IEA Bioenergy Task 37

BIOGAS IN THE SOCIETY
Information from IEA BIOENERGY TASK 37 Energy from biogas and landfill gas

100% BIOGAS FOR URBAN TRANSPORT IN LINKÖPING, SWEDEN

BIOGAS IN BUSES, CARS AND TRAINS

SUMMARY

The Linköping Biogas plant in Sweden was started in 1997 in order to treat organic waste from the agricultural sector in southeastern Sweden. Another main purpose was to produce biogas for the urban city buses in order to reduce the local, regional and global emissions from the urban transport system.
The plant has an annual treatment capacity of 100,000 tonnes and produces 4.7 million m^3 of upgraded biogas (97% CH_4) that is used in 64 buses and a number of heavy and light duty vehicles. Since 2002 there are only biogas buses in the urban transport fleet and the CO_2-emissions have been reduced by more than 9,000 tonnes per year.

FACTS

- Treatment of slaughter house waste and industrial organic waste
- Start of operation: 1996
- Total biogas production: 7.7 million m^3/year
- Digester volume: 2 * 3700 m^3
- Upgraded biogas delivered to vehicles (97% methane): 4.7 million Nm^3/year (2005)
- Total investment : 14 million EUR
- 64 biogas buses
- 12 public biogas filling stations (2005)

The Linköping biogas plant
Photo: Svensk Biogas

BACKGROUND

Linköping is a city on the east coast of Sweden with 140,000 inhabitants. The city both has a university and a number of important industries e.g. SAAB Aero airplane assembly.
The city is located in the middle of an agricultural district on the plains of eastern Sweden. The prerequisites for building a biogas plants were thus obvious. The manure from cattle and pigs in the area could be co-digested with abattoir waste and organic waste from other food industries in the area.
In the early 90's the city of Linköping was in the process of converting the bus fleet to an alternative fuel in order to reduce the local pollution from diesel buses. The most interesting alternative was natural gas. The decisions to expand the natural gas grid from the south of Sweden up to the central parts of Sweden was delayed and the City of Linköping instead decided to use locally produced biogas as fuel in the urban bus fleet.
Linköping Biogas AB was formed in 1995 as a result of co-operation between the City of Linköping, the local abattoir (Swedish Meats AB) and the farmers association, Lantbrukets Ekonomi AB.
The company decided in 1995 to build a biogas plant to be able to supply all the city buses in Linköping with gas. The construction work started March 1996 and the plant was taken into operation in December 1996. From 2005 on the plant is owned and operated by Svensk Biogas (Swedish Biogas), a subsidiary to the City of Linköping.

PROJECT

Biogas plant

The Linköping plant handles 2,000 tonnes per year of animal manure and 36,000 tonnes/year of other waste materials, mainly waste from different food industries (waste fat, vegetable waste, slaughter-house waste etc.)
The plant was originally designed to handle 100,000 tpy including 25,000 tpy manure but this amount has been reduced to 2,000 tpy due to better gas yields from other types of raw material. In 2005 the total throughput was 45,000 tons.
Abattoir waste (blood, rumen content and process water) is pumped through a 1.7 km long pipeline from the source to the biogas plant in an underground pipeline. The same trench is used by the low pressure pipeline for upgraded biogas to the refuelling station for buses.
The rest of the abattoir waste is minced before it is transported on road to the biogas plant
The waste is mixed with manure at the biogas plant and then pasteurised for 1 h at 70°C. The material is then fed to the digesters.
The biogas plant has two conventional stirred tank digesters, each 3,700 m^3 with a residence time of 30 days. The process is operated at mesophilic conditions.
The digestate is removed continuously from the digester and stored at the plant for a few days before it is transported back out to farmers and used as biofertilizer.
The annual production of bio fertilizer is around 52,000 tonnes. The bio fertilizer has a dry matter content of 4.5% and a nitrogen content of more than 7 kg/nm^3. It is certified according to the Swedish certification system SPCR120 and thereby approved for recycling to farmland. The main part of the bio fertilizer is recycled to farms in the surrounding area, at present 17 farms.
The plant has been in operation since 1996 and has achieved high gas yield with a raw material with a very modest manure content and high loading. Methane yields of 1,000 m^3/ton VS have been reported.

