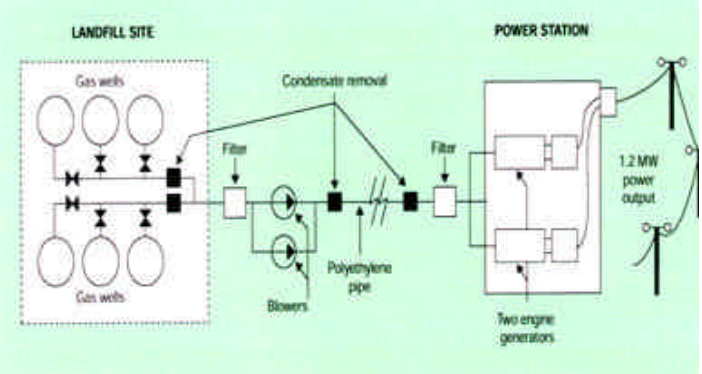
Biogas Extraction and Utilization System in Bulgaria



Project Title: Landfill Biogas Extraction and Energy Utilization System at the "Bratovo" Landfill in Bourgas, Bulgaria
Leader: Municipality of Bourgas (Bourgas, Bulgaria)
Partner: Brown, Vence & Associates, Inc. (BVA) (Roseville, California USA)
Location: Bourgas, Bulgaria
Project Duration: January 2000 - March 2001
EcoLinks Project Investment: Total Project Investment: $67,000; EcoLinks Grant Support: $43,000; Project Team Cost Share Contribution: $24,000.

Best Practice: Transferable Solution

This project is a Best Practice because it established a comprehensive methodology to assess the financial viability of various options for biogas capture and conversion. This methodology included an assessment of the potential markets for recovered energy, an analysis of the different technologies to convert biogas into marketable products, and a review of the institutional context including ownership issues and facility operations. Other municipalities and landfill owners in Bulgaria and throughout Central and Eastern Europe can benefit from the range of LBG utilization technologies evaluated at the Bratovo Landfill through this project.

Project Summary

The Municipality of Bourgas, which includes the fourth largest city in Bulgaria, operates one of the few sanitary landfills in the nation. The Bratovo landfill opened in 1981 and is expected to reach full capacity and be closed in 2007. The landfill currently receives 60,000 tones of solid waste annually generated by households and industry in the region (population: 270,000 people). Due to the decomposition of biological waste, the landfill produces landfill biogas (LBG). The biogas emitted

from the Bratovo landfill is in sufficient quantities to create health, safety, and environmental problems. Although Bratovo landfill incorporates many effective design and operational features to minimize the landfill's environmental impacts, it does not include a system to extract and manage the biogas produced by the decomposition of organic waste in the landfill.

Landfill biogas pollutes the air, contributes to global warming from the emission of greenhouse gases, and poses fire hazards due to the potential for uncontrolled combustion. Decomposing biological material at Bratovo Landfill emits carbon dioxide, hydrogen, and high levels of methane directly into the atmosphere. Methane gas is an especially potent greenhouse gas. One of the outcomes of this study revealed that the total methane production for the year 2000 at the Bratovo Landfill was approximately 2.4 million cubic meters. For the year 2007, when the landfill reaches its capacity, approximately 3.0 million cubic meters of methane are anticipated.

While unmanaged LBG is an environmental hazard, the capture and conversion of LBG makes it a useable energy resource. Alternatively, the flaring of methane gas limits the environmental hazards associated with its release. With the appropriate information, technology, and financing mechanisms, Bratovo landfill can convert its environmental problem into an economic resource or at least further reduce its environmental impacts. With the support of an EcoLinks Challenge Grant, the Municipality of Bourgas and an U.S. consulting firm, Brown, Vence & Associates, Inc., collaborated to conduct an assessment of Bratovo landfill biogas emissions and review options for capturing the biogas or converting it into a useable energy resource. Upon assessing the current biogas production and the environmental and economic benefits of various alternatives, various financing frameworks and technologies were explored to develop an implementation plan for converting biogas emissions into electricity at Bratovo.

Implementation of the proposed plan allows for several environmental and economic improvements. Implementation of a landfill biogas system would reduce methane emissions by 17,300-29,400 tons over a period of 20 years. In addition, the capture and conversion of biogas allows the Bratovo landfill to turn biogas into a useable energy resource and to generate revenue from energy sales.

Project Activities

The purpose of this project was to implement an efficient, environmentally sound landfill biogas (LBG) extraction and utilization system at the Bratovo landfill in Bourgas, Bulgaria. The project involved the following methods and materials:

1. Assessed recovery energy markets

Action: This activity involved identifying potential markets for energy recovered from landfill biogas (LBG) generated at the Bratovo landfill. Additionally, information was gathered and compiled on new legislation regarding energy sales and pricing.

The following potential markets for the energy were assessed:

- electricity sales to the National Energy Company
- biogas sales to the District Heating Plant
- electricity sales to industrial facilities
- biogas sales to industrial facility
- compressed natural gas sales for vehicle fuel
- use of the biogas on site for medical waste sterilization.

