

## Green gas on the move in Sweden

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### **SUMMARY**

Although a transmission pipe for natural gas reached Sweden in 1986 it came late and became a limited contributor to the nation-wide energy supply, as it still is geographically limited to the south west part of the country. However, in spite of these facts gas is currently receiving more interest than ever before in all Sweden. This has to do with the purposeful utilization of waste from different parts of the society as a raw material for the production of green gas. This green gas first came in the form of landfill gas, later in the form of biogas from anaerobic digestion and recently in the form of biomethane from gasification of wood residues and today also includes bio-DME. Today Sweden is home to some 250 production units for green gas. And unlike continental Europe, the vast amount of this gas is not used for heat and power, but as a vehicle fuel. However, in a country largely lacking a transmission infrastructure this means that big volumes of gas are transported on truck in compressed form. Liquefaction of biogas is also being made and in a near future rail transportation of liquid methane will also become a reality. This paper discusses how different policies have singled out Sweden as a key player in green gas manufacture and utilization. An overview of the remarkable journey from an almost white spot on the world gas map in the 1980's to a leading green gas nation is given, with a number of examples, also including the extensive use of biogas as a transportation fuel for buses, taxis – and also for a steadily growing number of private cars.

### **Early history**

#### Towngas

Town gas was the first modern infrastructure to be built in the cities marking the starting point of the industrial revolution. The towngas was introduced with the purpose of lighting up the city streets in an efficient way. The first streetlight in London was lit already in 1807, whereas Göteborg in Sweden – being home to the first towngas works in Scandinavia – started its production at first in 1846. Later on – just before the turn of the century, towngas found a new and more important market for stoves and indoor lighting (Kaijser 1986). At the same time the byproduct of towngas manufacture – cokes – became a valuable fuel for heating city homes. Towngas was the answer to many of the challenges of the time.

#### Towngas in Sweden

Towngas was introduced in a total of 37 cities between 1846 and 1918 (Ragnar 2008). Notable two of the twenty largest cities – Borås and Halmstad – never got towngas. In addition, no towngas works were built north of Sundsvall and Östersund, being located in the geographical midth of Sweden. From the beginning many towngas works were built by private companies, but at the turn of the century all works were municipally owned. However, the eight works built during the 1910's were all private investments and kept private for their lifetimes. Compared to continental Europe towngas never became the single answer to the energy challenges of the cities – not even during the 1890's just before the introduction of electricity. This is in large contrast to the situation in many continental countries. Denmark for example had a total of 112 towngas works (Thomsen 2011) serving a population roughly half of that of Sweden.

### **Sweden goes green when Europe fights**

Sweden's resources of coal are very limited. Accordingly, although Sweden did not participate in neither WW1 nor WW2, these wars meant problems for the towngas works relying on imported coal for the process. Partly imports managed to be continued, but partly domestic fuels in the form of biomass including torf had to replace coal. Long-term this meant that experiences were gained of using biomass for gas production.

### **The oil and gas revolutions**

#### Cheap oil

Following WW2 cheap oil in large amounts quickly became available. Initially this posed a threat primarily at the use of cokes for heating as the oil was perceived as cleaner and easier to handle. With the cokes market falling so did the production economy of the towngas works. However, the bigger the city the bigger the previous investments in infrastructure had been and thus a big city usually takes longer time to complete a

change. Small town gas works began to be closed down in Sweden starting in Mariestad already in 1949 (Ragnar 2008) and at the same time also in continental Europe.

However, cheap oil also meant an opportunity for the town gas works. Would a total gasification of the fuel be possible, then no low-priced byproduct would spoil the business. Cracked gas production using cheap petroleum-based naphtha presented the solution. However, electricity was also becoming less costly and in order to survive long-term the town gas works required new customers. The obvious market was for heating of houses and for industrial use.

### Natural gas found

Natural gas has been known for long. In early days drilling for oil and finding gas was considered a failure or at least a problem. Over time the attitude changed. The first shipment of liquefied natural gas from the US to the UK took place in 1960 and in 1963 the first transmission grid for transmission of large amounts of re-gasified natural gas made from LNG was opened in the UK. In the late 1950's, large amounts of gas was found in the Groningen region in the Netherlands. From here a transmission network for an efficient sales of natural gas to other towns in the Netherlands but also to other countries started in 1963.

The very first long transmission pipe for gas had been built in the US already in 1872 and there were long distance pipes in Europe at least also in the early 1950's. However, they were few and they were the exceptions to the rule that told that town gas was manufactured and consumed within a certain city. The introduction of natural gas clearly changed this situation fundamentally.

