RENEWABLE GAS
FRENCH PANORAMA
2016
France’s Energy Transition for Green Growth Law (LTECV) enacted in 2015 established an ambitious national objective: renewable gas must account for 10% of gas consumption by 2030. By means of the Decree of 27 October 2016, the Multi-annual Energy Programme (PPE), which is derived from this law, sets out production targets for biomethane injection of 1.7 TWh/year in 2018 and 8 TWh/year in 2023. In particular, these objectives are based on ADEME’s (French Environment and Energy Management Agency) Biomethane 2030 roadmap, which establishes a potential for biomethane injection of 30 TWh/year. This theoretical potential would represent the yearly average consumption of 133,340 buses running on Bio-NGV.

All stakeholders in the biomethane anaerobic digestion sector, the first renewable gas production chain to date, are working together to improve biomethane production and the progressive decarbonation of the natural gas network. In order to report on sector growth, GRDF, GRTgaz, SPEGNN, SER and TIGF are continuing to collaborate and publish detailed inventories of biomethane injection on regional, national and European levels.

→ SECONDOVERVIEWOFRENEWABLEGASBEINGINJECTED INTOTHEFRENCHNATURALGASNETWORK

The second edition of the “Overview of Renewable Gas” is an update of the data from network operators registered in France on 31 December 2016. This annual publication presents sector indicators in the form of computer graphics. All the information is compared with the French ambitions for renewable gas production in the years to come.

This overview includes news on the sector, economic and regulatory aspects, a European element and the presentation of biomethane injection projects. This edition also includes a presentation of the different classes of inputs and an update with regard to the development of other renewable gas production sectors.

→ RENEWABLEGASINJECTION IN PROGRESS IN 2016

In 2016, 215 GWh were injected into the gas network, compared with 82 GWh in 2015, which represents an annual increase of 162%. Biomethane plants had a maximum annual injection capacity of 410 GWh at the end of 2016, compared to 279 GWh at the end of 2015. The difference between the quantities injected and the installed capacity comes almost exclusively from the fact that many installations were brought into operation at the end of 2016.

2016 was also marked by regulatory developments, notably with the ordinance of 7 April 2016 validating the principle of using calls for tender to meet targets set for the biomethane sector development in France, these being complementary to existing support mechanisms. Other regulatory changes are expected by professionals, such as the adaptation of the coefficient for sites that have never recovered biogas under a purchase contract, the elimination of double recovery in landfill, switching from a monthly step to an annual step in the purchase contract between producer and gas supplier, the possibility of using waste locally to heat the digester, and the subvention up to 40% of gas connection costs. It will also be important to consider extending the contract period from 15 to 20 years, as it is the case for electricity produced from biogas since the Decree of 14 December 2016.

These evolutions are the result of the investment and collaboration of all sector stakeholders, in particular within the Biomethane Injection Working Group of the Biogas National Committee. Renewable gas professionals are continuing their efforts to generate and complete an increasing number of projects.

Nevertheless, it is important to consolidate 2016 developments and to endorse pending regulatory developments to ensure that PPE injection targets are met.

2. Average consumption of GRDF customers = 12 MWh/year and that of a bus/truck running on Bio-NGV = 225 MWh/year.
3. To date, no biomethane injection projects exist in overseas territories and communities or in Corsica (network operators).
4. 1 TWh = 1,000 GWh = 1,000,000 MWh = 1,000,000,000 kWh.
THE GAS NETWORK IN SUPPORT OF THE ENERGY TRANSITION

To meet the objectives set by the French State, distribution and transport networks are developing solutions to maximise volumes injected while guaranteeing the safety and security of the French gas network. The networks will therefore also be ready to accommodate new generations of renewable gases produced by gasification and power-to-gas technologies.

The injection of renewable gases into the natural gas network requires network operators to have specialised teams in various sectors: detailed or feasibility studies, technical connections, interconnection works, network management, etc. Moreover, stakeholders in the entire value chain in the renewable gas sector will continue to improve their skills and should create between 2,000 and 3,000 direct jobs that cannot be relocated by 2020, as demonstrated by the “Jobs in the biogas sector from 2005 to 2020” study by ATEE in 2011.

THE MESSAGE FROM OPERATORS OF DISTRIBUTION AND TRANSPORT NETWORKS

“2013 was a pivotal year for France with the end of Lacq’s natural gas injection into the TIGF transmission network and the arrival of the first biomethane injection in the agricultural world. Gas has been flowing through pipes since this biomethane was first produced and the injection into the French gas networks is now an anchored reality. This already provides significant feedback for network operators and allows them to make a positive assessment of the sector.

With regard to injection stations (interface between the biomethane production site and the network to which it is connected), we can now say that their operation is reliable and that actual availability rates, close to 97%, are higher than the contractual commitments of 95% taken by the operators.

Moreover, no matter the type of biomethane production site and the type of feedstock used for their production, the quality of gas measured complies with prerequisites and, in general, production is controlled and in line with goals.

Another lesson, is about built-up of capacity production of the sites. While it was anticipated that it could take several months, if not years, experience shows that, during the first few weeks, sites reach 80% of the maximum production capacity to very quickly reach a value closer to 100%.

In conclusion, operators agree that producers, as well as the technological and industrial solutions implemented, have proven their worth. Trust is in order.”

5. Source: REX GRDF Study
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1. Biomethane: an essential renewable gas

1.1. From biogas production to biomethane injection: a solution for reducing greenhouse gas emissions in the future

The controlled production of biogas is called anaerobic digestion. It is a process of animal and/or plant organic matter being decomposed by micro-organisms. It produces a gaseous mixture that is saturated with water and composed of 50-70% of methane. Organic matter can come from various sectors: agricultural, industrial, catering waste, municipal waste, gas from landfill, etc. Once collected and transported to the anaerobic digestion site, the organic matter is sorted, stirred and heated for a few weeks in a digester (oxygen-free enclosure). This organic matter anaerobic digestion process produces biogas that can be recovered by combustion in the form of heat and/or electricity. This biogas can also be upgraded in order to reach the same quality as natural gas. It is then called “biomethane” or “biomethane fuel” / “Bio-NGV” when it is intended to supply vehicles. Regardless of the production process used, this upgrading step is essential to remove impurities and undesirable components from the biogas, i.e. carbon dioxide, hydrogen sulphides and water. Once upgraded and odourised, biomethane can be injected into the natural gas networks.

