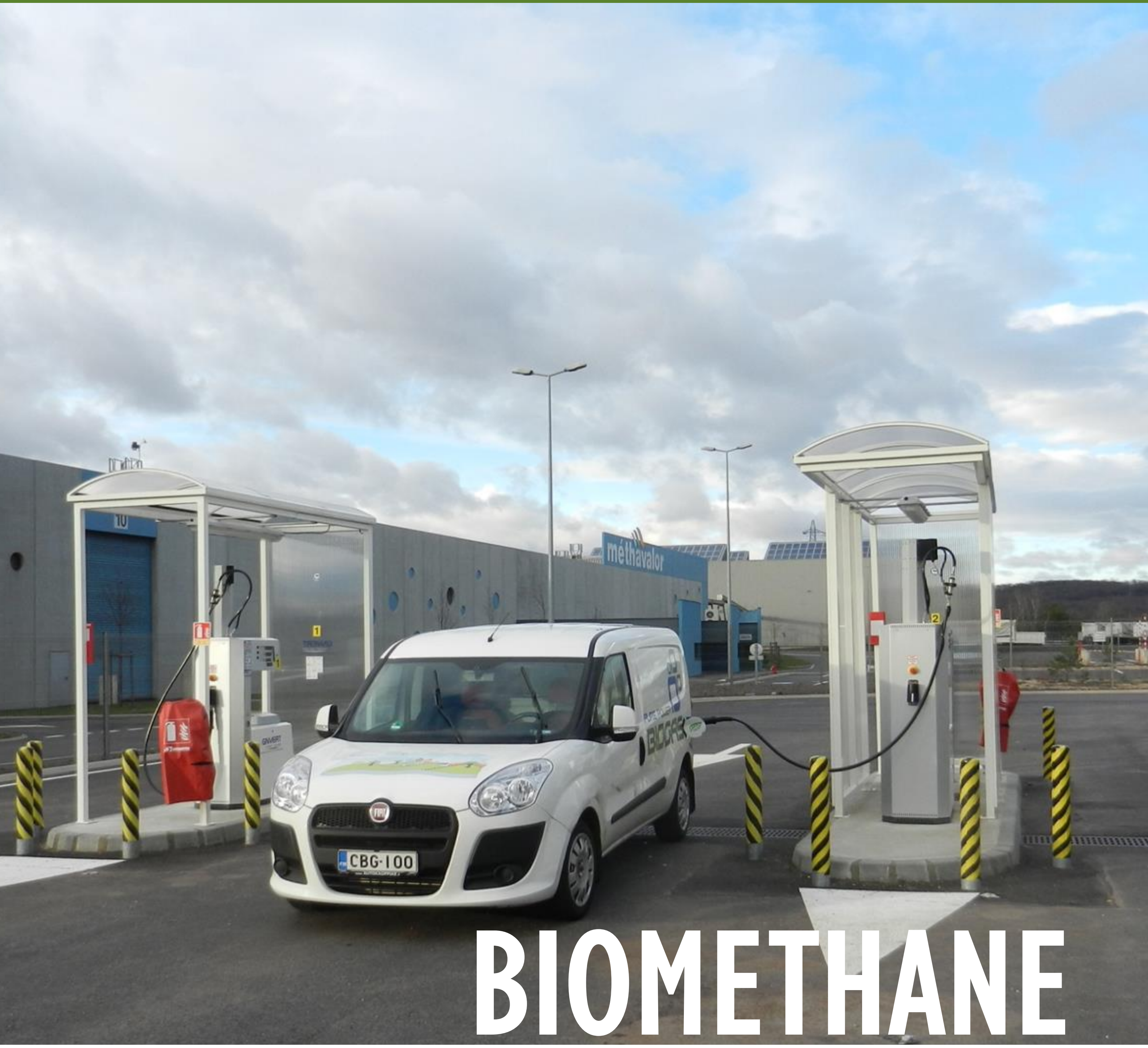
EBA
European Biogas Association



BIOMETHANE IN TRANSPORT

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List of abbreviations:

CNG - compressed natural gas

GHG emissions - greenhouse gas emissions

LNG - liquefied natural gas

EEG - German Renewable Energy Act (ger. Erneuerbare-Energien-Gesetz)

introduction

Biomethane is a renewable fuel produced through upgrading biogas and syngas to natural gas quality. Biomethane can meet all technical requirements set by the vehicle manufacturers and natural gas transportation system operators and – correspondingly – can be used everywhere in the same way as natural gas itself.

Biomethane is a very promising renewable source which usually punches below its own weight. Much of that is due to established misconceptions or a lack of awareness about the existence of renewable methane which comes from lesser known sources of renewable energy. Very often biomethane is overlooked in the energy debate. Nevertheless, there are several world leading producers of biomethane in Europe and there are many reasons to keep developing this sector.

This paper aims to serve as an introduction to biomethane in transport, going through its benefits and the challenges that lie ahead. The first chapter deals with Europe's transport sector and the gas-powered vehicles within it, listing the benefits of using biomethane in transport with the following one giving practical examples of successful projects. An overview of the sector's development is given in chapter 4 and lastly, current and future public policies are evaluated.

1. current challenges and future opportunities for gas powered transport

Similar to other fuels, biomethane requires distribution infrastructure. There are two principal ways of supplying vehicles with biomethane:

1 Dedicated retail filling stations supplying only biomethane (compressed or liquefied), which often comes from a plant nearby or is shipped in liquefied form (similar to LNG);

2 Fuelling stations which are connected to the gas grid and offer natural gas blended with biomethane. Note: it is impossible to distinguish biomethane from natural gas once it is injected into the natural gas network, but by means of independent and reliable documentation systems the biomethane volumes can be virtually traced and mass-balanced. This allows consumers to buy the equivalent of biomethane being injected by producers. An alternative is to create a propitious legal framework by setting a mandatory biomethane percentage (or blend) for fuelling stations as it is currently done for liquid biofuels in several countries, something that would require the active support of national decision-makers.

