

Organic waste recycling, production of renewable energy and clean fuel for transport, biofertilizers, greenhouse gas emissions reductions: the biomethane virtuous circle has been demonstrated by the European Biogasmax project.

# BIOGASMAX

## 2006/2010 **the synthesis**



*biogasmax*  
A DRIVING FORCE



coordinated by:



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*The EU directive on the promotion of renewable energy encompasses all renewable energy sources, including biogas. When its potential is fully exploited, biogas could significantly contribute to the achievement of the EU’s targets of 20% share of renewables in European energy consumption and 10% share of renewable transport fuels in the EU fuel mix by 2020. As biogas is made from organic waste, increased use of biogas could help in realizing the EU target of reducing greenhouse gas emissions by 20% of 1990 levels in 2020. Further, its clean burning properties can also improve urban air quality.*

*The results of the project should contribute to the specification of a European biomethane fuel quality standard that would increase its acceptance as a transport fuel and thereby its wider adoption. The project has also collated best practices in the whole biomethane value chain and summarized policies, incentives and guidelines for those interested in adopting the technology with special emphasis given to the new member states.*

*BIOGASMAX enhanced the prospects of biomethane as a vehicle fuel in EU25, contributing to the EU objective of decarbonising transport as enumerated in the EC communication «Europe 2020 – A strategy for smart, sustainable and inclusive growth».*

*At a time when EU is facing major challenges of mitigating climate change and enhancing energy security, the significant contribution of BIOGASMAX is especially valuable. The participating municipalities and regions -Lille (France), Rome and Lombardy (Italy), Torun and Zielona Góra (Poland), Göteborg and Stockholm (Sweden) and Bern (Switzerland)- as well as all partners involved are to be congratulated for their individual and collective achievement.*

*Jean-Eric Paquet  
Acting Director Directorate B  
Trans-European transport networks & Smart transport*

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# Biomethane: a great way of turning waste into transport fuel!

## Supporting the European Commission's objective towards clean and sustainable transport

In a Communication (which is a strategic proposal to European Council and European Parliament) published in May 2010, the European Commission highlighted the challenges facing waste management and renewable energies in transport. Between 118 and 138 million tonnes of biowaste are produced every year in the EU, of which about 88 million tonnes is municipal waste. It is projected to increase on average by 10% by 2020. About one-third of the EU's 2020 target for renewable energy in transport could be met by using biogas produced from bio-waste, while around 2% of the EU's overall renewable energy target could be met if all bio-waste was turned into energy.

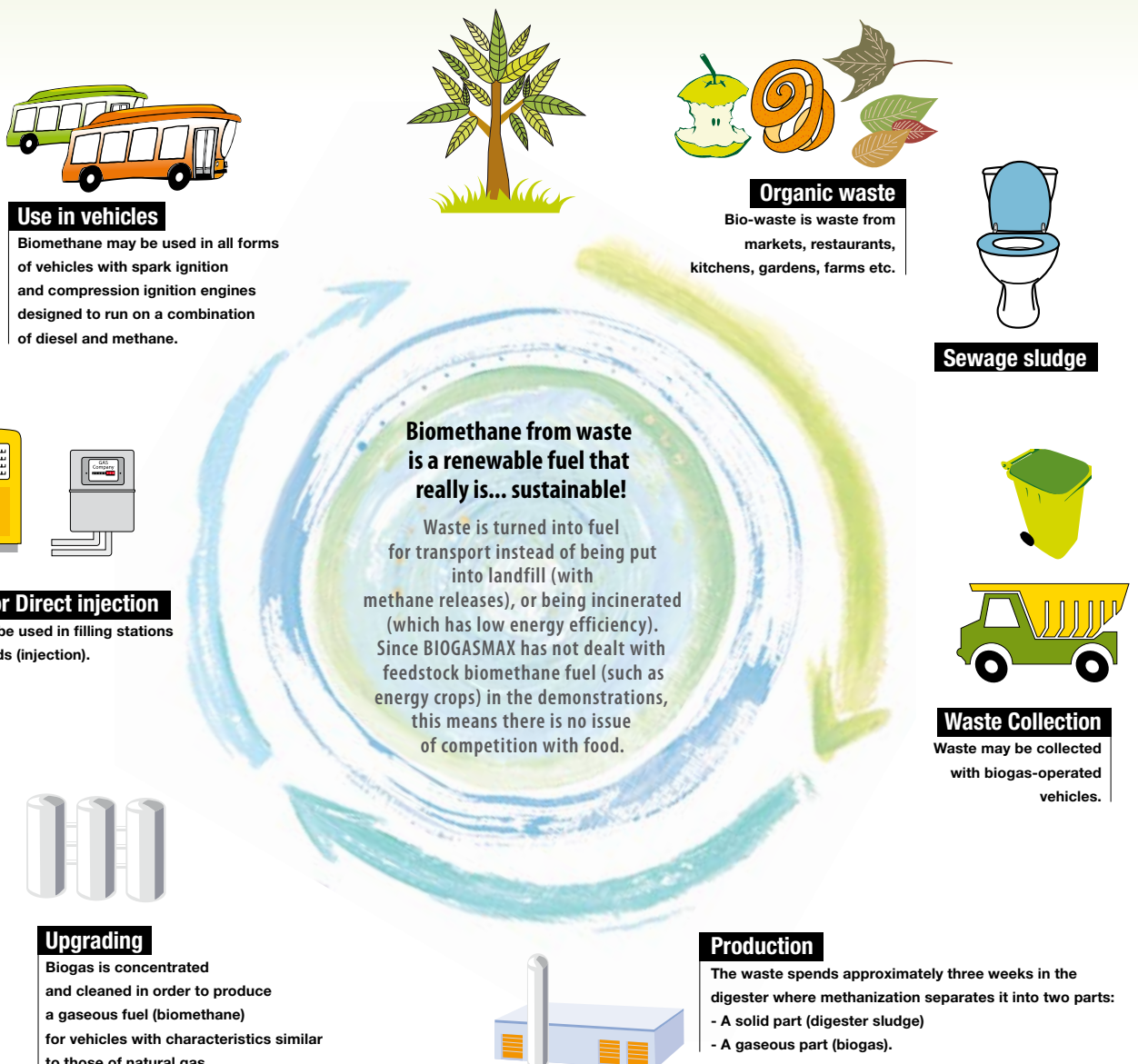
Further sustainable transport policies, biomethane plays a great role in municipal solid waste management policies. Biomethane fuel from biowaste helps cities and regions to match with the 1999/CE Directive on landfill objectives, the latter asking for gradual reduction of organic waste received by landfills, which results in the need to promote the organic recovery of biowaste.

BIOGASMAX aims to help the European Community in reducing dependency on oil and reducing greenhouse gas emissions through increased use of biomethane in the transport sector generated from a wide variety of feedstock available in urban areas and regions in Europe. In this regard, BIOGASMAX supports the European Commission's policy objective to introduce 5 to 8% biofuels into the transport sector.

## Biomethane life cycle

The implementation of digestion units which produce biogas fuel result in a triple win: treating organic waste; producing a quality organic fertiliser; and producing a renewable fuel.

Since 2006, BIOGASMAX has adopted the well-to-wheel approach: using the entire chain of biomethane from waste collection to use in vehicles, recovery of organic matter in agriculture; and the essential steps of upgrading, distributing and transporting biomethane.



### Organic waste

Bio-waste is waste from markets, restaurants, kitchens, gardens, farms etc.

### Sewage sludge

### Waste Collection

Waste may be collected with biogas-operated vehicles.

### Production

The waste spends approximately three weeks in the digester where methanization separates it into two parts:

- A solid part (digester sludge)
- A gaseous part (biogas).

### Upgrading

Biogas is concentrated and cleaned in order to produce a gaseous fuel (biomethane) for vehicles with characteristics similar to those of natural gas.

### Distribution or Direct injection

Biomethane may be used in filling stations or natural gas grids (injection).

### Use in vehicles

Biomethane may be used in all forms of vehicles with spark ignition and compression ignition engines designed to run on a combination of diesel and methane.



## ■ A driving force for European cities and regions

Producing biomethane from organic waste allows sustainable development to occur in European cities.

Waste can “clean the air”. Biomethane is a major part of Air Quality policies implemented by cities.

Biomethane is a closed-loop system. Using biomethane is closely linked to local and regional sustainable development. For example, the local and regional community benefits both economically and environmentally because the resources used are from local waste, and the end-use is in vehicles from the local community. Local farmers can use the quality organic fertilisers produced from biomethane production.

Moreover, biomethane can bring together strategic public policies for water and waste management, transportation management and public transport. The Biogasmax demonstration projects show that the life cycle of biomethane can be comprehensively developed on a local and / or on a regional scale and that cooperation between stakeholders in a territory is needed and successful.



## ■ Objectives of the Biogasmax project

Biogasmax, funded by the European Commission’s 6<sup>th</sup> Frame Programme FP on Research & Development, has four major objectives:

1. Demonstrate large scale digestion and biogas upgrading units, producing biogas from waste material available from the urban and close by rural areas;
2. Demonstrate the expansion of gas-driven fleets in public and private transport, for example buses, waste collection trucks, and service cars;
3. Prove the technical reliability, cost-effectiveness, environmental and social benefits of biogas fuels; and
4. Widely spread knowledge of results gained in the demonstration projects among other European cities and stakeholders by information and training materials, lectures and conferences, with particular emphasis on new Member States.

The project partners identified the technical, operational and institutional barriers that prevented biomethane from entering the market, and drew conclusions from the lessons learnt during the large scale demonstration projects. There were 30 partners from seven European countries involved in Biogasmax between 2006 and 2010.



## ■ Political commitment is crucial to success

Political commitment is essential to success because decisions involve all levels of the institutional hierarchy. Stakeholders play an important role by deciding the relevant course of action on:

- **Local issues** – biowaste and wastewater management, public transportation, use of clean vehicles, car parking policy, green procurement procedures, citizen awareness, and land planning.
- **Regional issues** – treatment plants, facilities implementation, mobility policies, and tax / incentives policy.
- **National issues** – biomethane is supported via policies such as national GHG emission reductions, legislation on environmental protection (waste, water, air), and tax / incentives policies.

- **European commitment** is a driving force towards biogas expansion. In 2001, a former project on the EC Directive on biowaste was planned. A Green paper on Biowaste was published by the EC’s DG Environment at the end of 2008 (EU [COM(2008)811ENDG]). In May 2010, there was a communication from the EC to the Council and the European Parliament called “Future steps in bio-waste management in the European Union”, which explains the steps considered necessary for optimizing the management of bio-waste, in the aim to produce biogas and use it as a fuel in road transport.

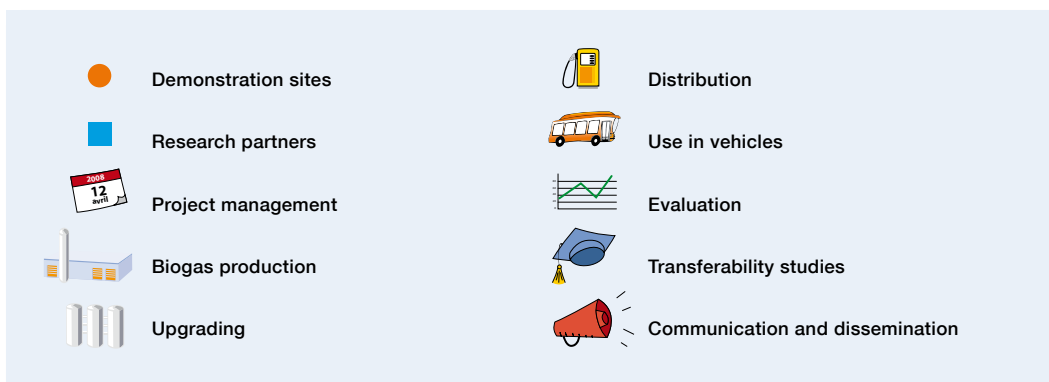
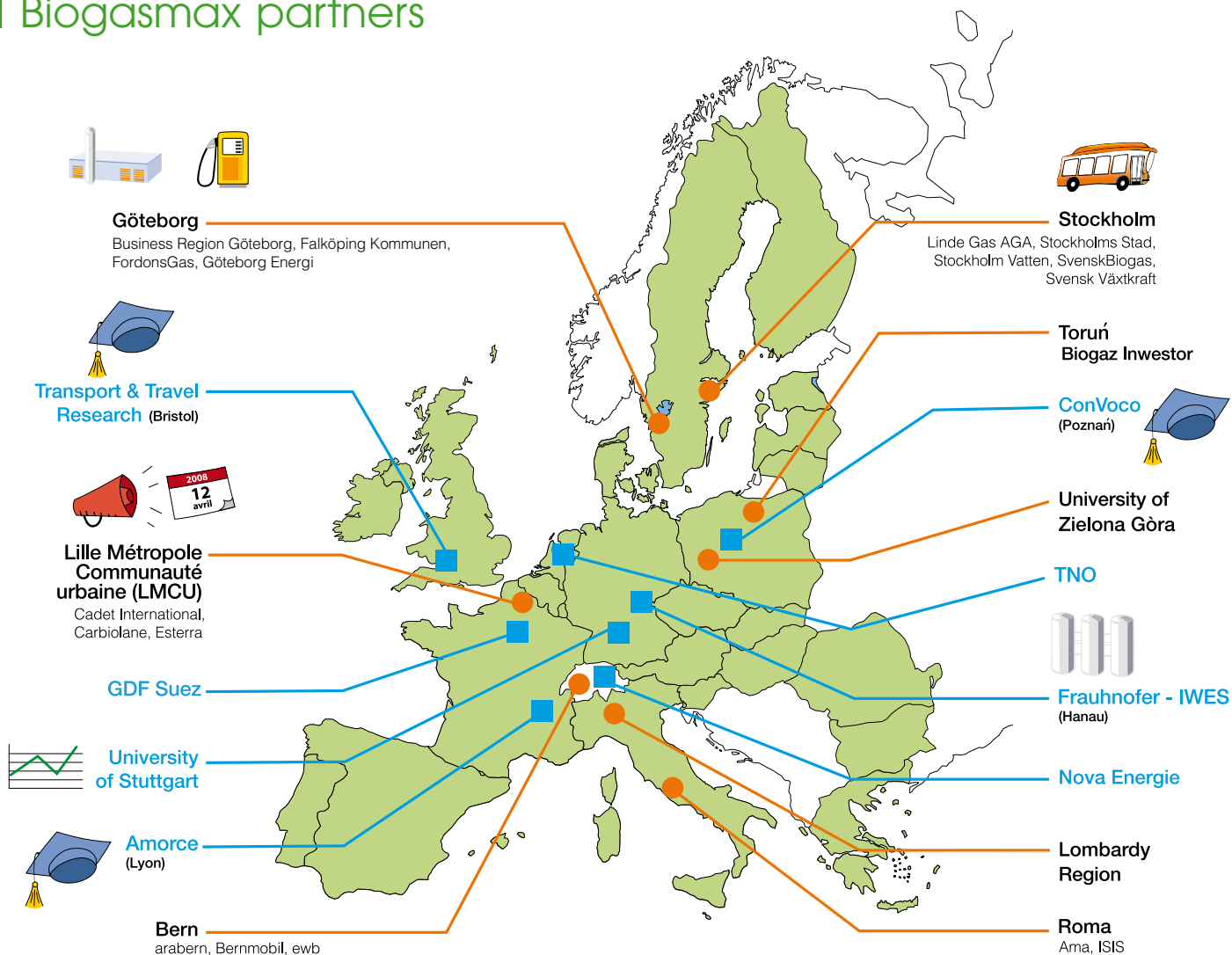