Anaerobic digestion has the added value of producing a renewable energy or fuel but also of providing an alternative process for treating organic waste. By collecting this waste to produce biomethane, their environmental impact is reduced by avoiding greenhouse gas (GHG) atmospheric emissions and by increasing their energy potential. In this respect, ADEME considers biomethane fuel recovery to be an excellent form of biogas recovery because it has significant potential to reduce GHG emissions compared to conventional organic waste management and disposal systems (composting, storage). Biogas production also produces a co-product called digestate. This is a natural organic fertiliser and it can be used on agricultural land and therefore substitute mineral fertilisers of fossil origin.

Given all these advantages, biogas production has been part of the renewable energy development strategy in France since 2011. France’s Energy Transition for Green Growth Law (LTECV) reinforces the ambitions attributed to the biomethane injection sector.

6. Gas produced in landfills, mainly resulting from the anaerobic degradation of biodegradable organic matter.
France has 548 biogas production units, 26 of which inject their purified biogas, biomethane production into natural gas network. While the number of biomethane injections may still appear to be low in comparison with the total number of biogas plants, one must remember that injection has only been authorised for 5 years – the first Biomethane production plant was inaugurated in November 2011. Since 2015, the Biogas National Committee, created on the initiative of the Ministry of the Environment, Energy and the Sea, brings together the stakeholders of the sector in working groups, in particular on biomethane injection and on BioNGV used in transport.

These groups allow:
- stakeholders to share their experiences and to express their expectations in order to catch a glimpse of possible changes in the State’s actions;
- for strategies and actions implemented to help the sector to be shared by the government.

**From anaerobic digestion to injection: distribution of roles**

*Source: GRDF*
→ **FIRST AMBITIOUS OBJECTIVES FOR BIOMETHANE**

The Decree governing the Multi-annual Energy Programme (PPE) under the France’s Energy Transition for Green Growth Law (LTECV, Article 176) was published on 27 October 2016. Objectives are based on two roadmaps – the first of which lasts three years (2016-2018) and the second, five years (2019-2023). This is the first regulatory text providing the biomethane sector with developmental objectives. The developmental objectives for biomethane injection into the gas network in terms of overall production are: 1.7 TWh in 2018 and 8 TWh in 2023. Despite this, the current rate of projects is not meeting the government’s target of 8 TWh of biomethane injected in 2023, set by the PPE.

→ **BIOMETHANE TO REDUCE GREENHOUSE GAS EMISSIONS**

A biomethane life-cycle analysis (LCA) carried out by GRDF and ADEME showed that developing the biomethane sector would avoid the emission of 750,000 tonnes of CO₂ in 2020 on the hypothesis of 4 TWh injected (based on projects already identified to-date, the biomethane injection potential is currently around 3 TWh). Cumulatively, the emission of over 2 M tonnes of equivalent CO₂ could be avoided thanks to the development of the biomethane sector at this time. In other words, for every megawatt hour (MWh) of biomethane produced, injected and consumed, a saving of 188 kg of equivalent CO₂ is achieved.

**1.2. Typology of biomethane injection sites and types of feedstock used for the production of biomethane**

→ **TYPOLOGY OF BIOMETHANE INJECTION SITES**

**AUTONOMOUS AGRICULTURAL**
- by one or more farmer(s) or by a structure owned mostly by one or more farmer(s)
- carrying out anaerobic digestion of more than 90% of agricultural materials from agricultural exploitations

**TERRITORIAL AGRICULTURAL**
- carried out by a farmer, a collective of farmers or by a structure, mostly owned by one or more farmer(s)
- carrying out anaerobic digestion of more than 50% (by mass) of materials from the agricultural exploitations
- including waste from the territory (industry, treatment plants, etc.)

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LIVESTOCK EFFLUENTS (SLURRY, MANURE)
Slurry (made of liquid and solid animal excrements) and manure (mixing manure with animal litter: straw, hay, etc.) account for the majority of the effluent. Livestock effluents are produced by livestock farming, in particular cattle and pigs, and are located in livestock buildings.

ENERGY CROPS
These are crops grown primarily to produce energy. They can be used as feedstock in anaerobic digestion units that will use the energy power of these plants.

TERRITORIAL INDUSTRY
- carried out by a project developer or one or more industrialist(s)
- including waste from the territory (industry, treatment plants, etc.)
- carrying out anaerobic digestion of agricultural and non-agricultural exploitations

HOUSEHOLD WASTE AND BIOWASTE
- carried out by a community, an agglomeration, a waste treatment trade union, one or more industrialist(s)
- carrying out anaerobic digestion of the organic part of household waste, sorted in the factory or collected separately, treating bio-waste

SEWAGE SLUDGE
- urban and industrial

LANDFILL

VARIOUS CLASSES OF INPUTS USED TO PRODUCE BIOMETHANE

LIVESTOCK EFFLUENTS (SLURRY, MANURE)

Slurry (made of liquid and solid animal excrements) and manure (mixing manure with animal litter: straw, hay, etc.) account for the majority of the effluent. Livestock effluents are produced by livestock farming, in particular cattle and pigs, and are located in livestock buildings.

ENERGY CROPS
These are crops grown primarily to produce energy. They can be used as feedstock in anaerobic digestion units that will use the energy power of these plants.

Decree No. 2016-929 of 7 July 2016 sets maximum supply thresholds for anaerobic digestion facilities. Non-hazardous waste or raw-material anaerobic digestion installations can be supplied by food crops (cereals and other plants that are rich in starch, sugar, oilseeds, legumes, for either human or animal consumption) or energy crops grown for that purpose, up to a maximum 15% of the total gross tonnage of feedstock per calendar year. These feedstock thresholds are calculated over three rolling years.
**INTERMEDIATE ENERGY CROPS / CATCH CROPS**

An Intermediate Energy Crop is a crop planted and harvested between two main crops in a crop rotation. Intermediate energy crops can be harvested for use as a feedstock for an agricultural anaerobic-digestion unit.

A catch crop is a temporary fast-growing plant designed to protect plots between two main crop cultures. Covers are mandatory in some regions or areas because of nitrate pollution. By using them for their growth, cover crops trap the remaining nitrates at the end of the previous main crop.