Out of a total of 343 million road vehicles in Europe, only 1.2 million ran on natural gas (and biomethane) in 2014, what is equivalent to 0.7% of the total vehicle market. Liquid fossil fuels, and to a lesser extent liquid renewable fuels, play a dominant role in the European transport sector. This brings forward two challenges for the biogas sector:

1 liquid fuels dominate renewable and non-renewable transport while gas is used at a small scale;

2 road transport is heavily reliant on fossil fuels.

The first challenge perpetuates the dominance of liquid fuels, since several European countries have few or virtually no CNG and LNG stations. In view of the low number of gas filling stations, experts have proposed alternative solutions such as building bi-fuel vehicles able to run on petrol when no gas refuelling is possible, also it was proposed to build home refilling facilities using own gas connections. However, these alternatives are likely to add costs for consumers, making the purchase of a gas-powered vehicle less attractive. As EU Directive 2014/94 defined it:

"[the lack of] alternative fuel infrastructure hampers the market introduction of vehicles using alternative fuels and delays their environmental benefits".

Vehicle manufacturers and researchers have also largely focused their resources and efforts over the past decades to develop diesel and petrol-powered cars, what has further consolidated the dominance of liquid fuels in the transport sector. This trend is slowly shifting where leading vehicle manufactures have developed an increasing number of gas-powered models, what offers more choices to consumers.

The second point is not only a barrier for the biomethane sector, but for all of us as transport is among the leading causes of climate change. The heavy reliance on fossil fuels coupled with a steep increase in the European demand for transport resulted in a 19.4% surge of GHG emissions in the whole transport sector between 1990 and 2013. Road transport remained the main source of GHG emissions in 2013, with a share of almost 73% of all transport emissions in the EU28 Member States (European Environment Agency, 2015). In 2013, transport stood as the biggest energy user at 31.6% of total EU energy consumption (*Figure* 1). For the EU to meet its 2020 targets for GHG emissions reduction, it is imperative that renewable transport fuels are deployed in a large scale.

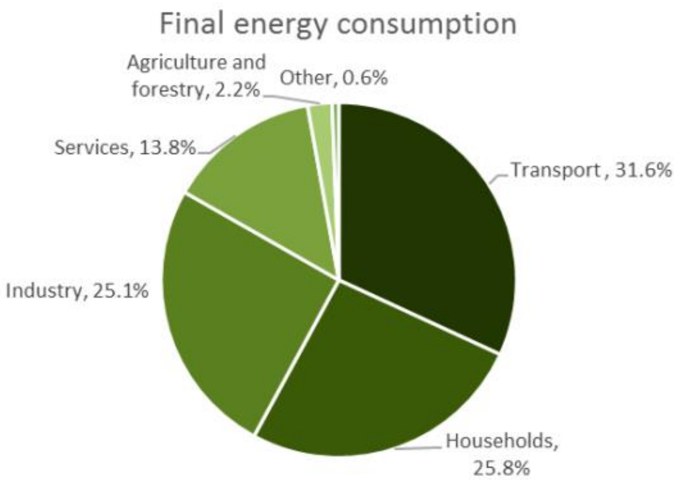

Figure 1. Final energy consumption in EU28 in 2013 (% of total, based on tonnes of oil equivalent)

2. the benefits of using biomethane in transport

When considering options to modernise the transport sector in Europe, biomethane offers a unique set of benefits.

2.1 the environment

Biomethane is a powerful weapon against climate change. Anaerobic digestion of manure and similar materials captures methane emissions which are up to 23 times more harmful than CO_2. In the absence of the biogas technology, methane is emitted to the atmosphere due to the decomposing manure and waste, such as sewage sludge, municipal waste, agro industrial effluents and agricultural residues. Therefore, the CO_2 emissions from burning biomethane are a small fraction of the avoided methane emissions from decomposing manure and waste. As a result, the total carbon footprint is very low, when compared with its fossil equivalents, as shown below in Figure 2.

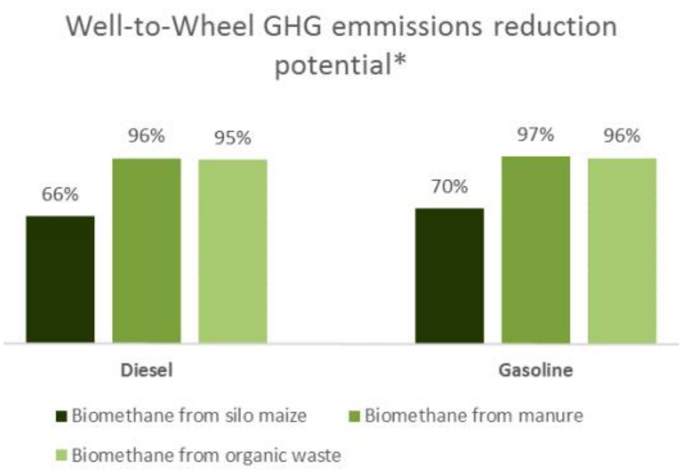

Figure 2. Well-to-Wheel GHG emmissions reduction potential of biomethane compared to diesel/gasoline (Environment Agency Austria)

**The data do not include the avoided emmissions of raw manure storage, landfilled organic waste and benefits of the produced digestate able to replace mineral fertilisers*

In the case of manure, it often has a negative emission balance (i.e.: by turning it into biomethane, it avoids more GHG to the atmosphere than what production releases), as it is shown in Figure 3. Other effluents reach very good levels ranging between 70 and 80%. Energy crops for biomethane production (such as maize) have a low carbon footprint due to their high production yields, which can go up to twice the yield per hectare compared to other crops destined to produce liquid biofuels. Therefore, under the right conditions biomethane from energy crops can save 66%-70% in emissions compared to oil products (Figure 2) and more than 50% when compared to EU fossil fuel mix including coal and natural gas (Figure 3). Moreover, if crops are co-digested with manure, as is often the case, the GHG savings are significantly higher.

