



International Best Practices Guide  
for Landfill Gas Energy Projects

**Appendix A**  
**Case Studies**

2012



Appendix A features a selection of 15 case studies of successful LFG and LFGE projects in GMI Partner Countries. Each case study includes a brief summary of the project, identifies environmental and social benefits achieved and describes barriers that were overcome during the project. Resources for further information as well as contact information are also provided for each case study.

## Case Studies



| No. | Landfill Name and Location                                  | Type of Project                                 |
|-----|---|---|
| 1   | Loma Los Colorados Landfill, Santiago, Chile                | Electricity Generation                          |
| 2   | Norte III-B Landfill, Buenos Aires, Argentina               | Flare Generation                                |
| 3   | São João Landfill, São Paulo, Brazil                        | Electricity Generation                          |
| 4   | Brazil MARCA Landfill, Cariacica, Brazil                    | Electricity Generation                          |
| 5   | Curva de Rodas and La Pradera Landfills, Medellín, Colombia | Flare   |
| 6   | Nejapa Landfill, Nejapa, El Salvador                        | Electricity Generation                          |
| 7   | El Verde Landfill, León, Guanajuato, Mexico                 | Flare with Transition to Electricity Generation |
| 8   | Greenwood Farms Landfill, Texas, USA                        | Pipeline-Quality Gas                            |
| 9   | Star Ridge Landfill, Alabama, USA                           | Direct Use                                      |
| 10  | Yancey-Mitchell County Landfill, North Carolina, USA        | Direct Use                                      |
| 11  | Barycz Landfill, Krakow, Poland                             | Electricity Generation                          |
| 12  | Closed Mariupol Landfill, Mariupol, Ukraine                 | Flare with Transition to Electricity Generation |
| 13  | Gaoantun Landfill, Beijing, China                           | Electricity Generation and Direct Use           |
| 14  | Jiaozishan Landfill, Nanjing City, China                    | Direct Use                                      |
| 15  | Daegu-Bangcheon-Ri Landfill, Daegu, Republic of Korea       | Direct Use                                      |

More case studies are available on GMI's website at: <http://www.globalmethane.org/projects/>.



**LOMA LOS COLORADOS LANDFILL ♦ SANTIAGO ♦ CHILE**

The Loma Los Colorados Landfill is located 63 kilometers north of Santiago, Chile, near the village of Montenegro. The site operations are managed by **KDM Energia S.A.** The landfill receives 64 percent of the municipal solid waste (MSW) generated in the Santiago Metropolitan Area, providing waste disposal services to 24 municipalities. Since May 2003, more than 90 percent of the MSW deposited at the landfill has been transported by train from a transfer station located in Quilicura (in central Santiago). The landfill gas (LFG) energy project at Loma Los Colorados was registered as a **Clean Development Mechanism (CDM)** project on 17 March 2007. In 2009, Phase I of the LFG energy project started with an electricity generation capacity of 2 megawatts (MW). Currently Phase II is in operation, adding 9.9 MW for a total of 11.89 MW of installed capacity. Phase III will consist of the installation of an additional 21.78 MW capacity.

The electrical power system in Chile is one of the most permissive in the world. Laws No. 20018 and No.19440 allow the owner of any power generation facility to sell power to the interconnected grid and receive energy and capacity payments. Additional regulations were adopted in 2006, making grid access for renewable projects up to 20 MW more streamlined, improving economic and legal conditions for these projects.

Information on this project can be found on the UNFCCC website at: <http://cdm.unfccc.int/Projects/DB/DNV-CUK1166695034.41/view>, Project No. 0822: "Loma Los Colorados Landfill Gas Project."

| PROJECT SUMMARY | General Landfill Facts                                     |                              |
|-----------------|--|------------------------------|
|                 | Opening Year   | 1996                         |
|                 | Closure Year (expected)                                    | 2045                         |
|                 | Total Waste in Place in 2010 (Mg)                          | 22 million                   |
|                 | Total Landfill Capacity (Mg)                               | 100 million                  |
|                 | Current Waste Footprint (ha)                               | 70                           |
|                 | Total Waste Footprint (ha)                                 | 210                          |
|                 | Landfill Gas Energy Project                                |                              |
|                 | Project Type   | Electricity Generation       |
|                 | System Start Up  | 2009                         |
|                 | Extraction Wells   | 280 vertical wells           |
|                 | Blower/Flare Station Capacity (m <sup>3</sup> /hr)         | 10,000                       |
|                 | Average Gas Flow in 2010 (m <sup>3</sup> /hr)              | 8,000 at 48% CH <sub>4</sub> |
|                 | Average Emission Reduction (tonnes CO <sub>2e</sub> /year) | 582,400                      |
|                 | Phase I - Total Investment (estimated, USD)                | \$3 million                  |
|                 | Phase I,II and III - Total Investment (estimated, USD)     | \$40 million                 |



Loma Los Colorados Landfill



MSW Transported by Rail



Blower/Flare Station



Loma Los Colorados Power Station

## Environmental Benefits

- Project reduces approximately 582,400 tonnes of carbon dioxide equivalent (CO<sub>2</sub>e) emissions annually.
- Mitigates slope stability and fire issues, as well as odors and LFG migration in surrounding neighborhoods.
- Minimizes air pollution, eliminating emissions of non-methane organic compounds, among other pollutants.
- Currently provides renewable energy for 200,000 people.
- Transportation of waste by rail offsets the emissions of previously used trucks.
- Provides economical renewable energy to the grid.
- Diversifies energy generation in the country, improving energy security.

## Social Benefits

- Generates job opportunities associated with construction, operation, and maintenance of the project.
- Expected to provide improvements to public services in 14 rural communities in the area surrounding the landfill.
- Regularly visited by college and university students as a national demonstration project.

## Past Barriers

- First CDM LFG energy project in Chile.
- The rural location of Loma Los Colorados Landfill and lack of nearby industry limited the potential for direct-use projects.
- Access of small renewable energy projects to the grid was limited by technical and legal issues.
- Energy pricing advantages for renewable energy were limited; in the open energy market, renewable sources must compete with larger-scale conventional sources.
- Strict oxides of nitrogen (NO<sub>x</sub>) emission limits apply to the project, resulting in the need for costly NO<sub>x</sub> abatement filters to be installed on each electricity generation unit's exhaust, as well as installation of expensive LFG siloxane removal systems.

## Additional Information

- Renewable Energy Law 20257 was enacted in 2008, which established that at least 5 percent of all electricity must be from renewable sources in 2010, increasing to 10 percent by 2024. This renewable energy standard, combined with higher energy prices in the grid, has led to higher prices paid to renewable energy projects and has created a surge in renewable energy projects. There are no other requirements to obtain the right to connect to the electricity grid.
- The Phase II total investment includes future cost to reach their maximum projected capacity of 33.67 MW, LFG treatment and air emissions control systems, a 20-kilometer interconnection line, and a substation.

## Contact Information

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**NORTE III-B LANDFILL ♦ BUENOS AIRES ♦ ARGENTINA**

The **Norte III-B Landfill** is located in the District of San Miguel, a province of Buenos Aires. The landfill receives waste from the City of Buenos Aires and some municipalities located in the suburbs of Buenos Aires. Under a contract executed with **Coordinación Ecológica Area Metropolitana Sociedad del Estado (CEAMSE)** on 16 December 2005, **Ecoayres Argentina S.A.** was awarded a license to benefit from the biogas generated within the landfill. The main objective of this project is to reduce greenhouse gas emissions through extracting, collecting and burning the landfill gas (LFG) generated by the anaerobic decomposition of the waste, including use of some of the gas for electricity generation. Ecoayres Argentina S.A. was responsible for building and managing a gas capture, incineration, and electricity generation system and for making all necessary investments under **the Clean Development Mechanism (CDM)**, while CEAMSE will continue to own and manage the landfill.

Construction of the LFG capture and treatment system began in March 2006. In October 2006, Ecoayres Argentina S.A. completed the first step for project registration under the CDM by obtaining national approval from the host country, Argentina. Approval from the investment country, the United Kingdom, was obtained in November 2007. In February 2007, the project's validation process was completed by **Det Norske Veritas (DNV)**. Project registration by the **United Nations Framework Convention on Climate Change (UNFCCC)** was granted on 27 April 2007. The biogas engine began operation in August 2010.

