IEA Bioenergy Task 37

BIOGAS IN SOCIETY
A Case Story from
IEA BIOENERGY TASK 37
"Energy from Biogas"

NON-GRID BIOMETHANE TRANSPORTATION IN SWEDEN AND THE DEVELOPMENT OF THE LIQUEFIED BIOGAS MARKET

PUBLISHED: SEPTEMBER 2014

INTRODUCTION

In most countries in Europe, where most of the residential and industrial sector have access to the natural gas grid, it is obvious that biomethane should be transported through the gas grid. However, in countries such as Sweden where the gas grid coverage is more limited and restricted to only a part of the country, other solutions have to be implemented. Today, only 8 of the 55 biogas upgrading plants are injecting biomethane into the national gas grid in Sweden. The remaining facilities are using alternative solutions to distribute the produced biomethane to the end-users.

Sweden is world leading both in terms of automotive use of biomethane and its non-grid based transportation. The biomethane is mainly transported in its compressed state in mobile storage units, but also in its liquefied state and by way of local gas grids. Since 2012, liquefied biogas (LBG) is produced in Sweden at the Lidköping Biogas Plant (see Figure 1). Besides increasing the economic distribution range of the biomethane, the production of liquefied biogas also widens the market scope of the fuel, making the fuel more attractive for long-distance road haulage applications.

Figure 1: Aerial view of Lidköping Biogas plant. The digesters can be seen in the top left corner of the picture, with the water scrubber for biogas upgrading adjacent. Next to that is the liquefaction plant and at the front of the site is the refuelling station (bottom right of picture). Photo: Gothenburg Energy

WHEN SHOULD BIOMETHANE TRANSPORTED BY ROAD BE LIQUEFIED OR COMPRESSED?

The relationship between transport distance and transported volumes for different upgrading and distribution alternatives available on the market has been examined in a Swedish study (Benjaminsson and Nilsson, 2009, "Distributionsformer för biogas och naturgas i Sverige"). For road transport up to distances of 200 km, the best option for all volumes is transport in the compressed state, whereas transport economics for longer distances are better for the liquefied state. In addition, when trying to handle larger volumes of compressed biomethane by road transport, the logistical challenges may offset the economic advantage.

The energy density of liquefied methane (LNG for natural gas, LBG for renewable) is much higher than the one of its compressed counterpart (CNG for natural gas). Also, it is carried in less heavy containers, resulting in a five times better transport economy compared to CNG at 260 bar. This is one of the main drivers behind the construction of the first LBG plant in Lidköping in Sweden, in operation since 2012. The biogas plant produces more biomethane than the local market requires so the excess biomethane has to be transported to reach a market with sufficient demand, in this case Gothenburg. Data for the biogas plant in Lidköping are given in Table 1.

Table 1: Data for the Lidköping Biogas Plant

Energy production	60 GWh (annually)
Production capacity	1.2 m^3 LBG/hour
Feedstock	Waste from the food industry
Upgrading technology	Water scrubber
Gas polishing	VPSA
Liquefaction technology	Reverse Nitrogen Brayton Cycle

To liquefy the biogas, hydrogen sulphide, water and carbon dioxide have to be removed to levels that are much lower than normally required during biogas upgrading. Today, only the amine scrubbing technology and cryogenic upgrading have the potential to achieve this high purity in one step. Other technologies have to be combined with an additional polishing step before liquefaction. This is commonly achieved by a type of pressure swing absorption technology. The LBG is subsequently produced by using different cryogenic technologies, such as reverse nitrogen brayton cycle or mixed refrigerant cycle. Existing biomethane liquefaction plants are operating in Sweden, Norway, UK, The Netherlands, USA and soon also in the Republic of the Philippines.

Figure 2: The first refuelling station for liquefied methane in Sweden opened in 2010. Photo: FordonsGas Sverige AB

A GROWING MARKET FOR LIQUEFIED METHANE

The first refuelling station for liquefied methane in Sweden (see Figure 2) opened in 2010 together with the introduction to the Swedish market of the first truck powered by liquefied methane. Currently, there are around 70 trucks that run on liquefied methane (August 2014).

Today there are six refuelling stations for liquefied methane in Sweden, with additional stations being planned. Globally a similar strong development can be seen in other countries, especially in China and USA, but also in the UK, Spain and the Netherlands, with more countries to follow. A distinguishing trait of the Swedish market is the significant fraction of renewable liquefied methane being sold. In all other markets natural gas is dominating. Likewise, liquefied biomethane is produced and used as automotive fuel to some extent in the USA and in the UK.

BiMe-TRUCKS PROJECT – DRIVER FOR THE SWEDISH LBG DEVELOPMENT

BiMe-Trucks, a project financed by the Swedish Energy Agency, has been an important part of the Swedish LBG development, coordinating refuelling stations construction and vehicle introduction. The aim of the project was to erect LNG refuelling stations and to develop, offer and deliver to market LNG/LBG powered road haulage trucks equipped with energy-efficient methane diesel engines (see Figure 3). Within the project three refuelling stations were constructed and 48 vehicles were delivered to customers. This project

Figure 3: Dual-fuel truck that is powered simultaneously by liquefied methane and diesel (dual fuel). The LBG/LNG storage tank is clearly visible on the side of the truck.

built a considerable amount of know-how on how to use liquefied biomethane as a vehicle fuel for heavy-duty vehicles. Knowledge was developed and transferred between the partners of the project that included the leading vehicle fuel producer and gas distributors within this field. A similar project, LNG Blue Corridors, is now running at European level.