In addition to using pure biomethane in vehicles, a smart cost-efficient way to reduce GHG emissions to meet national targets is by blending it with natural gas. Blending the two, even by using a low biomethane to natural gas ratio, can result in fuel that has substantially lower emissions than plain natural gas. For example, using a blend with 20% biomethane can yield GHG emission savings of 39% when compared to gasoline on the well-to-wheel basis (NGVA Europe, 2015). This is particularly the case when biomethane from waste with very low (or even negative) GHG emissions is used (Figure 3). Such policy can be implemented quickly and in a cost-effective way to match emission reduction targets, since most countries already have adequate natural gas grids and some even dispose of a good network of CNG stations. This would enable countries to make substantial GHG reductions in transport with mostly existing infrastructure in the coming years, ahead of developing additional long term alternatives. In order to implement this, it is essential that public authorities encourage and actively support the construction of biomethane upgrading facilities and the connection of these plants to the natural gas grid. If the biomethane and natural gas sectors work together, they can rapidly lower the total GHG emissions in the European transport sector. EBA is committed to cooperate with the natural gas industry, particularly with NGVA Europe, to promote sustainable gas-powered transport in the years to come.

Using biomethane and natural gas significantly reduces pollutant emissions (hydrocarbons, carbon monoxide, nitrogen oxides and particulate matter), compared to gasoline and diesel powered engines, and is also well below the levels of biodiesel and bioethanol (Fachverband Biogas e.V., 2011). This offers an ideal solution to reduce harmful emission levels in cities, which currently cause 400,000 premature deaths a year in Europe (European Environment Agency, 2014).

Biomethane use in transport also has the indirect environmental advantage of contributing towards a circular economy. In addition to energy, anaerobic digestion also delivers digestate (a valuable organic substance that can be used as organic fertiliser in agriculture), what in turn substitutes the need to produce millions of tons of CO2 intensive mineral fertiliser. Digesting waste is a much better alternative to landfilling and incineration, as it gives used material a second life.

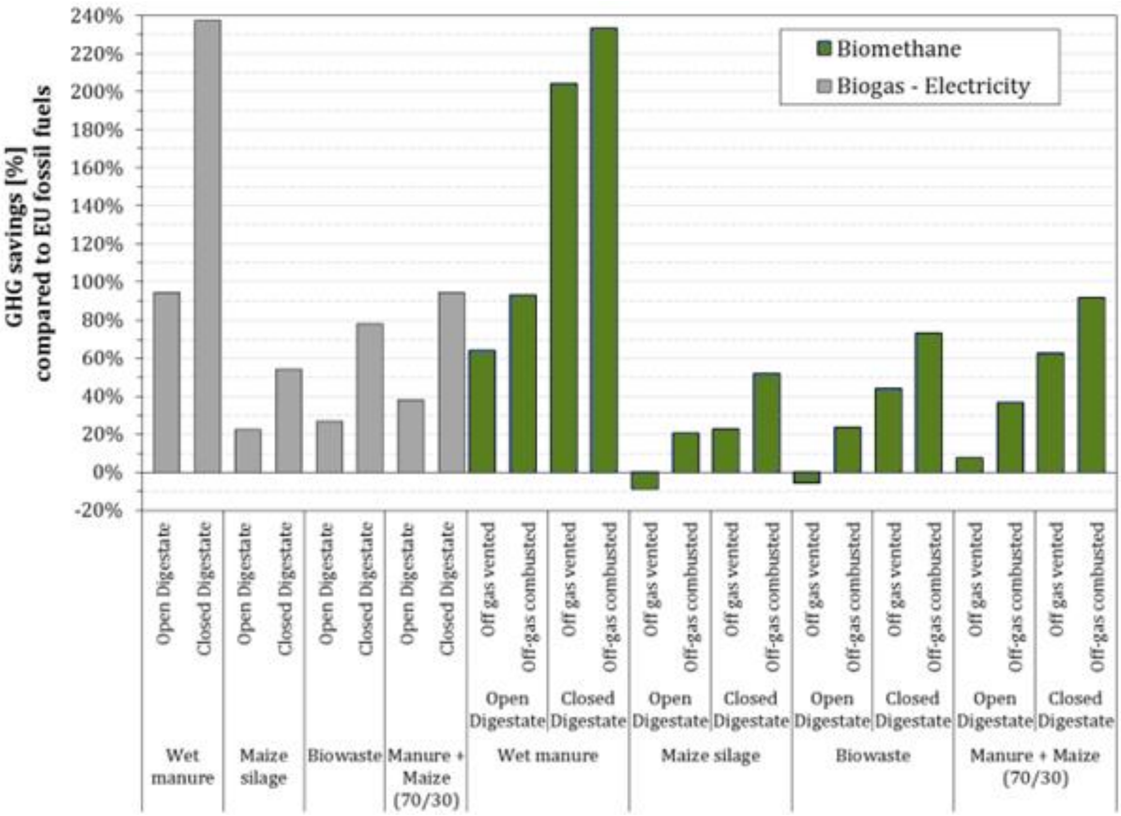

Figure 3. Illustration of GHG savings for the most representative biogas and biomethane pathways (JRC report on Solid and gaseous bioenergy pathways, 2014)*

