

BIOGAS

Landfill

BILBAO

(Spain)

Biogas is one of the most common sources of renewable energy. It can be produced by the anaerobic fermentation of wood or agricultural or urban waste. Coherent management of solid urban waste in landfill sites involves the artificial elimination of the gases that accumulate inside the landfill as a result of the actual fermentation of the waste. There are many advantages to using the biogas generated in Bilbao from urban waste – it is safe, its production generates a considerable profit, it is clean energy, jobs are created, and it contributes to technological development.

THE CITY

Bilbao, located on the estuary of the River Nervion, with a population of more than 400,000, is the administrative capital of the Spanish province of Vizcaya (Biscay). Since the 1974 crisis, the tertiary sector has taken over from the city's traditional industries. With the creation of the Guggenheim and the new metro, the city's appearance is changing as it takes on a new identity.

Weather information:

Hours of sunshine per year: XXXX hrs

Average yearly temperature: XX°C



CONTEXT

Coherent management of Solid Urban Waste (SUW) in landfill sites involves the artificial elimination of the gases that accumulate inside the landfill as a result of the actual fermentation of the waste.

Aware of the problem this poses, the Bilbao municipal authorities, in conjunction with the company operating the landfill site ("Fomento de Construcciones y Contratas, S.A."), in early 1984 devised an ambitious project to assess the possibility of using the biogas generated at the municipal landfill site at Artigas as a source of energy. The project on this started later that year, with the creation of six shafts and the fitting of a flare stack with a view, initially, to flaring the biogas generated. Work also began on studying the volumes and the physical and chemical characteristics of the Artigas biogas. It was not until 1988 that the Bilbao municipal authorities, in conjunction with the Basque energy authority ("Ente Vasco de la Energía" – EVE), considered making industrial use of this biogas, which had until then been flared. A feasibility study was carried out, taking into consideration all the possible uses that could be made of the biogas – sale to industries close to the landfill site, direct use in a furnace to incinerate hospital waste, direct transformation into electricity, etc; the study reached the conclusion that this last alternative was the most viable in technical and economic terms.

THE BILBAO EXPERIENCE

In order to carry out the project, the Bilbao municipal authorities, in conjunction with the Basque energy authority, decided to set up the company BioArtigas S.A. The company has been entrusted with construction of the site and its operation; its object is to produce energy from the waste, both for external use and for the landfill site's own installations, and to provide third parties with technical advice on producing energy at landfill sites. The installation started operation towards the end of 1992.

Characteristics of biogas

The Biomass Unit of the CIEMAT Institute of Renewable Energies carried out a thorough study in order to collect as much information as possible on the physical and chemical characteristics of the biogas generated at the landfill site. The main concern was to have available full preliminary specific information not only on the calorific or energy value of the fuel but also on the presence in the biogas of potentially corrosive compounds that could cause irreparable damage to motors.

Various analyses were carried out in order to determine both calorific value and levels of methane, VOCs (volatile organic compounds), hydrosulphuric acid and water vapour. These compounds are highly corrosive and their presence in substantial concentrations could cause irreparable damage to motors, mainly as a result of the formation of ClH and SH_2 . According to the results of the analyses carried out on the main compounds, the methane content is over 50%. This figure confirms the possibility of using the gas as a source of energy, and ensures that the technology envisaged would function properly. It is based on an automatic check of the percentage of methane in the sewer.

The results obtained from the analyses of VOCs and hydrosulphuric acid confirm that the biogas produced may be used without any risk to the energy production equipment. Those compounds which could cause problems by corroding motors are present in small quantities. However, the analyses also revealed that the biogas is supersaturated with water. This makes it necessary to add a further installation not included in the initial project to eliminate the condensate.

Main plant installations

The system for collecting, regulating and controlling the biogas must be such that the biogas extracted fulfils the following conditions:

- its minimum calorific value must be capable of guaranteeing the stable operation of the generators;
- its relative humidity must be lower than that corresponding to saturation point at the operating temperature, and it should not contain any harmful solid particles;
- the volume of gas must be sufficient for the generators to run properly;
- the oxygen content of the gas must be low, for safety reasons.