Information on this project can be found on the UNFCCC website at: <http://cdm.unfccc.int/Projects/DB/DNV-CUK1171431768.63/view>, Project No. 0928: "Methane Recovery & Effective Use of Power Generation Project Norte III-B Landfill."

|                        |   |   |
|------------------------|---|---|
| <b>PROJECT SUMMARY</b> | <b>General Landfill Facts</b>                         |   |
|                        | Opening Year  | 2005  |
|                        | Closure Year  | 2010  |
|                        | Total Waste in Place (Mg)                             | 15 million  |
|                        | Total Waste Footprint (ha)                            | 82.5  |
|                        | <b>Landfill Gas Energy Project</b>                    |   |
|                        | Project Type  | Flare with minimal electricity generation for self-supply |
|                        | System Start Up:                                      | Collection System<br>Biogas Engine                        |
|                        |   | March 2008<br>August 2010                                 |
|                        | Extraction Wells                                      | 270 vertical wells (operating and non-operating)          |
|                        | Blower/Flare Station Capacity (m <sup>3</sup> /hr)    | 13,000  |
|                        | Average Gas Flow in 2010 (m <sup>3</sup> /hr)         | 9,200 at 58% CH <sub>4</sub>                              |
|                        | Emission Reduction in 2010 (tonnes CO <sub>2</sub> e) | 669,600   |
|                        | Project Capital Cost (estimated, USD)                 | \$10 million  |



Aerial View of the Norte III-B Landfill



LFG Collection Network

## Environmental Benefits

- Reduced 669,600 tonnes of carbon dioxide equivalent (CO<sub>2</sub>e) emissions in 2010.
- Mitigates odors.
- Minimizes explosion and fire hazards.
- Offsets the consumption of electricity from the public network and reduces greenhouse gas emissions.
- Minimizes air pollution, eliminating emissions of non-methane organic compounds, among other pollutants.

## Social Benefits

- Generates new job opportunities and skill training associated with the project.
- Provides resources for research and technology transfer in Argentina.

## Past Barriers

- Limited financing opportunities existed in Argentina for the project. The project would not be financially feasible unless it was registered as a CDM project and the project income captured from the sale of Certified Emission Reductions (CERs).
- Lack of locally available technology and experience for the construction, operation, and maintenance of the LFG energy system.

## Additional Information

- The CDM registration cost for the project was \$121,652 (USD).

## Contact Information

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**SÃO JOÃO LANDFILL ♦ SÃO PAULO ♦ BRAZIL**

The **São João Landfill** is located near the **Municipality of São Paulo**, Brazil's largest city and a producer of 15,000 tons of waste each day. The landfill has generated large quantities of landfill gas (LFG) since its inception, but most of the gas was lost to the atmosphere through passive venting. In June 1996, the U.S. Environmental Protection Agency (EPA) conducted a feasibility study which indicated that the São João Landfill could support an LFG electricity project.

In April 2006, the Municipality of São Paulo applied to register the project under the **United Nations Framework Convention on Climate Change (UNFCCC) Clean Development Mechanism (CDM)** to procure project funding. São Paulo selected **Biogás Energia Ambiental S/A (Biogás)**, a Brazilian company specializing in LFG recovery, to manage the LFG capture project. Biogás commenced construction in May 2007 and began building the LFG electricity plant in June 2007. The project became operational in 2008. The plant combusts the LFG in 16 engines, each with a 1.54-megawatt (MW) capacity, and has a total electricity production capacity of 22.4 MW. Three flares destroy any LFG not used to generate electricity.

Information on this project can be found on the UNFCCC website at: <http://cdm.unfccc.int/Projects/DB/DNV-CUK1145141778.29/view>, Project No. 0373: "São João Landfill Gas to Energy Project."

| PROJECT SUMMARY                                       | General Landfill Facts                             |                            |
|---|--|----------------------------|
|   | Opening Year                                       | 1992                       |
|   | Closure Year                                       | 2008                       |
|   | Total Waste in Place (Mg)                          | 24 million                 |
|   | Total Waste Footprint (ha)                         | 70                         |
|   | Landfill Gas Energy Project                        |                            |
|   | Project Type                                       | Electricity Generation     |
|   | System Start Up                                    | 2008                       |
|   | Extraction Wells                                   | 160 vertical wells         |
|   | Blower/Flare Station Capacity (m <sup>3</sup> /hr) | 373 at 50% CH <sub>4</sub> |
| Average Gas Flow in 2009 (m <sup>3</sup> /hr)         | 11,555 at 50% CH <sub>4</sub>                      |                            |
| Emission Reduction in 2009 (tonnes CO <sub>2</sub> e) | 876,797  |                            |
| Project Capital Cost (estimated, USD)                 | \$2.8 million                                      |                            |



Photo of Degassing Station (1) & Power House (2)



Schematic of Degassing Station & Power House



Transmission Pipeline

## Environmental Benefits

- Reduced more than 3 million tonnes of carbon dioxide equivalent (CO<sub>2</sub>e) emissions from 2007 to 2010.
- Prevents the release of greenhouse gas emissions and volatile organic compounds into the atmosphere, both of which contribute to air pollution and odors.
- Mitigates health risks, fire and leachate issues.

## Social Benefits

- Projected to provide 85 percent of the total generated power to be dispatched into the S-SE-CO Brazilian Electric Grid, which has a total capacity of approximately 22.4 MW.
- Generates work opportunities related to construction, operation and maintenance of the project.
- Provides opportunities for student education through the “Ver de Perto” (Take a Closer Look) program and technology transfer.
- Promotes a model for LFG energy projects in Brazil that can be replicated.
- Provides emission reduction revenues to be shared with the Municipality of São Paulo, increasing available cash flow for other waste management investments such as closure of illegal dump sites, improved awareness of proper waste management practices and other environmental benefits.

## Past Barriers

- The remote location, layout limitations and air emissions regulations governing NO<sub>x</sub> were all barriers for the landfill.
- Miscalculations of the characteristics of the transmission line resulted in a misallocation of power capacity.
- The predominance of hydroelectricity production in Brazil limits incentives for investment in other renewable resources.
- LFG energy project opportunities are not fully explored in Brazil as a result of the lack of local technology and expertise.
- Lack of environmental regulations for active collection and flaring of LFG inhibits the cost-effectiveness of an LFG-fired electricity generation project.
- The São João project is the first of its size to be carried out in Brazil, where investor tolerance for risk has, in the past, limited the scale of financial resources needed for an LFG energy project of this magnitude. Carbon revenues were essential to moving the project forward.

## Additional Information

- Even though it has not achieved its full energy production capacity, as of September 2009 the São João LFG energy project is the largest LFG energy project registered by the UNFCCC and is also among the largest LFG energy projects in the world.
- The project’s CDM registration cost was \$161,888 (USD).

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**BRAZIL MARCA LANDFILL ♦ CARIACICA ♦ BRAZIL**

The Brazil MARCA Landfill Gas Energy Project is a joint initiative between **EcoSecurities Ltd.**, an environmental finance company, and **MARCA Construtora e Servicos**, a local Brazilian landfill management company. The objective of the project is to collect and use the landfill gas (LFG) of the landfill managed by MARCA. **Biogas Technology Ltd (Biogas)** imported technology from the United Kingdom for the project. In February 2004, EcoSecurities Ltd. submitted its first Project Design Document (PDD) under the **Clean Development Mechanism (CDM)**. In July 2005, EcoSecurities Ltd. submitted PDD version 2, in which the baseline and monitoring methodology using AM0003, "Simplified financial analysis for landfill gas capture projects," was approved by the **United Nations Framework Convention on Climate Change (UNFCCC)**. The MARCA Landfill Gas Energy Project has an installed capacity of 11 megawatts. The developer is planning to expand the gas collection system to two recently closed cells to increase the gas flow to more than 2,500 cubic meters per hour (m<sup>3</sup>/hr) and start generating electricity.