## **Cold war and independence**

### Sweden's neutrality

Sweden's neutrality policy grew particularly strong following WW2. Joining neither NATO nor the Warsaw pact Sweden tried to build a largely self-sufficient society. This policy *e.g.* led to large R&D spendings on the development of a nuclear power program relying on domestic uranium-238 resources. The program also had a military dimension and was the guiding star at least up until the mid-1960's, when policy was changed in favour of imported uranium-235 with no more military dimensions. During WW2, also a domestic fuel production had started with petroleum being produced from pyrolysis of oil shale. Also methane production from the same location was considered. In the mid 1950's, a transmission pipe for gas from this production site south of Örebro 200 km to Stockholm was seriously considered (SOU 1956:58). However, the petroleum production was not profitable and the plant was finally closed down in 1966 (Ekberg). The company running this business had been formed in 1940 and was a state-owned company called Svenska Skifferolje AB (SSAB). The self-sufficiency policy during the 1950's and early 1960's was in line with closure of town gas works, whereas policies in continental Europe were contrary. Within Western Europe, the embryo of the coming European Union was born and extending transmission grids for gas to a country like Italy was considered important also for cold war political reasons.

### No more cheap oil

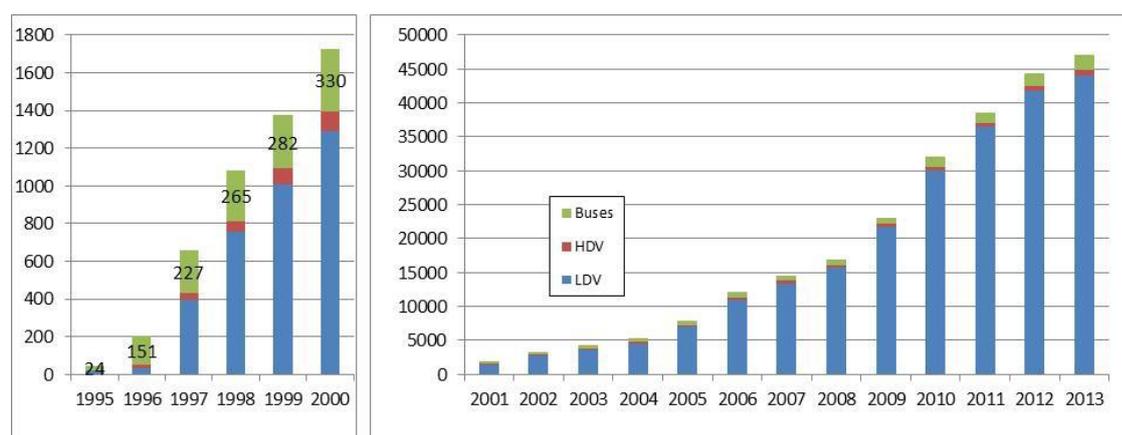
The first oil crisis hit the western world in 1973. Among many things, it meant that naphtha no longer was a cheap raw material for cracked gas production. In those parts of Europe where old town gas systems had not yet been interconnected with transmission pipes for natural gas supply, the town gas was now under strong pressure. In Denmark it was decided to start looking for domestic natural gas resources. Gas was also found here. In Sweden the immediate reaction instead was energy economization starting to insulate houses. However, in 1980 the Swedish parliament also decided to introduce natural gas also in Sweden through a future transmission grid from Denmark. The grid was opened in 1985. However, this was at a very late date, when most of the town gas works had already been closed down. Not even the town gas distribution grid in Helsingborg being one of the very first cities in Sweden to be connected to the transmission grid was kept more than marginally in spite of town gas production running there all the way until natural gas reached the city in 1986.

## **A green agenda**

### Environmental movement

If natural gas replacing town gas was seen as a big step forward in terms of perceived environmental awareness in continental Europe primarily during the 1960's and 1970's, introducing natural gas as a new source of energy in Sweden in the mid 1980's had a different political message. Although the natural gas replaced town gas in the cities of Malmö and Göteborg – town gas here had already become a marginal business. And although natural gas replaced oil in industries the mere aspect of industrial production was starting to be perceived as environmentally problematic in Sweden in those days. The natural gas therefore met difficulties. In Helsingborg the city even tried to escape from the entire project in the early 1980's although having signed a contract a few years earlier.

The growing environmental awareness in Sweden during the 1970's and 1980's meant an increased interest in alternative fuels for city buses in order to improve city air. Falde shows in a dissertation comparing the cities of Linköping and Helsingborg the differences in how gas was introduced as fuel for city buses (Falde 2011). In Linköping the first steps were taken in the early 1990's and done so with locally manufactured biogas as the only source of gas. In Helsingborg, the availability of natural gas already in the late 1980's turned out to be problematic rather than beneficial in the selection of an alternative fuel. Ethanol was chosen – largely because ethanol was at the time perceived as domestically produced and renewable at the same time as natural gas was perceived as imported and fossil. Later on – in 2003 – policies changed in favour of gas, when biogas was now available and perceived locally produced whereas ethanol to a larger extent became an imported commodity. This change partly was a result of lifting the public transportation issues from the primary municipal level to secondary level being the regional one. In Figures 1a and 1b the development of the number of gas propelled vehicles are given over time.



