Urban waste for biomethane grid injection and transport in urban areas

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Proposal on how to promote biomethane grid injection in Germany, Austria, Croatia, Portugal, and Latvia

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Authors: Michael Beil, Henning Hahn, Wiebke Beyrich, Fraunhofer IWES, Germany
Robert Bošnjak, Nijaz Dizdarević, Daniel Golja, Branka Jelavić, Bruno Židov, Energy Institute Hrvoje Požar, Croatia
Sabine Eggenreich, Ernst Meißner, Daniel Schinnerl, Eva Stadtschreiber, Graz Energy Agency
Flávia Duarte, Marcos Nogueira, IrRADIARE
Ilze Dzene, Ekodoma, Ltd.

Editors: Robert Bošnjak, Energy Institute Hrvoje Požar, Croatia

Contact: Robert Bosnjak
Energy Institute Hrvoje Pozar
Savska cesta 163, pp141
10001 Zagreb, Croatia
tel:++385 1 6326 105
fax: ++385 1 6040 599
rbosnjak@eihp.hr

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Abbreviations

a	year
ARegV	Anreizregulierungsverordnung - Verordnung über die Anreizregulierung der Energieversorgungsnetze (Incentive Regulation Ordinance)
BAFA	Bundesamt für Wirtschaft und Ausfuhrkontrolle
CHP	Combined heat and power (plant)
DVGW	Deutscher Verein des Gas- und Wasserfaches e.V. – Technisch-wissenschaftlicher Verein (German Technical and Scientific Association for Gas and Water)
EEG	Erneuerbare-Energien-Gesetz - „Gesetz für den Vorrang Erneuerbarer Energien“ (Renewable Energy Act)
G 260	Technische Regel Arbeitsblatt G 260 „Gasbeschaffenheit“ (Technical rule - worksheet „Gas quality“)
G 262	Technische Regel Arbeitsblatt G 262 „Nutzung von Gasen aus regenerativen Quellen in der öffentlichen Gasversorgung“ (Technical rule - worksheet „Utilization of gases from renewable sources in public gas supply systems“)
G 685	Technische Regel Arbeitsblatt G 685 „Gasabrechnung“ („Gas billing“)
GasNEV	Gasnetzentgeltverordnung - Verordnung über die Entgelte für den Zugang zu Gasversorgungsnetzen (Gas Network Tariffs Ordinance)
GasNZV	Gasnetzzugangsverordnung - Verordnung über den Zugang zu Gasversorgungsnetzen (Gas Network Access Ordinance)
h	hour
KfW	Kreditanstalt für Wiederaufbau
kWh	Kilowatt hour
kWh_{el}	Kilowatt hour (electricity)
LPG	Liquefied Petroleum Gas
m^3	Cubic meter
m_n^3	Cubic meter (standard conditions)
MW	Megawatt

1 Strategy for biomethane grid injection and use in Germany

Biomethane production in Germany has started again in 2006 when the first three biogas upgrading plants (using energy crops as biogas feedstock) had their start of operation. But also before 2006 a few upgrading projects had been realized. By the end of 2011 83 upgrading plants were in operation and 81 of these plants were feeding biomethane into the natural gas grid. Only two upgrading plants produced biomethane for the direct use as vehicle fuel at the site of production. The injected biomethane is mainly used for the cogeneration of heat and power (CHP) at sites where the complete heat is needed. [3]

In the following subchapters it will be described:

- in which way biomethane is mentioned in national energy strategic documents,
- which regulations are made for biomethane in legal documents,
- which incentives are given by policy,
- which technical standards are applied with regard to biomethane grid injection,
- which future legal and technical amendments can be expected. Furthermore experiences will be commented and recommendations will be given.

1.1 Biomethane grid injection in energy strategic documents and papers

Within the report of the Integrated Energy and Climate Program of the German government (IEKP – “Integriertes Energie- und Klimaprogramm der Bundesregierung”) from December 2007 it was stated that it would be possible to develop a biogas potential by 2020 that corresponds to 6 % and by 2030 a potential that corresponds to 10 % of the German natural gas demand [1]. One result of this political goal for biogas was the revision of the Gas Network Access Ordinance (see following sub-chapter) in 2008 where this target definition was implemented [2]. Within this revision of the ordinance it was defined to set the stage for the injection of a biogas potential of 6 billion m³ yearly by 2020 and 10 billion m³ yearly by 2030 [2].

The intention of the lawmaker was to create a facilitation of biogas injection into the natural gas grid to be able to [1]:

- reduce the dependency on natural gas imports and
- to give incentives for climate-friendly energy production.
- Furthermore decentralized produced biogas should be used primarily in combined heat and power systems (CHP) and in the transport sector as vehicle fuel.

This third bullet point was also mentioned in the version of the Gas Network Access Ordinance from 2008 [2] but won’t be found any more in the following revision of this Ordinance in 2010 [4].

1.2 Biomethane grid injection in legal documents

There are three main documents that regulate the injection of biogas into the natural gas grid:

- Incentive Regulation Ordinance (ARegV: Anreizregulierungsverordnung - Verordnung über die Anreizregulierung der Energieversorgungsnetze)
- Gas Network Tariffs Ordinance (GasNEV: Gasnetzentgeltverordnung - Verordnung über die Entgelte für den Zugang zu Gasversorgungsnetzen).
- Gas Network Access Ordinance (GasNZV: Gasnetzzugangsverordnung - Verordnung über den Zugang zu Gasversorgungsnetzen)

Selected relevant contents of these three documents related to biogas injection are listed below:

Incentive Regulation Ordinance (ARegV) [8]

The Incentive Regulation Ordinance governs the use of determination of prices for the access to power grids. Related to biogas (injection) within this ordinance so called "permanent restricted element of cost fractions" (for grid operators) are defined.

As "permanent restricted element of cost fractions" are stated:

- Costs or revenues from advanced (biogas) balance management less fees for advanced balance management corresponding to § 35 GasNZV.
- Fees for avoided grid costs corresponding to § 20a GasNEV.
- Necessary actions of the grid operator corresponding to § 33 (10), § 34 (2) and § 36 (3) and (4) GasNZV.
- Costs for the efficient grid connection and maintenance corresponding to § 33 (1) GasNZV.

In which way grid operators have to deal with these cost fractions will be described in the GasNEV (see following sub-chapter).

Gas Network Tariffs Ordinance (GasNEV) [9]

The GasNEV lays down the method how to calculate the fees for the connection to gas transmission grids and gas distribution grids (network charges).

Related to biogas three essential points are defined:

- For the injection of biogas into gas transmission grids no connection fees have to be paid.
- Transport customers (the owner of the biogas at the point in time when biogas is injected into the grid) get a fee of 0.7 Cent/kWh for "avoided grid costs" by the grid operator of that grid in which the biogas is injected. It will be paid for 10 years beginning from the start of operation of the grid access. This fee is independent on the grid level (e.g. pressure level).
- Following cost fractions (for grid access) are divided on all grids (and therefore on the natural gas customers that are connected to these grids) inside the specific market area where the grid - in which biogas is injected - is located:
    - Costs for the efficient grid connection as well as for maintenance and operation.

- Potential costs for financially reasonable measures for the increase of grid capacity to be able to ensure biogas grid injection over the whole year. This can include also costs for the reverse feeding/compression of natural gas of grids with lower pressure levels, respectively capacities, to grids with higher pressure levels.
- Costs for advanced (biogas) balance management less fees for advanced balance management that have to be paid by the responsible person for the balance group.
- Costs for gas conditioning, odorization and gas constitution measurement.
- Fees for "avoided grid costs".

Gas Network Access Ordinance (GasNZV) [2][4][5][6]

The GasNZV defines under which conditions gas customers have to get access to gas grids. Gas customers means here also operators of biogas upgrading plants that want to inject biomethane (in German legal documents mostly the term "biogas" or "upgraded raw biogas" is used) into gas grids.

The above mentioned targets of 6 billion m³ biogas per year (related to 2020) and 10 billion m³ biogas per year (related to 2030) for biogas injection have been also implemented in all three revisions of this ordinance from 2008, 2010 and 2012 [2][4][5]. In the past there was also the intention mentioned that the utilization of the injected biomethane should be mainly in combined heat and power plants CHPs and as motor fuel [2]. That meant in consequence that incentives for biogas upgrading should ensure also the efficient use of biomethane. However in the current version of the ordinance this addition is not implemented any more [4][5].

The first version of the GasNZV where comprehensive regulations for biogas were implemented is from 2008 [2]. A next revision that includes relevant changes for biogas injection was made in 2010 [4]. But also before 2008 biogas and biomethane were mentioned in the GasNZV [6].

Selected relevant contents of the GasNZV related to biogas injection are listed below:

- **Preferences for biogas** [4]

A basic intention is to ensure a prior connection of biogas plants to the gas grid. Furthermore grid operators have to ensure that transport contracts are concluded with a priority consideration with transport customers of biogas.

- **Information about the gas grid** [4]

Grid operators have to publish following information on their web page:

- Information about the gas grid that are minimum necessary for the approval of the grid connection request.
- Standardized conditions for the grid connection.
- A constantly updated clear illustration of capacities of their whole grids and declaration of actual and expected bottlenecks.

- **Definition of grid connection**

In the GasNZV it is defined which components belong to the grid connection. Following these components are listed [4][7]:

- Connection pipe between upgrading plant and gas supply grid
- Gas pressure regulation measurement equipment
- Feature for pressure increase
- Calibratable measurement equipment for biogas

That means that only for the above mentioned 4 components a cost division is applied (see next topic “Investment costs of grid connection stations”).

Other components such as:

- Equipment for the addition of odorants
- Gas conditioning equipment (e.g. for the addition of LPG)
- Gas constitution measurement

are not included. For these components the grid operator is responsible by 100 %.

- **Investment costs of grid connection stations:**

Before the revision of the GasNZV in 2008 it was stated that the costs for grid injection had to be financed by the person who is responsible for these costs [6], so the operator of the upgrading plant. Within the revision in 2008 a cost division was defined. 50 % of the investment costs had to be paid by the taker of the connection (normally the operator of the upgrading plant) and 50 % by the gas grid operator [2]. This cost division includes also costs for the biomethane connecting pipe to the gas grid up to a maximum of 10 km [2]. If this connecting pipe was longer than 10 km, these additional costs had to be paid alone by the operator of the upgrading plant [2].

In 2010 a significant change took place. It was stated that 25 % of the investment costs have to be paid by the operator of the upgrading plant and 75 % by the grid operator. This regulation covers also the costs for the first 10 km of the connecting pipe to the natural gas grid. The maximum amount that the upgrading plant operator has to pay, if the connecting pipe is maximum 1 km, is 250,000 €. If the connecting pipe is longer than 10 km then the taker of the connection has to pay the additional costs > 10 km by 100 % [4][7].

The gas grid operator is the owner of the grid connection station [4].

The allocation of costs to be paid by the grid operator is described in the GasNEV (see sub-chapter above). Cost fractions paid by the operator of the upgrading plant are no part of this allocation process.

- **Operation and operational costs for grid connection stations**

The grid operator is responsible for maintenance and operation of the grid connection station and has to cover the costs for these tasks. [4]

The allocation of these costs is described in the GasNEV (see sub-chapter above).

- **Availability of grid connection**

The grid operator has to ensure a permanent availability of the grid connection station but at least 96 % [4]. This corresponds to 8,410 h/a.

The declaration of this percentage is based on technical examinations [7]. The difference between 8,410 h/a and 8,760 h/a (350 h/a) is foreseen for:

- Maintenance work [7]

- Foreseeable repairs [7]
- Unplanned interruptions [7]

- **Quality requirements for biogas injection**

The person who is injecting the gas has to ensure that the biogas quality corresponds to the requirements of the technical standards G 260 and G 262 in its versions with status 2007(see chapter below). [4]

Within the ordinance “person who is injecting the gas” or “feeder” means not the operator of the injection plant (what would be the gas grid operator)! In most cases this will be the operator of the upgrading plant or in common the person who is the owner of the gas at that point in time when the gas enters the grid injection station.

Furthermore it’s stated that the grid operator is responsible for the calibration regulations at the exit point (gas discharge) corresponding to G 685 “Gas billing” (also status 2007).

It is important to note that the ordinance - also in the current version - refers to older versions of technical standards (status 2007). The above mentioned technical standards are dealing with “Gas quality” (G 260), “Utilization of gases from renewable sources in public gas supply systems” (G 262) and “Gas billing” (G 685). The reason for this is that the legislative body wanted to avoid that a commitment to use the respective current revision of technical standards could inhibit new biogas injection projects [12] e.g. by limit values that are very difficult to achieve.

- **Sustainability requirements**

Sustainability requirements with regard to methane emissions are also mentioned in the GasNZV. In that context it has to be distinguished between methane losses e.g. within the biogas upgrading process and methane emissions to the atmosphere. If there is no post treatment of off-gas-streams available then methane loss and methane emissions are the same.

Following these terms (related to the biogas upgrading process) will be defined:

- ***Methane loss*** *as the ratio of the methane load, that doesn’t attain the product gas flow to the methane load (included in the raw biogas) at the inlet of the biogas upgrading plant. [9]*
- ***Methane emissions to the atmosphere*** *as the ratio of the methane load, that is emitted unoxidized to the atmosphere to the methane load (included in the raw biogas) at the inlet of the biogas upgrading plant. [9]*

Within the ordinance a limit value for maximum methane emissions referring exclusively to the upgrading process, not to the biogas production process and also not to potential diffuse emissions of the injection plant, is stated. Following the historical development of these limit values within the revision process of the GasNZV is listed:

- Beginning from 2012-05-01: 0.2 % [4] [5]
- 2010-09-09 - 2012-04-30: 0.5 % [4] [5]
- 2008-10-23 - 2010-09-08: 1.0 % [2] [4]

The “person who is injecting the gas” has to provide the grid operator the confirmation of the required limit value at the point in time when the start of operation of the grid connection takes place. It is not defined that this confirmation has to be occurred periodic. [4][11]

- **Advanced balance management [4]**

The responsible person of a market area has to provide an advanced balance management for biogas.