**Values are based on default GHG emission values. Values higher than 100% represent systems in which credits from improved agricultural management more than offset any supply chain emission. Values lower than 0% indicate systems which emit larger amounts of GHG than the fossil fuel comparator. For illustrative purposes, values obtained for the co-digestion of a mixture of 0% (wet mass) and 30% (wet mass) maize are also included.*

2.2 the community

The biogas sector accounts for over 70,000 stable jobs in Europe. Most of Europe's 17,240 biogas plants are in rural areas, contributing to the economy of many disadvantaged regions and creating high skilled jobs (EBA, 2015). In addition, biogas plants are becoming more common in urban areas, as they are used to treat municipal waste and sewage sludge. This This is helping municipalities to better cope with their waste from environmental and an economic perspective. There is also an increase in suburban areas, where the food and beverage industry is increasingly using anaerobic digestion to treat their organic effluents. It is important to point out that biogas plants operate at a local level, since short feedstock routes give best economic and environmental results; therefore, anaerobic digestion creates durable local jobs.

Gasification operates at a larger scale employing a team of highly qualified labour. The regions which are most likely to use this technology, are large urban areas where it is necessary to treat organic waste that cannot be digested (such as used furniture), as well as rural areas with high forest density that have to be managed sustainably.

2.3 energy security

As the EU's fossil fuel reserves dwindle and its energy dependence worsens, biomethane offers a unique opportunity to offset the balance with a domestic gas source that is not only sustainable but also renewable, and thereby not finite. The EU imports currently 66% of its gas consumption, much of it coming from unstable regions where the political situation may interrupt vital supplies. Therefore, considering current economical, environmental and political circumstances, the time is right to develop the biomethane sector.

2.4 technical advantages

Anaerobic digestion is a mature and well-tested technology. This results in high energy production levels and good predictability, as well as in great versatility (depending on demand, biogas can be used to produce biomethane or electricity and heat). Gas (CNG and LNG) filling stations are not as dominant as their liquid fuel counterparts, but they are more available than refuelling installations for other alternative fuels such as electric and hydrogen-powered transport. It is important to note that by definition biomethane is a fuel produced exclusively from renewable sources, while other energy carriers in transport such as electricity or hydrogen may come from the country's energy mix (often including coal) unless it is specified that they were generated from renewable energy.

Biomethane can be adapted to suit the particularities of very different vehicles. Compressed biomethane is a safe, flexible and widely available renewable fuel for private cars and similar light duty vehicles. Liquefied biomethane is more energy dense and therefore it is optimal to power large engines (both on the road and at sea) for long distances with minimal storage space and weight.

Europe already has an extensive natural gas transportation network. Biomethane has the same properties as natural gas, and therefore, it can be blended, stored and transported across long distances within the EU at a very low cost and with minimal loses. The EU is committed to further integrate the natural gas networks of individual member states. This will increase the possibility to store and distribute biomethane, boosting the trade potential of this sustainable fuel.

For these reasons, and several others, the biomethane sector deserves every attention and support. In the years to come, it is expected that the share of biomethane in transport will increase rapidly.

3. best practices and innovative projects

The water treatment plant of Seine Amont has the capacity to treat 600,000 m^3 of sewage water a day, which comes from the city of Paris. Much of the waste is treated by an already existing biogas plant. The BioGNVAL project that was initiated in February 2013 plans to build and run an upgrading unit together with liquefaction facilities aimed at replacing over 1.1 TWh of fossil fuel annually for long haul heavy vehicles by 2030. This project puts in evidence the value of biomethane in transport in France, a country which has very recently started to develop this technology (ADEME, 2013).

The supermarket chain Sainsbury's in the UK, has been investing on technology to make biomethane from food waste to run its vehicle fleet. To date, the company has 51 trucks running on biomethane and 10% of its fleet (109 vehicles) has a dual fuel engine. Their aim is to reduce the "depot-to-store" GHG emissions by 35% in 2020 and achieve an absolute reduction of 50% by 2050 (NGV Journal, 2013).

The Nordvästra Skånes Renhållning AB (NSR) biomethane plant in Helsingborg, Sweden is an excellent example of a plant which produces high quality biomethane and organic fertiliser from food waste. The plant has been active since 1996 and it currently produces 80 GWh of biomethane a year from 160,000 tonnes of source separated food waste, which is equivalent to 60% of the household food waste or 55 kg per inhabitant of the area. The plant has 3 upgrading facilities with a combined capacity of 2,400 Nm^3 raw biogas/h. Biomethane is injected into the grid and is used as a vehicle fuel by buses, waste collection trucks, taxis and private cars. In December 2014, the industrial complex opened filling station for liquefied biogas and compressed natural gas to serve heavy trucks (IEA Bioenergy, 2014; Advantage Environment, 2014).

Figure 4. Biomethane plant in Ruhleben, Berlin

The Berlin City Cleaning Services (BSR) operates a biomethane plant in Ruhleben, Berlin (Figure 4). The plant uses as feedstock 60,000 tonnes per year of source separated waste. The effluents are collected weekly by garbage trucks in the north east of the German capital. The plant produces yearly around 4.5 million m^3 biomethane and has an upgrading capacity of 550 Nm^3/h biomethane. On average, 95% of the biomethane produced by the plant is used internally: the BSR powers 150 Mercedes-Benz Econic CNG garbage trucks (over half of its fleet) and it also uses it to cover part of its own demand for power and heat by using an onsite cogeneration plant. The remaining electricity is fed into the grid (Winner of competition "Biogaspartnerschaft des Jahres", 2014).