## Local strategic goals to sustain biomethane expansion

- In 2003, Stockholm decided that all biogas should be upgraded to fuel for environmental reasons.
- Lille aims to feed the Organic Recovery Centre with source-sorted household organic waste coming from 50% of the metropolis area.
- Linköping has set up a "pay as you throw" fee for household waste collection proportional to weight; this measure encourages source separation and thus, is relevant to the effectiveness of the biogas production plant.
- Rome decided to actively implement the source-sorted MSW collection (including biowaste). By 2013, waste from 30% of the citizens will be treated at the Maccarese Organic Treatment Plant that will be upgraded to accommodate the increased amounts of biowaste.
- Göteborg has developed the Biogas Väst cooperation project. The project's purpose is to develop a new industry. The vision is that biomethane will substitute 20% of fossil fuel used in the road transport by 2020.

## Biogasmax partners



The perfect combination  
of three city controlled companies



Bern



The Bern site includes three partners: the gas producer (arabern), the gas distributor (ewb) and the public transport operator (Bernmobil).

## 1) ARA Region Bern (arabern)

arabern treats the wastewater from roughly 250,000 inhabitants. Together with the co-substrates, the volume treated is equivalent to about 500.000 inhabitants. The WWTP plant in Bern was inaugurated in 1967. Since 1980 it has been continuously extended by adding a new CHP, an additional digester and an improved aerobic treatment. In 2006 at the start of the Biogasmax project, it was decided to increase gas production and inject biomethane into the grid.

With the increasing gas production, the gas line reached its maximum capacity and was subsequently renewed and improved over the last two years. All the cast iron gas lines have been changed to larger alloy pipes and the classic gas bell was replaced by a modern double membrane gas balloon.

arabern

Energie Wasser Bern  
ewb



Gas storage (ballon)

Status	Aktuelle Werte	Verlauf	Admin	Hilfe	Über
Werte	Einstellungen	erweiterte Einstell.		Entschwefelung	
PSA		Speicher			
O2 (%)	...	...	...	...	...
CH4 (%)	...	...	...	...	...
H2S (ppm)	...	...	...	...	...
H2 (ppm)	...	...	...	...	...
CO2_le (%)	...	...	...	...	...

Biomethane quality control

In total, the plant comprises of three digesters of 6,000 m<sup>3</sup> each. At an average retention time of 28 days, they produce up to 18,000 Nm<sup>3</sup>/d of biogas with a methane content of 65%. In January 2008, a gas upgrading unit (called a Pressure Swing Adsorption (PSA) system from Carbotech) was installed treating approximately 300 Nm<sup>3</sup> biogas per hour. The system has worked perfectly from the start, yielding about 200 Nm<sup>3</sup> of biomethane with a methane concentration of 98 to 99%.



Gas upgrading plant (PSA)

## 2) Energie Wasser Bern (ewb)

Filling stations expansion in Bern (Switzerland)

Year	Public	Private	Bernmobil
2008	8	1	3
2009	11	2	4

When biomethane production was developed, filling stations were also built and well-targeted local action has supported the market demand for gas-driven vehicles.

### Filling station development

Special effort was given to the development of filling stations. The indoor filling station at Bernmobil has been quite a challenge. The financial results show that the experiment should not be repeated elsewhere.

## Co-substrates

In order to increase gas production, co-substrates from industry and from restaurants are fed to the digesters. This also includes spent ethanol and methanol from pharmaceutical industry and de-icing liquid from the airport. About two third of the methanol substitutes clean methanol as carbon source for the nitrification / denitrification step, the rest is fed to the digester.



Sieve-hammer mill

The grease containing waste is hauled by tankers and emptied into a pre-storage tank with a volume of 24 m<sup>3</sup>, where it passes through a sieve-hammer mill to remove all the undesired particles. Then the waste is chopped down to a size of 2mm. After size reduction, the waste is stored in two heated (up to 60°C to avoid flocculation of the fat) and mixed tanks of 24 m<sup>3</sup> and is subsequently fed to the digesters. The goal is to maintain a constantly high production rate to avoid gas flaring. In 2009, two explosion-proof underground storage tanks for ethanol and methanol were installed for operation.



Co-substrate pre-storage



### Support to natural gas vehicles (NGVs) expansion

The local energy company ewb has successfully carried out a strong communication and marketing campaign to convince companies and institutions to replace their fleet cars with NGVs. The results are as follows:

- The Swiss postal service bought 110 Fiat Ducato (38 there of in Bern) and will buy an additional 750 LDV's;
- The largest car sharing company in Switzerland bought 50 NGV's (Ford Focus);
- The Swiss express postal service (TNT) in Bern has bought 10 Opel cars;
- The Swiss Army camp in Thun (next to Bern) will slowly change their staff cars to gas driven cars due to their good experiences with the first 40 Opel Zafira's;
- The city of Bern is testing a sweeping machine for sidewalks, parking lots, roads, etc. and is considering buying 8 machines as a first step;
- More than 100 companies around Bern drive at least 1 gas car (see list on [www.schlau-fahren.ch](http://www.schlau-fahren.ch));
- Approx. 1,000 private cars have been subsidised since 2006 between € 700 to € 1,400; and
- Another 180 Zafira's have been distributed with a reduced leasing cost.

*Development of personal cars*

Year	Number of cars
end of 2006	334
end of 2007	647
end of 2008	846
end of 2009	966
mid of 2010	1,060



Compressor



Indoor filling station

**BERN MOBIL**

**NOVA** Energie



### 3) Bernmobil

In 2006, the public transport company, Bernmobil, decided to progressively replace the diesel bus fleet by NG buses (Volvo and then Mercedes). The 48 first buses were delivered by Volvo (16 two axles and 32 three axle buses), the following 32 buses were bought from Mercedes (all with three axles) due to technical problems (independent of gas). By end of May 2010, 72 gas buses were in operation.

In 2010, nine new nozles were added to the 57 slow filling stations originally installed, and two new fast filling stations are under construction.



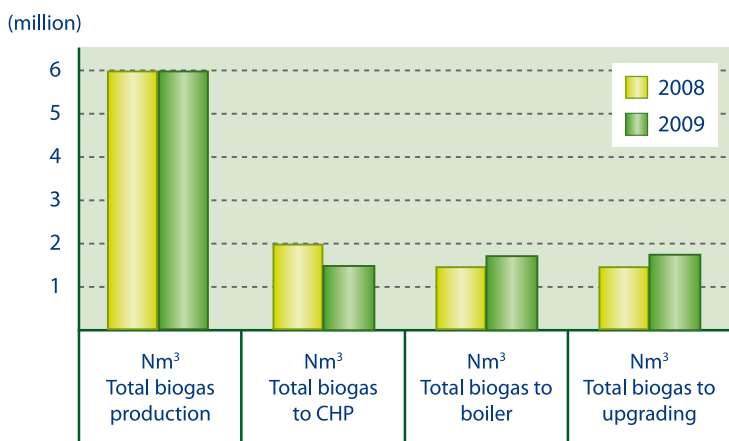
### Future plans

While the goal was to inject 1,3 million Nm<sup>3</sup> of biomethane per year, 85% was achieved in 2009. Indeed, biogas is currently used for other uses such as CHP and boiler because arabern is obliged to produce all of the process heat for digester heating and for sludge drying through renewable energy.

By 2014, a new waste to energy plant (incineration plant) will be completed not too far from the WWTP. The district heating system empowered by the municipal solid waste (MSW) and an additional wood boiler, will be extended connecting arabern. 50 % of the total MSW is considered to be renewable.

Hence, the heat needed to dry the sludge will be provided by the waste to energy plant and all of the biogas can be injected into the grid. The planning for the enlargement of the upgrading plant by additional 600m<sup>3</sup>/hr has been initiated as part of Biogasmax.

*Total gas production and utilization at Bern WWTP 2008/2009 [arabern, 2010]*



NGV in a driving-school



Public filling station

## ACHIEVEMENTS

- Development of gas-driven vehicles: bus fleet conversion from diesel to gas, personal cars, service cars
- Grid injection, labelling, green certificates
- Use of co-substrates for increased biogas production

Biogas expansion as a driving force  
for regional development



# Gothenburg



## Gothenburg region: a pioneer region for biogas as a fuel

Gothenburg and West Sweden is a forerunner in biogas production for vehicle use, where a third of Sweden's methane gas fuelling stations are located. By the end of 2009, there were around 7,500 gas-driven vehicles consuming 100 GWh biogas and 100 GWh natural gas.

The methane gas replaced more than 23 million litres of petrol and diesel and reduced the emissions of green house gases by 33,000 tons/year.

Gothenburg and West Sweden have a long history of using methane gas in vehicles. Volvo built their first methane gas-driven bus at the end

of the 1980s. In 1994, the first fuelling station for compressed biogas was built at Gryaab wastewater treatment plant where converted Volvo bi-fuel cars were refueled.

Since 1996, the city-buses in the City of Trollhättan have been fuelled by locally produced biogas, placing the city amongst the first in Sweden in biomethane use. Two years later the company FordonsGas was founded, now one of Sweden's leading gas-fuelling stations operators. These developments lead to the formation of the Biogas West project.



CNG waste collection trucks

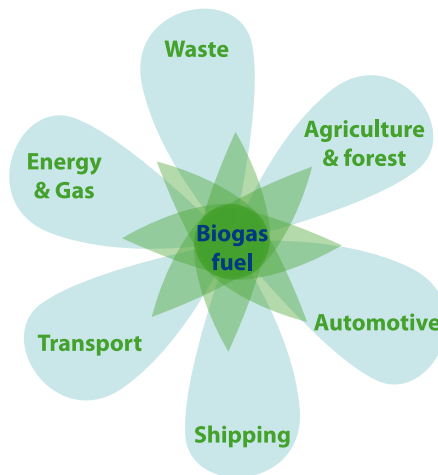


Gryaab wastewater treatment plant

## An innovative economic platform for biogas expansion: Biogas West

Launched in 2001, Biogas West is a regional cooperation project in Western Sweden to implement biogas as a vehicle fuel. Led by Business Region Göteborg, the project involves more than 25 stakeholders representing companies, municipalities in the western region, organisations and authorities.

Among the participants are Göteborg Energi, FordonsGas Sverige and the Municipality of Falköping, who are all partners in Biogasmax. The purpose of Biogas Väst is to develop a new environmentally-sound industry that stimulates market development for the pro-



duction, distribution and use of biogas as a vehicle fuel.

This will contribute to creating job opportunities, export opportunities, as well as attracting foreign establishments and investments. The increased use of biomethane and the development of the western Sweden cluster contribute to substantial decreases in greenhouse gas emissions. In addition, it solves waste problems and stimulates the production of organic fertilisers.



## Fuelling stations connected to the gas grid

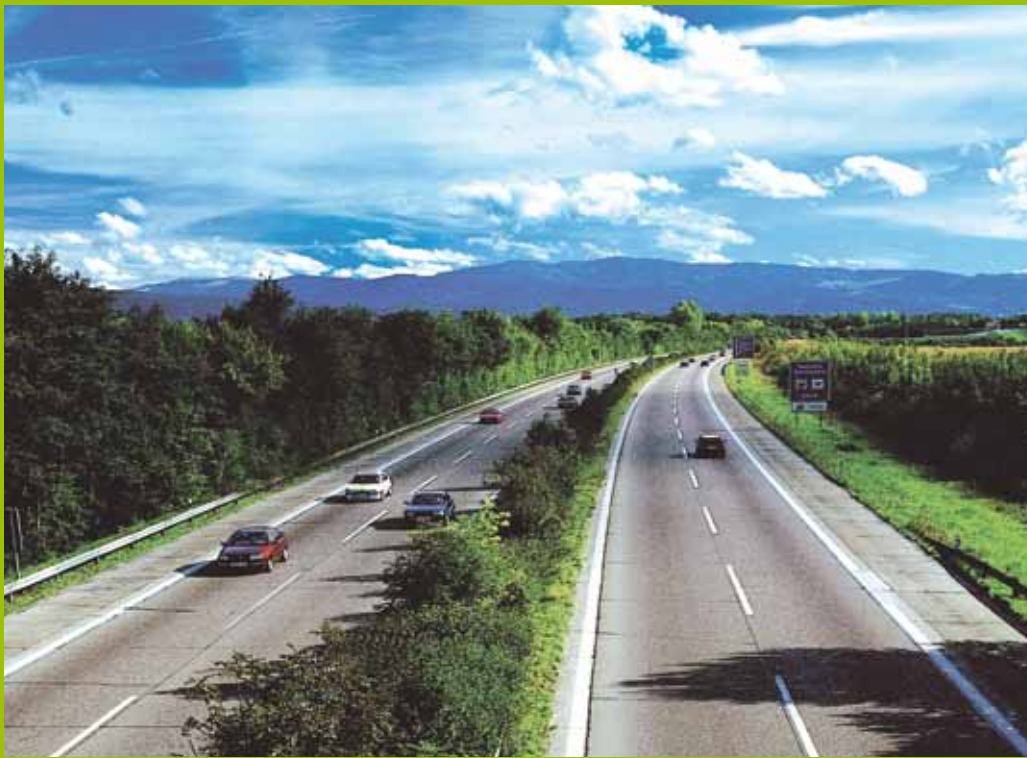
The Göteborg site partners: Business Region Göteborg, Falköping Municipality, FordonsGas AB and Göteborg Energi AB, have all contributed to different areas of the Biogasmax project.