In August 2005, MARCA completed the first step for project registration under CDM by obtaining national approval from the host country, Brazil. Approvals from the investment countries of the United Kingdom and Japan were obtained in September and August 2005. In November 2005, the project's validation process was completed by **Det Norske Veritas (DNV)**. Project registration by the UNFCCC was granted on 23 January 2006.

Information on this project can be found on the UNFCCC website at: <http://cdm.unfccc.int/Projects/DB/DNV-CUK1132565688.17/view>, Project No. 0137: "Brazil MARCA Landfill Gas to Energy Project."

|                        |  |                            |
|------------------------|--|----------------------------|
| <b>PROJECT SUMMARY</b> | <b>General Landfill Facts</b>                              |                            |
|                        | Opening Year   | 1995                       |
|                        | Closure Year (expected)                                    | 2017                       |
|                        | Total Waste in Place in 2005 (Mg)                          | 1.34 million               |
|                        | Total Landfill Capacity (Mg)                               | 4.7 million                |
|                        | <b>Landfill Gas Energy Project</b>                         |                            |
|                        | Project Type   | Electricity Generation     |
|                        | System Start Up  | July 2005                  |
|                        | Extraction Wells   | 67 vertical wells          |
|                        | Blower/Flare Station Capacity (m <sup>3</sup> /hr)         | 1,500                      |
|                        | Average Gas Flow in 2011 (m <sup>3</sup> /hr)              | 662 at 48% CH <sub>4</sub> |
|                        | Average Emission Reduction (tonnes CO <sub>2</sub> e/year) | 20,500                     |
|                        | Project Capital Cost (estimated, USD)                      | \$1.1 million              |



LFG Pipeline



Flare Station

## Environmental Benefits

- Reduces an average of 20,500 tonnes of carbon dioxide equivalent (CO<sub>2</sub>e) emissions annually.
- Mitigates health risks, fire and leachate issues, and LFG migration in surrounding neighborhoods and reduces stratospheric ozone layer depletion and ground-level ozone creation.
- Minimizes air pollution, eliminating emissions of non-methane organic compounds, among other pollutants.

## Social Benefits

- Provides electricity to the regional grid, thus displacing use of fossil fuels used for electricity generation.
- Promotes best practices to improve landfill management standards and contributes toward global sustainable development.
- Reduces risk of toxic effects from uncontrolled releases on local communities and the environment.
- Promotes clean technology and encourages less dependency on grid-supplied electricity throughout Brazil, which could be replicated across the region.

## Past Barriers

- The conservative assumptions of the financial analysis conducted for the project show that, as an investment, the internal rate of return of the MARCA project is not an economically attractive course of action.
- The centralized preference of hydroelectricity to produce national electricity in Brazil dominates the energy sector and limits incentives for investment in renewable resources.
- The lack of adequate collection and treatment of LFG at the landfill site was imposed by regulatory requirements.

## Additional Information

- The project has correctly applied the approved baseline and monitoring methodology (AM0003) which indicates that the project is not a likely baseline scenario and that emission reductions attributed to the project are additional to any that would occur in the absence of the project activity. The CDM registration cost for the project was \$30,000 (USD).

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**CURVA DE RODAS AND LA PRADERA LANDFILLS ♦ MEDELLÍN ♦ COLOMBIA**

In January 2007, **Empresas Varias de Medellin (EEVVM)**, a public utility company that owns both the **Curva de Rodas Landfill** and the **La Pradera Landfill**, signed an agreement with the **University of Antioquia** in Medellin to manage landfill gas (LFG) capture and flaring at the landfills. The agreement, unique in the LFG sector, was established not just to facilitate implementation of a project, but also to provide research and hands-on learning opportunities for the university and its engineering students. In addition, the university shares in the project revenue. The university issued a public request for proposals to find a strategic partner for development of the two sites as a single LFG flaring project under the **Clean Development Mechanism (CDM)**, resulting in the submittal of four proposals. In September 2007, the university awarded the project to **Consortium Green Gas Colombia (Green Gas)**, and Green Gas started construction at the landfills in January 2008. Three months later, the university completed the first step for project registration under the CDM by obtaining national approval from the host country, Colombia. Approval from the investment country, the United Kingdom, was obtained after, and in August 2008, the project's validation process was completed using **TÜV** of Germany. The project was registered by the **United Nations Framework Convention on Climate Change (UNFCCC)** on 6 February 2009. Before this project, neither of the landfills had active treatment of LFG. Passive collection systems consisting of extraction wells existed, but many of the wells were not operational, and the existing flaring systems were highly inefficient in destroying methane. The project resulted in installation of active gas collection and flaring systems at both sites, with the possibility of an electricity generation component that could be added later at the La Pradera Landfill.

Information on this project can be found on the UNFCCC website at: <http://cdm.unfccc.int/Projects/DB/TUEV-RHEIN1218645656.52/view>, Project No. 2183: "Curva de Rodas and La Pradera Landfill Gas Management Project."

| PROJECT SUMMARY                                    | General Landfill Facts       |                            | Curva de Rodas               | La Pradera      |
|--|------------------------------|----------------------------|------------------------------|-----------------|
|  | Opening Year                 |                            | 1984                         | 2003            |
|  | Closure Year                 |                            | 2003                         | 2027 (expected) |
|  | Waste in Place in 2003 (Mg)  |                            | 8.5 million                  | 3.5 million     |
|  | Total Landfill Capacity (Mg) |                            | 8.5 million                  | 10.7 million    |
|  | Current Waste Footprint (ha) |                            | 33                           | 10              |
|  | Total Waste Footprint (ha)   |                            | 33                           | 30              |
|  | Landfill Gas Project         |                            |                              |                 |
|  | Project Type                 |                            | Flare                        | Flare           |
|  | System Start Up              |                            | July 2008                    | December 2008   |
| Extraction Wells                                   |                              | 84 vertical wells          | 45 vertical wells            |                 |
| Monitoring Manifolds                               |                              | 10                         | 5                            |                 |
| Blower/Flare Station Capacity (m <sup>3</sup> /hr) |                              | 3,000                      | 2,000                        |                 |
| Average Gas Flow in 2009 (m <sup>3</sup> /hr)      |                              | 634 at 37% CH <sub>4</sub> | 1,465 at 50% CH <sub>4</sub> |                 |
| Emission Reduction (tonnes CO <sub>2</sub> e)      |                              | 24,349 (2009)              | 179,574 (2010)               |                 |



Curva de Rodas Landfill and Blower/Flare Station



La Pradera Landfill and Blower/Flare Station



## Environmental Benefits

- Project reduced 203,923 tonnes of carbon dioxide equivalent (CO<sub>2</sub>e) emissions in 2010.
- Mitigates odors, fire risks and LFG migration in surrounding neighborhoods.
- Improves slope stability as a result of the decrease of internal pressure in the landfill body through LFG extraction.
- Minimizes air pollution, eliminating emissions of non-methane organic compounds, among other pollutants.

## Social Benefits

- Provides research and technology transfer opportunities for the University of Antioquia, as well as strengthens the position of the university as a top institution of higher learning in Colombia. Provides hands-on learning opportunities related to renewable energy and climate change for engineering students.
- Generates job opportunities associated with construction, operation, and maintenance of the project.
- A share of the Certified Emission Reduction (CER) proceeds is contributed to research at the University of Antioquia.
- An additional revenue share of the CERs is allocated to EEVVM to improve environmental management at the landfills, including landfill post-closure.

## Past Barriers

- LFG modeling resulted in an overestimation of the LFG production from Curva de Rodas Landfill and subsequent misallocation of flare equipment.
- The rural location of La Pradera Landfill and lack of nearby industry limited the potential for direct-use projects.
- The low price of electric power and lack of renewable energy incentives limited the cost-effectiveness of an LFG-fired electricity generation project. In addition, the lack of significant on-site power demand limited the potential for a net metering or generation project.