Figures 1a and 1b. Number of gas propelled vehicles in Sweden over the years. The crucial role city buses played in the early years is apparent from Figure 2a. Given the fact that heavy vehicles consume fuel corresponding to some 20–30 private cars the importance of such vehicles is easily missed in the statistics. As of today about half of the CNG sales in Sweden goes to buses.

#### Organization, legislation and incentives as drivers

Crucial for the large scale introduction of biogas as a vehicle fuel in Sweden has been the organization and co-operation of municipal and/or municipally governed stakeholders. Setting up a biogas production facility is simply not done if there are no customers which you could rely on will buy the gas in large volumes for a long time. The municipalities govern both city busses and local energy companies. Using their power they could thus tell the local energy company to set up a biogas production unit and at the same time tell the public transportation company to buy biogas buses and make a long-term contract with the biogas supplier. This set up has proven very fruitful in the Swedish context. When the city busses started using biogas, soon could recycling trucks and taxis follow and when there was a filling station also private persons could buy a CNG car knowing that they could fill it up for a long time to come.

A new legislation banning landfilling of organic waste came into power in Sweden in 2005. This meant that the municipalities had to find new ways to get rid of their waste. Anaerobic digestion clearly presented an interesting alternative since it also meant that other important issues in the municipal context could be addressed at the same time – green fuel could be produced and used locally, new green high-tech-jobs could be created and a model of the circular society with recycling as a self-evident component could be established and communicated to the citizens.

Organization and legislation both were important. However, economical incentives were also required to boost the development. Municipalities and their energy companies could run projects perceived as good and rewarding without large economic profits – but, running projects with an annual loss would normally not be accepted long term. Through state initiatives economical support were given to partly finance the construction of biogas plants for some ten years starting in the early 2000's.

#### **Current status**

The current status of the Swedish gas industry is such that 18 TWh energy is consumed in the form of gas in Sweden per year, making up 3 % of the total energy supply. Natural gas is supplied from Denmark to a national grid limited to the south and west parts of Sweden, Figure 2.



Figure 2. The Swedish gas grids – existing grids in blue colour and visions for the future in beige colour – existing LNG terminals in blue and visions in orange. Source: Swedegas AB.

In a number of bigger towns local distribution grids for biogas prevail, usually linking a biogas production unit to a local filling station for CNG buses or cars. About 20 % of the buses used for public transportation in all Sweden run on CNG and in many cities all buses run on biogas. There are about 250 biogas production units in

operation in addition to the GoBiGas demonstration plant for gasification of forest waste. One unit for the production of liquefied biogas – LBG – is in operation since 2013. Linked to the anaerobic digestion plants are about 60 upgrading units for the production of biomethane. An innovative set-up of four farm-scale biogas plants interlinked with raw biogas pipes have a joint central upgrading unit and attract a lot of interest. Finally, as a result of the great interest in biogas production from the Swedish market technology suppliers have also grown strong and begun their international expansion including companies like Biogas Systems, Malmberg Water, MGE-Teknik, Purac, Scandinavian Biogas Fuels, Swedish Biogas International and others.

### **Analysis**

The introduction of natural gas in Sweden came late – too late to interconnect more than a couple of the once 37 town gas systems in the country. Gas was thus perceived a new energy source with fossil origin, rather than a clean continuation of the dirty town gas industry. With no domestic natural gas resources of any size no production economy able to carry investments in domestic transmission grids for gas prevailed. Neither did the Swedish state any take any lead in constructing any national grid for gas until the early 1980's. But also at this time the state was involved in the grid project only a few years before leaving the project in the hands of the private sector – contrary to *e.g.* the case for transmission of electricity in Sweden. It seems that the bigger the stake holder – private or official – the more interested they all become in large scale solutions, speaking in favour *e.g.* of a transmission grid. On the other hand – the more locally policy making has been made, the more focus has been devoted to a locally sustainable society which could be manifested in setting up a system for local biogas production and use of this biogas in the city buses. The existence of a natural gas grid all over continental Europe could, as the Helsingborg example shows, rather have delayed than supported the development of a local biogas production and market. Given the preferred policy from the 1970's to insulate houses as a reaction to increased oil prizes, the market for gas for heating definitely disappeared. Looking for local opportunities for biogas has therefore for obvious reasons been focused on biogas as a transportation fuel used at first in city buses and garbage trucks, later on in taxis and then in private cars.

### **Conclusions**

The development of a green gas sector does not necessarily benefit from the existence of a natural gas grid. On the contrary – the lack of a natural gas grid could be perceived as a positive factor to ensure that only renewable gas is bought and sold. Arguments for biogas include ecology, renewability and fighting climate change – but also has a dimension of independence, job creation and social sustainability. Strong municipalities with power to decide on policies both for public transportation and for energy and recycling have the power to create new systems fostering biogas production as well as biogas utilization. Eventually, when many municipalities follow the same path private supplier companies are created to take advantage of the evolving demand. Having grown on the domestic market some of these will become big exporting companies important for both the profile and the economy of the country.

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