This is one of 12 case studies presented in the report "Biogas from manure, and waste products – Swedish case studies"
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The biogas plant in Västerås

Facts/unique: cooperation between interested partner organisations and individuals, with farmers participating actively in the project. The project is explained as a 'mechanical cow', which has been constructed to supply nutrients and organic matter to agriculture.

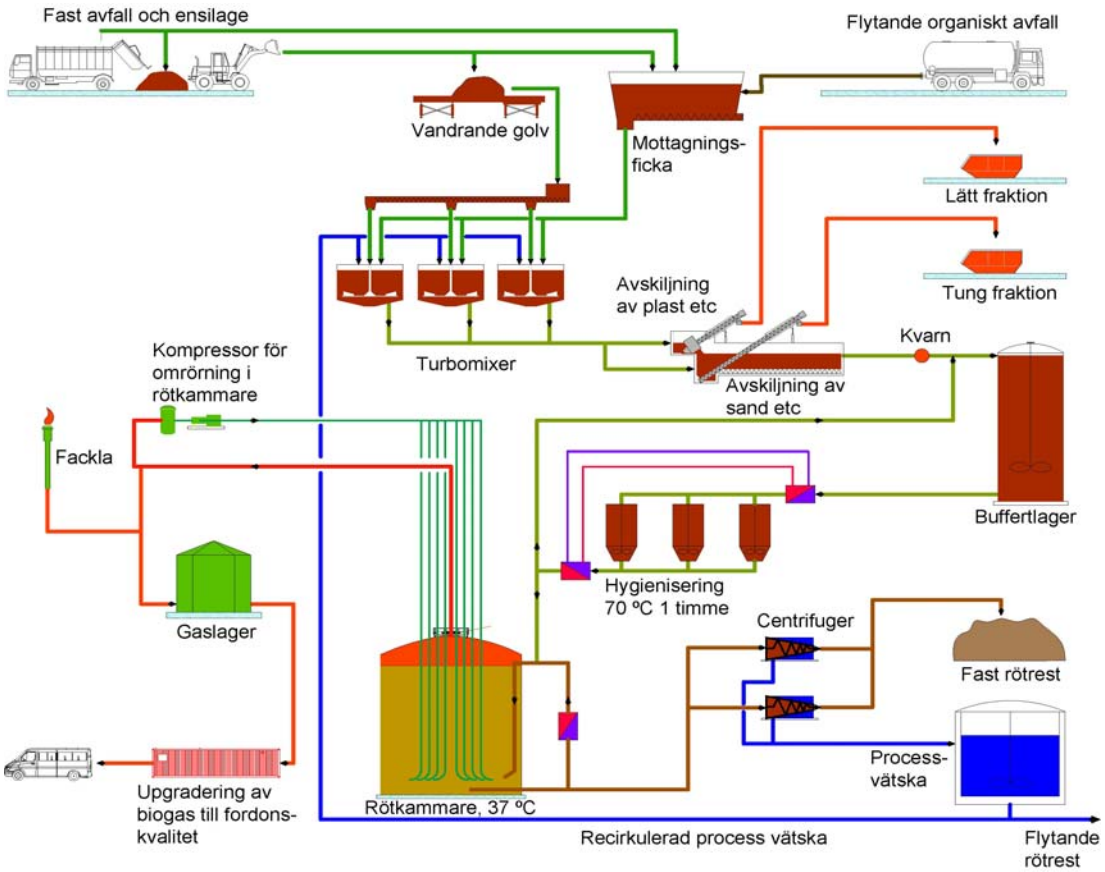

Figure 1 Diagram of the biogas plant at Gryta, Västerås

The 'Plant Power' project in Västerås was conceived in 1990 by some farmers in the district. Many farms in the area have no animals, so that their soils do not receive manure. Manure provides nutrients and humus, as well as contributing to an

improved soil structure. The farmers were advised to supply nutrients to the soil by applying mineral fertilizer. At the same time, a waste management company in the region, VafabMiljö, was planning to expand the biological treatment of food wastes from households and restaurants.

In 1995, the first plans were drawn up for a biogas plant that would digest both agricultural crops and household organic waste in the same process. The company 'Svensk Växtkraft AB' ('Swedish Plant Power' Ltd.) was formed in 2003. Many of those who took the first initiative are included in the group of 17 farmers who own 20% of the company. The other co-owners are VafabMiljö, LRF (the national farmers' organisation) and Mälarenergi (Mälar Energy). In the same year, 'Plant Power' became a demonstration project for optimisation of biogas production from organic waste and crops within the EU project 'Agroptigas'. In autumn 2004, the upgrading plant started operating and sixteen of the city buses began running on biogas. Initially, only the biogas produced at the town sewage treatment plant was upgraded. In the summer of 2005, a new biogas plant opened for co-digestion of household wastes and silaged ley crops at Gryta waste treatment plant outside Västerås.

