site on adjoining land. Viewing this as a good opportunity, preparations for implementation of the project have been advanced under cooperation by the Ukrainian and Japanese sides.

In the project, gas extraction wells and pipes will be installed on the landfill site to collect LFG, and methane, the major constituent of this, will be incinerated and destroyed by flaring and utilizing as fuel in a gas engine. A major greenhouse gas emissions reduction effect can be expected by preventing the dissipation of methane gas, which has a high warming effect, into the atmosphere. Moreover, since electricity generated in the gas engine, not including the portion used for auxiliary power supply inside the plant, can be sold to the power grid, the resulting alternative energy effect is expected to reduce emissions of CO_2 from existing power plants.

(2) Overview of the host country

Ukraine, located furthest west of the former Soviet states, borders Russia, Belarus, Poland, Slovakia, Hungary, Rumania and Moldova and faces onto the Black Sea in the south. The name Ukraine derives from the Ukrainian word 'kray' meaning outlying region. The national land of Ukraine, located at latitude of 49 degrees north and longitude of 32 degrees east, covers 603,700 km^2, approximately 1.6 times larger than Japan and makes Ukraine the second largest country in Europe behind Russia.

Ukraine had the second most developed economy behind Russia within the former Soviet Union. Its fertile and level plains enabled high agricultural production and earned Ukraine the reputation of being the breadbasket of the Soviet Union. Ukraine produced more than one-quarter of all the Soviet Union's meat, dairy products, cereals and vegetables. Today, Ukraine is known as an agricultural and industrial nation possessing rich agricultural land, a well-developed industrial base, abundant skilled labor and a high level of education. Production in the two sectors of agriculture and manufacturing industry accounts for more than 40% of GNP.

Ukraine became a sovereign republic on July 16, 1990 and declared its independence on August 24, 1991, at which time it adopted its current name of Ukraine. A referendum was held on December 1, in which more than 90% of voters elected to support full independence. The declaration of independence by Ukraine, which had been an important component of the Soviet Union, was a turning point in collapse of the Soviet regime.

On January 23, 2005, the former Prime Minister, Mr. Yuschenko, was elected as president on a platform of democratization and participation in the European Union (EU). With this change in the presidency, it now appears that government activities geared to closer ties with Europe and America as well as greater democratization will be commenced in the former Soviet sphere.

(3) CDM/JI acceptance criteria, DNA establishment and other policies and conditions regarding CDM/JI in the host country

Ukraine currently does not possess any official JI criteria or procedures for approving JI projects. However, it is almost certain as a result of inter-ministry coordination that the Ministry of Environmental Protection will become the DNA, although this too has not yet been officially decided. This was supposed to be settled by the end of 2004, however, it has been delayed due to the change in government.

Having said that, the Ministry of Environmental Protection is constantly open to receive JI project applications for approval. The approval application process will be carried out based on the draft procedure prepared by the Ministry of Environmental Protection. In specific terms, as the first step, the PIN is submitted and the LOE (Letter of Endorsement) is issued; and as the second step, the PDD is submitted and the LOA (Letter of Approval) is issued.

Concerning whether or not it is possible to obtain approval for this JI project in the current situation where there are no JI criteria, it will be necessary to meet and confirm with the Ministry of Environmental Protection in advance.

It appears that basic items regarding JI criteria and JI project approval procedures will be officially determined during 2005.

(4) Structure for the study implementation (in Japan, in the host country, and other points)

- **In Japan**

  1) **Shimizu Corporation:** the project coordinator
  2) **The Chugoku Electric Power Co., Inc. (sub-contractor):** information collection on power -related matters and for examining profitability
  3) **DNV (sub-contractor):** determination process (desk review only)

- **Host country**

  1) **Protos:**
     owner and operator of the waste landfill site; information provision
  2) **Lugansk Municipality Environment Department:**
     local government, information provision, and supporting this study
  3) **Ministry of Environmental Protection:**
     central government, contact point for JI (DNA)

2. Project Planning

(1) Specific contents of the project

The system is composed of gas collecting facilities (vertical extraction wells, lateral piping, blowers, airtight sheet), gas treatment facilities, gas reservoir facilities, power generating equipment and flaring equipment.