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**CROP RESIDUE**

Agricultural waste from crops (e.g. corn stover).

**AGRO-FOOD INDUSTRY SLUDGE AND CO-PRODUCTS**

Agro-food industries generate numerous co-products during the technological processes they use to develop finished products (dairy products, meat, grain products, fruit and vegetables, etc.). Once the product is valued, it will be called a “co-product”.

Agro-industrial sludge emerges from slaughterhouses, dairies, cheese factories, biscuit factories, breweries, canneries, etc.

**ANIMAL BY-PRODUCTS (ABP)**

European Regulation (EC) No 1069/2009 classifies animal by-products into three categories. It defines the manner in which materials from each category must or can be removed or recovered for certain uses in order to maintain high hygiene levels.

**HOUSEHOLD WASTE**

This refers to waste from households and similar waste. Waste generated by municipal services, sewage waste, street-cleaning waste, from markets do not fall within this scope.

**GREEN WASTE**

Green waste (GW) refers to vegetable waste resulting from maintaining and renewing public and private green spaces (parks and gardens, sports fields, etc.), from local authorities, public and parapublic organisations, private companies and individuals.

**OTHER (SLUDGE FROM WASTEWATER TREATMENT PLANTS, ETC.)**

Sludge treated in wastewater treatment plants is the result of human activity. Their use for the production of biomethane has been authorised since 2014.
2. Biogas injection: key figures, development and challenges

2.1. Key figures 2016

- **215 GWh renewable production**
  - +162% in 2016

- **0.05% of natural gas consumption**
  - +146% in 2016

- **410 GWh/year maximum capacity**
  - +47% in 2016

- **26 biomethane injection sites**
  - +53% in 2016

**TOTAL NUMBER OF SITES IN SERVICE AND ANNUAL CHANGE**

- Biogas injection sites injected 215 GWh into natural gas networks (+162% in one year).
- The annual average gas consumption coverage rate by the production of the biogas injection chain is close to 0.05%, i.e. +146% in 2016. The France’s Energy Transition for Green Growth Law (LTECV) has fixed this rate at 10% for 2030.
- The list of production plants consists of 26 injection sites as of 31 December 2016, compared with 17 installations as of 31 December 2015 (+53% in one year). These new plants increase the installed capacity by 47%.

QUEUED PROJECTS AS OF 31 DECEMBER 2016 (CF.4.1)

- A project is included in the connection queue when it reaches the Phase II study order: feasibility studies for transmission system operators (TSO) and detailed study for distribution system operators (DSO). At this stage, a project will take 2 to 5 years to complete.
- The cumulative maximum production capacity of the 241 projects registered in the biomethane injection plant connection queue is 5 TWh/year. It corresponds to the average annual consumption of 416,000 customers or 22,000 buses or trucks running on Bio-NGV.

2.2. Development framework

Significant targets have been defined by France and Europe for reducing greenhouse gas emissions, energy efficiency and developing the share of renewable energies in total energy consumption. Biomethane injected into gas networks will help achieve these objectives.

2.2.1. Regulatory framework

In 2010, the National Action Plan (PNA) for renewable energy laid the foundations for a new feed-in-tariff for biomethane injected into natural gas networks, which is similar to that which was established for electricity. In November 2011, the 8 Decrees and Orders allowing the biomethane injection sector were published. Producers can therefore benefit from two economic tools:
- a regulated and guaranteed feed-in-tariff for 15 years;
- a guarantee of origin system, which ensures biomethane for consumers can be traced.

INTRODUCTION OF A FEED-IN-TARIFF FOR BIOMETHANE INJECTED INTO NATURAL GAS NETWORKS

Thanks to this system, a producer is guaranteed to sell the biomethane produced by its installation to a natural gas supplier at a rate fixed by Decree for a period of 15 years. The producer will benefit from a feed-in-tariff of between 46 and 139 €/MWh. This tariff depends on the production facility’s size, referred to as the maximum capacity of biomethane production (expressed in Nm³/h) and the nature of the waste or organic matter being treated. For anaerobic digestion facilities, feed-in-tariff are made up of a reference tariff and a “feedstock” premium.

According to Decree No. 2016-411 of 7 April 2016 on the various adaptation measures in the gas sector, the State may use tenders in addition to feed-in-tariff to support the biomethane injection sector.

10. The maximum production capacity expressed in TWh/year was calculated based on the following assumptions:
   Maximum capacity C_{max} extracted from the capacity register expressed in m³(n)/h, HHV = 10.9 kWh/m³(n) and 8,200 hours of annual operation.
GUARANTEES OF ORIGIN: GUARANTEE OF BIOMETHANE TRACEABILITY

THE GUARANTEES OF ORIGIN SYSTEM

Biomethane injected into a network is physically consumed in an area close to its point of injection. However, consumers located anywhere in France (community, private, industrial, etc.) may wish to buy "green gas" through their supply contract. For this, guarantees of origin (GO) make it possible to disconnect the physical consumption of the biomethane molecule, from its contractual sale to a consumer. The GO system ensures that the biomethane injected into natural gas networks can be traced, as well as related operations.

The GO Register is a tool that records quantities injected, exchanged, sold and thus traces each biomethane molecule produced. GRDF responded to the call for tender launched in 2012 by the Ministry of the Environment, Energy and the Sea to create and manage this register and was chosen to fulfil a Public Service Delegation, for a period of 5 years.

To access the guarantees of origin website, go to: https://gobiomethane.grdf.fr/

THE TRANSACTIONS

Biomethane producers enter into a purchase contract with a gas supplier of his choosing. The guarantees of origin (GO) are given to the supplier: each MWh of injected biomethane gives right to the creation of one GO. Each Guarantee of Origin created will be entered in the register by the gas supplier who is purchasing the biomethane. Once established, GOs are valid for 24 months. GO transactions between suppliers are carried out through a transfer between account holders. However, the market is not open to traders. When a gas consumer uses green gas supply, the GO is deleted from the register.

To sell their biomethane, producers may contact any gas supplier, as defined by the Energy Code, and in particular Article L.443-1.

