Feasibility Studies on Power Generation Utilizing Biogas from Sewage Sludge and Organic Wastes in Kazakhstan

Feasibility Study on Power Generation Utilizing Biogas from Sewage Sludge and Organic Wastes in Kazakhstan

Digest Version of the Report

(1) Basic factors for implementation of the project

Outline of the proposed project and background of the planning

Astana City is the capital of the Republic of Kazakhstan, the largest country in Central Asia. The population of the city has increased from 270,000 in 1997 when the capital was transferred from Almaty to 517,000 as of June 1, 2004 and is forecasted to reach a million in 2030 according to some sources.

Along with the rapid population growth, emergence of environmental problems in Astana City due to lack of waste disposal sites and degrading and decrease in function of sewage plants has been reported to the Study on Master Plan for Comprehensive Development of the New Capital City, Astana, Kazakhstan (the Feasibility Study on Water Supply and Sewerage) by Japan International Cooperation Agency (JICA) and, against this backdrop, "Astana Water Supply and Sewerage Project" is currently underway by Japan Bank for International Cooperation.

This is a project to introduce an anaerobic cofermentation system into a sewage plant in Astana City and install generating facilities which utilize biogas to be produced, aiming to alleviate the above environmental problems and realize a JI project.

Initially, it was planned to create the anaerobic cofermentation system by utilizing an anaerobic digester chamber for sewage sludge treatment at the sewage plant in Astana and putting organic wastes from nearby food factories and livestock processing business into the chamber. However, as we proceeded with the study, we found out that there are not so many food factories nor livestock processing firms in and around Astana City since the capital was transferred there quite recently and that a new waste disposal site is currently under construction with help from Spain and LFG flaring is planned there.

Consequently, we had to reexamine the plan.

In this report, on the assumption that sorted collection of wastes which is presently under discussion in Astana City is started, we have planned to use the anaerobic cofermentation system by organic wastes to be collected through the sorted collection and sewage sludge.
Since the signing of the Kyoto Protocol, the Interagency Commission and working groups have been established in the nation and discussion has been made on issues toward ratification of the Convention in 1995. At the Fourth Conference of the Parties (COP4) held in 1998, the nation expressed its intention to undertake voluntary emission reduction commitments and submitted the Initial National Communication under UNFCCC in the same year.

Kazakhstan stated its intent to accede to Annex I to the UNFCCC. Prior to that, the nation has decided to reductions in 2006 and accede to Annex I in time for First Commitment Period. Kazakhstan is aiming to set a quantitative target of GHG emissions reductions in 2006 and also formally ratified the Kyoto Protocol in June 1999.

In March 1999, the nation signed the Kyoto Protocol as a non-Party to Annex I of the UNFCCC and as a non-Party to Annex B of the Kyoto Protocol. Then, in April of that year, Kazakhstan signed the Kyoto Protocol as a non-Party to the COP. Generally, Kazakhstan has a negotiation position and has a position of a non-Party to the Kyoto Protocol. Therefore, the nation has decided to reductions in 2006 and accede to Annex I in time for First Commitment Period. Kazakhstan is aiming to set a quantitative target of GHG emissions reductions in 2006 and also formally ratified the Kyoto Protocol in June 1999.

As a non-Party to Annex I of the UNFCCC, Kazakhstan has not established any obligations under the Protocol.

Cooperation and negotiation positions of Kazakhstan are as follows:

- Energy sector
- International Negotiation Process
- Transfer and introduction of technologies
- Inventory and monitoring of GHG sinks and sources
- Energy savings, energy efficiency, and alternative sources
- Non-energy sector (Industry, Land-use, etc.)
- Introduction of flexible market mechanisms and JI projects
- Strategy, microeconomic analyses and GHG emission forecasts

In Fig. 2, the structure of GHG is shown.
Meanwhile, municipal departments of Astana City and its affiliate public corporations, which cooperate for the study as a whole.

Change Coordination Center.