Capacity of the power generating equipment will be set so as to secure stable power output and also enhance the investment effect. In other words, capacity will be set so that rated power supply can be secured irrespective of fluctuations in the amount of gas that is recovered during the project period. According to the current forecast, it appears that one generator of 500 kW can be installed. It is scheduled to consume part of the power generated by the gas engine generator within the plant (blowers, etc.) and then sell the excess power to the grid.

Capacity of the gas engine generator will be finally determined upon commencing LFG collection and reviewing the actual quantity. If the generated amount of LFG is much lower than expected or is highly unstable, consideration will be given to the option of not installing a generator and merely destroying methane gas by flaring.

Flaring equipment will be installed to destroy excess methane gas not used in the gas engine generator. Moreover, when the generator cannot be used due to inspections or emergency stoppages, all generated methane gas will be removed in the flaring equipment.

The following figure gives a schematic view of the project system.

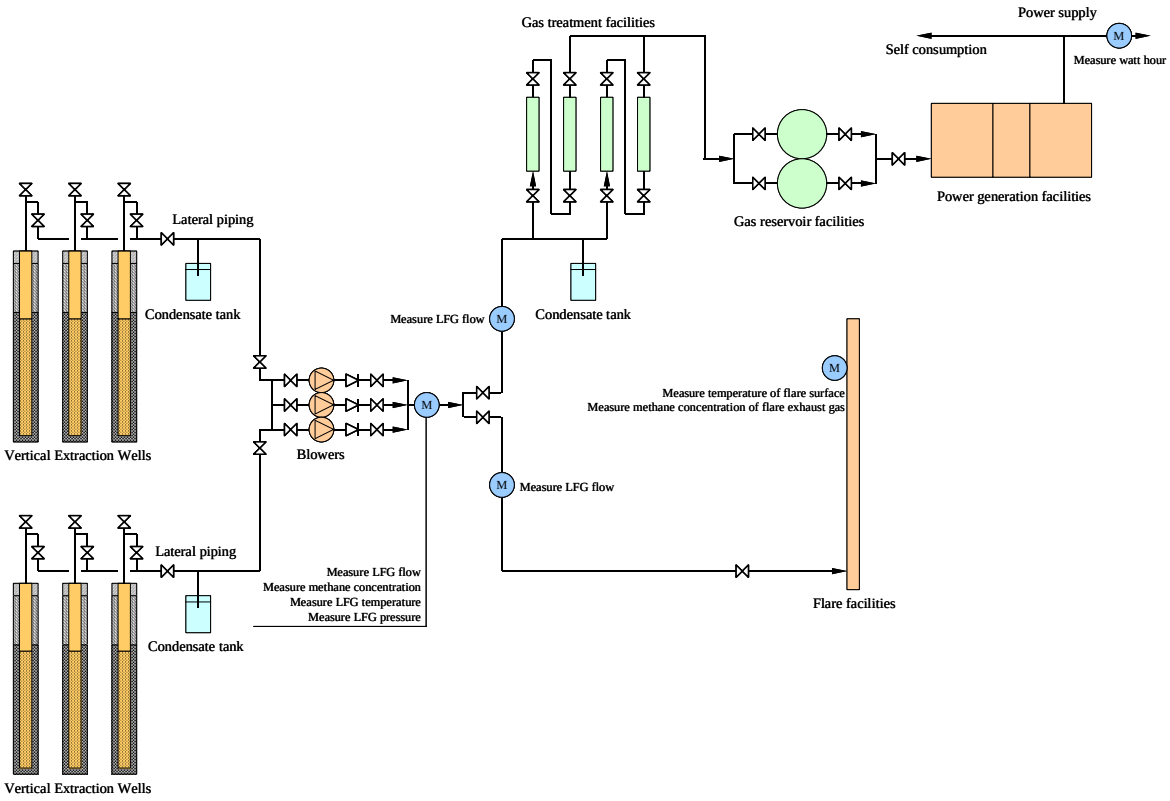

Figure 1 Project system schematic

(2) Setting of project boundaries and baseline and demonstration of additionality

In the project, the consolidated baseline methodology for landfill gas project activities (ACM0001) and the consolidated monitoring methodology for landfill gas project activities are adopted as the baseline and monitoring methodologies. In the project, emission reductions resulting from substitution of energy generated on the grid side will be claimed, however, figures approved by the Government of Ukraine will be used as the baseline when doing this.

