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# Position Paper: Biomethane

## The renewable natural gas



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## Biomethane, the renewable kind of natural gas

This paper aims to shortly describe the characteristics of biogas and biomethane, the purified end product of biogas (but also derived from landfill gas or synthetic gas produced via gasification of lingo-cellulosic biomass) that is similar in energy content to natural gas. There exists a vast potential of feedstocks, which can be recovered with a higher efficiency than any of the competing biofuel technologies, often with unprecedented performance regarding area efficiency of energy crops and carbon footprint. The European technical biogas potential is described in detail. In addition, the different types of gas distribution are detailed, and the synergies of the joint distribution and utilization of biomethane and natural gas are explained. Finally, the reasons behind rating biomethane used as automotive fuel as the best application of biogas are presented, and the current legislative situation of biomethane in Europe is overviewed in brief.

## What is biomethane?

Methane of renewable origin, when upgraded to heating values comparable to natural gas, is usually referred to as biomethane. Intermixing with natural gas in all proportions is possible, since they have the major constituent in common, methane. The only difference is the origin or rather age of the methane molecules. In terms of heating value, no clear definition of biomethane exists. The methane content in natural gas varies greatly depending on origin and quality requirements. In Europe, the lowest grade of supplied natural gas has a heating value corresponding to the one of the reference gas G25 with a methane content of 86 % (v/v). From a technical viewpoint, any dried biogas purified from hydrogen sulfide and other harmful trace elements can successfully be used as fuel, e.g. in road vehicle engines. However, Most NGV market actors strive to maximize the energy density of the gas, in order to satisfy customer demand for driving range.

## Benefits of the biogas process, the only present source of biomethane

Biogas is formed naturally through microbial degradation of organic material in the absence of oxygen. The organics are degraded into methane and carbon dioxide, the bulk of the energy of the degraded matter being stored in the methane. In a biogas plant, the natural processes are amplified and contained, facilitating a secure harnessing of the produced biogas. Besides methane, the main constituent of biogas is carbon dioxide. Other minor and trace constituents, such as hydrogen sulphide, siloxanes and ammonia, are usually removed before the actual upgrading process, in order to avoid interferences downstream. Removal of these trace compounds is important in order to prevent corrosion and mechanical wear during distribution and utilization. Conventional upgrading, e.g. water scrubbing, is designed to remove the bulk of the carbon dioxide, thus leaving behind nitrogen and oxygen. Oxygen content is rarely over 0.5 %, since oxygen is consumed in the biological process. Nitrogen content may be higher than that if the gas is of landfill origin. Besides other purification techniques, both the nitrogen and oxygen can be effectively removed by implementing cryogenic upgrading technology, where the different gases are separated on basis of their boiling points. Here a valuable byproduct is the liquefied carbon dioxide ($LCO_2$), a commodity which demand is on the increase, e.g. for use as a renewable source of cooling in refrigerated trucks. Estimations show that a price of 0.1 EUR/kg of liquefied carbon dioxide would decrease the specific costs of cryogenic upgrading to the same level as conventional upgrading technologies[1] (*Pettersson et al. 2006*).

[1] Approximately 0.1EUR/Nm$^3$ biomethane on a scale of 1,000 m$^3$ raw gas/hour

The liquid and solid residues produced by the anaerobic digestion process, composed of now more plant accessible nutrients (e.g. nitrogen, phosphorus and trace elements) and soil improving humic compounds of lignocellulosic origin, can be used as a high quality fertilizer. The liquid part, containing most of the nitrogen and potassium, is preferably spread into the growing crops, while the solid part containing most of the phosphorus is spread out of season. This type of nutrient management through anaerobic digestion greatly decrease the losses of nutrients and production of greenhouse gases associated with traditional spreading of undigested manure and ploughing-in of crop residues, and can be managed in the same way as precision farming with mineral fertilizers. The addition of organics of urban/industrial origin recycles the nutrients contained in food products, ultimately closing the now open loop of nutrients flowing from agriculture to the city. Research indicates that the digestate produced during anaerobic digestion might be a just as efficient fertilizer as the mineral types (*Gissén et al. 2008*).