The following assessment criteria were used when comparing different market opportunities:

- market reliability
- delivery costs
- pricing and price stability
- unique requirements
- ease/difficulty of contracting

The analysis revealed the following:

- The sale of electricity to the National Energy Company is a feasible option. Beginning Jan. 1, 2002, the "Ordinance on Setting and Applying prices and Rates of Electric Energy" goes into effect in Bulgaria. According to the Ordinance, renewable power enjoys preferential pricing, moreover transmission and distribution enterprises must purchase all quantities of renewable power that independent producers make available. Under such conditions, the LBG power plant will be able to recover its capital and operating costs, even if its production costs are higher than conventional energy supplies.
- The sale of biogas to the District Heating Plant is not feasible because of a relatively long distance from the landfill to the heating plant (15 km) and due to problems with the construction of a pipeline to transport the gas through protected wetlands and breeding grounds.
- The sale of direct electricity or biogas to an industrial facility requires further investigation. There are no neighboring, large gas or electricity-using facilities. The only remaining option would be to sell electric energy to the Municipality. However, a full evaluation of this option requires negotiations with the National Power Grid.
- Selling compressed gas for vehicle fuel is not feasible as no sizeable vehicle fleet was identified in the vicinity of the landfill that would be interested in utilizing compressed natural gas.
- Use of the biogas for on-site medical waste sterilization is feasible.

Product(s): 1) An assessment of potential markets for energy produced from biogas at the landfill 2) Criteria for assessing different market opportunities 3) Analysis of the different, potential market options.

2. Identified the quantities and characteristics of biogas generated at the Bratovo Landfill

Action: The amount and nature of biogas generated at the Bratovo landfill were determined. Existing information on forecasting methane production and accelerated biogas generation using bioreaction methods was compiled.

Product(s): Data on biogas production at the landfill including forecasts for production to the year 2007.

3. Developed plans for LBG collection and destruction (burning) systems

Action: The design and costs (system capital and maintenance costs) of an LBG collection system were determined. A flaring system was also designed for use when the utilization system undergoes maintenance. A flaring system can also be used if an energy utilization system does not prove to be economically feasible. A conceptual layout was produced and included a series of gas wells, a network of gas conveyance pipes, a collection header, an enclosed flare station, and a blower. The total capital costs for the collection and flaring system are about $300,000. Operation costs will amount to $20,000.

Product(s): 1) Design and costs of LBG collection system 2) Destruction system design.

4. Reviewed technology options

Action: Technologies that convert landfill biogas into marketable products and their commercial availability were reviewed. Several options were generated including:

- Generation of heat through biogas combustion;
- Generation of electricity using an internal combustion engine fueled by biogas;
- Cogeneration of electricity and steam using an internal combustion engine fueled by biogas;
- Utilization of the biogas to incinerate or sterilize medical wastes
- Generation of electricity with a fuel cell using biogas as a source of hydrogen; and
- Production of compressed natural gas.

The list of criteria used to evaluate the options included:

- Degree of demonstration in similar situations,
- Reliability,
- O&M requirements,
- Emissions, and
- Efficiency.

Based on these criteria three alternatives were proposed for further consideration:

- Incinerating or sterilizing medical waste,
- Generating electricity, and
- Combination of the first two options.

Product(s): 1) Conversion technology options and their commercial availability 2) Criteria for evaluating the options 3) Conversion option alternatives.

5. Conducted an economic analysis of alternatives

Action: The costs and revenues of the three potential project options were determined. An economic analysis including lifecycle assessment of capital costs, construction and installation costs, operation and maintenance costs and financing costs was conducted for each project option.

Product(s): A document assessing economic costs and benefits for a range of project alternatives

6. Identified options for project financing and setting up institutional arrangements

Action: Private and public options for financing the biogas project were identified. Three basic institutional arrangements were identified:

- Public ownership and operation;
- Public/private joint venture with private operation; and
- Private ownership and operation.

Product(s): A proposal outlining an organizational structure, technical and economic requirements, and alternatives for the development of a biogas utilization enterprise at Bratovo landfill.

7. Reviewed significant environmental impacts of the selected alternatives

Action: Significant environmental impacts of the proposed project were reviewed including an estimate of emissions from the existing uncontrolled landfill and potential benefits associated with landfill biogas control and utilization.

Product(s): Documentation of environmental impacts of proposed project.

8. Developed recommendations and an action plan

Action: Recommendations regarding further program developments were developed. The criteria used to develop the recommendations included:

- Characteristics of available LBG supply,
- Marketability of products,
- Technical reliability of the installation,
- Economic feasibility,
- Ability to finance the project, and
- Environmental impacts.

The recommendations are as follows:

- The City of Bourgas should implement an LBG-to-electricity project in combination with a medical waste incineration facility;
- Before sizing the power plant, additional testing on LBG production and quality should be performed;

- Bioreaction methods should be tested on the landfill to confirm that methane production can be enhanced; and
- A public-private joint ownership structure with private operation of the projects is recommended.

Implementing the recommended projects is estimated to require approximately 18 months, beginning with selecting a strategic partner and ending with operation of the projects. The negotiation process regarding the permits for building and operation of the plant were initiated.