(2-1) Project boundaries

In accordance with the ACM0001 methodology, the project boundaries were set as follows.

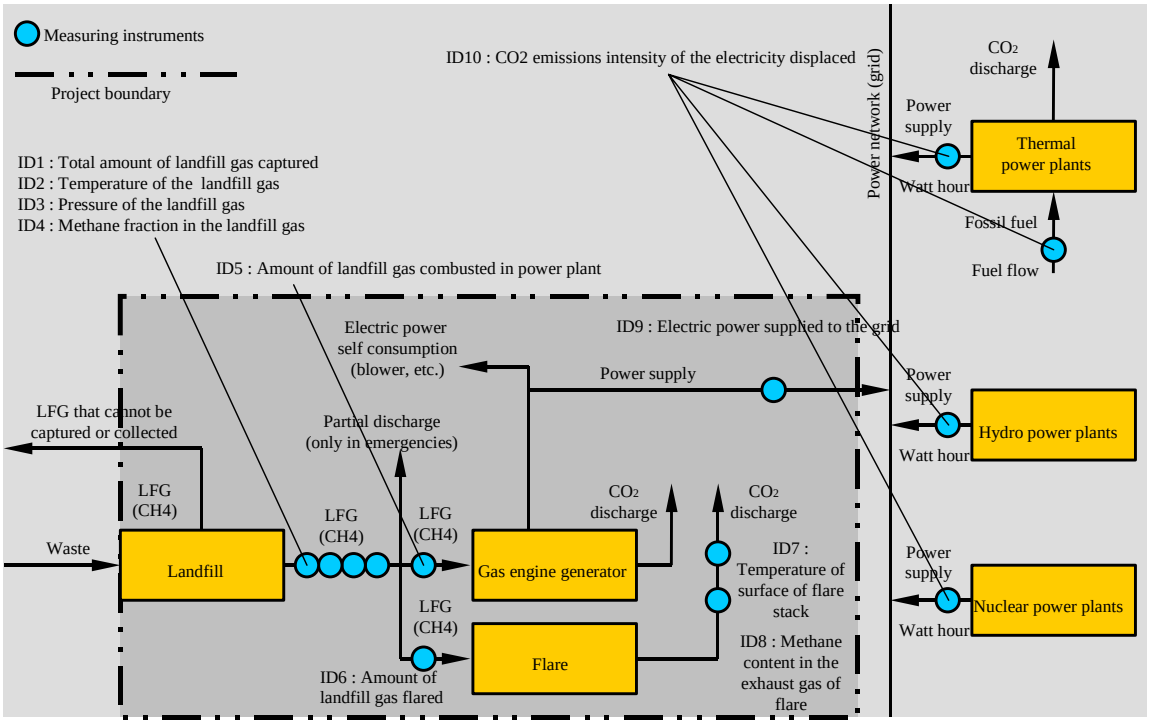

Figure 2 Project boundaries and monitoring plan

(2-2) Baseline setting

The following scenario was set for the baseline:

- Handling of LFG : there is no LFG collection at all.
- Grid emission factor : a figure approved by the Government of Ukraine

(2-3) Demonstration of additionality

Additionality is demonstrated using the tools for the demonstration and assessment of additionality. Within this, the baseline scenario will be identified and demonstrated by means of screening and investment analysis. In the investment analysis, it is demonstrated that the project is not the baseline by using the benchmark. As the benchmark here, interest on long-term government bonds in Ukraine is adopted. Concerning the reason why, in the event where a Japanese private sector company makes an investment decision concerning a project in Ukraine, unless returns on the project at least exceed the interest rate of long-term government bonds in Ukraine, the company will not feel any appeal in the project investment and will probably decide it is better to purchase government bonds.

(3) GHG reduction (CO_2 absorption) and leakage arising from project implementation

(3-1) GHG emission reductions

Calculation is carried out according to the ACM0001 methodology. The preconditions and results of calculation are as indicated below.