## All types of biomatter can be used as a source of biomethane

Any material of organic origin can be treated anaerobically. However, without pretreatment, substrates high in lignocellulosic content, e.g. wood chips have a too low biodegradability to be interesting. In general, wet, organic substrates are more suitable for anaerobic treatment. For drier fractions high in lignocellulosics, thermal gasification, followed by gas cleaning and reforming steps to increase the proportion of methane (methanation) in the gas, is a more suitable technology. This large-scale technology is on the verge of being commercialized. The product is usually referred to as bio-SNG (substitute natural gas produced from biomass).

The flows of renewable energy on Earth are many times larger than the current global energy utilization, which in 2007 amounted to 347 exajoules (EJ, corresponding to 8,286 Mtoe, or 96.4 petawatthours, PWh) (*IEA 2009*). Technologies to harvest these flows are getting more and more competitive. Considering assets suitable for biomethanation purposes, the theoretical energy potential of the global annual primary production of biomatter is enormous, 4,500 exajoules (EJ). Out of the 2,900EJ theoretically harvestable biomass, approximately a tenth is considered technically available on a sustainable basis, 270EJ (75 PWh) (*WEA 2000*). Other research indicates an upper limit of 1.135EJ in 2050 for a sustainable global bioenergy production not interfering with the supply of food crops (*Ladanai and Vinterbäck 2009*). On European level, it is reported that the sustainable primary biomass potential, waste streams included, will increase from 8 EJ (2.2PWh) in 2010 to 12EJ (3.3PWh) in 2030 (*EEA 2006*). A large share of this may come from agriculture, increasing from 2EJ (547TWh) in 2010 to 5.9EJ (1.6PWh) in 2030 (*EEA 2007*). Higher total estimations are also reported, for example a technical potential of biomass of 17EJ (4.7PWh) for EU-27 (*Ericsson and Nilsson 2009*). Cultivation of dedicated energy crops for biomethane is a competitive option when utilizing this potential.

With responsible and more efficient stewardship of our still not fully exploited agricultural resources, together with the expected increases in area efficiency of agriculture in general, dedicated energy crops is a viable and sustainable alternative for the future production of biomethane and other biofuels. Compared to other biofuels, the area efficiency of energy crops for biogas is currently very high, and in addition plant breeding prospects are showing great promise. Another important aspect is the shorter growth period needed for many energy crops, allowing for double cropping systems in many European countries (*Åhman 2010*). The biogas production in Germany and Austria is already today dominated by energy crops, Germany alone generating 122PJ (34TWh) in 2008. With a conservative land utilization (5% of the arable land), estimations on the biogas potential of energy crops from anaerobic digestion in EU-27 show yields ranging between 908 to 2,724PJ (252-758TWh) with harvest yields of 10-30 tonnes dry solids per hectare (*Holm-Nielsen 2008*).

Besides the situation in Germany, the most common substrate type for biogas production in today's Europe is waste and residual products, mostly of urban origin. Statistics for EU 2008 have 11.6TWh biogas from wastewater treatment, 33.9TWh of landfill gas origin and 42.2TWh biogas from municipal solid waste and agriculture combined (energy crops), a total of 88TWh (317PJ) (*EurObserv'ER 2009*). The potentials of waste are of course much higher. EU recently released a commission report on the management of biowaste, which in EU is defined as garden and park waste, food and kitchen waste from households, restaurants, caterers and retail premises as well as comparable waste from food processing plants (*EU 2010*). As much as 138 million tonnes is produced annually, which could correspond to 180TWh of biomethane[2]. Since 40% of the biowaste is still landfilled, a large share of the potential will accumulate and be available as recoverable landfill gas. With the emergent commercialization of cryogenic upgrading, the source base of biomethane will thus significantly increase, despite the long-term reduction of European landfill gas potentials due to the on-going efforts to divert as much as possible of the waste streams away from the landfills, trying to limit the share of biowaste landfilling to 35% by 2016-2020. The new EU

