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The biogas plants in Stockholm city

Facts/unique: Ambitious development plans to increase biogas production and distribution. Upgrading of biogas at one of the world's largest underground sewage treatment plants.



Figure 1 Biogas bus in Stockholm

Two sewage treatment plants in Stockholm, Bromma and Henriksdal, upgrade the biogas they produce to vehicle fuel quality. Both plants are briefly described below.

Bromma (earlier Åkeshov/Nockeby) was the first sewage treatment plant in Stockholm. It opened in 1934, and since then the plant has been extended and improved in several stages. The plant now has 42 purification basins, and the average inflow of wastewater to the plant is 130,000 m³ per day. The treatment

process includes chemical purification by precipitation with iron sulphate, sedimentation, aeration, anaerobic digestion, nitrogen removal and filtration. Anaerobic digestion takes place at the plant in Åkeshov, while the aeration basins are located at Nockeby. From Åkeshov, the water flows under gravity c.600 m to the Nockeby plant for further treatment.

The facility at Henriksdal is one of the world's largest underground sewage treatment plants. The first nine purification basins were constructed in 1941, and a further 25 were built in the years up to 1971. After several purification steps, including sedimentation and aeration, the clean water is discharged into the lake Saltsjön. The plant at Henriksdal treats up to 370,000 m³ of wastewater per day.

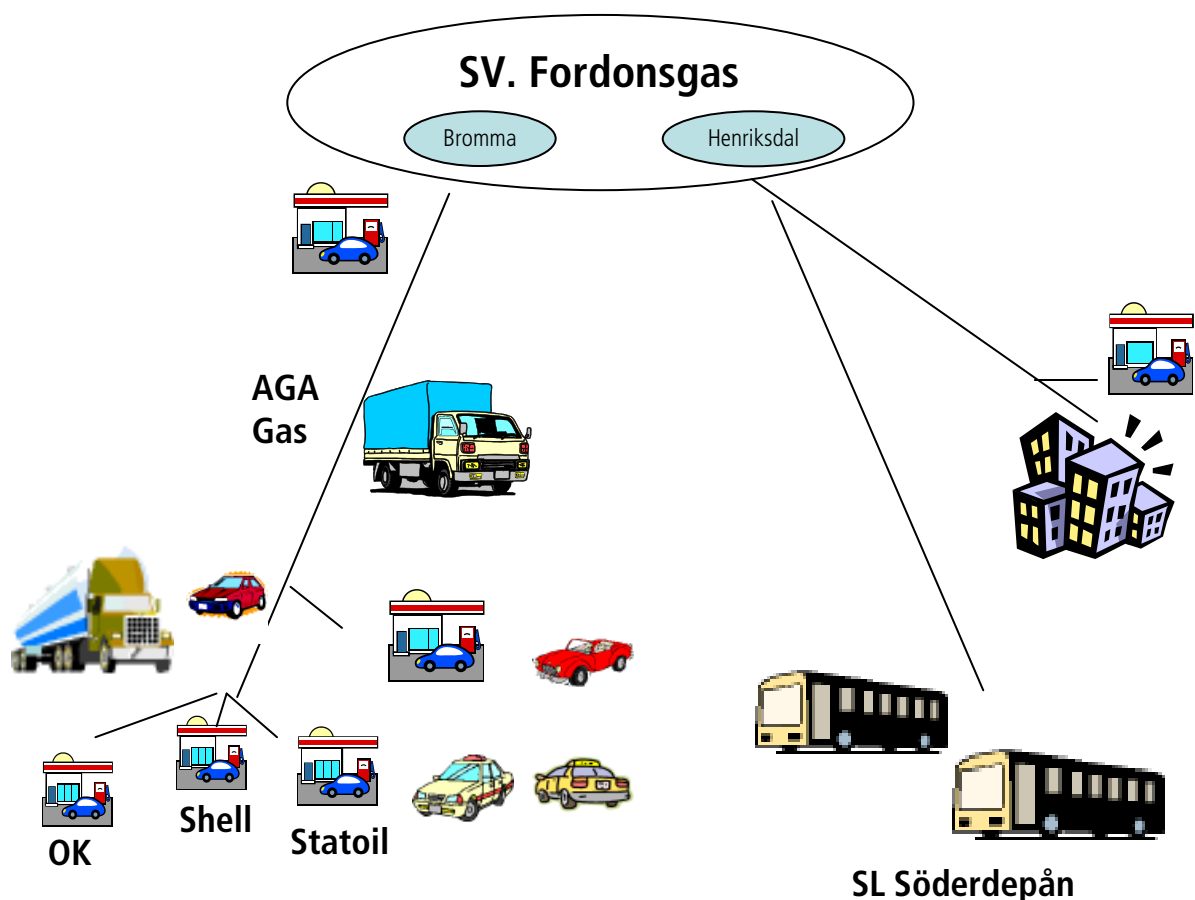


Figure 2 Distribution of the biogas from the plants in Bromma and Henriksdal.