4. biomethane today and in the future

4.1 european figures and trends

Biomethane, the renewable alternative to natural gas, is principally produced from two complementary technologies: anaerobic digestion and gasification.

1

Anaerobic digestion is becoming a key renewable energy source in Europe which in 2014 counted with 17,240 plants and over 70,000 people working in the sector. In 2013, it produced the natural gas equivalent of 15.6 billion Nm^3 (Kovacs, 2015), while that year's total EU gas consumption was of 472 billion m^3 (COWI, 2015). Note that this comparison in only theoretical, since just a small fraction of 15.6 billion Nm^3 was upgraded into biomethane, where over 90% of total energy was used in the form of raw biogas (not upgraded to natural gas quality) to produce electricity and heat in cogeneration units. Additionally, only a fraction of the upgraded biomethane was used in 2013 exclusively for transport amounting to 0.1 billion m^3 (COWI, 2015). Although this is only a small share of the total biogas production, several factors are encouraging producers to make the switch to biomethane upgrading for transport, particularly declining electricity prices, scarcity of fossil fuels and commitments to reduce GHG emissions in transport.

2

Gasification technology has been developing rapidly in several reputed researcher centres and innovative companies from across Europe. Although gasification has not yet been deployed at a large industrial scale, its high efficiency rates compared to incineration make it a very interesting environmentally friendly option. This technology complements anaerobic digestion very well, as it can turn feedstock that is impossible to digest such as woody biomass and polluted organic waste into biomethane. This cutting-edge offers the best solution for the management of various organic materials and amplifies the potential of renewable energy.

Table 1 shows the production forecast for 2030 measured in natural gas equivalent for anaerobic digestion and gasification.

Table 1. Substrate potential estimations in billion m3/year for biomethane (Kovacs, 2015)

Origin	Production forecast 2030 [x10^9 m^3/year]
Manure	6
Straw	2
Sewage sludge	4
Biodegradable waste	3
Industrial waste	2
Landscape management	1
Energy crops	12
Woody biomass	20
Total	**49**

There is high biomethane potential stemming from large scale gasification deployment and the continued growth of an anaerobic digestion sector which focuses more on biomethane upgrading. The Green Gas Grids project (www.greengasgrids.eu) concluded that under the right conditions Europe can produce 48 - 50 billion m^3 of natural gas equivalent by 2030 from gasification and anaerobic digestion, out of which the biomethane share could represent an estimate of 40% or 18 - 20 billion m^3. This prediction is in line with the overall commitments of each EU country's National Renewable Energy Action Plan, which amount to 28 billion m^3 of biogas/biomethane by 2020 (EBA, 2013 (2)). The total maximum technical potential for renewable gas that can be achieved in Europe through the combination of both technologies is of 151 - 246 billion m^3, where the lower end represents a pathway with low energy crop use and the upper one a more intensive deployment of dedicated crops (see Table 2). Note that a technical potential cannot be realised in practice but it provides an indication of the magnitude of possibilities.

Table 2. Maximal technical biomethane potential (GreenGasGrids, 2013)

Resource	Billion Nm^3	%
Woody biomass	66	44-27
Herbaceous biomass	11	7-5
Wet biomass residues	26	17-11
Energy crops	48 – 143	32-58
Total	**151-246**	**100.0**

4.2 bringing biomethane to the transport sector

According to NGVA Europe's estimates, presently about 3.3 billion m^3 of methane are used as transport fuel in Europe (EU+EFTA). Even if this volume is relatively low compared to gasoline and diesel, it is still a sizeable amount demonstrating mass deployment in parts of Europe. Moreover, a comprehensive study by Le Fevre (2014) shows that gas-powered transport (both on roads and waterborn) has excellent prospects for the coming decades. The low penetration case projection (maritime transport and road transport) puts the total yearly consumption in 2025 of gas-powered transport at 20.0 billion m^3, the medium projection is at 34.5 billion m^3 and the high one at 76 billion m^3 as shown in Table 3. In all three scenarios biomethane could realistically provide at least 20% of the total demand in gaseous transport fuel. With the right infrastructure and incentives in place, biomethane producers could quickly make the switch towards the transport sector in only a few years. Beyond 2030 it is likely that the share of biomethane will increase above 20% with the aim to fulfil the strategic objective to decarbonise all transport by 2050, alongside with other alternative fuels such as electricity and hydrogen from renewable sources.

Table 3. Forecast for methane used as road vehicle fuel – low penetration case (Le Fevre, 2014)

Vehicles*	Consumption in 2020 [10^9 m^3]	Consumption in 2025 [10^9 m^3]	Ultimate market share in 2025 [%]
Cars and LCV	7.0	9.0	1.0
MDV	1.4	2.4	1.0
HDV	1.3	2.1	2.0
Buses	2.0	3.0	10.0
Total	**11.7**	**16.5**	

**LCV – light commercial vehicle; MDV – medium duty vehicle; HDV – heavy duty vehicle*

4.3 Biomethane costs

While a speedy decarbonisation of the transport sector is required, it is essential to make a gradual transition which does not cause serious disruptions or shocks to the transport sector. Natural gas prices for transport are very competitive compared to liquid fossil fuels and they are also lower than biomethane costs (see table below). Blending biomethane with natural gas can combine the environmental advantages of the former with the competitive prices of the latter, which would result in a significantly cheaper and cleaner fuel than what is currently available. This possibility would avoid price hikes for gas-powered transport, something that is crucial as consumers weigh the advantages of this alternative fuel. As biomethane volumes increase and production costs decrease, it will be possible to increase its share in the fuel blend and thereby move towards fully decarbonised renewable transport.