[2] Calculating with a yield of 130 $Nm^3$ methane/tonne of biowaste

member countries in Eastern Europe have EU funds allocated to comply with these goals[3]. However, the choice of treatment is not always governed by environmental concerns, and there are discussions on the possible need for supplementary regulation. Wastewater treatment is another untapped resource. A coarse estimate for the 500 million inhabitants of EU-27 indicates a biogas potential of 68TWh from wastewater sludge[4]. In agriculture, animal manure represents a very large biogas potential. Estimates for EU-27 show a theoretical potential of 205TWh (*Holm-Nielsen 2008*). Summing up, as much as 453 TWh (1.6EJ), not including landfills, could come annually from waste streams. Energy crops could optimistically add to that figure up to 1500TWh (5.4EJ), depending on share of arable land and crop yields. Nevertheless, as previously indicated, the largest share of the future biomethane potential is represented by waste and residual products high in lignocellulosics, such as forest residuals. Thus, the biomethane potential of EU increases considerably if taking the technology of thermal gasification into account. The scale of the technology makes it necessary to arrange for the gas production to be integrated with new and existing infrastructures for distribution of gas, e.g. through injection to the national gas grid, in order to secure its full utilization.

Most European countries have extensive grid coverage, enabling a large share of the biomethane potential of Europe to be realized through injection schemes. A German biomethane injection study (*Thrän et al. 2007*) shows that the biomethane potential of anaerobic digestion and thermal gasification from residual products and a sustainable production of energy crops in the vicinity of the European gas grid (EU-28) may in 2020 be in the range of 2,000-3,500TWh. If including the potential of the CIS countries, the potential increase to 4,000-6,000TWh, large enough to cover the current EU-28 natural gas utilization. The main advantage of the bio-SNG process over competing gasification technologies such as the DME (dimethylether) and BtL (Biomass to Liquids, such as naphta and synthetic diesel) processes is its high efficiency; efficiencies as high as 60-70% can be expected from bio-SNG processes, while DME and BtL reach 50-60 and 35-45%, respectively (*Held 2007*). The high efficiency of the biomethane route is mainly due to low gasification temperature and the relatively high levels of methane formed in the gasifier (40-50% on energy basis (*Åhman 2010*)), reducing the amount of gas that needs to be synthesized. The development of new

[3] 'Green jobs' focus for €105bn in funds to EU regions http://euobserver.com/9/27741/?rk=1 Over EUR 90 million for energy efficiency and climate measures in Eastern Europe http://www.sweden.gov.se/sb/d/7952/nocache/true/a/136065/dictionary/true

[4] Calculating with an average substrate production of 50kg dry solids per person and year, and an optimized biogas yield of 272 $Nm^3$ methane per tonne dry solids treated.

processes, such as indirect gasification in combination with fluidized bed methanation, opens up for gasification plants in the 10-100MW (80-800GWh/yr) scale with fuel efficiencies of 60-70% (wood chips to methane), and heat recovery of up to 20%, giving a high total efficiency. The lower financial risk associated with that lower level of scale and the much simpler synthesis process constitutes an additional advantage of bio-SNG production compared to the other product routes, which are more complex, requiring higher levels of scale to become financially viable (*Held 2007*). Existing boilers may be adapted to the indirect gasification technology by attaching a gasification unit, thus making it possible for district heating actors to add bio-SNG to their product portfolio. No air is allowed to enter the gasifier, providing a nitrogen free product gas, which facilitates the cleanup process. The necessary heat of the indirect gasification process is generated outside of the gasifier unit, partly through injection of steam, generated from heat exchange with the product gas, partly through hot sand recirculation from the fluidized bed boiler, where residual ungasified biomass is incinerated after being separated from the product gas.

## Biomethane distribution and the synergies of jointly used natural gas and biomethane

Depending on the location and type of upgrading, the upgraded biomethane may be distributed in several ways: By injection to a central or local gas grid; by road in mobile units, either in the compressed or liquefied state. Used in an optimized manner, all of them have a role to serve in reaching full utilization of the available biomethane potential. Methane being a major component in both of them makes joint distribution and utilization of natural gas and biomethane a natural step, which has been shown through market experience to give raise to several synergies.

