Deliverable D5.2:

Report on the biomethane injection into national gas grid

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1. Report on Italian and European regulatory framework on the biomethane injection into national gas grid

1.1 Biomethane in Europe

In 2014, in Europe there are over 360 plants for the production of biomethane, showing that the purification technology is now mature and tested and is therefore not to be considered as a limit. 83 new biogas upgrading units were commissioned in Europe in 2014 representing 23% INCREASE compared to 2013.

Biomethane, defined in Article 2 of Legislative Decree 28/2011 as "gas produced from renewable sources having characteristics and conditions that correspond to those of natural gas and eligible to enter into the natural gas network", turns out to be a bioenergetic carrier with enormous potential.
A big selling point for the biogas-biomethane supply chain is the fact that the existing infrastructure for transport and distribution of natural gas can also be used to bring biomethane to the final consumer. Thanks to its flexibility, biomethane can contribute to the reduction of greenhouse gases (GHG - GreenHouse Gases) in the production of electricity, heat production and transport.
Will be also important in the future, the possibility to enter into the natural gas network not only as biomethane produced biologically but also as biomethane produced from the excess of electrical energy (through the withdrawal from the electricity grid of electricity from intermittent sources without other application in times of excess supply, to be used for the electrolysis of water to hydrogen and the subsequent methanation with CO_2).
The possibility to inject the bio-methane as a replacement or additional gas in transport and distribution networks comes from the implementation of the European Directives 55/2003 / EC and 28/2009 / EC, which give particular importance to the use of gas produced from renewable energies, identifying biomethane as a possible solution for achieving the goals set by the Kyoto treaty for the fight against climate change.
These directives require Member States to ensure that the gas resulting from biomass fermentation and thermochemical processes, as well as from other origins gas (resulting, for example, by the methanation of hydrogen produced from renewable sources), in compliance with the requirements of quality fixed, have non-discriminatory access to the transmission network and distribution of natural gas, if it is provided, conveyed and accumulated safely and that the end user can exploit it without any further risk and respecting the environment.
Over the past 10 years, the upgrading of biogas to biomethane (Figure 1) has expanded considerably in some countries where it already had consolidated the production of biogas from anaerobic digestion of agricultural and agro-industrial biomass and purification of domestic waste water.

The following Table 1 gives data on biomethane production in Europe and other aspects of performance in biomethane production and use.

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

[b] blend
[p] pure (100%) biomethane
**NGVA Europe*

Table 1 Number and types of biomethane plants in Europe

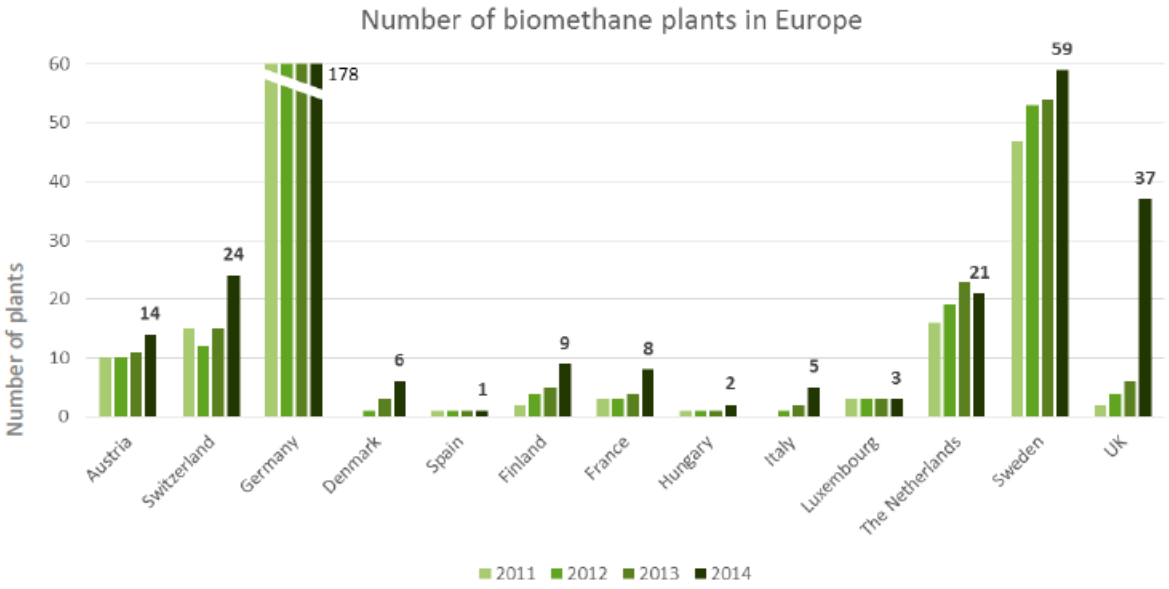

Figure 1 Numbers of biomethane plants in Europe from 2011 to 2014

According to the data submitted, 255 plants in Europe are connected to national gas grids, eight with direct connection to either CNG (compressed natural gas) or LNG (liquefied natural gas) stations and four with connection to both.

1.2 Biomethane in Germany

Germany is the European country where the market of anaerobic digestion with particular reference to the agro-livestock sector has seen the greatest development.

Since the introduction of Feed-In-Tariff for the generation of electricity from biogas plants, in 1991, until the beginning of 2000 in Germany there has been a continuous development of technologies for the production of biogas.

The scenario undergoes a first change since April 2000 with the introduction of the law on renewable energies (EEG) to replace the Feed-In-Tariff and evolves in 2004 with the introduction of a bonus for energy crops. From this time also the largest and structured companies start to invest in the sector, developing a high technological standard.

At the end of 2014 the number of installations were 10786 units, with an installed capacity of about 3800 MWe.

At the end of 2005, appears in the German market a possible alternative use of biogas that is the conversion

in biomethane, which is done through a commonly called purification or "upgrading" process. Its primary goal is to increase the relative concentration of methane in the mixture to obtain a gas with similar characteristics to natural gas and therefore compatible with the injection into the national grid.
The biogas produced by anaerobic digestion is purified through a process that guarantees the removal of sulfur, water and carbon dioxide (main passage). It may be necessary the addition of small amount of LPG (liquefied petroleum gas) to increase the calorific value of biomethane to respect the standards required by the network (Table 2).

The fields of application are the same as currently envisaged for natural gas: biomethane can be used for heating, without requiring any customization of end devices (e.g. stoves or gas boilers), for combined heat and power (CHP) or to fuel natural gas vehicles.
Germany is facing a significant moment of transformation of the national energy system. In fact, some energy sources, such as nuclear, are destined to disappear while other ones, including also bio-methane, will be of fundamental importance for the development of technologies concerning the production of energy.

The objectives of Germany are very ambitious: it is expected a production of 6 billion Nm3 / year of biomethane by 2020 in addition to the replacement of 10% of the total consumption of natural gas with biomethane across the country by 2030.
Biomethane in Germany is promoted through the production of electricity. In other words, the purified biogas to biomethane is injected into the national grid and the utility that produces electricity from a renewable source fetches the equivalent heating value entered at the point of entry of biomethane. The amount must be balanced at the end of each calendar year. The electricity produced is considered to be a renewable source and obtains a bonus, compared to biogas, ranging from one to three cents / kWh for the upgrading of biogas to biomethane. In this way the production of electrical energy can be displaced at a consumer who has also a significant heat demand, where it is then possible to effectively exploit the heat cogeneration.
The introduction of biomethane into the natural gas network (over 440,000 kilometers in Germany) is an efficient and flexible energy solution, especially favoring the use of heat in areas located far from where the biogas is generated.
The German market of biomethane injected into the grid is still young. The first two plants were put into operation in 2006 in Pliening and in Straelen, with an hourly capacity input of biomethane into the natural gas network, respectively of 480 and 550 Nm3 / hour.
In 2014 there were 168 biomethane plants with a total capacity of 204,000 Nm3 / h of which 165 feeding into the natural gas grid.
The average capacity of the upgrading plants is about 750 Nm3 / h of biomethane, but in order to benefit from the increased economic bonus, most of the plants falls into the category between 350 and 700 Nm3 / h

of biomethane.

The large plants like those in Gustrow (operating since 2009 and with a capacity of 5,000 Nm3 / hour), Zörbig (operational since 2010 and 2500 Nm3 / hour) and Schwedt (operating since 2010 and 3,500 Nm3 / hour) have definitely raised the average that is calculated in 600 Nm3 / h of biomethane (without taking into account the large plants).

	Units of measure	**value**
Wobbe index gas L	*MJ/m³*	*37.8*
Wobbe index gas H	*MJ/m³*	*46*
High heating value	*MJ/m³*	*30.2-47.2*
density	*'*	*0,32-0,55*
Water dew point	*°C*	*-8 (70bar)*
Hydrocarbons dew point	*°C*	*-2 (1bar-70bar)*
CH_4	*%*	*98,3*
CO_2	*%*	*Max 2,5*
hydrogen (H_2)	*%*	*Max 0,2*
Oxygen in dry gas (O_2)	*%*	*3*
Oxygen in wet gas (O_2)	*%*	*0,5*
nitrogen (N_2)	*%*	*Max 0,2*

Total sulfur	*mg/m³*	*Max 30*
Hydrogen sulfur (H_2S)	*mg/m³*	*Max 5*
mercaptans	*mg/m³*	*Max 6*
Ammonia (NH_3)	*mg/m³*	*Max 3*

Table 1 Standards for biomethane injection into the natural gas grid in Germany

1.2.1 German inventory of regulatory framework

In Germany there is a complex and extensive regulatory framework for both biogas and biomethane. In this chapter will be described the most important acts for what regards the support system of biomethane and its injection into the natural gas grid.