List of authorised suppliers (to sell gas):
http://www.developpement-durable.gouv.fr/sites/default/files/listefourgaz%20novembre%202016.doc

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Among the suppliers whose gas supply activity in France is subject to ministerial authorisation, some have declared to the Ministry of the Environment, Energy and the Sea that they are interested in buying biomethane. The list of these suppliers, available on the website of the Ministry of Energy, is detailed below.

List of suppliers interested in purchasing biomethane

![List of suppliers interested in purchasing biomethane](http://www.developpement-durable.gouv.fr/sites/default/files/Liste%20des%20fournisseurs%20int%C3%A9ress%C3%A9s%20par%20l%E2%80%99achat%20de%20biom%C3%A9thane.pdf)

THE COMPENSATION MECHANISM ASSOCIATED WITH FEED IN TARIFFS

A compensation mechanism was set up in November 2011 to compensate suppliers for expenses incurred through purchasing biomethane, namely:

1. The additional cost of the biomethane purchase price in relation to the price of natural gas on the wholesale market;
2. Related costs: the cost of reporting the guarantees of origin, management costs of the clearing house, and the costs of managing natural gas suppliers for purchasing biomethane.

This compensation mechanism is managed by the Caisse des dépôts et consignations (CDC).

Act No. 2015-1786 of 29 December 2015 on 2015 Finances (LFR 2015) introduced an energy taxation reform, notably on how public service charges for electricity and gas are to be financed.
Until 31st December 2015, the compensation mechanism for biomethane injection development was supported by a “biomethane contribution” paid by all French gas consumers. The elimination of this contribution was offset in 2016 by an increase in the Domestic Consumption Tax on Natural Gas (TICGN) paid by French gas consumers subject to tax. The rate of the TICGN was set at 4.34 €/MWhHHV in 2016, excluding exemption (5.88 €/MWhHHV in 2017). In 2016, a fraction of the product (2.16%) was allocated to the earmarked account. The TICGN, recovered by Customs, was then transferred to the earmarked account or to the general State budget, which, in conjunction with the Specifications, provides compensation payments to gas suppliers bearing the aforementioned costs.

On 1st January 2017, following the adoption of the Finance Act 2017 (No. 2016-1917 of 29 December 2016), the earmarked account will now be provided with a significant share of the Domestic Consumption Tax on Energy Products (TICPE), a large share of which is collected from petroleum products (€6.9 billion from over €17 billion collected nationally by this tax will go to the earmarked account). In addition, the Energy Transition account is furthermore financed by a fraction of the domestic tax on coal, lignite and coke adding up to the amount of 1 million Euros. The taxes used in 2016 on electricity and gas consumption remain applicable, but their product is paid into the general State budget.

The decision of the Regulatory Commission of Energy (CRE) of 13th July 2016 on the assessment of public energy service charges for 2017 specifies the costs associated with developing biomethane injection into gas networks.

<table>
<thead>
<tr>
<th>Earmarked account</th>
<th>Expenses recorded 2015</th>
<th>Provision update 2016</th>
<th>Projected cost 2017</th>
</tr>
</thead>
<tbody>
<tr>
<td>Biomethane</td>
<td>€ 7,1 M</td>
<td>€ 20,9 M</td>
<td>€ 49,9 M</td>
</tr>
</tbody>
</table>

The €29 M increase between 2016 and 2017 is part of the projected path to commission the new facilities.

A virtuous mechanism associated to the GOs provides a return into the Fund of 75% of profits made by the suppliers through the valuation of GOs, in order to reduce the public service charges. There is an exception to this rule: in the case of proving the consumption of biomethane in transport (Bio-NGV), gas suppliers can retain all the benefits associated with the GOs. It is a strong incentive to increase the share of biomethane as a fuel.

This support for fuel recovery is based on a study by ADEME which indicates that use of biomethane as a fuel is virtuous. Indeed, it allows the petroleum fuels to be substituted with a renewable energy offering an excellent CO2 balance with an 80% reduction in GHG emissions in the Life Cycle Assessment. Like Natural Gas Vehicle, biomethane fuel reduces up to 90% of nitrogen oxide (NOx) emissions, compared to diesel fuel, by virtually eliminating emissions of sulphur and fine particulate matter (PM 2.5) and halves engine noise emissions. Bio-NGV also reduces GHG emissions by 80% compared to petrol13.

11. For more information on TICGN, see the Customs website http://www.douane.gouv.fr/articles/a10992-taxe-interieure-de-consommation-sur-le-gaz-naturel-ticgn
2.2.2. Additional measures

The first texts of regulations that govern biomethane injection activities are from November 2011 and aim to promote the development of the sector. In 2013, texts on “double valuations” were added, which implement the benefit of feed in tariffs linked to production, on the same site, for electricity, heat and biomethane injection.

In June 2014, further texts were published, which authorised the injection of biomethane produced, in particular, through the recovery of residues resulting from wastewater treatment (sewage sludges) and to collect a specific tariff for it.

Following the revaluation of feed in tariff and the 15 to 20-year extension of purchase contracts for electricity produced from biogas\(^\text{14}\) for installations with a capacity of below 500 kWe, stakeholders have begun discussions with the Ministry departments in charge of energy, regarding a change in purchase conditions for biomethane injected into the natural gas networks set by the Decree of 23 November 2011. These changes must enable:

1. the preservation of the balance of various biogas recovery channels in the context of recasting the tariff for purchasing electricity produced from biogas and thus ensuring the necessary complementarity of these sectors;
2. the achievement of the biomethane injection targets defined by the PPE. The target of 8 TWh by 2023 requires a threefold increase in the number of projects compared to current dynamics.

To go further, the following measurements will be recommended as early as 2017:

- Remove the specific coefficient for installations that have never benefited from a tariff for the purchase of electricity produced and biomethane injected;
- Open up the possibility of using a nearby intermittent energy source for the digester’s heating needs;
- Eliminate the double-valued tariff for landfill;
- Moving from a monthly step to an annual step in standard purchase contracts for new facilities;
- Consider extending the purchase contract between producer and gas supplier period from 15 to 20 years, as has been the case for electrical recovery since the Decree of 14 December 2016.

2.3. Typical examples of renewable gas uses

Developing biomethane production in France is all the more relevant as consumers have a demand and appetite to consume green gas.

Thanks to this renewable gas, an industrialist like Terreal in Chagny, Saône-et-Loire (Burgundy-Franche-Comté) is reducing its CO\(_2\) emissions for its tile production. Biomethane guarantees that gas consumers will be able to access renewable energy without changing facilities, while retaining the flexibility offered by natural gas.