A special biogas balancing zone contract includes a balance management of 12 months and a flexibility range of 25 %.

The flexibility range refers to the cumulated deviation between the biomethane injection into and discharge out of the grid within the 12 month period.

The responsible person for the balancing group of a special biogas balancing group contract has to pay a fee of 0.1 Cent/kWh to the responsible person of the market area. The fee has only to be paid for the in fact claimed flexibility range.

1.3 Incentive systems for biomethane

The German incentive system for biomethane is partly based on the defined targets in the IEKP (see above). There was stated that decentralized produced biogas should be used primarily in combined heat and power systems (CHP) and in the transport sector as vehicle fuel. Therefore the aim is to give primarily incentives for climate-friendly (final) energy production.

Reduction of barriers for biogas grid injection:

Basically especially the regulations given by the above described ordinances ARegV, GasNEV and GasNZV can be seen as incentives for biomethane production by the reduction of barriers.

Market incentive programme [24]

The market incentive programme by the Federal Ministry for the Environment, Nature Conservation and Nuclear Safety contains two segments:

- *"investment grants for renewable heating installations up to 100 kW thermal (competency BAFA)*
- *long-term low-interest loans (soft loans), including a redemption grant, for installations larger than 100 kW or infrastructure measures (competency KfW)*

Innovation support can be granted for installations that upgrade biogas to natural gas quality and feed the upgraded gas into a gas grid, if proof is furnished that:

- *the methane emissions to the atmosphere from upgrading are at most 0.2%,*
- *upgrading and feed-in requires a maximum electricity consumption of 0.5 kilowatt-hours per standard cubic metre untreated gas, and*
- *the supply of process heat from renewable sources or pit gas or from the exhaust heat of the gas upgrading or feed-in system does not involve the consumption of additional fossil energy.*

For installations up to an installation size of 350 m³/h upgraded biogas (biomethane, biogas of natural gas quality), the repayment grant amounts to up to 30% of the net investment costs eligible for support.

The support cannot be cumulated with other types of support from public funds. The provision of support is limited up to 31 December 2012. Continuation will be decided on the basis of the scientific evaluation."

Following incentive systems with regard to the utilization path of biomethane will be described.

Electricity [22]

The most relevant law in the German renewable energy sector is the Renewable Energy Act „Gesetz für den Vorrang Erneuerbarer Energien“ (Erneuerbare-Energien-Gesetz - EEG). This act refers to the electricity production of several renewable energy sources and therefore also for biogas (direct utilization in CHP at the site of production) and biomethane (in biomethane CHP at sites with sufficient heat demand).

The basic intention of the EEG is to increase the share of renewable energy of the electricity supply till 2020 up to 30 %. Therefor the EEG guarantees a payment for the injection of power from renewable sources for a duration of 20 years plus the year of start of operation.

Because of the complexity of this act, this chapter will be focused only on the current version of the EEG and features with regard to biomethane:

The basic requirement is that the amount of biomethane that is removed from the gas grid has to be equal to the amount of biomethane that has been injected into the gas grid (somewhere else in Germany) over the period of one year. For the balancing process a so called mass balancing system has to be applied.

The fee is not paid for the amount of biomethane that has been injected into the gas grid but for the amount of electricity produced by the biomethane CHP. But there is the requirement that – compared to biogas CHPs – biomethane CHPs have to be operated in all cases heat-led.

In the current version of the EEG for electricity from biomethane an extra premium, the so called “gas upgrading bonus”, will be paid. The level of this premium depends thereby on the capacity (m^3/h related to biomethane) of the upgrading plant and applies to landfill gas, sewage gas and biogas (agricultural feedstock or bio waste) and a maximum capacity of the CHP of 5 MW:

- ≤ 700 m_n^3/h: 3 Cent/kWh_{el}
- ≤ 1000 m_n^3/h: 2 Cent/kWh_{el}
- ≤ 1400 m_n^3/h: 1 Cent/kWh_{el}

Furthermore following requirements have to be ensured:

- Methane emissions to the atmosphere within the upgrading process of maximum 0.2 %.
- Electricity demand for the upgrading process of maximum 0.5 kWh_{el}/m_n^3 raw biogas.
- Provision of process heat for biogas production and upgrading only from renewable sources, mine gas or by process heat of the upgrading or injection plant without utilization of further fossil energy.
- The gas has to be upgraded and injected into a natural gas grid.

Vehicle fuel

Due to German Energy Tax Act [25] biomethane is tax-exempt by 2015. Alternatively for biomethane there exists also the eligibility on the biofuel quota [27]. If the quota is claimed, tax exemption is not possible. If particular feedstock are used for biogas production there is also the possibility to claim the quota twice (so called double counting) [28]. Certainly there is the premise that the sustainability criteria requested by the Biofuel Sustainability Ordinance [26] will be fulfilled (for tax exemption as well as for quota eligibility).

Heat

Currently there exists no real incentive system for the use of biomethane in the heat sector (except the demand of the EEG to use the heat produced in biomethane CHPs).

But the Renewable Energy Heat Act mentions also biomethane. The law has the intention to increase the share of renewable energy in the heat and cooling sector till 2020 up to 14 %. One requirement of this law is that new constructed buildings have to be supplied by a share of heat from renewable sources. This can be also fulfilled by biomethane. The premise is that this heat is produced in a CHP. For basically renovated public buildings there is the exception that for heat provision, if this will be done by biomethane, also a gas boiler that has to be in accordance with the best available technology can be applied. [23]

Conclusion

- The costs for incentives provided by the GasNZV and GasNEV are financed by the consumers of natural gas.
- The incentives given by the EEG gratification for electricity from biomethane are financed by the consumers of electricity.
- Incentives for the use as vehicle fuel result from the obligation to reach the biofuel quota and are therefore directly financed by the mineral oil industry respectively by refunding of tax.

Finally it has to be stated that the German incentive system is wide spread and revised continuously.

1.4 Biomethane grid injection in technical standards

There are several technical rules and notes as working sheets and technical instructions available that have to be considered when biogas is upgraded and injected into the grid.

Following the most relevant ones, prepared by the German Technical and Scientific Association for Gas and Water (DVGW), will be mentioned.

- **G 260 "Gas quality"** [13][14]:
  - Relevant for the person who is upgrading the biogas. Gas quality requirements have to be fulfilled at the inlet of the injection plant.
  - Relevant status, according to GasNZV, is version from 01/2000 (most current version in 2007).
  - Currently newer version available but by now not to be applied for biogas injection.
  - Following table shows an excerpt of relevant parameters.
- **G 262 "Utilization of gases from renewable sources in public gas supply systems"** [15][16]
  - Relevant for the person who is upgrading the biogas. Gas quality requirements have to be fulfilled at the inlet of the injection plant.
  - Relevant status, according to GasNZV, is version from 11/2004 (most current version in 2007).
  - Currently newer version available but by now not to be applied for biogas injection. This version contains significant more parameters.
  - Following table shows the only two parameters mentioned in G 262.

Table 1: Limit values for biomethane injection into the public gas grid in Germany (Excerpt of G 260 and G 262, status: 2007) [13][15]

Parameter	Unit	L-Gas	H-Gas	Comments	Source	Status
Wobbe Index	MJ/m³	37.8 - 46.8	46.1 - 56.5		G 260	01/2000
Upper heating value	MJ/m³	30.2 - 47.2			G 260	01/2000
Hydrocarbons (condensation point)	°C	Soil temperature		Related to grid pressure of connected grid	G 260	01/2000
Water dew point	°C	Soil temperature		Related to grid pressure of connected grid	G 260	01/2000
O_2-concentration	Vol.-%	≤ 3		Dry distribution areas	G 260	01/2000
O_2-concentration	Vol.-%	≤ 0.5		Humid distribution areas	G 260	01/2000
H_2S-concentration	mg/m³	≤ 5			G 260	01/2000
Total sulphur	mg/m³	≤ 30		Yearly average, without odorant	G 260	01/2000
CO_2-concentration	Vol.-%	≤ 6			G 262	11/2004
H_2-concentration	Vol.-%	≤ 5			G 262	11/2004

- **VP 265-1 „Plants for upgrading and injection of biogas into natural gas grids – Part 1: Gases from anaerobic digestion processes; planning, assembly, installation, testing and commissioning"** [18]

  - Describes safety-related minimum requirements for compression, pressure control, gas conditioning and measurement for upgrading and injection equipment.
  - It is related to planning, assembly, installation, testing and commissioning.
  - Therefore for planners, constructors and operators of upgrading and injection plants relevant.

- **G 265-2 (M) „Plants for upgrading and injection of biogas into natural gas grids – Part 2: Gases from anaerobic digestion processes – Operation and maintenance"** [19]
  - Relevant for operation and maintenance of equipment that has been constructed according to VP 265-1.
  - Therefore as well for operators of upgrading plants as well for operators of injection plants to be applied.
- **G 280-1 „Gas odorization"** [21]
  - In most cases, if injecting in distribution grids, an odorization is demanded.
  - Relevant for the operator of the injection plant.
- **G 685 "Gas billing"** [20]
  - Relevant for the operator of the injection plant.
  - Basis for the mostly applied gas conditioning to ensure requirements of gas billing for consumers.
  - Relevant status, according to GasNZV, is version before [20] (most current version in 2007).
- **G 290 (M) „Reverse feeding of injected biogas respectively natural gas towards upstream transmission pipelines"** [17]
  - Relevant for the grid operator, if the necessity of reverse feeding occurs.

1.5 Expected future legal and technical amendments, comments and recommendations

For a successful implementation of relevant amounts of biomethane in an energy supply system, there is the necessity to reduce hurdles and to give incentives that ensure a competitiveness of biomethane compared to conventional energy carriers.

As consequence this means that there has to be a willingness to reduce potential hurdles and to finance these incentives. If talking only about a few projects it's less relevant (regarding questions of acceptance) which incentive instruments will be chosen because the specific costs for the public body, group or persons who have to pay for it are manageable or better said are not noticed so much. In the year 2012 in Germany around 5 Tw of biomethane had been injected into the natural gas grid what's still far away from the defined injection targets of the German Government. It seems that the major part of this gas amount is utilized in biomethane CHPs that claim the EEG-fee for the produced electricity. According to the German system the additional costs caused by the EEG-fee are divided less or more on all electricity consumers. Because this EEG-allocation is expected to be in 2013 > 5 Cent/kWh$_{el}$ [30] for end consumers of electricity, it's not only noticed but discussed very intensively [29]. Of course currently electricity from biomethane has only a small share on these additional costs for consumers but it's also part of this discussion. This is only one example of discussions around the incentive system for biomethane in Germany but at the moment in January 2013 the most essential topic.

Therefore it is essential to point out the pros and cons of biomethane and to involve all key persons in this discussion:

- Policy:

  Policy's main task with regard to renewable energy policy is to provide a legislative framework that considers national economics as well as local (e.g. waste management) and global (e.g. the reduction of greenhouse gases) environmental aspects and finally also social matters. And of course it's policy's job to market their ideas and their actions continuously.

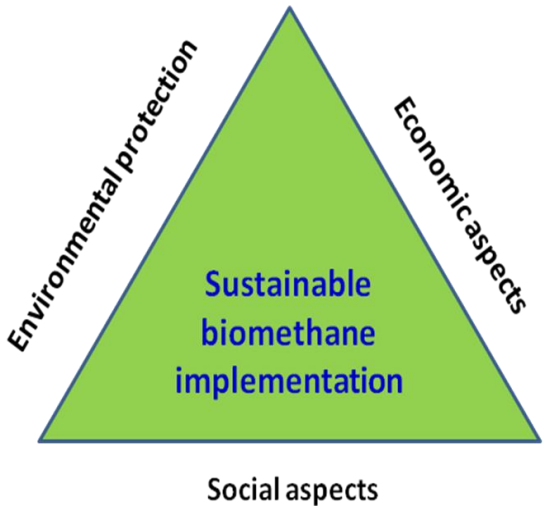


Figure 1: Triangle of sustainable biomethane implementation [IWES, 2013].

Problems occur in that point in time when the proportion between these mentioned three fields of interest gets out of balance. Therefore the reasons why decided incentives are given such as:

- Decreased CO_2 emissions compared to fossil energy carriers (global environmental protection)
- Influence on securing environmentally friendly energy provision and final energy production (local environmental protection)

- Reduction of dependency on energy imports
- Creating and increasing of national energy reserves
- Increasing of local and national value chains by support of economy and creating of new jobs

But also what they cause,

- Currently increasing energy prices (related to the current situation in Germany)
- Potentially replacement of jobs in fossil energy sectors

have to be explained to citizens, industry, utilities and entrepreneurs continuously. Furthermore instruments have to be established to monitor and evaluate processes to be able to adapt legislative framework conditions as long as they are necessary to implement biomethane in the market. Examples for this are the German Clearing House for the EEG or the Federal Network Agency. Furthermore also research projects are an important element to monitor and evaluate developments and impacts in practice.

- Gas grid operators and utilities:

The statement of an employee of one of the biggest German utilities hits the core of the problem “Some years ago my job was it to find reasons why biogas upgrading and injection does not (or should not) work. Today my job is it to find alternatives how it can work (better).” It has to be pointed out to gas grid operators and utilities of the natural gas and electricity sector which chances can be offered by biomethane. It seems that the German natural gas sector has recognized and accepted that biomethane can become positive influence on the natural gas market and infrastructure in Germany, because:

- Natural gas becomes “greener” by biomethane
- Investments in natural gas infrastructure increase
- The conversion of the natural gas and the electricity sector will become an increased relevance in the future. The trend in Germany is that biomethane shall be used primarily for electricity production in a future energy supply system with increasing shares of fluctuating producers.
- Biomethane increases the national gas reserves

But biomethane products are more complicated to explain to customers and, if natural gas distribution doesn’t increase, of course biomethane substitutes natural gas.

