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Overview of the biomethane sector in France

and ideas for its development

OCTOBER 2017

A study conducted in partnership with

BIOGAZ/ALLÉE®
Le cluster de la méthanisation

Cryo Pur
From waste to fuel

GRDF
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About ENEA Consulting

ENEA is a strategic advisory consulting firm contributing to the advancement of energy and environmental transition and the development of energy access world-wide, with offices in Paris, Melbourne and Hong Kong. Since 2007, ENEA has been advising and supporting leading private sector companies and public authorities around the world on the topic of energy transition sectors and markets.


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Executive Summary

The anaerobic digestion of organic waste, be it agricultural, industrial or household, produces biogas that is 50 to 70% methane, the main component of natural gas. The purification of this biogas produces biomethane, a gas that is very similar to natural gas. Once injected into gas grids, biomethane can be put to use in vehicle and heating fuel applications. This renewable gas is therefore a concrete alternative helping to reduce carbon emissions from natural gas uses.

Launched in 2011 with the introduction of feed-in tariffs for biomethane injected into the grid, France's biomethane sector is a young and vibrant industry whose initial projects have proven to be economically viable.

The feedback received so far demonstrates that the feed-in tariffs defined in 2011 ensure the viability of biomethane injection projects by covering production costs[1], although these costs remain higher than current wholesale natural gas prices. For example, economic modelling of a typical French autonomous agricultural biomethane production unit indicates that current production costs stand at 95 €/MWh with a feed-in tariff of 120 €/MWh (the wholesale natural gas price in the first half of 2017 was around 17 €/MWh Bib.1).

At the end of June 2017, the situation in the French biomethane sector was as follows:

35 sites injected biomethane into the gas grid, supplying the equivalent of 315 GWh of annual production. This represents 0.05% of France's natural gas consumption Bib.2.

297 additional projects were on the waiting list to be connected to the gas grid, corresponding to an additional injection capacity of 6.5 TWh/year Bib.2, i.e. 2% of France's natural gas consumption.

This vibrancy is encouraging, especially in view of France's ambitious development objectives, targeting 10% renewable gas in the country's total consumption by 2030 (the Energy Transition for Green Growth Act - LTECV Bib.3). The promising demand outlook for biomethane makes this an achievable target, as rapid growth is expected in its use as vehicle fuel (with the rise of bioNGV) and for heating applications (for instance, targets have been set for the use of renewable energy in district heating networks, new environmental regulations have been introduced in the building construction sector, and interest from local authorities and major consumers is growing).

A number of drivers could allow biomethane to carve out a larger slice of the French energy mix:

From an industrial perspective, cost reductions are necessary and have become conceivable as a result of innovation and the optimisation of technologies and operating practices. The study shows that a 30% reduction in production costs is achievable within the next five to ten years[2].

1 Feedback based on a year-long study of some ten biomethane injection projects

2 Economic analysis based on the current project development context. This cost reduction potential does not take into account possible changes in external factors impacting costs (e.g., the strengthening of regulations or pressure on feedstock markets that may lead to a rise in production costs).

From a regulatory perspective, gradual changes to the support framework in place, in line with the sector's growing maturity, could enable the current dynamic to be maintained:

→ **In the short term,** stimulating demand for renewable gas by proposing a clearer view of usage support mechanisms. Currently structured around Guarantees of Origin (which certify that biomethane is produced from renewable sources) and tax breaks for gas suppliers, these mechanisms are not sufficiently clear to stimulate and facilitate biomethane trade between producers, suppliers and consumers.

→ **In the medium term,** developing the regulatory framework to maximise France's potential by facilitating the exploitation of resources located at a significant distance from gas grids by structuring dedicated mechanisms and creating the regulatory conditions needed for greater quantities of gas to be injected during the summer months.

→ **In the long term,** when the cost of producing biomethane has dropped sufficiently, replacing feed-in tariffs for the gas injected with income supplements to limit costs for the authorities.

From a financial perspective, the emergence of effective financing plans suited to the specifics of biomethane will also be vital. The study estimates that the sector will require €1-2 billion in financing to fulfil its growth potential over 2019-2023. To attain the targets set by the LTECV, €10 billion in financing will be required between now and 2030.

From an administrative perspective, simplifying the process of obtaining authorisations to operate biomethane production units will help cut project development times.

With a footprint in every region, the biomethane sector offers a wide range of positive externalities, which, when fully harnessed, will help to secure the industry's long-term future. In particular, the development of biomethane will make it possible to:

Firmly establish waste management and recycling processes within local circular economies.

Ramp up the development of sustainable mobility solutions in the transport sector through the use of biomethane vehicle fuel (bioNGV) in the form of bioCNG or bioLNG, to improve air quality.

Contribute to local economic development by providing farmers with an additional source of income (90% of biomethane's production potential lies in agriculture).

Attain the greenhouse gas emissions targets set by the Energy Transition for Green Growth Act.

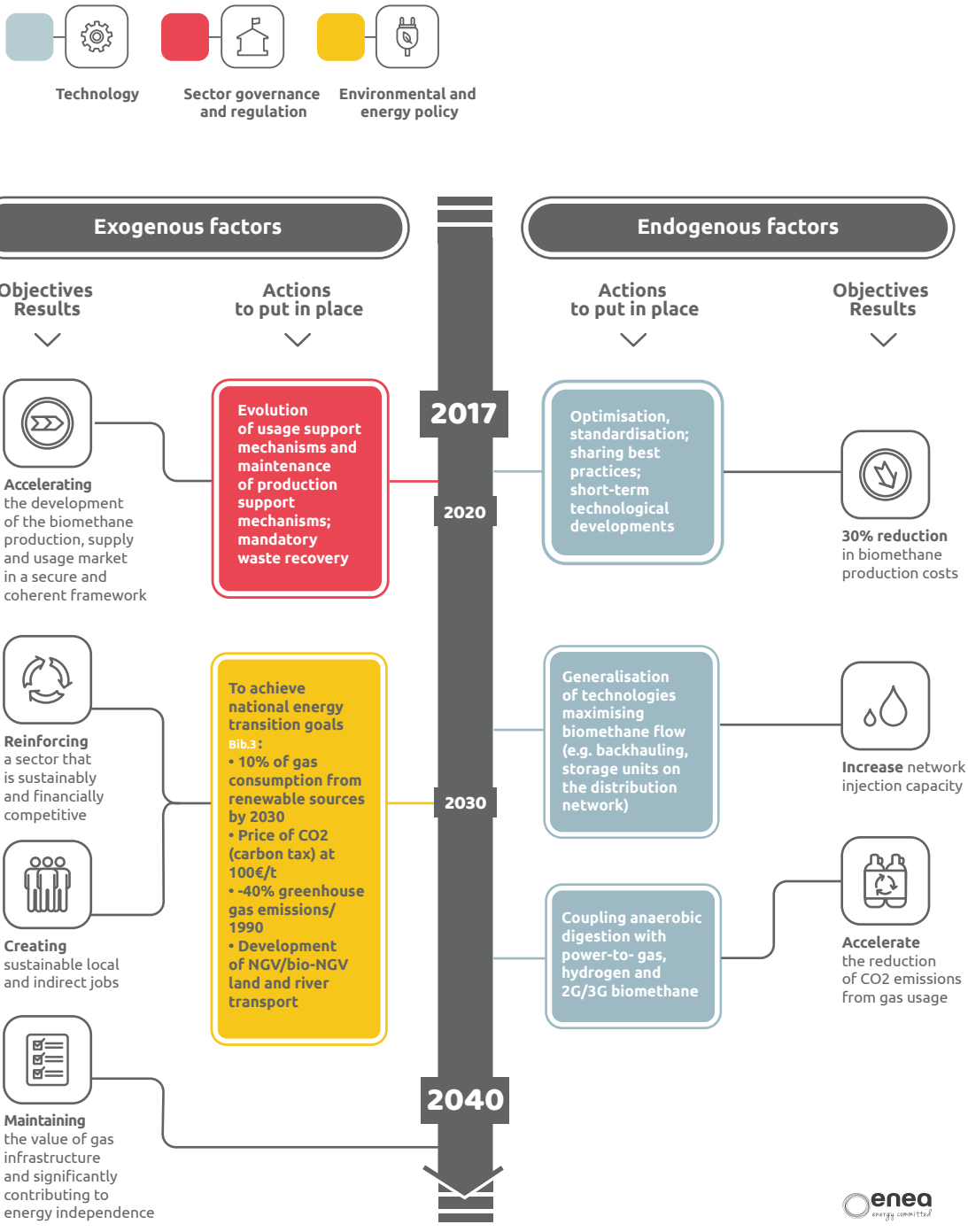
With these expected evolutions and the harnessing of positive externalities, the development of a strong and durable biomethane sector in France will be possible when combined with:

Factors internal to the sector, which will help maximise the intrinsic competitiveness of projects. For instance, technological advances will boost performance and productivity while reducing production costs.

Conditions external to the sector, which must converge if the sector is to develop successfully. These are dependent on government decisions, but also on developments within markets (the price of natural gas, the deployment of NGV filling stations, the price of CO_2, etc.).

Figure 1

Ideas to ensure long-term competitiveness for the sector



Co-built by all the participants in this study, this initial roadmap lays down the conditions for the emergence of a competitive French biomethane sector that will create value for all the stakeholders.

Table of contents

ANALYSIS

"Biomethane production through anaerobic digestion is an opportunity to be seized by France, the European country with the highest largely under-exploited biogas production potential. Energy is crucial to all business sectors, be they public or private, and anaerobic digestion provides a resource that enables the adoption of a truly circular approach.

Biomethane is a secure, virtuous and local energy source that must play a significant and active role in our country's energy transition. Now is the time to take the sector to the next level, to support the industry and to lay the foundations for a new French model!"

Objectives and content

The French biomethane sector has a potential for development which should enable it to contribute significantly to renewable energy production objectives in France. It is a sector rich in opportunities, as it simultaneously straddles the waste and energy, but also complex, and for which it is necessary to clarify the advantages and areas of improvement in order to fully realise its potential in the short, medium and long terms.

Based on six months of in-depth work, some twenty interviews with key stakeholders in the biomethane value chain and a technical visit to one of the sector's most innovative sites (located in the UK), ENEA Consulting conducted a study geared towards understanding the dynamics and potential of the biomethane sector in France. The ultimate aim was to draw up a roadmap for a sustainably competitive industry.

