Introduction to biomass gasification and the relation to biomethane

There are large volume of forest biomass available the Botnia-Atlantica region. The demand for biofuels for transport is projected to increase rapidly in the near future. Gasification enables the transformation of forest biomass into biofuels for transport. Gasification, digestion and power-to-gas are three methods for producing methane and may be used complementarily to ensure a cost efficient use of infrastructure. The result is based on a literature review and stakeholder interviews within the strategic network BioFuel Region and Biogas Norr.

Accessible raw material and vehicle fuel market

Methane in the form of compressed natural gas (CNG) or liquefied natural (LNG) is considered as possible alternative to diesel. Methane may have a fossil origin from natural gas or in the case of biogas, a renewable origin. Natural gas burns clean and improves vehicle emissions (particles, nitrogen oxides and sulphur) but does not improve the climate performance, nor it improves energy security. Biomethane, can be produced from local renewable raw materials with different techniques. Most common in Sweden is digestion of sewage sludge or food waste. Projects are underway in Sweden to gasify biomass from forest to biomethane, BioSNG (Bio Synthetic Natural Gas).

The total theoretical potential of biogas through anaerobic digestion has been estimated at about 20% of transport demand (6 TWh/year) in the BA region[1] of which about half are considered to be economically feasible. To be able to realise this expansion, infrastructure for methane gas is required. To get such infrastructure viable it needs to be used extensively. Thus, both gasification and digestion are needed to get sufficient amounts of methane on the market.

Biomass available for gasification is assessed to up to 12 TWh/year in BA the region, with a 50% restriction due to ecological, technical and economic factors[2]. Along with digested biogas, this could account for more than double of the transport needs, i.e. the transport sector could function completely without the involvement of fossil natural gas. The region could even export fuel to regions less rich in forest biomass. Today's mass-produced gas-powered vehicles are available for the majority of transport applications.

Biomethane can be produced from three processes; digestion, gasification and power-to-gas. The connection between these three and how they can interact is new in our region and of great interest to the market.

DIGESTION AND UPGRADING BIOGAS TO BIOMETHANE

Organic material is broken down into biogas by anaerobic bacteria in a completely oxygen free environment. How efficient this is depends on the properties of the organic material. Manure and food waste is easy to break down, while lignocellulose biomass is more difficult. At Domsjö Fabriker in Örnsköldsvik cellulose-rich wastewater is digested as a part of their cleaning process. Biogas produced in the anaerobic digester contains about 60-70 % methane and 30-40 % carbon dioxide and water.

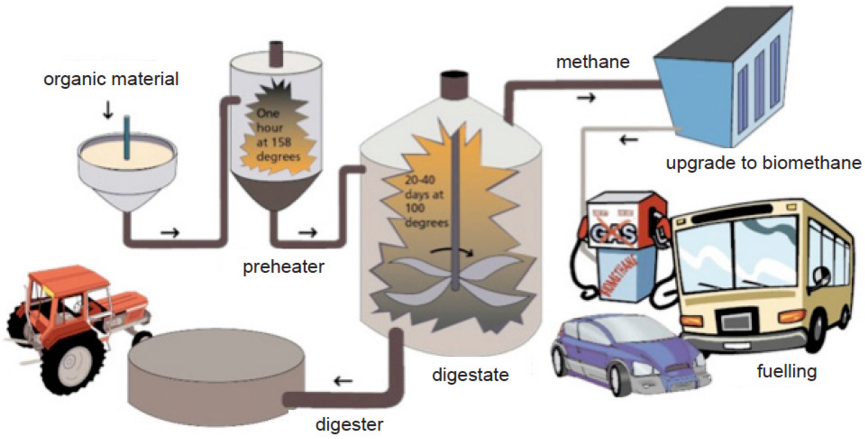

Figure 1. How organic material is transformed into biomethane and biofuel. Source: BioFuel Region

Biogas may be refined to biomethane if the carbon dioxide and water is removed in an upgrading process. The biomethane has a fuel quality corresponding to natural gas. See picture:

GASIFICATION

Woody biomass (solid or liquid) is gasified at high temperatures to varying gas mixtures of CO, H_2 CO_2, H_2O, CH_4 and heavier hydrocarbons, known as syngas. Depending on the process used different types and amounts of pollutants are also created. In order to further refine the syngas to fuel it needs to be cleaned (especially for tars, particulates and sulphur) and upgraded to the right H_2/CO ratio. Through a catalytic transformation and if needed subsequent optional refining, you can then create different types of fuels with different degrees of effiency, see figure 2.

Depending on the scale of the biomass conversion system you want, different types of gasification processes are chosen. For most cost-efficient large scale conversion, high pressure and temperature entrained flow gasifiers are most commonly used. This technology is currently used in the gasification of coal and several commercial establishments in the world (mainly Asia)[3] and these plants are very large. For entrained flow gasification of biomass raw materials, some kind of pre-treatment technology (torrefaction, steam explosion or pyrolysis) is suggested to get sustainable raw material supply for these large systems.

Presently, much work is also focused on lower temperature gasification: GobiGas in Gothenburg since 2014 and the Güssing gasification projects. By gasifying at a lower temperatures, a significant amount of methane still remain in the raw gasification gas, beneficial for the total bio-SNG production in smaller scale. The downside is that tars and other smaller hydrocarbon components remain in the gas. Before further processing into bioSNG the syngas therefore needs to be cleaned. This cleaning stage is usually expensive. When the syngas is cleaned the H_2 and CO can be transformed to bioSNG through catalytic methanation. This is a strong exothermic reaction and a heat sink is therefore needed to make the plant energy efficient.

$$\mathbf{3H_2 + CO \rightarrow CH_4 + H_2O + heat}$$

Today, there are only two biomass gasifiers in the world using methanation to produce bioSNG: The gasifier in Güssing has a fuel capacity of 8 MW and the methanation unit 1 MW. There is also a methane filling station. The plant has been in operation since 2009. GobiGas in Gothenburg since 2014 and Güssing gasification[4]. The GoBiGas project aims for an upscale of the Güssing to 20 MW, and the technique is still to be evaluated[5]. The path Gothenburg has chosen is rather expensive, but there are other alternatives that take into account the smaller scale and optimize the process on the right scale[6].