## Additional Information

- Lower than expected LFG flows from the Curva de Rodas Landfill resulted in insufficient LFG to efficiently operate the flare. As a result, the Curva de Rodas LFG project was decommissioned and the flare was moved to La Pradera Landfill in December 2009 to augment the existing flare capacity. Green Gas obtained UNFCCC approval under CDM for this modification to the Project Design Document (PDD) in February 2011.
- The CDM registration cost for the project was \$31,964 (USD).

## Contact Information

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**NEJAPA LANDFILL ♦ NEJAPA ♦ EL SALVADOR**

The Nejapa Landfill receives municipal solid waste (MSW) from the San Salvador Metropolitan Area through a 20-year agreement with **MIDES S.E.M. de CV (MIDES)**, the owner and operator of the landfill. From 1999 through June 2005, roughly 2.7 million tonnes of MSW was disposed at the Nejapa Landfill, and this tonnage is expected to increase to 12.5 million tonnes by 2024. Environmental impact, health, and safety issues for the population, as well as energy potential, led the project developer and former owner, **Biothermica Energie Inc. (Biothermica)**, to conduct a feasibility study at the site to minimize these impacts and assess the potential for developing a landfill gas (LFG) energy facility. In 2005, Biothermica entered into an agreement with MIDES for project development, financing, construction, and operation of the LFG collection system, flaring station, and power plant under the **Clean Development Mechanism (CDM)**.

In September 2005, Biothermica completed the first step for project registration under the CDM by obtaining national approval from the host country, El Salvador. Approval from the investment country, Canada, was obtained in November 2005. In December 2005, the project's validation process was completed by **Det Norske Veritas (DNV)**. Project registration by the **United Nations Framework Convention on Climate Change (UNFCCC)** was granted on 12 March 2006. Biothermica started construction of the LFG collection system and flaring station in February 2006. In March 2008, Biothermica sold the project to **AES Nejapa Gas Ltda (AES Nejapa)**, a subsidiary of AES Corporation. AES Nejapa has expanded the LFG collection system in response to increased LFG production. AES Nejapa developed a 6-megawatt (MW) power plant that went on line in May 2011 and has the potential capacity to expand to 24 MW in future years.

Information on this project can be found on the UNFCCC website at: <http://cdm.unfccc.int/Projects/DB/DNV-CUK1134486361.05/view>, Project No. 0167: "Landfill Gas to Energy Facility at the Nejapa Landfill Site, El Salvador."

|                        |  |                              |
|------------------------|--|------------------------------|
| <b>PROJECT SUMMARY</b> | <b>General Landfill Facts</b>  |                              |
|                        | Opening Year   | 1999                         |
|                        | Closure Year (expected)  | 2024                         |
|                        | Total Waste in Place (Mg)  | 6 million                    |
|                        | Total Landfill Capacity (Mg)   | 12.5 million                 |
|                        | Total Waste Footprint (ha)   | 80                           |
|                        | <b>Landfill Gas Energy Project</b>   |                              |
|                        | Project Type   | Electricity Generation       |
|                        | System Start Up  | June 2006                    |
|                        | Extraction Wells   | 134 vertical wells           |
|                        | Average Gas Flow in 2010 (m <sup>3</sup> /hr)  | 3,100 at 48% CH <sub>4</sub> |
|                        | Emission Reduction in 2010 (tonnes CO <sub>2</sub> e)  | 196,000                      |
|                        | Project Capital Cost – LFG Collection System, LFG Rights, Distribution Grid update and 6-MW Power Plant (estimated, USD) | \$58 million                 |



Nejapa Facility



Nejapa LFG Collection System

## Environmental Benefits

- Project has reduced emissions by 753,560 tonnes of carbon dioxide equivalent (CO<sub>2</sub>e) emissions from 2006 to 2010.
- Contributes to sustainable development in El Salvador.
- Mitigates odors, fire issues, and LFG migration in surrounding neighborhoods.

## Social Benefits

- Generates management, operation and maintenance opportunities associated with the project.
- Improves environmental and health-related conditions.
- Creates opportunities for socioeconomic development through technological transfer and collaboration with MIDES.
- Contributes to the reduction of dependency on fossil fuel.
- Promotes replication of similar projects to other landfill owners, project developers, and energy companies in El Salvador and Central America.

## Past Barriers

- Financial analysis of the LFG energy project revealed that, without the Certified Emission Reduction (CER) revenue contribution, the project was not economically feasible.
- In the absence of regulations related to emissions from landfills in El Salvador, venting remains the most economically attractive means to control LFG.

## Additional Information

- The project was developed in two phases: Phase 1 involved design, construction, and operation of the LFG collection and flaring system; Phase 2 involved design, construction, and operation of an LFG electricity system.
- Acquisition cost includes all capital cost, LFG rights, 6-MW power plant, interconnection and distribution grid update.
- The CDM registration cost for the project was \$20,000 (USD).

## Contact Information

### Project Developer and Owner:

**AES El Salvador / AES Nejapa Gas Ltda.**

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**EL VERDE LANDFILL ♦ LEÓN ♦ GUANAJUATO ♦ MEXICO**

**Promotora Ambiental S.A.B. de C.V. (PASA)** is a private waste collection and disposal firm in Mexico and is the owner and operator of the **El Verde Landfill**. The plan for the El Verde Landfill Gas (LFG) Project is to capture LFG, use part of it to evaporate leachate, and initially flare the remaining gas. Once LFG capture is established and the volume of LFG captured is known, three 0.8 megawatt (MW) engines will be installed to generate electricity. PASA contracted **MGM International** to prepare a project design document related to capturing and using landfill gas under the **Clean Development Mechanism (CDM)**.

Construction for the LFG capture, leachate evaporations, and flaring systems began in January 2009 and was completed in late 2009. In March 2009, PASA completed the first step for project registration under the CDM process by obtaining national approval from the host and investment country, Mexico. In October 2010, the project's validation process was completed by **SGS United Kingdom Limited**. Project registration by the **United Nations Framework Convention on Climate Change (UNFCCC)** was granted on 27 October 2010.

Information on this project can be found on the UNFCCC website at: <http://cdm.unfccc.int/Projects/DB/SGS-UKL1265732335.87/Review>, Project No. 3378: "Landfill Gas Recovery and Flaring Project in the El Verde Landfill in Leon."

| PROJECT SUMMARY  | General Landfill Facts            |                            | El Verde Landfill                               |
|--|-----------------------------------|----------------------------|---|
|  | Opening Year                      |                            | 2001  |
|  | Closure Year                      |                            | 2017  |
|  | Total Landfill Capacity (Mg)      |                            | 8.5 million                                     |
|  | Total Waste Footprint (Ha)        |                            | 60  |
|  | Current Waste Footprint (Ha)      |                            | 30  |
|  | Total Waste in Place in 2007 (Mg) |                            | 2.9 million                                     |
|  | Landfill Gas Project              |                            |   |
|  | Project Type                      |                            | Flare with Transition to Electricity Generation |
|  | System Start Up                   |                            | Late 2009                                       |
| Extraction Wells   |                                   | 48 vertical wells          |   |
| Blower/Flare Station (m <sup>3</sup> /hr)                          |                                   | 1,869                      |   |
| Estimated Average Gas Flow (m <sup>3</sup> /hr)                    |                                   | 509 at 50% CH <sub>4</sub> |   |
| Average LFG Flow to the Evaporator (m <sup>3</sup> /hr)            |                                   | 310                        |   |
| Total Emission Reduction Annual Avg. (tonnes of CO <sub>2</sub> e) |                                   | 178,901                    |   |
| Project Capital Cost (USD)   |                                   | \$1.2 million              |   |



Aerial View of El Verde Landfill



Leachate Evaporator at El Verde



Blower/Flare Station

## Environmental Benefits

- Projected to reduce an average of approximately 178,901 tons of carbon dioxide equivalent (CO<sub>2</sub>e) annually.
- Mitigates odors and landfill gas migration in surrounding neighborhoods.
- Mitigates risk of explosions and slope stability.
- Reduces leachate contamination and methane emissions.
- Minimizes air pollution, including non-methane hydrocarbons.

## Social Benefits

- Generates work opportunities associated with construction and operation and maintenance of the project.
- Promotes technology transfer with design, equipment and installations complying with international standards with regard to quality, reliability, operational safety and environmental aspects.

