

# BIOGAS CHP

# BESANCON France

Several municipalities have started to investigate the possible energy uses as fuel oil of biogas, a renewable energy produced from the gasification of household and/or agricultural waste or in waste water treatment plants. The City of Besançon, member of Energie-Cités, for example, uses the biogas produced at its sewage plant to generate heat and electricity together in a single process called combined heat and power (CHP). This process allows to increase energy efficiency up to 80% and more, depending on the technology used.

## GENERAL ASPECTS

Besançon is the capital of the Franche-Comté Region and has about 120,000 inhabitants. The city centre is located in a meander of the River Doubs with the 'Citadelle', a fortification built by Vauban, towering above the city. In the 18<sup>th</sup> century, Swiss clock and watchmakers came to settle in the city, creating a tradition for horology. This activity has been partially replaced by the microtechniques.

### Climatic data:

Degree days (Base 18 °C): 2,878



## CONTEXT

Besançon is one of the French cities where energy-demand management, renewable energy sources and environmental concerns in general are traditional municipal matters. In 1977, the function of Deputy Mayor for the Environment was created and amongst the many actions carried out by the Municipality of Besançon, the following ones are worth mentioning: Computerised management of municipal buildings: follow-up and monitoring of energy consumption in each individual building is made by computer. This system allows to monitor, control and regulate 160 remote boilers and makes it possible to deliver data sheets with technical and financial ratios, which can be used to compare building performances, as well as annual energy balances. At the end of the 80s, Besançon introduced a remote management and control system for public lighting. This computerised management system controls public lighting electricity consumption and is useful in optimising electricity supply contracts.

Since 1992, geothermal energy has been used at the Besançon municipal head offices. A two MW central boiler with a small heat network connected to the municipal head offices and a water/water heat pump mounted in parallel operates thanks to the energy available in underground water.

## EXPERIENCE OF BESANCON

The sewage plant at Port Douvot has been in existence since 1968. The main sewage line of 120,000 inhabitants-equivalent was commissioned in 1978 and was extended in 1992 with the installation of an additional 80,000 inhabitants-equivalent line. These two lines use the so-called technique of activated sludge after primary settling. The average load of the installation is currently of around 145,000 inhabitants-equivalent, and approximately 34,000m<sup>3</sup> per day were treated by biological means in 1998.

### Sludge treatment

The treatment process which is common to the two lines include three steps: thickening, digestion and dehydration. It is during the digestion process that biogas is produced. Sludge is



heated at 37°C and mixed under an oxygen-free atmosphere, thus creating the conditions for an active biological activity. Three weeks later, at the end of the digestion phase, dry matters have been reduced by one third and about 3,500 m<sup>3</sup> of biogas with a 65% methane content are produced on a daily basis. Digested sludge is then dehydrated before being recycled for use in the agriculture.

The production of biogas is directly linked to the quantity of organic matters introduced during the digestion process, since 1 kg of organic matters gives a maximum of 0.5 m<sup>3</sup> of biogas. Production optimisation implies a strict follow-up of sludge digestion conditions.

### Utilisation of biogas

The biogas produced during the digestion process is used on site in a CHP plant to generate heat and power together. A first plant operated from 1980 to 1993. It was composed of a series of small 1,000 m<sup>3</sup> engines producing 11kW each.

A call for tenders was launched in 1993 with a view to upgrading the installation which had become obsolete. The CEGELEC company was selected to supply and install a JENBACHER CHP system to exploit all of the biogas produced.

Biogas is then stored in two types of storage facilities. It is stored in 3 gas holders of 1,200 m<sup>3</sup> each at a pressure of about 15 mbars. A second storage tank with a capacity of 70 m<sup>3</sup> and a pressure of 30 bars (i.e. approx. 2,100 Mm<sup>3</sup> ) and located above the digesters provides additional storage.

The average level of biogas currently produced implies that the CHP unit functions 12 to 16 hours per day with an hourly consumption of 220 Nm<sup>3</sup>. Under pressure stored gas management allows to match energy production with electricity day rate. The thermal energy of the engine is used through water tubular exchangers to heat the sludge in the digesters (from 7,000 to 10,000 kWh of heat per day). Additional biogas-fired boilers are used as back-up in the case of production falling short of thermal needs. Unless a technical failure happens, the installation is self-sufficient as regard thermal energy and produces no surplus in winter. Sludge temperature being indeed lower in winter, thermal needs are higher than during the rest of the year and all the biogas produced is burnt.