Göteborg is a medium-sized city, with 800,000 inhabitants in the Göteborg region, where a larger scale biogas system for transportation has been implemented.

The city's waste resources are used for producing biogas in a system with very low methane slip. Distributing upgraded biogas through

the local natural gas grid to the gas fuelling stations is both cost-efficient and energy-efficient. The infrastructure for the gas fuelling stations is one of the best in Europe with eighteen stations for the public, bus and garbage truck fleets.

The Göteborg region also has one of the largest markets for gas-powered vehicles in Sweden, with a unique mix of company fleets, municipal fleet and private owners.



*The Biogas Highway, connecting Göteborg with Stockholm*

## ■ Expanding the motorway distribution network: the Biogas Highway project

From a European perspective, the Biogas Highway is a unique infrastructure project. Twelve fuelling stations have been built between Göteborg and Stockholm along the E20 Highway (500 km). Swap-body and back-up systems have also been built to secure methane gas delivery.

Now it's easy to travel between the two cities without the risk of running out of fuel. FordonsGas have built nine of the twelve stations,

and three other stations have been built by AGA in the Stockholm region.

A filling stations network will encourage people to buy CNG cars. In Falköping, 3.5% of all new car sales last year were gas-powered vehicles and for Göteborg, the figure was 4.6%. In 2009, the gas vehicle market increased by 35% in Sweden, rising from 17,000 to 23,000.

## ■ Production plants and feedstock: a diversity of size and resources are treated

### **Gryaab wastewater treatment plant and Gasendal upgrading unit**

In Göteborg, biogas is produced at the wastewater treatment plant, Gryaab. The plant consists of two digest chambers, a sludge silo, and equipment for energy recovery / heating and gas treatment. The main feedstock for the digestion is sludge, but there are also co-substrates from industries and restaurants like grease and food waste.

The production of biogas is around 60 GWh per year and it is sold to Göteborg Energi to upgrade and inject into the gas grid. Gryaab is applying for permission to treat a further 70,000 tons of organic material to increase biogas production.

The biogas from Gryaab in Göteborg is distributed through the local natural gas grid via the upgrading and injection plant at Gasendal. The upgrading facility is a chemical scrubber with a very low methane slip of below 0.1%.



*Sewage sludge come from wastewater treatment*



Upgrading unit in Falköping



## The Falköping experience: how biomethane can work in a small sized city



Filling station in Western region of Sweden

Falköping is a small-sized municipality with 30,000 inhabitants that has implemented a small scale biogas system for transportation. The municipality's waste resources (biowaste from door-to-door collection or sewage sludge) are used for biogas production. The gas is upgraded and distributed to one fuelling station. All of the city buses run on biogas as well as a large number of municipal and company cars.

In Falköping, household waste is the base for biogas production. Some industrial waste is also processed and digested, mostly from food production and dairy waste. A mixer tank is used to reduce temporary or seasonal effects. Sewage sludge is digested in a separate chamber. The upgrading plant was built in 2008 by Göteborg Energi and co-funded by the EU through the Biogasmax project. The production has risen from 3 to 4 GWh annually, due in part, to an increased amount of sorted household waste. The upgrading plant has a capacity of 10 GWh/year.

## Vision for the future

In Göteborg and Western Sweden, biogas is used on a large scale and replaces 20% of the fossil fuels used in the transport sector. Biogas is used in cars, buses, trucks and ships.

Biogas is produced from household and industrial waste, as well as agricultural and forest residues, making Göteborg the leading centre for thermal gasification, producing large amounts of biomethane from forest residues.

Thanks to the well-developed natural gas grid, regional biogas grids and liquefied biogas, Western Sweden is a leading centre for the production, distribution and use of liquefied biogas.

A farm-based biogas production treating feedstock, such as liquid



manure, is planned in Falköping. This decentralized system of rural biogas production should be connected to the upgrading and distribution system. This will increase total biogas production.

The region is a world-leading cluster for developing biogas engines and vehicles. Methane-diesel engines for heavy duty trucks, buses, construction vehicles and ships are being developed, as well as vehicles with gas-electric hybrid power trains.

## ACHIEVEMENTS



- Increased biogas production with very low methane slip
- Injection of biogas into the gas grid, with the green gas principle applied (please refer to the "Quality" section of this report)
- Building and operating a new upgrading plant
- Concept definition for an urban and rural biogas system
- A model-based calculation tool achieved to aid decision-making – the "Falköping model" (please refer to the "Training" section of this report).



Biomethane from source – separated biowaste and grid injection: a pioneer city in France

# Lille metropolitan area



The Organic Recovery Centre

## Biomethane production at the Organic Recovery Centre

### Objective of 100 buses run by biomethane

The Organic Recovery Centre (ORC) is located in the Lille metropolitan area and has been in operation since September 2007. It has been designed to treat 108,000 tons of organic waste (kitchen and green waste), with the objective of producing four million Nm<sup>3</sup> of biomethane and 34,000 tons of dried compost.

The biowaste comes from a selective door-to-door collection (from half of the local area equivalent to 500,000 inhabitants), from recy-

cling centres located homogeneously in the metropolitan area, and from institutional public catering.

The biogas production site is near the consumption site. There is a bus depot situated in front of the ORC, where 150 gas-driven buses are refuelled with a mix of natural gas and biomethane produced from the ORC (where production is equivalent to 100 buses). The bus depot (owned by the LMCU) has been operated by the Transpole Company since the end of 2005.

## What have been the historical reasons for biomethane as a fuel in Lille metropolitan area?

Biomethane has become a reality thanks to a strong political will and an institutional context. This single local authority (namely LMCU) is accountable for public transport, waste management and sewage treatment services, which has led to biomethane projects being implemented in the area in the late 1990s. The fact that these three major responsibilities were held in the hands of one local authority was a crucial condition for the success of biomethane expansion in Lille and as a fuel for public transport.

Off the back of the success of the Pilot Marquette project which ran in the 1990s, two major decisions set up the conditions needed for the ambitious biomethane project. Firstly the urban Mobility Plan, launched in 1999, facilitated an increase in gas-fuelled urban buses, with the aim to convert the whole fleet (400 buses) with NGVs by 2011. Secondly, it was decided in the meantime to treat household organic waste with the maximum energy and matter recovery, which led to the ORC project, where the aim was to fill gas buses with biomethane.



The first natural gas bus in Marquette WWTP in 1990's

## The Marquette pilot project: the starting point of biomethane as a fuel



Digesters

Between 1994 and 2004, four gas-driven buses were refuelled with biomethane produced from an experimental water scrubber installed in the Marquette WWTP. Since September 2009, a new upgrading unit has been built. It should produce 0,28 Million Nm<sup>3</sup> per year (80 Nm<sup>3</sup>/hour), intended to refuel buses and service cars.



Sludge decant in bassin



Trucks refuelled at the upgrading plant



# Biomethane into the natural gas grid

## Organic recovery centre in Lille: the first place to implement in France

Lille has pioneered biomethane gas grid injection in France. Until 2011, it will be the only area in France where grid injection is feasible. LMCU set up conditions for injecting biomethane into the natural gas grid prior to the national supportive feed-in tariffs (which is expected to be published in early 2011). In 2007 LMCU built the injection unit and the physical connection with the

natural gas grid was made in late 2009 by the GrDF distribution grid operator and two parallel contractual agreements were set up in mid-2010.

This allowed GrDF to transport biomethane and the GDF SUEZ operator to purchase the biomethane. Biomethane has been injected into the grid since October 2010.

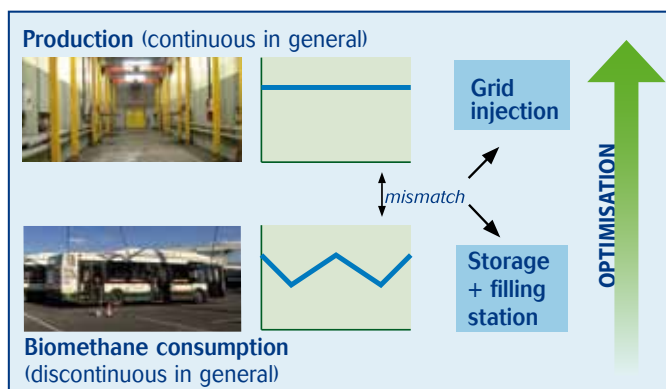
## A way of optimizing biomethane consumption

Digesters run continuously, therefore, biogas production is continuous whereas consumption is discontinuous as buses are mainly refuelled during the night. So, in order to manage the mismatch between the continuous production and discontinuous consumption, there are two solutions: storage or grid injection.

Biomethane delivery is made through the local dedicated pipeline. In periods with low demand the biogas is stored in two 5000 m<sup>3</sup> tanks (this is equivalent to half-a-day of production capacity). There are three reasons why this solution limits the efficiency of the production plant:

1. Storage capacity is limited. A certain amount of biomethane may be flared in periods where demand is low (flaring is needed in such cases in order to avoid methane emissions in the atmosphere);
2. Safety management measures can result in further expenses to the operation of the plant; and
3. When the upgrading unit faces discontinuous biomethane consumption, the operation may be also discontinuous, which may decrease the environmental and economic benefits of the whole process (because there might be higher energy consumption to attain the rated operation and methane slip).

On the other hand, injecting biomethane continuously into the natural gas grid is a way of transporting all that is produced without building a parallel system of transport, and without investing in heavy safety management measures. Flaring is only needed during a maintenance operation. Grid injection is consequently the best solution to optimise environmentally and economically beneficial biomethane production and consumption.



## A starting phase delayed by national legislation not adapted to local production of gas

In Lille Metropolitan Area, there are two ways to distribute biomethane: the biomethane can either be transported via a dedicated 100-metre pipe that connects the biogas plant to the bus depot, or the gas can be injected directly into the natural gas grid. The plant was operating in 2007 but delivery of the biomethane to the bus depot began in 2010.

The main reason for the delay in biomethane delivery was a gap between the innovative aspect of the project and national legislation regarding transporting gas. The latter was not adapted for this kind of local production, which was quite new at the time. Indeed, the same authorisation procedures were applicable to the 100-metre pipe transporting 600 Nm<sup>3</sup>/h, as for 1000-km pipe transporting thousands of Nm<sup>3</sup>/h. Moreover, the request for legal authorisation was even further complicated by two new pieces of legislation on gas transportation published within a three-month pe-



Fuelling of pure biomethane in trucks

riod (between the end of 2009 and early 2010). Additional procedures (measurement, pipe reliability checks, and so on) were needed to get final authorisation. It was finally granted in September 2010.

Whilst waiting for legal authorisation to use the pipe, a small compression unit was installed on the ORC site directly linked to the biomethane production unit. During 2009, two waste collection trucks and one service car were refuelled with 9,000 Nm<sup>3</sup> of pure biomethane over the year. No operational problems related to the use of biomethane were identified in any of these three vehicles.





Organic Recovery Centre and the bus depot



## ■ Grid injection in France: a long story...

Grid injection in France was first discussed in 1989 (in a project in Amiens). It was already an option in 2004 whilst the ORC was being designed. The technical and legal procedures needed for grid injection were initiated by LMCU following national guidance (*décret*) published in 2004 as part of a national law on the opening of the gas market. This legislation gave the possibility of injecting biomethane into the natural gas grid. Central administration had stated that it was possible to carry out a health assessment. LMCU expressed an official request on the issue to the Ministry in July 2004.

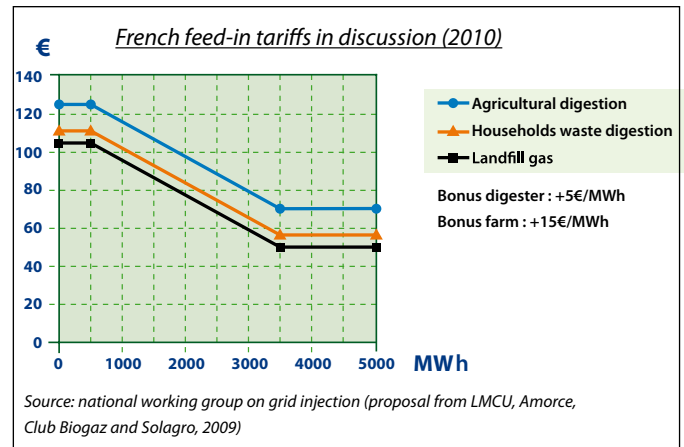
In November 2004, LMCU together with Gaz de France, (known today as GrDF), identified five key points for additional surveys: health, gas standards, grid system integrity, injection unit and contractual aspects.

A common task on gas standards for grid injection was made between 2005 and 2007. In October 2008, the National Health Agency (*AFSSET*) published the health assessment: it concluded that using biomethane does not face additional dangers when compared with the use of natural gas.