DEVELOPMENT OF ENGINES FOR LIQUEFIED METHANE

Different manufacturers have developed the Methane-Diesel technology for compression-ignition engines in heavy-duty vehicles. The diesel acts as a liquid spark plug, igniting the regasified methane mixed together with the air. The substitution rate depends on the driving pattern, for the Volvo truck this reaches 75% in highway applications. The range is extended to 800 km for trucks equipped with the largest tanks. Mercedes, Scania and Iveco and others also offer liquefied methane powered trucks, equipped with spark-ignited engines.

DEVELOPMENT OF LOCAL GAS GRIDS TO TRANSPORT BIOMETHANE AS AN ALTERNATIVE TO ROAD TRANSPORTS

Local gas grids are an option that gains more and more attention in Sweden as a means of transporting biomethane and natural gas outside the existing national natural gas grid. In larger volume markets, their economics are competitive with road transport, in spite of the much larger investment cost. Rather large-scale local or even regional grids are being projected, aiming to interconnect larger industries, cities, biomethane production plants and LNG terminals at the coast. There are ongoing detailed investigations for such grids in the Gävle area and in the Lake Malar valley (Mälardalen), the latter with Stockholm wrapped around its Baltic Sea outlet.

Already there are smaller local gas grids in a number of Swedish cities. The largest is situated in Stockholm with biomethane injected at several sites and then delivered to refuelling stations in the region. The current delivery capacity amounts to 525 GWh annually. The other city grids are commonly smaller, used to connect digesters situated a few kilometers from each other, typically at a wastewater treatment plant and a food waste handling facility. The raw biogas is transported from one of the plants to the other and subsequently upgraded to biomethane in a joint facility. The biomethane is transported to the refuelling stations through a separate gas pipe or by road transport (see Figure 4). Recently, a local gas grid has been built in Sweden that connects four different farm-scale digesters with a joint upgrading unit and a vehicle gas refuelling station in the Brålanda plains region, west of Lake Vaner (Vänern) (see Figure 5). More farmers will probably be connected to this grid in the future, designed to handle 30 GWh/year, more than four times its current capacity. This system is similar to the gas grid in Brazil that is described in the IEA Bioenergy Task 37 Case story called "Bio-Energy in Family Farming: A new sustainable perspective for the rural sector in Brazil".

Figure 4: Container used for transportation of compressed biomethane in Sweden. The container is filled with high pressure gas cylinders.

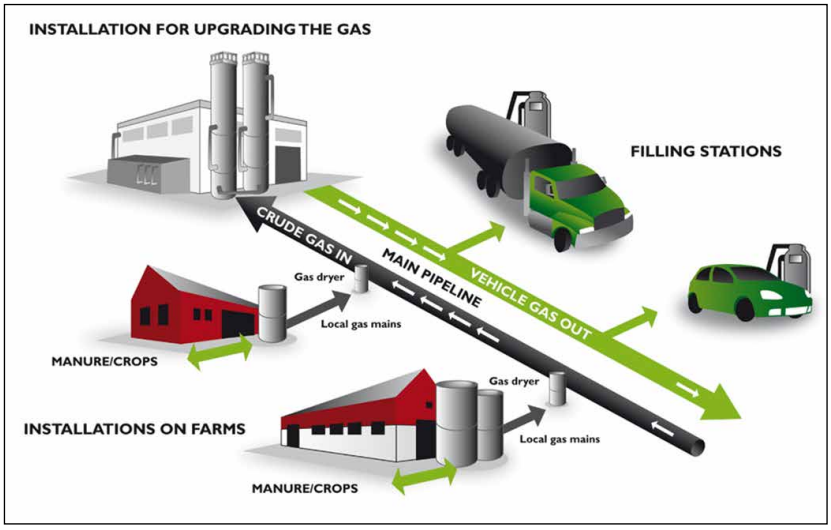

Figure 5: The raw gas grid in the area of Brålanda connects four agricultural biogas plants to a centralised upgrading unit. Illustration: Biogas Brålanda.

CONCLUDING REMARKS

It is challenging to create a national market for domestically produced biomethane in countries such as Sweden, with its limited national gas grid coverage. Transportation in the compressed state has its merits up to a certain distance, but when the volumes increase or the end-user is more distant, local or regional gas grids as well as liquefaction of the biomethane are important solutions to consider. Thus, in lower volume markets, local gas grids and CNG/LNG transport by road is the best economic fit, followed by regional grids when reaching larger volumes. Interconnection of these might eventually lead to an expansion of the national gas grid.

ADDITIONAL INFORMATION AND CONTACTS

The BiMe-Trucks project:
http://www.bimetrucks.com/

The EU-project Blue corridors:
http://lngbc.eu

Description about Lidköping Biogas:
http://www.lidkopingbiogas.se/eng/

Movie about Lidköping Biogas:
https://www.youtube.com/watch?v=Vsk6AniIIfs

Information about Biogas Brålanda:
http://www.visitcleantechwest.se/biogas-bralanda-english/

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