Implementation structure for this study on Japan’s side is as follows. We recommissioned a survey and examination on

renewable energy including the use of biogas as one of the promising options.

hoping to introduce foreign investments and new technologies and has cited development of

diversification of industries have been stated. While there has been a debate in discussions

against achieving economic goals and setting an obligation of

emission reductions with the accession to Annex I, the nation has set the target of doubling

among agencies over a balance between achieving economic goals and setting an obligation of

emission reductions in the nation under joint projects. So far, the Commission has discussed

UNFCCC, international climate change negotiations and implementation of activities toward GHG

making with regard to ratification of the

Kyoto Protocol to the UNFCCC, implementation

coordination among agencies on decision

Commission (set up in April 2004) is to make

the Protocol.

In Kazakhstan, we carried out the study under the

Environmental Protection Department of

Ministry of Environmental Protection

Neutralization Subcontract

Organization chart on sewage treatment and waste disposal in Astana

Gorkommunhoz

Public Welfare Department of

Department of Energy

Astana Su Arnasy

Sanitary Control Department of

Fig. 3 Changes in GHG emissions from 1992 to 2001

Tohoku Electric Power Co., Inc. & Water resources Department of Energy

Control Environment

The objective of the Interagency Commission is to make

mitigation and adaptation measures. The Commission is

ministry, and has also served as the secretariat of the abovementioned working groups.

Under the Interagency Commission, the Climate Change Coordination Center has been placed as

such issues as challenges for the accession to Annex I and mechanism for GHG emission reductions.

So far, the Commission has discussed

Climate Change Negotiations and Implementation of Activities toward GHG

International Commission on

National Working Group on Climate Change Coordination Center

Earth Environment

Ministry of Health
Planning of the project

Specific description of the project

This is a project to put organic wastes collected separately and sewage sludge produced at the sewage plant into the same fermenters to coferment, collect methane gas produced from the cofermentation and generate electricity using the gas in Astana City.

The following are GHG reductions to be achieved in this project.

- LFG reductions at the landfill site by putting organic wastes, which would otherwise anaerobically ferment and release methane into the atmosphere at the site, into the anaerobic fermenters
- CO₂ reductions by decreasing a part of the grid electricity through power generation utilizing methane gas produced from sewage sludge and organic wastes at the methane fermenters

Meanwhile, the yen-loan-financed project which includes the sewage plant in Astana City, “Astana Water Supply and Sewerage Project” (hereinafter referred to as JBIC project) was provided in July 2003. Our project has adopted a grid and facilities which do not exert any huge impacts on the existing system on the premise of implementation of the JBIC project.

The amount of gas to be produced in this project has been calculated on the assumption that the project system has the capacity to take in 60,130 /year of organic wastes (food wastes) which are acceptable to the cofermenters among all the general wastes transported to the landfill site and the amount of sewage water treated at the sewage plant is 136,000 m³/day. As a result of the calculation, the amounts of gas to be produced from organic wastes and sewage sludge are 7,235 Nm³/day and 11,125 m³/day respectively.

Based on the above, daily average electricity production calculated with the above gas generation is 30.07 MWh and average output is 1.25 MW. The flow of this project is from Receiving and feeding equipment → Methane fermentation equipment → Energy recovery equipment → Sludge treatment equipment.

Arrangement plan for the equipment is shown in the following page.

Project boundary

In this project, the project boundary is considered to be as indicated in Figure 5 since the project equipment is to be installed in the sewage plant.

In this regard, separation of wastes and transportation of the wastes to the anaerobic fermenters at the sewage plant are the tasks the administration is responsible for.

Receiving and feeding equipment (Raw garbage) : Receipt → Grind/Separation → Storage (solubilization) → Methane fermentation equipment

Methane fermentation equipment (Raw garbage solubilizer) : Input and adjustment → mesophilic methane fermentation → Retention → sludge treatment equipment (Digested sludge) : Adjustment → dehydration → Disposal → Separated water goes to inlet of wastewater treatment plant

Energy recovery equipment (Biogas) : Electricity generation → Heat waste → Hot Water
Determination of baseline/Verification of additionality

In Astana City, all wastes are being collected together, both organic and inorganic wastes are being transported to the landfill site and, after sanitary landfill, LFG flaring is being carried out at present. Sewage sludge at the sewage plant is being anaerobically fermented at a digester chamber and biogas produced from the fermentation is being used to fuel boiler during the winter season. Based on this situation, the following 12 scenarios are conceivable.