The local authority in Stockholm and Stockholm Vatten (Stockholm Water), who run the treatment plants, have long had the goal of increasing the use of biogas as a vehicle fuel. One example is the project 'Environmental cars' in Stockholm, which distributes EU grants to companies and organisations that invest in biogas vehicles. A pilot-scale upgrading plant started operating in Bromma as early as 1996. Large-scale upgrading started in 2000, and an upgrading plant began operating at Henriksdal in 2003. A number of biogas filling stations have opened and more and

more biogas cars are being bought. The demand for biogas is therefore greater than the supply, so that plans are underway to further increase the production and availability of biogas in the greater Stockholm area. This is a collaborative effort involving Stockholm Water, the city of Stockholm, Stockholm Gas AB, Aga Gas and Greater Stockholms Lokaltrafik (SL, the public transportation company in Stockholm).

The biogas plant and substrate

Only sewage sludge is digested at Bromma. Anaerobic digestion takes place in six reactors with a total volume of 12,000 m³. The processes are one-step and continuously-mixed, with a temperature of 35 to 37°C and a retention time of 20 days. A new reactor 6,000 m³ in size, is being built (2008).

The first reactors at Henriksdal were built during the 1940's. Sewage sludge is the main substrate, with 600,000 tons digested every year. Apart from sludge from the sewage treatment plant, the substrate consists of organic material in the form of fats from the city's 2,000 grease separators (c. 25,000 tons per year) and smaller amounts of food wastes from restaurants and shops (c. 2,000 tons per year). In total, the substrate comprises 80-85% sludge, 15-20% fats and 1-2% food wastes. The imported substrate is mixed with the sludge and digested in seven reactors with a total volume of 39,000 m³. The process is one-step, continuously-mixed and mesophilic (35 to 37°C), with a retention time of c. 19 days.

New production

Stockholm Gas AB, a subsidiary company wholly owned by Fortum Värme, is planning a new production plant for biogas. The plant will produce c. 100,000 MWh of upgraded biogas per year from crops and the waste products of the agricultural and food industries. The intention is to locate the plant next to the Sofielund landfill in Huddinge.

The new liquid natural gas (LNG) plant that will replace the town gasworks at Värtan will be located next to the biogas plant. Town gas has been produced from naphtha (light petrol) at Värtan since 1971. The gasworks will be decommissioned from 2010 to make way for new offices and homes. The gas from the new plants in Huddinge will be distributed to Stockholm in a new pipeline to Hammarby.

Upgrading and use of the biogas

Nowadays, most of the biogas produced at Bromma and Henriksdal is upgraded to vehicle fuel quality. Previously, the biogas was used to heat plant buildings and, at Henriksdal, to generate electricity. Both Bromma and Henriksdal are now heated through the district heating network. The upgrading plant at Bromma uses the PSA technique and can purify c. 30,000 MWh of biogas per year. The upgrading plant at Henriksdal uses the water wash method and can purify up to c. 69,000 MWh of

biogas annually. Together, the plants currently produce c.55,000 MWh of upgraded biogas per year. A small amount of the upgraded gas (c.2%) is used in household gas ovens in Hammarby sjöstad (a Stockholm suburb), while the remainder is used as vehicle fuel. The upgraded biogas produced at Bromma and Henriksdal replaces c. 60 million litres of petrol per year. There are also plans to run city ferries on biogas.

The production of biogas is expected to increase at both Bromma and Henriksdal as a result of optimisation of the processes and selection of new substrate mixtures (i.e. more food waste). Sewage treatment plants at Lidingö (Käppala) and Södertälje (Himmerfjärden in Grödinge) are also planning to increase biogas production, as well as begin upgrading to vehicle fuel quality.

Distribution of the biogas

Some of the biogas produced at Bromma is distributed through a pipeline to the Shell filling station located at the entrance to the Åkeshov plant, and some by container transport (Aga) to public filling stations in the Stockholm area. Upgraded gas from Henriksdal is transported in a c. 2 km long pipe under a pressure of 4 bars to SL's bus depot at Söderhallarna, where it is compressed to 350 bars and used to run biogas buses. Today, SL has 50 biogas buses, but intends to increase this number in the future. Biogas from Henriksdal will then support 140 of SL's buses. Another pipeline transports gas to Fortum, who supply gas to ovens in 1,000 apartments in Hammarby sjöstad. A biogas filling station is also located in the area.