The 'Plant Power' project is unique in its way, considering the degree of local involvement and collaboration between the local authority, energy companies and farmers, the composition of the substrate and the many benefits accruing to the environment. Digesting ley crops to produce a bio-manure that can be spread on purely arable farms is one way to maintain crop production in otherwise marginal rural areas suffering from poor profitability. The biogas plant can be seen as a 'mechanical cow', replacing the work carried out by ruminants. The application of bio-manure improves the nitrogen status and structure of the soil, and there is no need to buy mineral fertilizer. This means that the farmers participating in the 'Plant Power' project are contributing to maintaining a thriving rural landscape.

The biogas plant and substrate

The biogas plant treats food wastes, silaged grass ley and sludge from grease separators in a one-step continuously-mixed mesophilic (37°C) digester with a volume of 4000 m^3. The source-sorted household waste is collected in paper bags in ventilated containers. About 90% of the 144,000 households in the area participate. At the biogas plant, the waste is chopped up, mixed with water and pasteurized at 70°C for one hour, before it is fed into the reactor.

The farmers are contracted by the company to grow two or three-year leys on 300 ha of land, with a high proportion of clover to improve soil structure. The ley is harvested two or three times per year, in the same way as for normal large-scale silage production for cattle. At harvest, the crop is dried and chopped. It is then stored in air-tight plastic bags with a diameter of 3.5 m and a length of 80 to 90 m.

The silage is transported to the nearby biogas plant continuously during the year, and is fed into the reactor without any pre-treatment.

Figure 2 The silage is packed in plastic bags, Västerås

Upgrading and use of the biogas

Most of the biogas is upgraded to vehicle fuel. The remainder is used to produce electricity and heat. Upgrading takes place in a pressurized re-circulated water wash, with a capacity of 150 to 550 Nm^3 per hour. At full capacity, the system is fed with slightly less than 1 m^3 of fresh water per hour. The plant at Gryta produces biogas with an energy content of 15,000 MWh each year, equivalent to more than 1.6 million litres of petrol. The upgrading plant also receives biogas from the sewage treatment plant equivalent to 8000 MWh. The total amount of gas that can be used as vehicle fuel is therefore equivalent to 2.5 million litres of petrol.

Distribution of the biogas

The biogas is produced both at Kungsängens sewage treatment plant and at Gryta waste treatment plant, where the upgrading facility is also located. Pressurized raw gas from the sewage treatment plant is carried through an 8.5 km long pipeline to the upgrading facility at Gryta. The pipeline for the upgraded gas is laid, for the most part, in the same trench as the pipeline for the raw gas from the sewage treatment plant. Both pipelines are made of polyethylene and withstand a maximum pressure of 4 bars.

Another pipeline, which is c. 900 m long, takes the gas from Gryta that is not upgraded to a gas engine and boiler to produce electricity and heat. Optical cables

were buried in the same trenches as the gas pipelines for communication between the plants.

The upgraded biogas is pressurized at the bus depot in a compressor with a capacity of 400 Nm^3 per hour. The gas is stored in a 32 m^3 (wet volume) high pressure container that withstands a pressure of 350 bars. There is one station for quick re-filling of buses and refuse collection vehicles and another public filling station for cars. A store of liquid natural gas (capacity 21 tons, or 50 m^3) guarantees a supply of fuel to the city buses.