Table 1 List of preconditions

Item	Unit	Value	Source, Basis
Ratio of Category I waste	%	40.50	Values calculated by Ukrainian LFG experts based on actual waste composition data from Lugansk
Ratio of Category II waste	%	13.63	
Ratio of Category III waste	%	29.68	
Ratio of Category IV waste	%	16.20	
k of Category I	1/y	0.116	Values estimated by Ukrainian LFG experts
k of Category II	1/y	0.076	
k of Category III	1/y	0.046	
k of Category IV	1/y	-	
L0 of Category I	Nm^3-CH_4/t-waste	74.40	Values calculated by Ukrainian LFG experts based on actual waste composition data from Lugansk
L0 of Category II	Nm^3-CH_4/t-waste	128.80	
L0 of Category III	Nm^3-CH_4/t-waste	128.30	
L0 of Category IV	Nm^3-CH_4/t-waste	0	
Lower heating value of methane gas	kcal/Nm^3	8,560	Thermal and Nuclear Generation Handbook, 1991 (supervised by the Thermal and Nuclear Power Engineering Society, Ministry of International Trade and Industry, Agency for Natural Resources and Energy), p158,
Total capacity of new gas engine	kW	500	Planned values by the project participants
Generating efficiency of new gas engine	%	39.20	Specifications of the European maker J Co.
Self power consumption rate of the new gas engine	-	0.10	Planned value by the project participants
Operating days of new gas engine per a year	Days/year	335	Planned value by the project participants
Methane density D_{CH4}	t/Nm^3	0.00071680	UNFCCC CDM EB Consolidated baseline methodology for landfill gas project activities
Global warming potential of methane GWP_{CH4}	-	21.0	IPCC Second Assessment Report: Climate Change 1995
Power tariff for sales	UAH/kWh	0.1000	Based on actual unit power price sold to power distribution companies by independent power producers
Exchange rate	UAH/EURO	6.77	Actual rate in banks
Volumetric rate of contents of methane in LFG w_{CH4}	-	0.50	Values estimated by Ukrainian LFG experts
LFG collection efficiency EqC	-	First year:0.500 Following:0.668	Values estimated by Ukrainian LFG experts. 0.668=ground coverage rate 90% x well and pipe efficiency 75% x operating rate 99%. Meanwhile, 0.500 in the first year is a conservative estimate including anticipated loss in the startup period.
Flare efficiency FE	-	0.995	Specifications of the European maker Z Co.
Adjustment factor AF	-	0.00	Based on the viewpoint of the Ukrainian Ministry of Environmental Protection
CO_2 emission factor of the grid $CEF_{electricity}$	t-CO_2/MWh	0.815~0.486	Operational Guidelines for Project Design Documents of Joint Implementation Projects Volume 1: General guidelines Version 2.3 Ministry of Economic Affairs of the Netherlands May 2004 (To be on the conservative side in line with the above guidance purport, values from 1999 and before were made the same as those from 2000, and values from 2013 onwards were extrapolated from values for 2011 and 2012.
Interest on long-term Ukrainian government bonds as the benchmark	%	7.65	Actual values s of March 8, 2004
Crediting period	-	15 years from 2008~2022	Based on the viewpoint of the Ukrainian Ministry of Environmental Protection
Profit tax rate	%	25	Ukrainian Government
Depreciation rate	%	6.75	Ukrainian Government
Total initial cost	EURO	1,280,000	Planned value by the project participants
Running cost	EURO/Year	94,000	Planned value by the project participants

Table 2　Calculation of GHG Emissions Reduction and Annual Baseline Emissions

Year	Baseline emissions	Project emissions	Emission reductions
Year	t-CO_2	t-CO_2	t-CO_2
2008	7.21E+04	3.62E+04	3.59E+04
2009	6.66E+04	2.23E+04	4.43E+04
2010	6.40E+04	2.06E+04	4.34E+04
2011	5.94E+04	1.91E+04	4.03E+04
2012	5.51E+04	1.76E+04	3.75E+04
2013	5.12E+04	1.64E+04	3.49E+04
2014	4.77E+04	1.52E+04	3.25E+04
2015	4.44E+04	1.41E+04	3.03E+04
2016	4.14E+04	1.31E+04	2.83E+04
2017	3.86E+04	1.22E+04	2.64E+04
2018	3.60E+04	1.14E+04	2.47E+04
2019	3.37E+04	1.06E+04	2.31E+04
2020	3.15E+04	9.87E+03	2.16E+04
2021	2.95E+04	9.21E+03	2.03E+04
2022	2.76E+04	8.60E+03	1.90E+04
2008~2022 total	6.99E+05	2.36E+05	4.63E+05

(3-2)　Leakage

According to the ACM0001 methodology, there is no leakage.