All this is carried out using sensors, communications using optic fibres and appropriate computer programs. The excess gas not used by the generators is flared in a flare stack fitted with automatic mechanisms and pilots. Basically, the overall plant consists of



36 extraction shafts set out in 12 lines, regulated individually by pneumatic valves located at the end of each line. These valves regulate the flow according to the instructions given by the regulation station, closing down the installation if the O₂ level becomes too high.

The system collects the following data:

- temperature and volume of the flared gas, as the flare stack requires a minimum volume to be able to keep operating;
- temperatures, pressure and volumes in each generator.

The system also includes all the necessary safety features such as electrical earths, gas leak detectors, fire prevention systems, etc.

The gas contains considerable quantities of condensate and this makes it necessary to include substantial dehumidification devices to ensure the longevity of the motors. The proposed solution should be such that the level of humidity in the biogas is kept far from its dewpoint, so that no condensation is formed on contact with the colder surfaces of the inlet piping feeding the gas into the motors.

A system was designed to do this; it comprises the following stages:

- the gas is cooled to 20°C; this dehumidifies the gas, guaranteeing a maximum humidity content of 20 mg/litre;
- the drops are separated;
- the biogas is heated to 50°C; this definitively ensures distance from the dewpoint.



Properties of the biogas

- Specific heat: 0.373 Kcal/Nm³°C
- Specific weight: 0.95 kg/Nm³
- Volume: 600 Nm³/hr (could be increased to 1 200 in a second stage)
- Temperature:
 - on entering the system: 55°C
 - on leaving the system: 50°C
- Pressure: 0.12 mbar (relative)
- Humidity content:
 - on entering the system: 64 mg/litre
 - on leaving the system: 30 mg/litre



Generators

The plant also includes two GUASCOR motors (FGLD360 model) which operate two synchronised generators, each generating 450 kW at 380V, 50Hz and 1500 rpm. Two more motors with the same characteristics are to be added to the plant at a later date. The generators operate in parallel with the electricity network of Iberdrola S.A., which receives the electricity produced, less the quantity used on site. Operation is continuous, 24 hours a day, with programmed shutdowns for preventive maintenance. Before being fed into the motors, the biogas is filtered (5 microns) to eliminate any solid particles it may still contain.

The main features of the generators are:

- 12-cylinder V-formation motors; 36-litre capacity, turbocharged and aftercooled;

- high-tech chamber designed to run on weak gas/air mixtures;
- emission levels complying with all European standards;
- Otto cycle with spark ignition;
- cooled by electro-radiators; the exhaust gases pass through silencers.

The generators are synchronised (LEROY SOMER brand, LSA49L6A model) and self-energising without brushes. The control system comprises an electrical panel displaying the electrical parameters of the motor and the electrical parts. The panel deals with starting, synchronisation, coupling with the network and control of the power generated, all automatically. The possible presence of organic halides, which could generate hydrochloric and hydrofluoric acid, is revealed in the oil and could affect its TBN (Total Base Number). The TBN is an indication of the alkaline capacity of the oil to counteract the acids, hence the need to carry out regular motor oil analyses.

EVALUATION AND OUTLOOK

The overall investment amounts to €961 500. Average annual income obtained since commissioning amounts to €300 480 (from the sale of the electricity generated). Of this, €60 100 are taken up in operating costs, including plant maintenance, consumables (oil, filters, etc), insurance, etc.

To finance these investments, grants were received from the following institutions:

- European Commission – Energy Directorate-General (DG XVII), through its Demonstration Programme currently entitled THERMIE;
- Ministry of Industry and Energy – Energy Directorate-General;
- Basque regional government:
 - CADEM, S.A., Basque energy authority (EVE) group, Department of Industry and Energy,
 - Office of the Deputy Regional Minister for the Environment, Department of Town Planning, Housing and the Environment.

FOR MORE INFORMATION

EVE – Ente Vasco de la Energía (Basque energy authority)

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