Challenges

- Market
- Technologies
- Economics
- Financing

Methodology

- 6 months of preparation
- Some 20 interviews
- A technical visit

Partners

Beyond the analysis performed by the teams at ENEA Consulting, this study is above all the fruit of collaboration with key partners in industry:

Structure

1. THE MARKET
2. THE TECHNOLOGIES
3. THE ECONOMICS
4. THE FINANCING

This report provides an overview of the study's results, structured around the four aforementioned areas. For each of these areas, the report presents an overview of the industry, identifies the sector's main challenges and opportunities, and puts forward recommendations to facilitate biomethane's emergence in France.

It was decided that this report would not name specific projects or stakeholders. The study's content is based on information known to its authors and contributors in June 2017.

1

THE MARKET

A VIBRANT INDUSTRY WITH STRONG GROWTH POTENTIAL

- Overview
- Challenges and opportunities
- Recommendations

THE MARKET
Overview

Biomethane is a renewable natural gas obtained from biogas upgrading. The biogas produced by anaerobic digestion of organic matter and containing 50 to 70% methane, is purified to achieve the same quality as natural gas. Once injected into gas transmission or distribution networks, biomethane can be used in the same way as natural gas for vehicle fuel or heating applications. In France, biomethane is produced mainly from organic agricultural, industrial or household waste, thus contributing to waste recovery. The industry also generates digestate, a fertilizing material that can be used instead of traditional fertilizers see Fig.2.

A wide variety of stakeholders are involved in the biomethane value chain. They fall into one of two categories:

- Economic stakeholders, who are involved throughout the chain.
- Cross-functional stakeholders, who stimulate, organise and promote the industry see Fig.3.

France's vibrant biomethane industry is still in its infancy, with vehicle fuel accounting for the largest share of the market.

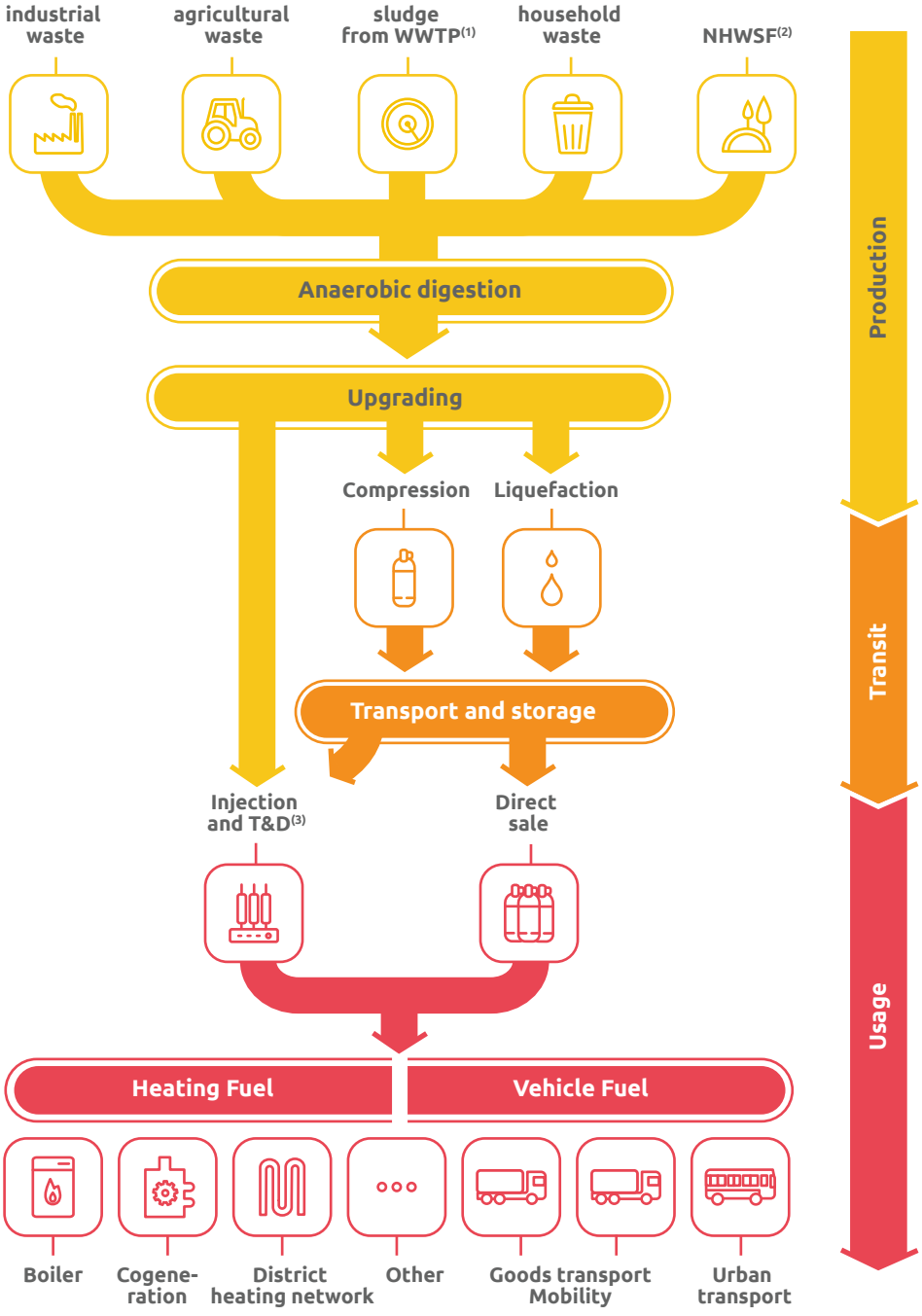
Since it was launched in 2011 with the introduction of feed-in tariffs, the French biomethane injection sector has grown considerably. At the end of June 2017, 35 sites were injecting biomethane into the gas network, supplying the equivalent of 315 GWh of annual production Bib.2, or 0.05% of France's total gas consumption. This was three times the volume injected in 2015, making France the 5th-ranked European gas-producing country in 2016 according to this metric Bib.4. . What's more, 297 additional projects are now on the waiting list to be connected to the gas grid, corresponding to an injection capacity of 6.5 TWh/year Bib.2. The industry has been buoyed by the government's ambitious targets: the objective set by the Energy Transition for Green Growth Act is for renewable gas to represent 10% of France's total gas consumption by 2030 Bib.3.

In 2015, the French biomethane sector began operating under the Guarantee of Origin system, which ensures the traceability of renewable gas, with approximately 80% of the resource being used as vehicle fuel and 20% for heating Bib.3. As regards vehicle fuel applications, the leading consumers of biomethane are the transport companies that serve mass retail, which are very keen to reduce their greenhouse gas emissions, and, to a lesser extent, public transport operators. As regards heating applications, it is primarily local authorities that use biomethane to heat public buildings and supply district heating networks.

Figure 2

The biomethane sector, bridging the divide between waste and energy

The biomethane value chain in France



(1) WWTP : Waste Water Treatment Plant
(2) NHWSF : non-hazardous waste storage facility.
(3) T&D : Gas transport and distribution

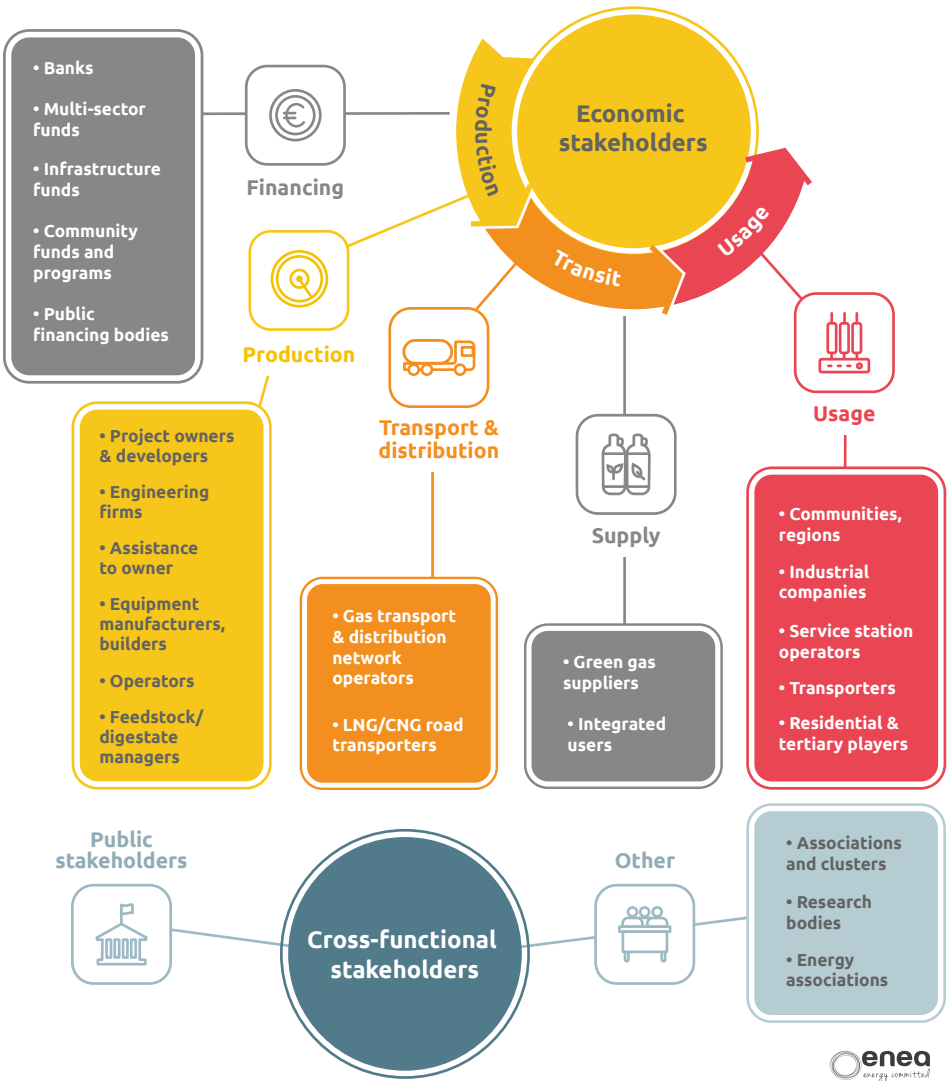
Mechanisms are in place in France to support the production, supply and use of biomethane and boost the industry's development.