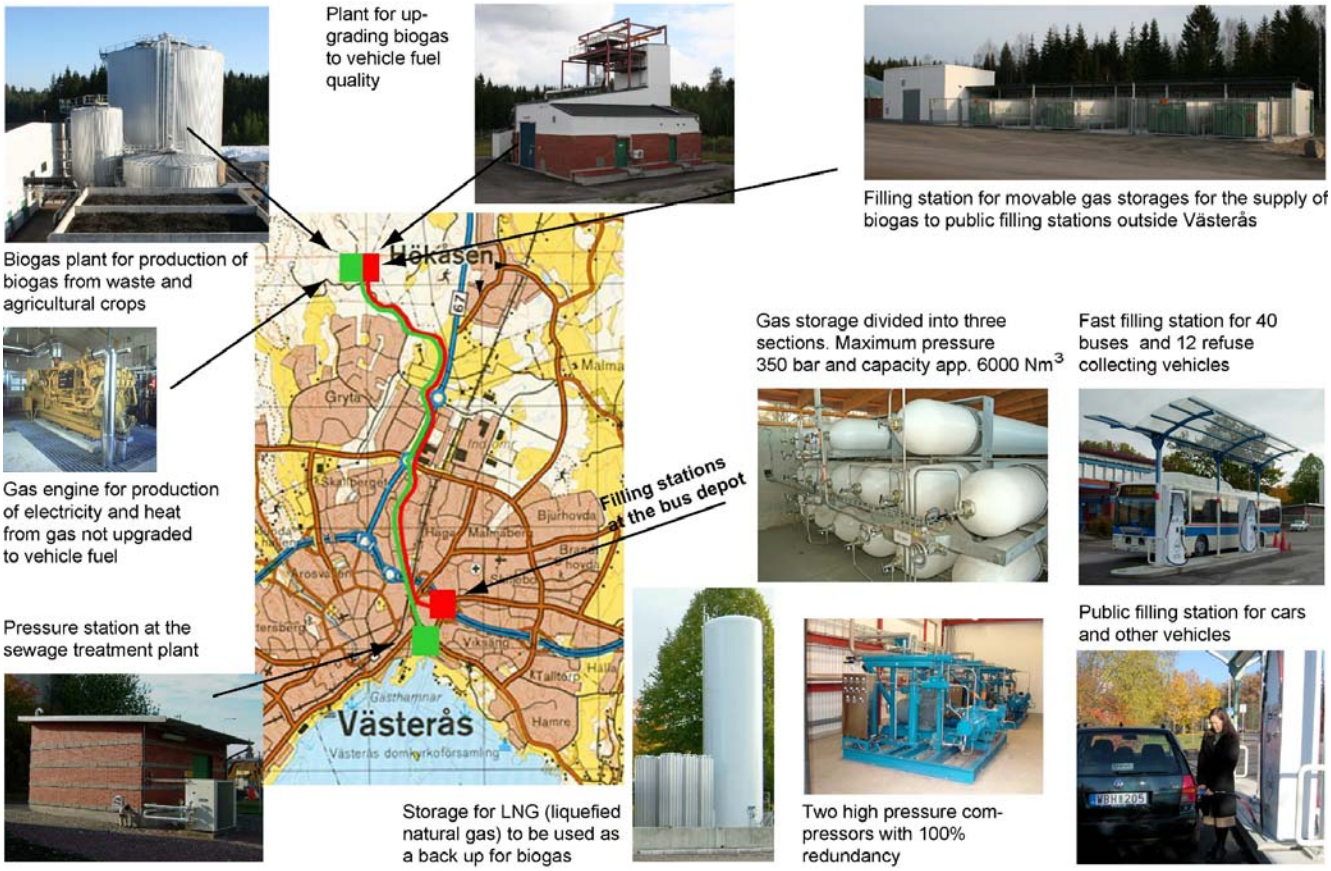

Figure 3 Schematic diagram of the system for gas distribution in Västerås

Bio-manure

The bio-manure is separated into solid and liquid phases. The solid bio-manure has a dry weight content of 25 to 30% and is handled as normal solid manure, with conventional solid manure spreaders. The liquid bio-manure, with a dry weight content of 2-3% is pumped and spread with conventional liquid manure spreaders. The division of the bio-manure into two phases also results in a partitioning of the plant nutrients and fibre content, so that the solid phase can be seen primarily as a phosphorous-rich soil conditioner, while the liquid phase is a nitrogen-rich fertilizer.

Financing

The project is financed by the share capital invested in the company by the owners, loans, investment support from the local investment program LIP, and support from the EU through the Agroptigas project. The development of biogas in Västerås has been an economically viable project.

Lessons learned

The construction of the plants went mostly according to plan and full production of biogas was achieved after the plant had been operating for c. one and a half years. At an early stage, the plant was complemented with an extra crusher and sieve for more effective pre-treatment of household waste. The technique of feeding the process with silage has taken some time to develop, but this has been working satisfactorily since 2008. One experience from the project is that all parties should be involved from the beginning and that legally binding contracts should be drawn up for the supply of raw materials and delivery of bio-manure.

Benefits for the environment and society

The 'Plant Power' project in Västerås is unique in its own way. The biogas plant is an important component of a complete system for re-cycling raw materials, waste, nutrients and energy between urban and rural areas. Farmers participate actively through their co-ownership of a company that links together the activities of the local authority with waste management and energy generating companies. The project has many winners, not least the farmers themselves who, after digestion, receive a high-quality fertilizer. This makes ecological farming economically favourable, even without access to animal manure.

To date, the project has resulted in energy savings in the form of fossil fuel equivalent to 2.5 million litres of petrol per year. The amount of organic waste incinerated has decreased by 14000 tons per year. The reduction in fossil carbon dioxide emissions has been calculated at 5500 tons per year. The bio-manure delivered from the plant returns c. 1000 tons of organic matter, 100 tons of nitrogen, 11 tons of phosphorous and 60 tons of potassium to arable land each year.

Facts 1. Basic data on the biogas plant

Start year (biogas production):	2005
Digester volume:	1 x 4 000 m^3
Process temperature:	37°C
Start year (upgrading):	2004
Upgrading method:	Water wash

Facts 2. Yearly inputs and outputs

Substrate:	
Source-sorted organic household waste	14 000 tons
Sludge from grease separators	2 000 tons
Silaged ley crops	5 000 tons
Biogas:	
From the biogas plant	15 000 MWh
From the sewage treatment plant	8 000 MWh
Upgraded biogas	23 000 MWh
Bio-manure:	
Solid bio-manure	3 500 tons
Liquid bio-manure	13 000 tons

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Suppliers

Biogas plant:	Ros Roca International AS www.rosroca.de
Upgrading plant and filling station:	YIT Vatten och miljöteknik www.yit.fi
Gas pipelines and storage tanks:	Lindesberg Grus och Maskin Telephone: +46 581 176 75