- Consumers

Currently it shows more and more which influences the conversion of the energy sector becomes for citizens and the industry. Therefore it’s necessary to explain the above mentioned pros and cons to the people. May be in central and western Europe it’s today a normal situation that energy is available anytime. But it needs only to look back a few decades or a few hundred kilometres away to realize that it has not to be the matter of course. Nearly all European countries are dependent on energy imports from partly political unstable regions. Biomethane is only a small building block in a future energy system but especially because of its flexibility biomethane has the potential to become an essential one and can therefore also contribute to reduce these dependencies.

This is of course a very global point of view but it’s sometimes necessary to envision this. If using the local point of view, it can be stated that biomethane, as well as most

other renewable energy carriers that are produced decentralized, can boost the regional value chain. The best way to convince somebody is to let people or also industry partake in the value chain of projects (e.g. within registered cooperative societies).

Finally it's the triangle of sustainability that all involved decision makers and acceptors have to respect.

What is discussed currently and has been discussed in the past in Germany?

- Divisibility by balancing of produced biomethane fractions:

  Besides increasing costs for electricity, this is the most important point that's currently discussed in the German biomethane sector. At the moment it's possible to produce biogas from different feedstock (e.g. energy crops and bio waste) in one biogas plant but it's not possible to divide these produced biogas streams again to sell e.g. the fraction produced by bio waste to the transport sector and e.g. the fraction produced by energy crops to the utilization path EEG-CHP.

- Competition between natural gas and biomethane CHPs:

  In Germany there are two acts that give incentives for CHPs. Natural gas combined heat and power is supported by the Combined Heat and Power Act [31] and biomethane combined heat and power by the EEG [22]. It's currently discussed that competition between natural gas and biomethane CHPs occur and therefore it could become more difficult to implement new biomethane CHPs.

- Open the heat sector for biomethane:

  In the past there had been strong requests to change the Renewable Heat Act [23] and to allow the fulfilment of requirements for renewable heat provision for buildings not only by biomethane CHPs but also by efficient gas boilers (e.g. condensing technology) driven by biomethane. One adaption of this act was that for basically renovated public buildings for heat provision, if this will be done by biomethane, also a gas boiler that has to be in accordance with the best available technology can be applied [23].

- Biogas Injection Act:

  In the past the implementation of a Biogas Injection Act instead of the incentive mechanism for biomethane provided by the EEG had been requested by parts of the German biogas scene. The main intention was that it should become easier to implement new biomethane projects. The background is that the bottleneck for new projects is mostly the challenge of managing the distribution of biomethane what means especially the development of new biomethane CHP sites.

- Consequences of switch of natural gas quality in grids:

  In Germany there are two main natural gas qualities available (L- and H-Gas). It has to be expected that in future some L-gas grids will be replaced by H-gas quality. This could become to problems at some biogas injection sites because plants are partly adapted on the requirements of the specific grid injection point. Within a revision of the GasNZV in 2010 [4] it has been clarified, that the grid operator has to cover potential occurring costs, that can be caused by an adaption of the upgrading plant.

- Related status of technical standards:

  The GasNZV refers to older versions (status 2007) of technical standards "Gas quality" (G 260), "Utilization of gases from renewable sources in public gas supply systems" (G 262) and "Gas billing" (G 685). The German Technical and Scientific

Association for Gas and Water (DVGW) update these standards and adapt them to the current state of the art. It's partly criticized that the ordinance requires the application of these old standards. This topic is evaluated currently. Within the GasNZV the Federal Network Agency has the possibility to change this topic without a basic revision of the ordinance.

- Consequences of reverse feeding:

  Mainly two technical requirements, the stricter limit-value for oxygen and the demand on the elimination of odorants, within the potential necessity of reverse feeding of gas streams from distribution grids to transmission grids are discussed. In practice there can be currently observed that grid operators try to avoid reverse feeding by the application of alternatives such as connecting the injection plant with two natural gas pipes.

Expected future amendments

A main task is to reduce specific costs for biomethane injection. In the last years a significant increase of specific investment costs of injection plants could be observed. This trend has to be returned. Nevertheless the main fractions of specific injection costs are costs for dosing of LPG and electricity for compression of biomethane to the pressure level of the natural gas grid. Solutions to decrease or omit LPG addition are available and partly in large scale projects applied (e.g. addition of unconditioned gas in grids with high volume flows or the installation of calorific value areas); other systems like heating value reconstruction are in a pilot phase. But also electricity costs for compression have to be reduced. It has to be evaluated and specified which injection points are the most energy and economic efficient ones and in which number these sites are available. For the future one option is that primarily these optimized injection concepts should be supported by incentives or regulations e.g. given by the GasNZV.

Finally it can be stated that the German incentive system for biomethane has been a definite success story by now. Barriers for grid injection have been removed especially by the Gas Network Access and Tariffs Ordinances. A sustainable biomethane provision could be amongst others ensured by limit-values for maximum methane emissions to the atmosphere of 0.2 % what caused the implementation of exhaust gas treatment modules at many upgrading plants. But meanwhile it shows also that acceptance for renewable energy carriers is a function of increasing costs.

Therefore it can be expected that upcoming revisions of the legislative framework will deal primarily with measures to reduce specific costs for biomethane provision, respectively final energy provision of biomethane.

2 Strategy for biomethane grid injection and use in Austria

There was a considerably increase in the number of biogas plants from 2002 to 2005 in Austria. Attractive tariffs for feeding green electricity into the grid (10,5 to 16,65 €Cent/kWh) and low costs for energy crops (2004: 16 to 25 €/t for maize) motivated quite a lot of farmers to install biogas plants with a CHP. After 2005 the number of biogas plants remained nearly stable. One reason was definitely the increasing price-level for substrates (2012: 25 to 40 €/t maize) but also stronger legal requirements, barriers from neighborhood etc. were reasons for this development. In the year 2011, 363 biogas plants with a total capacity of 105,41 MW were registered. Figure 2 shows the development of biogas plants in Austria.

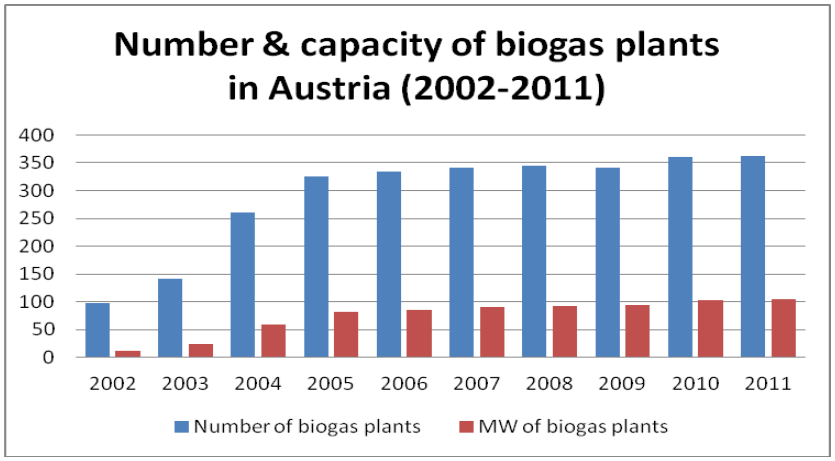


Figure 2: Number and capacity of biogas plants in Austria (2002-2011) (Source: E-Control, 2012, p. 82)

About 15% of the total capacity is from plants with biomethane grid injection. At the rest of the plants the biogas is used in most cases in local CHP-plants (in 2010 about 540 GWh of green electricity was fed into the grid).

The biomethane upgrading in Austria started in 2005 with a plant in Pucking in upper Austria. In 2006 a very important and innovative research project from the Styrian Gas Wärme GmbH about fermentation tests, laboratory experiments and the analysis of different upgrading technologies for grid injection was completed. This was the basis for the biogas and biomethane upgrading plant in Leoben.

By the end of 2011 7 active upgrading plants were in use (Asten/Linz, Bruck an der Leitha, Engerwitzdorf, Pucking, Schwaighofen bei Eugendorf, Steindorf and Wiener Neustadt). The plant in Leoben was out of operation at the end of 2011 and in 2012 but it started the operation at beginning of 2013 again. Furthermore there are 3 biogas upgrading plants existing, that don't feed in the public gas grid, but supply public filling stations (St. Margarethen am Moos, Rechnitz and Güssing). There is a plant expansion going on at the plant in Margarethen am Moos and this plant is also going to feed into the gas grid in the future. The construction of a micro biogas/biomethane grid in Güssing is in planning status right now. Biomethane from the local biogas plant should then be fed in that micro grid.

Table 2 and Table 3 give an overview over the biogas upgrading plants in Austria.

Location	Year of installation	Technology	Operator	Capacity	Note
Pucking	2005	PSA	OÖ Gas-Wärme GmbH	6 Nm3/h	1st biomethane upgrading plant in Austria
Bruck an der Leitha	2007	Membrane technology	Energiepark Bruck/Leitha	100 Nm3/h	
Schwaighofen bei Eugendorf	2008	PSA	GRASKRAFT REITBACH/Salzburg AG	40 Nm3/h	
Asten/Linz	2010	Water scrubber	Linz AG	342 Nm3/h	Fuel for the own car fleet and 2/3 of the busses of Linz
Engerwitzdorf	2010	Amine scrubber	Naturgas Engerwitzdorf GmbH/OÖ Ferngas AG	125 Nm3/h	
Leoben	2010	Amine scrubber	LE Gas/Steierische Gas-Wärme GmbH	160 Nm3/h	
Steindorf	2011	PSA	Salzburg AG	150 Nm3/h	
Wiener Neustadt	2011	Membrane technology	EVN	120 Nm3/h	

Table 2: Overview of the biogas upgrading plants in Austria feeding into the gas grid (Source: ARGE Kompost und Biogas, 2013)

Location	Technology	Operator	Note
Margarethen am Moos	Membrane technology	EVM	CHP + filling station; at the moment plant expansion with feed-in
Rechnitz	PSA	Entsorgung Stipitz	CHP + filling station
Güssing		Biogas Strem	CHP + filling station; micro grid planned
Utzenaich		Bioraffinerie Forschungs- u. Entwicklungs GmbH	Research and demonstration plant

Table 3: Overview of the biogas upgrading plants in Austria without feeding-in the public gas grid (Source: ARGE Kompost und Biogas, 2013)

The production capacity of the upgrading plants feeding into the natural gas grid is about 1.050 Nm^3/h which is approximately results in 9m Nm^3/a (methane content > 98%).

The injected biomethane is used for transport (public transport in cities like in Linz; company cars and vans; private cars), for feeding CHP-plants and for heating (mainly in private households as there is an “Ökobonus” when green gas is used).

2.1 Biomethane grid injection in energy strategic documents and papers

There are no separate strategic documents regarding the biomethane grid injection in Austria up to now. The following aspects draw a picture of the current situation in Austria:

- In the Energy Strategy 2007 (Energie Strategie Österreich, 2010), biomethane is an important issue:
  - The energy strategy explicitly points out biogas / biomethane due to its "substantial potential" regarding the future energy supply. Grid-injection is mentioned as one means to fulfill this potential.
  - Additionally, biomethane is mentioned regarding its usage for fuelling cars. By doing so, the European goal of 10 % renewable energies in the transport sector by 2020 shall be achieved. The proclaimed aim is to have 200.000 gas-powered cars by 2020.
  - The Austrian government strives to establish a stable market for biogas by using various instruments. It is also mentioned that a biogas- and biomethane strategy will be developed by 2011. So far, this official strategy has not been published.
  - The work group also discussed an expansion of the biogas production in Austria to 10% of the whole natural gas demand which would result in 800 Mio. Nm^3. This topic is also included in the list of measures of the Energie Strategie Österreich 2010.
- The Austrian government has recently published a bill regarding a new energy efficiency law, which does – so far – not contain any aspects regarding the biomethane grid injection (status June 2013).

2.2 Biomethane grid injection in energy and renewables laws

The basic principles regarding the injection of biogas into the Austrian gas grid are defined in the Austrian Natural Gas Act (Gaswirtschaftsgesetz GWG 2011), which is thus the most important law regarding this issue.

Following **extracts from the 107th federal law** (Gaswirtschaftsgesetz GWG 2011) help to understand the current situation in Austria:

§ 4.5 *The defined aim of this federal law is to establish a basis for the increasing usage of the potential of biogenic gases for the Austrian gas supply.*

§ 7. (1) Terms and definitions:

9*. Feeder (i.e. person injecting the gas): A natural or legal person or a registered business partnership passing on natural or biogenic gas at the feed-in point for further transport.*

12. *Remover (i.e. person who takes over the gas): A natural or legal person or a registered business partnership who/which takes over the natural gas at the exit point.*

4. *Balancing group: A compilation of grid users in a virtual group among whom a balance between feed-in and usage of the gas takes place.*

§ 28. The requirements for the grid access to the gas grid have to include …

3. *… those quality requirements, which are valid for the feeding-in and the transport of natural gas and biogenic gases;*

4. *… the possible entry points for natural gas and biogenic gases;*

9. *… within a period of 14 days maximum the operator of the distribution grid has to respond to the request of a feeder concerning a potential grid access.*

Refusal of access to the grid:

§ 33. (1) *The access to the grid can be denied due to the following reasons:*

2. *Insufficient grid capacity or insufficient grid network*

Duties of the operator of the distribution grid:

§ 58.10. *The operators are obliged to connect the producers of biogenic gases, which correspond to the quality criteria determined in the general grid conditions, to the gas grid*

Grid user fee in the distribution grid:

§ 73. (6) *The grid user fee for the feed-in into the distribution grid from the production/generation of biogenic gases relates to the capacity per entry point and has to be paid by the producer/generator of biogenic gases as agreed by contract*

Access authorization to the grid:

§ 122. *(2) … producers of biogenic gases (biogas or wood gas) can demand, on behalf of the customers, access to the grid provided that the interoperability of the grids is not affected.*

Labeling:

§ 130. *(1) suppliers which provide Austrian consumers with natural gas and/or biogas, landfill gas or with gas from purification plants, are obliged … to clearly indicate the supplier mix for the consumer.*

Further aspects on biomethane in Austria:

Distributors are obliged to come up with „General conditions regarding the distribution grid“. These have to be approved by the so-called e-control commission. In these general conditions, the decisive quality requirements for the feed-in and the transport of biogenic gases and possible feed-in points are to be determined.