Cofely, for its heating network in Outreau in Pas-de-Calais (Hauts-de-France) or City of Bourg-en-Bresse in Ain (Auvergne-Rhône-Alpes), chose green gas in their energy mix.

However, the most iconic use of biomethane comes from mobility. Carrefour, Ikea, Monoprix, Biocoop and Picard already use biomethane fuel, also called Bio-NGV, for their logistics fleets. Ile de France Region public transport company, RATP runs bus line 24 in Paris using this fuel, which is perfectly suitable to noise and CO\(_2\) emission reduction – it also emits practically no particulate matters (PM).

As of 1 January 2017, pursuant to Article 26 of Law 2016-1917 of 29 December 2016 on the 2017 budget, consumption of biomethane for non-fuel uses is exempt from TICGN. The sector now waits for biomethane fuel (Bio-NGV) use to be exempt from TICPE (Domestic Consumption Tax on Energy Products, i.e. diesel and petrol mostly).

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\(^\text{14}\) Decree of 13 December 2016, fixing the conditions for purchasing electricity produced by installations, which primarily use biogas produced by means of anaerobic digestion of non-hazardous waste and raw vegetable matter located in continental metropolitan France, with a strictly lower installed capacity of 500 kW as referred to in 4° of Article D. 314-15 of the Energy Code.
2.4. Mapping biomethane injection in Europe

Overview of biomethane injection in Europe
Source: GRDF and CRIGEN / ENGIE “Biomethane injection in Europe - Summary of work 2015 - February 2016” & Biomethane Observatory June 2016 SIA PARTNERS - FRANCE BIOMETHANE

INJECTION IN EUROPE INCLUDES APPROXIMATELY 430 INSTALLATIONS FOR 18 TWh OF MAXIMUM CAPACITY INSTALLED AT THE END OF 2016 AND A REAL PRODUCTION OF ABOUT 13 TWh/YEAR.

United Kingdom
Biomethane production has been subsidised since 2011 and is attracting increasing interest: in 2016, 80 sites, representing a maximum installed capacity of 3 TWh/year, inject about 2000 GWh/year into the natural gas network.

France
In 2016, 26 sites with a maximum installed capacity of 410 GWh/year injected 215 GWh/year into the natural gas network.

Spain
In 2015, the Valdemingomez site, with a maximum capacity of 23 GWh/year, injected into the transmission network. There is currently no incentive policy for biomethane in Spain.

Italy
In 2013, a feed in tariff for biomethane production was implemented. However, there are currently only 3 biomethane production projects and injection is not currently allowed.

Netherlands
Biomethane has been being injected into the distribution network for over 20 years, including biogas from landfills. In 2015, 26 sites injected more than 900 GWh/year.

Finland
In 2016, 10 sites were injecting around 98 GWh/year in the natural gas distribution network.

Sweden
In 2015, 18 sites were injecting around 191 GWh/year in the natural gas distribution network.

Norway
In 2016, 2 sites were injecting in the natural gas network for a maximum installed capacity of 164 GWh/year.

Denmark
In 2015, 14 sites were injecting in the natural gas network for a maximum installed capacity of 360 GWh/year.

Luxembourg
In 2016, 3 sites were injecting in the natural gas network for a maximum installed capacity of 62 GWh/year.

Austria
Austria has injected biomethane into the grids since 2005, and today 13 sites inject more than 240 GWh/year.

Germany
In 2016, 201 units were injecting 9100 GWh/year of biomethane in the natural gas network for a maximum installed capacity of 12 TWh/year.

Switzerland
The country has been injecting biomethane in networks since 1997. In 2016, 34 sites with a maximum installed capacity of 262 GWh/year injected more than 130 GWh/year of biomethane.

Jennifer
In 2013, a feed in tariff for biomethane production was implemented. However, there are currently only 3 biomethane production projects and injection is not currently allowed.

INJECTION IN EUROPE INCLUDES APPROXIMATELY 430 INSTALLATIONS FOR 18 TWh OF MAXIMUM CAPACITY INSTALLED AT THE END OF 2016 AND A REAL PRODUCTION OF ABOUT 13 TWh/YEAR.
3. Biomethane injection facilities in France

3.1. Characteristics of the connected production sites

Distribution of total installed capacity\(^{10}\) by type of injection site
Source: DSOs and TSOs

- Autonomous agricultural: 10 sites · 101 GWh/year · 25%
- Territorial agricultural: 8 sites · 98 GWh/year · 24%
- Household waste and biowaste: 4 sites · 106 GWh/year · 26%
- Sewage sludge: 3 sites · 58 GWh/year · 14%
- Territorial industry: 1 site · 47 GWh/year · 11%
- Landfill: 0 site · 0 GWh/year · 0%

Average size of biomethane injection installations according to the nature of the facility, expressed in maximum production capacity\(^{10}\)
Source: DSOs and TSOs

- Landfill: 0 GWh/year
- Autonomous agricultural: 10 GWh/year
- Territorial agricultural: 12 GWh/year
- Sewage sludge: 19 GWh/year
- Household waste and biowaste: 26 GWh/year
- Territorial industry: 47 GWh/year

---

10. The maximum production capacity expressed in TWh/year was calculated based on the following assumptions:
Maximum capacity \( C_{\text{max}} \) extracted from the capacity register expressed in \( m^3/nj/h \), HHV = 10.9 kWh/m\(^3\) and 8,200 hours of annual operation.
3.2. Regional distribution of facilities

Regional distribution of maximum capacity\(^{10}\) installed per flow rate band as of 31.12.2016

**2016 regional record in terms of installed capacity**

Source: DSOs and TSOs

<table>
<thead>
<tr>
<th>Flow Rate Band</th>
<th>Maximum Production Capacity</th>
<th>Sites</th>
</tr>
</thead>
<tbody>
<tr>
<td>&gt; 60 GWh/year</td>
<td>&gt; 5.5 millionsNm(^3)/year</td>
<td>11</td>
</tr>
<tr>
<td>40 - 60 GWh/year</td>
<td>3.5 - 5.5 millionsNm(^3)/year</td>
<td>10</td>
</tr>
<tr>
<td>20 - 40 GWh/year</td>
<td>2 - 3.5 millionsNm(^3)/year</td>
<td>9</td>
</tr>
<tr>
<td>1 - 20 GWh/year</td>
<td>1 - 2 millionsNm(^3)/year</td>
<td>7</td>
</tr>
<tr>
<td>0</td>
<td></td>
<td>5</td>
</tr>
</tbody>
</table>

10. The maximum production capacity expressed in TWh/year was calculated based on the following assumptions:
Maximum capacity C\(_{\text{max}}\) extracted from the capacity register expressed in m\(^3\)/(n)/h, HHV = 10.9 kWh/m\(^3\)/(n) and 8,200 hours of annual operation.
WHAT IS A NORMAL CUBIC METRE? Nm$^3$ ou m$^3$(n)

Normal cubic metres are units of measurement for gas quantity. They correspond to the contents of a volume of one cubic metre, for gas under normal conditions of temperature and pressure.