Table 4. Biomethane and natural production costs

Dominating substrate	Biomethane cost, €c/kWh	Source
Manure	4.2–5.1	IRENA 2013
Manure	7.0 (average)	IEA (Thrän, D et al. 2014)
Energy crops	6.4–8.4	DBFZ (Grope, J & Holzhammer, U 2012)
Energy crops	6.3–8.3	Uni Stuttgart (Panic, O 2013)
Maize (90%) + waste (10%)	7.9–8.7	IRENA 2013
Energy crops	8.7 (average)	IEA (Thrän, D et al. 2014)
Organic waste	5.0–8.0	SGC (Svensson, M 2013)
Biodegradable waste	5.4–6.2	EBA (Kovacs, 2015)
Energy crops + slurry	7.5–7.7	EBA (Kovacs, 2015)
	Natural gas price level in EU 28, Eurocent/kWh	
Filling stations	8	NGVA Europe (2013)
Price for households	6.5	Eurostat (2015; data for 2013)

4.4 national developments

The switch from making biogas for electricity and heat to upgrading this gas to more versatile biomethane is not taking place at an even pace across Europe. While biogas is being produced in all EU member states (except Malta), not all countries started to convert it into biomethane. There are fourteen European countries (AT, CH, DE, DK, FR, FI, HU, IS, IT, LU, NL, NO, SE, UK) that currently upgrade part of their biogas production into biomethane. In 11 countries (AT, CH, DE, DK, FI, FR, LU, NL, NO, SE, UK) biomethane is injected into the natural gas pipeline system and it is used as vehicle fuel in 12 countries (AT, CH, DE, DK, FR, FI, HU, IS, IT, NL, SE, UK); (GreenGasGrids, 2013). Therefore, in order to understand the European biomethane market and be able to draw conclusions, it is essential to follow key developments at the national level.

Note that only anaerobic digestion is analysed in this section, as for the moment there is little data dedicated to gasification; nonetheless, governments should consider putting adequate policies in place, as gasification can deliver large amounts of biomethane from woody biomass and residues in the coming years.

Germany is responsible for 75% of the total biomethane production in Europe, most of which is injected into the grid and mixed with natural gas for electricity generation and heating purposes. In 2012, biomethane doubled its share and supplied 12% of the total gas consumption in transport (EBA, 2013), by 2013 the biomethane share in gas-powered transport went up to 15% (EBA, 2014). There are currently 165 fuelling stations that offer biomethane for vehicles in the country (EBA, 2015). The feedstock for biomethane in transport is constituted out of an average of 91.5% waste and residues and 8.5% maize (Bundesanstalt für Landwirtschaft und Ernährung, 2014). Since the 2014 EEG reform removed bonuses for biomethane used for electricity generation, it is likely that the growth in the transport sector will continue.

Sweden is the 2nd largest producer of biomethane in Europe with 59 upgrading plants. Although the country has roughly a third of Germany's plants in numbers, most of the production is used for transportation purposes and in 2012 biomethane overtook natural gas taking 57% of the gas-powered transport market (EBA, 2013) and reached a 73% share in 2015. Out of the 1,303 GWh that were produced in 2014, 78% was used as transport fuel (EBA, 2015). With its 218 refuelling stations, Sweden provides the second highest coverage in Europe after Germany. The country uses exclusively waste for biomethane production, 52% coming from organic residues and 48% from sewage sludge. The country has rapidly increased the use of biomethane in transport through exemptions from CO_2 and energy taxes.

The UK made during 2014 a leap from the bottom to the third place in terms of biomethane plants and production in Europe. Much of this progress is due to supportive policies, particularly the introduction of an attractive Renewable Heat Incentive (RHI) providing a bonus paid on top of the market value of the gas injected, but also due to an increase in the maximum oxygen concentration level that is allowed in biomethane. Only a very limited amount of biomethane (100 TJ) is yet produced for supply to the transport sector (DfT, 2014). However, the national administration has recognised the several benefits of biomethane as a transport fuel related to greenhouse gas emissions savings, air quality and energy security (Ricardo-AEA, 2015). It can therefore be expected that favourable policies will be put in place to promote the transport use in the future.

The Netherlands is the fourth biomethane producer within the European Union and its 21 upgrading plants are connected to the country's extensive natural gas grid. These plants present a perfect mixture of plants that utilise fedstock such as agricultural fedstock, biowaste, sewage sludge and landfill material. There are 141 CNG filling stations in the country and at least 6,700 gas-powered vehicles. Biomethane develops with the help of the country's excellent gas infrastructure and a 41.5% tax reduction of the investment costs made in renewable energy or energy-efficiency technologies such as upgrading plants (EBA, 2015).

Austria has a long tradition of biomethane production, although due to the decrease in support and the implementation of caps on new plants, its production stagnated over the last years. Nonetheless, there were 14 upgrading units in 2014 which reached over 70 GWh that year. Over half of Austria's biomethane is used for transport, distributed through its 180 CNG filling stations across the country (EBA, 2014). The Austrian government has set the ambitious target of 200,000 gas powered cars by 2020, though this objective will be hard to achieve under the current conditions.

There are also a number of countries that have a smaller production of biomethane, but which show great promise in the years to come. France is modestly increasing its production by 1 upgrading unit in 2013 and another 4 in 2014. The use of biomethane in transport took off in France in 2011, mainly destined for public transport in cities, but it remains rather limited as it represents 0.4% of the country's total consumption in the transport sector (Club Biogaz, 2014).