The most important act for the Financial support is the Renewable Energy Act. The first Renewable Energy Act (EEG) was already published in 2000 and it defined the Feed-in Tariffs (FIT) and the non-discriminatory access to the grid. The EEG has been revised five times and the latest version comes from 2014.

The Targets set by the German regulatory framework are very ambitious. As example, the Share of electricity generated from renewable energy sources should be 40-45% by 2025, 55-60% by 2035, at least 80% of gross electricity consumption by 2050.

-**The Feed in Tariff follows the following scheme**:

23.73 ct / kWh for power from small manure plants (up to 75 kW, minimum share of manure 80 %); then, depending on size, for power from biomass-biogas < 150 kW 13,66 ct / kWh, < 500 kW 11,79 ct / kWh, < 5,000 kW 10.55 ct / kWh, < 20,000 kW 5,85 ct / kWh; for power from biowaste-biogas < 500 kW 15.26 ct / kWh, < 20,000 kW 13,38 ct / kWh; Note: From 2016 onwards, there is a degression of 0.5 % of the compensation every three months; if a cap of 100 MW installed capacity/year is exceeded, degression will amount to 1.27% per quarter; feed-in tariffs paid for 20 years. Apart from the feed in tariff, there are also tax exemptions for biogas and biomethane used in CHPs and for electricity. Provisions are stated in the Energy Tax Act and the Electricity Tax Act. The use of biogas in combined heat and power plants (CHPs) is exempted from tax, as well as using it solely for heat production. However, as soon as the biogas/ biomethane is mixed with other energy carriers, like biomethane that is fed into the gas grid, it is not tax-

exempt. There are specific regulations for biomethane injection into the grid to ensure safe, efficient and environmentally friendly grid-bound supply. This includes the Act on the Supply of Electricity and Gas, the Gas network Access Ordinance and the Gas network charges ordinance on conditions to access gas grid.

-Act on the Supply of Electricity and Gas – Energiewirtschaftsgesetz

This act describes the regulatory conditions necessary for the supply of electricity and natural gas in a secure, affordable, consumer and environmentally friendly way.

-Gas network Access ordinance

This ordinance lays down the conditions under which access must be provided by grid operators to their networks to those who are entitled to such access. Moreover, it covers the feed-in of biogas and the connection of biogas plants to the pipeline networks.

-Gas network charges ordinance

In this ordinance are defined the methods to calculate charges for access to gas pipelines and gas distribution networks for the transmission of natural gas to consumers by the networks of the gas network operators.

-DVGW worksheets

The requirements that biomethane has to respect in the public supply grids are described in the worksheets published by the German Technical and Scientific Association for Gas and Water-(German: DVGW).

The guideline for the quality of gas from renewable sources is DVGW worksheet G 262. If the gas is to be fed into the public gas grid, it needs to meet the regulations of DVGW worksheet G 260. In particular it has to comply with the second gas family within the local gas groups. DVGW worksheet G 265-1 provides detailed information on minimum requirements for technical safety and summarizes all plants and components necessary for biogas utilization. DVGW Data Sheet G 415 presents minimum requirements for the planning, construction and operation of gas pipelines in which raw biogas or partly upgraded biogas is transported.

1.3 Biomethane in France

In France the biogas sector for the production of electrical energy has grown rapidly and for many years, especially as regards the production of biogas from landfill, from agro-industrial by-products and waste water

treatment sludge. The existing 736 plants have been achieved by the introduction of feed-in-tariff for electricity from biogas. It is a real opportunity for France which is one of the major natural gas importers for own consumption (over 98%) in addition to the production of energy through nuclear facilities and supplies of petroleum products.

Before 2002, the French national gas transmission network was state owned. Today, natural gas is transported at high pressure in a network of properties of two different operators: GRTgaz (a subsidiary of GDF Suez) on the eastern part of the north and the south of France and TIGF (a subsidiary of Total) in the south-eastern part of the France, on the border with Spain.
The distribution network is always public property and is mainly managed by the multinational GDF Suez through its subsidiary GrDF, as well as 30 local companies. The number of vehicles powered by natural gas and the number of service stations in France are mediocre. In fact, there are currently 49 filling stations (six of them will open soon; among these, 48 sell CNG, 3 sell LNG and 12 sell bio-CNG) and about 3500 vehicles (mainly trucks, buses and garbage trucks). The length of the natural gas distribution network is about 181,500 km, and the length of the natural gas transport network is 36,000 km. In total, the length of the natural gas network is 217,500 km.

At the end of 2015, fourteen plants were injecting into the local natural gas grid, and three were injecting into the transmission grid. The total injection of biomethane into the grid was 260 GWh/year.

The Law on Energy Transition for Green Growth (LTECV) fixed a target of 10% of the total gas consumption that should be represented by green gas till 2030.

Biogas production in France has different support mechanisms depending on the type of use:

- Electricity production

- Biomethane production

- Injected into the grid

    -Used as biofuel

    -Used as town gas

- Non injected into the grid (used as a biofuel mostly)

Whatever its intended use, the composition of biomethane for both automotive use and injection shall be equivalent to natural gas quality, which must meet the technical requirements as shown in Table 3.
The only exception relates to the content of oxygen, for which the specification is particularly narrow (100 ppm).

	Units of measure	***value***
Wobbe Number	*MJ/m³*	*Gas H : 49.1 - 56.52* *Gas B : 43.24 - 47.02*
Gross calorific value	*MJ/m³*	*Gas H : 38.52 - 46.08* *Gas B : 34.2 – 37.8*
Relative density *(Air = 1)*		*0.555 – 0.7*
Water dew point	*°C*	*< - 5°C at the MOP*
Hydrocarbon dew point		*< - 2°C from 1 to 70 bar*
CH_4	*%*	*> 95*
CO_2	*%*	*< 2.5*
Hydrogen (H_2)	*%*	*< 6.0*
Carbon monoxide (CO)	*%*	*< 2.0*
Oxygen in dry gas grids (O_2)	*%*	*< 100 ppmv*
Sulphur in total	*mgS/m³*	*< 30*

Hydrogen sulphide (H_2S) + COS	*mgS/m³*	*< 5.0*
Mercaptans	*mgS/m³*	*6.0*
Odorant level (THT)	*mg/m³*	*15 – 40*
NH_3	*mg/m³*	*< 3.0*
Heavy metals (Hg)	*µg/m³*	*< 1.0*
Chlorinated compounds	*mg/m³*	*< 1.0*
Fluorine containing compounds	*mg/m³*	*< 10.0*

Table 2 Standards for the injection of biomethane into the natural gas grid in France

1.3.1 French inventory of regulatory framework

The French biogas sector has quickly grown since 2011. Currently there are specific Feed-in Tariffs for electricity and biomethane. Most French environmental laws have indeed been revised since 2011. For what regards biomethane, there are several support systems that will be described in the following lines.

a) Feed-in tariff

The order of 23 November 2011 fixed a feed-in tariff for the injected biomethane, regardless of the type of recovery: household gas or biofuel. For the use of certain types of feedstock, like agricultural matter and residues (including energy crops and manure), waste from local authorities and households and sludge from wastewater treatment plants, is granted a bonus payment. Tariffs go from 6.5 to 12.5 euro cents / KWh. The tariff increases with the use of agricultural input and agro-food waste, household waste, catering waste and public waste and decreases when the CHP power increases.

b) Subsidies

Biomethane projects benefit from national subsidies and/or local subsidies. Subsidies from the State agency for environment and energy (called ADEME) must not exceed 30% of the investment. Total subsidy amount

must not exceed, according to EU rules, 45% of the investment for big companies, 55% of the investment for medium sized companies, and 65% of the investment for small companies.

c) Tax incentives

Biomethane is submitted to the Domestic tax on natural gas consumption (TICGN), whereas BioNGV (Natural bio-Gas for Vehicles) is submitted to the Domestic tax on energetic products (TICPE). There are no specific tax incentives for the injection into the grid, but there are several tax incentives for the use of biomethane as a biofuel:

-exemption on the cost of registration certificates for vehicles

-an amortization of the purchase of a bioNGV vehicle (up to 18,300€ / year)

-an extra depreciation on the purchase of bioNGV truck for a period of two years, from January 1st 2016 to December 31st 2017.

There are also tax incentives for on-farm installations. These installations benefit since January 1st 2016 from a total exemption from Property tax on buildings (Taxe Foncière sur les Propriétés Bâties – TFPB) and Company real-estate contribution (“Cotisation Foncière des Entreprises” - CFE).

Direct use of biomethane for transport without injection

The direct use of biomethane is barely developed, as there are no feed-in tariffs yet, nor guarantees of origin. Biomethane used as a biofuel benefits nevertheless from subsidies (for anaerobic digestion and biomethane production) and tax incentives (described before).