If the determined quality requirements are met, the distributor has to grant a connection and access to the grid. By doing so, the biogas producer is entitled to grid access and at the same time it is ensured that the quality requirements for the feed-in of the biogas are met.

In chapter 6 of the other specific market rules, a reference is made to the quality criteria defined in the ÖVGW-guidelines G 31 (ÖVWG-guideline G31, 2011). If the quality specifications according to the other specific market rules chapter 6 or the necessary delivery pressure are not met, the operator of the distribution grid has the right to refuse the take-over of the natural gas.

The other specific market rules also refer to relevant regulations specified in other ÖVGW-guidelines. Therefore, also regulations of the ÖVWG-guideline G B220 are to be met.

The operators of the distribution grid invoice the plant operator those expenses, which occur during the first-time connection of the biogas plant with the distribution grid. The invoice corresponds to the grid access fee.

These costs are carried fully by the one feeding in the biogas. Financing this “grid extension“ through user fees, as it is the case for the expansion of the Austrian gas grid, is currently not planned. Additionally, there are currently no regulations regarding the tariffs of the biogas to be transported or regarding the compensation of biogas which is to be fed-in. Therefore, the general system user fees apply.

ÖVWG-guideline G31:

The guideline defines the quality requirements for the injection into the grid and the requirements regarding the transport of natural and biogenic gases in the grid.

Within the ÖVWG-guideline G31, the quality requirements for gas are defined. Those requirements shall ensure a safe transport of the gas within the Austrian gas grid.

It is crucial that the quality requirements within the guideline G31 solely relate to entry points and not to the quality of the gas when it reaches the end consumer. That means that the gas to be injected into the grid needs to fulfill all quality requirements at the point of feed-in, even if only very small amounts of gas are to be fed-in.

Tabelle: Qualitätskriterien der ÖVGW Richtlinie G 31 [ÖVGW 2001]

Brenntechnische Daten		
1.	Wobbe-Index	13,3 – 15,7 kWh/m³
2.	Brennwert	10,7 – 12,8 kWh/m³ **<- Calorific value**
3.	Relative Dichte	0,55 – 0,65
Gasbegleitstoffe		
4.	Kohlenwasserstoffe: Kondensationspunkt	maximal 0° beim Betriebsdruck
5.	Wasser: Kondensationspunkt	maximal -8° bei einem Druck von 40 bar
6.	Sauerstoff (O2)	< 0,5 Vol. %
8.	Kohlendioxid (CO2)	< 2 Vol. %
9.	Stickstoff (N2)	< 5 Vol. %
10.	Wasserstoff (H2)	< 4 Vol. %
11.	Gesamtschwefel	10 mg S/m³ (auf Dauer) 30 mg S/m³ (im Schnitt)
12.	Mercaptanschwefel	< 6 mg S/m³
13.	Schwefelwasserstoff (H2S)	< 5 mg/m³
14.	Kohlenstoffoxidsulfid (COS)	< 5 mg/m³
15.	Halogenverbindungen>	0 mg/m³
16.	Ammoniak (NH3)	technisch frei
17.	Fest-und Flüssigbestandteile	technisch frei
Andere Bestandteile, welche die Betriebssicherheit und den Bestand des Netzes gefährden, dürfen nicht enthalten sein		

Table 4: Quality criteria according to ÖVWG-guideline G31 (source: Biogas-Netzeinspeisung online)

ÖVWG-guideline G B220:

This ÖVGW guideline is applicable for the injection of biogas from renewable processes as biomethane in the gas grids of the operators.

Guideline G B220 describes the minimum requirements and quality controls for the injection and distribution of renewable gases in the natural gas grids of the operators. Through the injection of renewable gases the safety of the downstream natural gas pipeline facilities must not be impaired. The operational requirements of the distribution grid operator must be met, and the proper functioning of the distribution grid must be guaranteed. In contrast to Guideline G 33, this revised version provides a new regulation for the use of sewage mud.

Tax regulation for gas:

According to the Austrian Erdgasabgabegesetz (Erdgasabgabegesetz, online 2013) there is a tax of 6,6 €Cent/m³ on each m³ gas delivered to a customer. If the biomethane is fed into the natural gas grid it is handled like natural gas and the tax of 6,6 Cent/m³ has to be paid. If the biomethane is used on site of the biogas/biomethane plant for refuelling cars (without feeding into the natural gas grid), there is no tax on this gas.

If the gas (natural gas or biomethane) is used in a CHP-plant there is a chance to get the Erdgasabgabe for the part of the gas, needed to produce electricity, back (Erdgasabgabenrückvergütung) because there is also a tax on the produced electricity. If the heat produced in the CHP-plant is used, for the part of the gas used for producing this heat the Erdgasabgabe has to be calculated.

2.3 Biomethane grid injection basic tariff elements

Currently, there are no tariff models for the biomethane grid injection in Austria.

However, there are attractive tariffs for the electricity grid injection originating from CHPs driven by renewable energies (Ökostrom-Einspeisetarifverordnung 2012). Heat use is obligatory and there is also a bonus system for particularly efficient CHPs.

Ökostrom-Einspeisetarifverordnung 2012 in detail:

§ 10 (1): Feed-in tariff for Ökostrom generated from biogas out of agriculturally substrates – direct convert into electricity - for plants build in 2013:

- Generation out of agriculturally substrates
  - Up to 250 kW: 19,50 €Cent/kWh
  - above 250 up to 500 kW: 16,93 €Cent/kWh
  - above 500 up to 750 kW: 13,34 €Cent/kWh
  - above 750 kW: 12,93 €Cent/kWh
- (2) Minimum 30% animal manure
- (3) 20% reduction on above mentioned tariffs when using non-agriculturally substrates
- (4) Additional bonus of 2 €Cent/kWh for CHP-plants operated exclusively with biogas and reaching special efficiency criteria (CHP-Bonus) – only for plants commissioned till end of 2013

§ 10 (6): Feed-in tariff for Ökostrom generated in CHP-plants driven by biomethane from biogas out of agriculturally substrates – convert decentralized into electricity (injected Biomethane) - for plants build in 2013:

- Generation out of agriculturally substrates
  - up to 500 kW: 16,93 €Cent/kWh
  - above 500 up to 750 kW: 13,34 €Cent/kWh
  - above 750 kW: 12,93 €Cent/kWh
- (3) 20% reduction on above mentioned tariffs when using non-agriculturally substrates
- (7) Additional bonus of 2 €Cent/kWh for the quantity of electricity generated from gas which was fed into the gas grid based on the quality of natural gas (Technologiebonus)

At the moment (status May 2013) the market price for 100% biomethane is at about 5,5 to 6,5 €Cent/kWh from urban waste and 6,5 to 7,5 €Cent/kWh from NAWARO (energy crops).

OeMAG is the clearing and settlement company for the Austrian green energy.

The tasks of OeMAG are:

- Financial management of the annual funding budget
- Verification of Green Energy providers during the registration at OeMAG
- Funding of the injected energy for existing and new green energy plants

AGCS has developed the Biomethane Registry Austria together with the market experts (www.biomethanregister.at).

As a result a transparent and targeted generation for biomethane certificates in Austria was realised - the Biomethane Registry Austria.

Biomethane Registry Austria

The tasks of the Biomethane Registry Austria are:

- Transparent registration of market participants
- Standardised issuance of certificates for injected biomethane
- Generation for secured transmission of biomethane certificates
- Activation of the biomethane certificate database and support

Functionality of the certificate system:

- Gas amounts and certificates are separated
- Central database for certificates with electronic interface to gas clearing system
- Monthly generation of certificates after clearing
- Transfer of ownership and retirement

The biomethane registry covers all distribution areas in Austria, like distribution area east, Tyrol and Vorarlberg.

Participants & Parties

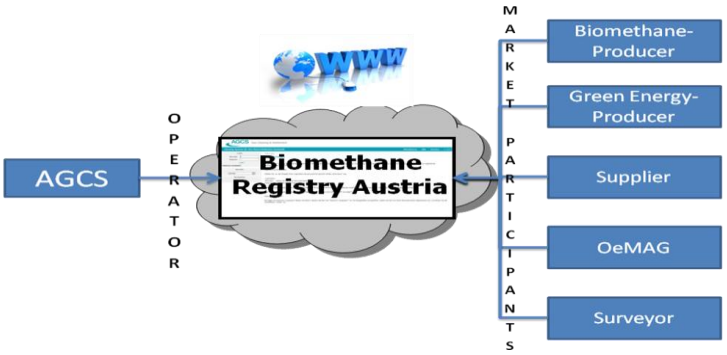


Figure 3: Biomethane Registry Austria - Participants & Parties (source: Biomethanregister AGCS, 2013)

Functional principle of the registry

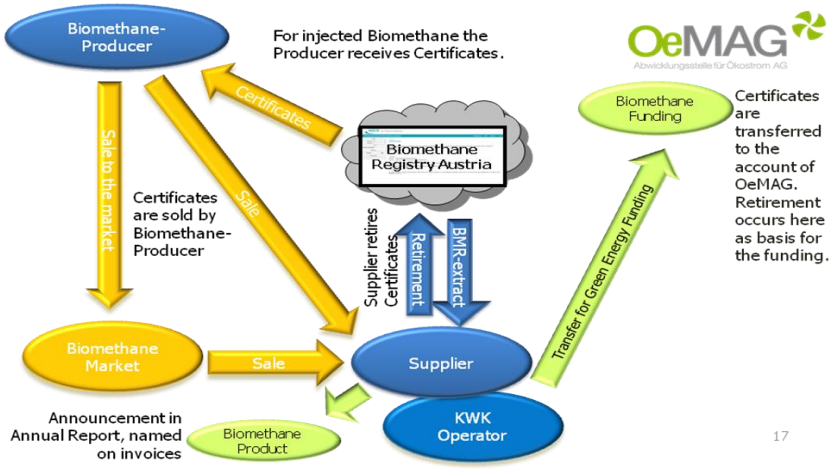
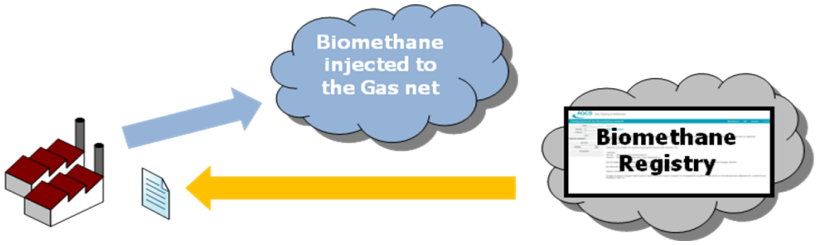


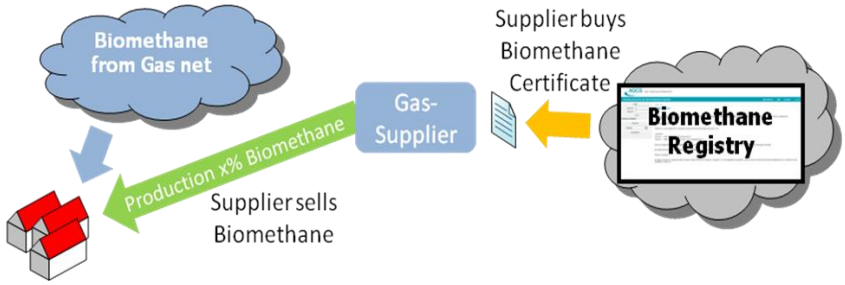
Figure 4: Functional principle of the registry (source: Biomethanregister AGCS, 2013)

Application possibilities for market participants

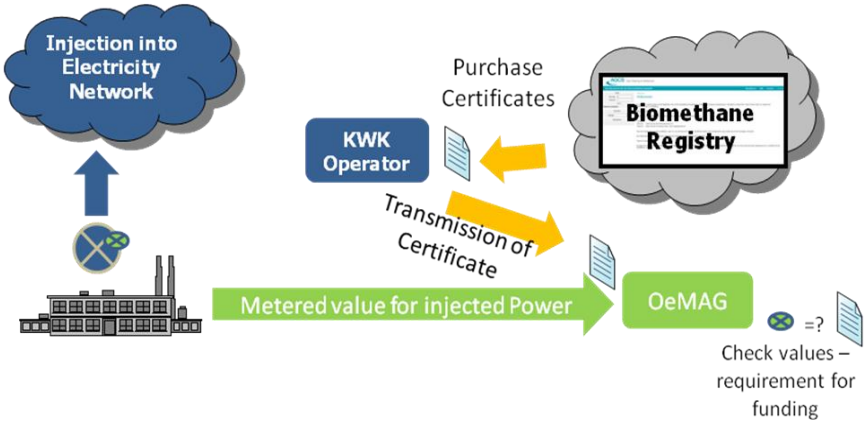
Biomethane-Producer:



Gas Supplier:



Gas user - conversion into electricity:



With status March 2013 the following market participants were in the Biomethane registry Austria:

Alias	Company Name	ROLE
TIGAS	TIGAS-Erdgas Tirol GmbH	Biomethane-Producer
TIGAS	TIGAS-Erdgas Tirol GmbH	Biomethane-Conversion
MASTERMIND	Mastermind Ingenieurbüro GmbH	Surveyor
OE-GAS-WAERME	OÖ. Gas-Wärme GmbH	Biomethane-Producer
TÜV AUSTRIA	TÜV AUSTRIA SERVICES GMBH	Surveyor
PRESCON	Prescon technische Überprüfungs GmbH	Surveyor
EVN-WAERME	EVN Wärme GmbH	Biomethane-Producer
ENERGIEALLIANZ	ENERGIEALLIANZ Austria GmbH	Certificate Trader
BIOGAS-BRUCK	Biogas Bruck/Leitha GmbH	Biomethane-Producer
EVN-VERTRIEB	EVN Energievertrieb GmbH & Co KG	Certificate Trader
WIENENERGIE	WIEN ENERGIE Vertrieb GmbH & Co KG	Certificate Trader
SALZBURGAG	Salzburg AG für Energie, Verkehr und Telekommunikation	Biomethane-Producer
SALZBURGAG	Salzburg AG für Energie, Verkehr und Telekommunikation	Biomethane-Producer
SPIEGLTEC	SPIEGLTec Tech. Büro für Maschinenbau GmbH	Surveyor
STFG	Steirische Gas-Wärme GmbH	Biomethane-Producer

The average monthly feed–in quantity to the Biometnane Registry Austria in 2012 was about 4.400 GWh. The following figure shows the feed-in quantities from January to March 2013 and also the issued certificates.