## Project Barriers

- The advanced processes for treatment of solid waste require large investments and high operating costs compared with landfilling. With limited experience with these alternative processes in Mexico, the proposed CDM project relies heavily on technology transfer and CDM support.
- Substantial investments are required for capturing LFG, operating and maintenance, leachate evaporation, and technical equipment; if it had not been registered under CDM, the project would not be financially feasible.
- PASA had to ensure the LFG met the specifications and guidelines of environmental protection of both international and Mexico regulations. Mexico regulations are not always implemented, nor do they specify minimum requirements regarding the amount of gas to be collected and used or flared.

## Additional Information

- Provides education and resources for research. PASA has an agreement with the Universidad de Nuevo León and the Fundación Mundo Sustentable (Sustainable World Foundation) to develop a course on climate change.
- The CDM registration cost for this project was \$32,280 (USD).

## Contact Information

**Project Management:**  
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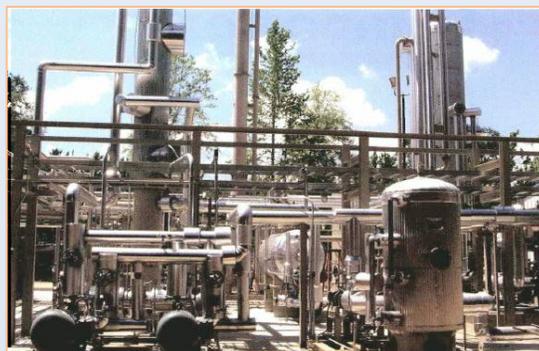
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**GREENWOOD FARMS LANDFILL ♦ TEXAS ♦ USA**

The **Greenwood Farms Landfill** is located in the U.S. State of Texas and is owned by the **City of Tyler**. The City of Tyler and landfill operator **Republic Services, Inc.**, partnered with project developer **Morrow Renewables, LLC**, to build a “pipeline-quality gas” project. Within 9 months, Morrow constructed the landfill gas (LFG) collection system, gas treatment plant and pipeline. The gas treatment plant has been cleaning and treating LFG for sale into the Gulf South Pipeline since early 2009. The project uses the latest advancements in technology to remove carbon dioxide, water vapor, hydrogen sulfide and other impurities. The pipeline-quality gas that results is composed of more than 95 percent methane with a heating value similar to natural gas. Hence, the landfill can capitalize on higher gas prices even with low LFG flow rates. The captured LFG, which was previously flared, is now used to heat homes and businesses.

Information on this project can be found on the **U.S. Environmental Protection Agency (EPA) Landfill Methane Outreach Program (LMOP) website** at: <http://www.epa.gov/lmop/projects-candidates/profiles/greenwoodfarms.html>.

| PROJECT SUMMARY | General Landfill Facts                                     |                      |
|-----------------|--|----------------------|
|                 | Opening Year   | 1989                 |
|                 | Closure Year (expected)                                    | 2020                 |
|                 | Total Waste in Place (Mg)                                  | 5.0 million          |
|                 | Total Landfill Capacity (Mg)                               | 67.0 million         |
|                 | Current Waste Footprint (ha)                               | 33                   |
|                 | Total Waste Footprint (ha)                                 | 81                   |
|                 | Landfill Gas Energy Project                                |                      |
|                 | Project Type   | Pipeline-quality Gas |
|                 | System Start Up  | April 2009           |
|                 | Extraction Wells   | 60 vertical wells    |
|                 | Average Gas Flow (m <sup>3</sup> /hr)                      | 2,718                |
|                 | Average Emission Reduction (tonnes CO <sub>2</sub> e/year) | 189,000              |



Greenwood Farms Landfill

## Environmental Benefits

- Reduces an average of approximately 189,000 tonnes of carbon dioxide equivalent (CO<sub>2</sub>e) emissions annually.
- The landfill truck fleet is powered by an on-site compressed natural gas (CNG) refueling station. Morrow is voluntarily minimizing the negative impacts of greenhouse gases at this site, which does not require review under EPA's federal "new source performance standards."

## Social Benefits

- Generates employment opportunities associated with construction, operation, and maintenance of the project.
- Yields annual energy savings that equate to heating 5,400 homes.

## Past Barriers

- A major barrier to widespread commercial use of LFG is reliable, economically sound removal of contaminants in the recovered gas. In past years, it was not feasible to develop pipeline-quality gas recovery projects, which require a much higher standard of purification to make the LFG pipeline-ready. LFG recovery and plant operation models historically followed the LFG electricity model for this reason, using much less refined LFG to power motors and a conversion system that would produce electricity for sale to the grid, usually with more opportunity to benefit local power consumption needs. This business model produces a larger carbon footprint than the pipeline-quality gas model, but nevertheless has some appeal to communities that can benefit more directly when LFG is converted to a local source of electricity. However, recent advancements in LFG purifying technology have reduced costs, making the production of LFG for pipeline transport not only a more profitable long-term venture, but a cleaner one as well. The Greenwood Farms LFG energy project is an example of community mindset evolving to embrace greater investments in pipeline-quality LFG recovery as an environmental tool.

## Additional Information

- The cleaned and treated LFG is being sold into the Gulf South Pipeline.

## Contact Information

### Project Management:

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### Project Developer:

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**STAR RIDGE LANDFILL ♦ ALABAMA ♦ USA**

The **Star Ridge Landfill** is located in the U.S. State of Alabama and is owned by **Veolia Environmental Services (ES)**. **Jenkins Brick Company**, headquartered in Montgomery, Alabama, built a new manufacturing facility (the Jordan Plant) next to the landfill, with the goal of utilizing the landfill gas (LFG) as fuel for the plant. Jenkins Brick Company chose this location for the manufacturing plant based on a study conducted by its consultant, **CH2M HILL**, in 2003 and 2004, as well other criteria such as proximity to high-quality feedstocks, railroad systems and other business considerations. A contract was signed between Jenkins Brick Company and the landfill owner in November 2004. The LFG energy component of the project was self-developed by the Jenkins Brick Company, while CH2M HILL designed the 9.6-kilometer pipeline system and supervised its installation. The new manufacturing plant was opened in October 2006.

Information on this project can be found on the **U.S. Environmental Protection Agency (EPA) Landfill Methane Outreach Program (LMOP) website** at: <http://www.epa.gov/lmop/projects-candidates/profiles/jenkinsbrickjordanplantla.html>.

|                        |  |   |
|------------------------|--|---|
| <b>PROJECT SUMMARY</b> | <b>General Landfill Facts</b>                              |   |
|                        | Opening Year   | 1982                                    |
|                        | Closure Year (expected)                                    | 2060                                    |
|                        | Total Waste in Place in 2009 (Mg)                          | 2.3 million                             |
|                        | Total Landfill Capacity (Mg)                               | 35.9 million                            |
|                        | Total Waste Footprint (ha)                                 | 15.8                                    |
|                        | <b>Landfill Gas Energy Project</b>                         |   |
|                        | Project Type   | Direct Use                              |
|                        | System Start Up  | January 2007                            |
|                        | Extraction Wells   | 33 vertical wells<br>3 horizontal wells |
|                        | Average Gas Flow (m <sup>3</sup> /hr)                      | 1,274 at 53% CH <sub>4</sub>            |
|                        | Average Emission Reduction (tonnes CO <sub>2</sub> e/year) | 88,500                                  |
|                        | Project Capital Cost (USD)                                 | \$4 million                             |



Star Ridge Landfill and Jenkins Bricks

## Environmental Benefits

- Reduces demand for – and emissions from – fossil fuel use.
- Nearly 40 percent of the manufacturing plant's energy requirements are currently met by the produced LFG, and this level is projected to grow to 100 percent over 10 years, reducing the need for electricity from sources operating on fossil fuel.

## Social Benefits

- The brick manufacturing facility is the largest one ever built at one time in the United States and was instrumental in generating new jobs in a rural area of Alabama.
- Uses an otherwise wasted alternative energy source, which saves money.