The most important regulations/orders for the production and the injection of biomethane into the natural gas grid are:

-Order of November 23rd 2011

This order lists the feedstock that must be used to produce biomethane. Biomethane must be produced with household waste, household waste from landfill, biowaste, agricultural by-products (organic waste and manure), catering waste, agri-food industry waste and agro-industrial waste.

-Order of September 16th 1977, order of March 28th 1980, order of January 28th 1981

The grid operator sets conditions for the injection of biomethane, in particular a minimum proportion of undesirable components to limit corrosion, physico-chemical characteristics which have to be similar to those of natural gas (at least 97% of methane), guarantee of stability of the production, both in quality and in quantity (in particular regarding the calorific value of biomethane), a safety certification regarding health hazards (bacterial proliferation for example) and odorisation of biomethane.

-Prescription n° 2010 - 418, Decree n° 2012 - 615, Order of March 5th 2014

To buit and/or exploit existing pipelines is required an authorization procedure if it could create significant danger or inconveniences for the environment (articles L.555-1, L.555.2 of the Environment Code). The regulations on pipelines set minimum rules, which are completed by 2 standards (NF EN 1594 and NF EN 12583) and 16 guidelines. According to the authorization procedure, they are subject to an impact study and a hazard study, as well as a public inquiry.

1.4 Biomethane in Sweden

In the field of renewable energy, Sweden is the country with a prominent position in Europe. Along with high production of hydropower, most of the energy comes from renewable forest biomass, which is used primarily in industry, district heating and electricity production.
The remaining domestic demand for energy is mainly covered by nuclear power. Dependence on oil, therefore, is a problem limited to the transport sector, with a share of 94%; it dominates the current consumption of fossil fuels in Sweden, representing roughly a quarter of total energy use (equal to 404 TWh - 1,454 PJ).
The consumption of solid fossil fuels (6%) and natural gas (2%) is significantly lower than the EU-27 average (18% and 24% respectively). The current consumption of natural gas amounts to 10.5 TWh. The extension and the subsequent coverage of the natural gas network is weak compared to the rest of Europe. Natural gas was introduced in Sweden in 1985, when it was built the first part of the pipeline connected to the Danish gas network, which even today remains the only power point. Currently, the natural gas network runs along the west coast of Sweden, branches off once the Swedish hinterland, up to Gislaved and Gnosjo, covering a distance smaller than the main axis.
The gas is used mostly for the industry (70%) and for district heating (26%). A small fee is used as a motor fuel (4%), which to a lesser extent is imported and stored in the form of liquefied natural gas (LNG). In 2014, there were 279 operational anaerobic digestion plants: 37 biogas plants from agriculture, 139 from sewage, 60 from landfill and 43 from biowaste and industrial waste. About half of the biogas production is destined for the heating, 40% is purified into biomethane, the remaining part is used to generate electricity.

The digestate coming from consortium co-digestion facilities or from company plants can be distributed using the same methods used for manure. An economically and agronomically interesting solution is the one adopted in the municipality of Helsingborg, where the digestate is transported and distributed on agricultural land of more companies thanks to a system of underground pipes.

As previously described Sweden is a relatively small country in terms of gas consumption, requiring between 11 TWh and 13 TWh of natural gas and 1.7 TWh of biogas and biomethane combined. However, this doesn't prevent Sweden from being the front runner in biomethane production and the use of biomethane in transport. With 78% of its 1,303 GWh (13 million m3) of production of biomethane used for transport sector in 2014, Sweden fuels 47,000 cars and 2,200 buses. In 2014 was sold around 38% more biomethane than natural gas for vehicular use. Additionally, Sweden was the first country to use liquefied biogas (LBG) in heavy goods vehicles.

The quality requirements of biomethane to be used both for motor vehicles (Table 4) or for injection into the natural gas network shall be fixed by special regulations.
The municipalities where you can stock up on natural gas can be divided into three different categories: the cities where gas stations are powered solely by biomethane, such as Stockholm, Linköping, Kalmar; the cities of the west coast (Malmö, Lund) in which, thanks to the presence of the main line of the Swedish natural gas pipeline, are spread only service stations where natural gas is delivered and cities such as Gothenburg, Helsingborg, Eslöv where there are stations supplied with both biomethane and natural gas. In the latter case, the situation varies from city to city. It goes from situations in which the natural gas and biomethane are sold through the same dispenser, to cases where the natural gas and biomethane are sold separately.

	Units of measure	***value***
Water dew point	*°C*	*< - 5*
CH_4	*%*	*> 97*
CO_2	*%*	*< 3*
Hydrogen (H_2)	*%*	*< 0,5*

Carbon monoxide (CO)	*%*	
Oxygen in dry gas grids (O_2)	*%*	*< 1*
Sulphur in total	*mgS/m³*	*< 23*
Hydrogen sulphide (H_2S) + COS	*mgS/m³*	*< 10*
Mercaptans	*mgS/m³*	
halocarbons	*mg/m³*	
siloxanes	*mg/m³*	*< 5ppm*
Heavy metals (Hg)	*µg/m³*	
Ammonia (H2O)	*mg/m³*	*< 20*
odorant	*Mg THT/m³*	
Particles	µm	*<1*

Table 3 Standards for biomethane injection into the natural gas grid in Sweden

In the field of biogas production and its purification into biomethane Sweden still has considerable potential for growth. The estimates are very different in different scenarios. Based on recent studies, in Sweden the potential production of biogas from organic by-products and waste can be about 74 TWh / year, which by the end of 2100 could reach 150 TWh / year. If dedicated energy crops start to spread, it is possible to assume an additional annual increase of 10-30 TWh.

1.4.1 Sweden inventory of regulatory framework

What has been achieved in the field of renewable energy and, in particular, biogas and biomethane, has been made possible thanks to the efforts of the Swedish Government that, in the period 1998-2002, has granted 180 million SEK for the development of the biogas sector through local investment programs "LIP" and other 1,800 million in the period from 2003 to 2008, with the investment program for the "Klimp" climate.

Other important incentives were the awards for eco-friendly cars, the dispensation of the tolls for cars fueled by natural gas, the reduction of taxes on vehicles, subsidies for CNG filling stations.
In the future much will depend on new incentive policies that the Swedish government will decide to implement or confirmation. The goal will still be to reduce dependence on oil in the transport sector, replacing it with biomethane.

1.5 Biomethane in Netherlands

In Netherlands there were 252 biogas plants in 2014 representing the 8th biogas market in Europe. At the moment approx. 60% of the installed capacity is used for electricity production, 30% for biomethane and 10% for heat [IEA 2014]. 105 plants are agricultural biogas plants, 82 are fed with sewage, 24 with biowaste and industrial waste and 41 from landfill. Manure makes more than a half of the total feedstock fed to the digesters (by volume).

Natural gas plays a crucial role in the Netherlands. About 46% of domestic energy demand, that amounts about to 1510 PJ, is satisfied by using this source of energy.
In Europe, the Netherlands, with an average annual production of 84 billion cubic meters, have the largest resources of natural gas. In addition there are 24 billion cubic meters imported mainly from Russia, the UK, Norway and Denmark (as well as a certain amount of liquefied natural gas from Qatar -GNL- transported).

The quantity exported (56 billion cubic meters) to Germany, Belgium, France and Italy slightly exceeds domestic consumption, amounting to about 52 billion cubic meters.

The Netherlands has also an extensive gas grid infrastructure as well as the LNG terminal and aims to become an interchange for North- West Europe. With 21 biomethane plants (6 biowaste, 4 industrial, 4 landfill, 4 sewage and 3 agricultural plants), between 8370 and 11900 Nm3/h of upgrading capacity and the 53 kWh of biomethane production per capita the country is one of the world-wide green gas forerunners. At the moment all upgraded biogas is injected into the grid. According to NGVA statistics (2014), approx. 6700 natural gas vehicles were driving on Dutch roads and tanking on 186 (mostly public) refuelling stations.

Biomethane plants have a priority access to grids, but they have to meet quality requirements imposed by TSO (Transmission System Operator) and DSO (Distribution System Operator). Connection costs are charged to the plant operator. Conditions for grid connection and transport are regulated by the Article 12b of the Dutch Gas Act (Gaswet). However, different grid operators may have additional requirements, which can lead to long consultation processes.

1.5.1 Netherland inventory of regulatory framework

From the point of view of incentives, support to renewable energy had many changes over the past decade. The previous support scheme, considered too generous, was replaced with a feed in tariff scheme, called "MEP", in July 2003. The MEP modified specific rates from year to year and paid for 10 years in addition to the electricity market price. The tariffs were financed by a budget proceed from a tax paid by all consumers of the electricity market.

The MEP was replaced with the premium tariff system SDE "Stimuleringsregeling Duurzame Energieproductie" ("stimulation of production of renewable energy") which provided for a specific support system for photovoltaic, biomass, hydro and wind onshore.

The incentives were determined based on calculations that take into account both the costs of production for each technology and the possible other income of producers (e.g. release for consumption of biofuels). Now in Netherlands the production of energy from renewable sources and, in particular, biomethane is supported by the SDE + system, the costs of which (approximately 1.5 billion € / year) until the end of 2012, were borne entirely by the state. At the beginning of 2013 they were passed to consumers in the form of surcharges on the electricity and gas sales.