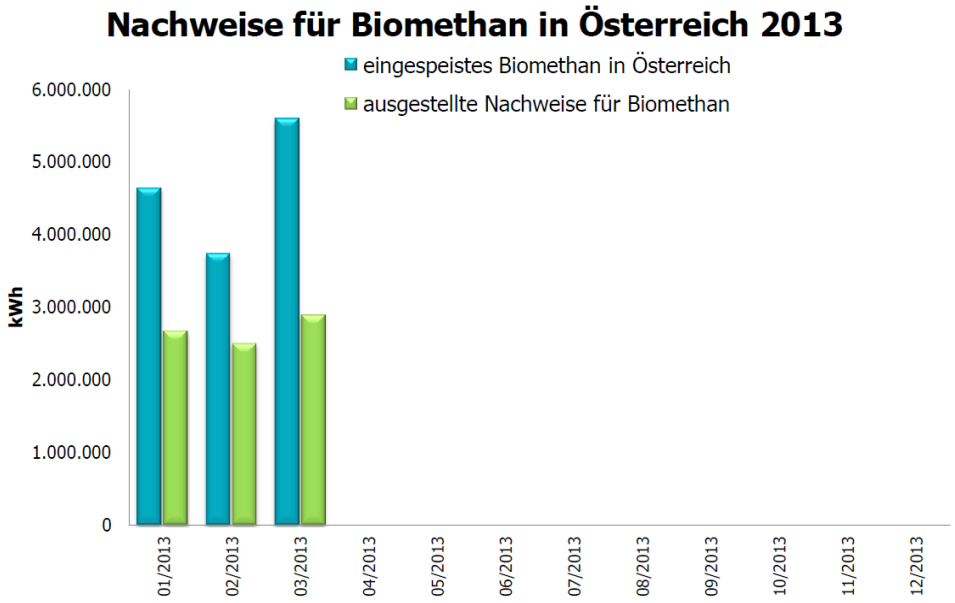


Figure 5: Certificates for biomethane in the Austrian Biomethane registry for January to March 2013 (source: Biomethanregister AGCS 2013)

2.4 Expected future legal and technical amendments, comments and recommendations

As mentioned before the Austria biogas/biomethane-market is quite stagnant in the last years. The reasons are various. Beginning with increasing price-levels for substrates and problems with the acceptance of neighbourhood and authorities there are also some legal and technical barriers:

- Biogas plants (without upgrading and connection to gas grid and low heat consumption/sale) whose subsidies for the green electricity feed-in tariff already expired or expire in the next years often face severe financial problems
- Access to the gas grid often problematic – distance of existing biogas plants to gas grid too long/expensive, not enough capacity in the low-pressure grids, access costs to the gas grid are solely carried by the one feeding in the gas/biomethane
- No attractive subsidies/tax benefits for the investment/usage of CNG cars/busses to make these cars interesting for private and commercial users
- Unclear situation about tax on biomethane
- Way from biomethane-producer to potential customer too complex

Facing these problems several ideas and concepts were discussed in various task force meetings about the thematic legal and technical framework conditions for biomethane in the natural gas grid. The following list represents a summary of these discussions:

- Clear statement of the policy to biomethane grid injection in energy strategic documents and papers (targets and plan to reach these targets)
- Elimination of the tax ("Erdgasabgabe") for biomethane fed into the grid
- More attractive subsidies and/or tax-benefits for CNG cars/busses
- Promotion of use of CNG cars/busses in cities for (public) transport – municipalities, authorities, etc. should be an ideal for the population
- Better promotion of the already existing Austrian Biomethane Registry to bring biomethane producers and potential customers together
- Easier and secured access to gas grid for producers – transparent plans of gas-network with capacity-profiles for the different pressure levels to find out ideal positions for biogas/biomethane plants
- Fair sharing of the access costs to the gas grid between producer and gas supplier
- Feed-in tariff for the green electricity should be available immediately after submitting the application to the authority
- Transparent and attractive follow up tariff system for green electricity feed-in tariff

3 Strategy for biomethane grid injection and use in Croatia

3.1 Biomethane grid injection in energy strategic documents and papers

Croatian legal framework does not recognize biomethane as a fuel. According to the law, biogas is defined as gaseous fuel produced from biomass and / or from the biodegradable fraction of waste, that can be purified to natural gas quality, to be used as biofuel for blending with natural gas or wood gas. For this reason, when we talk about the use of biogas in traffic we mean biomethane.

Croatian legal framework that describes utilisation of energy from biogas is not sufficiently elaborated to allow maximal utilisation of biogas. Biogas is described in some 40 legal documents that could be arranged in three main categories: energy, agriculture and environmental protection. Within energy policy, biogas is described as one of RES while in other policies, biogas is positioned as a tool for achieving a specific goal of agriculture policy (say, a rural development measure) and environmental policy (say, a GHG emissions saving tool, agriculture pollution prevention measure).

One of the most important bottlenecks for Croatian biogas market development in general is lack of knowledge within responsible bodies on biogas properties. Biogas is the most versatile of all RES, both in terms of potentials (substrates) and useful energy forms. It is only RES that participates in all energy markets: electricity, heat, natural gas, transport. This versatility calls for synchronised measures in order to either maximise (the best energy conversion efficiency) or optimise (according to energy planning demand) utilisation of biogas potential.

In strategic documents, biogas potential is under-estimated as it is based on manure monodigestion of 20% total livestock units. The vast spectrum of available substrates has been completely disregarded: waste and by-products of agro-food industry, organic part of municipal waste, "ex-food", waste sludge from waste water treatment plants as well as

energy crops. Final version of **NREAP** is missing which should specify what desirable forms of biogas useful energy are, including biogas heat.

Currently, biogas production has two, mutually exclusive, incentives: FiT for RES-E from biogas (set of laws from energy) and 50% grant in investment for building and/or reconstruction of a biogas plant (set of laws from agriculture). Law on RES-H has been pending since 2008.

The Energy Development Strategy states that the Republic of Croatia, due to favorable effects on the reduction of emissions into the environment, will encourage the use of compressed natural gas (CNG) in transport. Place of its use are truck corridors (blue corridors) and city buses, as well as car traffic. Application of CNG in traffic opens the possibility of the application of compressed biomethane which will be especially stimulated, because it facilitates the fulfillment of obligations of renewable energy sources in transport.

Today, biogas is recognized in a legislation that describes biofuels, but its use in the production or transportation is still not stimulated.

3.2 Biomethane grid injection in energy and renewables laws

Law on biofuels for transport (**NN 145/2010**) encourages the production of following biofuels (Article 20): (1) biodiesel from rapeseed, used cooking oils and lignocellulosic raw materials, (2) bioethanol from corn, sugar beets, and lignocellulosic materials (3) biogas and (4) biomethanol. However, the encouraging model has been developed only for biodiesel and bioethanol.

According to the Law, user of fuel in public transport and public sector shall ensure that in each year at least 70% of newly purchased or leased vehicles or boats use:

1. biofuel blended into diesel or petrol at a share of more than 5% or
2. biodiesel in the form of pure biofuel or
3. biogas in the form of pure biofuel or
4. hybrid power or
5. electric power or
6. hydrogen.

According to the law the county and major cities are required to develop and adopt a Program to encourage the production and use of biofuels in transport. The program is a planning document that is adopted for a period of three years, in accordance with the National Action Plan to encourage the production and use of biofuels in transport for the period of 2011- 2020. The program, among others, should include the review and assessment of the present condition and the needs of the market in fuel consumption for transportation in the county, comparative analysis, long-term goals, measures to encourage increased production and use of biofuels in transport, etc.

In achieving the goals of the share of biofuels in transport, biofuels energy produced from wastes, residues, non-food cellulosic material and lignocellulosic material is taken twice a value higher than actual consumption.

According to the National Action Plan to encourage the production and use of biofuels in transport for the period of 2011- 2020, 9.81 percent of the total fuel consumed in traffic should be biofuels. Of this, the share of biogas should be 0.62 percent or 8.466 million administrative m^3 of biogas from waste, or in energy units, 4.233 million m^3. During the year 2011, 16 mil. m^3 of bigas was already produced in Croatia, which represents about 8 million m^3 of biomethane. According to this document, as part of measures to encourage the production of biofuels for transport, conducting necessary research is predicted and the system to encourage production of compressed biomethane will be defined in accordance with the results. According to the National Action Plan, preparation and adoption of the

Decree on the promotion of biogas production for transportation and admission of biogas use within the promotion of compressed natural gas use for transportation, has been predicted only for the period after 2016.

GUP (General Spatial Plan) of city of Zagreb prescribes the condition of building the gas stations. It shows existing and planned gas stations. Locations of planned petrol stations are provisional. Petrol stations can be built on other sites, provided that they are located:

- in mixed, mostly business use area, the size of a building plot of 2000 m², with mandatory 20% of the natural terrain of the building plot to be arranged as a complete green horticultural area according to existing or planned buildings adjacent to the building plots;
- in economic purpose;
- In the areas of infrastructure systems.

Reconstruction and construction of new petrol stations in the corridors of roads is possible with the opinion of the City Institute for Physical Planning.

Existing and planned gas stations can be reconstructed and constructed so as to ensure:

- the safety of all road participants;
- environmental protection by regulation of at least 20% of the building plot as a whole horticultural area, with preliminary design forming a protective green belt.

Petrol stations may have supporting facilities in the function of street traffic.

The regulations of this decision relating to the construction of gas stations are also applicable for the construction of CNG filling stations for motor vehicles, which makes CNG station development very complicated.

GUP (General Spatial Plan) of city of Zagreb prescribes the condition of building the gas supply systems.

General Urban Plan defines areas and corridors for the construction of:

- the main high-pressure gas pipeline ø 600, 75 bar, which will be built for needs of INA, with existing VT pipeline along the city's bypass, from Lučko to the new PPMRS - East, Ivanja Reka, which should provide a corridor of 30 m on both sides of axis of the pipeline;
- gas transceiver measuring-reduction stations; the main high-pressure gas pipeline Ivanja Reka - TE-TO Zagreb under the jurisdiction of City Gasworks and distribution of high-pressure pipelines;
- gas regulation stations (PRS) and transmition (RS) and blockade station (BS).

Gas regulation stations (PRS) are overhead or underground structures. If necessary, around some of them is placed a protective fence outside the danger of explosion. Just next to them are placed high-pressure lines (HPP) or medium-pressure pipelines (MPP), and from them to the consumer medium-pressure water pipelines (MPP) or low-pressure pipelines (LPP). Location of PRS must have an access road to public traffic area with one parking space for occasional parking of personal or commercial vehicle.

Transmition (RS) and blockade station (BS) are built above ground. Around them, if necessary, a safety fence is set outside the danger zone of explosion. Location of RS and BS must have an access road to public traffic area with one parking space for temporary parking of personal or commercial vehicle.

Gas pipelines are buried underground at a depth of 1m minimum, from the overlay up to the level of landscaped grounds.

Minimum safety distances from sensitive neighbouring buildings are:

- Pipeline Ivanja Reka - TE-TO Zagreb 30 m from the axis of the pipeline;
- RS, BS, PRS 10 m and 3 m public traffic area;
- HPP 10 m;

- MPP 2 m;
- LPP 1m.

Minimum safety distances from sensitive neighbouring buildings for HPP, MPP and LPP may be reduced in exceptional and duly justified cases, with additional use of special safeguards and consent of City Gasworks Zagreb.

In parts of the city where, along the gas distribution network, other energy sources exist or are planned, energy source that is more acceptable to the consumer will be used.

When planning biomethane pipeline connections to the gas network, the above mentioned obligation should be followed, and pipelines should be planed within the new GUP.

City of Zagreb spatial plan recognize energy savings and efficiency, the introduction of gas, expanding the CTS and the development of additional alternative energy as a measure of protecting and improving air quality.

3.2.1 Grid injection

In Croatia there is overarching legal framework for the production of biomethane from biogas and its injection into the natural gas network in compliance with applicable rules stemming from the **Gas Market Act (NN 40/07, 152/08, 83/09, 114/11).**

The rules established by this Act and the regulations issued there under are applicable to biogas, gas from biomass and other types of gas if these types of gases can be safely transported through the gas system.

Network Gas Distribution System rules (NN 50/09) permit blending of the biogas, gas from biomass and other types of gas with natural gas, but only if these types of gases can be safely added to the flow, and if the resulting gas mixtures can technically and safely be distributed through the distribution system. Biogas or gas mixtures shall meet the standard quality natural gas from **Appendix 1** of the **General Conditions of Energy Supply of natural gas (NN 43/2009).** Gas blending is approved by the Distribution System Operator.