A National Working Group on Grid injection, started at the end of 2008 by both the Sustainable Development and Agriculture Ministries, identified the ways of supporting biomethane production and grid injection. Together with other partners (Amorce, Solagro,

Atee-Club biogaz), LMCU made some proposals regarding feed-in tariffs. The group, including other stakeholders such as GrDF and GDF SUEZ, who made some recommendations on technical aspects.

Once the principle for purchase obligation was integrated into the Grenelle 2 law in July 2010, feed-in tariffs should be published in early 2011, which should set up the conditions for biomethane expansion in France.



## ACHIEVEMENTS

- Grid injection and national supportive feed-in tariffs
- Expansion of door-to-door selective biowaste collection
- The waste collection fleet saw a progressive shift from diesel to NGVs
- Pure biomethane used in waste collection trucks
- Optimisation of the mass flow of transport of households waste in the metropolitan area
- Upgrading of biomethane produced from sewage sludge

# Lombardy region



## ■ The key role of the region in stimulating the natural gas vehicles market

The Lombardy region has demonstrated that a region can strongly support natural gas market expansion, through actions such as regulatory instruments policy, strategy and incentives. For the moment, the Lombardy region is identifying potential case studies for a biomethane production plant through discussions with investors and the professionals involved in the field and from within the regional territory.

## ■ Economic incentives to citizens

In order to increase the number of clean vehicles in the Lombardy region, a number of economic incentives have been implemented. Citizens of the Lombardy region have received a grant when buying a new natural gas vehicle, if they simultaneously scrap their old car and are below a certain maximum household income. It has also been possible to obtain a grant to convert a second-hand vehicle to run on natural gas. These incentives resulted in the introduction of thousands of new green cars to the region (from 22,000 vehicles in 2003 to 27,300 in 2009, over a total fleet of 8,250,000 units).

Other financial incentives have been offered to Lombardy citizens to purchase NG (other than LPG) vehicles, which have resulted in an

exponential increase in NG vehicles in 2009 (around 60,000 new NG vehicles).



The incentives comprised of the following grants:

- up to 2000 € (in addition to the national incentives) for each new Euro4 methane vehicle against the demolition of an euro 0, 1, 2 or 3 vehicle;
- 600 € for second-hand vehicle transformed to methane;
- 25 M€ overall funding from Lombardy in 2009.

## Normative and financial incentives implemented by the region

The region of Lombardy follows several paths in its strategy towards clean fuels and biogas / biomethane, starting with incentivising

and promoting biogas production from a legal (regional) point of view.

## Regional law as a framework and strategy for NGVs development

The Regional law (n. 24, 12-11-2006) for the prevention and reduction of air emissions to protect health and the environment includes action lines on "Biogas from agricultural products and sub-products" with the following provisions:

- Revision of legislation to promote the simplification of procedures in co-digestion processes (waste / non waste assessment of some organic matrix);
- Development of agreements within industries to promote efficient energy conversion of organic matrix and mitigation of the environmental pressures of agriculture;

- Technical and economic planning to support decision-making processes, to ensure stability in business guidelines and finding financial guarantees and incentive instruments;
- Efficiency and technological innovation to remove nitrogen from the matrix subjected to anaerobic fermentation; and
- Greater attention to biogas quality and purity for its introduction into the gas distribution networks.

Regional incentives have continuously operated during the time-frame of Biogasmax, where there is scope to "prepare the field" for wider adoption of clean fuels (with a particular focus on NG).

## Expanding the distribution network through economic incentives and mandatory requirements.

Significant effort was devoted to increasing the distribution network through direct grants to fuel pumps owners. This has been linked to the inclusion of NG within their products (total funding of six million Euros were distributed for 25 new and upgraded fuel pumps in 2009 alone).

*Filling stations and NG volume sold between 2001 and 2009 in Lombardy region*



There has been significant growth in the methane distribution network in Lombardy. This is based on not only the effects derived from the Regional agreement on natural gas (finalised in September 2006), but also based on grants which have been offered for the installation of natural gas fuel pumps combined with the mandatory requirement to have natural gas in any new fuel pump established in the regional territory.



## Vision for the future

The Lombardy strategy for the future includes:

- Giving continuous support in developing the NG distribution network, with particular focus on the motorways;
- Sustaining and supporting the Italian Government in solving bureaucratic and administrative barriers in the field;
- Experimenting with innovative forms of distribution, in particular where problems for pipeline and NG network connection exist, (with particular focus on biogas-based solutions);
- Incentivising and growing the demand, with an objective of reaching 500,000 NG+LPG vehicles in Lombardy by 2012; and
- Increasing cooperation between other Italian and European Regions in the short term to develop a homogeneous area of "low impact" in Europe.



## ACHIEVEMENTS

- Increased market share of CNG cars (of up to 150,000 NGVs by the end of 2010)
- Economic and regulatory tools launched by the regional authority for expanding the distribution network (148 filling stations are expected to be in place by 2011)
- Transfer of knowledge on biomethane amongst private investors through dedicated training sessions



Key actions to transfer knowledge from western European countries to Poland and other New Member States

# Knowledge transfer in New Member States



University of Zielona Góra



**In Poland the topic of biomethane use in transport is a new concept. Public discussion focuses on biogas for heat or electricity production. There are neither legal nor technological solutions for biogas as a vehicle fuel application. On the other hand, the potential for biogas production in Poland is significant. It seems crucial to raise awareness of biogas production and use. Being a member of Biogasmax Project, ConVoco has aimed to transfer the knowledge of biogas used as fuel from France, Sweden, Italy and Switzerland to Poland and other New Member States.**

## How to achieve knowledge transfer

### Training sessions, interaction and practical recommendations

The Biogasmax Project has focused mainly on the transfer of knowledge related to organisational, legal, economical and technical issues concerning the full biogas cycle in transport.

All the activities have aimed at raising awareness and stimulate discussions on biogas in transport at national and local levels, thus creating pathways for further use of biogas as a vehicle fuel in this region of Europe.

As for New Member States, the purpose in Biogasmax was achieved through:

- Addressing target groups (project managers and head of technical

departments from Cities, Deputy Mayors) and from neighbouring countries (such as Ukraine);

- Network support actions. Collaboration with the United Nations Institute for Training and Research (in Plock in March 2009 and in August 2010);
- Effort towards transferability with two levels of transfer-political and technical level; and
- Evaluation and recommendations. Interaction with the target groups provided useful lessons for further technology and knowledge transfer to Central and Eastern Europe.





## Next steps: future actions needed

The expansion of biogas in Eastern Europe looks promising. Cities are interested in considering local biogas scenarios. In order to gain a commitment from a city, the cost-benefit balance must be positive for this city.

Cities from under-developed parts of Europe need to be addressed sooner rather than later. Vehicle fuel will not be produced from biogas if a city invests in other usage of biogas (e.g. co-generation). Therefore cities should be addressed before investment is made. Therefore the following actions need to be implemented:

- Make the cost-benefit balance of the total well to wheel cycle transparent for cities outside of the consortium;
  - Provide recommendations for national level legislation; and
  - Provide individual coaching for the most promising cities, in order to create showcases in a few locations across Eastern Europe.
- European directives strictly demand from Poland a reduction in fossil fuels usage and the implementation of innovative ecologically friendly solutions in the area of transport. This ensures that the Biogasmax project efforts are bound to bring measurable effects.



## Transparency of the costs / gains of the total biogas cycle is needed

It is clear that the sine qua non of the expansion of biogas as a vehicle fuel in the Eastern part of Europe is a transparent presentation of the economical viability of biogas as a vehicle fuel.

For the transfer of knowledge to be effective, the following conditions are needed:

- The cost-benefit analysis of the project demonstration sites, and analysis of the local and national framework of the given location are relevant;

- Environmental, social and other benefits are valid arguments, but proof of overall economical feasibility are necessary for the success of biogas in a NMS; and
- The balance should include, but not be limited to the environmental gains.

National level decision makers should be addressed and national regulations play a crucial role in achieving a positive economical balance in local biogas scenarios.

### ACHIEVEMENTS

- Three international training seminars for Polish cities
- Eight Knowledge Transfer sessions for other important target groups
- Interventions and presentations at four other events (conferences, workshops, seminars, fairs)
- Specific Knowledge Transfer information packages prepared as a "Biogasmax Core Knowledge Package for knowledge transfer in Central and Eastern Europe" (please refer also to "Training" section)



An innovative city  
for source separated biowaste  
collection

Roma

## A sustainable strategy

The Municipality of Rome promotes the use of alternative fuels in public and private fleets as an instrument to locally reduce the city's air pollution and to achieve its Kyoto Protocol targets. Since the early 1990s, AMA (the environmental municipal agency of Rome in charge of integrated municipal solid waste (MSW) management) has tested the use of biomethane in 18 waste collection Heavy Duty Vehicles (HDVs).

At the moment, the sole biogas facility located in Rome is the landfill site of Malagrotta, owned by a private company. The landfill produces a considerable amount of biogas used mostly for an on-site power plant and in part provides biomethane (once upgraded) to the AMA waste collection vehicles.

In the framework of environmental strategies for waste reduction and recycling in Rome, and in light of the landfill being close to full capacity, the Municipality has decided to increase the waste selected collection, with a particular focus on organic waste, which represents

more than 30% of the overall 1.8 million tons of MSW produced in Rome each year.

Since 2003, AMA has operated an aerobic digestion plant in the North-West province of Rome (in Maccarese), producing high quality compost, processing organic waste from restaurants, fresh vegetables and fruit markets (with a capacity of 30,000 tons / year).

In 2006 AMA released a "Master Plan for selective collection in the city of Rome": This included the implementation of several "pilot projects" where traditional on-street waste collection was entirely replaced by the door-to-door collection of different waste fractions including an organic one.

As a consequence of the increased amount of selected waste, AMA has planned to increase the capacity of the Maccarese plant, adding a new section for the anaerobic treatment of 95,000 tons / year of organic waste to produce primarily raw biogas for energy production and upgraded biogas as fuel for the waste collection trucks.

## Expansion of CNG vehicles and of door-to-door waste collection

Following Rome's environmental policy of reducing air pollution, in 2006 AMA purchased 18 new HDV CNG waste collection trucks from IVECO, partly fuelled by landfill upgraded biogas. One year of close monitoring on two waste collection trucks highlighted an overall positive operational and maintenance performance, including drivers' acceptance and confidence in use.

At the end of 2009, AMA had purchased 20 new DULEVO 5000 CNG eco sweepers (including PM high filtration), and rented 133 new Fiat Panda Natural Power fuelled with CNG for 48 months, replacing the old polluting car fleet. In recent

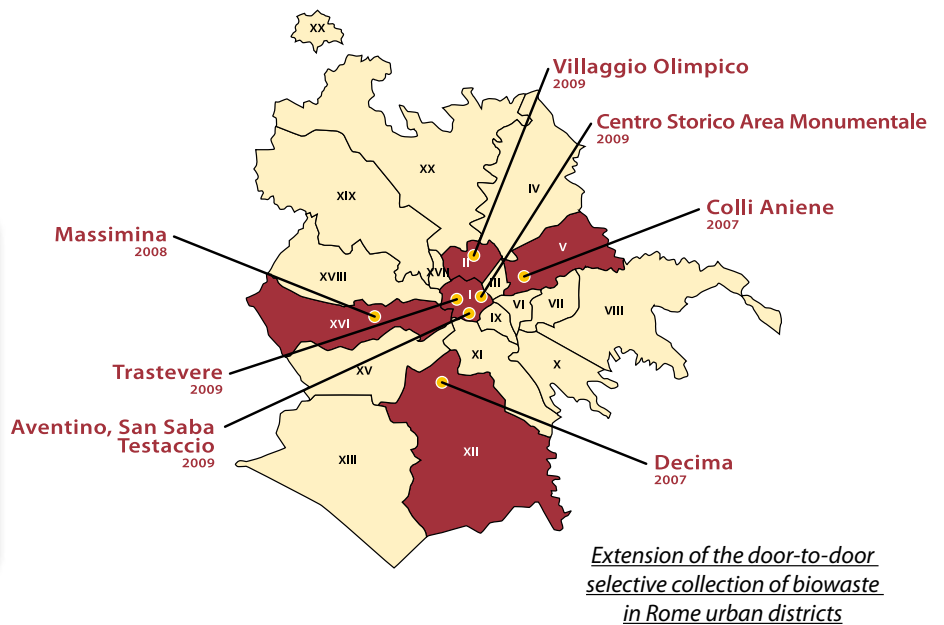


years, the Rome public transport company (ATAC) put 400 CNG IVECO IRISBUS buses and 7 CNG IVECO minibuses into operation (the latter fuelled with landfill upgraded biogas). In parallel to this, since 2006 there have been several pilot projects implemented for door-to-door selected collection in 7 urban districts, covering about 420,000 inhabitants with a 66% rate of selected waste thus proving the effectiveness of the new collection system.

In addition, the procedures for building the new anaerobic plant in Maccarese are in progress and the plant is planned to be operational by 2014.

Expansion of the public waste collection and transportation gas-driven fleet (2006-2009)

units	Type
18	IVECO CNG HD waste collection trucks
20	DULEVO CNG 5 m <sup>3</sup> sweeping machines
133	FIAT PANDA NATURAL POWER
400	IVECO CNG IRISBUS CITYCLASS
9	IVECO CNG MINIBUS



## Lessons to be learnt and recommendations for future actions

An obstacle for the methane fleet expansion is limited availability of CNG / CBG refuelling stations, (there are only 9) in the urban area of Rome (with 2,800,000 inhabitants) where biogas is only available at the landfill site.

At a national level, market research on the price of IVECO CNG HDV and CNG LDV showed that the extra costs of the CNG / CBG vehicles, in comparison with diesel versions for HDV (+30%) and LDV (+26%), were fully covered by (national and regional) economic incentives for the latter, whereas the incentives covered less than 10% of the extra costs for the former.

A feasibility study by AMA concerning the use of upgraded biogas for transport versus its employment for energy production highlighted that only economic incentives similar to the present "green certificates" existing for energy production, could make biomethane production and use in Italy profitable.