Two mechanisms launched at the end of 2011 gave the biomethane market a real impetus:

- **Support for producers,** via feed-in tariffs and direct investment subsidies. Tariffs are structured to ensure that the biomethane industry is virtuous, by strongly encouraging the recovery of waste, regardless of its origin, and thus minimizing the cultivation of energy crops. Germany, on the other hand, had specifically focused on developing such crops when its own industry was burgeoning, leading to unbridled opportunism on the part of producers. In response, the German government greatly reduced the subsidies granted for biomethane use in 2012 and phased them out completely in 2014, which has caused the biomethane market's growth to stagnate Bib.6.

Figure 3

The French biomethane sector, a point of convergence for a wide range of stakeholders



- **Support for suppliers ,** via the Guaranties of Origin (GO) system, the workings of which are detailed see fig.4. One GO is equivalent to a producer injecting 1 MWh of biomethane into the grid. The national GO register ensures the traceability of biomethane and guarantees transactions between suppliers and users. The system decouples the physical production of biomethane from its contractual sale by a supplier to a consumer.
- GOs are a source of income for renewable gas suppliers, who retain 100% of their value when selling biomethane as vehicle fuel and 25% in the case of heating fuel (the remaining 75% is paid into a compensation fund managed by the CDC – the French Government Investment Fund) Bib.7.
- This distinction has an impact on the uses targeted by suppliers, which partly explains the dominance of biomethane as vehicle fuel, which the government considers to be its most virtuous application from an environmental standpoint see Fig.4.

A mechanism to support the use of biomethane was launched at the end of 2016, but its impact on the market's buoyancy remains uncertain. It provides for complete exemption from TICGN, a tax applied solely to the use of natural gas for heating. The measure was passed as part of the 2017 Finance Act and covers biomethane injected into the grid Bib.8.

Finally, it is also worth noting that funding is available for biomethane use in district heating networks, as it is for other renewable energies used for heating. Gas certified as renewable by the Guarantee of Origin system and used in district heating networks contributes to attaining the figure of 50% renewable and recovered energy in the mix, allowing users to enjoy a reduced VAT rate of 5.5% Bib.7.

The European biomethane industry does not currently share a unified vision

To date, no EU-wide targets have been set with regard to biomethane production and use. Member States are free to choose the production or usage support mechanisms they wish to develop:

- National support plans are set up and tailored to each country's strategy (integration of renewable energy, waste processing, clean mobility, etc.).
- These support mechanisms differ in terms of their scope. For instance, Germany offers subsidies for grid connection by pooling almost all costs within network usage prices, whereas in France the average cost of connecting to the grid is covered by feed-in tariffs.

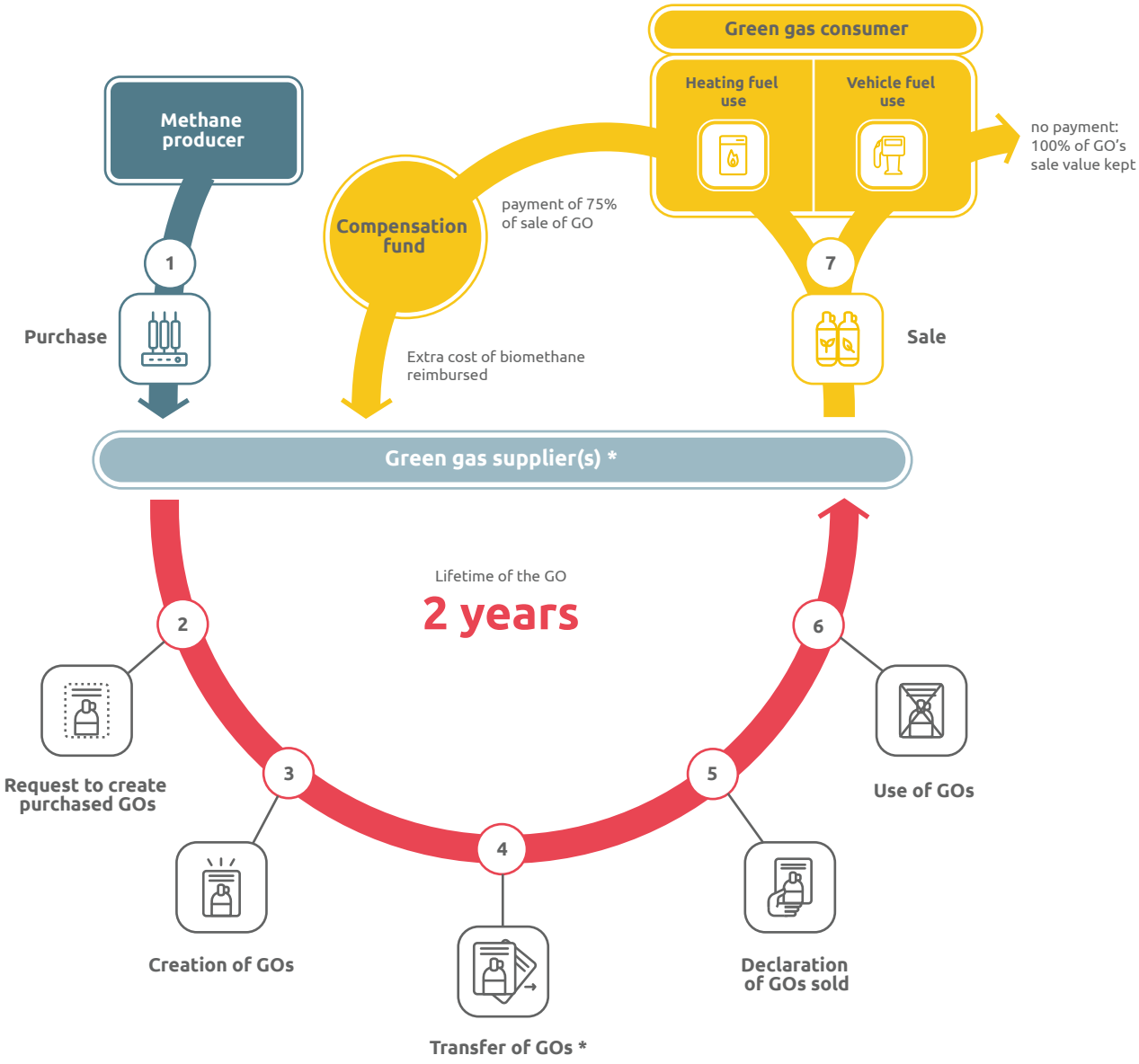
As yet, there is no open European market for Guarantees of Origin. Nonetheless, several countries have developed their own traceability system for renewable gas – notably Germany, the UK and France – based on criteria and principles that differ immensely from one country to the next.

1 TICGN: Domestic tax on natural gas consumption

Figure 4

Guaranties of origin (GO) certify that the gas comes from a renewable source

Working principles



* In most cases, a single green gas supplier is involved in the process.
However, if several suppliers are involved, a stage transferring the GOs between the suppliers is required

THE MARKET

Challenges and opportunities

Production

Despite enjoying sustained growth, the industry's development must be further ramped up to meet national targets

Based on the information supplied by the "Biomethane injection" Working Group[1] that analysed the data held in the capacity register, ENEA Consulting drew up a forecast of biomethane production growth over the coming years see Fig.5. While it may already be growing rapidly, France's production capacity must develop even faster if the 2023 national targets are to be met.

Today, three main challenges stand in the way of new production projects:

1. Sector's complexity

The decision to process and recover a wide variety of waste makes the French biomethane industry heterogeneous in terms of its feedstock mix. The emergence of biomethane production projects therefore tends to be complicated by the sheer variety of supply sources and the quantity of feedstock required for anaerobic digestion:

- It is difficult to ensure a reliable supply of feedstock (in terms of both quantity and quality) for the entire duration of projects.
- The large areas of land required to spread the digestate are not always available in close proximity to anaerobic digestion units.

To obtain the volume of feedstock required to produce biomethane, it is sometimes necessary to involve a variety of stakeholders (from agriculture, industry, local authorities, etc.) with limited knowledge of the biomethane sector. This diversity of stakeholders can make setting up and structuring projects a complex task.

2. Setting up a project can be a lengthy and costly process

It can take anywhere between 18 months and 6 years to set up a project, due in particular to the complexity of the administrative procedures involved in obtaining ICPE status[2] ("authorisation" is required, particularly for larger projects). Moreover, this is an expensive undertaking: the administrative process costs in the region of €60,000 to €100,000[3].

A lack of social acceptability may also be an obstacle to the industry's development. This often stems from fears of odour, noise pollution and health risks.

1 The "Biomethane injection" Working Group is comprised of natural gas network operators and is co-steered by the ADEME Environmental and Energy Management Agency and GRDF.

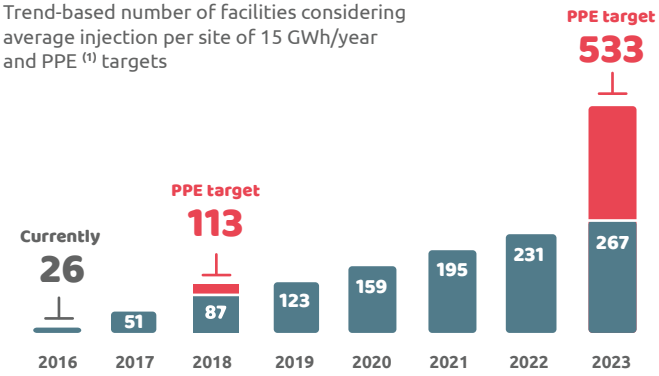
2 ICPE: Environmentally sensitive facilities

3 Analyses by ENEA Consulting based on interviews with industry professionals.

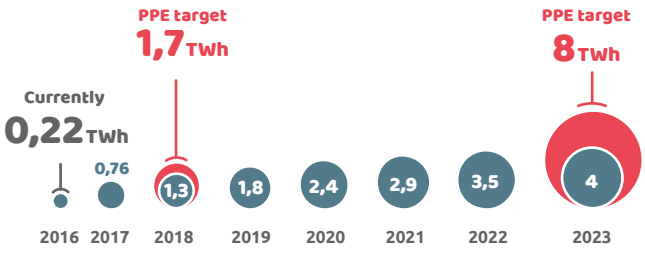
Figure 5

Sustained growth but falling short of targets

Number of production sites
Trend-based number of facilities considering average injection per site of 15 GWh/year and PPE (1) targets



Quantity of biomethane injected in France
Source GT Injection in May 2017, trend-based evolution of capacities recordedbetween 2014 - 2016 reaching 4 TWh injected in 2023 and goals targeted by the PPE(1)



(1) PPE: Programmation Pluriannuelle de l'Énergie – Pluriannual Energy Programme

« GRDF considers that the dynamic observed since the second half of 2016 makes achieving 8 TWh a realistic target. »

The biomethane sector has been developing rapidly since the second half of 2016: over 1.3 TWh/semester capacity recorded in the queue and 6.5 TWh total capacity recorded at the end of the first half of 2017.