In Finland the biomethane used in the transport sector profits from tax exemptions and biogas plants in general of an investment subsidy of up to 40%. As a result of the support, biomethane has reached a 30% share of methane in transport and the amount of biogas and biomethane plants have slowly but steadily increased between 2011 and 2014 respectively from 75 to 83 biogas plants and from 2 to 9 biomethane plants. Likewise, Denmark opened 2 plants in 2013 and 4 in 2014 with the help of new Feed-in premiums. Most of the feedstock digested in these countries comes from manure/slurry and organic waste (EBA, 2013- 2015).

Italy is a particular case. Although the country only had 2 biomethane plants in 2013 and 5 in 2014, the potential of biomethane in transport is enormous. Italy is the 2nd biggest biogas producer in Europe with 1,391 plants and is by far the European leader of natural gas-powered transport with over 885,300 vehicles. In the past, the country had generous tariffs for biogas fuelled power plants; however, since December 2013 biomethane incentives have become more attractive. Therefore, it is expected that there will be a biomethane boom in 2015 and after (EBA, 2014).

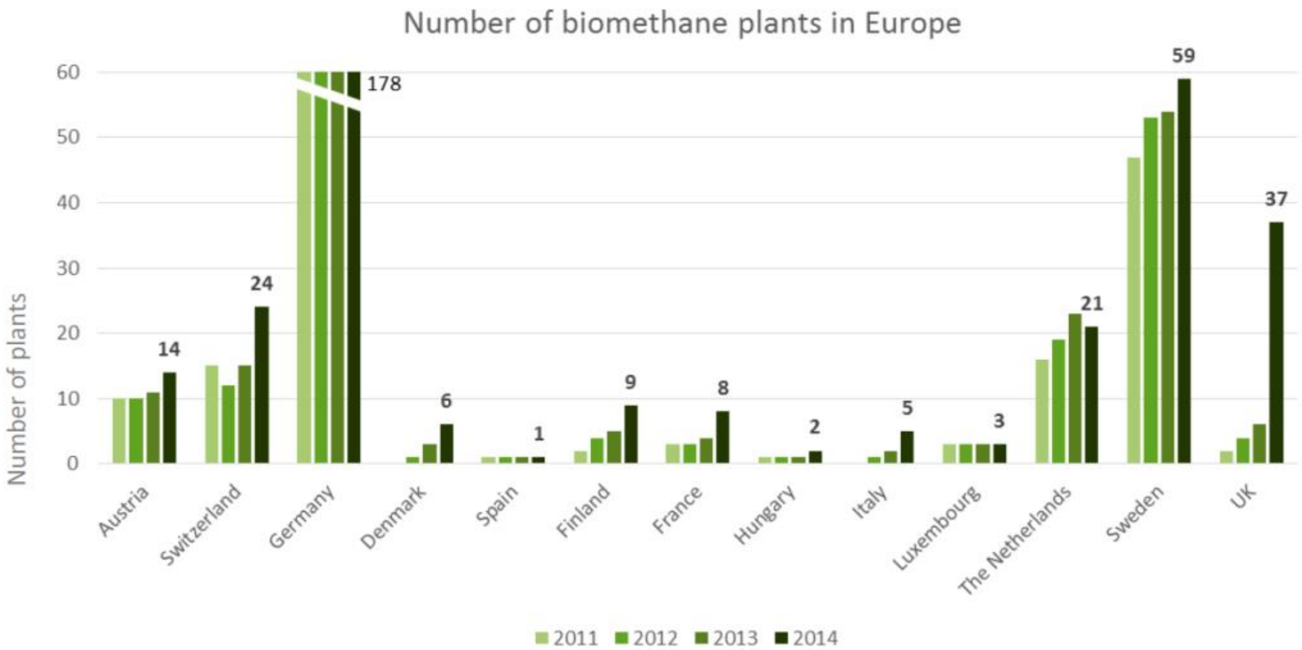

Figure 5. Number of biomethane *plants in Europe (EBA, 2015)*

5. finding the right national and european policies

5.1 the importance of national support schemes and adequate investment on infrastructure

This mixed picture shows that today merely a small part of biomethane's potential is being realised and that such development takes place only in some parts of Europe. Producers and policy makers start to see the advantages of this very promising segment of anaerobic digestion, particularly due to the more efficient use of produced renewable energy carrier when compared to local electricity generation; as well as biomethane's excellent environmental performance in the transport sector. However, building and operating upgrading units causes additional costs compared to traditional biogas plants. If these costs are not taken into account by national support schemes, it is not realistic to expect that private companies will invest into this sector.

Judging by biomethane's performance in different European countries over the past years, it is clear that support schemes and national legal frameworks play a pivotal role on the sector's development (see Figure 6). The types of support systems vary substantially from one country to another. Overall, investors across Europe value stable legal conditions and support schemes that span over long enough periods so as to make important long term investments. Feed-in tariffs is the preferred system by most biomethane producers, as it grants adequate security, although well placed price premiums (bonus tariffs) and tax exemptions can also work in a well-functioning market. Therefore, there is no single winning formula, nor should there be one. What matters most to producers is that the legal framework is transparent and stable over time.