Door-to-door waste collection is the most effective in terms of selective collection rates. However, it is also a more complex and expensive system compared to on-street collection, and requires citizens' involvement, information campaigns and continuous follow-ups.

## Vision for the future

In the short term, the Municipality of Rome foresees that door-to-door waste collection will reach 30% of Rome's citizens by 2013 and will contribute to 12% of the overall target of 35% selective collection. The additional quantity of 95,000 tons / year of household organic waste from door-to-door collections will be treated in the new anaerobic digestion section in Maccarese. The amount of raw biogas that will be produced is estimated in about 13 million Nm<sup>3</sup>/year which will be used in a power plant, and in a biogas upgrading unit (the latter is subject to approval).

An increase in the number of methane fleet vehicles (by AMA and other municipal companies) coupled with the building of the new biogas plant, will contribute an improvement in the environmental performance of the city of Rome.



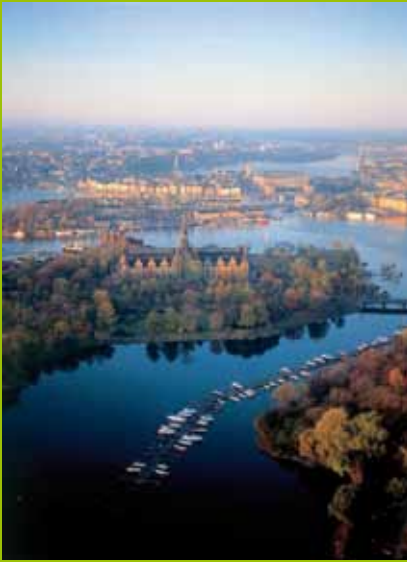
Waste Organic Treatment Plant in Maccarese

## ACHIEVEMENTS

- Progressive implementation of the door-to-door waste selective collection model (including organic fraction) to reach about 420,000 citizens, thus achieving a high collection rate
- Expansion of the waste collection and transportation gas-driven fleet
- Decision to increase the capacity regarding the new anaerobic digestion plant in Organic Waste Recovery Plant (from 60.000 t/y to 95.000 t/y)
- Preparation of the tendering procedures for the international bid concerning the building of the new AMA anaerobic digestion plant
- Feasibility study and project design of a biogas upgrading and on-site distribution unit in AMA anaerobic digestion plant

A city as a leader  
for biomethane fuel expansion

# Stockholm



## How to achieve biomethane market expansion

Both the public and private sectors need to be involved in implementing actions to expand the use of biogas as a fuel for transport. For example:

- Set up powerful incentives, such as exemption from congestion charges and reduced tax on the use of company cars for private purposes. Statistical analysis indicates that exemption from congestion charges in Stockholm has been the single most important incentive. Its impact increased sales of alternatively fuelled vehicles by about 23% in Stockholm County in 2008;
- Promote sales of gas cars in the private sector. A national purchase subsidy of SEK 10,000 (1,070 € eq.) promoted sales. This is significantly less than the exemption of congestion charges. This incentive has mainly affected sales of petrol and diesel-powered low-CO<sub>2</sub> cars;
- Requirement of gas cars or other clean technologies in procurement of transport services such as service cars, buses, waste collection and taxis. During the project, several types of gas cars have emerged: City buses have increased, Airport buses have been introduced for the first time, waste collection has increased, there has been a breakthrough in taxis, delivery cars have been introduced, and so on;
- Communicate the benefits of biomethane to companies. There was a lack of knowledge about environmental performance, practicalities (such as the location of the filling station) and cost issues around biomethane;
- Increase production.





Stockholm-Arlanda is the first airport in the world to use biomethane vehicles.



## Biomethane expansion based on a dedicated distribution network

### No natural gas grid

The City of Stockholm has an extensive program to introduce clean vehicles and an ambitious target to become fossil fuel free by 2050. The Stockholm case study is interesting as there is no natural gas grid in the Stockholm region. Distribution is done through using small local biomethane grids, in combination with transporting the biogas using trucks and swap-bodies common in the gas industry.

In Stockholm, there are several different technologies in use, but water scrubbing is dominant. The plants produce biomethane according to the Swedish Biogas Standard established in 1999. No problems related to gas quality have been reported, and upgrading biogas to natural gas quality is now considered a mature industrial product. The Swedish Biogas Standard makes it possible to mix biomethane from different plants using various feedstock and different upgrading technologies. There was only one temporary problem of the compressor oil additive leaking into the gas but this was remedied.

### When demand exceeds supply...

Biogas or CBG (compressed biogas) has been used as a fuel in the City of Stockholm since 1996. The municipality of Stockholm pioneered the introduction of biogas-driven cars in Sweden. This was later followed by the introduction of biogas buses, trucks, vans, taxis and company cars, thus increasing the demand for biogas. However, in 2006, the sales of biogas for vehicle fuel in Sweden increased by 47%, rising for the eleventh consecutive year in a row, which resulted in demand exceeding supply.

### Strong local policy

There are several reasons why there was an increase in interest for biogas cars in the City of Stockholm. The reasons being; the municipality has introduced free parking in the city for clean vehicles, biomethane fuel is cheaper than petrol, and the City of Stockholm has actively communicated the advantages of clean vehicles to its citizens. In Stockholm city, sewage sludge is mainly used in the production of biogas, as well as substrates, (such as grease trap removal sludge from restaurants and institutional kitchens) and some pumpable food waste (from restaurants, institutional kitchens and market halls). So far, CBG has only been produced in the wastewater treatment plants of Henriksdal and Bromma, both owned by Stockholm Vatten AB. The gas produced is upgraded at each WWTP and distributed either through a gas pipe to the bus depot, or by trucks with swap-body units to public gas filling stations.

In order to meet the demand in Stockholm, CBG is transported through swap-body units on trucks from Linköping and Västerås, where production of CBG is higher than the local consumption.



Filling of liquefied natural gas (LNG) to swap-bodies



Svensk Biogas - Linköping plant

#### Compressed biomethane production in Stockholm site

City	Feedstock	Upgrading (technology/ capacity)	Production of CBG/year	
			2006	2009
Stockholm	Sewage sludge, Grease	Water scrubber: 600 and 800 m <sup>3</sup> /h PSA: 600 m <sup>3</sup> /h	3,5 MNm <sup>3</sup>	6,0 MNm <sup>3</sup>
Västerås	Sewage sludge, Household waste, Ley crops	Water scrubber: 480 m <sup>3</sup> /h	1,0 MNm <sup>3</sup>	2,3 MNm <sup>3</sup>
Linköping	Sewage sludge, Slaughterhouse and industry waste Manure	Water scrubber: 1400 and 660 m <sup>3</sup> /h	5,4 MNm <sup>3</sup>	8,6 MNm <sup>3</sup>

## ■ After two years, biomethane fuel increased by 90%

Since the beginning of the Biogasmax project in 2006 the sales of biogas as vehicle fuel in the Stockholm site has increased substantially :

Year	2006	2007	2008	2009
Approximately sold volumes of CBG in the Stockholm site	10 MNm <sup>3</sup>	12 MNm <sup>3</sup>	16 MNm <sup>3</sup>	19 MNm <sup>3</sup>

Biomethane sales rose by 90% over the course of the project as a result of growing interest in biomethane. Public bodies, as well as private transport companies, see biomethane as a way to reach greenhouse gas reduction targets.

The sale of gas cars has been variable due to availability of models on the market and economic incentives. In 2009, sales went up considerably when new energy-efficient gas cars were introduced to the market.



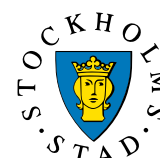
### ➤ The Clean Vehicle initiative in Stockholm

With the aim to promote clean vehicle and fuels such as biomethane and ethanol, the City of Stockholm launched an initiative in 1994 called "Clean Vehicles in Stockholm". This action has led to an increased demand for biomethane and gas vehicles in the local area. Clean Vehicles in Stockholm prioritised private companies as the main target group to receive local communication since they purchased the majority of new cars.

Good communication is essential in order to disseminate knowledge and be persuasive of the advantages of renewable

fuels compared with petrol and diesel. Communication aimed to provide potential car buyers with accessible and accurate information on the available vehicle models, fuelling facilities and upcoming infrastructure, environmental benefits, technologies and cost issues.

Communication with private companies has been supported through investment from the EU and national funds. New filling stations and fleets of private gas-vehicles have received part of the investment cost through the Clean Vehicles programme.





Reception area and digester



## Västerås: how to produce and use biomethane fuel in a small city



Liquid digestate used as biofertilizers

Växtkraft project, located in Västerås city, is a co-digestion plant using household waste and cultivated crops. The plant was inaugurated in 2005 and has continuously been fine-tuned over the course of the Biogasmax project. The production of the plant now exceeds the designed capacity. An interesting development is the synergy within the agricultural industry that not only delivers crops, but also receives the biofertilisers produced in the co-digestion plant.

*Incoming substrates to the biogas plant at Västerås.*

	Annual amount
Source-separated organic waste from households and institutional kitchens	15,000 tons
Liquid waste (grease trap removal sludge)	2,000 tons
Ley crop from a contracted acreage of 300 hectares	3,000 tons

## Visions for the future

- The main concern is to increase the supply of gas to the expanding market. Three new local biomethane plants (Käppala, Skarpnäck and Loudden) are under construction and will use sewage sludge, organic waste from the food industry and cultivated crops as feedstock. New contracts have also been written with biomethane producers in the region (up to 300km from Stockholm).
- Ensure further steps are taken to make biomethane a more commercial fuel and increase competition. In addition to AGA, there will be two more private distributors on the market in 2010.
- In a few years' time, the entire inner city bus fleets (of about 450 buses) is planned to run on biomethane. By 2011, the target is to use 50% renewable fuel (biomethane and ethanol) in Stockholm public transport.
- A new EU-funded project, CleanTruck, has begun which will launch trucks running on biomethane in diesel engines (methane-diesel engine concept). During 2010 - 2013, there will be a demonstration of 30 methane diesel trucks in the goods distribution sector.
- Whereas today biomethane is transported from production plants to filling stations via swap-body units, there is a shift in technology to produce and distribute biomethane. Liquid biogas (LBG) will be produced at one of the upgrading plants. This product is much more compact than compressed gas and thus, much cheaper to distribute. A dedicated pipe will connect the production plants to the bus depots and the major public filling stations, and provide a more rational distribution than the current swap-bodies.

## ACHIEVEMENTS

- Strong growth in biomethane sales, up 90% from 2006 to 2009
- 100% biomethane trucks in urban waste collection
- Three new filling stations along the Biogas Highway
- Roundtable meetings for smooth co-operation between municipal and private stakeholders

# Extending resource collection, increasing biogas production, and using residual materials

**Biomethane fuel is produced from organic waste collected within the cities and close by suburban and rural areas. Biogasmax demonstration sites have successfully increased the collection of the organic fraction of MSW, industrial by-products and agricultural waste and demonstrated an increase of biomethane production. The reliability of using waste as a substrate for biomethane has been proven. Biogasmax demonstration sites have tried to increase the resources collection throughout the optimisation of the entire biomethane chain, from waste through to by-products, in order to increase biomethane production and to maximise use of compost and residual materials.**

## Source separated waste: a success



In the metropolitan area of Lille, a selective door-to-door collection for biowaste has been set up, involving half of the population (500,000 inhabitants). Areas with houses (rather than block flats) have been focused as they have the most significant biowaste potentials (they often include a garden, there is more space to store an additional bin dedicated to biowaste...) Biowaste is also collected in canteens and public catering establishments, representing 8,000 tons per year of biowaste.

The experiences in Falköping of collection, treatment and digestion of household waste, shows that it is a suitable substrate for digestion. The site concluded that organic household waste should be collected in paper bags instead of plastic bags.

In Västerås (Stockholm region), the Våxtkraft biogas plant digests 15,000 tons of source-separated organic waste from households and institutional kitchens, over a total amount of 20,000 tons of substrates.



*A new information campaign, targeted to households, was launched in 2010 in the aim to keep inhabitants informed about the ways of sorting out their biowaste at home.*





Bassins in Marquette wastewater treatment plant (Lille)



Delivery of co-substrates in arabern plant



Storage of co-substrates in arabern plant

## Co-substrates as a way of increasing biogas production

Adding co-substrates is an effective way to significantly increase biogas production in a given sewage sludge digester. However, the new substrate has to have the same structure and fluid dynamic behaviour as the sewage sludge. In order to fit with the digester design. In Göteborg and Bern's WWTP for example, substrate has to be pumpable.

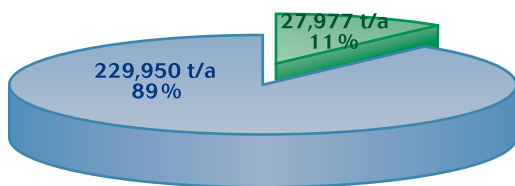
Often, the application of co-substrates is limited by legal restrictions like in Lille, where the organic recovery centre is allowed to digest organic household waste but not waste coming from agrofood industries. In Bern – so far without limitation - biogas production increased by 23% in two years. Whereas co-substrates represent only 11% of the whole feedstock in Bern WWTP, co-substrates contribute to 67% of biogas production.



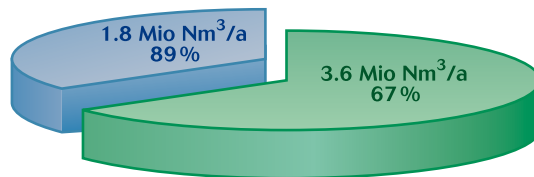
Amount of co-substrates delivered in 2008 in Bern [arabern]

Type of co-substrate	Origin	Weight [kt/a]
Yeast cell walls	Cellulose factory	10.7
Coffee press water	Production of Nescafe	5.66
Food waste	Community kitchen	5.0
Fatty water	Sewer cleaning	4.24
Fat separator	Chicken slaughterhouse	1.58
Milk serum, whey	Cheese dairy	1.07
De-icing water	Airport	0.96
EtOH (40%)-water mix	Pharmaceutical industry	0.66
Waste drinks	Fruit juice factory	0.3
Edible oil	Oil mill	0.3
<b>Total</b>		<b>30.1</b>

Input : Feedstock



output : Biogas production



■ Sewage sludge

■ Co-substrate

## Co-fermentation in wastewater treatment plants

The co-fermentation (sewage sludge plus co-substrates) helps to cover the energy needs of water treatment with renewable energies. Despite this, it is often viewed as being non-ecological because the sewage sludge must be incinerated and therefore, nutrients are lost. In a study by Swiss Federal Technical University (EPFL) and Nova Energie,

co-fermentation was examined in terms of sustainability, using the example of arabern. It was demonstrated that, due to the outstanding assessment of energy and CO<sub>2</sub>, as well as good cost-effectiveness, the advantages of co-fermentation surpass the drawbacks.



