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The biogas plant in Linköping

Facts/unique: Effective process with high methane production.
The Biogas train, Amanda.



Figure 1 Biogas car in front of the biogas plant in Linköping

Discussions began in the early 1990's in Linköping on how to reduce emissions of exhaust pollutants from buses in the town centre. Various alternative vehicle fuels were compared. At the same time, the local slaughterhouse was experiencing problems dealing with waste, and large quantities of manure were also available from local farms. Linköping Biogas AB was formed in 1995 in a collaboration between the Technical Office of the local authority, the co-operative agricultural company 'Swedish Meats', Konvex and LRF (the national farmers association) through the company 'Lantbrukets Ekonomi AB'. A pilot biogas project was carried out between 1990 and 1994. Following an evaluation, a full-scale biogas plant was built at Åby, near Linköping, which started operating in spring 1997.

In 2004, the Technical Office became sole owner of the plant and Linköping Biogas AB changed their name to 'Svensk Biogas i Linköping AB' (Swedish Biogas in Linköping). The biogas was upgraded right from the beginning, to use as a vehicle fuel for the city buses. The first public filling station in Linköping for biogas was opened in 2001, and several more have opened since. A number of improvements and extensions to the biogas plant and distribution system have been made since 1997, which have increased the production and use of biogas.

'Svensk Biogas i Linköping' were among the first in Sweden to upgrade biogas to vehicle fuel quality. Significant developments to the process have taken place during the eleven years that the plant has been in operation. The biological process has been specially adapted to enable the digestion of substrate comprising large amounts of slaughterhouse wastes that are rich in energy and proteins. Up to 1000 m³ of methane is extracted per ton of organic material. The process has been stable for many years, despite high contents of nitrogen in the form of ammonium (5.1 g per litre) and a relatively high pH (8). Svensk Biogas have also received attention as a result of the biogas train (Amanda), which has been running between Linköping and Västervik since April 2006.

The biogas plant and substrate

The substrate, which totals c. 45,000 tons per year, consists of c. 55% waste products from slaughterhouses and 45% of other food wastes. The slaughterhouse waste is finely ground and mixed with the other substrates in a homogenizing tank. The substrate is then pasteurized by heating with steam to 70°C for one hour. The material is then cooled before being pumped into the two reactors, each of which has a volume of 3,800 m³. Decomposition takes place at 38°C in a continuously mixed one-step process with a retention time of 30 days.



Figure 2 Aerial photograph of the biogas plant in Linköping, with a schematic diagram of the plant

Upgrading and use of the biogas

All the biogas produced at Åby is upgraded to use as vehicle fuel. As early as 1992, some of the biogas produced at the town sewage treatment plant was upgraded in a smaller plant (capacity 150 Nm³ biogas per hour) using the PSA technique. This supplied five town buses with biogas fuel. A new upgrading plant based on the water wash method opened in 1997. It has a capacity to upgrade 500 Nm³ biogas per hour. A third plant, using the same technique, was built in 2002, with a capacity of 1,400 Nm³ biogas per hour. Including the gas from the sewage treatment plant, approximately 65,000 MWh of upgraded biogas is produced each year, which supplies fuel to the town's buses, refuse lorries and a number of filling stations in the region. A train (Amanda) was converted from diesel to biogas in 2006. The train operates on the line between Linköping and Västervik and can run 600 km on one tank.

Distribution of the biogas

The three upgrading plants are all located at the biogas plant in Åby. The upgraded biogas is distributed through 8 km of buried pipelines under a pressure of 4 bars to the bus depot and to public filling stations in the area. At the bus depot, the gas is pressurized to 250 bars, and the buses are filled slowly overnight. Svensk Biogas own and run thirteen different biogas filling stations in Linköping and the surrounding region.