## Past Barriers

- Jenkins worked creatively as it sought ways to avoid potential impacts to the Upper Cahaba River Watershed. The watershed is near the landfill, and the new plant could have been located within the watershed. Jenkins proactively pursued locating property outside of the watershed, even though it necessitated construction of an expensive 9.6-kilometer pipeline.

## Additional Information

- This project is the first instance in the United States of a manufacturing facility that is built next to a landfill specifically for the purpose of using LFG as fuel. In 2004, as a result of demand for its products, Jenkins decided to expand its output and set about to do so with a site evaluation and selection process that had a landfill energy source as its core strategy. Jenkins evaluated hundreds of existing landfills in eight states. The evaluation included a review of the landfills, an assessment of the economic considerations for each prospective landfill, identification of the brick kiln fuel needs, an evaluation of the landfill's existing gas collection systems, and a projection of the future LFG supply for each landfill.
- Jenkins Brick Company was awarded LMOP's Project of the Year in 2006 and the Alabama Governor's Conservation Achievement Award for Air Conservationist of the Year in 1999 and 2007.

## Contact Information

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**YANCEY-MITCHELL COUNTY LANDFILL ♦ NORTH CAROLINA ♦ USA**

The **Yancey-Mitchell County Landfill** is located in the U.S. State of North Carolina and is managed by **Yancey County**. The landfill is located in a rural area and is home to unique native plants. When the landfill closed in 1994, three organizations — **Blue Ridge Resource Conservation and Development Council (BRRC&D)**, **HandMade in America (HandMade)** and **Mayland Community College (MCC)** — teamed together to design and develop the landfill gas energy (LFG) project and the EnergyXchange Renewable Energy Center at the landfill.

In 1996, BRRC&D, a local branch of the U.S. Department of Agriculture, began to research new ways to capture and use LFG. With the help of a feasibility study conducted by the U.S. Environmental Protection Agency (EPA) Landfill Methane Outreach Program (LMOP), it was determined that the quality of LFG at this landfill was sufficient for use as an energy source. The captured heat energy is now being used to run pottery kilns and glass blowers, in addition to supplying radiant heat for a greenhouse and other buildings located at the landfill. HandMade and MCC provided the resources necessary to set up facilities at the landfill for local pottery artists and horticulturists. The system was commissioned in April 1999, and the EnergyXchange Renewable Energy Center opened for business in 2001.

Information on this project can be found on the LMOP website at:  
<http://www.epa.gov/lmop/projects-candidates/profiles/energyxchangerenewableene.html>.

More information on the EnergyXchange Renewable Energy Center can be found at: <http://www.energyxchange.org/>.

|                        |  |  |
|------------------------|--|--|
| <b>PROJECT SUMMARY</b> | <b>General Landfill Facts</b>                              |  |
|                        | Opening Year   | 1973                                   |
|                        | Closure Year   | 1994                                   |
|                        | Total Waste in Place (Mg)                                  | 0.35 million                           |
|                        | Total Waste Footprint (ha)                                 | 2.4                                    |
|                        | <b>Landfill Gas Energy Project</b>                         |  |
|                        | Project Type   | Direct Use                             |
|                        | System Start Up  | April 1999                             |
|                        | Extraction Wells   | 8 vertical wells<br>2 horizontal wells |
|                        | Average Gas Flow (m <sup>3</sup> /hr)                      | 60 at 50% CH <sub>4</sub>              |
|                        | Average Emission Reduction (tonnes CO <sub>2</sub> e/year) | 4,000                                  |
|                        | Project Capital Cost (estimated, USD)                      | \$2 million                            |



EnergyXchange Renewable Energy Center



Greenhouse



Glass Studio

## Environmental Benefits

- Reduces an average of approximately 4,000 tonnes of carbon dioxide equivalent (CO<sub>2</sub>e) emissions annually.
- Reduces local smog.

## Social Benefits

- This project has demonstrated the power of partnerships and has become a model for other projects regionally, nationally, and internationally.
- The LFG energy project has generated work opportunities associated with construction, operation and maintenance of the project, including creation of three permanent jobs.
- In the greenhouse, boilers are heated using the captured LFG and waste wood to grow native plants from seed for sale to local plant wholesalers. Visitors learn innovative ways to propagate and preserve rare, native flora. The area is now home to 15 new native plant businesses.
- In the craft studios, local artisans use kilns and glass furnaces heated using the captured LFG, to create art that is sold at the on-site craft gallery. The artists pay a nominal fee to use the facilities but have saved a total of approximately \$1 million during the first 10 years of the project's operation, when compared with the use of traditional fuel sources.
- Two new glass businesses and five new pottery businesses have opened in the area.

## Past Barriers

- In the past, the Yancey-Mitchell County Landfill was considered to be too small to be commercially viable. However, this LFG capture and use project has illustrated that LFGE projects at small landfills can be successful.

## Additional Information

- The EnergyXchange Renewable Energy Center includes four greenhouses, three cold frames, a retail craft gallery, a visitor center, and clay and glass studios.
- This LFG energy project was awarded LMOP's Community Partner of the Year award in 1999.
- The EnergyXchange recently added a pallet-fired pottery kiln to utilize another wasted fuel resource.
- The EnergyXchange recently completed a major facility renovation and added new boilers.

## Contact Information

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**BARYCZ LANDFILL ♦ KRAKOW ♦ POLAND**

The **Barycz Landfill** is located in Krakow, Poland, and is owned by the **Kraków Municipal Cleaning Company Ltd. (MPO Sp. z o.o.)**. The landfill was developed in three phases: the first two phases are closed, and the landfill is now operating in its third phase.

The landfill gas (LFG) collection and utilization project was primarily financed by the landfill owner and operator as well as the **Instrument for Structural Policies for Pre-Accession (ISPA)/Cohesion Fund**. Before construction began, the **Polish Academy of Science** conducted a feasibility study at the landfill and suggested a design for the LFG collection system. The blower and flare station were built in 1994 and four internal combustion engines were installed, one each in 1998, 1999, 2002 and 2008. The combined generating capacity of these engines is 1.3 megawatts (MW) with an average output of 1.0 MW. Currently, about 600 cubic meters per hour (m<sup>3</sup>/hr) of LFG with a methane content of 55 percent is produced from more than 3.4 million megagrams (Mg) of waste at the site. The landfill sells not only the electricity, but also the associated Green Certificates, which produce 280 Polish Zloty (approximately \$80 USD)/megawatt-hour) in addition to the conventional electricity price.

Information on this project can be found on the MPO and GMI websites at:

<http://www.mpo.krakow.pl> and [http://www.globalmethane.org/documents/events\\_land\\_101411\\_tech\\_klimek.pdf](http://www.globalmethane.org/documents/events_land_101411_tech_klimek.pdf).

| PROJECT SUMMARY  | General Landfill Facts            |                        |
|--|-----------------------------------|------------------------|
|  | Opening Year                      | 1974                   |
|  | Closure Year (expected)           | 2016                   |
|  | Total Waste in Place in 2002 (Mg) | 3.4 million            |
|  | Total Landfill Capacity (Mg)      | 4.2 million            |
|  | Current Waste Footprint (ha)      | 10.8                   |
|  | Total Waste Footprint (ha)        | 36                     |
|  | Landfill Gas Energy Project       |                        |
|  | Project Type                      | Electricity Generation |
|  | System Start Up                   | May 1998               |
| Extraction Wells   | 70 vertical wells                 |                        |
| Monitoring Manifolds                                       | 1                                 |                        |
| Blower/Flare Station Capacity (m <sup>3</sup> /hr)         | 1,000                             |                        |
| Average Gas Flow (m <sup>3</sup> /hr)                      | 600 at 55% CH <sub>4</sub>        |                        |
| Average Emission Reduction (tonnes CO <sub>2e</sub> /year) | 55,000                            |                        |



Engines at Barycz Landfill

## Environmental Benefits

- Reduces an average of approximately 55,000 tonnes of carbon dioxide equivalent (CO<sub>2</sub>e) emissions annually.
- Mitigates odors that had been the subject of complaints by residents in surrounding neighborhoods.

## Social Benefits

- The response to the project from the press and the public has been positive.