## Residual materials: use and quality of by-products

Use of by-products resulting from biogas production is a key issue. Digestion residues play a role on environmental impact (reutilisation of residues leads to less waste), and economic balance of the system (compost or other by-products bring an extra income).

Two types of residues exist:

### • Residues from wastewater treatment and sludge digestion.

In Sweden and in Switzerland, such materials are not allowed to be spread on farm lands. In such a case, sludge is dried and used

in cement industry, or incinerated.

- **Residues from organic households waste.** Dried or liquid composts are used by farmers. The quality of such bio-fertiliser is fundamental. In the European Union soil quality has decreased in the last 30 years because of intensive (rather than sustainable) agriculture. Spreading compost on farm land is a sustainable way to improve the quality of soils.



Compost



Dried compost in Lille is delivered by barge to farmers



Liquid digestate spread on farm lands in Vasterås

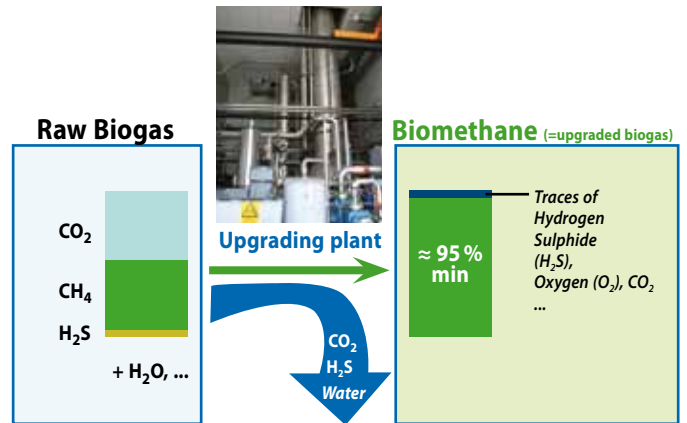


Pressure Swing Absorption, arabern

# Biomethane quality for vehicle use and grid injection

## The upgrading phase

Universally, biogas must be cleaned of its content of CO<sub>2</sub>, H<sub>2</sub>S and H<sub>2</sub>O. There is a range of technologies available to remove these components and contaminants. This is known as the upgrading phase, which aims to produce a gas with a quality equivalent to natural gas, and is suitable for vehicle use and grid injection. Biomethane needs to match the regional (or national) requirements in terms of quality, i.e. the technical specifications (called "Spec"), so it can be used in vehicles or injected into the natural gas grid.



## Upgrading biogas to vehicle fuel is a mature technology ready for large scale application

The experience of the Biogasmax project has proven the reliability of injecting upgraded biomethane into local grids for natural gas, when the biomethane is conditioned to match the quality of the natural gas. There have been no technical difficulties when using biomethane as a fuel in vehicles (see "vehicle-use" chapter).



Chemical Absorption at Arendal (Göteborg)

## The reliability of grid injection has been proven

Previously, the injection of biogas into natural gas grids was legally prohibited in some European countries. Various European Directives have now opened the European natural gas market to this opportunity once the directives have been introduced into national legislation. As part of Biogasmax, grid injection has been demonstrated by the companies GE in Göteborg (Sweden) and ewb in Bern (Switzerland), and by the local authority LMCU in Lille (France).



Grid and pipe before connection (Lille)



*Biomethane quantities injected into the natural gas grid in Bern and Göteborg (Nm<sup>3</sup>)*

Year	2007	2008	2009
<b>Göteborg*</b>	4,300,000	5,619,237	6,293,600
<b>Bern</b>	-	1,034,592	1,096,065

\*Including propane addition



## The health issue

In some countries, grid operators or administration still have the right to require certain precautionary studies, such as in France.

Academic research (university of Lund & SGC, GTI) have demonstrated that risks are not higher for biomethane than for natural gas.



## Towards an EU standard: why is it needed?

Following a request from the European Commission, Biogasmax project has made recommendations for the establishment of a European standard for biomethane.

### A way of sustaining new biomethane projects

Since the European gas market was opened in 2007, harmonization of standards regarding biomethane uses between countries is a crucial issue. Such a standard along with defining a common technical specification will ensure that the quality of biomethane is stable throughout Europe.

Stable quality will lead to positive conditions, i.e. similar tunings for upgrading units and analyses equipment, as well as a distinct falling-off of investments and operation costs by an economy of scale. Authorisation procedures for biomethane injection into the grid will be significantly simplified as soon as quality requirements will be fulfilled, which will help local stakeholders to implement such projects.

### The common standard should be flexible and take into account current European experiences

Nevertheless, for an EU standard not to add a further barrier but to be a driving force for biomethane expansion, conditions for success will have to be met. An EU standard will have to ensure flexible technical specifications. Consequently, legal frameworks currently applied in the present injector countries will have to be considered as a basis beyond which a common technical specification will not be defined.

Recommendations made in the Biogasmax report involves both dilution of low methane content biogas (> 50% vol.) into high pressure natural gas grid and substitution of natural gas with upgraded biogas (=biomethane) into both distribution and transport gas networks.



*Biogasmax proposal for a European technical specification on biomethane (Nov.2010)*

Parameter	Unit	L-Gas	H-Gas
Wobbe Index (range) $W_{s,n}$	kWh / m <sup>3</sup>	10.86 – 12.44	12.69 – 15.19
	MJ / m <sup>3</sup>	39.1 – 44.8	45.7 – 54.7
Heating value (range) $H_{s,n}$	kWh / Nm <sup>3</sup>	8.4 – 13.1	
	MJ / Nm <sup>3</sup>	30.2 – 47.2	
Relative density $d_n$	-	0.55 – 0.75	
CO <sub>2</sub>	Vol.-%	≤ 11	≤ 6
Hydrocarbons (without CH <sub>4</sub> ): condensation point	°C	Soil temperature (related to grid pressure of connected grid)	
Water dew point	°C	Soil temperature	
Dust	-	Technically free	
O <sub>2</sub>	%	≤ 3	
Sulphur (total)	mgS / Nm <sup>3</sup>	≤ 30	
THT	mg / Nm <sup>3</sup>	15-40	
H <sub>2</sub> S	mg / Nm <sup>3</sup>	≤ 5	
H <sub>2</sub>	Vol.-%	≤ 10	
NH <sub>3</sub>	mg / Nm <sup>3</sup>	≤ 3 - 20	
<b>Additional parameters (depending on specific substrates*)</b> (Based on current range applied in Europe)			
Organic silicon compounds (calculated as Si)	mg / Nm <sup>3</sup>	≤ 10	
F	mg / Nm <sup>3</sup>	≤ 10 - 25	
Cl	mg / Nm <sup>3</sup>	≤ 1 - 50	
Hg	µg / Nm <sup>3</sup>	≤ 1	

\* Landfill gas, sewage sludge,...

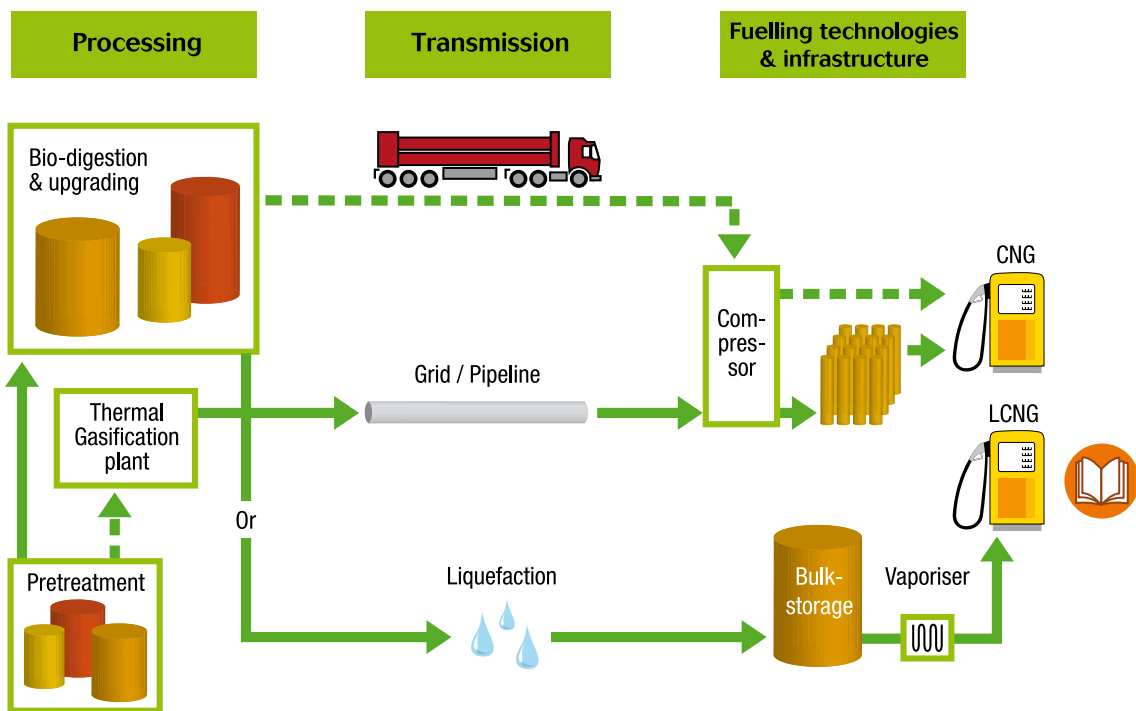
## RECOMMENDATIONS FOR FURTHER POLICIES

- Introduce national targets for "percentage of renewable gas" in the natural gas grids
- Support the organisation of large-scale farming community projects
- Support purchase obligation of biomethane through 15-20 year-contracts and associated feed-in tariffs, with the aim to give a long-term perspective
- Take landfill biogas into consideration by analysing Dutch experiences and conducting experiments on landfill biogas upgrading treatments
- Support the definition of a common European Standard on biomethane. Ensure that this common standard allows flexibility and would not be stricter than current national standards.



# From production to the end-users: distribution as a key step

Biomethane can be handled and distributed like natural gas. If the production plant is close to the consumption site, biomethane can be transported via a dedicated pipe. If the consumption site is further away, then transporting biogas over distances from producer to end-user can be done in two ways; through the existing natural gas grid or, when grid injection is not possible, via high-pressure canisters on swap-body trucks. For transport and storage, gas can be compressed (CNG) or liquefied (LNG).



For distribution in vehicles, biomethane is delivered through filling stations. Three main supply systems exist:

- a network of filling stations, using containers delivered by trucks (in areas where there is no gas grid). This solution maintains gas quality and pressure and minimises the infrastructure costs for filling stations operators (in Stockholm),
- a network of filling stations connected to gas grid (in Göteborg, Lombardy, and Lille),
- a filling station using a dedicated pipeline (in Falköping, Lille, and Stockholm).

## Criteria for new filling stations

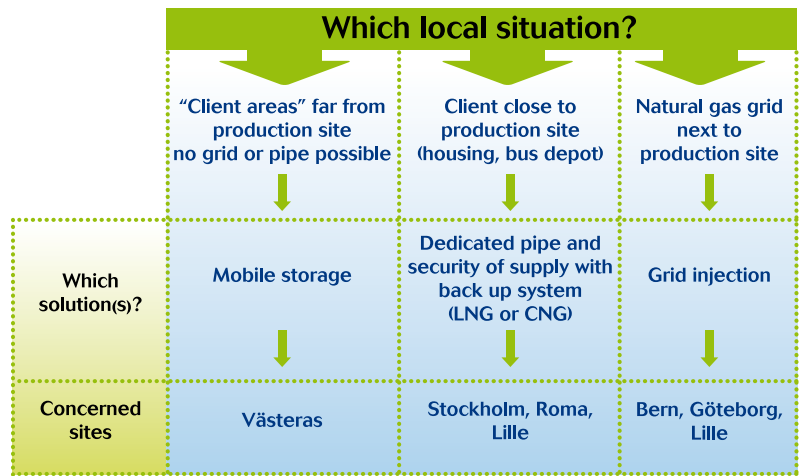
To install new filling stations the following parameters have to be considered:

- characteristics of the fleet: type of vehicles (light vehicles, light duty vehicles, buses, trucks), number of vehicles making up the fleet, distance run per vehicle per day; and
- local/national regulations.

As GDF SUEZ's research department has demonstrated within Biogasmax, the choice depends on physical configuration (gas grids, biogas plant localisation) and economical parameters.







## Design of filling stations

Two main filling configurations exist, depending on the fleet characteristics and the needs:

- A slow-filling solution is chosen when the vehicle fleet can stay for a few hours to be refilled. Usually it is a privately owned fleet that is filled during break-time in a private station (a bus fleet or a small fleet with 5 to 7 vehicles). Significant space is required (one stand per vehicle), which is a constraint that needs to be taken into account. Experience in Bern has shown that such stations must be outdoor and not indoor;
- Fast-filling station (usually a refill lasts between 2 and 10 minutes). Fast-filling is an option if the station refuels private cars; or if the fleet consists of a large number of vehicles and / or there is not enough space onsite for a slow-filling configuration; or if the vehicles cannot stop for a few hours.