Implementing regulations to provide a simple and transparent way to the consumer, such as biomethane technical requirements for biomethane injection, positive discrimination towards the use and / or injection of biomethane into the natural gas network, payment terminal, etc. are currently lacking.

By the end of 2012 in eleven European countries biogas was upgraded to biomethane. In nine countries thereof biomethane was injected into the grid. Sweden and Switzerland have the longest experience which started back in the early 90s. All of the biomethane countries developed standards for injection (plus some more countries not injecting biomethane yet). However, a lot of differences could be found in fundamental aspects such as parameters and/or concentrations of compounds other than methane, with variations even up to a factor of 100 (i.e. for mandated oxygen levels).

According to the GrinGasGrids project, in Europe and also in Croatia, a number of points are still open for discussion, either because reliable data are still to be compiled or because the relevant data are not available yet and must be part of future research projects:

- Sulphur
- Siloxanes
- Trace components that may (or can) have an effect on health
- Exposure models for these trace components
- Oxygen
- Hydrogen
- Methane number (parameter linked to the risk of knocking in engines, cf. octane number for liquid fuels). In the case of insecurity preliminary figures will be used in the standard that will subsequently be adapted. There is still dispute if these values will arbitrarily be set at a low value and weakened afterwards if possible or if they should

be set at the upper limit of known band width and subsequently be reduced if necessary.

The following table shows a comparison of the quality of natural gas between countries. It is obvious that in Croatia a plenty of data is still missing or not defined.

Table 5. Standard gas quality (GrinGasGrids project)

		Austria	Germany	Switzerland	France	Netherlands	Croatia
Wobbe index	MJ/m3	47,88-56,52	37,8-56,5	47,88-56,52	43,24-56,5	43,46-44,41	41-55
Calorific value	MJ/m3	38,52-46,08	30,2-47,2	38,16-47,16	34,2-46,08	31,6-38,7	33,1-44,3
Specific density		0,55-0,65	0,55-0,75		0,555-0,7		
Water	mg/kg		40				
Dewpoint water	°C			-8	-5	-10	-10
CH_4	Vol %			>96			>85
CO_2	Vol %	2	6	6	2		7
N_2	Vol %	5					
O_2	Mol %					0,5	
CO	Vol %			0,5	2		
H_2	Vol %	4	5	4	6	12	
S total	mg/m3	10	30	30	30	45	100
H_2S	mg/m3	5	5	5	5	5	7
Mercaptans	mg/m3	6	6	5	6	10	-
Siloxanes	mg/m3	10				5	
NH_3	mg/m3	0		20	3	3	
Hg	µg/m3				1		
Cl	mg/m3				1	50	
F	mg/m3				10	25	
Heavy metals tot.	mg/m3			5			
Propane	Vol%		6				6
Butane	Vol%		2				
Ethane	Vol%						7

In Croatia, standard quality natural gas is described in the **Energy Act (NN. 120/12)** and in the **General Conditions of Energy Supply of natural gas – Appendix 1 (NN. 43/2009)**.

Monitoring the quality of natural gas and reporting on the same lies in legislative competence of the transmission system operator Plinacro Ltd. and in the distribution system operator (DSO).

3.2.2 Public transport

Ministry of the Interior in agreement with the Ministry of Environmental Protection, Physical Planning and Construction has issued **System Regulation for the supply of motor vehicles with compressed natural gas (NN 134/09)**, which determines safety and technical requirements in design, development, assembly, installation and testing of components and assemblies that form the technical and technological supply system of motor vehicles with compressed natural gas, as well as the implementation of protective measures against fire and explosion.

Supply system for motor vehicles with CNG, within the meaning of above-mentioned Regulation, is the part of the station for motor vehicles supply with CNG on which the system

for the supply of motor vehicles with CNG is positioned. It consists of technical and technological unit which performs refuelling of vehicles at the location of the station, or equipment used at the location for pressurization, storage or further preparation of natural gas, and furthermore it is then delivered in a state of drive fuel required for the supply of motor vehicles powered by CNG into car tanks.

This Regulation prescribes that the system for supply of motor vehicles with CNG, including all components of the filling stations for motor vehicles with CNG, from the input flange at the connection point with the supply pipeline to the vehicle filling connectors, is assembly constructed in accordance with applicable regulations of the pressure equipment and Croatian standards related to their application.

Also, this Regulation prescribes the safety and technical requirements in design, manufacture, assembly, installation and testing of components and assemblies which are filled under pressure on vehicles with nominal (normal) filling pressure of 20 MPa (200 bar) at a temperature of 15 °C. Conditions are related to the supply systems of motor vehicles with CNG with a total maximum capacity of compressor more than 10 m³/h (working within the design parameters of the system) and/or with the maximum compressor pressure higher than 20 MPa (200 bar).

Built-in compression devices must provide a possibility of safe and continuous operation of the system for the supply with CNG. Each compressor should have an appropriate mechanism for protection against excessive pressure pulsations. In the case of power failure each compressor must independently be shut down safely. A safety valve with adequate relief capacity should be fitted at the output of the compressor. Gas temperature at the output of each compressor should not damage the implanted devices. Construction of the compressor must be in accordance with the zone of danger area potentially endangered by explosive atmosphere in which they are situated. Operating temperature must be monitored (switch in the case of unallowed temperature).

When filing the tank under pressure in vehicle, safety mechanism of CNG system should enter into operation at the time (no later) of reaching the maximum allowable working pressure. For vehicles powered by natural gas which are filled with CNG and whose tanks suit the requirements for installation in the vehicle according to the document UNECE-R-110 or 84/525/EEC, maximum allowable pressure when filling the tank must be matched with following (it is not allowed to exceed):

- Pressure of 20 MPa (200 bars) in terms of the steady state of gas in the vehicle tank at a temperature of 15 °C.
- Pressure of 26 MPa (260 bar) which may result in case of the maximum expected temperature regardless to the ambient temperature

In cases where the supply system for motor vehicles with CNG is installed at the location where ambient temperatures exceed 30 °C, the maximum allowable pressure when filling the vehicle must be adapted to the pressure of 26 MPa (260 bar) – this pressure should not be exceeded over a temperature of 65 °C (e.g. at the temperature of minus 40 °C filling pressure should be limited to 18 MPa).

Vehicles powered by natural gas whose tanks do not meet the requirements of the UNECE-R-110 or 84/525/EEC are filled with special precautions.

Connector for filling must be set in such a way that it allows fast and safe separation from the vehicle at any moment. Filling connectors that meet the requirements for installation must be in accordance with **ISO 14469-1:2004**. Filling adapter must meet the requirements for pressure equipment and own label with maximum allowable working pressure.

Protective enclosures must tolerate expected (predictable) mechanical stress and meet requirements with regard to aging. They must be constructed from the non-combustible materials in class A1 or A2,-s1, d0 according to **EN 13501-1**.

Structural elements must be made of materials resistant to fire or with a fire resistance of at least 90 minutes. The same applies to the non-structural elements, doors and openings. The

fire resistance of 90 minutes shall be determined in accordance with standards mentioned at the end of this section.

Requirements of the Regulation (NN 134/09) may also be applied to systems with a higher filling pressure, taking into account the safety of the components, i.e. safety distances, mechanical strength and ensure the safety of installation of pressure equipment.

Regulation includes all equipment built into the system for the supply of motor vehicles with CNG starting from input flange to outlet connector for filling, associated buildings and facilities and traffic areas. Holes on connectors for the supply of motor vehicles with CNG at the station are considered as the endpoint to which these conditions apply.

Any project should be developed in accordance with the design solution and the applicable regulations in Croatia and in accordance with Croatian and other worldwide recognized norms and standards.

The International Standard (ISO 11439:2000) specifies minimum requirements for serially produced light-weight refillable gas cylinders intended only for on-board storage of high pressure compressed natural gas as a fuel for automotive vehicles to which the cylinders are to be fixed. The service conditions do not cover external loadings which may arise from vehicle collisions, etc. This International Standard covers cylinders of any steel, aluminium or non-metallic material construction, using any design or method of manufacture suitable for the specified service conditions. This International Standard does not cover cylinders of stainless steel or of welded construction.

ISO 14469-1:2004 (NGV standard) specifies CNG refuelling nozzles and receptacles constructed entirely of new and unused parts and materials, for road vehicles powered by compressed natural gas. A CNG refuelling connector consists of, as applicable, the receptacle and its protective cap (mounted on the vehicle) and the nozzle. ISO 14469-1:2004 is applicable only to such devices designed for a service pressure of 20 MPa (200 bar), identified by the code B200, to those using CNG in accordance with ISO 15403 and having standardized mating components, and to connectors that prevent natural gas vehicles from being fuelled by dispenser stations with service pressures higher than that of the vehicle, while allowing them to be fuelled by stations with service pressures less than or equal to the vehicle fuel system service pressure.

List of other relevant standards is given below.

- HRN EN 60079-10 Classification of endangered areas – Explosive gas atmospheres
- HRN EN 60079-14 Explosive atmospheres. Part 14: Design, selection and execution of electrical installations
- IEC 1340-4-1 Floor covering evaluation
- HRN EN 1127-1 Prevention and explosion protection. Part 1: Basic concepts and methodology)
- HRN EN ISO 13943 Protection against fire.
- HRN EN 13501-1: 2002 Classification of construction products and elements due to the behaviour in case of the fire. Part 1: Classification based on the reaction to fire.
- HRN EN 1364-1 Fire resistance tests for non-structural elements. Part 1: Walls.
- HRN EN 1364-2 Fire resistance tests for non-structural elements. Part 2: Ceilings.
- HRN EN 1365-1 Fire resistance tests for structural elements. Part 1: Walls.
- HRN EN 1365-2 Fire resistance tests for structural elements. Part 2: Floors and roofs.
- HRN EN 1366-1 Fire testing of service installations. Part 1: Channels.
- HRN EN 1366-2 Fire testing of service installations. Part 2: Fire dampers.
- HRN EN 1634-1 Fire resistance tests for doors and shutters.

3.3 Biomethane grid injection basic tariff elements

There are no rules or regulation on biomethane injection tariffs.

3.4 Main legal barriers and recommended amendments

Based on the analysis of legislative environment it can be concluded that there are no barriers for biomethane access to gas transmission or distribution network. Pipeline access is guaranteed to all types of gas that can be safely transported by gas network and meet the General terms and conditions for natural gas supply as well as prescribed gas quality requirements.

Although the benefits of using biomethane produced from waste in transport have been recognized at national and local level (share of biomethane is administratively recorded twice), the largest barriers to its implementation are set at that same level.

Although the existing biogas production today is already higher than the planned production levels for 2020 (according to the National Action Plan to encourage the production and use of biofuels in transport for the period of 2011-2020), the adoption of incentives for the use of biomethane in transport (Decree on the promotion of biogas production for transportation and admission of using biogas in the promotion of the use of compressed natural gas for transportation) is predicted only for the period after 2016.

At the local level, the most significant barriers are stipulated by regulations from spatial planning documentation. For construction of gas stations for the supply of motor vehicles same regulations are applied as for the construction of petrol stations. These regulations are certainly acceptable and desirable for public gas stations, but have a negative impact on the possibility of building a gas station for own use.

3.4.1 Grid injection

Related to biomethane, grid injection recommendations from Germany should be followed, and are represented with:

- For the injection of biogas into gas transmission grids no connection fees have to be paid.
- Biomethane injection fee: the owner of biogas at the point in time when biomethane is injected into the grid should get a fee that will allow him to operate the biomethane facility with appropriate revenue (in Germany of 0.7 Cent/kWh) for “avoided grid costs” by the grid operator of that grid in which biogas is injected. It should be paid for minimum 10 years beginning from the start of an operation of grid access, and should be independent on the grid level (e.g. pressure level).
- Following cost fractions (for grid access) should be divided among all grids (and therefore among natural gas customers that are connected to these grids):
    - Costs for grid connection as well as for maintenance and operation.
    - Potential costs for financially reasonable measures for an increase in grid capacity to be able to ensure biogas grid injection over the whole year. This can also include costs for reverse feeding/compression of natural gas of grids with lower pressure levels, respectively capacities, to grids with higher pressure levels.
    - Costs for advanced (biogas) balance management minus fees for advanced balance management that have to be paid by the responsible person for a balance group.
    - Costs for gas conditioning, odorization and gas constitution measurement.
    - Fees for “avoided grid costs”.

The Government should set a target for future biomethane production that should be subsidised by the proposed measures.

Rule for the priority access of biomethane to gas grids should be established: grid operators have to ensure that transport contracts are concluded with a priority consideration with transport customers of biomethane.

The components that should be considered as biomethane grid connection should be defined:

- Connection pipe between upgrading plant and gas supply grid
- Gas pressure regulation measurement equipment
- Feature for pressure increase
- Calibratable measurement equipment for biogas
- Equipment for the addition of odorants
- Gas conditioning equipment (e.g. for the addition of LPG)
- Gas constitution measurement

Gas grid operator should participate in investment costs of the grid connection aider in full amount or with a certain percentage.

The grid operator should be responsible for maintenance and operation of the grid connection station and has to cover the costs for these tasks.

The grid operator has to ensure a permanent availability of the grid connection station.

The person who is injecting the gas has to ensure that biomethane quality corresponds to the requirements of General Conditions of Energy Supply of natural gas.

The appropriate biomethane grid injection tariff system should be developed.

3.4.2 Public transport

Related to the System Regulation for the supply of motor vehicles with compressed natural gas (NN 134/09) and related spatial planning regulation, amendments related to filling stations with working capacity of more than 10 m³/h should be considered. The filling stations for public use and for investor's own use should be considered differently. According to the current regulation, the development of investor's own use filling station should follow the same procedure as one for the public use. This means that procedure related to the building of a petroleum project filling station should be followed (changes in spatial plans, fulfillment of defined minimum distances and similar) which is very complicated and it resulted in abandonment of the planned project by one investor. The procedure for development of the investor's own use filling station should be simplified as much as possible but taking into account that safety requirements are met.