Raising capital from banks or investment funds and obtaining government subsidies can be a complex affair:

- **Banks** are very cautious when it comes to funding anaerobic digestion projects and their financing criteria are extremely strict. Before financing an anaerobic digestion project, banks look closely at the intrinsic quality of the project and its potential to generate revenue in the future. The main indicator used is DCR (Debt Coverage Ratio), which must be over 140%[1]. Banks also perform a whole host of audits: audits of the official project authorisations, technical audits, audits of the insurance policies in place, etc. They also impose sizable bank guarantees.
- **Investment funds** currently display little interest in the biomethane industry, given the relatively small scale of projects (the average injection capacity is 165 m³(n)/h, which represents an investment of 3.4 to 4.8 million euros[2]) and their variability in terms of the feedstock used, their legal and financial structure, their organisational model, etc.
- **Applying for subsidies** tends to be a laborious and costly endeavour (a preliminary study is required at a cost of €20,000 to €40,0001[1]). In addition, the subsidies available differ from region to region and according to the type of project.

3. Solutions are emerging to harness currently unexploited production potential

An analysis of the full range of resources available to produce biomethane allows us to establish a sectoral breakdown of the volumes that could realistically be injected into the grid by 2030 see Fig.6. The agricultural sector offers the greatest potential: agricultural materials are expected to account for around 90% of the total.

However, usable agricultural resources are often located in rural areas a significant distance away from natural gas networks. Thus, a certain proportion of the total capacity is difficult to access, including:

1 Analyses by ENEA Consulting based on interviews with industry professionals.

2 Analyses by ENEA Consulting

- **Potential capacity located near the gas grid** but in areas of network saturation where biomethane cannot be injected during periods of low consumption. However, such situations are rare today. Technological solutions are being developed to maximise the injection capacity of these networks, including backhauling to a higher-pressure network in the opposite direction to the normal flow of gas, as well as temporary biomethane storage
- **Potential capacity that is too distant from the gas grid** for connection to be viable. Alternative delivery solutions exist, i.e., road transportation of biomethane in compressed liquid or gas form, for subsequent injection into gas networks that can take on larger volumes of green gas.

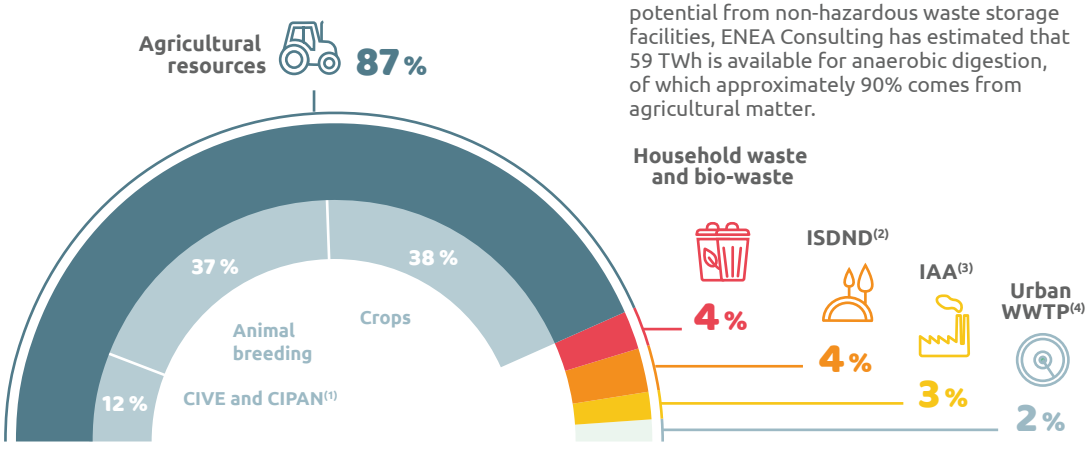
These solutions can also be considered to transport biomethane directly to consumption points, thus bypassing its injection into the grid. There are currently no support mechanisms in place for this type of configuration, whether it be without injection or with "centralised" injection (where several production sites transport their biomethane by truck to a single shared injection point).

Certain existing biogas cogeneration facilities could also be modified to produce biomethane. However, the current sliding scale of feed-in tariffs linked to the length of time for which a facility has been producing biogas (S1 coefficient) hinders the emergence of such projects. Launching invitations to tender for these projects could be a more effective solution that would enable potential to be exploited at a relatively low cost, as it would be marginal compared with the initial investment.

Figure 6

Agriculture, the leading contributor to biomethane production in 2030

By analysing the studies on resources carried out for the ADEME B.11 et B. 12, and assessing the potential from non-hazardous waste storage facilities, ENEA Consulting has estimated that 59 TWh is available for anaerobic digestion, of which approximately 90% comes from agricultural matter.



(1) CIVE: intermediate crop for energy purposes. CIPAN: intermediate nitrate-trap crops
(2) ISDND: non-hazardous waste storage facility
(3) IAA: food industry
(4) WWTP: Waste water treatment plant

Using the available agricultural resources, often located in rural zones far from the natural gas networks, represents a technological challenge. Alternative transport solutions are now emerging to make the most of this potential.

ABOUT NETWORK SATURATION

" Almost 90% of the biomethane production sites that will inject gas into the grid will be connected to distribution networks. However, certain of these networks currently consume too little natural gas to allow all the biomethane produced to be injected. This can restrict the injection capacity of facilities that are already operational, while also compromising the feasibility of some projects, as investors may consider that the lack of an outlet generates too high a financial risk. These situations occur chiefly in the summer when consumption for heating or industrial purposes falls drastically

. Network operators have teams that are working on designing and implementing solutions that will enable biomethane producers to inject as much renewable natural gas into these networks as possible, today and in the future.

In most of these situations, simple and mature solutions can be implemented: regulating the pressure of certain sections of the grid differently in summer and winter, connecting an area where consumption is low to one where it is high (this is known as meshing), etc.

A number of less mature solutions are now being examined, including backhauling, where gas is compressed and transferred from a distribution grid to a network with a higher pressure (distribution or transmission) that is able to absorb the biomethane injected into it. Another possibility is temporary biomethane storage in liquid or gaseous form, which can be reinjected into the grid when consumption rises. Two pilot distribution/transmission backhauling facilities are currently being developed and are set to go into service in late 2019, allowing the design to be validated, different technical options to be tested and the operation of grids equipped with the system to be checked. Both pilots will be incorporated into wider territorial development programs as well as programs focusing on smart grids and the use of digital technologies."

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Supply and consumption

Gas suppliers have much to gain from developing their biomethane offerings

End consumers still find it difficult to fully understand and access green-gas offerings. Packages that focus primarily on major consumers (local authorities, office buildings, industrial firms, etc.) have been available from long-established suppliers for several years now, but these are not available to the public and are tailored to customer requirements. However, two suppliers positioned themselves in 2017 to open the market to French consumers.

ABOUT ROAD TRANSPORTATION

" Biomethane liquefaction is in its early days in France. It enables biomethane to be transported from remote agricultural sites to locations at which it can be injected into the natural gas distribution grid. To facilitate the production of biomethane in isolated agricultural regions, setting up a regulated tariff for uninjected gas would allow bioLNG to be used as vehicle fuel, thus enabling trucking companies to reduce their greenhouse gas emissions by 90% compared to diesel, while benefitting from the high range offered by LNG (1500 km)".

Cryo Pur From waste to fuel

The number of filling stations offering bioNGV remains very small: at the end of 2016, out of the 50 or so public NGV stations in France, only 30 offered bioNGV[1] Bib.13.

Meanwhile, demand for renewable natural gas is set to grow over the next few years and demand for biomethane as a heating fuel should attract new consumers:

- **In the short term:** following the introduction of the TICGN tax exemption Bib.8 for biomethane injected into the grid, major gas consumers have been requesting that suppliers provide them with renewable natural gas. This demand is also driven by the CSR[2] considerations and marketing strategies of large groups. Furthermore, firms that supply green electricity to private individuals believe that one third of their customers are interested in green gas[3]. Switching to biomethane means accessing renewable energy without having to modify existing gas heating systems.
- **In the medium term:** district heating networks are showing high potential demand and the ADEME has forecasted that their consumption of gas will double between 2013 and 2030 (from 16 to 30 TWh) Bib.14. District heating network operators receive tax incentives when over 50% of the energy they use is renewable or recovered. This takes the form of a VAT rate reduced to 5.5% Bib.9. The new building sector could also be a crucial market for the biomethane industry in the context of France's 2018 Environmental Regulations (RE 2018), which will impose limits on the sector's CO2 emissions Bib.15.
- **In the longer term:** if the price per ton of CO2 on the allowance market is sufficiently high, this could well attract major consumers that are subject to CO2 emissions allowances (EU ETS[4]).

Demand for bioNGV should rise in line with the growth of NGV: the network of NGV fillings stations has expanded steadily in the last few years, with more than 50% of stations offering bioNGV by the end of 2017. The application of the European AFI (Alternative Fuels Infrastructures) directive, which requires Member States to develop a network of stations offering alternative fuels, will enable the network to more than triple in size by 2025, as shown in Fig.7. The National Action Plan for the Development of Alternative Fuels (CANCA), drafted by the government in response to this directive, does no more than maintain the current trend and targets the figure of 140 stations by 2025 Bib.16. The French Natural Gas Vehicle Association (AFGNV) is much more ambitious and estimates that 300 NGV filling stations will need to be in place by 2025 to reach the same targets Bib.17. Lastly, the plans announced by public transport operators and mass retailers to roll out bioNGV-powered vehicle fleets will be vital to achieving the growth required.

ABOUT DEMAND FOR BIONGV

" Our objective is to support and speed up the sector's development by opening more than 100 NGV filling stations in the next five years to ensure coverage across the country. BioNGV offerings that cater to the needs of our customers will of course be a part of this deployment."