It is important to have dedicated filling stations for the fleets of heavy duty vehicles

## Optimising compression and storage



Storage facilities above the bus depot of Bernmobil



Compressor, Bern

Compression and storage raises issues regarding energy demand during operation and resulting economic and environmental impacts. Electricity consumption along the distribution chain may be important.

Truck transport is less efficient than gas grid injection. Cryogenic transport requires a substantially higher effort before transporting (the liquefaction of gas needs a certain amount of energy), but is efficient as more gas (and consequently more energy content) is transported on a comparable truck.

Compression and storage have to be optimised. The number and the size depend on the needs (gas volume, number of vehicles and so on). The storage capacity installed in the station is linked to the compressor size. It also depends on local / national regulations. For slow-filling configurations, there is usually no need for large storage (only buffer storage) and the opposite is true for fast-filling configurations.

## RECOMMENDATIONS FOR FURTHER POLICIES

- Develop a filling station network. The customer will get a gas driven vehicle if there is a network of filling stations in the area
- Public incentives (finding the location and ground financing)
- Common technical / safety rules for the building and the operation of filling stations
- Urban planning rules to support gas filling stations network



# Vehicles use

## ■ Technical reliability of biomethane fuel

### Biogasmax clearly shows biomethane works as a fuel

Biomethane vehicles are operated in fairly large numbers at all Biogasmax demonstration sites. The experience of biomethane vehicles dates back over ten years in some cases. Biomethane is used in many different kinds of vehicles. Buses and waste collection are the most common applications. The biomethane vehicles are used in everyday service and fulfill the requirements of the fleet operators.

Technical monitoring was carried out over a period of 12 months, involving seven fleets gathering 61 CNG vehicles: four waste collection fleets and three bus fleets, in order to examine the reliability of biomethane fuels used in vehicles.

The demonstrations clearly show that biomethane is well suited for use in vehicles. Technical monitoring further verifies that there is no appreciable difference between using biomethane and using natural gas in heavy duty vehicles. Technical problems encountered during the project have been solved, and today the reliability of heavy duty gas vehicles is more or less comparable to similar diesel vehicles. In some cases technical problems were due to initial difficulties adapting the engine and the gearbox to each other, or adapting the engine and gearbox to the energy content of methane.



### Technical problems are not related to the methane fuel

Another important observation is that many technical problems encountered within the Biogasmax project are unrelated to the use of methane in vehicles. Problems with the waste collection vehicles, for example, have most often been related to the compacting system. Technical monitoring also shows that although indoor garages need

to be adjusted for safety reasons, the adjustments needed are fairly limited. Even if some monitored vehicles were occasionally out of service due to technical problems, the general attitude of fleet owners and drivers is positive. Most fleet owners are willing to increase the number of gas vehicles in their fleets in the future.

### Margin for progress in vehicles performance

The range and energy efficiency of gas vehicles still needs improvement. Ideally, the operational range of heavy duty gas vehicles should be roughly comparable to the range of heavy duty diesel vehicles. Operational range could be improved by installing more gas storage capacity in the vehicles, but it is even more important to increase the energy efficiency of the engines. The monitoring of biomethane

vehicles, compared to already existing information about similar diesel fuelled vehicles, indicates that a gas powered heavy-duty vehicle needs at least 30% - 40% more energy than a diesel vehicle, to perform the same work or operate for the same distance. There is still room for development even if it is not likely that a gas engine (Otto engine) will reach the same efficiency level as a diesel engine.



## ➤ Biomethane quality and engine performance

How can biomethane reach the light-duty and heavy-duty NGVs' fuel specifications? In Biogasmax, the research organization TNO has assessed the impact of key gas parameters, usability in NGVs, and the impact on catalyst performance:

- biomethane quality can be used in almost all NGV's without influence on the NGV's performance, fuel economy and emissions:
- A new gas quality parameter - the "Sonic Bievo index" - which compares various biomethane gas qualities with NGV fuel specifications was introduced. This parameter avoids the erratic results obtained using the current "lambda shift factor"; and
- Catalyst performance when using biogas is similar to the performance on natural gas. The use of biogas in unmodified NGV's should therefore not pose any problems related to the catalyst(s) fitted to the NGV.



## In Bern, car sellers as partners

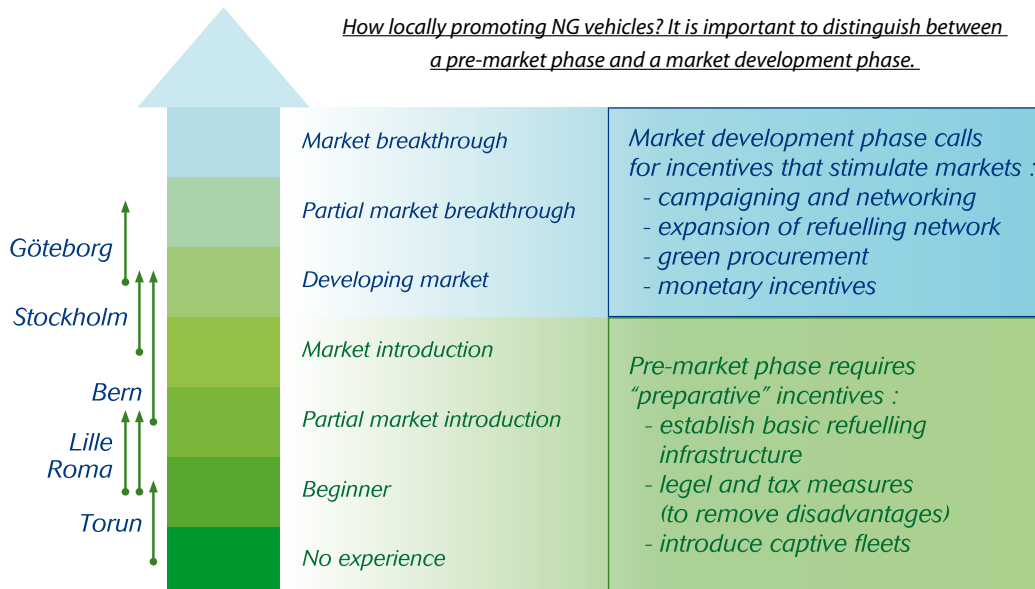
- In total 35 garages were appointed as partner organisations with the obligation to present a range of NGVs in their show room and to distribute promotion material. To complement this, ewb is promoting their car makes and has organised special training courses for the car sellers
- In March 09 car shows with NGVs were organised in all 35 partner garages in Bern
- ewb participated with HDVs and LDVs at the largest Swiss exposition for public procurement

## Local policies to expand market

The Biogasmax project has identified several milestones in the process of achieving a self-sustained market for biomethane. Local stakeholders (local authorities and companies) who opt for biomethane fuel need to stimulate local use of biomethane as a fuel.

Monetary incentives are an important part of an overall policy to promote clean cars, but these incentives will not have a significant impact until clean cars have the performance and reliability comparable to a conventional car.

Economic incentives to choose clean cars are very powerful instruments to increase sales. Incentives that reduce operating costs (e.g. lower price of fuel) seem to be stronger than incentives affecting purchase price, even if in Bern and Västerås such dedicated aid has had a certain impact. Incentives that introduce a privilege for clean cars are stronger than incentives that attempt to "even out" differences between clean cars and their conventional counterparts.



Own channels for communicating towards target groups were the Newsletter from Clean Vehicles in Stockholm, the websites [www.miljofordon.se](http://www.miljofordon.se) and [www.stockholm.se/miljoforlar](http://www.stockholm.se/miljoforlar). This was complemented by other actions (seminars, press releases, study visits, interviews in filling stations...).



Communication campaign to market NGVs. In Bern, car market was down by 12% in the first half of 2009. However, NGV market was up by 31%!



## RECOMMENDATIONS FOR FURTHER POLICIES

- Green procurement is a starting point for expanding NCG vehicles
- Carry out further research on NGVs performance
- Strengthen cooperation with car manufacturers in order to improve engine performance.



# Economic feasibility



Filling biogas in a clean taxi in Stockholm

## ■ Various concepts for market development

The business concept regarding the way to bring biomethane into the market can vary. In Linköping and Västerås, there is one municipal company that produces and distributes the gas to the end user and takes responsibility of the whole chain. In Stockholm, a more commercial concept is applied where a private distributor has

purchased biomethane from different municipal producers and has supplied a network of public filling stations.

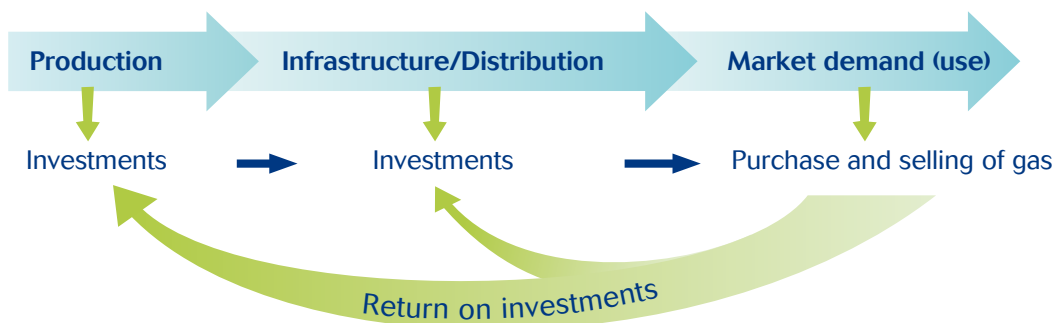
In Lille, the transport operator is the major purchaser of biomethane as the local authority responsible for public transport (LMCU) has made this purchase to be mandatory in the public contract.

## ■ Pathway towards market expansion

### Stimulate demand to achieve economic viability

The most important condition of success is to find a balance between the three components Production / Infrastructure-Distribution / Market demand. To this regard, Göteborg is actively working with

market players, whilst simultaneously building the infrastructure. Gas filling stations require big investment, and therefore, the market has to be active as soon as possible after the station is built.



## ■ Labelling: interests and methodology for an EU wide application

A small but significant number of European car drivers are keen to use clean cars as long as the fuel cost is lower than petrol. However, there is a second group growing in size of environmentally sensible drivers that are willing to pay a little more for renewable fuel than for petrol, as long as there is a guarantee that the fuel is

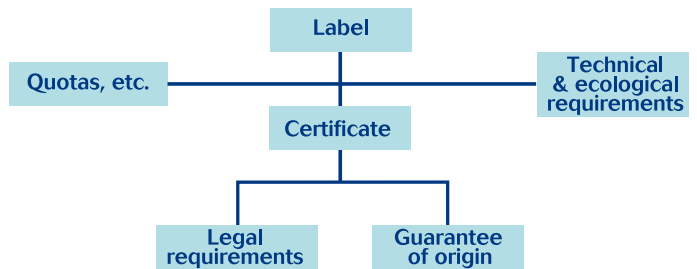
clean (i.e. it has a positive Life Cycle Assessment (LCA)). Drivers also want to know where the fuel is from and how the fuel has been produced at the point of purchase in the pumping station.

## Stimulate demand to achieve economic viability with Naturemade, a certification process set up in Switzerland

In 2008, Switzerland, in collaboration with producers and providers of gas, NGOs and renewable energy (RE) associations established a label called "Naturemade" to apply to biomethane. This initiative is an interesting example because it is a step towards biomethane certification which could benefit other sites in Europe, or even at an EU-wide level.



The background to developing a certification system is legal regulation. The requirements for a certification system have to be seen as additional to the legal requirements. A label system might establish even more stringent requirements.



The "Naturemade" label defines a set of ecological standards and criteria for the certification of energy going beyond the "declarations of origin", which only name the origin of the energy produced (kWh). Every producer has to pass a (simplified) LCA.



## Grid injection: costs and economic feasibility

Currently, upgraded biogas is in almost all cases more expensive than natural gas. Upgrading technologies have a strong cost-to-scale relationship, which levels off at biogas production rates around

700 Nm<sup>3</sup>/h. A number of ways of supporting biomethane economics exist.

### Feed-in tariffs

Countries such as Germany and France have opted for the feed-in tariff system. Once a producer asks to inject biomethane into the grid, the gas operator (distributors or gas providers) has the obligation to purchase this biomethane. The question is then how to make biomethane's price the same as the market price (i.e. the natural gas price) to secure investments.

As in the case of other renewable energies (such as photovoltaic, wind energy), the purchase of biomethane needs to be financially supported by a specific compensation fund for the producer to sell biomethane at the same price as natural gas price. In that case, tariffs are subsidised nationally via a national dedicated fund, the latter being fed for instance by the natural gas consumers or other

energy consumers (through their invoice) or any other legal means. Contracts between producers, grid and gas operators have to be made along a period sufficient of time, for the producer to have a long-term perspective to secure their investments (15-year term as a minimum).

As long as the biomethane market expands and as biomethane production costs consequently decrease, tariffs for new oncoming contracts are gradually revised downward. After a while (duration depends on the market expansion), feed-in tariffs become closer to the price of natural gas. This has been experienced by wind energy, the price of which is similar, in some areas in Europe, to the current market price of electricity.

### Green gas trade

This is identical to the concept of "green electricity" and, in some cases, legislation has yet to allow for the conceptual sale of renewable energy. This is where fossil energy is consumed at the price of renewable energy in one site, while the same amount of renewable energy is consumed at the price of non-renewable energy at another site. In the case of Sweden, the process of updating legislation for the sale of "green gas" is underway. Without such legislation, it is not possible to sell renewable gas with available tax rebates to designated customers. In Switzerland the model for green gas trade is in place. The production and injection of the biomethane is audited (guarantee of origin) and the amount is registered at an independent office working on behalf of the government.



Once the gas is sold to a consumer, the record is redeemed. Double counting is excluded. Trade of certificates is not allowed so far. There has to be a physical injection, transport and utilisation of the gas. The system is based on the experience with green electricity (e.g. renewable energy certificates, RECS).