Whole sets of other measures could be implemented with the final goal of reaching the use of biomethane or CNG in public and civil transport.

Motivation by own example and use of non-technical measures

Motivation by own example

Encouragement by example means the use of vehicles powered by compressed natural gas in fleet vehicles of local, regional and national government. Companies for distribution of natural gas also belong among the companies that are today mainly owned by local governments.

Among non-technical incentives (and based on existing European models) the following could be included:

- Free parking for vehicles that use alternative fuels, meaning environmentally friendly vehicles, including natural gas vehicles.
- For taxis - the advantage of waiting in line for passengers compared to taxis using classic fuels.

- Allowing vehicles on natural gas to park in areas where access is restricted to all other vehicles (eg. access to delivery vans on natural gas in the old town).
- Favourable treatment of other transport companies who use measures for clean environmentally friendly transport in their fleet (through a variety of non-technical and non-financial benefits, like the previous example).

Tax policy measures

Tax policy measures also cover certain activities at the level of vehicles, namely fuel:

- Lowering taxes and excise duties for corporations in procurement of vehicles for official purposes. Given that the vehicles powered by compressed natural gas are more expensive than their equivalent models on gasoline or diesel fuel in this way it is possible to reduce or cancel the above differences in investment. Considering that in the initial stage the number of vehicles, especially for the fleet owned by corporations, won't be very large compared to gasoline or diesel fuel, there won't be a significant reduction in income tax and excise duties (especially because the complete abolition of taxes and excise duties hasn't been proposed, but only parts of them).
- Neutral tax measures for natural gas as a fuel for power of motor fuels, ie. release from the introduction of taxes on CO2 emissions in case of its introduction in the price of other fuels.
- Guaranteed (and long enough) period in which the natural gas as a fuel for motor vehicles power will be exempt of taxes, excluding value added tax. Regarding the last point, a favourable difference in the price of natural gas in relation to motor fuels (gasoline and diesel fuel) is already present, but measures are necessary for its retention in the predetermined time period.

Correction of the associated charges for natural gas vehicles

In Croatia, while registering a reconstructed gas power vehicle (or the original factory-produced natural gas vehicle), an additional fee is paid for road tolls in the amount of 550kn for cars and 2,000kn for trucks.

Therefore it is necessary:

• To balance the charges for natural gas vehicles with furniture vans and light commercial vans, i.e. equate them with the amount for passenger cars.

Dedicated financial incentives to projects using natural gas in transport by Environmental Protection and Energy Efficiency Fund

- Active role of the Environmental Protection and Energy Efficiency Fund and an increase in the proportion of funds collected from the transport sector in the form of earmarked funds that are returned back to the transport sector.
- Correction of the coefficient depending on the type of engine and fuel, which is part of the equation that determines the amount of environmental charges in terms of its reduction.

Drafting legislation and regulations related to garages

One of the main issues related to the use of buses powered by compressed natural gas is the possibility of their entrance into the existing garage (for maintenance of diesel buses) for daily and routine maintenance and unscheduled repairs, in other words operations needed to be carried out from safety standpoint. It is necessary to point out the claims of all bus manufacturers and the experience of public transport operators who use them, that natural gas buses are as safe as, if not safer, the buses on diesel fuel considering a relatively narrow area of explosiveness of mixtures of gas and air, and natural gas is lighter than air and is not retained in the workspace.

Below, as an example, we list activities carried out in the garage for maintenance of diesel bus operators of public transport in Torino, in order to accept natural gas buses: setting up

partitions and separation of work space in order to provide structural resistance to flame (for 120 minutes) - all the interior doors or doors that are used for communication with other parts of the garage must have 120 minutes fire resistance coefficient, the front door must be open under normal conditions, some skylights must be modified in order to be able to ensure their openness; installing ventilation towers for the provision of three air changes per hour in the roof section, installing a system for detecting gas leaks associated with ventilation towers and front doors to ensure air circulation for forcing natural gas through the roof vents.

In case of a request by the Department of fire protection, a heat detection device can be installed.

The proposed measure, which is one of the preconditions for development of use of natural gas powered buses (primarily public transport), is:

- Development and adoption of regulations related to garages for maintenance of buses to be able to accept natural gas buses as well (in addition to diesel buses).

Encouraging the development of "blue corridors"

The term "blue corridor" entails the network of filling stations distributed primarily along major roads and highways, which allows transit through several countries without having to use any other fuels apart from natural gas.

Proposed activities in the Republic of Croatia in that direction are:

- Development of blue corridors at existing gas stations for fuel supply of motor vehicles or filling stations close to major highways and motorways - the development by gas industry with promotional measures by the state meaning local governments leading by example (use of vehicles powered by compressed natural gas in their driving park, along with filling at those stations).
- Involvement of large gas company in development of "blue corridors", i.e. showing confidence in the project of natural gas use in transport and also encourages trust and beneficiaries into the project.
- Marketing activities by gas companies as promotion of new technologies and possibilities of gas use.

Encouraging joint procurement of vehicles

To encourage joint procurement of natural gas vehicles, marketing activities are required along with conducting audits to introduce fleet operators owned by companies and operators in local city bus transport as well as utility companies with technical, economic and environmental aspects and possibilities of natural gas use for motor vehicles in their fleet, as well as the existing legislative framework.

Interest of individual vehicle manufacturers, who have natural gas vehicles in their production program, should be encouraged through joint procurement of vehicles by merging multiple corporations for achieving sufficiently large orders, which would be interesting for them (in this case they must provide needed service and spare parts).

Marketing activities and education

In order for these measures to have satisfactory results, it is necessary to use promotional and marketing activities, as well as educating companies and individuals about the use of natural gas in transport.

Although the benefits of using biomethane produced from waste in transport have been recognized at national and local level (share of biomethane is administratively recorded twice), the largest barriers to its implementation are set at that same level.

With the purpose of successful application of biomethane in transport it is necessary to remove the barriers set by the National Plan as soon as possible and provide adequate support for the use of biomethane in transport.

At the local level, the most significant barriers are stipulated by regulations from spatial planning documentation. According to the current regulation, the development of own use filling station should have the same procedure as one for the public use. This means that the procedure related to the building of a petroleum project filling station should be followed (changes in spatial plans, fulfilment of defined minimum distances and similar) which is very complicated and it resulted in abandonment of a planned project by one investor. The procedure for development of own use filling station should be simplified as much as possible but taking into account that safety requirements are met.

4 Strategy for biomethane grid injection and use in Portugal

4.1 Biomethane grid injection in energy strategic documents and papers

Portugal is developing actions to increase and improve the environmental issues in the energetic laws, based on the "Estratégia Nacional para a Energia" - RCM n.º 169/2005 (Portuguese National Energy Strategy). With the approval of Portugal National Renewable Energy Action Plan (NREAP), a set of aims were defined for each renewable energy technology aiming at the fulfilment of the commitments.

All the efforts are to look for a more sustainable energy using the best available technology and, in long term, to support the development of new technologies (2).

4.1.1 Estratégia Nacional para a Energia (ENE 2020)

The Portuguese National Energy Strategy (ENE 2020) hinges around five unfolding and detailed main axes, which act as a vision, a focused set of priorities and an outline of enabling measures (1) (3):

Axis 1 - AGENDA FOR COMPETITIVENESS, GROWTH AND ENERGY AND FINANCIAL INDEPENDENCE - ENE 2020 stimulates the different economic areas adding value and job creation by betting on innovative projects in the fields of energy efficiency, renewable energy, including the decentralisation of production and electric mobility in a balanced territorial framework; by promoting competition in the marketplace by consolidating the Iberian Electricity Market (MIBEL), creating the Iberian Natural Gas Market (MIBGAS), and regulating the national oil system, thus contributing to enhance Portugal's energy and financial independence in times of external energy shocks.

Axis 2 - BETTING ON RENEWABLE ENERGY by promoting the development of a national industrial sector, a generator of economic growth and job creation, and which allows the attainment of national targets for renewable energy production by increasing the range of renewable energy types in the country's available sources of energy supply (energy mix). By doing so, Portugal aims to reduce its external dependence, which translates into increased supply safety.

Axis 3 - PROMOTION OF ENERGY EFFICIENCY by targeting a 20% reduction in overall energy consumption by 2020, through both behavioural and fiscal measures, as well as through innovative projects, namely electric vehicles and smart grids, renewable-based decentralised production, and the optimisation of public lighting models and energy management of public, residential and services buildings.

Axis 4 - GUARANTEEING SECURITY OF ENERGY SUPPLY by sticking to a policy of a wide energy mix of both sources and supply origins, and by strengthening transport and storage infrastructures which will allow the consolidation of the Iberian market in accordance with European energy policy guidelines (3).

Axis 5 - SUSTAINING THE ENERGY STRATEGY - ENE 2020 promotes economic and environmental sustainability as crucial to the success of the energy policy, by resorting to instruments of fiscal policy, to some revenue generated in the energy sector by CO2 emission allowances, and other revenues generated by the renewable energy sector, for the creation of a tariff equilibrium fund that enables a continuous renewable energy growth process (3).

Betting on renewable energy

As part of the European commitments, Portugal assumed a goal of final energy consumption of 31% from renewable sources in 2020. The national renewable production basis is based on the combination of hydroelectric and wind power. However, the national vision for this sector is the diversification of renewable energies portfolio, by betting in mature technologies that can give an immediate contribute to the electricity generation system. Plus, also in research and development of technologies, and projects in testing/demonstration phase with potential to create value in the national economy.

The procedures for the power assignments to demonstration projects in new technologies will be streamlined in order to use the results to support the capacity expansion options linked to a strategy of new industrial clusters creation.

Within the framework of Climate and Energy Package for Portugal and in order to promote the integration of renewable energy sources, the ENE 2020 also provide the possibility of the market of origin guarantees be used.

In the specific case of the utilization of biogas in Portugal, the ENE 2020 highlight the importance of promote the potential exploration associated to biogas, in particular to landfill biogas and biogas from anaerobic digestion of waste and effluents, whose enabling should be associated with the internationalization of environmental benefits.

The Portuguese National Energy Strategy also includes the promotion of biofuels utilization. The European directives regarding the biofuels will be followed, in particular in terms of the definition of the sustainability criteria and ensuring the maintenance of the highest quality standards in the fleet operation. The use of endogenous resources for biofuels production will also be propelled (1).

4.1.2 National Renewable Energy Action Plan (NREAP)

Following the Directive 2009/28/EC of the European Parliament and of the Council of 23rd April 2009 regarding the use promotion of energy from renewable sources, the National Renewable Energy Action Plan (NREAP) to Portugal was prepared for the year 2020 (4).

The Directive 2009/28/EC sets for Portugal the goal of 31% for the quote of renewable energies in the gross final energy consumption to Portugal, to be achieved by 2020. This implies a raise of 11.3% over the value recorded in the year 2005, which was 19.8% (4)

In sectorial terms, Portugal has as aim to achieve a 10% quota of renewable energy in the transport sector, a 30.6% quota in the heating and cooling sector, and a 60% quota on electricity (4).

According to the available data regarding the reference year, 2005, in the transports sector was verified a contribution of renewable sources of 0.2%, almost marginal. (4)

Promoting the use of biomethane in NREAP

The NREAP provides the evaluation of biomethane potential in Portugal and its alternative investments. The study should be performed in a technical and economic perspective, considering international best practices (1).

In addition, it is also provided the regulation to the necessary specifications for the injection of biomethane from biogas on the network GN. This measure will enable the use of biogas/biomethane in a general way and for purposes other than electricity production (1).

4.2 Biomethane grid injection in energy and renewables laws

The injection of biogas in the form of biomethane on the NG network is provided for in Decree-Law 231/2012 of 26 October. The technical requirements of quality and safety of biogas are defined, as well as the procedures of licensing of the respective treatment facilities and its injection in the infrastructures of Portuguese National Natural Gas System and its acquisition scheme for ordinances (1).

The Decree-Law establish that the disposals regarding the access to transports and distribution networks and others infrastructures of SNGN (Portuguese National Natural Gas System), as well as to commercialization are applicable to biogas and to biogas from biomass or other types of gas, as far as those gases can be injected and transported in natural gas networks, from the perspective of technical, quality and safety.

The definition of the technical, quality and safety requirements of the biogas, the gas from biomass and other types of gas, as well as the licensing procedures of the treatment facilities of these gases in raw state and its injection in the infrastructures of Portuguese National Natural Gas System will be approved by ordinance of the Government members responsible for the areas of energy and environment, after hearing Energy Services Regulatory Authority and the operator of RNTGN (Portuguese national network transportation of natural gas).

Similarly, also the acquisition scheme of biogas, of gas from biomass and other types of gas will be defined by ordinance of the Government member responsible for the areas of energy, after hearing Energy Services Regulatory Authority, Portuguese Environment Agency and the operator of RNTGN (Portuguese national network transportation of natural gas), in the scope of their assignments.

4.3 Biomethane grid injection basic tariff elements

There is no tariff code for biomethane grid injection in Portugal. The Natural Gas Networks access tariffs are non-discriminatory, being defined by Energy Services Regulatory Authority (ERSE). ERSE is a public corporate body which performs its duties independently, within the framework of the law (5).

However, the current legislation contemplates electricity production from renewable energy sources, including biogas, with the application of feed-in tariffs to power grid connection at or less than 250kW.

Natural Gas Networks access tariffs

For each activity of Natural Gas Sector value chain (acquisition / importing, reception / storage / re-gasification, underground storage, transmission, distribution and sales), ERSE determines the profit allowed in accordance with the methodologies of regulation defined in the Tariff Code (5).

The profit allowed gives rise to the natural gas tariffs which are defined and published annually by ERSE, in accordance with what is established in the Tariff Code (5).