Bio-manure

After digestion, the bio-manure is cooled to 20°C and storage in a tank before being delivered to 30 farmers in the surrounding area. Roughly 45,000 tons of bio-manure is produced annually (figure from 2007). The bio-manure has a dry weight content of 4.2% and a nitrogen content of 6 kg per m³ and is certified according to SPCR 120. The bio-manure is spread with conventional techniques for liquid manure application.

Financing

Roughly 130 million SEK has been invested in the construction of production and distribution systems for biogas in Linköping. Most of this was self-financed, although grants from LIP and KLIMP have been obtained on a number of occasions (c. 17 million SEK in total). These grants were used to finance improvements to the biogas and upgrading plants as well as investments in new gas filling stations and vehicles. The biogas project in Linköping will be economically profitable in the long-term.

Lessons learned

One significant change that has taken place is the availability of raw materials and their price. When the plant in Linköping started production in the 1990's, as one of only a few in Sweden, few difficulties were experienced in finding suitable raw material to fill the reactor. Many local authorities in Sweden are now developing biogas plants, which of course increases competition for organic wastes. Svensk Biogas has therefore decided on a different concept for a new biogas plant being planned in Norrköping. Initially, biogas will be produced from agricultural crops, and in a second phase, the process will be adapted to treat as many different types of materials as possible. It is therefore recommended that organisations planning to develop a biogas plant should investigate the local market for organic wastes to determine the most suitable materials that will guarantee a reliable supply and profitability.

With respect to the biogas process itself, Linköping has put a lot of effort into extracting as much methane as possible from the added substrate. A close collaboration with Linköpings University has played an important role in the development of the process. Support from the local authority is important in any effort to establish biogas, for example by encouraging the purchase of biogas vehicles. A secure home market in terms of biogas-driven town buses and refuse trucks can be critical for success.

Benefits for the environment and society

The biogas plant in Linköping has been successively extended and improved to meet the continuously increasing demand in the region for renewable energy resources such as biogas. Total emissions of fossil carbon dioxide have decreased by

more than 9,000 tons per year. Since 2002, all town buses are run on biogas and the air in Linköping town centre has become much cleaner, being almost free of particulate matter and sulphurous and nitrogenous compounds. In 2006, biogas accounted for 6% of the total fuel consumption in Linköping.

A great deal of effort has been put into optimizing the process, with the result that a planned third reactor is no longer necessary. Instead, the capacity of the existing plant has increased, partly by adapting the microbiological process, and partly by adjusting the substrate mixture. The proportion of energy-rich slaughterhouse waste in the substrate has successively increased, replacing manure.

Environmental issues have also received attention at the plant. For example, odour problems have been reduced by installing a compost filter and a biological reactor to treat wastewater from the upgrading plant. In addition, an 'odour panel' has been set up, consisting of 25 persons living in different parts of Linköping. These various measures have significantly reduced odour problems at the plant.

The biogas train is another example of the environmental benefits of biogas. The train was earlier driven on diesel, and the conversion to biogas has reduced emissions of greenhouse gases to near zero. Conversion to biogas was considerably cheaper than the alternative, which was to electrify the line between Linköping and Västervik.

Faktaruta 1. basic data on the biogas plant

Start year (biogas production):	1997
Digester volume:	2 x 3 800 m ³
Process temperature:	38 °C
Start year (upgrading):	1992, 1997, 2002
Upgrading method:	Water wash and PSA
Total investment costs:	c. 130 million SEK

Facts 2. Yearly inputs and outputs

Substrate:	
Slaughterhouse waste	22 000 tons
Food wastes and others	23 000 tons
Biogas:	
Upgraded biogas	65 000 MWh
Heat	1 600 MWh (newly installed, estimate)
Bio-manure:	
Certified bio-manure	45 000 tons

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Suppliers

Biogas plant	Läckeby (now PURAC AB) www.purac.se
Upgrading plants	Carbotech www.carbotech.com YIT Vatten och miljöteknik AB (finns ej kvar) www.yit.fi Flotech www.flotech.com
Filling stations	Processkontroll www.processkontroll.com
Gas pipelines	Stadspartner www.stadspartner.com