### The benefits of injecting biomethane into the natural gas transport network

All over the world, biogas upgraded to natural gas quality is injected into existing gas grids. A recent IEA task 37 publication lists close to 100 upgrading facilities and ca 70 of them inject the generated biomethane into the grid (*Petersson and Wellinger 2009*). Grid transport is one of the most energy efficient and environmental friendly ways existing to transport energy (*Papadopoulo 2009*). In addition, the produced biogas is fully utilized, thus avoiding unnecessary flaring or other losses such as underutilization of the heat in combined heat and power generation.

Since natural gas and biomethane can be intermixed freely and are fully interchangeable, virtual distribution networks of “green gas” are easily implemented, often referred to as utilizing the green gas principle, a direct reference to the established concept of green electricity. The principle is the same, irrespective of distribution distance and type, spanning from the $CO_2$ neutral cycles of local distribution networks, where the biomethane is produced, upgraded, injected and utilized in the same area, to the still not realized option of selling the injected gas abroad, disregarding actual physical transmission capacity. The accounting of the produced and subsequently sold biomethane can be done in the same way as with green electricity. Green gas systems are already in existence, either in the form of distribution companies’ own internal accounting, such as in Sweden, or by way of an independent certificate trading company or body, such as is in Holland[5] and Switzerland (*Kornmann and Wellinger 2009*).

From a technical viewpoint, biomethane grid injection is established and uncomplicated. Issues remaining to be addressed are related to feed-in regulations and economy. It is important to deliver a gas quality within specifications to the customers. Most grid injection so far has been in the low pressure distribution lines, close to the customer. If needing to meet a higher heating value specification, such as is the case with H gas in Europe and the Danish gas used in Sweden, it is sometimes necessary to add propane. This off course incurs an extra cost. In a catalyzed process, renewable ethane or propane can be synthesized from biomass based glycerol in a financially feasible manner, and cleaned from carbon dioxide together with the biogas in the upgrading unit of the biogas plant (*Brandin et al. 2008*). In most of Europe, the mixing of gas with different gas specifications is already done in large scale. Here, it would be better to inject the biomethane before the mixing points, into the high pressure transmission lines. This solution would also circumvent the potential problem of the lower customer demand during summer, effectively lowering the maximum amount of biomethane allowed to be injected into that particular distribution area.

The investment costs associated with upgrading and subsequent grid injection, together with the necessity of adding propane or high pressurization work, can be economically prohibitive for the individual biogas plant owner. Still, from a societal point-of-view, the benefits of increasing the availability and utilization of domestic gas production are obvious. Therefore it has been suggested that the upgrading and injection of biomethane should be an integral part of the grid infrastructure responsibility, the costs thus being shared by all gas customers (*SEI 2009, EP ITRE 2008, EP C 2009*).