TOTAL

1 BioNGV: Biomethane as vehicle fuel (NGV: Natural Gas for Vehicles).

2 CSR: Corporate Social Responsibility.

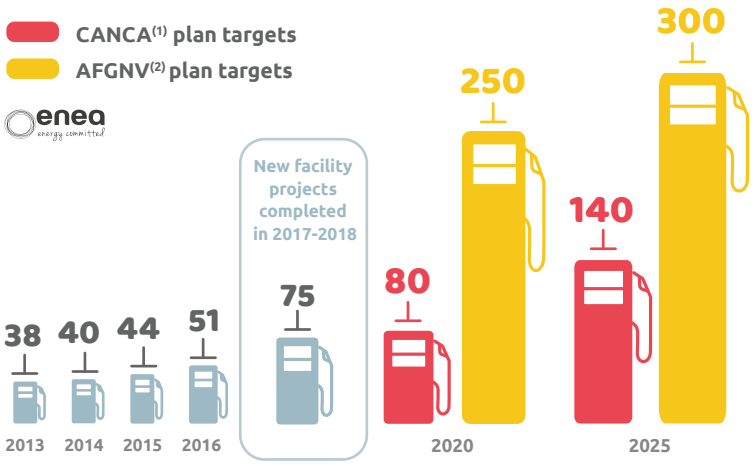
3 Analyses by ENEA Consulting based on interviews with industry professionals.

4 EU ETS: European Union Emission Trading Scheme.

Figure 7

A potential of 300 filling stations by 2025

Potential growth of France's network of NGV filling stations by 2025



The number of NGV filling stations in France should at least triple by 2025. However, if we consider a realistic, proactive deployment scenario, the current number could be multiplied by 6, covering all of France.

By gaining a clearer long-range visibility, gas suppliers and consumers will be able to ramp up their involvement in the industry.

The support mechanisms in place need more clarity and consistency. The fact that biomethane suppliers retain 25% of the value of GOs for heating applications, compared to 100% for vehicle fuel applications, essentially means that there is indirect support for the latter. However, this mechanism is not consistent with other tax measures that tend to favour heating applications: biomethane for vehicles (bioNGV) is not exempted from the TICPE[1], consumption tax, which is notably applied to polluting fuels, while the use of biomethane for heating is exempted from TICGN, a tax on the consumption of natural gas that is paid directly by users.

The difficulty involved in anticipating future changes to the sector's support mechanisms prevents users and suppliers from making lasting commitments: setting up long-term supply contracts with fixed volumes or prices is practically impossible, particularly for those suppliers that do not purchase biomethane directly from a producer (the price of the GOs exchanged is relatively high and there are no guarantees regarding its short- and medium-term variations). Suppliers are also uncertain as to whether they should direct their efforts towards vehicle fuel or heating applications.

Setting up a common and fair GO market at European level will require the structuring of incentive schemes.

Within the scope of RED II[2] – the new European Union renewable energy directive for 2020-2030 – an open biomethane GO market is now being considered. However, this could well lead to a degree of dumping. Indeed, given the highly heterogeneous nature of incentive schemes, it is very likely that GOs would be drained from countries that offer strong incentives for production (where the cost of GOs is low) towards those that primarily promote the use of biomethane (where purchasing GOs is well rewarded by incentive systems).

1 TICPE: Taxe Intérieure de Consommation sur les Produits Energétiques (Domestic Tax on the Consumption of Energy Products).

2 RED II: Renewable Energy Directive II, the new European Union renewable energy directive for 2020-2030.

THE MARKET
Recommendations

Based on these analyses, three main recommendations for the government and the sector's decision makers have been identified to speed up the sector's development.

1. Simplify administrative procedures to reduce the time it takes to set up a project

Setting up an ICPE project is a particularly long and costly undertaking, particularly for facilities classed as requiring prior authorization. Raising the thresholds applied to the quantity of material processed would reduce the time needed for a significant number of projects on the waiting list to obtain administrative approval: we recommend increasing the threshold from 30t/day to 60t/day for projects classed as requiring registration and an increase from 60t/day to 100t/day for those requiring prior authorization[1].

2. Improve the clarity and long-range view of the support mechanisms available, by ensuring that they are consistent with the goals set and favour the long-term development of biomethane in France

The incentive framework in place to develop biomethane's use as motor and heating fuel remains inconsistent. It would therefore make sense to clarify the preferred development strategy by establishing a typology of uses and ranking them in terms of their energy efficiency and environmental performance, relative to the energy sources currently used for the same purposes.

Publishing a timetable indicating possible changes to feed-in tariffs – and more generally to the support mechanisms available – would offer stakeholders in the industry a clearer long-term outlook and thus favour the development of biomethane.

To bring current rules up to date, it will be important to involve the market's various stakeholders, suppliers and consumer representatives in discussions on support mechanisms held within the "Biomethane Injection" Working Group.

Lastly, setting up a more appropriate support mechanism for biomethane transported by road (and not injected) will be key to exploiting the significant potential of remote locations.

3. Highlight France's specificities when the likely harmonization of European markets and mechanisms takes place

French stakeholders, and primarily the government, must channel their energy into RED II so as to play a proactive role in building a shared European vision. It will be crucial to harmonize the European mechanisms to establish a common and fair GO market in Europe to avoid GO dumping[2].

1 These recommendations are the same as those made in the France Biomethane White Paper published in November 2016 **Bib.26**.All proposals for the 1st focus area "Facilitate the process of obtaining administrative approval and the operation of production plants so as to attain biomethane production targets") should be examined by the government.

2 The term dumping refers to commercial practices that go against the spirit of competition

2

THE TECHNOLOGIES

AN OPPORTUNITY TO DEVELOP A WHOLE HOST OF INNOVATIVE AND VALUE-CREATING FRENCH TECHNOLOGIES

- Overview
- Challenges and opportunities
- Recommendations

THE TECHNOLOGIES
Overview

The production and injection of biomethane requires a number of separate technologies, including:


Feedstock processing


Anaerobic digestion of feedstock


Compression of the biogas produced


Biogas upgrading


Transport and storage of biomethane

The initial feedback from biomethane production sites is positive

The feedstock mix and biomethane production capacity both condition the technological choices to be made and the size of facilities. The sheer variety of projects in France makes standardising technologies for suppliers a complex task.

Despite this context, the initial feedback from network operators regarding the first facilities to produce and inject biomethane has been positive: facilities that are operating at rated production are able to inject the necessary quantities of biomethane; the quality of the biomethane injected complies with the specifications of network operators (no noncompliance issues), and the availability of injection points at facilities operating at rated production is much higher than contractually required, with an average availability rate of 98% observed[2] Bib.18.

1 Feedback based on a year-long study of around ten biomethane injection projects

2 Injection point unavailability is calculated as the time during which no injection is taking place in periods when it should.

FEEDBACK FROM THE ADEME STUDY ON INJECTION TRENDS *

According to the conclusions of the study commissioned by the ADEME **Bib.18** from ENEA Consulting and APESA, which involved monitoring eight biomethane production sites over a full year: "Four sites are generating a profit in their first year.

"Four sites are generating a profit in their first year. According to the data for the first year and assuming that they will operate at rated production in future years, six out of the eight sites boast internal profitability rates of more than 8%, which takes into account subsidies but not provisions for depreciation, financial expenses and tax."

The study's results confirm that France's biomethane injection sector has the capacity to open facilities that are fully operational and efficient in their first year of service. While this sample of sites is not statistically representative of the sector as it stands today, it does reflect the diversity of feedstock, anaerobic digestion processes and facility sizes. The study's findings are encouraging, because they highlight the technical and economic success of most of the sites monitored. They also indicate that the conditions for success are attainable and replicable. In addition, it is worth noting that the errors and incidents observed at the study's less successful sites can be avoided in the future

*** bib.19**

ADEME
Agence de l'Environnement et de la Maîtrise de l'Energie

France's technology offer, which is still being consolidated, is gradually gaining in experience and adapting to the country's specificities, thanks to a growing number of technical options.

The anaerobic digestion offering initially available in France grew thanks to technology providers from neighbouring countries where the biogas industry is more mature; most are based in Germany. Liquid anaerobic digestion (which is better suited to easily degradable materials such as energy crops) is employed in most cases: 90% of France's biogas production facilities employ a liquid process[1].

Since 2010, an increasing number of equipment manufacturers have entered the market to diversify the technologies on offer and tailor them to French feedstock, notably by developing technologies to pre-process undesirables and dry processes. The latter are suited to the whole spectrum of dry substrates from agricultural, territorial and industrial projects.

Biogas upgrading facilities were initially developed by German suppliers: from 2011 to 2014, half of all biomethane production units used German upgrading technologies. In terms of technologies employed, membrane-based systems have achieved the greatest market penetration. They were

1 Analyses of France's existing facilities by ENEA Consulting

used in three-quarters of the biomethane production sites operating over the period. However, French equipment manufacturers recently opted to diversify their commercial offerings by marketing several different upgrading technologies (including amines and washing with water). Their current development stages range from R&D to commercial applications. A number of start-ups are developing cryogenic upgrading technologies, which are notably suited to biogas from refuse sites, whose composition makes it incompatible with standard upgrading technologies.

France's technology specialists are engaged in a process of continuous improvement

Cross-professionalisation is gradually developing between equipment manufacturers and operators, to ensure that facilities run smoothly throughout their lifetime. Cooperation is also taking place within associations comprising project owners, construction firms and operators, to professionalise their practices, develop expertise and draw up quality charters.

French equipment manufacturers now export their industrial know-how

The French sector is now offering a comprehensive and fast-growing range of technologies: a plethora of start-ups and SMEs operating across the value chain have emerged as a result of the French market's growth and the government support pledged to boost the sector.

These companies recently started exporting their expertise to other countries in which the sector is developing, such as Italy, Spain and Ireland. This recognised technological offer must continue to benefit from development of the French market as a springboard for international success.

ABOUT THE INDUSTRY IN FRANCE

"Biomethane offers France an opportunity to develop fresh expertise and create champions of industry, who will generate value across the country and export their solutions. Today, French firms are developing internationally in various innovative sectors such as biowaste depackaging, digestate processing, biogas upgrading to produce biomethane, biomethane liquefaction and remote injection, etc.
The ability of today's solutions to cater more closely to the specificities of the French market and the inroads French industrial firms are now making abroad demonstrate the clear progress made in the last two or three years alone.
Releasing and exploiting the full potential of biomethane in France will ultimately generate new sources of innovation and industrial jobs!"

BIOGAZ'ALLÉE®
Le cluster de la méthanisation

THE TECHNOLOGIES
Challenges and opportunities

Anaerobic digestion

There is room for improvement when it comes to adapting technologies to the French market

The development of dry anaerobic digestion is key, given France's potential to produce biomethane from agricultural feedstock, whose dry matter content is high. As yet, discontinuous dry anaerobic digestion is not a fully mature method. Despite an expanding offering, user feedback remains limited and a number of operating conditions need to be simplified to ensure that the process is sufficiently robust, stable and straightforward. Research efforts are now focused on this area, led by increasingly active research groups. Although already used on three German sites, biomethane production using this technology warrants further development to achieve the best possible results.