Those who are only going to use the gas for electricity and heat may use a relatively cheap air-blown fluidized bed (of sand). The air gives some dilution of the syngas with nitrogen thus not suited for synthesis and methanation.

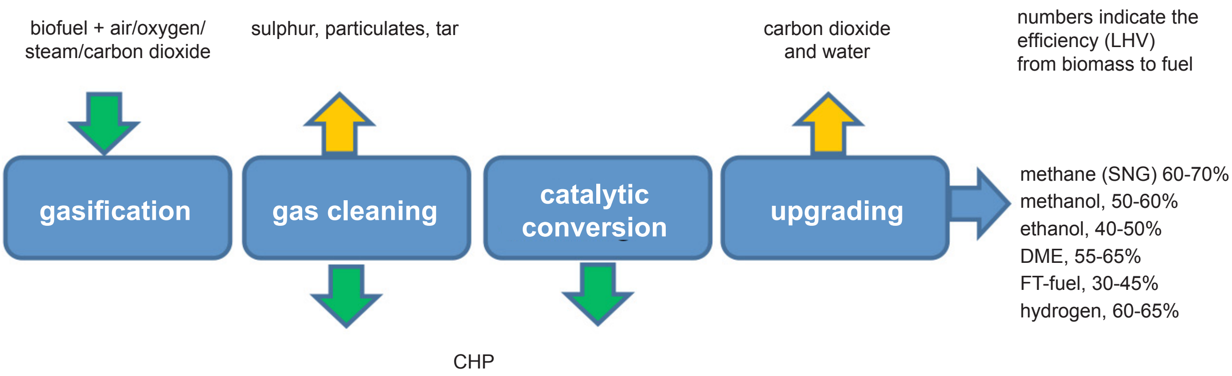

Figure 2. Schematic description of gasification of biomass and upgrading to biofuel[7] . Source SGC

POWER TO GAS

Power-to-gas is a method of storing excessive power as hydrogen or methane from, for example, windmills. Electricity is used to electrolytic split water into hydrogen and oxygen. Depending on the marked need and distribution channels the end product can either be hydrogen or methane. To produce methane, the hydrogen are put together with carbon dioxide from other industries (such as gasification or combustion plants) and then transformed into methane.

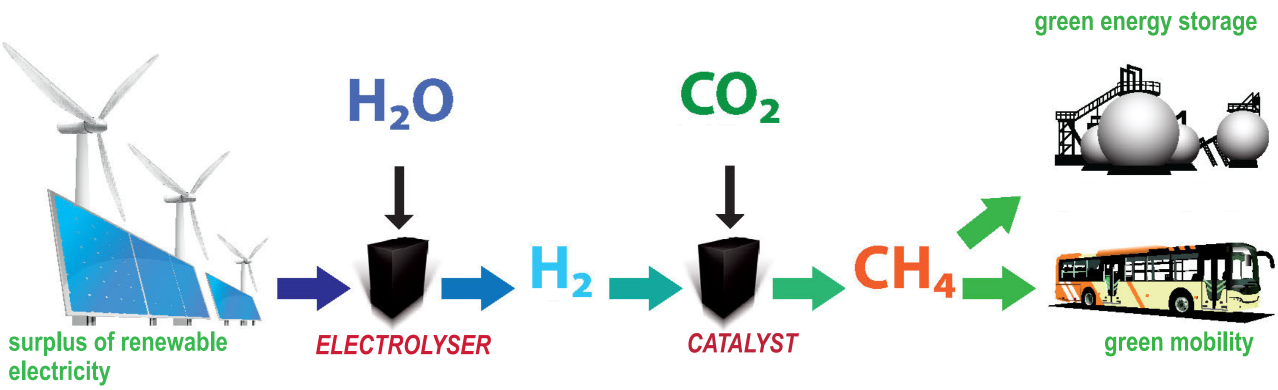

Figure 3. Illustration of the process “power-to-gas”. Source SGC[8]

CONCLUSIONS

Biomass potential in the BA region is larger than the need in the transport sector in the region. There are several advantages of interaction between digestion, gasification and power-to-gas since it is possible to use the same infrastructure for the production of methane although the methane comes from different sources. Large volumes of methane are distributed in gas distribution grids or as liquid natural-/biogas. These infrastructures need to handle large volumes to be cost efficient and this may be reached by combining the three production methods. Since methane (as in natural gas) is the fastest growing alternative fuel in the world at the moment this will ensure that vehicles and supporting equipment will be developed further by big and stable companies.

Literature

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3. T. Nguyen Topsoe's synthesis technology for SNG 2014
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6. P. Simell VTT 2014
7. P. Börjesson et al 2013, S. Dahlgren et al WSP 2013. Illustration from Framställning av gröna gaser with allowance from The Swedish Gas Technology Centre (SGC).
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Author

Anna Säfvestad Albinsson

Biofuel Region AB

anna.albinsson@biofuelregion.se

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European Union
European Regional Development Fund
Botnia-Atlantica
Cross-border cooperation over mountain and sea
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