## Past Barriers

- The distance between the pump and flare system and the LFG utilization system was large and required an extensive network of pipelines.
- The horizontal extraction pipelines have flooded with water on occasion; future plans include installation of only vertical wells.
- Some equipment was acquired from Germany, making operation and maintenance expensive. Local equipment manufacturers will be used in the future at this landfill.

## Additional Information

- The waste heat from the engines is being used to heat buildings at the landfill.
- A composting facility at the site became operational in 2005; it has a capacity of 6,000 tonnes per year. At this facility, MPO composts only green waste from parks and gardens to make the process safer and ensure high-compost quality. The compost is used at the Barycz Landfill and is also sold externally.
- The sorting plant became operational in 2006 and can sort approximately 20,000 tonnes of waste per year.

## Contact Information

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**CLOSED MARIUPOL LANDFILL ♦ MARIUPOL ♦ UKRAINE**

The **Closed Mariupol Landfill** is located in the City of Mariupol, Ukraine, and is owned by the **Mariupol City State Administration**. The landfill is located in a mixed-use area with residential, agricultural, commercial and industrial uses. Until its closure in 2008, the landfill accepted domestic and commercial waste from the City of Mariupol. During its active phase, certain landfill management practices led to significant leachate production, storm water runoff, and unintended fires. Post-closure, the landfill accepts only soil and some construction and demolition debris.

In August and September 2008, the U.S. Environmental Protection Agency (EPA) Landfill Methane Outreach Program (LMOP), as part of the Global Methane Initiative (GMI), conducted pump tests at this landfill. The pump tests yielded a landfill gas (LFG) recovery rate capable of supporting a flare or electricity project. In February 2009, the Mariupol City Council awarded the LFG capture and utilization project at two of the city's landfills to **TIS Eco Company**. TIS Eco Company, in partnership with **Scientific Engineering Center (SEC) Biomass**, began construction at the Closed Mariupol Landfill in June 2009. The system was commissioned in February 2010. In August 2010, the **National Environmental Investment Agency** issued a Letter of Approval to the "Collection and recycling of methane from solid waste landfills, Mariupol, Ukraine" for a **Joint Implementation (JI)** project.

Information on this project can be found on the GMI website and the UNFCCC JI website at:  
<http://www.globalmethane.org/activities/actSiteDetailsForLandfill.aspx?myObjId=a09A0000004vISCIA2> and  
<http://ji.unfccc.int/JIITLProject/DB/ZEVLPVNPJNVYMFSAZCZ1ARDF02JTY7/details>.

|                        |   |   |
|------------------------|---|---|
| <b>PROJECT SUMMARY</b> | <b>General Landfill Facts</b>   |   |
|                        | Opening Year  | 1967  |
|                        | Closure Year  | 2008  |
|                        | Total Waste in Place (Mg)   | 2.1 million                                     |
|                        | Total Waste Footprint (ha)  | 12.3  |
|                        | <b>Landfill Gas Project</b>   |   |
|                        | Project Type  | Flare with Transition to Electricity Generation |
|                        | System Start Up   | February 2010                                   |
|                        | Extraction Wells  | 43 vertical wells                               |
|                        | Monitoring Manifolds  | 3   |
|                        | Blower/Flare Station Capacity (m <sup>3</sup> /hr)                    | 160-800   |
|                        | Average Gas Flow in 2010 (m <sup>3</sup> /hr)                         | 390 at 50% CH <sub>4</sub>                      |
|                        | Average Emission Reduction (tonnes CO <sub>2</sub> e/year)            | 40,000-75,000                                   |
|                        | Project Capital Cost – Collection and Flaring System (estimated, USD) | \$867,000                                       |



Pipeline Installation



LFG Collection Well



LFG Flare

## Environmental Benefits

- Expected to reduce 40,000 to 75,000 tonnes of carbon dioxide equivalent (CO<sub>2</sub>e) emissions annually.
- Mitigates odors and LFG migration in surrounding neighborhoods.
- Minimizes air pollution by eliminating emissions of hazardous organic compounds and other pollutants.
- Improves slope stability and mitigates fires issues.
- Helps with leachate management by reducing its quantity and toxicity.

## Social Benefits

- Generates employment opportunities associated with construction, operation, and maintenance of the project.

## Past Barriers

- Ukrainian landfills are relatively small, and the lack of reliable technical data and financial assistance from local municipalities makes project implementation challenging. To overcome these barriers, GMI has been providing technical assistance on an as-needed basis and facilitated the identification of private investors at the Project Expo held in 2010 in New Delhi, India.

## Additional Information

- The LFG collected is being directed to a cogeneration plant, where up to 1.25 megawatts of electricity are expected to be generated and supplied to a distribution network. Some of the electricity produced will also offset the needs of the LFG collection and distribution system. Heat energy generated at the plant will provide an alternative energy source for a nearby greenhouse and brick manufacturing facility using an infrared heater or a kiln. Any surplus LFG will be flared.
- The LFG collection system and cogeneration plant are expected to function for up to 15 years.
- The JI registration cost for the project was \$20,000 (USD).

## Contact Information

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**GAOANTUN LANDFILL ♦ BEIJING ♦ CHINA**

Gaoantun Landfill is a sanitary landfill owned and operated by the **Beijing Chaoyang District Garbage Innocent Disposal Center (CDGIDC)**. In February 2007, the **U.S. Environmental Protection Agency (EPA)** met with municipal officials to evaluate the potential to expand use of landfill gas (LFG) at this site. The site was selected for a pump test evaluation. Later that year, EPA conducted the pump test and produced a pre-feasibility study about the technical viability of producing additional LFG energy at the site. Currently, LFG from the landfill is used to generate electricity from three 500-kilowatt (kW) and one 1,000 kW reciprocating engines and to fuel a 700-kW boiler. The boiler operates 24 hours per day in the winter and 3 to 4 hours per day during the other seasons; the total generating capacity is 2.5 megawatts (MW). CDGIDC plans to ultimately increase the power generating capacity to 5 MW.

Information on this project can be found on the GMI website at:

<http://www.globalmethane.org/activities/actSiteDetailsForLandfill.aspx?myObjId=a09A0000004vJolAM>.

| PROJECT SUMMARY  | General Landfill Facts            |                                       |
|--|-----------------------------------|---------------------------------------|
|  | Opening Year                      | 2002                                  |
|  | Closure Year (expected)           | 2022                                  |
|  | Total Waste in Place in 2007 (Mg) | 4.19 million                          |
|  | Total Landfill Capacity (Mg)      | 8.0 million                           |
|  | Current Waste Footprint (ha)      | 30                                    |
|  | Landfill Gas Energy Project       |                                       |
|  | Project Type                      | Electricity Generation and Direct Use |
|  | System Start Up                   | 2007                                  |
|  | Extraction Wells                  | 150 vertical wells                    |
| Monitoring Manifolds   | 5                                 |                                       |
| Average Gas Flow in 2011 (m <sup>3</sup> /hr)                      | 2,500 at 60% CH <sub>4</sub>      |                                       |
| Current Average Emission Reduction (tonnes CO <sub>2</sub> e/year) | 34,000                            |                                       |



Aerial View of Gaoantun Landfill



Typical Gas Well at Gaoantun Landfill

## Environmental Benefits

- When fully implemented, the project is estimated to reduce a total of 306,000 tonnes of carbon dioxide equivalent (CO<sub>2</sub>e) emissions from electricity generation and 213,000 tonnes of CO<sub>2</sub>e through direct use for the period 2008 through 2022.
- Mitigates odors and LFG migration in surrounding neighborhoods.
- Offsets the use of fossil fuels.

## Social Benefits

- Provides revenue from the sale of unused electricity to the local power grid or the sale of Certified Emission Reductions (CERs).
- Provides thermal energy for industrial or agricultural use.

## Past Barriers

- As a result of problems at nearby landfills, the actual waste inflow to Gaoantun Landfill has been higher than originally designed, and the landfill's capacity would be exhausted before the expected closure year of 2022.
- Whether a direct-use project at the solid waste or medical incinerator is economically feasible depends on the cost of retrofitting the incinerator for gas use and how much the potential user is willing to pay for energy.