The heating value of biomethane corresponds to the amount of energy contained in an Nm$^3$ of this gas.

There is a difference in the Higher Heating Value (HHV) in kWh/Nm$^3$ between geographical areas with high heating value known as “H zones” and those areas with low heating value, called “L zones” (in northern France fed by dutch Groningen gas) to the order of 10%.

So, the average HHV of biomethane obtained in H zone is 10.9 kWh/Nm$^3$ and the average HHV obtained in L zone is 9.8 kWh/Nm$^3$

Source: DSOs and TSOs

3.3. Facilities production

The table below shows monthly productions of biomethane injection facilities for 2016.

### Monthly production of biomethane injection installations for 2016 (MWh)

<table>
<thead>
<tr>
<th>Month</th>
<th>Production (MWh)</th>
</tr>
</thead>
<tbody>
<tr>
<td>J</td>
<td>11,265</td>
</tr>
<tr>
<td>F</td>
<td>13,108</td>
</tr>
<tr>
<td>M</td>
<td>11,008</td>
</tr>
<tr>
<td>A</td>
<td>15,313</td>
</tr>
<tr>
<td>M</td>
<td>16,493</td>
</tr>
<tr>
<td>J</td>
<td>17,097</td>
</tr>
<tr>
<td>J</td>
<td>19,366</td>
</tr>
<tr>
<td>A</td>
<td>19,210</td>
</tr>
<tr>
<td>S</td>
<td>21,156</td>
</tr>
<tr>
<td>O</td>
<td>22,509</td>
</tr>
<tr>
<td>N</td>
<td>24,901</td>
</tr>
<tr>
<td>D</td>
<td>24,910</td>
</tr>
</tbody>
</table>

Changes in the number of injection sites in 2016

The smooth curve below represents the cumulative production of all existing installations since 01/01/2016.

### Cumulative production in GWh (0°C) in 2015 and 2016

<table>
<thead>
<tr>
<th>Month</th>
<th>Production (GWh)</th>
</tr>
</thead>
<tbody>
<tr>
<td>J</td>
<td>82</td>
</tr>
<tr>
<td>F</td>
<td>215 x 2,6</td>
</tr>
</tbody>
</table>

Renewable gas French panorama as of 31 december 2016

19
4. Growth prospects for the sector

4.1. Injection projects queue

→ CAPACITY REGISTER

As part of managing biomethane injection capacities, it was decided to create a registry in order to manage capacity booking and monitor the progress of projects from their study phase through to production.

To anticipate a potential saturation of natural gas networks into which the production will be injected, it is necessary to define priority rules that will apply when several projects want to connect in the same area and are “competing” to obtain available injection capacity.

The capacity register (or queue) is shared by transmission and distribution system operators. It allows projects to be entered according to their order of arrival with a number allocation, which will allow, if necessary, allocations of injection capacity to be prioritised. GRTgaz and TIGF have been appointed as managers of the capacity management registry by decision of the Regulatory Commission of Energy (CRE) dated April 2014.

The maximum production capacity expressed in TWh/year was calculated based on the following assumptions:

- Maximum capacity Cmax extracted from the capacity register expressed in m³(n)/h, HHV = 10.9 kWh/m³(n) and 8,200 hours of annual operation.

THE QUEUE OF BIOMETHANE PROJECTS WAITING CONNECTION AND INJECTION INCREASED TO 5TWH/YEAR for 241 PROJECTS, WHICH CORRESPONDS TO AN AVERAGE ANNUAL CONSUMPTION OF 420,000 CUSTOMERS OR 22,000 BUS OR TRUCKS RUNNING ON BIO-NGV.
4.2. Development of the network architecture

In an effort to expand the natural gas network, operators are developing solutions to address constraints and maximise the volumes being pumped:

- meshing of the distribution network;
- additional market opportunities thanks to the increased use of gas in particular its use as a transport fuel;
- virtual pipelines, i.e. transport and injection of biomethane into another part of the network grid;
- gas storage.

Network operators are also conducting experiments on reverse flow plants (also called “green gas booster”) towards higher-pressure networks in order to access wider consumption areas.

In the coming years, and in order to go further than simply allocating existing capacity, network operators would like to set up new mechanisms for the development of capacity for receiving renewable energy sources in gas networks. Some existing producers could limitate their volumes reductions in summer. Above all, these network developments would offer an opportunity to accept as many new projects as possible and limit the risk perceived by investors in order to ensure adequate financing of the sector. To reach the ambitious renewable gas development objectives set by the State, a pre-requisite will be to use these new tools.
4.3. Projection of national resources that can be used in anaerobic digestion

In 2013, ADEME conducted a study on the “estimation of potential substrate resources that can be used in anaerobic digestion”. It shows that the deposit, which can be leveraged by 2030, consists of 130 million tonnes of raw material, equivalent to 56 TWh/year of biogas. On this potential, ADEME’s Biomethane 2030 roadmap\(^\text{15}\) has established a voluntary potential for biomethane injection of 30 TWh/year from 1,400 sites.

![Distribution of national resources that can be used for anaerobic digestion by type of feedstock](source: “Estimation of potential substrate resources that can be used in anaerobic digestion” (ADEME - April 2013). Study carried out on behalf of ADEME by SOLAGRO and INDDIGO)

4.4. Prospective: more solutions for renewable gas production

Biomethane, derived from anaerobic digestion, is the first renewable gas production technology, which has reached maturity. In the medium- and long-term, new biomethane production processes will develop:

- Gasification of dry biomass and SRF (Solid Recovered Fuels);
- Power-to-gas, i.e. the production of hydrogen by electrolysis of water from renewable electricity and its use, either via direct injection into the grid, or after conversion to synthetic methane by methanation;
- Use of microalgae.