As regards the pre-processing of agricultural biomass, the technological adaptations already initiated by manufacturers must be further pursued. Possible avenues include stricter sorting of foreign bodies found in straw and manure, designing technical solutions that allow the use of heterogeneous feedstock, and improving the biodegradation of straw and manure.

The possibility of standardising equipment is currently being investigated by manufacturers. One solution being considered is the development a range of biogas plants that are able to process typical varieties of feedstock mixes (e.g., a mix of agricultural residue generated mainly from cereals and manure).

Upgrading

Current upgrading technologies have room to mature and improve

Biogas upgrading is still a young sub-sector of the industry in France, having only really begun to pick up speed in 2015 when the number of facilities became significant. The development portfolio of upgrading technology manufacturers has been limited by the number of projects undertaken each year. The biomethane sector's current growth dynamic should enable technology developers to increase the number of products they are able to market.

To increase the competitiveness of French facilities, R&D work is underway to improve their energy efficiency. In addition, remote monitoring is gaining ground and will improve response times and feedback quality in the event of operational issues or process interruption.

Finally, some suppliers are going down the standardisation route by developing upgrading technologies that cater to common ranges of biogas inflow rates and injection pressures. However, the risk is that this will lead to equipment being over dimensioned with respect to a facility's actual needs.

Injection maximisation and storage

Gaining access to the potential of unexploited sources will stimulate the development of new technologies

Transport and injection technologies must be developed to exploit feedstock that is located too far

from the grid. These technologies will focus on the road transportation of biomethane in compressed or liquid form, from the production site to a point at which it can be injected into the gas grid or delivered to consumers. However, it will be difficult for such methods to emerge in France's current regulatory context, which does not provide for these options Bib.20.

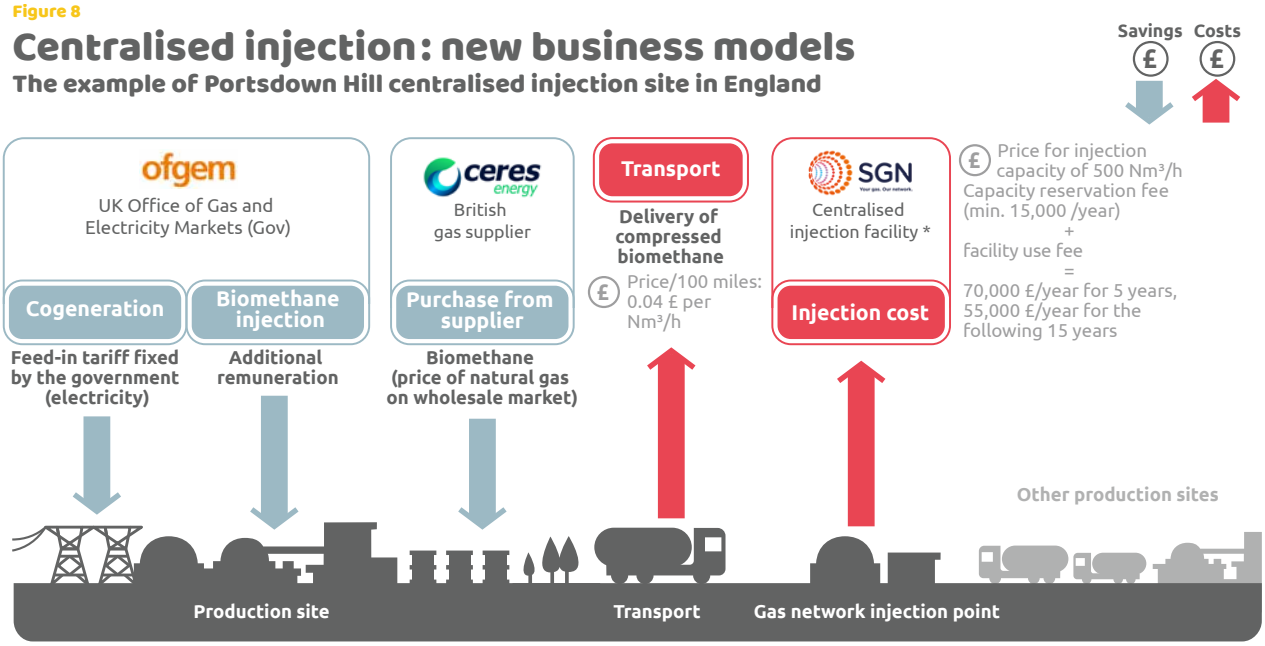
To enable more projects to see the light of day, the creation of centralised injection points would allow injection costs to be shared. To enhance their techno-economic understanding of this approach, which remains unheard of in France, in June 2017 the study's various partners visited the centralised injection site in Portsdown Hill (United Kingdom), the first and only facility of its kind in operation in Europe. By the time of the visit, eight biomethane production sites had signed contracts with SGN – a major British gas distributor and the firm responsible for the facility – to take advantage of its centralised injection services. The Portsdown Hill business model, which is applicable to a typical biomethane production facility, is presented in Fig.8.

Lastly, reduced gas consumption during the summer months can restrict the injection capacity of some parts of the distribution grid. New technologies could be developed to maximise biomethane injection, including backhauling, which allows gas to be transferred from a distribution network to a transmission network, and storage technologies, which allow biomethane to be stored temporarily when the grid is saturated.

Figure 8

Centralised injection: new business models

The example of Portsdown Hill centralised injection site in England



*Capex 7 M£ (next installation 2.5 to 3 M£)
Opex 100 k£/year – Claimed ROI: 6 to 7 years

The tour taken in June 2017 of Portsdown Hill, Europe's only centralised injection facility in operation, allowed us to analyze its business model and use it as an inspiration for France.

At the time of the visit, 8 biomethane production sites had signed contracts with SGN – a major British gas distributor and the firm responsible for the facility – to take advantage of its centralised injection services. The production sites can collect revenue from three different channels thanks to the simultaneous production of electricity and biomethane:

- *Via a feed-in tariff for heat and power cogeneration*
- *Via additional remuneration for biomethane production added to the sale of renewable gas to a supplier*

To access centralised biomethane injection, producers must pay a transporter to deliver the gas to the centralised facility, as well as SGN via an injection fee (actual capacity reservation and injection). The current regulatory framework in France must change to take into account this type of situation (for example, the way in which producers are paid for the quantity injected).

THE TECHNOLOGIES

Recommendations

A number of actions have been identified to support the sector's professionalisation and industrialisation, as well as the development of technological innovations:

1. Set up certified quality procedures specific to biogas/biomethane and share feedback across the sector, to ensure that processes continue to be perfected

Collaboration between project owners, manufacturers and operators via national and regional associations serves to professionalise the industry's practices and develop French expertise in the biomethane sector. These initiatives are also the opportunity to introduce labels (which already exist for solar and wind power) to certify the quality of a site's equipment and/or project management and/or operations, so as to offer performance guarantees to industry stakeholders and users. It is essential that we continue down the path of certification.

Local authorities can also take advantage of their influence to set up specialist advisory bodies allowing best practices and feedback to be shared.

2. Build a national R&D roadmap for anaerobic digestion and injection, to ensure that technological development continues in the sector

It will be crucial to implement a national R&D roadmap centred on technological innovation and the industrialisation of developed processes. The government must identify the right candidates to fulfil this role: it might be an association, grid operators or other industry professionals, the relevant government ministry, etc.

The creation of specialist research clusters would also boost technological innovation. Meanwhile, equipment manufacturers could establish ties with research centres to industrialise the solutions developed by these units and, in particular, the anaerobic digestion technologies that cater to France's specific requirements.

Encouraging the set-up of pilot projects in the country to test backhauling and road transport technologies will also be key. As is the case in Germany and the UK, this would enable French stakeholders, notably operators of gas transmission and distribution grids, to stay ahead of the curve in terms of developing and marketing technological solutions to maximise biomethane's development potential (two pilot backhauling facilities are currently being developed and are set to be commissioned in late 2019).

3

THE ECONOMICS

SUPPORT MECHANISMS ADAPTED FOR TODAY AND EFFECTIVE ECONOMIC DRIVERS FOR TOMORROW

- Overview
- Challenges and opportunities
- Recommendations

THE ECONOMICS
Overview

In a previous study carried out by GRDF and ENEA Consulting, production costs in the biomethane sector and their reduction prospects were modelled for three standard sub-sectors (autonomous agricultural, territorial agricultural and territorial industry), according to techno-economic hypotheses based on a sample of existing French installations. The economic analysis in this publication is derived from the results of that study.

According to the modelling, biomethane production projects are currently mostly profitable with feed-in tariffs

Today, a biomethane producer can sell biomethane The main cost items are feedstock purchasing and management and the upgrading stage that together may represent over 50% of total production costs over the project life. Given the range of different types of biomethane production projects in France, the actual project production costs may vary significantly. These results must hence be viewed with caution.

The sliding scale feed-in tariff in France tends to favour the competitiveness of small production units.