The incentives for the electricity production vary from 0.07 € / kWh to 0.15 € / kWh and, for the heat, from € 19.44 / GJ to € 41.67 / GJ (Table 5).

Biomethane incentives are provided exclusively in the case of injection into the natural gas network and are modified annually based on the market price of natural gas to ensure that the plant operator receives the same feed-in-tariff for a period of 12 years. In 2013 they were provided in five different rates, from a minimum of € 0.483 / Nm3 to a maximum of € 1.035 / Nm3.

It is allowed to create consortium upgrading systems that collect and purify biogas produced from different biogas plants, only if biomethane is injected into the natural gas grid.

Biomethane for transport is not supported directly but can benefit from special "biotickets" arising from the obligation to release for consumption of biofuels.

step	Aperture	Max electricity (€ct/kWh)	Max heat(CHP (€/GJ)	Max Biomethane (€ct/Nm^3)
1	4/04/2013	7	19,444	48,28
2	13/05/2013	8	22,222	55,17

3	17/06/2013	9	25,000	62,07
4	2/09/2013	11	30,556	75,86
5	30/09/2013	13	36,111	89,66
6	4/11/2013	15	41,667	103,45

Table 4 Support scheme in Netherland 2013 SDE+

In addition to SDE + incentives, in the Netherlands for the production of biomethane you may qualify for a special tax regime called "Energy Investment Allowance - VIA" that supports investment in equipment and systems for energy efficiency and renewable energy (for example, you can purchase an anaerobic digestion plant for the production of biogas or an unit to upgrade biogas to biomethane). In this way, 41.5% of the investment costs can be deducted from income tax or corporation tax, with a net benefit of approximately 10% for those who have made the investment. So entrepreneurs that use EIA get a double benefit: their energy costs are lower and they pay less tax.

The requirements for the quality of biomethane to be injected into the natural gas grid and methods of access are regulated by Article 12b of the Dutch Law on Gas.
It is possible to use biomethane derived from purification processes of the biogas produced using any feedstock (agricultural biomass, agro-industrial by-products, municipal wastewater, landfills, MSW - municipal solid waste). In order to ensure that the gas injected into the network is free of pathogenic microorganisms, the use of a HEPA (High Efficiency Particulate Air filter) or of a particular filtration system with high efficiency of fluids (liquids or gases) is required in the feeding point. It is also mandatory to make analysis of biomethane twice a year.
The injection of biomethane is possible both in the natural gas distribution network (which operates at a maximum of 8 bar) and in the transport network (operating at 40 bar).
Because of lower costs and the usual proximity of the upgrading plant and the network, the injection in the distribution system is the preferred choice by the producers of biomethane in the Netherlands.

In 2014 a national technical gas specification was incorporated into legislation. In 2009 GasUnie had established a certificate issuing body Vertogas to guarantee the green origin of the green gas. The Netherlands has the first biomethane trading experience with Germany and in the future it may also import this green gas from Russia, as in 2011 GasUnie and Gazprom signed a Memorandum of Understanding to explore import possibilities to the Netherlands.

	Units of measure	***value***
Water dew point	*°C*	*< - 10°C at the MOP*
CH_4	*%*	*> 85*
CO_2	*%*	*< 6*
Hydrogen (H_2)	*%*	*< 12*
Carbon monoxide (CO)	*%*	*< 1*
Oxygen in dry gas grids (O_2)	*%*	*< 3*
Sulphur in total	*mgS/m³*	*< 45*
Hydrogen sulphide (H_2S) + COS	*mgS/m³*	*< 5.0*
Mercaptans	*mgS/m³*	*10.0*
halocarbons	*mg/m³*	*50*
siloxanes	*mg/m³*	*< 5ppm*
Heavy metals (Hg)	*µg/m³*	
Ammonia (H2O)	*mg/m³*	*< 3*
odorant	*Mg THT/m³*	*> 10.0*

Table 5 Standards for biomethane injection into the natural gas grid in Netherland

1.6 Biomethane in Austria

In 2015 in Austria there are 436 biogas plants with a total capacity of 81 MWel. 201 are agricultural biogas plants, 95 are feed with sewage, 15 from landfill and 125 from biowaste and industrial waste. Including 4% of agricultural land for biogas production, Austria has a potential of about 26.2 PJ or 7,284 GWh from biogas production. The gas consumption in 2014 in Austria was 83500 GWh. The biomethane injected into the grid represent the 0.1% of the total consumption with 106 GWh of production. The potential of the biomethane, if all the biogas plants will be converted into biomethane plants injecting it into the grid, could be around the 1.8% of the total consumption.

In Austria the gas grid amounts to 46,000 km and there is good cooperation between biogas and natural gas stakeholders, with 180 methane filling stations and around 10,000 methane vehicles already running.

The first biogas plant that upgraded biogas to biomethane and injected it into the natural gas grid in Austria was in 2005. In 2014 the biomethane plants connected to the grid were 11 and the biomethane plants with their own filling station were 3.

It is expected that only about 30% of biogas potential will be directly used as transport fuel and about 70% will be used for CHP. Due to the efforts reaching high efficiency, CHP applications often cannot be installed directly at the plants but biogas will be upgraded and biomethane injected into the natural gas grid before its application in CHP where the heat also can be used. Injected biomethane, which is used in high efficient CHP for renewable electricity production, can get feed in tariffs for their produced electricity. Biomethane which is directly used as transport fuel without being blended with natural gas is exempted from paying natural gas taxes. If biomethane is blended with natural gas, thus tax exemptions are not applied and natural gas taxes must be paid also for biomethane. The use of biomethane for heat application is not subsidized so far.

1.6.1 Austrian inventory of regulatory framework

In 1999 in Austria was published the first regulatory act promoting renewable energy (ELWOG), that stated that each state has to introduce targets and FIT for renewables.

Each state published its own law, so there were 9 different regulations on renewable energy support in 2002, so Austria decided to create a direct federal law (Ökostromgesetz). This law was modified several times since 2011 establishing new targets for renewable electricity and criteria for obtaining the Feed-in Tariffs by the operators. Every year the Ministry of Commerce publishes Feed-in Tariffs for renewable electricity, called

Ökostromeinspeisetarifverordnung, thanks to which it is possible to quickly react on the technical and economic development of renewable technologies.

There is another bonus in addition to Feed in tariff: the first 25000 kWh of self-consumed electricity from renewables and the direct use of biomethane (not mixed with natural gas) are fully or partially exempted from energy taxes (VAT). Moreover if biogas is upgraded to biomethane, injected into the natural gas grid and used for electricity production, there is another bonus of 2 ct/kWhe. Two other important legislative acts are Kraftstoffverordnung and Landwirtschaftliche Ausgangsstoffe für Biokraftstoffe, that set the Sustainability criteria of biomethane, the method to calculate double counting and a registration requirement of biomethane fuel producers. As regards digestate trade, two legislative acts are in place, depending on the feedstock: Düngemittelverordnung for agricultural feedstock and Abfallwirtschaftsgesetz for biowaste.

For what regards the standards that the biomethane has to respect to be injected into the natural gas grid, they are present in the technical guidelines from the Association of the Austrian Gas and Water Suppliers. Two guidelines are regulating the requirements:

- ÖVGW GB 220
- ÖVGW G 31

The first one gives additional requirement for biomethane grid injection while G 31 describes in general the natural gas quality and requirements for it. The list below shows also many other guidelines which are important for the biomethane sector:

Austrian transport fuel regulation

StF: BGBl. II Nr. 398/2012 [CELEX-Nr.: 32009L0028, 32009L0030, 32011L0063] The quality requirements for the use of methane as transport fuel is set in the Austrian transport fuel regulation with no difference regarding quality between natural gas or gases from renewable sources. In this regulation also the general targets for biofuels are written down (5.75% based on energy content) from 2009 onwards. There are no direct subsidies etc. laid down in this regulation. The stimulation for blending biofuels to fossil fuels is done through setting lower taxes for fuels which has a blend of required 5.75% biofuels. For counting biofuels under RED (Renewable Energy Directive) they have to be produced in a sustainable process. Criteria and consideration for the latter are also written down in this regulation and, if agricultural feedstock is used, also in the regulation agricultural feedstock for biofuels (Landwirtschaftliche Ausgangsstoffe für Biokraftstoffe: 250/2010 CELEX-Nr.: 32009L0028). The biofuel production site itself has to be registered via the Environment Agency Austria.

	Units of measure	***value***
Water dew point	*°C*	*< - 8°C at 40 bar*
CH_4	*%*	*> 96*
CO_2	*%*	*< 3*
Hydrogen (H_2)	*%*	*< 4*
Oxygen in dry gas grids (O_2)	*%*	*< 0,5*
Sulphur in total	*mgS/m³*	*< 10*
Hydrogen sulphide (H_2S) + COS	*mgS/m³*	*< 5.0*
Mercaptans	*mgS/m³*	*<6*
siloxanes	*mg/m³*	*< 10*
Ammonia (H2O)	*mg/m³*	*Thech free*

Table 7 Standards for biomethane injection into the natural gas grid in Austria

1.7 Biomethane in Denmark

Currently in Denmark there are 154 biogas plants with a biogas production of 1289 GWh/year. The main feedstock use for the biogas plants is manure. According to the Danish Biogas Association, roughly 7% of the animal manure is today supplied to biogas plants in Denmark. The aim is to increase it to 50% by 2020. Organic wastes from industry and sewage sludge also make a significant contribution to the biogas production.