## Additional Information

- Prior to EPA's assessment, the landfill installed a 500-kW reciprocating engine generator to generate electricity for consumption by the on-site leachate treatment plant.
- Gas is still being flared at the site, so investment opportunities exist for productive uses of this gas. Furthermore, in addition to the energy used on site, energy will be available to sell to potential users near the landfill.
- Gas generation and recovery at the site have been reduced as a result of decline in raw waste intake, a trend that began in 2009 and is continuing because of Beijing's policy to completely ban landfilling of raw waste by 2012. As a result, since 2009, increasing amounts of daily raw waste accepted have been diverted to an adjacent incinerator.

## Contact Information

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## JIAOZISHAN LANDFILL ♦ NANJING CITY ♦ CHINA

The Jiaozishan Landfill is located in Nanjing City, China, and is owned by **Nanjing Yunsheng New Energy Development Company, Limited (NYNED)**. The landfill is located in a rural area and consists of three storage areas: areas 1 and 2 are being used for this landfill gas (LFG) recovery and utilization project, while area 3 has been closed and exhaust vents direct its LFG to the atmosphere.

In August 2006, the host country, China, approved the LFG recovery and utilization project at Jiaozishan Landfill, and registration under the **Clean Development Mechanism (CDM)** was initiated. In April 2007, CDM consultant **CAMCO International Limited** facilitated the project's validation process through **SGS United Kingdom Limited** of the United Kingdom. The project was registered by the **United Nations Framework Convention on Climate Change (UNFCCC)** on 30 November 2007 and approved in August 2009. NYNED started construction in October 2005 and installed two sets of boiler systems and a flare. The flare destroys excess LFG when boiler load is low or they are out of service for maintenance. The boilers were commissioned in May 2006 and began operating 2 months later. The flare began to operate in September 2010.

Information on this project can be found on the World Bank website at:

<http://cdm.unfccc.int/Projects/DB/SGS-UKL1178631263.99/view>, Project No. 1120: "Jiaozishan Landfill Gas Recovery and Utilisation Project."

| PROJECT SUMMARY  | General Landfill Facts                             |             |
|--|--|-------------|
|  | Opening Year                                       | 1992        |
|  | Closure Year (expected)                            | 2022        |
|  | Total Waste in Place in 2005 (Mg)                  | 2.8 million |
|  | Total Landfill Capacity (Mg)                       | 5.5 million |
|  | Total Waste Footprint (ha)                         | 28          |
|  | Landfill Gas Energy Project                        |             |
|  | Project Type                                       | Direct Use  |
|  | System Start Up                                    | July 2006   |
|  | Blower/Flare Station Capacity (m <sup>3</sup> /hr) | 2,000       |
| Average Gas Flow (m <sup>3</sup> /hr)                      | 1,130 at 53% CH <sub>4</sub>                       |             |
| Average Emission Reduction (tonnes CO <sub>2</sub> e/year) | 153,000  |             |



Equipment at Jiaozishan Landfill

## Environmental Benefits

- Project reduces 153,000 tonnes of carbon dioxide equivalent (CO<sub>2</sub>e) emissions annually.
- Provides a heat supply system for the city that will reduce its dependence on coal, oil or electricity.
- Mitigates odors and LFG migration in surrounding neighborhoods.
- Mitigates fire issues.

## Social Benefits

- Demonstrates the use of new technologies obtained through international partnerships and facilitates technology transfer for other LFG management projects across China.
- Serves as a model for LFG management experience in China since it is one of the earliest LFG recovery projects initiated in the country.
- Generates work opportunities associated with construction, operation, and maintenance of the project.

## Past Barriers

- This landfill is one of the earliest sanitary landfills established in China and is representative of a typical medium-sized landfill. Prior attempts to harvest LFG from landfills have not been economically viable. This project presents an opportunity to understand how to successfully collect and manage LFG for beneficial use.

## Additional Information

- LFG is combusted in boilers to produce steam, which heats water through heat exchangers. Heat generated by the LFG is expected to be used to heat water for the use of nearby commercial establishments such as hotels and bathhouses. The hot water is trucked to customers in Nanjing City. This project is the first such direct-use application of LFG in China. The CDM project registration cost was \$29,148.80 (USD).

## Contact Information

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**DAEGU-BANGCHEON-RI LANDFILL ♦ DAEGU ♦ REPUBLIC OF KOREA**

The **Daegu-Bangcheon-Ri Landfill** is located in the southeastern part of Korea in Daegu City. The treatment of landfill gas (LFG) from Daegu Bangcheon-Ri Landfill was managed as “simple on-site treatment” to prevent odor, air pollution and fire before this project was installed. In 2004, **Taegu Energy & Environment Co. Ltd. (TEEC)** signed a Build-Operate-Transfer agreement with the **Daegu Metropolitan City (Daegu City)** to build and operate the landfill’s gas capture and utilization project. TEEC also signed an agreement to supply the LFG to **Korea District Heating Corp (KDHC)** to produce thermal energy for businesses, apartments and commercial buildings in KDHC’s service area. In January 2006, Daegu City announced that the Daegu-Bangcheon-Ri Landfill gas recovery project would be submitted as a **Clean Development Mechanism (CDM)** project.

In January 2005, TEEC started construction, which included installation of vertical LFG wells, a flare stack, a blower system, a refinery that includes filters and scrubbers, a generation facility and a gas storage tank. In January 2007, Daegu City completed the first step for project registration under the CDM by obtaining national approval from the host country, Korea. Approvals from the investment countries, Switzerland and the United Kingdom, followed. In May 2007, the project’s validation process was completed by **Lloyd’s Register Quality Assurance Limited (LRQA)**. Project registration to the **United Nations Framework Convention on Climate Change (UNFCCC)** was granted on 19 August 2007.

Information on this project can be found on the UNFCCC website at:

<http://cdm.unfccc.int/Projects/DB/LRQA%20Ltd1168417374.37/view>, Project No. 0851: “Daegu Bangcheon-Ri Landfill CDM Project.”

|                        |   |                              |
|------------------------|---|------------------------------|
| <b>PROJECT SUMMARY</b> | <b>General Landfill Facts</b>                         |                              |
|                        | Opening Year  | 1990                         |
|                        | Closure Year (expected)                               | 2026                         |
|                        | Total Waste in Place in 2009 (Mg)                     | 14.7 million                 |
|                        | Total Landfill Capacity (Mg)                          | 24.8 million                 |
|                        | Total Waste Footprint (ha)                            | 59.7                         |
|                        | <b>Landfill Gas Energy Project</b>                    |                              |
|                        | Project Type  | Direct Use                   |
|                        | System Start Up                                       | 2006                         |
|                        | Blower/Flare Station Capacity (m <sup>3</sup> /hr)    | 150                          |
|                        | Average Gas Flow in 2009 (m <sup>3</sup> /hr)         | 5,400 at 48% CH <sub>4</sub> |
|                        | Emission Reduction in 2009 (tonnes CO <sub>2</sub> e) | 307,300                      |
|                        | Project Capital Cost (estimated, USD)                 | \$20 million                 |



Aerial View of Daegu-Bangcheon-Ri Landfill



LFG Storage Tank

## Environmental Benefits

- Reduced 307,300 tonnes of carbon dioxide equivalent (CO<sub>2</sub>e) emissions in 2009.
- Mitigates odors, air pollution, and risk of explosion in surrounding areas.
- Mitigates climate change by controlling methane emissions to the atmosphere and replacing fossil fuels.

## Social Benefits

- Contributes to sustainable development by providing an alternative energy source.
- Creates economic benefits for the local area by selling medium-quality gas.
- Provides financial benefits from the sale of the Certified Emission Reductions (CERs).

## Past Barriers

- The successful completion of the CDM process led to the realization that the distribution of the CERs had not been adequately agreed on by the parties involved in the project. The issue was resolved through arbitration and led to the formation of the Korean Carbon Law Society to help in resolving carbon emission-related issues.

## Additional Information

- The CDM registration cost for this project was \$79,474 (USD).

## Contact Information

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