→ GASIFICATION OF BIOMASS AND SRF

The gasification process

Source: GRTgaz

“SYNTHETIC METHANE FROM PYRO-GASIFICATION” LOOKS TO BE PROMISING

Pyro-gasification is a thermochemical process used to obtain synthetic gas (syngas) from biomass or prepared waste (SRF - Solid Recovered Fuels). The syngas produced is then processed to produce electricity, heat or synthetic methane that can be injected into the gas network. Gas obtained in this way is called “second-generation biomethane”, if the latter is generated from renewable inputs and “recovery methane” when it is generated from the non-renewable portion of RDF (waste).

Pyro-gasification processes, which vary greatly from anaerobic digestion processes, can provide innovative, efficient and additional solutions for anaerobic digestion. They can be used to optimise energy recovery of different biomasses and waste products, which cannot currently be recovered in the form of materials or are difficult to treat. In addition to the many technical and environmental advantages of the pyrolysis and gasification processes, the “injection into gas networks” can:

- contribute, alongside biomethane resulting from anaerobic digestion, to the achievement of the 2030 target of having renewable gas constitute 10% of overall gas consumption as foreseen by the France’s Energy Transition for Green Growth Law (LTECV);
- develop a new sector to deal with typologies of non-food biomass, which are more difficult to recover by means of anaerobic digestion (non-fermentable agricultural residues, ligno-cellulosic biomass, etc.);
- propose an alternative to the production of electricity and heat, with more attractive yields, liberating them of any seasonal heat-removal constraints, and adapting the facilities to volumes of inputs available in the regions;
- help optimise regional waste management policies with the energy recovery of SRF (production of partially-renewable synthetic methane), with increased energy efficiency and significantly lower atmospheric emissions than incineration;
- help develop a circular economy: produce renewable energy in the regions (or recovery for SRF), which is not intermittent, at a price that can be controlled, thus improving the France’s energy independence.

This sector, the first projects from which are expected in 2020, will, in the future, effectively supplement the quantity of renewable gases projected from anaerobic digestion. Indeed, the in-depth study carried out by GRDF in 2013 foresees a technical potential for the production of biomethane via gasification ranging from 150 to 250 TWh/year over the 2030-2050 period (depending on the scenario envisaged).

Although these figures are still to be confirmed by additional studies and the technology for the synthetic gas purification still needs to be technically validated, these estimates still demonstrate the value of the pyro-gasification injection sector in relation to the Environment Grenelle objectives, as well as biomethane produced by anaerobic digestion. The technical tools developed for first-generation biomethane (injection, odorisation, metering stations, etc.) could also be taken over, or even shared, in some cases by common anaerobic digestion/pyro-gasification platforms. Reverse flow plants are also essential to facilitate the implementation of these projects.

GAYA, THE FIRST DEMONSTRATOR IN FRANCE

This project, called Gaya, whose platform is being built in Saint-Fons (Auvergne-Rhône-Alpes), in the Vallée de la Chimie, is developing an innovative demonstration chain across the entire supply chain (gasification, methanation, synthetic gas treatment and biomethane fuel recovery). It will evaluate the yields and environmental and economic relevance of second-generation biomethane production. About 20 engineers and technicians will work on the site.

The GAYA project, launched in 2010 by Engie, brings together 11 partners with complementary expertise and represents an investment of €60M, financially supported by ADEME to the tune of €19M.

Source: Biomethane from gasification - production potential in France by 2020 and 2050, GRDF Study conducted by GDF SUEZ and co-managed by ADEME, MEDDE, MINEFI & MAAF, February 2013
POWER-TO-GAS: A NEW TOOL FOR RENEWABLE ELECTRICITY

Power-to-gas is a new tool that is particularly relevant in supporting the massive deployment of renewable electricity and to ensure that the whole production can be used. During periods of abundant intermittent power, Power-to-gas transforms surplus electricity at marginal low cost into hydrogen by electrolysis of water. This hydrogen can then be injected into the natural gas network:

- either as it is;
- or after being converted to synthetic methane by associating it with CO₂ by methanation.

By 2030, Power-to-gas with injection into the grid will be a solution for managing the surplus of renewable electricity production. On the other hand, Power-to-gas, coupled with network injection, means that one can take advantage of the significant storage capacities of the gas infrastructure (transit stock and underground storage). Indeed, at this time, prospective studies foresee large and long-term production surpluses (> 1 day) which cannot be managed using “conventional” electrical storage solutions (dams, batteries). Storage is now regarded as one of the major challenges facing renewable electricity in the energy transition.

While the attractiveness of Power-to-gas is proven by prospective studies in 2030⁰, its technical feasibility and economic model remain to be established. This is the objective of several demonstration projects supported by stakeholders in the European sector, as well as in France.

HYDROGEN INJECTION IN NETWORKS

The possibility of injecting hydrogen into the gas networks gives direct access to its very large transport and storage capacities: in France, gas storage capacity is 300 times greater than that of the electrical grid (137 TWh compared to 0.4 TWh)¹⁷. Nowadays, the percentage of hydrogen that can be injected into the network and mixed with natural gas is the subject of research and demonstrators have been built by network operators in order to remove uncertainties relating to safety and compatibility with the grid. It is likely that the proportion acceptable from the network operators’ point of view will be increased to reach 10%, or even 20% in the long-term.

CONVERSION OF HYDROGEN TO SYNTHETIC METHANE BY METHANATION

Methanation represents an additional step to combine hydrogen with carbon dioxide (CO₂) to form synthetic methane (CH₄), 100% miscible with natural gas. There are numerous carbon dioxide sources: recovery of CO₂ after biogas or syngas upgrading (gasification of biomass), capturing CO₂ from industrial emissions (cement, petrochemical, as well as all combustion equipment) and emissions linked with electricity production.