<table>
<thead>
<tr>
<th>Idea</th>
<th>Collected Wastes</th>
<th>Sewage Plant</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>After collected all together, landfilled</td>
<td>Wastes are landfilled and produced LFG is flared</td>
</tr>
<tr>
<td>2</td>
<td>After collected all together, landfilled</td>
<td>Wastes are landfilled and produced LFG is utilized for power generation at the landfill site</td>
</tr>
<tr>
<td>3</td>
<td>After collected all together, landfilled</td>
<td>Wastes are landfilled and produced LFG is supplied to other facilities than the landfill site</td>
</tr>
<tr>
<td>4</td>
<td>Disposed by other methods than landfill</td>
<td>Organic wastes gathered through sorted collection or from factories are used to produce compost</td>
</tr>
<tr>
<td>5</td>
<td>Flammable wastes are incinerated.</td>
<td>Methane fermentation by sewage sludge</td>
</tr>
<tr>
<td>6</td>
<td>Disposed by other methods than landfill</td>
<td>Organic wastes gathered through sorted collection or from factories are transported to the sewage plant</td>
</tr>
</tbody>
</table>

Fig. 06 Project boundary
Sewage sludge is cofermented with organic wastes at anaerobic fermenters. The produced methane gas is utilized for power generation. As a result of examining with legislation/environmental impacts, regional trend and market conditions, Scenario 1 has been defined as the project scenario. The scenario is characterized by the following points:

- All wastes are collected together, then landfilled.
- Organic, Inorganic Wastes are composted.
- Flammable Wastes are incinerated as fly ash.
- Organic wastes are disposed by other methods than landfill (e.g., incineration or recycling).
- LFG is flared. Sewage sludge is anaerobically fermented with produced methane gas combusted at a boiler.

Scenario 1 is; all wastes are collected together, then landfilled, with produced methane gas (hereinafter referred to as LFG) flared. Sewage sludge is anaerobically fermented with produced methane gas combusted at a boiler.

Verification of additionality

To verify additionality, Scenario 12 has been defined as the project scenario. The scenario is inferior to the baseline scenario in technical barriers and investment barriers. However, by carrying out the project as a JI project, we can overcome the technical barriers with technical guidance and lower the investment barriers through CO2 credits trading.

The project scenario is to coferment sewage sludge and organic wastes at anaerobic fermenters. Therefore, the project scenario has additionality.

Schematic overviews of the conceivable scenarios are shown below.
Problems of noise or vibration are of a risk analysis should be included. (In the case of afforestation, result as follows.

*Environmental impact/Other indirect emissions. Outline of the monitoring plan is critical for precise calculation of GHG emissions in the case that the project is carried out are determined by the following implementation of the project.

- CO2 reductions by decreasing a part of the grid electricity through power generation
- LFG reductions by putting organic wastes, which would otherwise produce methane that would
- Leekage due to transportation

GHG reductions to be achieved in this project. The following are GHG reductions expected from CO2 credits toward significantly decreased positive factors considerably downward, which had we had to revise GHG emission reductions decrease in GHG reductions. As a result, in Astana City. However, in the process on the condition of solid waste disposal of the study, we had found out that the reductions at about 160,000t/year based on the dehydrated cake.

Fig. 9 Outline of
conceivable as specific environmental impacts in this project since gas engines using biogas are installed and operated. Odor issues from organic wastes are also possible as the wastes are brought to the sewage plant.

However, the environmental impacts can be fully diminished by taking countermeasures. The following table sums up the countermeasures.

<table>
<thead>
<tr>
<th>Possible environmental impact</th>
<th>Problem and countermeasures</th>
</tr>
</thead>
<tbody>
<tr>
<td>Noise and vibration by installation of gas engines</td>
<td>Noise and vibration will be small as several small engines are installed inside the plant.</td>
</tr>
<tr>
<td>Exhaust gas from gas engine</td>
<td>Identification and assessment of environmental impacts should be made. However, as gas engines are small with little amount of emissions, additional countermeasures are considered unnecessary.</td>
</tr>
<tr>
<td>Odor at the time of organic waste transport</td>
<td>It can be solved by such devices as deodorizing equipment</td>
</tr>
</tbody>
</table>

### Stakeholders' comment

#### Residents living in the vicinity of the project site

No interview is currently held, however basically the residents are considered to be positive for realization of the project as the ambient environment is expected to improve.