Almost all the electricity generated by the CHP system is consumed by the sewage plant, which receives 930 kW from the mains in off-peak periods. Self production covered one fourth of the electricity needs during the first four years in operation. Sales to EDF are marginal during peak load periods in winter thanks to the optimised cut-off of consumption points in the sewage plant.

### Technical features of the CHP plant and production data

TECHNICAL FEATURES	ENERGY PRODUCTION
<p><b>Gas engine:</b></p> <ul style="list-style-type: none"> <li>• 12 V cylinders</li> <li>• capacity of 30 litres</li> <li>• turbo-charging with exchanger</li> <li>• shaft mechanic power: 630 hp at 1.500 rpm</li> <li>• thermal power: 567 kW</li> <li>• electrical efficiency: 37.1%</li> <li>• thermal efficiency: 46.3%</li> <li>• total efficiency: 83.4%</li> </ul> <p><b>STAMFORD</b> power generator: 450 kW under 400 V</p>	<p><b>Electric energy</b> (round figures) :</p> <ul style="list-style-type: none"> <li>• 1995: 1,518,000 kWh</li> <li>• 1996: 1,306,000 kWh</li> <li>• 1997: 1,506,000 kWh</li> <li>• 1998: 885,000 kWh</li> </ul> <p><b>Heat production:</b> 7,000 to 10,000 kWh per day</p>

### Financing

The installation was mainly financed by the Sanitation Department of the Municipality of Besançon with the help of the Rhone Mediterranean Corsica Water Agency

Sanitation budget of the Municipality of Besançon	341,800 €
Rhone, Mediterranean, Corsica Water Agency	
• Subsidy	201,200 €
• Refundable advance	100,000 €
Installation cost	640,000 €

### Maintenance

Maintenance costs during the first four years in operation turned out to be higher than expected, whereas the percentage of electricity produced on site at the Besançon sewage plant was decreasing.

Year	Percentage of self-production	Maintenance costs (€, round figures)	Marginal cost per kWh produced (€-cents, exclusive of taxes)
1995	28%	16,000	1.58
1996	24%	27,000	2.10
1997	28%	47,000	3.13
1998	16%	34,000	3.86



Various phenomena occurred simultaneously: the quantity of electricity generated did not meet with expectations; maintenance costs increased; as a consequence of this, the marginal cost per kWh produced has been increasing since 1995; electricity prices are declining.

All these factors led the Municipality of Besançon to only use CHP during the five months corresponding to the EDF "winter" rates. In winter,

three rates from 0.145 to 0.047 Eur apply

depending on the period of the day, the lowest rate corresponding to night off-peak periods. In summer, rates are much lower and range from 0.03 to 0.021 Eur. These extremely low prices deter from producing electricity in summer, since the annual cost of producing one kWh is 0.039 Eur. This decision will also allow the Municipality of Besançon to spread equipment depreciation over a longer period while continuing to benefit from most of the gain on the energy bill. During summertime, biogas is then used to heat sludge by means of combined biogas / fuel oil boilers (fuel-oil is used to start up digestion or as back-up in the case of a toxic pollution having an inhibiting effect on the activity of the methanogenic bacteria). Surplus production will then have to be burnt off without being used to produce energy.

## EVALUATION AND PERSPECTIVES

The experience of Besançon is a good example of the influence that energy prices may have on CHP development and on the use of renewable energy sources. Even if the cost of producing one kWh from biogas is one of the cheapest compared to other renewable energy sources, the rates that EDF applies hinder the development of such technique in France under current conditions. A decrease in the electricity prices has led the Municipality of Besançon to shut down the CHP plant during the five months corresponding to the EDF winter rate et to accept de facto to purely waste biogas. If this solution appears as more cost-effective from an economical point of view, it is far less appropriate as far as energy efficiency is concerned. Given the extremely low electricity prices applied in summer, the energy produced from CHP (with an energy efficiency of 80%) will be replaced by electricity (with a production efficiency of c.a. 35%). If the objective of any energy policy is to increase the energy efficiency of the energy production sector and to promote renewable energy sources, it is then indispensable that the following measures be taken:

- More subsidies to renewable energy sources,
- More attractive buying price that would make it possible to achieve an integrated resources planning.

### FOR FURTHER INFORMATION

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This case study was prepared by Energie-Cités in collaboration with the Municipality of Besançon. It received funding from the ALTENER Programme of DGXVII of the European Commission.