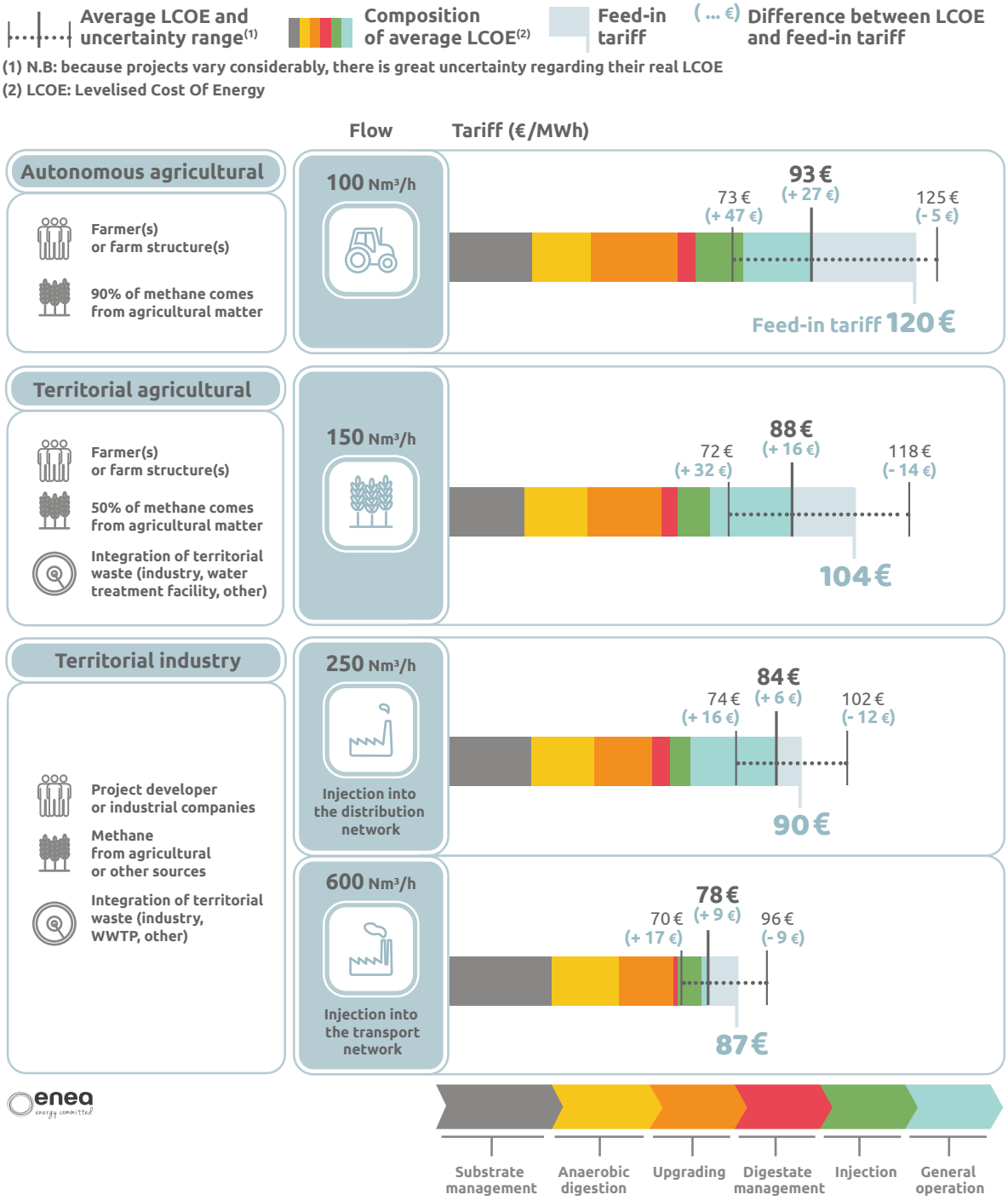
The decrease in the feed-in tariff for biomethane injected into the network due to the increase in the size of installations is greater than the cost reductions from economies of scale. Moreover, territorial installations suffer from more complex and risky feedstock supply management, which is reflected in their loan conditions. As a result, the margin generated on feed-in tariffs is higher for small capacities, of the autonomous agriculture type (below 150 m³(n)/h) than for average capacities, of the territorial industry type (roughly 250 m³(n)/h of injection capacity). Above 350 m³(n)/h, the feed-in tariff no longer decreases according to capacity and economies of scale make it possible to improve the project margins for high capacity units see Fig.9.

1 The definitions of these sub-sectors, illustrated in **Fig.9**, come from the Renewable Gas French Panorama **Bib.4**.

Figure 9

Current feed-in tariffs make the sector profitable

Economic analysis of the current sector looking at 4 standard production types. Results taken from an earlier GRDF and ENEA Consulting study.



Today, a biomethane producer can sell biomethane to a supplier at a price defined in the feed-in tariff and cover their production costs, which range from 80 €/MWh to 95 €/MWh, excl. subsidies, depending on the sub-sectors modelled (autonomous agricultural, territorial industry). The main cost items are feedstock purchasing and management and the upgrading stage that together may represent over 50% of total production cost over the project life. As the uncertainty zone suggests, given the range of different types of biomethane projects in France, the actual project production costs may vary considerably. These results should therefore be viewed with caution.

THE ECONOMICS
Challenges and opportunities

The sector's competitiveness without a feed-in tariff is evaluated with respect to the wholesale market price of natural gas. It is dependent on CO2 price evolutions and cost reduction prospects

Biomethane production costs are currently much higher than natural gas prices. In view of a possible feed-in tariff decrease, it is necessary to find ways of improving the competitiveness of biomethane, which essentially depends on evolutions in the price of natural gas and of CO2, via the climate-energy contribution (carbon tax[1]), and also on the prospects of lower production costs.

The first cost reduction strategies studied, associated with an increase in the carbon tax, would make biomethane competitive with natural gas priced between 50 and 60 €/MWh on the wholesale market in 2030

Natural gas price fluctuations are hard to predict in the long term. France does however have a schedule for carbon price evolutions, with a target price of 100 €/tCO2 set by the LTECV for 2030 Bib.3. This carbon tax, which has already been integrated as a "climate-energy contribution" in domestic energy consumption taxes (TICFE[2] for electricity, TICGN for natural gas and TICPE for fuel), will make it possible to significantly reduce the difference between biomethane production costs and the price of natural gas including the carbon tax[3]. However, given current biomethane production costs and natural gas prices, a carbon tax of 100 €/tCO2 would be insufficient to make biomethane competitive without a feed-in tariff. It is therefore necessary to bring down production costs to ensure the competitiveness of the biomethane sector.

An analysis of cost reduction potential shows in Fig.10 that the implementation of three sets of strategies could significantly reduce costs: increasing production efficiency and improving biomethane quality, lowering upgrading costs, and standardising skills, methods and equipment. A deeper investigation into these topics shows that the resulting cost reductions would be possible within 5 to 10 years. These three strategies are linked to technological improvements, economies of scale and new know-how[4]:

- **An increase in the quantity of biogas produced** or in the biogas' methane content at an identical feedstock blend and quantity: five associated improvements could generate an additional decrease of 3 to 4 €/MWh – a reduction in the losses of the methanogenic potential of manure, the systematic grinding of feedstock, the use of insulating gasometric membranes, improved biogas monitoring and the decoupling of the hydrolysis and acidogene-

1 The increase in the European emissions allowance price via the EU ETS (to which major industrial consumers are subject) may improve the competitiveness of biomethane compared with natural gas for these users. This possibility was not modeled in the study.

2 TICFE: Domestic tax on final electricity consumption.

3 The impact of an increase in the cost per ton of CO2 on the LCOE is clear Fig.9. It was modelled in the fuel usage case (via the "climate-energy contribution" of the TICGN), as equal to a subsidy reducing biomethane's LCOE, compared with the wholesale market price of natural gas.

4 ENEA Consulting analyses pursuant to interviews carried out with industry professionals and the evaluation of the proposed technological solutions.

sis phases.

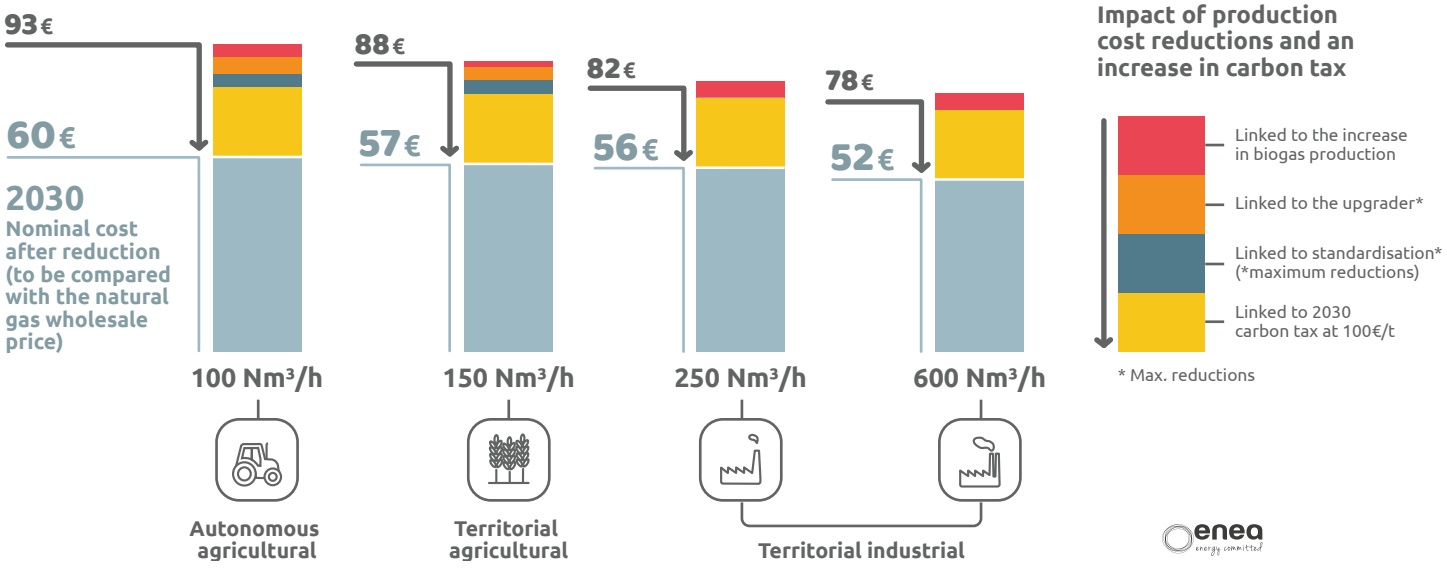
- **Cost reductions for upgrading technologies:** an average decrease of 10% in upgrading CAPEX (a unit's biggest investment item) is being considered by membrane upgrading system suppliers, to be achieved through lower integration costs, additional R&D, and economies of scale. These solutions represent an additional 6% decrease in LCOE[1].
- **Sector standardisation** throughout the entire value chain (project development / financing / construction / operations and maintenance): this requires fewer made-to-measure systems and the establishing of standard anaerobic digestion unit models. According to the stakeholders interviewed, the effects of standardisation could be a 10% decrease in total CAPEX, especially for agricultural projects with relatively stable feedstock mixes (autonomous and territorial agriculture) leading to an additional 5% decrease in LCOE (excluding upgrading that was already considered in the previous strategy).

Hence, these first cost reduction strategies could generate significant additional decreases making it possible to reach an LCOE that is 30% lower than its current level. When associated with a carbon tax at 100 €/tCO2, biomethane would be competitive with natural gas priced between 50 and 60 €/MWh on the wholesale market.