[5] www.vertogas.nl

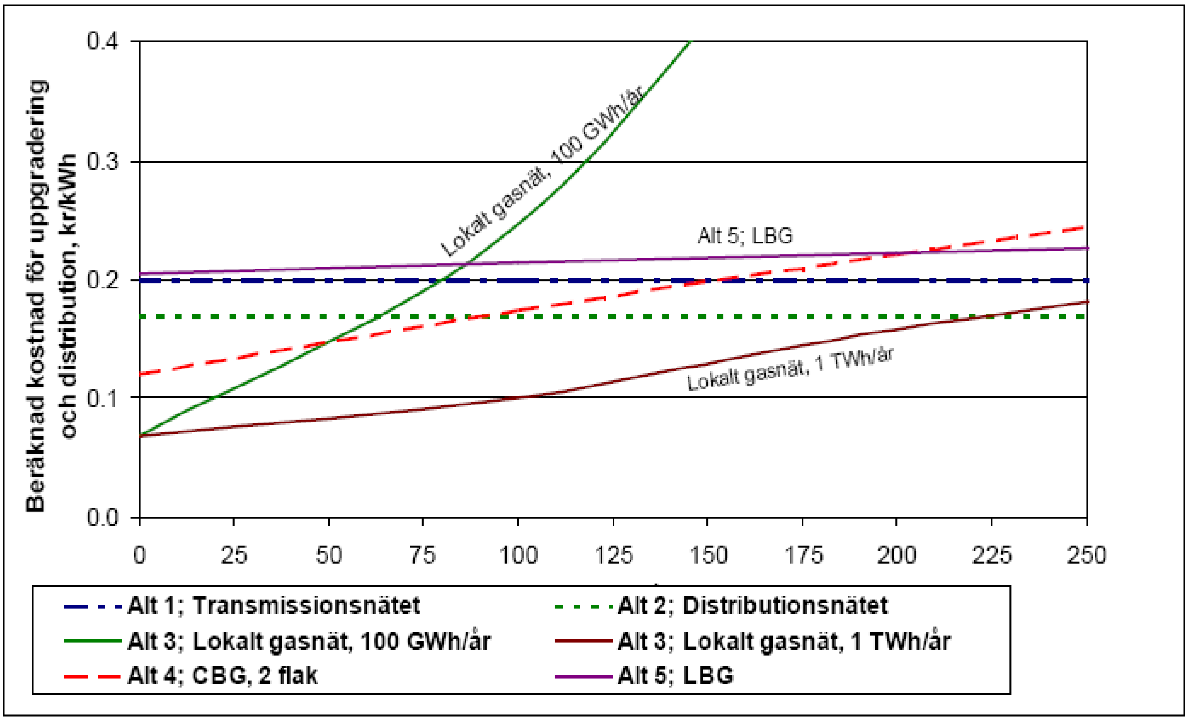


*Figure 1. Comparison of costs (SEK/kWh) depending on transport distance (km) for different upgrading and distribution alternatives at a biomethane volume of 100 GWh/yr (Benjaminsson and Nilsson 2009). Alt 1: The high pressure transmission natural gas network; Alt 2: The low pressure distribution natural gas network; Alt 3-green: Local gas grid, 100 GWh/yr; Alt 3-brown: Local gas grid, 1,000 GWh/yr; Alt 4: CBG, 6,000 $Nm^3$/truck; Alt 5: LBG, 35,000 $Nm^3$/truck. Please note that the extra costs of cryogenic upgrading are included. For reference, the costs of transport in national transmission and distribution network is also included – the grid benefit is not included in the estimate, which would otherwise decrease the costs.*

## Distribution solutions far from the natural gas transport network

Far from the national natural gas transport network, other biomethane distribution solutions come into play such as by road in mobile storage units, either in the compressed or liquefied state, or by laying down local gas lines. A report issued by the Swedish Gas Association shows the relation between transport distance and transported volumes for the different upgrading and distribution alternatives available on the market (*Benjaminsson and Nilsson 2009*). For short to medium distances and larger volumes, local gas grids provide the best alternative. Considering road transports, CMG[6] is the best option for all volumes up to distances of 200 km compared to LMG[7],

[6] CMG, common designation for compressed methane containing gases, irrespective of origin.

which has higher investment costs but much lower transport costs. It should be considered though that the handling of CMG mobile units when reaching higher volumes is a logistical challenge.

An added advantage of local biogas grids is of course the creation of new opportunities for biomethane injection along its entire length. Since current commercial upgrading processes available needs to be of a certain size to be economical, it is a good idea to supplement the grid with a parallel raw biogas grid, collecting and transporting the biogas of several smaller biogas plants to a central upgrading facility. Thus it is possible to realize the agricultural biogas potential, quite disperse in nature, and avoid the erection of a centralized facility with its inherent disadvantage of transporting large volumes of substrate and digestate.

Liquefied biomethane or LMG at -150 to -130 °C (at 3-8 bar overpressure), generated through either dedicated cryogenic upgrading or liquefaction of conventionally upgraded biogas, is the latest biomethane distribution state. With an energy density comparable to CMG at 600 bar, and carried in less heavy containers, the transport economy of LMG is five times better than for CMG at 260 bar in type 1 steel cylinders. The extra liquefaction costs are quickly compensated for by increased economical transport range and less cumbersome transport logistics. Strategically placed mother stations with both LMG and CMG refuelling capability may supply surrounding daughter CMG stations through CMG mobile units, effectively creating a virtual grid type of distribution.