The reason of these is that the first priority for Danish Government is to use easily available waste materials. For environmental sustainability reasons, it introduced limitations for the share of energy crops used for biogas production. Instead the interest in using deep litter and straw in the production of biogas in Denmark

is growing. Recent estimations (AgroTech, 2012- quoted by Biogas Task Force, 2014) of the biogas potential in Denmark show that the maximum potential for biogas production in Denmark lies between 12 and 22 TWh, depending on time horizon and share of energy crops.

According to the Danish Energy Strategy 2050, biogas shall play an essential role in the fossil free energy system. Biogas will balance fluctuating electricity production from wind turbines through cogeneration and biomethane will replace natural gas in grids. Use as a transport fuel will play only a minor role due to the national favouritism of electric vehicles.

Today biogas is mainly used for heat and power production in Denmark. In 2014 there were 6 biomethane plants with a raw biogas upgrading capacity of 8650 Nm3/h and 7 biomethane filling stations (100% biomethane). Only one biomethane plant injected biomethane into the natural gas grid.

1.7.1 Danish inventory of regulatory framework

The main elements of the Danish support system for biogas are:

-0.056 EUR/kWh for biogas used in a CHP unit or injected into the grid (115 DKK/GJ),

-0.037 EUR/kWh for direct usage for transport or industrial purposes (75 DKK/GJ).

These tariffs include natural gas price compensation of maximum 0.012 EUR/GJ (26 DKK/GJ) and temporary support of 0.005 EUR/GJ (10 DKK/GJ) up to 2016.

It is also possible, if it is used mainly manure, to apply for investment grants. Support for upgraded biogas supplied to the natural gas network in calendar year 2013 was 111.6 DKK per GJ. The support is payable to both upgraded biogas supplied to the natural gas grid and to purified biogas entering a town gas grid.

In the energy agreement, new support frames for biogas to transport and other applications were also agreed:

-€10.6/GJ in basis subsidy for combined heat and power heating (direct and indirect subsidies),

-€10.6/GJ in basis subsidy for upgrading and distribution via the natural gas grid,

-€5.2/GJ in basis subsidy for industrial processes and transport.

In addition:

-€3.5/GJ for all applications – scaled down with increasing price of natural gas. If the natural gas price the year before is higher than a basis price of €7.1/GJ the subsidy is reduced accordingly.

-€1.34/GJ for all applications – scaled down linearly every year from 2016 to 2020 when the subsidy expires. (IEA)

Currently there is no national standard for biomethane injection into the grid. The injection of biomethane is allowed only if the following regulations are respected:

•Rules for supply of upgraded biogas (Bio Natural Gas) to the Danish gas system

•Gas Regulations, part A, enclosure 1A

•Safety Authority's draft requirements for upgraded biogas

•Rules for Gas Transport

In order to document the trade of biomethane was established a certification scheme by Energinet.dk. Recently was signed also a joint declaration together with Belgium and Netherlands to promote 100% carbon neutral gas supply and increase the share of biomethane within their infrastructure by 2050.

	Units of measure	***value***
Water dew point		*< - 8°C at 40 bar*
Wobbe index	*WWh/m3*	*14,1-15,5*
CO_2	*%*	*< 3*
Hydrocarbon dew point	*°C*	*< - 2°C at70 bar*

Oxygen in dry gas grids (O_2)	*%*	*< 0,5*
Sulphur in total	*mgS/m³*	*<30*
Hydrogen sulphide (H_2S) + COS	*mgS/m³*	*<5*
siloxanes	*mg/m³*	*< 0,1*
Bacteria, micro-organism		*No health risk*
Ammonia	*mg/m³*	*<3*

Table 8 Standards for biomethane injection into the natural gas grid in Denmark

1.8 Biomethane in UK

In 2014 there was an important growth in **United Kingdom**: the sector has this growth due to the rush to commission plants in order to receive higher Feed-in Tariffs and Renewable Heat Incentive tariffs, so in 2014 were commissioned 86 new plants considering agriculture, water and industry waste sectors. According to the International Energy Agency (IEA), there are about 440 landfill biogas plants with a total capacity of about 5 GWel. The biogas market started in UK in the 2000s, mainly in the water sector after the introduction of the Renewables Obligation in 2002. In 2010 was introduced the Feed-in Tariff and in 2011 the Renewable Heat Incentive. This allowed the development of electricity production and the injection of biomethane into the natural gas grid from biogas. Currently in UK there are 813 biogas plants: 129 from agriculture, 150 from sewage, 442 from landfill and 92 from biowaste and industrial waste. According to the British Renewable Energy Strategy (NREAP), 15% of primary energy should come from renewable sources by 2020. Approximately 12% of heat, 31% of electricity and 10% of road transport fuels (including biomethane) will be produced from RES. The main use for biogas in the UK today is for electricity production (103 MWel from AD alone).

The potential of biogas and biomethane sector in UK is huge. In the UK there are nearly 300000 farms (Eurostat, 2014) and the biggest sheep and goat herds, with a production of 10.5% of the total livestock in the EU. Due to the well-developed food industry in the UK, there are great amounts of residues from food processing that can be utilized in anaerobic plants.

The UK possesses great infrastructure for gas consumers; about 80% of homes have a gas connection. The scenario for what regards the NGV owners is totally different: at the beginning of 2015, the total number of gas vehicles was more than 700 and there were only 11 natural gas filling stations and 9 LNG filling station. There are several causes for this situation, for example the delays and difficulties in obtaining planning approvals for refueling stations and commissioning the stations and the limited experience of gas vehicles in the UK. There are eight gas distribution networks (GDNs), each of which covers a separate geographical region of Great Britain. These eight networks are owned and managed by the following companies:

- National Grid Gas plc
- Northern Gas Networks Limited
- Wales & West Utilities Limited
- Scotia Gas Networks Limited

The National Transmission System (NTS) is the network of gas pipelines throughout the United Kingdom that supply gas to 40 power stations from natural gas terminals situated on the coast, and also to gas distribution companies which supply indirectly homes.

1.8.1 UK inventory of regulatory framework

In the United Kingdom there are different support schemes both for the generation of electricity from renewable sources and for renewable heat production.

There are three different support systems for biogas plants:

-Feed-in tariffs (FiT),

-Renewables Obligation Certificates (ROC),

-Renewable Heat Incentive (RHI).

The RHI is a support for heat production from biogas boilers and CHP as well as biomethane injection. FiT and RHI (heat) tariffs are currently banded by capacity to encourage both small and large capacity AD plants. From 2015 there is a new tiered tariffs system for biomethane injection which was published to

enable all sizes of plant to develop. Current biomethane injection projects have largely utilized crop feedstocks or sewage.

The feed in tariff , based on annual generation, is:

- 1st 40.000 MWh 7.24p.

-Second 40.000 MWh 4.25p.

-Above 80.000 MWh 3.28p.

For what regards the standards that biomethane has to respect were written in The Gas Safety (Management) Regulations 1996 (GSMR). Biomethane has to comply with the safety requirements and quality criteria of the regulations. The Renewables Obligation, introduced in 2002 for the whole UK, supports all renewable energy technologies over 50kWel. Each Renewable Obligation Certificate (ROC) represents 1MWh of electricity and is banded according to technology; 2 ROCs for AD, ¼ ROC for landfill and ½ ROC for sewage gas. The buy-out price for the 2013/14 Obligation was set at £42,02 per ROC. To support the development of small biogas plants this scheme offers more certificates for smaller plants, for example 4 ROCs for small plants, up to 50kW, 4 ROCs for plants between 50kW and 500kW and 3 ROCs for plants above 500kW.

The RO places an obligation on electricity suppliers to match a percentage of their electricity supplies with ROCs. The obligation rises each year, it began at 3% of electricity supplies in 2002/03 and rose to 15% in 2015/16. The RO will close to new application in 2017.

The most important acts and regulations for what regards the support system in UK are the following:

- The Electricity Act 1989, c.29
- The Energy Act 2008, c. 32
- The Utilities Act, c.27
- The Renewables Obligation Order 2009, No. 785 (ROO)
- The Renewables Obligation (Scotland) Order 2009, No. 140 (ROO SCO)

•The Renewables Obligation (Northern Ireland) Order 2009, No. 154 (ROONI)

•The Feed-in Tariffs (Specified Maximum Capacity and Functions) Order 2010 (FTO)

	Units of measure	***value***
Water dew point	*°C*	*< - 10°C at 30 bar*
Wobbe index	*MJ/m3*	*47,2 to 51,41*
Soot index		*0,6 max*
Incomplete combustion factor		*0,48 max*
Hydrocarbon dew point	*°C*	*< - 10°C at 30 bar*
CO_2	*%*	*< 3*
Hydrogen (H_2)	*%*	*< 0,1*
Carbon monoxide (CO)	*%*	
Oxygen in dry gas grids (O_2)	*%*	*< 1*
Sulphur in total	*mgS/m³*	*< 50*
Odorant concentration		*7 (operating)*
Pressure	*Bar*	*tba*
Temperature		*0-20*

Flow	*Sm3/h*	*Tba*
Corbon dioxide	*%*	*0-7*
Methane	*%*	*78-100*
Propane	*%*	*0-8*

Table 9 Standards for biomethane injection into the natural gas grid in UK

1.9 Biomethane in Italy

During the last years a relatively low number of new plants was built in **Italy**, a country that usually delivers hundreds of anaerobic digestion projects. In 2014, around 100 new agricultural plants were built. The Italian support scheme changed in 2013, which had an adverse effect on the number of new biogas projects. The other reason for such a gradual increase is that the new support scheme favors smaller biogas plants. This explains the fact that the total installed capacity increased by only 50 MWel in 2014.