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17. Source: ADEME GRDF / GRTgaz Study

Renewable gas French panorama as of 31 december 2016
DEMONSTRATOR PROJECTS

As part of the “Hydrogen Regions” call for tender launched in early 2016 by the Ministry of the Environment, Energy and the Sea, several methanation and synthetic methane injection demonstration projects into the natural gas networks have emerged. Some of these concern the recovery of intermittent industrial gases (hydrogen, carbon dioxide), while others highlight synergies with anaerobic digestion, recovering the CO₂ released during the biogas upgrading phase. These projects could each inject 20 to 150 Nm³/h into natural gas networks by 2018-2020. They will be carried out by consortia that bring industrialists and local authorities together; they will make it possible to check the technical and economic viability of such processes.

GRHYD DEMONSTRATOR

The GRHYD field demonstrator consists of two batches: the first batch piloted by GRDF will test the injection of a variable part of hydrogen into a natural gas distribution closed network for a new district of Cappelle-la-Grande in the Urban Community of Dunkirk. Its objective is to measure the technical feasibility and to evaluate the economic relevance of hydrogen injection into the natural gas distribution network with the aim to recover renewable electricity produced outside of consumption periods through natural gas uses (heating, domestic hot water, fuel). The proportion of hydrogen injected to be tested in the demonstrator ranges from 6 to 20% (by volume). The hydrogen-natural gas mixture will supply a new neighbourhood of about 100 housings (collective and individual) as well as a health facility. Hydrogen injection is expected to start in autumn 2017, with the authorisation of the Directorate General for Risk Prevention (DGPR). The second batch is designed to test Hythane® fuel (mixture of natural gas & hydrogen) on a fleet of buses.

THE JUPITER 1000 DEMONSTRATOR

In addition, GRTgaz and 7 partners (including TIGF) launched a Power-to-gas demonstration project with the production of hydrogen and synthetic biomethane by means of methanation, called “Jupiter 1000”, which is located in Fos-sur-Mer. TIGF is a partner in this project. Connected to the gas transmission network, this synthetic biomethane production site aims to recover the surplus production of renewable electricity and recycle the CO₂ captured at a neighbouring industrial site. It will also test the direct injection of hydrogen, this time in transport networks. The first injections are planned for 2018. This will be the first Power-to-gas installation on this scale in France. The Jupiter 1000 project is co-financed by the European Union as part of the FEDER fund, by the French State as part of the “investissements d’Avenir” [Future Investments] programme entrusted to ADEME and the Provence-Alpes-Côtes d’Azur Region. This project has also been certified by the Capénergies competitiveness cluster.
A forecast of the development of renewable gases presents a vision of the future in terms of renewable gas injection evolution in France by 2035. The main production channels being analysed are biomass anaerobic digestion, the gasification/pyro-gasification of biomass or SRF (Solid Recovered Fuels), methanation of hydrogen produced from electricity or of industrial origin, hydrogen injection blended in natural gas.

The main objective is to estimate the amount of renewable gas injected into all natural gas networks in France by 2035. For anaerobic digestion, the exercise is carried out on a national and regional level, also analysing the injection capacity for each year and the number of new injection sites throughout France. For the other channels, the model only shows the GWh injected on all the networks on a national level.

From 2030, Power-to-gas will be in full swing when renewable energies will have become a structuring factor in the operation of electrical systems. Power-to-gas represents:

- a storage capacity of renewable electricity of up to 2 TWh in the form of synthetic biomethane by 2030;
- a storage capacity of renewable electricity of between 20 and 70 TWh by 2050, generating between 14 and 46 TWh in the form of synthetic biomethane;
- by 2050, CO₂ required for methanation could be fully provided by anaerobic digestion sites or by recycling industrial CO₂;
- By 2050, Power-to-gas facilities could also be used to co-produce between 5 and 18 TWh of heat and between 3,400 and 11,700 kt of oxygen.

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18. Source: ADEME GRDF / GRTgaz Study
19. In particular, data is based on the Overview of Renewable Gas in 2015 carried out by GRDF, GRT gaz, SPEGNN, SER and TIGF
Introduction to stakeholders

As France’s leading natural gas distributor, GRDF operates and develops the natural gas distribution network in more than 9,500 municipalities. Owned by the communities, this near 200,000 km network supports the development of biomethane. Through its support of project owners, GRDF is fulfilling its commitment to develop innovative energy transition solutions throughout the regions. GRDF conducts feasibility studies, ensures biomethane injection into the network (counting, quality control and pressure regulation). Finally, the company has been in charge of registering guarantees of origin since December 2012.

GRTgaz is one of the largest natural gas transporters in Europe and is a world expert in gas-transmission systems and networks. In France, GRTgaz owns and operates 32,300 km of underground pipelines and 27 compressor stations to transport gas between suppliers and consumers (distributors or industrial directly connected to the transmission network). GRTgaz carries out public service duties in order to guarantee that supply to consumers is ensured and also provides transport services to network users. GRTgaz, as a player in the energy transition market, invests in innovative solutions to adapt its network and reconcile competitiveness, security of supply and environmental preservation.

As a professional union of municipal and similar gas companies, it brings together 29 local gas companies that actively promote natural gas and biomethane. In addition to their strive towards constant safety, quality and continuity requirements that have always been essential components of the public gas distribution service, members of the SPEGNN, in accordance with the missions entrusted to them by communities, are local players, which are fully involved in the energy transition.

There are 360 members in the French Syndicate for Renewables representing a turnover of 10 billion euros and more than 80,000 jobs. This professional union connects those involved in renewable energy sectors: biomass (EBF Commission), wood energy, biofuels, biogas, wind power, renewable marine energies, geothermal energy, hydroelectricity, heat pumps, photovoltaic energy (SOLER), solar thermal energy and thermodynamics. Its missions are to promote renewable energy and to defend the interests of professionals in the sector by developing dynamic and sustainable industrial sectors.

TIGF, which has over 70 years of experience and is the second-largest gas operator in France, is a major player on the energy market. TIGF is strategically positioned internationally and provides links that contribute to the security of supply in Europe in a competitive, high-quality environment and with optimal security. The company provides – and is developing – gas storage and transmission services in energy transition. TIGF in numbers: More than 5,100 km of pipelines, 14% of French gas pipeline transmission network, 16% of the national volume of gas transmission, 24% of French gas storage capacity, 17 operational sites in 15 Departments throughout the Greater South West region of France.