(4)　Monitoring plan

In the project, the consolidated baseline methodology for landfill gas project activities (ACM0001) and the consolidated monitoring methodology for landfill gas project activities are adopted as the baseline and monitoring methodologies. Based on the methodology, the following items will be monitored.

Table 3 List of monitoring items

Data variable	Source of data	Data unit	Measured (m), calculated (c), estimated (e),	Recording frequency
LFG_{total} Total amount of landfill gas captured	Flow meter	m^3	m	Measured continuously and recorded once a month
T Temperature of the landfill gas	Thermo meter	K	m	Once a month
P Pressure of the landfill gas	Pressure gauge	Pa	m	Once a month
w_{CH4} Methane fraction in the landfill gas	Methane fraction meter	%	m	Once a month
$LFG_{electricity}$ Amount of landfill gas combusted in power plant	Flow meter	m^3	m	Measured continuously and recorded once a month
$LFG_{flared,}$ Amount of landfill gas flared	Flow meter	m^3	m	Measured continuously and recorded once a month
Tf Temperature of surface of flare stack	Thermo meter	Degree C	m	Continuously
wf_{CH4} Methane content in the exhaust gas of flare	Methane fraction meter	%	m	Quarterly, monthly if unstable
EG Electric power supplied to the grid	Watt hour meter	kWh	m	Measured continuously and recorded once a month
$CEF_{electricity}$ CO_2 emission factor of the grid	Data received from the Government of Ukraine	-	c	Once a year, on regular basis
AF Adjustment factor	Data received from the Government of Ukraine	-	n/a	Once a year, on regular basis
FE Flare efficiency	Tf wf_{CH4}	%	m and c	Quarterly, monthly if unstable

Note: Data will be stored for the crediting period and two years after that.

(5) Environment impact and other indirect impacts

(in case of forestation, include risk survey findings)

(5-1) Environment impact

The project has the following beneficial environmental impacts and thus complies with environmental protection policy in Ukraine:

>> Environmental improvement effect via landfill site odor prevention

>> Environmental improvement effect via reduction of pollutant emissions into the atmosphere through collection of LFG
>> Environmental improvement effect through prevention of landfill site fires
>> Substitution of deteriorated power generation systems

Furthermore, project implementation will lead to employment creation, i.e. it will have a positive impact on the socioeconomy of Ukraine, too. However, concern also exists over the following impacts, so the measures described will need to be taken in order to minimize their effect.

>> **Noise and vibration:**

Installation of the blowers for LFG collection and the GEG will create noise and vibration. However, since these facilities will be located sufficiently apart from houses around the landfill site, there shouldn't be any problems. Rather, the only problem will be that concerning the working environment (impact on hearing, etc.) for operators on the site. This can be resolved by installing appropriate soundproof covers and vibration-proof frames.

>> **Air pollution resulting from GEG exhaust gases:**

It is possible that operation of the GEG will lead to pollution of the atmosphere by SOx and NOx contained in the exhaust gases. However, since these facilities will be located sufficiently apart from houses around the landfill site, they shouldn't pose any problems. Having said that, it will be necessary to install appropriate LFG desulfurization equipment and NOx reduction technology (on the generating machinery side) to avert any pollution.

>> **Risk of fire from installation of flaring equipment:**

Installation of flaring equipment and the artificial collection of methane gas may increase the risk of fires occurring along pipe routes and around the flaring equipment. This can be resolved by measuring and monitoring oxygen concentration inside LFG collection pipes, stopping the system when the

oxygen concentration becomes too high, and stabilizing flame by means of burner combustion control of the flare equipment.

(5-2) Indirect impacts

>> Economic impact

Since labor-intensive works will arise during the project construction stage, there will be an employment creation effect. Also, in the operation stage, the local economy will be vitalized through the employment of operating staff and contracting of maintenance work to local companies.

>> Social impact

In social terms, since the project will lead to permeation of the thinking that waste products are resources, it can be expected to contribute to the building of an environmentally friendlier society based on the principles of reuse and recycling, etc.