- The various stakeholders in the Natural Gas Sector are involved in the process for the approval of the tariffs and the Tariff Code.
- The LNG (Liquefied Natural Gas) Reception, Storage and Re-gasification tariff must provide profits for the LNG reception, storage and re-gasification activities.
- The tariff for the Underground Storage of Natural Gas must provide profits for activities related to the underground storage of natural gas.

- The tariff for the Global Use of System must provide profits for activities related to the global technical management of the system of the natural gas transmission network operator.
- The tariff for the Use of Transmission Network must provide profits for transmission activities of the High Pressure natural gas transmission network operator (applicable to natural gas deliveries at High Pressure, Medium Pressure and Low Pressure).
- The tariff for the Use of Distribution Network must provide profits for natural gas distribution activities at Medium Pressure (applicable to natural gas deliveries at Medium Pressure and Low Pressure) and at Low Pressure (applicable to natural gas deliveries at Low Pressure).
- The Energy tariff must provide profits for activities related to buying and selling of natural gas to supply wholesale and retail last resort suppliers.
- The Retail Commercial tariff must provide profits for activities related to the supply of natural gas. They are applied by wholesale last resort supplier to so-called large clients supplied in the Regulated Market and are applied by retail last resort suppliers to the remaining clients supplied in the Regulated Market.

The Networks Access tariffs are paid by each natural gas consumer in the Free Market or in the Regulated Market and are obtained through the sum of the tariffs for the Global Use of System, the Use of Transmission Network and the Use of Distribution Network, and are included in the final tariffs of each supplier. These tariffs are approved and published annually by ERSE (5).

The last resort supplier's End User tariffs are obtained by adding the prices of the Networks Access tariffs, applicable to the delivery in question, to the prices of the Energy tariff and the Retail Commercial tariff, and are only applied to Regulated Market consumers. In the Energy tariff applied by the last resort supplier, in addition to the natural gas acquisition costs, costs of the reception, storage and re-gasification of the natural gas and underground storage costs of the natural gas are also included. These tariffs are approved and published by ERSE (5).

The prices practised in the Free Market are determined by each supplier and negotiated individually with each client (5).

Renewable electricity feed-in tariffs

The legal system applicable to electricity production from renewable resources, through minigeneration and microgeneration unites, approved by Decree-Law no. 34/2011 of 8th March and by Decree-Law no. 118-A/2010 of 25th October, respectively, provide for a subsidized regime based on a predefined reference tariff subject to the application of an annual reduction percentage also prefixed (6) (7).

The following table shows the main components of the subsidized regime applicable to electricity production, from renewable resources, through minigeneration and microgeneration units. The values shown are for the tariff applicable to one unity production, in 2013, to the first production year (6) (7).

Table 6. Subsidized tariffs applicable to minigeneration in 2013 (6)

	Minigeneration		
Installed capacity	≤20 kW	]20; 100] kW	]100; 250] kW
Reference feed-in tariff	151 €/MW	(1)	(1)
Feed-in tariff for solar power	151 €/MW	100% reference feed-in tariff	100% reference feed-in tariff
Feed-in tariff for wind power	121 €/MW	80% reference feed-in tariff	80% reference feed-in tariff
Feed-in tariff for hydropower	76 €/MW	50% reference feed-in tariff	50% reference feed-in tariff
Feed-in tariff for biogas power	91 €/MW	60% reference feed-in tariff	60% reference feed-in tariff
Feed-in tariff for biomass power	91 €/MW	60% reference feed-in tariff	60% reference feed-in tariff
Feed-in tariff for hydrogen fuel cell power	(2)	(2)	(2)

(1) Remuneration based on the higher tariff that results from the larger discount offers to the reference tariff determined in the respective levels.

(2) Remuneration based on the applicable tariff to the renewable energy type used for hydrogen production.

Table 7. Subsidized tariffs applicable to microgeneration in 2013 (7)

	Microgeneration	
Installed capacity	≤3,68 kW	]3,68; 5,75] kW
Reference feed-in tariff	196 €/MW	(1)
Feed-in tariff for solar power	196 €/MW	(1)
Feed-in tariff for wind power	157 €/MW	(1)
Feed-in tariff for hydropower	78 €/MW	(1)
Feed-in tariff for biogas power	137 €/MW	(1)
Feed-in tariff for biomass power	118 €/MW	(1)
Feed-in tariff for hydrogen fuel cell power	(2)	(1)

(1) The sale tariff of electricity is equal to the energy cost of the tariff applicable by the supplier of the last supply resource to the consumption installation.

(2) Remuneration based on the applicable tariff to the renewable energy type used for hydrogen production.

4.4 Main legal barriers and recommended amendments

The delay regarding the publication of specific legislation for the production and use of biomethane affect the development of this sector and the market stimulation of this energy source.

As referred in section 2, the definition of the technical, quality and safety requirements of the biogas, the gas from biomass and other types of gas, as well as the licensing procedures of the treatment facilities of these gases in raw state and its injection in the infrastructures of Portuguese National Natural Gas System, and the acquisition of these products has not been yet regulated by ordinance.

In order to promote the production and use of biomethane, it is essential to conclude the regularisation process of this sector appropriately, minimizing bureaucratic processes and creating incentive and/or financing systems that ensure the competitiveness of biomethane compared to conventional energy carriers.

Next there are shown some points considered as priorities for the injection of biomethane in the national gas network, and for the use of this product.

Evaluate the endogenous potential and create technological competences.

Promote research and development of biomass resources in Portugal for biomethane production and methanisation technology more appropriate to the available resources. Thus, the characteristics of the available resources on national territory can be specified, and the specifications of technologies more appropriate to the production process can be defined.

Encourage the creation of technological skills for installation and exploration of biomethane production for injection in the natural gas network in order to determine the technical, energetic and environmental conditions more appropriate.

Definition of the technical, quality and safety requirements of biomethane for injection in natural gas network

According to the Directive 2009/73/EC of the European Parliament and of the Council of 26 June 200, Member States should ensure that, taking into account the necessary quality requirements, biogas and gas from biomass or other types of gas are granted non-discriminatory access to the gas system, provided such access is permanently compatible with the relevant technical rules and safety standards. These rules and standards should ensure that these gases can technically and safely be injected into, and transported through the natural gas system and should also address the chemical characteristics of these gases (8).

Regulate and ensure an easy access to the electricity and gas grids

Ensure the absorption capacity of electricity produced from biogas, by the national electricity network.

Similarly, review the link regulation to natural gas network specifying the access conditions from the part of installations producers of biomethane.

Guarantee the links of these installations to the national natural gas network. Priority for biogas, guarantee, non discrimination and free access must be secured.

Assess the need for infrastructure

The project's strategy considers the holding of a set on investments that will support the achievement of the expected goals. It is the case of intangible investments that are based on a strong component of studies, specifications and drafts of technological systems that allowed overcoming the absence of specific experience in biomethane production, since this is a pioneer project in Portugal.

Ensure financial support and security of income

As biogas is particularly capital intensive, creation of long term financing mechanisms and security of income is essential (9).

Financial support instruments are particular relevant in first stages of the sector development, namely for building needed infrastructures such as biogas pipelines, upgrading stations, biogas plants, heat networks to use the heat from cogeneration plants

The legal requirements should encourage the cooperation between private sector and local authorities, as well as attracting investors for infrastructures development.

Ensure the competitiveness of biomethane

The recent submission of the natural gas to tax on petroleum fuels can be complemented with a remuneration system able to ensure biomethane competitiveness with regard to fossil natural and other energy sources (renewable and non- renewable).

A system of subsidized tariffs or benefits can be created to value the use of biogas and biomethane, similarly to the remuneration system applicable to renewable production of electricity in minigeneration and microgeneration, for example.

The implementation of a green certificates system can also be an element of strengthening of the biomethane competitiveness.

In the context of the use of biogas for electric energy production, the application of thermal energy in commercial and industrial terms can also be a contribution to the economic sustainability of the biogas/biomethane sector.

Incentives for biomethane vehicles

Biomethane cars have especially low emissions (NOx, particulates) and should be promoted by providing advantages such as low tax (upon buying them and using them) and lower parking fees.

These incentives should be extended to public transport sector. Bus fleets with steady and regionally bound fuel consumption are a perfect first step to introduce biomethane and biomethane filling stations to urban areas.

A significant tax reduction for company cars running on biomethane would offer a great market for clean cars (9).

Ensure the harmonization of the regulation sector with other regulation and strategic plans

Biogas project developers have to face many regulations related to waste management, soil protection, prevention of water table pollution by nitrogen, and others. The excess of such non technical barriers is a main obstacle to a quicker implementation of biogas plants in Europe (9).

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5 Strategy for biomethane grid injection and use in Latvia

Majority of energy in Latvia is generated using natural gas and other fossil fuels like oil products. In 2009 the share of renewable energy sources (RES) in the gross domestic energy consumption of Latvia was 35.5% [1]. According to the Directive 2009/28/EC, The national target for Latvia is to increase the share of renewable energy in gross final consumption of energy (GFCE) from 32.6% in 2005 to 40% in 2020 [2].

There are more than 40 biogas plants operating in Latvia. However the share of biogas in the total energy generation is very small. Nevertheless, the potential of biogas in Latvia is high. Some studies state the biogas potential at 179.25 million m^3 per year [3]. Biogas is mostly used in combined heat and power (CHP) plants to generate electricity that is sold for the feed-in tariff. However at the moment the further support for renewable electricity in Latvia is under discussion and if support is reduced, biogas plant owners might start thinking about biogas upgrading to biomethane.

5.1 Biomethane grid injection in energy strategic documents and papers

Currently there is is only one gas supplier in Latvia. Natural gas supply is provided solely by JSC „Latvijas Gaze“. Latvian gas transportation system has connections with three countries – with Russia, Estonia and Lithuania. To all three Baltic countries gas is supplied from Russia and there are no other alternative supply options. On the basis of what is stipulated in the share-acquisition contract, JSC “Latvijas Gaze” has been granted exclusive rights for the transmission, distribution and storage of natural gas up to 2017, and exclusive rights to utilise the Incukalns underground gas storage facility [2]. Basically the natural gas market liberalization in Latvia is legally and politically difficult process and unless the market is not liberalized, the establishment of biomethane market using natural gas grid infrastructure is almost impossible.

Regarding biomethane in Latvia legal framework conditions are not set. In policy planning documents and legal acts biomethane is not considered as substitute for the natural gas and is not recognized as suitable transport fuel. In the National Renewable Energy Action Plan Latvia state that since JSC “Latvijas Gaze” has exclusive rights for the transmission, distribution and storage of natural gas up to 2017, there is no sense to plan actions related to extending existing gas infrastructure and to streamline the integration of gas generated from biogas (biomethane) [2].

In Sustainable Development Strategy of Latvia until 2030 it is mentioned that biogas has good perspectives in order to ensure transport sector with energy, however nothing is mentioned about biogas upgrading. One of the long-term priorities in the transport sector is transition to the use of more environmental friendly vehicles. It is stated that pilot projects for adoption of the transport infrastructure to the use of locally produced biogas and biofuels should be supported [4].

We may conclude that Latvian government do not have a clear strategy regarding biomethane, however, if this sector will be developed, it will mostly be targeted to the direction of using biomethane in transport.

5.2 Biomethane grid injection in energy and renewables laws

Currently, there are no technical standards for third party access to the natural gas grid. Also nothing exists on potential biomethane tariff calculation mechanisms.

The attempt to solve this issue has been made by developing the new Law on Renewable Energy. The draft Law on Renewable Energy intended to set the right for biogas producers to receive biogas certificates and to gain right to access natural gas grid to transfer biomethane in natural gas pipes if the quality requirements are fulfilled [2]. The draft law was discussed in 2011, however it never went through the adoption process and the latest decision was to

replace this Law by a new Law on Green Economy. However the new proposal does not include any more sections related to biogas and biomethane use.

5.3 Biomethane grid injection basic tariff elements

As discussed above, it is not legally possible to inject biomethane in the grid; therefore even the basic tariff elements for biomethane grid injection do not exist in Latvia.

For natural gas the regulation of gas tariffs is done by the public regulator - Public Utilities Commission (PUC). Regulation of gas tariffs is strongly related to the monopoly position of JSC "Latvijas Gāze" in local natural gas market. The majority of factors affecting gas tariffs have link with a procurement price of gas and they are not under control to JSC "Latvijas Gāze". Cost of natural gas in the final tariff of realization is in average about 80%, and the remaining 20% are expenses of adjustable services. Expenses of adjustable services are confirmed by regulator for the certain period of time when tariff is valid, and do not change. Therefore elements that are affecting those 20% of expenses are not essential [5].

Basic factors, which have an impact on natural gas tariffs, are following:

1) Quotation changes of oil products;
2) EUR/USD quotation changes, which is set by ECB;
3) Changes in procurement structures (if gas is supplied from Russia, or from the underground storage facility);
4) difference between projected demand and actual use of natural gas;
5) Implementation of “Take or pay” rule set in the contract with OJSC Gazprom [5].

The applied differential natural gas sale end-user tariffs consist of two parts: fixed regulated service tariffs and the natural gas sale price, which changes with a step of 5 Ls/thousand nm^3 depending on the actual natural gas purchase costs. For users with annual natural gas consumption over 25 000 nm^3, the applicable natural gas sale end-user tariff changes monthly, whereas for users with the annual natural gas consumption up to 25 000 nm^3 changes twice a year - on January 1 and July 1 [6].

5.4 Main legal barriers and recommended amendments

The main legal barrier is the lack of legal framework for biomethane grid injection. However, to overcome the legal barriers, first the political barrier – liberalization of natural gas market – must be overcome.

If this is done, the set of legal documents must be elaborated, including:

- Provision of rights to the third party access to the natural gas grid
- Technical standards for biomethane injection
- Methodology and system for the biomethane tariff calculation
- Other incentives for biomethane as renewable fuel

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