Table 1: Linköping biogas plant – inputs & outputs (2005)

Input	tonnes/year
Manure for pigs and cattle	2,000
Abattoir waste	30,000
Industrial organic waste	6,000
Household waste	250
Others	7,000
Total	**45,000**
Output	
Certified bio-fertilizer to farming	52,000
Other	0
Total	52,000 [1]

[1] Water is added to the process to reduce the dry matter content in the digester

Biogas upgrading

Biogas from the sewage treatment plant has been upgraded since 1992 with a PSA-plant (Pressure Swing Adsorption) of an upgrading capacity of 200 Nm^3/h This plant was built to upgrade biogas from the sludge digesters at the adjacent sewage treatment plant. A new upgrading plant (pressurised water wash) with a capacity of 660 Nm^3/h was erected in parallel with the co-digestion plant and was taken into operation in 1997. A third pressurised water wash plant was built in 2002 (capacity: 1,400 Nm^3/h) in order to cope with the increasing market demand for fuel.
The biogas upgrading plants are located at the same site as the co-digestion plant.
The upgraded gas from the upgrading plant is piped to the bus filling station and two quick filling stations in a low pressure PE pipeline. The upgraded biogas is compressed to 250 bar at the filling stations before it is filled into the vehicles.
The gas production from the upgrading plants is approximately 5 million Nm^3/year, which corresponds to 5.5 million liter diesel.

Table 2: Linköping biogas plant – energy statistics (2004)

	MWh/year
Total biogas production	48,000
Biogas delivered to vehicles	45,000

Bus refuelling station

The upgraded biogas is used both in buses, trucks and in light duty vehicles (private cars, taxis and distribution vehicles).

Slow filling system for city buses in Linköping
Photo: Svensk Biogas

Linköping got the first 27 buses in 1997 and the number was increased to 45 buses in 1998. In 2000 60 buses were in operation on biogas and since 2002 all the diesel buses in operation in Linköping have been replaced by biomethane buses.
The buses all use the slow filling system i.e. the buses are parked adjacent to a gas nozzle that is connected to the bus in the evening and the bus is refuelled during the night. This refuelling strategy allows the gas storage capacity to be reduced to a minimum and also reduces the capacity requirements for the gas compressors.

Public refuelling stations

Svensk Biogas owns and operates 12 public refuelling stations in Linköping and in the surrounding area. The filling stations are used by private cars as well as by taxis and distribution vehicles from different companies. The filling stations are of two different types: stations connected to the low pressure pipeline for upgraded gas and filling stations where the gas is delivered to the station with a container system.

Public biogas refuelling station in Linköping
(Photo: Margareta Persson, SGC)

Biogas train

The worlds first biogas train headed down the track between Linköping and Västervik on the east coast of Sweden in June 2005. The train is converted from diesel to biomethane propulsion by changing the engine and equipping the train with storage cylinders for compressed biogas. The train has storage for 530 Nm^3 upgraded biogas and an operating range of 600 km. The train will operate on a railroad line that otherwise would have to be electrified to decrease the emissions from the train traffic. The change from diesel to biomethane was far cheaper than the electrification of the whole track.
By converting the train from diesel to biogas the conversion costs for the railway could be avoided which would have been much higher than the conversion costs for the train. The new biogas engine lowers the emission levels from Euro 1 to Euro 5 levels and brings down the greenhouse gas emissions to zero.

RESULTS

The Linköping biogas plant has made it possible for the city of Linköping to decrease the CO_2-emissions from urban transport by 9,000 tpy and also to decrease the local emissions of dust, sulphur and nitrogen oxides. The plant has also made it possible to replace artificial fertilizer by digestate and provided an environmentally sound process for treatment of the organic waste in the region.

Biogas train at the station in Linköping
Photo: Svensk Biogas

The biogas from the plant annually replaces 5.5 million l of petrol and diesel thereby decreasing the need for import of fossil fuels.

CONCLUSIONS

The biogas plant in Linköping is a good example of how a biogas plant can solve several environmental problems simultaneously. It provides a possibility to turn a waste material into a raw material for a process that produces a certified bio fertiliser and a vehicle fuel that substantially reduces both local and global emissions from the transport sector.
The novel approach to use biogas in a train has also received much attention and shows the versatility of upgraded biogas, a fuel that can be used in the same way and in the same applications as natural gas.

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