Currently the operating biogas plants in Italy are about 1555, of which more than 1200 agricultural, with a capacity of 1345 MWel installed.

On the basis of these numbers Italy is the second largest producer of biogas after Germany, and the third in the world after China. The Investment made over last years has been of the order of 3,500,000,000/4,000,000,000 euro, with a significant increase of stable employment in the sector for over 12,000 employees.

The previous three-year period, from 2009 to 2012, was a key period for the development of the biogas and biomethane sector. The sector has grown considerably up to the 2012 to a consistency of more than a thousand plants with an installed capacity of 900 MW; in particular, in the field of agricultural biogas, according to the estimates presented by TERNA for the year 2013, there were about 1,200 plants built by the Italian agricultural sector with a total installed power of about 900MWe distributed for 85% in the regions of north and the remaining 15% distributed among the regions of central and south Italy. A similar evolution has been possible thanks to the form of support resulting from the feed-in-tariff of Law n. 244 of 2007. The Italian biogas sector is characterized by a high percentage of plants of agricultural origin. More than 80% of biogas plants in Italy is powered by biomass of agricultural origin, 12% from landfill, 3% of MSW and 5% with biomass-derived water treatment.

In the position paper of 2011 the Italian Biogas Consortium had estimated the potential production in 8 billion Nmc equivalent of biomethane to be achieved by 2030 using 400,000 hectares of land making an extensive use of integrated biomass, biomass that today do not constitute income (i.e. often have a cost) for farmers. These biomass are:

a) Crops of second crop (Colture di secondo raccolto), in precession or succession to forage or food crops
b) Livestock effluents
c) Agricultural by-products
d) Agro-industrial by-products
e) Biomass resulting from biorefinery
f) Crops dual purpose (Colture a duplice attitudine), or if otherwise not possible, no food crops and not on land not easily used for foragers.

This potential is then calculated exclusively from abandoned land, products and wastes that are generally not reused, and often represent a disposal cost for the company, land that was not used to the full potential so do not limit in any way the production of other sectors such as FOOD.

The 2012/2013 data published by ISPRA confirm that the industrial sector of the recovery of the organic fraction continues its expansion phase, with an average growth in the last decade by almost 10% per year. From almost 2 million tonnes collected in 2003 it moved to over 5.2 million tonnes in 2013. The separate collection of organic waste or the sum of wet (MSW) and green waste is constantly increasing; the fraction represented in 2010 37% of urban waste collected separately and in 2013 the share rose to 42%; these fractions together represent the first sector of recovery of materials in Italy. In 2013 the sector of composting and anaerobic digestion reached a potential capacity of approximately 8.3 million tons, probably overestimated because the quantities authorized often refer to combined plants (anaerobic-aerobic) with possible duplication of authorized quantities. Based on the recovery data to biological treatment plants, 88% of the organic waste from selective collection of municipal waste is targeted for recovery in composting plants while 12% is recovered in anaerobic digestion plants. On the other hand, the sector of the production of biogas is relatively recent, but in the expansion phase.

The number of anaerobic digestion plants increases by almost 60% in the 2011/2013 three-year period, with a total of 42 operating plants, capable of treating the biowaste from differentiated collection. If the waste collection will be widespread throughout the national territory (the outlook is good but we are "half the battle") it could generate about 8-9 million tons of kitchen waste. If this spread was transformed into biogas and then in biomethane could be produced in Italy more than 450 Gm3 of biomethane; the estimate would reach really remarkable quotas considering also the potentially producible biogas from landfills. Landfills which, will

always receive less biodegradable waste in the future but in Italy the "landfill" system has been dominant for decades and the "heart" of the landfills is a biogas mine. For what regards the damp coming from separate waste collection, as evidenced by the decree, there may be incentives for the production of biomethane especially injecting it into the natural gas network and using it in automobiles. The field of organic recycling has a great potential if transformed in biomethane to be used as transport fuel. It is estimated that, even with the current generation of "wet" and if all the moisture was turned into biomethane through anaerobic digestion, biomethane produced would feed the fleets dedicated to the collection of waste with a self-sufficiency of 80%. The estimated number of biogas plants to be realized in the next three years is 12-20, with an average production capacity for every plant of 500 m3 / h of biogas.

As previously anticipated, in 2013 the biogas market has stopped its growth trend than in previous years. As provided by D.L. 6/7/2012, the 2014 incentive fee was reduced (2%) because more than 80% of the original quota was allocated; for the same reason also the 2015 rate was reduced by a further 2%. In this context of great difficulties in the sector, the approval of the decree on the production of biomethane is a great opportunity to re-launch the market and development for our companies. The possibility of producing biomethane both to inject it directly into the natural gas grid and for use in high-yield cogeneration plants or CNG vehicles can relaunch the development of new business initiatives and give a chance to continue to use more efficiently the existing installations. Since June 2015, in Italy five plants producing biomethane are in operation. The older plant is in Rome at the Malagrotta landfill, in operation since the mid-90s. It is a system that uses the technology of the wash water, capable of treating about 200 m3/h of biogas (upgrading from the landfill). The biomethane is not injected into the grid and is used as biofuel in vehicles for the collection of waste. The other four plants are demonstrative plants. No one is connected to the gas grid. Three of them are linked to agricultural plants (in the provinces of Lodi, Bologna and Mantua), and one is linked to MSW1 treatment plant (near Turin).

The Italian gas grid is composed by 280,000 km of pipeline (mostly concentrated in the northern regions), divided between primary transport grid (34,000 km) and distribution grid (250,000 km). Italy has a long tradition in the field of methane-fuelled vehicles and is still European and worldwide leader in the technology used for this kind of means of transport. At the end of 2014 the Italian distribution topped 1,000 service stations, out of which 14 on highways and other 20 owned by public transport companies. Further, more than 950 million cubic metres are consumed for traction among service stations and company vehicles.

Complying with the AEEG (Electric and Gas Energy Authority) regulations, biomethane is compatible with natural gas, which is already distributed in-country in the gas pipelines and secondary grid. Thus, it can be used by all the 790,000 vehicles, which are fueled with natural gas. It will be also possible to draw upon cylinder or tanker trucks. This kind of transport is common in Italy and useful to provide many different

consumers (civil, industrial, traction) with natural gas, which are not served by the pipelines grid, or are experiencing an emergency or grid maintenance works. The transport network is made up of: a "primary" (or dorsal) network, transporting gas directly from production or import, and a "secondary" network, covering all pipelines (adductors secondary) that connect the primary network to the centres of consumption. The main Italian pipeline has a length of approximately 34,000 km and spreads over the national territory (excluding Sardinia). The network of Snam represents 93.8% of the national primary network. Other operators have developed local networks, particularly in the Adriatic regions (Marche, Abruzzo and Molise). According to the resolution nr. 120/01 “Development of criteria for the determination of tariffs for the transportation and regasification of natural gas and the use of LNG terminals and the booking of capacity” ("*Definizione di criteri per la determinazione delle tariffe per il trasporto e dispacciamento del gas naturale e per l’utilizzo dei terminali di Gnl e della prenotazione di capacità* ") the distribution network is divided into two parts:

- the National Gas Pipeline Network, for a total of 9,268 km,

- and the regional transportation network for the remaining 24,500 km.

The National network consists of pipelines, connected to compressor stations. The regional transportation network consists of the remaining part of the carrier pipelines not included in the National Gas Pipeline Network and the plants connected to it with the main function to move and distribute natural gas in defined territorial areas, typically on a regional scale. The transport service should be understood as an integrated service from the above mentioned pathways of entry into the national network to the delivery locations of the regional network.

The distribution is done by about 5,800 booths; almost 210,000 final reduction groups; almost 250.000 km networks (including 1,350 km non-operating), 41% on average pressure and 58% in low pressure. The networks are located mainly in the North (148,500 km against 56,500 km in Central Italy and 43,700 km in Islands and South Italy). The networks, on average, belong 75% to the same distributors and 5% to the municipalities. The ownership of the networks, which can be the Municipality distributor or other organizations (for this reason the sum of the percentages may not be equal to 100), however, varies quite significantly between the different regions.

1.10 Summary of national support schemes

The Decree of 5th December 2013 (Biomethane Decree), establishes the subsidy scheme for biomethane introducing three types of subsidy for biomethane produced and injected into the natural gas grid; these types are:

a) biomethane injected in transport and distribution grid of natural gas;

b) biomethane used in transport after injection into the natural gas grid;

c) biogas plants used in CAR (High efficiency cogeneration – “Cogenerazione ad Alto Rendimento”).

According with the decree, the national gas grid includes both the natural gas and biomethane grids, and more in details:

• transport grid and distribution of natural gas whose managers have an obligation to connect third parties;

• transport systems by gas road tanker;

• public and private filling stations, including agricultural use, also not involved in the transport and distribution grid;

• other transport grids.