An additional way of generating LMG, directly from the natural gas grid, is by way of utilizing the expansion work of MR stations for liquefaction and electricity generation purposes. Depressurizing from 60 to 4 bars, the electricity generated is sufficient to fully sustain the liquefaction plant, providing enough cooling to divert as much as 30% of the total stream as LMG (*Pettersson et al. 2006*). Using the green gas principle, this outtake of LMG can be sold as renewable methane.

## Synergies of joint distribution and utilization of biomethane and natural gas

The synergies of joint distribution of biomethane and natural gas are quite obvious. It is the same molecule, so allowing biomethane to utilize the natural gas transport infrastructure decrease the total costs and make it possible to reach full utilization of the energy of the biogas potential. At the same time, the renewability of the energy gas infrastructure is increased.

When grid distribution is not an option, several synergies are at hand when allowing for joint utilization of natural gas and biomethane for automotive fuel purposes. The irrefutable

[7] LMG is a common designation for all types of liquefied methane gas, irrespective of its origin, biomethane or natural gas.

environmental benefits of biomethane make it the preferred choice at all times, but in an emerging market situation its production is too insecure and small to smoothly adapt. Here, the natural gas can initiate and accelerate the market penetration during the build-up of the biomethane production capacity and hence facilitate the unavoidable hen-and-egg situation, but also serve as a backup and secure supply source in the event of production failures or sudden growths in demand.

The Swedish NGV market is a showcase for this type of synergy. The gas grid coverage is limited to the west coast of Sweden, making it necessary to utilize biogas as the main source of gas in the rest of the country. Natural gas in compressed and liquefied form is used as backup to sustain the biomethane market development. At times of accelerated market expansion, the use of natural gas may increase for a time, but customer preferences motivates the gas suppliers to strive for a growing share of renewable methane, also in the parts of Sweden with natural gas grid access. Over time, the volumes of biomethane on the Swedish NGV market have continually increased, now reaching 60% on energy basis on a total market of 685GWh (2009), supplying over 23,000 vehicles.

Road transport of biomethane should of course be avoided for larger volumes, since grid transport is so much better both regarding costs and energy expenditure. This is addressed by investing in local gas grids. The expansion and connection of such local grids to the national grid is of course a natural progression in an expanding biomethane market, once again showing the importance of natural gas and biomethane working together on the same market.

It can be envisaged that the invention of LBG production will change the market conditions in a very positive manner for countries with conditions such as Sweden. The three types of distribution, by grid and LMG/CMG by road will co-exist, fulfilling different needs of the market.

## Global solution: providing clean fuels and waste management at the same time

The need to counter the hazardous pollution and climate influencing emissions of our energy generation and utilization is acute. Regarding heat and power, a lot of avenues are available, but a tougher challenge is what to find as a replacement of the almost total oil dependency of our transport system? Besides minimizing our transport needs, the system needs to both become more energy efficient and based on a higher proportion of renewable fuels. Biomethane is a high-quality energy carrier, fully miscible and interchangeable from a combustion point-of-view with its fossil counterpart natural gas, which is not the case for other biofuels. Of the second generation biofuels, biomethane is comparatively less dependent on specific technical developments, less dependent on scale of production, greater feedstock flexibility and potential and can be integrated into the natural gas distribution network (*Åhman 2010*). Apart from renewable electricity, the regulated and unregulated emissions of biomethane, together with its carbon footprint, are lower than for all other biofuels. In contrast to electric vehicles, the NGV market is fully mature and ready to deliver given the proper incentives, inclusive of the long-distance road transport sector within the next few years, through implementation of LMG and dual-fuel technology. Of course the climate benefit is less costly when directly using the produced biogas in combined heat and power schemes replacing coal, but heat losses are then inevitable, especially during summer, and why waste such a top of the class high-quality energy carrier such as biogas on that, when the oil dependency of our transports need to be solved today, not in a distant, uncertain future? It is argued that the large-scale use of biomethane have been wrongfully overlooked in studies focusing on the long-term and large-scale options for the transport sector. Also, current trends show that poly-generation concepts of biofuel, heat and electricity are the most likely to develop, making it difficult to formulate efficient regulations based on pure conversion routes for separate allocation to the tree different sectors (*Åhman 2010*).