Aga Gas also collects biogas from Henriksdal to deliver to public gas filling stations. Aga Gas collect on average 5 loads of upgraded biogas in containers from Bromma and Henriksdal daily, equivalent to half of the daily demand in the Stockholm region. Aga Gas build and manage the compressor stations for biogas and are continually increasing the number of filling stations in the greater Stockholm area, in collaboration with Shell, Statoil, OK/Q8, among others. There are today (March 2008) 11 gas filling stations in the Stockholm area.

Stockholm Gas is planning to build a new pipeline network to distribute vehicle gas (mainly biogas), making use of disused sections of the 800 km long town gas network. The network will be constructed in stages, depending on demand, and the first sections are expected to be operational in 2009. In the long run, the network should link several of SL's bus depots and filling stations with the city's sewage treatment plants.



Figure 3 Map of existing (green dots) and planned (red dots) filling stations in Stockholm (March 2008).

Aga Gas has built a depot for LNG in Knivsta. The depot acts as a reserve in case the biogas runs out. The gas is distributed to filling stations in containers. Aga Gas is also planning to establish an LNG plant in Nynäshamn together with Nynäs Refinery.

Digestion residue

The residues from digesting the various substrates (sludge, food wastes, fats) at Henriksdal are de-watered together. The de-watered digestion residue is used as a soil material to remediate mine wastes at the Aitik mine near Gällivare. Plants are able to establish themselves in the mine waste areas by utilizing the nutrients in the digestion residues. De-watered sludge from Bromma is mixed with ash and used as a cover material at the disused landfill at Lövsta. Roughly 75,000 tons of de-watered sludge is produced annually at Stockholm Water's plants.

Financing

The total investment cost for the upgrading facilities at Bromma and Henriksdal was 134 million SEK. This was mostly self-financed, although a grant worth 27 million SEK was received from LIP in 1998. Together with the city of Stockholm, Fortum Värme received a KLIMP grant in 2007 to build the new biogas plant for

digestion of agricultural crops. In the short term, the income generated will just about cover these investments costs. In the longer-term, they are expected to become profitable.

Lessons learned

The extensions to the upgrading plants were completed according to schedule, but the cost was greater than budgeted for. One reason may be that the upgrading technique is relatively new and untested. Up to now, the distribution system for gas in Stockholm has been inadequate, and there are too few filling stations. It is very important that the entire biogas system works satisfactorily, from production through to distribution and marketing. Planning is made difficult by some key factors which are uncertain and continually changing, for example taxes, prices and market conditions.

Benefits for the environment and society

The efforts at Henriksdal and Bromma waste treatment plants to develop biogas as a vehicle fuel have led to the establishment of a market for biogas in greater Stockholm. Interest is increasing in the Stockholm region in the use of biogas as an environmentally-friendly vehicle fuel. As a result of these recent developments, emissions of fossil carbon dioxide have so far decreased by c.14,000 tons per year. Biogas cars are exempt from the Stockholm traffic congestion toll charges. The more biogas replaces petrol-driven cars, the cleaner the city centre air in Stockholm will become. This has long been the objective of both the municipality of Stockholm and Stockholm Water, and there is now a political will to develop biogas in the city of Stockholm. The great interest in biogas cars has led to a situation in which fuel supplies sometimes run out. However, the efforts being made to increase production and improve the 'back-up' should resolve these problems and finally establish biogas on the market in Stockholm. This will benefit the environment in the coming years.

Facts 1. Basic data on the Bromma plant

Start year (digestion):	1934
Digester volume:	7 reactors, total volume 18000 m ³
Process temperature:	35-37°C
Start year (upgrading):	1996, 2000
Upgrading method:	PSA
Investment costs (upgrading):	35 million SEK

Facts 1. Basic data on the Henriksdal plant

Start year (digestion):	1941
Digester volume:	7 reactors, total volume 39000 m ³
Process temperature:	35-37°C
Start year (upgrading):	2003

Upgrading method:	Water wash
Investment costs (upgrading):	99 million SEK

Facts 2. yearly inputs and outputs, Bromma

Substrate:	
Sewage sludge	12000 tons dry weight
Biogas:	
From the biogas plant	21 000 MWh
Upgraded biogas	19 000 MWh
Digestion residue:	
De-watered sludge	19 700 tons (31.6% dry weight)

Facts 2. Yearly inputs and outputs, Henriksdal

Substrate:	
Sewage sludge	27 000 tons dry weight
Source-sorted food waste	2 000 tons
Fats	c. 25 000 tons
Biogas:	
From the biogas plant	65 000 MWh
Upgraded biogas	58 000 MWh (maximum)
Digestion residue:	
De-watered sludge	56 500 tons (27,5 % dry weight)

Contacts

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Suppliers

Upgrading plant, pipes, gas pipes, filling stations	<p>Läckeby Water www.lackebywater.se</p> <p>Malmberg www.malmberg.se</p> <p>Carbotech www.carbotech.com</p>
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