#### Local distribution company

Astanaenergo is highly in favor of the project. We have received a reply from the company that they would like us to consult with them in case that electricity is sold.

#### Sewage treatment management company and Solid waste disposal company

In Astana City, there are Astana Su Arnasy which has managed sewage treatment and Gorkommunhoz which has managed solid wastes. Both companies have expressed their interest in the project, however further approaches are needed to deepen their understanding about the project toward its materialization.

#### Local government

Astana City has been working to raise the quality of collection method of solid wastes produced from households and factories to the international level in accordance with Master Plan for Comprehensive Development of Astana and has shown a positive attitude to this project.

### Toward implementation

#### Implementation structure for the project (in Japan/the host country/others)

In this example, the project is not in the form of IPP through project financing. Participation of ASA and Gorkommunhoz, crucial partners to the project, is the key to the realization of the project.

#### Financial scheme for implementation of the project

We have planned to finance project expenses through a loan from commercial banks. The following is an example of conceivable schemes for the biogas power generation project.
In this plan, the ratio of capital to liabilities in project financing is set as 3 to 7. The capital (investments) will be raised by companies in Kazakhstan as well as ones in Japan. In terms of money borrowed, we will consider to raise the full amount from Japanese financial institutions given the ability of financial institutions in Kazakhstan for foreign currency-denominated loan.

<table>
<thead>
<tr>
<th>Necessary funds</th>
<th>Fund raising</th>
</tr>
</thead>
<tbody>
<tr>
<td>EPC expenses</td>
<td>12,970</td>
</tr>
<tr>
<td>Development expenses</td>
<td>130</td>
</tr>
<tr>
<td>Start-up costs</td>
<td>200</td>
</tr>
<tr>
<td>Other expenses</td>
<td>6</td>
</tr>
<tr>
<td>Initial working capital</td>
<td>230</td>
</tr>
<tr>
<td>Interest during construction</td>
<td>380</td>
</tr>
<tr>
<td>Financial outlay</td>
<td>198</td>
</tr>
<tr>
<td><strong>Total project expenses</strong></td>
<td><strong>14,114</strong></td>
</tr>
<tr>
<td><strong>Total funds raised</strong></td>
<td><strong>14,114</strong></td>
</tr>
</tbody>
</table>

We have decided to use the investment credit system of Japan Bank for International Cooperation to the utmost extent to obtain loans and, for the remaining amount uncovered with the system, to get finance from Japanese commercial banks.

With regard to capital funds, in addition to funds from Tohoku Electric Power Co., we will call on such entities as Japanese trading companies which are knowledgeable about various matters in Kazakhstan to raise funds when we advance the development of the project from now on. Meanwhile we will encourage Astana Su Arnasy (ASA) and Gorkommunhоз to participate in the project in some ways including provision of financial contribution for the success of the project.

Cost-effectiveness
Cost-benefit analysis of this project has been made through (1) financial analysis (without credit value taken into account, with credit value taken into account, the initially expected baseline), (2) CO2 credit cost (the current baseline, the initially expected baseline). The analysis has proven that there is a low possibility for this project to be realized as a JI project in the current baseline, however on the other hand there exists sufficient feasibility for cases in which different baseline can be adopted.

<table>
<thead>
<tr>
<th>Financial analysis</th>
<th>Without Credit</th>
<th>With Credit</th>
<th>Initially Expected Baseline</th>
</tr>
</thead>
<tbody>
<tr>
<td>Project IRR</td>
<td>Impossible to calculate</td>
<td>Impossible to calculate</td>
<td>12.10%</td>
</tr>
<tr>
<td>Equity IRR</td>
<td>Impossible to calculate</td>
<td>-1.00%</td>
<td>17.90%</td>
</tr>
<tr>
<td>Payback period</td>
<td>N.A.</td>
<td>N.A.</td>
<td>7 years</td>
</tr>
<tr>
<td>NPV ($-1,000 USD)</td>
<td>-12,609</td>
<td>-10,167</td>
<td>109</td>
</tr>
</tbody>
</table>

†Discount rate was set as 12% in reference to Philippine 10-year government bond which has the same S&P rating.