## Well-to-tank balance compared to other biofuels

Well-to-Tank Life cycle analysis (LCA) data for biomethane are highly dependent on the circumstances of the production and the choice of substrate. Regarding substrates, waste and residual products show better results, since the substrate is deemed “free” from the LCA expenses of dedicated cultivation of crops. In addition, the application of biogas treatment may prove to be a better waste management technology than conventional handling, thus giving a performance that is better than 100%, since extra emissions are avoided by implementing anaerobic digestion.

In the production of dedicated energy crops, many improvements can be done compared to conventional farming practice in order to decrease the carbon footprint. The most important factor is the type of fertilizer used, responsible for the largest share of the energy spent and a fair share of the total emissions if using conventional mineral fertilizers. If fully taking advantage of the biofertilizer produced, the carbon footprint may be diminished significantly. Also the biogas production and upgrading can be optimized in terms of its carbon footprint. The end result may very well be both more cost efficient biomethane generation and improved climate mitigating performance (*Lantz et al. 2009*).

In the following table, the results of a Swedish LCA study on first generation biofuels implementing system expansion are presented (*Börjesson et al. 2009*). Here it is important to note that the results (besides the Brazilian bioethanol) are only applicable to Swedish conditions. Such restrictions are typical of all LCA studies. For example, the harvest yields vary depending on climate, and the direct and indirect land use change forecasts may be different. In addition, the implementation of system expansion makes it important to note that the values in some cases only are valid up to certain production limits, since the byproduct utilization e.g. as fodder is taken into account in the calculations.

The values show that in all cases, biomethane provides the best option in terms of decreasing the carbon footprint. This is especially true for waste and residual products, but also energy crops. The best performance of biogas from manure is explained by the avoidance of methane emissions occurring during conventional handling of manure. Being colder in climate, the figure of Sweden is probably conservative in comparison to the figures that could be reached in warmer climate zones. Please also note that the future prospects of energy crops plant breeding has not been considered in this study:

| | |
|---|---|
| **Biogas from manure** | **148%** |
| **Biogas from food waste** | **119%** |
| **Biogas from the organic fraction of household waste** | **103%** |
| **Biogas from ley crops** | **86%** |
| **Biogas from sugar beets including tops** | **85%** |
| **Ethanol from sugar beets** | **80%** |
| **Ethanol from sugar cane** | **79%** |
| **Biogas from maize** | **75%** |
| **Wheat based ethanol** | **71%** |
| **RME (Rapeseed Methyl Ester)** | **68%** |
| **Wheat based ethanol combined with biogas production** | **67%** |

**Climate mitigating effect of biofuels under Swedish conditions. As reference petrol and diesel are used, having the same greenhouse gas emissions of 83.8 g $CO_2$ per MJ.**

## Successful experiences

Naturally, the successful combination of waste management and clean fuels production in the form of biomethane has been the most logical and obvious step in all emerging NGV-biomethane markets. The natural key player is a local or regional actor in charge of not only waste management and its refuse collection, but also public transport. The local or regional government has the authority to formulate tenders for e.g. captive fleets of city buses and refuse collection trucks. By combining waste management and biomethane production not only the streets are thus kept clean, but also the city air; emissions of nitrous oxides and particles are significantly decreased when replacing diesel with methane powered transport. In cities such as Berne, Lille, Stockholm, Oslo and Madrid a few thousand of biomethane powered buses and refuse trucks are already rolling, and in numerous other cities worldwide there are captive fleets presently powered by natural gas, representing a potential for additional portions of waste management being transformed into gaseous biofuels factories. It has been shown that bus fleet operators in Sweden provided a niche for the growth of the emerging market of gas powered vehicles, facilitating the later introduction of a larger and more diversified market (*Sandén and Jonasson 2005*). Similar market dynamics and success factors have been identified and described by the EU projects Biofuel Cities and Biogasmax.