Product(s): 1) Recommendations 2) An implementation plan including a time line and estimated costs of each task.

9. Convened a workshop

Action: A workshop on LBG conversion at Bratovo Landfill was conducted. Local and national government representatives, private enterprises, and media representatives attended the workshop.

Product(s): Workshop on LBG conversion at the Bratovo Landfill informing multiple parties of the project.

Project Benefits

Several benefits were generated from this project. The project promoted learning about LBG conversion, and established important networks for fundraising to promote the capture and use of landfill biogas. It further establishes the possibility for limiting air pollution and greenhouse gas production from the decomposition of organic waste and promoting more efficient landfill operations.

Capacity Building Benefits

This project built the capacity for introducing LBG conversion at the Bratovo Landfill. By researching the feasibility of implementing LBG conversion, project participants learned about biogas capture and conversion. The information gathered and analyzed as part of this project provided the necessary framework for initiating a fundraising strategy targeting key parties. Hence the capacity to raise funds for LBG conversion was especially enhanced by this project.

A workshop on LBG utilization technologies in Bulgaria involving multiple parties including local and national government representatives, private enterprises, and media representatives further expanded the knowledge base regarding LBG conversion. Also, by convening these different parties, an implementation network was initiated for promoting the installation of an LBG conversion system at Bratovo Landfill as well as encouraging its use in other parts of the region.

Environmental Benefits

This project promotes several environmental benefits. For example, greenhouse gas emissions and air pollution are reduced with the installation of an LBG processing system. Pressure on non-renewable energy resources is also alleviated if the LBG is converted to electricity. The specific environmental benefits of this project include:

- Implementation of a landfill biogas system would reduce methane emissions by 17,300-29,400 tons over a period of 20 years depending on the methane recovery level. Between 50% and 85% of generated LBG can be recovered through an LBG-to-electricity facility.

- An LBG-to-electricity plant compared to a landfill without a conversion plant reduces uncontrolled emissions of methane and carbon dioxide (if the methane is not collected and burned on-site).

- An LBG-to-electricity plant reduces the demand for other fuel resources such as fossil fuels and nuclear power (which is associated with significant human health risks and conflict-based waste disposal problems).

- The emission of sulfur dioxide, nitrogen oxides and carbon dioxide from the flare are reduced with the installation of an LBG collection and destruction system.

- Captured LBG decreases ambient smog formation and reduces fire hazards that can result from the uncontrolled emission of LBG.

Economic Benefits

The alternatives for addressing the problem of LBG emissions require investments of varying degrees. The different alternatives in turn create different possibilities for economic benefits. The revenues generated through the operation of the methane utilization system, for example, will depend on the results of future negotiations concerning the price of electricity and the charges for medical waste destruction.

The Bulgarian "Ordinance on Setting and Applying prices and Rates of Electric Energy" provides that renewable power enjoys preferential pricing. Moreover, transmission and distribution enterprises are required to purchase all renewable power from independent producers. Under such conditions, capital and operating costs can be recovered with an LBG power plant even if production costs are higher than conventional energy supplies. Production costs for every system vary depending on the ownership and financing conditions built into the analysis. Combining the power plant project with the incineration of medical waste reduces the incineration project costs by an average of 8% and the electricity costs are reduced by 5%.

A financial analysis of the different systems for handling LBG is provided in Table 1.

Table 1. The results of a financial analysis of different system options

System	Investment outlays	Production costs
Collection and destruction system	$0.3 million	-
Medical waste incinerator	$0.6 million	0.58-0.61 $/kg
485 kW power plant (50% methane recovery)	$0.7 million	0.056-0.061 $/kWh
830 kW power plant (85% methane recovery)	$1.0 million	0.048-0.052 $/kWh
2,000 kW power plant (acceleration of methane generation required employing bioreaction methods)	$2.3 million	0.038-0.042 $/kWh
Combined medical waste and 2,000 kW power plant	$2.9 million	0.53-0.56 $/kg 0.036-0.039 $/kWh

Investment outlays for a medical waste incinerator and for various power plants do not include the costs of a collection and destruction system which must be installed in every case.
It is expected that all of the electricity generation projects would be able to recover their costs through revenues from electricity sales. The current payment to independent producers is approximately 0.055 to 0.06 $/kWh. The options presented have costs per kWh that are within or below that range of payment. It is expected that under the new Ordinance, recovery of the full capital and operating costs will be able to be negotiated with the electricity buyer. The facility will be likely to recover electricity generation costs, and the project will also pay for an LBG collection and control system.

Lessons Learned

The following lessons were learned during this project:

- When implementing international partnership projects, extra time should be allotted for work completion due to business cultural differences and language differences (e.g., document translation).

- The challenge of implementing projects in Bulgaria is largely due to the lack of financial resources rather than a lack of professional resources.

- To help ensure a realistic and conservative economic analysis, costs estimates should be a combination of U.S.-based costs and Bulgarian-based costs as it is difficult to obtain appropriate estimates for project capital costs when considering only data available in Bulgaria.

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