## RECOMMENDATIONS FOR FURTHER POLICIES

A city or a region is able to influence the market expansion of clean cars. It is important that the city leads. But achieving effects beyond municipal administrations requires co-operation with strategic public and private partners. Following actions are crucial:

- A long term commitment
- Both vehicle supply and fuel infrastructure are critical components of city policies
- A constructive dialogue with national government authorities to convince the latter to adopt legislation (transport of gas, feed-in tariffs, labelling) with the aim to create a framework which would help biomethane production and use.



# Life Cycle Assessment

The provision and use of biomethane as a substitute for natural gas is considered to be a sustainable technology. But exactly how sustainable is it? How can sustainability be quantified at all? Life Cycle Assessment (LCA) is an internationally accepted tool for the provision of information about the environmental relevance of products and services. As part of Biogasmax, it has been the responsibility of the University of Stuttgart to conduct LCA studies of biomethane from the participating plants across Europe. As the project results of

Biogasmax show, biomethane is not 100% climate neutral, but it offers great reduction potential compared to fossil fuels. At this point, we estimate about 50 - 70% less climate impact than natural gas over the entire life cycle. Since natural gas is considered rather clean compared to fossil fuels, biomethane comes out with even lower emissions against gasoline and diesel. The evaluation report contains the complete portfolio of impact categories.



## What is Life Cycle Assessment?

The core element of the LCA methodology is thinking in product systems and accounting for several environmental goals simultaneously. Decision-makers can use LCA to build a proper information base as a foundation for decisions. This ensures that when a system is changed and environmental burden is shifted between life cycle stages or between impact categories, the decision-maker is informed

about the burden shift and can allow or stop the system change. The ability for multi-dimensional evaluation of system solutions is crucial in times when singular technology efficiencies have been maxed out and substantial improvements can only be achieved through system solutions. The following figure describes the methodology from the bottom up.

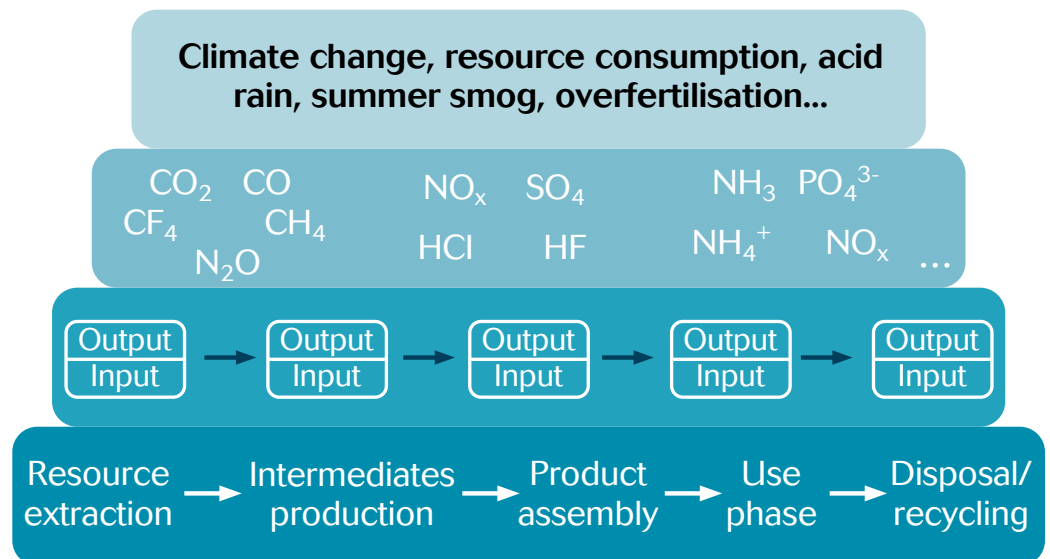
Overview of the LCA methodology

### 4. Impact assessment

3. Inventory  
(resource, exhaust air, by-products...)

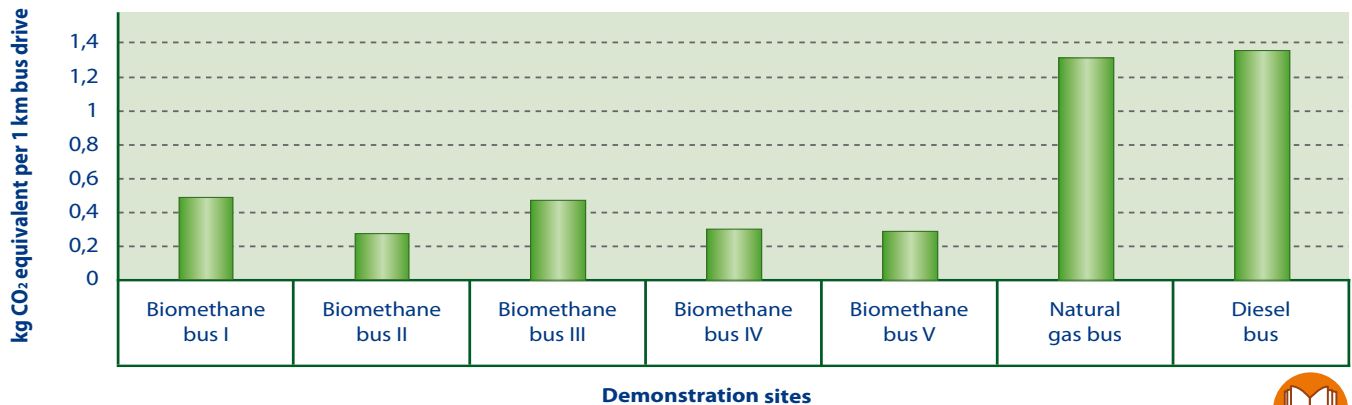
2. Model

1. Life Cycle



## Life cycle assessment results for biomethane (based on Biogasmax demonstration sites)

*Global warming potential per 1 km bus drive*



### Global warming potential

The figure above shows the results for the global warming potential of biomethane buses, compared to fossil fuel-powered buses. Contrary to fossil fuels, the majority of carbon in the product system is passed through (rather than dug up and released), which is why the numbers for biomethane transport are significantly lower than for fossil fuel buses.

The differences in environmental impact (global warming, in this case) reflect the differences in layout of each plant. The plants are all

fairly unique. Each applies its own combination of heat provision and recovery systems for the fermenter, as well as upgrading techniques. The data for the buses are generic data. In the evaluation report, the differences in environmental impact are related to the plant layout. In the course of the analysis, there are several factors identified that influence the environmental impacts of biomethane.

### Which elements influence the environmental profile?

The provision of heat for the digester has been identified as an important aspect. Heat may come from different sources and therefore influences the environmental profile.

The use of district heating (waste heat from industry) and the combustion of on-site biogas have been shown to keep emissions from heat provision low. The environmental impact is reduced when residual materials from the digestion process can be used as an

organic fertiliser or a secondary fuel (e.g. in cement kilns).

The upgrading stage and distribution need energy to operate and do influence the environmental profiles, depending on the energy sources. The energy needed in the upgrading process depends on the technique. The distribution of biomethane consumes electricity similar to natural gas distribution.

### Exhaust air and by-products

Finally, the use of biomethane affects the environmental profile: natural gas (and biomethane, which is technically identical) can be combusted with fewer by-products than heavier fuels, e.g. gasoline and diesel. Contrary to natural gas, carbon dioxide emissions from biomethane combustion is biogenic (not fossil) and is cancelled by the credit for using a renewable feedstock. The life cycle environmental impacts of biomethane transport are more or less in the same range

as natural gas and diesel with regard to other environmental impacts such as acidification, eutrophication and summer smog creation.

This is mostly due to the fact that biomethane in the context of Biogasmax is produced from waste, so there is no environmental burden from producing the feedstock.



# Training



## ■ Objectives of training actions

Under Training and Transferability Analysis the project partners have:

- Identified the key economic, social and political conditions required to create pathways for biomethane production in Europe, with a focus on end-users in the transportation industry;
- Developed a Decision Making Guide for policy makers, based on the practical experience of the Biogasmax project partners;
- Developed a 'core curriculum' for training events, which can then be modified or added to in order to produce country and participant specific events;
- Developed a number of additional training modules on topics such as Community Engagement for Biogas Plant Developers and Communication Strategies on Biomethane Vehicles;
- Produced and distributed an Excel based decision support tool to support analysis and understanding of Biomethane production,

distribution and use in vehicles from a supply-chain perspective, including a full range of costs, impacts and organisational roles. It is anticipated that by the end of the project over 200 people will have downloaded this tool to support their work and interest in biomethane scenarios;

- Organised a range of training events covering topics from the technical, policy, financial, partnership and community engagement spheres at workshops that have included interactive sessions, hands-on use of planning and decision-aid tools plus opportunities for networking and partnership building;
- Undertaken a series of meetings and coaching sessions, both with public sector (Municipalities) and the private sector (enterprises).

## ■ Actions carried out

Training activities have taken place across Europe, including Central and Eastern Europe. The work involved transforming the data and knowledge available from project evaluation into material for the New Member States (EU countries).

This has been done on three levels: level 1 (technical) targeted at technicians and municipal companies; level 2 (management of change process) targeted at the executives; and level 3 (general) targeted at politicians.

As part of this process an international training seminar was carried out for cities from different NMS and the neighbouring countries, with

workshops on the key topics and for various levels of involvement and interest.

In total we foresee that several hundred people will have participated in the training and knowledge transfer events organised under the Biogasmax project from a range of professions and regions in the EU. This is in addition to the people attending conference events. Presentations and tools used in the training have been made available via the project website for interested individuals to download free of charge, so we anticipate that people who were not able to directly participate in training events have been able to benefit from the knowledge transfer activities developed to accompany the training.





## Recommendations and training tools and materials developed

In order to support market expansion of biomethane as a road transport fuel the following activities and actions would be beneficial:

- Promote a clear understanding of the underlying policy and context of EU member states that historically and currently either support or challenge the market expansion for biomethane use in vehicles among senior policy makers and decision takers, with the objective of sharing best-practice actions that act as levers for change;
- Improve levels and quality of citizen engagement on topics of renewable energy production (including biomethane via Anaerobic

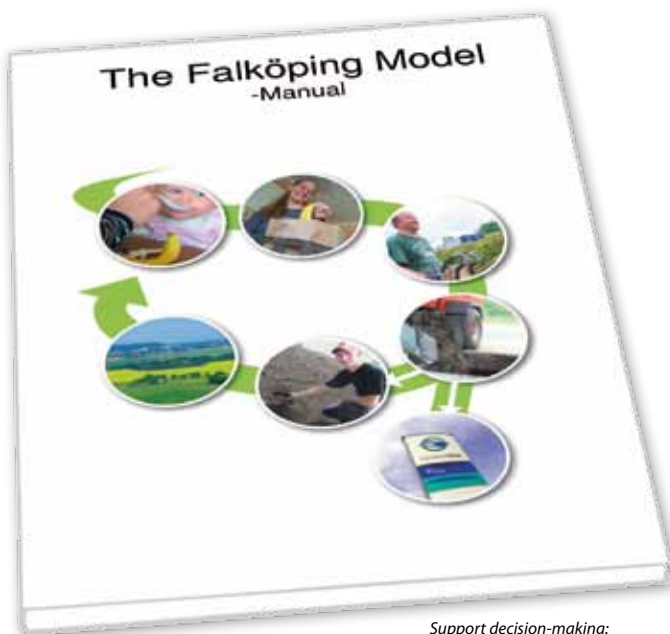
Digestion) as a prelude to expansion of the network of distributed energy production at various scales of Plant;

- Promote good practice experience in topic areas of production, upgrading, distribution and use in vehicles using case studies, direct contact with experienced practitioners and a network of speakers available for future training and knowledge transfer events; and
- Build up a database of regional or local biomethane systems via the (FK Model) modelling tools developed during the Biogasmax project so that a library of good practice examples exists with inherent data on costs and productivity from across the EU.

## All training materials on [www.biogasmax.eu](http://www.biogasmax.eu)



*Video: Biomethane: a great way of turning waste into clean fuel for transport*



Support decision-making: the Falköping Model

# Biogasmax partners



Lille Métropole Communauté urbaine - LMCU (FR)

Business Region Göteborg (SE)

Göteborg Energi (SE)

City of Stockholm (SE)

University of Stuttgart, LBP (DE)

European Natural Gas Vehicle Association

FRAUNHOFER - IWES (DE)

TNO (NL)

Transport & Travel Research (UK)

GDF SUEZ (FR)

Nova Energie (CH)

ADEME (FR)

Esterra (FR)

Carbiolane (FR)

Cadet International (FR)

Amorce (FR)

City of Falköping (SE)

Fordonsgas Sverige (SE)

Stockholm Water Company (SE)

AGA Gas AB (SE)

Svensk Växtkraft AB (SE)

Svensk Biogas AB (SE)

Azienda Municipale Ambiente, AMA (IT)

Istituto di Studi per l'Integrazione dei Sistemi, ISIS (IT)

University of Zielona Góra (PL)

Biogaz Inwestor (PL)

ConVoco (PL)

EWB - Energie Wasser Bern (CH)

Bernmobil (CH)

Arabern (CH)

Regione Lombardia (IT)

# Glossary

- CBG:** Compressed Biogas Gas
- CHP:** Combine Heat Power
- CNG:** Compressed Natural Gas
- DG:** Directorate-Generale
- EC:** European Commission
- EU:** European Union
- GWh:** Giga Watt hour
- GHG:** Green house gas
- H<sub>2</sub>S:** Hydrogen sulphide
- HDV; LDV:** High Duty Vehicle; Light Duty Vehicle
- LCA:** Life Cycle Assessment
- LNG:** Liquefied Natural Gas
- MSW:** Municipal Solid Waste
- NG:** Natural Gas
- NGO:** Non Governmental Organization
- NGV:** Natural Gas Vehicle
- Nm<sup>3</sup>/d:** Normo cubic meter per day
- NMS:** New Member States
- ORC:** Organic Recovery Centre
- PSA:** Pressure Swing Adsorption
- RECS:** Renewable Energy Certificate System
- SEK:** Swedish Krona
- WWTP:** Wastewater Treatment Plant

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