<table>
<thead>
<tr>
<th>Table-3</th>
<th>3</th>
<th>基本の構造化 (単位: 番元)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>番元: 番元</td>
<td>番元: 番元</td>
</tr>
<tr>
<td>基本的な構造</td>
<td>番元: 番元</td>
<td>番元: 番元</td>
</tr>
<tr>
<td>番元: 番元</td>
<td>番元: 番元</td>
<td>番元: 番元</td>
</tr>
<tr>
<td>番元: 番元</td>
<td>番元: 番元</td>
<td>番元: 番元</td>
</tr>
<tr>
<td>番元: 番元</td>
<td>番元: 番元</td>
<td>番元: 番元</td>
</tr>
<tr>
<td>番元: 番元</td>
<td>番元: 番元</td>
<td>番元: 番元</td>
</tr>
</tbody>
</table>
The acquisition for this financial analysis is 20 years.

In calculation of CO2 credit cost, Net Present Value such as necessary funds for GHG reduction activities and repayment of loans has been divided by CO2 generation. Then it has been examined in two ways; i.e., with and without project cash flow (profits from commercial operation) by the power generation operation taken into account. In this regard, all the credits to be generated have been assumed to belong to sponsors, following the example of ongoing NEDO model projects.

The calculation has resulted in 11.96$-11.97 US$/t-CO$_2$ in the current baseline and 1.81 US$/t-CO$_2$ in the initially expected baseline.

Prospect and challenge for concretization of the project

This project is based on the premise that sorted collection of wastes is put in place in Astana City. Thus, materialization of the project is subject to the progress of the examination on sorted collection. However, efforts have been made currently in Astana City to raise the quality of collection method of solid wastes produced from households and factories to the international level based on Master Plan for Comprehensive Development of Astana and sorted collection is considered likely to be put into practice in the near future.

It has been found out that there exists a problem on the baseline in Astana City by the construction project of a new waste disposal site and it will become a major obstacle to implementation of this project. It is regrettable that these conditions have become obvious after the launch of the study. We are planning to further improve a preliminary survey on local conditions going forward.

In the meantime, this project scheme is applicable to other cities which have the same challenges as Astana City if no baseline-related issue exists. We have found out situations in Almaty City and Karaganda City in this study as new potential sites for the project. As a result, it has been proven that Karaganda City has a possibility for the use of biogas at a sewage plant and LFG at a waste disposal site and this scheme is applicable to the city. Meanwhile, Almaty City has also turned out to have an availability of biogas at a sewage plant, have sorted collection of wastes in place and have a possibility that this project scheme can be applied.

We will examine whether this project scheme shall be applied to projects in these regions or they shall be carried out as an independent project, taking economical efficiency of the projects into consideration.

Apart from the above, Kazakhstan also has rich potential for the use of biomass such as wheat husks obtained from wheat, which is a staple of the nation's production, paltry manure and livestock manure in the livestock industry. We have planned to conduct studies on these options.
Validation/Determination (if this process is carried out)

Outline of Validation (Determination) or Desk Review

The host country, the Republic of Kazakhstan, is scheduled to ratify the Kyoto Protocol as a JI country and is currently undertaking adjustments at home. A system is gradually set up in the nation to accurately grasp its greenhouse gas emissions. However, it cannot be denied that there is a possibility that the nation may ratify the Kyoto Protocol without the system firmly put in place. Therefore, this time we created PDD and asked Designated Operational Entity to verify it to go through the verification process called "Second Track" by third-party institutions similar to CDM Executive Board and Designated Operational Entity in the case of CDM.

Progress of communications with DOE

We carried out determination by DOE (DNV) by submitting PDD to them early in January and having an interview on the 26th of January.