The subsidies provided by the Decree apply to:

• new plants built in the country and in operation since 18th December 2013 and no later than five years from the date of entry into force of the Decree;

• existing installations for the production and utilization of biogas, located within the national territory, in operation since 18th December 2013 and no later than five years from the date of entry into force of the decree, converted, partially or totally, to the production of biomethane.

Subsidy for grid connection without a specific destination

The producer can inject biomethane in the transport or distribution of natural gas grid, with or without the aid of gas road tanker. In the case in which the biogas is fed into the network without a specific final destination of use, the amount of the incentive depends on both the size of the plant and the type of biomass used to produce the raw biogas. The incentive is equal to the difference between twice the annual average price of natural gas, found in 2012 on the natural gas balancing market run by the Energy Markets Operator (GME) and the average monthly price of natural gas in the same market, found in each month of release of biomethane in the network. The values are expressed in € / MWh.
The incentive defined as above applies only in the case of plants with a production capacity from 501 to

1000 Sm3 / h. Plants with a production capacity of up to 500 Sm3 / h benefit from an incentive increased by 10%, while the large plants with capacities higher than 1000 Sm3 / h benefit from a reduced incentive of 10%. The type of biomass used for the production of raw biogas impacts both on the amount of the incentive and admissibility. The legislature did not impose any limitation on the use of biomass that feed small plants, with a production capacity up to 250 Sm3 / h of biomethane. However, above this threshold, the biomethane is supported only on condition that at least 50% by weight of the biomass used for the production of raw biogas is constituted by by-products, as defined in Table 1 of the DM July 6, 2012, or waste. In case the biogas is produced exclusively from these by-products and waste, including any increase or reduction of 10% due to the nominal plant size, the support is increased by 50%.

Producers with plants with a nominal hourly output of up to 500 standard cubic meters / hour (Sm3 / h) of biomethane have the right to opt for the gas purchased by the GSE, as an alternative to the sale on the market. This is defined with the dedicated term "ritiro dedicato" (withdrawal). Producers wishing to use the option of the dedicated withdrawal must request to the GSE withdrawal of the entire production minus any internal consumption. To the producer who will opt for the option of dedicated retreat by the GSE will be recognized a feed-in-tariff, equal to twice the annual average price of natural gas found in 2012 in the natural gas balancing market, which will be added the bonus for further increases described in the biomethane Decree (bonus for small plants capacity, bonus for use of by-products or waste etc..).

Example of a type of support scheme: plant with a production capacity below 500 Sm3 / h, not entitled to the increase of 50%, of which in article 3, paragraph 5 of the decree, which opts for the dedicated withdrawal.

Average price of gas in GME market in the year 2012 (Pma2012): 28,52 €/MWh

Average price of gas in June (month of injection) 2015 (Pmgiugno2015): 22,32 €/MWh

subsidy = (2 x Pma2012 - Pmgiugno2015) = 34,72 €/MWh

Bonus for plants with an installed capacity below 500 Sm^3/h (bonus) = 0,1 x 34,72 = 3,47 €/MWh

Total subsidy = 2 x Pma2012 + bonus = 57,04 + 3,47 = 60,51 €/MWh

Pending the completion of the framework regulatory, this way of subsidy is not active yet.

Subsidy for high efficiency cogeneration (CAR)

The Decree identifies as a second modality to support biomethane plants when used for high efficiency cogeneration (CAR). In this case, the biomethane is not encouraged directly, but through the recognition of feed in tariffs for the production of electricity from biogas, according to modalities and conditions set by decree of the Minister of Economic Development 6 July 2012. Pending the completion of the framework regulatory, this way of subsidy is not active yet.

Subsidy for biomethane as biofuel

In Italy biofuels are encouraged by the system of mandatory quotas. This is the mechanism chosen to achieve the target set by the European Union for the consumption of renewable energy in the transport sector (10% in 2020). The obligated parties, e.g. operators that release gasoline and diesel fuel for consumption, have an obligation to mix with biofuels the 5% (for 2015, next years the % will increase up to 10%) of the energy value of fossil fuels (diesel and gasoline) released in consumption in the same year. Biofuels released for consumption in transport must be provided with sustainability certificate accompanying the biofuel in the transition from producer to distributor (Certificate of Release for Consumption - CIC "Certificato di Immissione in Consumo"). The biomethane distributor, which releases biomethane for consumption, receives a CIC by the GSE every 10 Gcal.

There are two types of allocation of CIC according to the raw material used to produce biofuels:

• persons which release for consumption biofuels produced from dedicated crops (e.g. corn) get 1 CIC every 10 Gcal of biofuel released for consumption (*single counting*);

• persons whose authorization to build and operate the plant for biomethane production contains the exclusive use of one or more of the following type:
- Biodegradable fraction of municipal waste after the collection;
- By-products referred to in paragraph 5-ter art. 33 of Legislative Decree no. 28/2011, which have no other production or commercial use outside of their use for the production of fuels or energy purposes, as defined, identified and tracked in accordance with Legislative Decree no. 152/2006;
- Algae and non-food materials shown in Table 1-B of the Decree of 6 July 2012;
- Products referred to in Table 1A and 1B to the Decree of 6 July 2012;
will get 1 CIC every 5 Gcal of biofuel released for consumption (*double counting*).

Limited to new installations, in cases where the authorization overs the use of biomass described above in co-digestion with other products of biological origin, in a percentage not exceeding 30% by weight, the double counting will be paid on 70% of the production of biomethane released for consumption.

The producer of biomethane signs a bilateral agreement with the subject which put fossil fuels in transport. The latter subject receives, for 20 years from the starting date of the plants, 1 CIC every 10 Gcal of biomethane put in consumption, or 1 CIC every 5 Gcal (double counting) if the biomethane is produced from the organic fraction of municipal solid waste (MSW) after the collection or by-products. In addition there is a surcharge of 50% of the incentive for 10 years, when the producer leads directly biomethane into a new distribution facility built at his own expense. In this case, the CIC are assigned directly to the owner of the biomethane plant who acts as both manufacturer and distributor.

1.10.1 Italian inventory of regulatory framework

Italy has nearly 20 regulations related to biogas and biomethane. The first act promoting energy from biogas production was published in 1992 (*Delibera CIPE N°6 1992*) and it defined the prices and the incentives of electricity produced. In 1999 Italian legislator released the *DM 11/11/1999* to define formulas and methods of calculation of renewable energy that is entitled to obtain an incentive. However, the most decisive decree for the biogas sector in Italy was published in 2008 (*D.M. 18/12/2008*), introducing an attractive Feed in Tariff of 0.28 Euro/kWh. This allowed the great expansion of the biogas sector in Italy, reaching more than 1000 biogas plants in five years. In 2012 was published in Italy *D.M. 06/07/2012* to modify the support scheme for biogas installations, reducing FIT and giving bonus for smaller plants as well as for utilization of sub-products, waste and animal manure. In 2013 a biomethane dedicated decree came into force to provide incentives for this fuel injected into the gas grid, distributed directly for transport or using tube trailer. Due to lack of technical rules of the gas grid operators, it is not yet administratively possible to inject renewable gas into the natural grid.

In the following chapter will be briefly described the most important regulations for biomethane in Italy.

Decreto 5 dicembre 2013 (Biomethane Decree)

The Biomethane Decree defines the subsidy mechanism for the biomethane injected into the natural gas grid as well as the duration and value of the subsidy previously explained. The article 8, paragraph 9 of the decree provides that, pending the entry into force of the European regulations for the specific quality of biomethane for transport and of technical specifications for the injection of biomethane into the grid, to be issued by CEN TC 408 in the implementation of the mandate M/475 EC, in order to protect the health of

populations and ensure the optimal functioning of motor vehicles, are permitted only the injection into the natural gas grid of biomethane produced from biogas resulting from the anaerobic digestion of organic products, by-products and the organic fraction of municipal solid waste for recycling (MSW). Therefore, it is not allowed to inject into the natural gas grid the biomethane derived from biogas produced by thermochemical (gas pyro gasification processes), landfill gas, residual gases from purification processes and fermentation of sludge and other waste from MSW. With reference to the quality of biomethane injected into the transportation and distribution of natural gas grid, the decision of the Authority 46/2015 / R / gas, imposes to the grid operator to define and publish the specifications quality of biomethane to allow the injection in the grid specifying that, in any way, for the entire duration of the European mandate M / 475, the grid operator must refer to the current provisions of the Ministerial decree of 19 February 2007 and under the conditions identified by the biomethane decree, concerning the exclusion of bio-methane derived from biogas / gas produced by thermochemical, landfill gas, residual gases from purification processes, sludge and other waste from MSW. Biomethane must be technically free from all the components identified in the report UNI / TR 11537, for which the maximum limits by law are not identified yet.

Deliberazione 46/2015/R/gas

With the Resolution 46/2015/R/gas, the Authority defines the guidelines for connection of biomethane plants to the natural gas grid and the provisions relating to the determination of the amount eligible for subsidy.