Table 5. Biomethane production and infrastructure in Europe (EBA Biogas and Biomethane Report, 2015)

Country	Biomethane plants	Raw biogas upgrading capacity [Nm^3/h]	Produced biomethane [GWh]	Plants feeding into grid	Biomethane used in transport	Number of biomethane filling stations	Number of CNG filling stations*	Tariff (FiT) or premium (P) for biomethane [€/MWh]
Austria	14	5 160	70	11	n/a	3^p	180	8 (FiT)
Denmark	6	8 650	n/a	n/a	n/a	n/a	7	18.8 (P)
Finland	9	2 731	40	3	43%	24^p	25	n/a
France	8	2 610	41	6	n/a	n/a	310	129.7 (FiT)
Germany	178	204 082	9 140	165	3%	$165^p + 143^b$	920	n/a
Hungary	2	625	4	1	n/a	1^p	19	n/a
Italy	5	500	n/a	n/a	n/a	n/a	1 040	150 (FiT)
Luxembourg	3	850	26	n/a	n/a	n/a	7	n/a
Netherlands	21	16 720	683	n/a	n/a	60^p	141	1.03 €/Nm^3
Spain	1	4 000	n/a	n/a	n/a	n/a	69	n/a
Sweden	59	38 858	1 303	13	78%	218^b	218	n/a
Switzerland	24	6 310	166	22	33%	137^b	137	n/a
UK	37	18 957	700	34	n/a	n/a	8	70 (FiT)
TOTAL	367	310 053	12 173	255		$253^p + 498^b$	2041	

[b] blend

[p] pure (100%) biomethane

**NGVA Europe*

Building adequate distribution and fuelling infrastructure is also pivotal for the adequate deployment of biomethane. Constructing dedicated biomethane stations with a direct connection to production plants is a good alternative to supply remote areas. However, in most cases it is more efficient and economical for producers to connect a plant to the natural gas grid system. Having access to the grid enables them to store their product without building additional infrastructure and it also grants them the chance to sell their product where the price is most attractive. In addition, consumers can profit from green products at their local filling stations. For these reasons, it is imperative that public authorities and financial institutions provide support to plant operators in order to gain access to the grid. This implies state support for at least part of the costs of establishing the grid connection, as well as access to adequate loan conditions for biomethane producers irrespective of plant size and turnover.

5.2 the need for adequate european legislation

EU legislation also has great influence on the development of the sector. While new European renewable energy targets could provide confidence to investors, the restrictions of national “state aid” or caps on the construction of new plants would do the opposite. Biomethane is produced, consumed and supported in different ways across Member States. Therefore, while a move towards harmonisation is desirable to boost trade, the EU should also consider national differences within the EU28. To a certain extent, this may also apply to feedstock availability. The new ‘ILUC Directive’ (EU 2015/1513) amending the Renewable Energy Directive and the Fuel Quality Directive caps the support for biofuel production from crops whereas it incentivises many other important feedstocks such as biowaste, manure, sewage sludge and energy grasses (as listed in Annex IX of the Directive).

By implementing the right measures, the European Union could boost biomethane production and thereby drastically reduce GHG emissions from the transport sector. Still a couple of EU countries remain energy islands, physically cut off from their neighbours, making trade almost non-existent. If producers were given the possibility to sell across borders, this could increase the demand substantially. Therefore, it is essential to move towards energy union by removing administrative barriers. In this respect, the sector hopes that the EU will coordinate the creation of a mass balancing system that boosts intra-European biomethane trade. This means firstly that the European gas network shall be recognised as one single logistical facility and secondly, that the sustainability verification and the volumes of injected and withdrawn biomethane are properly registered and recognised on the European level.

New Directive 2014/94/EU was adopted on the Deployment of alternative fuels infrastructure. This promising piece of legislation requires all EU Member States to have an appropriate number of CNG refuelling points accessible to the public by 31 December 2020 so that motor vehicles can circulate in densely populated areas. Similarly, the directive also compels countries to have an adequate coverage of LNG stations for heavy transport across water and land by 2025. While the European Commission was proposing ambitious objectives, it will eventually be up to governments to draft national plans and to build a wide network of filling stations.

The Technical Committee 408 within the European Committee for Standardisation (CEN), or in short CEN/TC 408, is a platform integrated by EU member states, several non-EU neighbouring countries and by industrial sectors. This Technical Committee is currently developing two European Standards: one on biomethane injection into the NG network (prEN 16723-1) due for 2017 and another on automotive fuel specifications (prEN 16723-2) due for 2016. Once these European Standards (EN) are voted and approved by member states via a weighted majority, they must be considered "identical to a national standard and every conflicting national standard must is withdrawn" (CEN/TC 408, 2015). This work towards the elimination of technical barriers is very positive for the deployment and trade of biomethane and should be supported by national authorities.

Finally, in order to gradually switch from fossil fuels to renewable fuels, the EU should equally promote blends of natural gas-biomethane as currently liquid biofuel blends. This means that harmonised product names and terminology for blends (e.g. 10% bioCH_4; 20% bioCH_4) should be established in the EU and also averaging GHG emission values should be allowed for blended gaseous fuels as well as for all different biomethane feedstocks.

6. conclusions

Biomethane could substantially contribute to the decarbonised transport sector of tomorrow. The technology is advancing year upon year, making the growing number of upgrading units more cost-efficient. Unlike the electric transport, the mature technology of gaseous transport does not require further big investments and innovation in order to be deployed. CNG and LNG can provide a bridge technology for passenger cars and an ultimate solution for heavy duty vehicles and maritime transport.

However, the further development of biomethane industry together with the whole low carbon transport sector depends heavily on public policies and true commitment at the national and European levels. Europe's ambitious transport and GHG emission targets can only be achieved if the right measures are implemented in the coming years.

European Biogas Association (EBA) has a key role in Brussels in discussing these legislations and barriers with other stakeholders and in prompting the EU institutions to remove legislative burdens. Also within the framework of the project BIOSURF (www.biosurf.eu), many of these issues are addressed. The results and deliverables are published on the website which is regularly updated.

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Printed in April 2016

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