(6) Comments by local stakeholders

The following paragraphs describe the comments of anticipated stakeholders in the project.

(6-1) Closed Joint Stock Company 'Protos':

This company is responsible for collecting and transporting general solid waste in Lugansk, and disposing of it in Lugansk landfill site.

The company believes the project to collect methane gas from the landfill site and utilize it in power generation is promising. Upon digging test wells in the landfill site and analyzing the gas properties, it confirmed that gas of a concentration suited to power generation in a gas engine can be extracted. However, in the existing economic climate, neither Protos nor Lugansk City Municipality on the Ukraine side have the financial capacity to invest in the project. They would welcome implementation of the project as a joint implementation undertaking with financing provided by the Japan side.

(6-2) Lugansk City Municipality:

the project counterpart, this is responsible for promoting the project on the local government side.

Lugansk previously prospered around the armament industry under the former Soviet system. However, armament factories lost their competitiveness and were forced to close down following collapse of the Soviet Union. Since then, the city has not been so successful in attracting new industries. In these circumstances, the city would welcome a project like the one here that contributes to environmental improvement and attracts overseas investment, and it wants to actively participate as a counterpart. The city hopes that the project will prove to be a turning point in attracting more factories, etc.

(6-3) Closed Joint Stock Company "Luganskenergo" (Lugansk Regional Power Distribution Company):

a major power supply company in Ukraine. This is a monopoly corporation in the Lugansk region. When Protos connects to the grid, it will need to apply to this company for the necessary technical conditions.

Concerning power supply in the Lugansk region, existing thermal power plants are operating at around 50% and still have room to spare. Accordingly, the company has refused to accept supply from new power sources. However, since power generation utilizing biomass like in the project is also important in terms of environmental policy, the company would be willing to accept it as a new power source.

3. Towards realization

(1) Structure for the project implementation (in Japan, in the host country, and other points)

Upon holding discussions with Lugansk Municipality and Protos during the site survey, the following project implementation setup was arrived at.

>> **Japan side:**

Project participants on the Japan side (Shimizu Corporation and Chugoku Power Company) will invest in the formation of a special purpose company (SPC), which will be responsible for all project implementation affairs (design, execution, monitoring, equipment operation and maintenance, and ERU acquisition).

>> **Ukraine side:**

Lugansk Municipality will undertake to conduct project monitoring and operation (system operation and maintenance) under contract from the SPC. It will also furnish the land and human resources. Lugansk Municipality will also subcontract part of the work to the site company Protos.

(2) Funding plan for project implementation

The main source of funds currently under consideration for the project is funding by the SPC. Other potential sources include borrowing from city banks, utilizing the Japan GHG Reduction Fund (JGRF), utilizing subsidies from the Ministry of Environment or Ministry of Economy, Trade and Industry (NEDO), borrowing from JBIC, and so forth.

(3) Cost effectiveness

The following table indicates the results of analyzing the investment effect of the project.

Table 4 IRR Calculation Results

CO_2 Credits		IRR Figures in parentheses show after-tax values.
Without CO_2 credits	0 EURO /t-CO_2	Minus (minus)
With CO_2 credits	2 EURO /t-CO_2	Minus (minus)
	5 EURO /t-CO_2	3.73% (0.77%)
	7EURO /t-CO_2	13.25% (9.60%)
	10 EURO /t-CO_2	26.13% (21.23%)

(4) Prospects for and issues facing concrete realization

It is scheduled to advance the project with a view to commencing operation from January 2008, when credits can be acquired. Following completion of the FS, it is scheduled to acquire LOE and LOA and make an official decision on qualification (including the DOE site visit), etc. in the first half of 2005. Also, it is hoped to form the project consortium and conduct negotiations on fundraising with a view to launching the SPC in 2006.

Issues facing the project are detailed below.

(4-1) Issues in Ukraine concerning project approval

Ukraine still has no concrete experience of officially approved projects, and many areas remain unclear concerning the procedures and judgment criteria for approval. In order to deal with such risks, it is essential to collect information from numerous officials or related persons in various standpoints. In this respect, the fact that the new government launched at the start of 2005 is aiming for EU participation means there is a possibility that the approach to JI may make rapid progress from now on under encouragement from other EU countries. Here too, it is hoped to exploit human channels established in the past in order to collect information.