Deliberazione 210/2015/R/gas

With the Resolution 210/2015/R/gas, the Authority approves the first directives on market processes relating to the injection of biomethane in transport and distribution grid of natural gas, and establishes the implementation instructions to the allocation of biomethane in cases of withdrawal by the GSE, as an alternative to the direct sale on the market for plants with a production capacity up to 500 Sm3/h. The Resolution establishes that the charge of balancing market will publish a proposal for updating the Grid Code within 90 days of publication of this resolution, or identify temporary specific mode to perform the activities referred to the measure, to be submitted by 30 days of its publication.

UNI/TR 11537:2014

In order to obtain subsidy, the production facilities of biomethane must respect all the technical requirements and comply with the standards of the sector, as defined by the Authority and by the responsible standardization bodies, relating to the standards of quality and odour, especially the technical indications for injection of biomethane in transport and distribution grid established in the technical report UNI/TR

11537:2014 "Entering biomethane in transport and natural gas distribution grid", drawn up by the CIG (Italian Committee for Gas). In accordance with the aforementioned measure adopted by the authority, grid managers must activate the procedures to modify their grid codes, updating them with a number of elements aimed at promoting the introduction of biomethane.

Therefore, the subsidy mechanism of biomethane, when injected in transport and distribution grid of natural gas, requires the update of the grid codes, as well as the definition and publication of biomethane specific quality. Similarly, the application of the subsidy scheme providing for the withdrawal and the sale of biomethane, by GSE, for plants with production capacity up to 500 Sm3/h, requires the full implementation of the legal and regulatory framework.

Other references:

UNI/TS 11567

The article 4, paragraph 5 of the biomethane decree provides that for the purpose of verifying the sustainability of biomethane used as biofuel as well as for the recognition of the bonus for the 100% use of by-products, the decree of the Ministry of the environment, land and sea protection of January 23th 2012 will be applied, in accordance with specific guidelines for biomethane, defined by the Italian Thermo-technical Committee (CTI). The Technical Specification defines the qualification scheme for all organizations, called "economic operators", who work in the production chain of biomethane and its intermediates in a sustainable manner as defined by the European and national legislative framework that guarantees traceability and transparency. The economic operator who applies the qualification scheme described in the technical regulation ensures that:

- The sustainability criteria relating to land are still respected and ensured traceability of the product along the chain of custody;

- The allocation of the savings value of CO_2eq or emission value of CO_2eq of individual batches of sustainability is issued in accordance with the criteria indicated in RED and EU Directives;

- Every single lot is traceable.

It also defines the requirements for the implementation of a traceability system that allow to meet the requested requirements and describes the requirements of the accounting management of the mass balance. The technical specification also provides specific values of sustainability and calculation methods to

be used in the absence of other indications of the legislator and requires that the values and methods, however defined, are to be managed by the organization (economic operator) in order to ensure compliance with the principles defined by the European and national legislative framework, ensuring traceability and transparency.

	Units of measure	***value***
Higher heating value	*MJ/m3*	*34,95 to 45,28*
Wobbe index	*MJ/m3*	*47,31 to 52,33*
Relative density		*0,5548 to 0,8*
water dew point	*°C*	*< - 5°C at 7000 Kpascal*
CO_2	*%*	*< 3*
Hydrogen (H_2)	*%*	*< 0,1*
Carbon monoxide (CO)	*%*	
H2S	*mg/m³*	*< 6,6*
Sulfor from mecaptanes	*mg/m³*	*< 15,5*
Toal sulfor	*mg/m³*	*<150*
CO	*%*	*<0,1 mol*
Si	*%*	*<5 ppm*
Nh3	*mg/m³*	*<3*
H2	*%*	*<0,5*

Hg	*µg/m3*	*<1*
F	*mg/m³*	*<3*
Cl	*mg/m³*	*<1*

Table 10 Standards for the injection of biomethane into the natural gas grid

1.11 European regulatory framework for the injection of biomethane

European producers of biomethane adopt parameters for feeding and for use as fuel which can differ widely between the various Member States (for some parameters and / or the concentration of different compounds from natural variations occur even up to a factor of 100).
For this reason, the European Union, in late 2010, has decided to standardize the quality of biomethane issuing the Mandate M 475 according to which the CEN, through the establishment of the Project Committee, CEN / TC 408 "Biomethane for use in transport and injection into the natural gas grid" will define the characteristics of biomethane to be used for transport and discharge into natural gas networks carrying both H gas to gas L.

In view of the mandate M / 475, the CEN Project Committee PC 408 is activated. : Biomethane for use in transport and injection into the natural gas grid.
The decision of the Bureau Technique C109 / 2012 changes the title and scope of PC 408 that becomes: Natural gas and biomethane for use in transport and biomethane for injection into the natural gas grid. The PC 408 must keep in mind the work of TC 234 (M / 400 on gas quality) and in particular the WG11 / TC 234 competent in matters of natural gas quality.
Some of the biomethane quality parameters of the TC234 / WG11 competence in prEN16726 specifies the quality requirements, parameters, and for the type H gas limits (EN 437: 2003 + A1: 2009). The rule does not apply to gas transported in isolated local networks and gas prior to their entry into the European transmission networks.
The Project Committee PC 408 is structured in four expert groups (EG).

- **EG 1** – Determination of the bio-methane organic content (no document produced to date). very expensive 14C method.

- **EG 2** – standards for natural gas and biomethane to be used as a motor fuel (**prEN16723-2**).
- **EG 3** – Standards for the grid injection of biomethane (prEN 16723-1). In collaboration with labor CEN / TC 234 / WG11 (prEN16726).
- **EG 4** – «Special missions»: data collection on siloxanes, tools for the evaluation of health risks (Annex X of prEN16723-1), quality control, etc.

prEN16723-1:2014: Specific requirements and test methods for biomethane to the entry point of the natural gas network.

prEN16723-2:2014: Specific requirements and test methods for natural gas, biomethane, mixtures of both the point of use as a motor fuel.

The subject of the litigation, due to the lack of approval, was mainly related to the parameters contained in the table below:

	Units of measure	***value***
Silicon	*Mg/m3*	*(a)*
Chlorinated elements (CL)	*Mg/m3*	*<1*
Carbon monoxide (CO)	*%*	*<0,1 (b)*
poliaromatic Hydrocarbon		*(c)*
Amines		*Technically free*
NH3		*Technically free*
HCN		*(c)*

Table 11 Some concerns raised by the public inquiry on prEN 16723-1 and -2

(a) Expected to be between 0.1 and 5.0, but more research is necessary to be able to fix.

(b) According exposure model (Annex X) limit <3.1%

(c) More research needed

Strong opposition / disagreement on specific limits:

- **siloxanes**: Euromot(*) ≤0,1 mg(Si)/m3; France ≤ 1 mg(Si)/m3;
- **CO**: Netherland wants ≤3,1% as described in Annex X; Sweden wants ≤0,5%; Italy and other countries want ≤0,1%.

About the status of the three documents described is necessary to assess whether they will be EN rules or if, given the gaps and purely informative parts, will be EN / TS or EN / TR so not prescriptive documents.

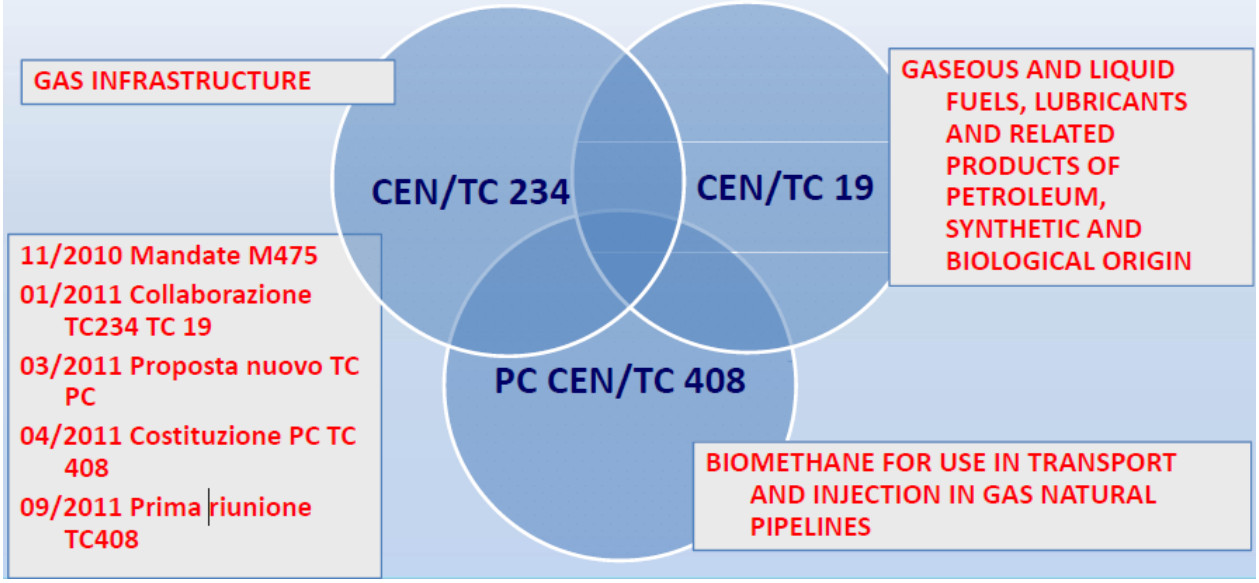

Figure 2 Scheme of M475