# Legislative situation in Europe for biomethane

## Standardization issues

In order to meet climate mitigation goals and lessen the future dependency on gas exports, upgrading of biogas to biomethane and its subsequent use as vehicle fuel, or its injection into the natural gas grid, attracts larger and larger interest. The economical and technical barriers are more easily overcome in Europe with respect to grid injection, due to the widespread grid coverage. The most important barrier has instead turned out to be gas quality issues, where resolving issues of standardization regarding trace compounds such as siloxanes, halogenated hydrocarbons and microbial activity are high on the agenda. Some grid owners voice fears of risking the health of the natural gas customers through the spreading of pathogens, and fears of compromising the gas grid integrity through corrosion inducing agents and compounds. Nevertheless, biomethane injection has been in operation ever since the beginning of the 1990's, and at a rather large scale in countries such as Holland, Switzerland, and Sweden and of lately at a quickly increasing rate also in Germany.

As of yet, no reports exist on problems attributable to grid injected biomethane. With respect to pathogens, earlier studies have shown that the microbial content of biogas is similar to the one of natural gas, which in turn is lower than the one of ordinary air. Since no pathogens were identified and since the exposure to gas from e.g. cookers and refuelling of cars may only result in the inhalation of small volumes of gas, the risk of spreading disease via biogas was judged to be very low (*Vinnerås et al. 2006*). An extensive GTI study concluded that dairy waste based biomethane of high quality may be produced within typical natural gas tariff and contract constituent values. Regarding microbiologically influenced corrosion, levels of such microbes were low, but further studies into the quantity and type of microbes compared to the ones of natural gas were recommended (*GTI 2009*).

A number of national standards and regulations are in place in several European countries regarding injection of biomethane to the natural gas grid, such as Germany, Switzerland, France, Holland, Austria and Sweden (*Marcogaz 2006*). Interest to establish regulations are reported from many other countries, e.g. United Kingdom and Denmark. Within CEN (The European Committee for Standardization), in TC234/WG9, work is on-going to establish a unified European standard for grid injection. Regarding biomethane and natural gas refuelling, work is in progress on both CEN level (CEN/TC 326) and recently the International Organization for Standardization (ISO) has shown interest to start working on the subject (ISO/TC 252). In addition, the European Commission has requested that CEN start working on a standard for biomethane used as vehicle fuel. To date, the only standard of this kind has been the Swedish standard SS 155438, "Motor fuels – Biogas as fuel for high-speed otto engines". Regarding natural gas, DIN has requested of CEN to consider the German national standard DIN 51624 "Automotive fuels – Compressed natural gas – Requirements and test methods" as a template for the work on a corresponding CEN standard.

## Regulations and policy instruments

As in many emerging market situations, the production, distribution and end-use of biomethane often relies on supporting policies and state benefits to become profitable. With time, technology learning curves together with presumed increases in fossil fuel prices will change the situation, making biomethane profitable on its own.

The most common policy instrument is tax reductions and exemptions. Regarding NGV's, it is quite common that also natural gas has benefits in the form of tax reductions and exemptions. However, in certain European countries, such as Denmark, the utilization of biogas for local heat and power schemes is the preferred route, restricting the tax benefits to that type of utilization.

As noted earlier, investment costs can be quite steep to cover, slowing down important investments in production and infrastructure. In many countries special government programs facilitate the emergence of new markets by awarding investment grants, e.g. for the erection of biogas plants and refuelling stations. Often the grant is tied to fulfilling certain conditions, such as treating a certain minimum proportion of animal manure, in order to maximize the environmental benefit of the grant.

Regulations can also be used to support the market, e.g. demanding that refuelling stations offer alternative fuels such as gaseous fuels, which has been done in Sweden and Italy. Emission restrictions on heavy-duty traffic in the city centres make NGV's a more interesting alternative for freight companies. Demands for gas propelled buses in public transport tenders is often the first step in quickly establishing an NGV market, which is the case in Sweden, France and Spain.

In the EU project Biofuel Cities a wealth of information has been compiled regarding the role of supporting policies (*Biofuel Cities 2009*).

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