(4-2) Issues concerning the amount of landfill gas

When predicting the amount of landfill gas generated in Ukraine, situated in a region of harsh cold, it is necessary to utilize unique constants in the IPCC formulae. Concerning this point, data collected in Ukraine were carefully examined and projections that are trustworthy from the viewpoint of Japanese corporations were estimated. However, concerning the certainty of projections, it is extremely difficult to make prior assessments. Accordingly, in order to reduce the level of risk at the time of project implementation, capacity of the power generating equipment, which requires large investment, shall be determined after actually operating the LFG collection system.

(4-3) Issues concerning the partners

Lugansk City is considered as the counterpart in the project, however, according to legal regulations in Ukraine, local governments are not allowed to participate in SPCs. The issue facing project realization in this respect will revolve around how to select the partner on the local side.

(4-4) Issues concerning construction works

Although the project entails relatively small initial cost, because it includes numerous civil works elements, risk exists concerning cost overruns and works delays Having said that, Shimizu Corporation can avert these risks because it has numerous experience of works in former Soviet states and has a record of building trustworthy relations with local companies.

(4-5) Issues concerning fluctuations in power sale prices

It is planned to sell the power generated in the project, not including that consumed within the project system, to the grid distribution company; however, because the sale price will be the market price, is possible that prices will fluctuate. Since it is forecast that the price of electricity will increase in line with growing demand for power in the long-term future, the project estimate is considered to be on the safe side; however, there is still a risk that prices will fall in the short term. Accordingly, just to be on the safe side, the project plan shall be compiled assuming a unit price on the low side.

We believe the abovementioned issues facing realization of the project can be overcome in future project examination. With a view to achieving early realization of the project, it is planned to commence specific activities starting with submission of the PIN and PDD to the Ukrainian government following completion of the FS.

4. Validation/Determination (in the case where this process is implemented)

(1) Outline of validation (determination) or desk review

(1-1) Selection of OE

It is necessary to select an OE that has an operating base in Japan and actual experiences in CDM validation and/or JI determination. It was also considered necessary to select an OE that has received the accreditation from the CDM Executive Board in the field of this project (Sectoral Scopes 1 and 13). As a result, DNV Co. was selected as the OE.

(1-2) Scope of preliminary determination

The scope of preliminary determination by the OE covers the following:

A. General Description of Project Activity

- A.1. Project Boundaries
- A.2. Technology to be employed
- A.3. Compliance with host country requirements

B. Project Baseline

- B.1. Baseline Methodology
- B.2. Baseline Determination

C. Duration of the Project/ Crediting Period

D. Monitoring Plan

- D.1. Monitoring Methodology
- D.2. Monitoring of Project Emissions
- D.3. Monitoring of Leakage
- D.4. Monitoring of Baseline Emissions

E. Calculation of GHG Emissions by Source

- E.1. Predicted Project GHG Emissions
- E.2. Leakage Effect Emissions

E.3. Baseline Emissions

E.4. Emission Reductions

Determination Opinion and Determination Report

(1-3) Schedule of preliminary determination

The rough schedule of preliminary determination is as follows:

- January 7, 2005 Submission of the PDD (first edition) to DNV
- January 21, 2005 Interview with Shimizu Corporation
- February 10, 2005 Submission of the PDD (second edition) to DNV
- February 17, 2005 Receipt of the final report from DNV

(2) Past communications with the OE

Communications with the DNV have so far comprised the interview with Shimizu Corporation implemented on January 21, 2005. Within this, the DNV pointed out one CAR (Corrective Action request) and 10 CL (Clarification). These items were reflected in the second edition of the PDD, meaning there were no more pending items in the final report issued on February 17. The following conclusions were demonstrated with respect to the project: 1) In the view of the determination team, "Lugansk Landfill Gas Capture and Power Generation Project in Ukraine" is likely to meet the UNFCCC criteria for JI project activities. 2) Emission reductions attributable to the project are hence additional. 3) The project is likely to achieve the estimated amount of emission reductions. (Each of these are quoted from 5. Determination Opinion of the Preliminary Determination Report prepared by the DNV.