Figure 10

Competitive biomethane at a natural gas wholesale price between 50 and 60 €/MWh in 2030

Results from an earlier GRDF and ENEA Consulting study



The first three studied cost reduction strategies could generate an additional decrease making it possible to reach an LCOE that is 30% lower than the current level. When associated with a carbon tax of 100 €/tCO2, biomethane would be competitive with natural gas priced between 50 to 60 €/MWh on the wholesale market. Only some of the possible cost reductions could be quantified and further improvements must be planned over the coming years. It should be noted that this economic analysis does not consider the possible development of exogenous factors that could have an impact on costs (e.g. tougher regulations or a tight feedstock market that could put production costs up). These results should therefore be viewed with caution.

1 ENEA Consulting analyses pursuant to interviews carried out with industry professionals and the evaluation of the proposed technological solutions

What's more, only a part of the cost reductions were quantifiable; additional production cost reductions, based on R&D work whose effects cannot yet be measured, remain conceivable in the long term. This may concern the three previously studied strategies (for example, adding enzymes to the digester to increase the methane content in the gas produced) or other strategies such as maintenance optimisation, lower network connection costs via standardisation, and the integration of feedback concerning injection facility characteristics.

Additional revenue may be generated from the sale of biomethane co-products thus increasing the profitability of production projects.

Digestate is considered as a waste produced by an ICPE (environmentally sensitive facility), which obliges the installation to implement a land spreading plan to return the digestate to the ground. There are options available today to commercialise digestate but they are costly and complex to set up Bib.21 :

- **Process the digestate** to meet compost usage standards making it possible to spread the digestate without limitations and to sell it.
- **Obtain a marketing authorisation (AMM[1])** from Anses[2] to approve the digestate for sale as fertilizer.

Regulatory changes are currently being studied both at the European scale and in France to facilitate the recovery of digestates. In this framework, specifications for the marketing and use of agricultural anaerobic digestion digestates as fertilizers were recently approved Bib.22.

In certain applications, CO2, a co-product of biogas upgrading, may also be recovered. This would require the use of cryogenic upgrading technology to produce extremely pure liquid CO2 that can be transported and used for specific purposes: refrigerated transport, in greenhouses or for industrial uses such as dry ice.

Beyond the pure project economics, the development of the biomethane sector generates many positive externalities

Firstly, the biomethane sector contributes to the development of a local circular economy:

- Biomethane is not only an energy source; it also contributes to organic waste processing and recovery.
- Anaerobic digestion enables the production of fertilizers that are rich in humic and renewable materials. The sector creates wealth for the agricultural sector – it enables farmers to generate additional income but also to rethink their farming practices.
- The sector creates local jobs: 1 to 2 full-time equivalents per production site and 3 to 4 in an indirect manner[3]
- Lastly, biomethane production provides an opportunity to promote local energy consumption.

What's more, the sector also helps attain long-term national objectives:

- It helps to reach greenhouse gas emission reduction objectives by replacing natural gas or other fossil fuels such as Diesel or petrol for NGV uses. This positive externality can today be monetised via CO2 prices (carbon tax and emission allowance market).
- Injection makes it possible to perpetuate and modernise existing gas transport and distribution infrastructure in the long term, in the context of decreasing gas consumption.
- In the long term, the sector contributes to France's energy independence by fostering the local production of non-intermittent and storable energy.
- Lastly, biomethane represents an opportunity to reduce atmospheric pollution (fine particulate matter and NOx).

1 AMM: Autorisation de Mise sur le Marché – marketing authorisation

2 Anses: French national food safety agency

3 ENEA Consulting analyses of agricultural-type biomethane injection sites.

THE ECONOMICS
Recommendations

On the basis of these analyses, 3 main recommendations were identified that may further the reduction of biomethane production costs and boost positive externalities:

1. The public authorities must use legislative tools to facilitate access to organic matter to reduce feedstock supply costs.
Making the recovery of organic waste mandatory and forbidding the transfer of certain types of organic matter to incinerators would make it possible to reduce the cost of feedstock for anaerobic digestion projects.

2. Pursue research by technology developers and projects working on production cost reduction strategies
The implementation of the first cost-reduction strategies, in particular the pooling of maintenance on different project process units (injection, upgrading, and digestion) will make it possible to decrease biomethane production costs.

Finally, stronger support for innovation would accelerate the development of breakthrough technologies aimed at significantly reducing biomethane production costs. A national R&D roadmap focusing on technological innovation and the industrialisation of the developed processes needs to be implemented[1].

3. Take into account the sector's positive externalities in its economic assessment, at the scale of the national and local authorities
The biomethane sector is not solely an energy sector and the long-term changes to support mechanisms must take into account the biomethane sector's positive externalities that are not otherwise monetised. A calculation of these positive externalities should drive positive changes to the support mechanisms provided by the public authorities. For example, the virtuous contribution of biomethane to waste treatment is already rewarded in the feed-in tariff's feedstock premium, which is based on the nature of the waste used for production[2].

Similarly, the local authorities have a role to play in taking into account biomethane's positive externalities at the local scale, by developing their production fleet as well as modifying their gas supply or reconsidering their energy mix.

1 See page 31, Technologies: recommendations – item 2 "Structure an R&D roadmap at a national level"

2 There currently exist three different subsidies: the wastewater treatment residue subsidy, the agricultural and agrofood waste subsidy and the urban waste subsidy.

4

THE FINANCING

THERE ARE REAL OPPORTUNITIES TO BE HAD FOR ACTORS THAT KNOW HOW TO INTEGRATE ALL OF THE SECTOR'S SPECIFIC CHARACTERISTICS

- Overview
- Challenges and opportunities
- Recommendations

THE FINANCING
Overview

Financing is a key element when putting together a biomethane production project. There are three different financing methods that involve different types of actors see Fig.11.

- Bank debt
- Subsidies
- Equity

The current stock of facilities was mainly debt financed

Biomethane production projects are essentially financed through bank debt that represents 55 to 75% of the total financing, depending on the project . The debt leverage for biomethane projects is however lower than it is for wind power or solar projects, as the required debt service coverage ratio is higher for the biomethane sector. The share of debt in the overall project financing depends on the type of project and its ability to meet bank financing criteria. Fig.11 shows the breakdown of biomethane production project financing in terms of bank debt, equity and subsidies, as well as the financing bodies positioned on these segments.

The biomethane sector is of minor interest to financing bodies due to the difficult early stages of the first biogas cogeneration sites

The difficult beginnings of the first biogas cogeneration sites have resulted in the limited appeal of the sector to financing bodies (mainly banks) and to more stringent requirements in terms of guarantees to limit their risk.

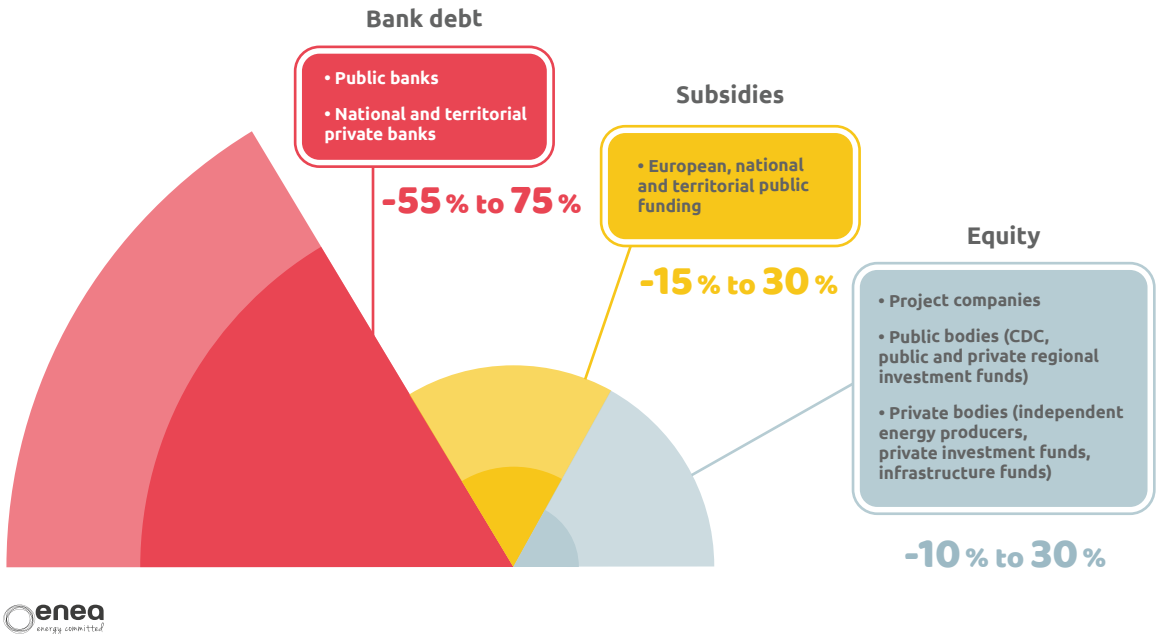
The perceived investment risks depend both on the technology selected for the production chain and the production site development phase, specifically the commissioning or rated production phase see Fig.12. A key element in a biomethane production project's success is the securing of feedstock quantity and quality. Feedstock availability is considered as a major risk by financing bodies: smooth technical operation and revenues generated for the project owner depend on the reliability of the supply plan. The performance guarantees given by the manufacturers and the professionalism of the future operators are other key elements for success.

1 ENEA Consulting analyses pursuant to interviews carried out with industry professionals and the evaluation of biomethane injection project financing models.

Figure 11

There are different sources of financing for the sector

Breakdown of production site financing and the financial bodies involved



Strategies are being set up by project owners to generate increased investor interest

To mitigate the risks associated with the technologies and facility operation (particularly during commissioning), biomethane sector stakeholders are working together to improve their credibility with financial bodies.

Project owners are thus increasingly structuring their governance processes:

- **Agricultural cooperatives** share best practices and are supported by chambers of agriculture: project teams are set up as associations with an elected leader and are organised into specialised working groups to spread the workload associated with project structuring (resources to be used, digestate to be processed, setting up of logistics, etc.)
- **The major territorial project developers** involve all their partners more to make them accountable, for example, via equity investments or by implicating them in operations.
- **Third-party stakeholders** (communities and syndicates in particular) are more involved upstream in the discussions to ensure the sustainability of the sites.

More generally, a "cross-professionalisation" is gradually developing between project owners, builders, equipment manufacturers and operators, particularly with the framework of associations, to ensure the smooth running of the installations throughout the service life of the sites.

Lastly, different strategies are emerging to ensure the secure and reliable feedstock supply for territorial projects, including:

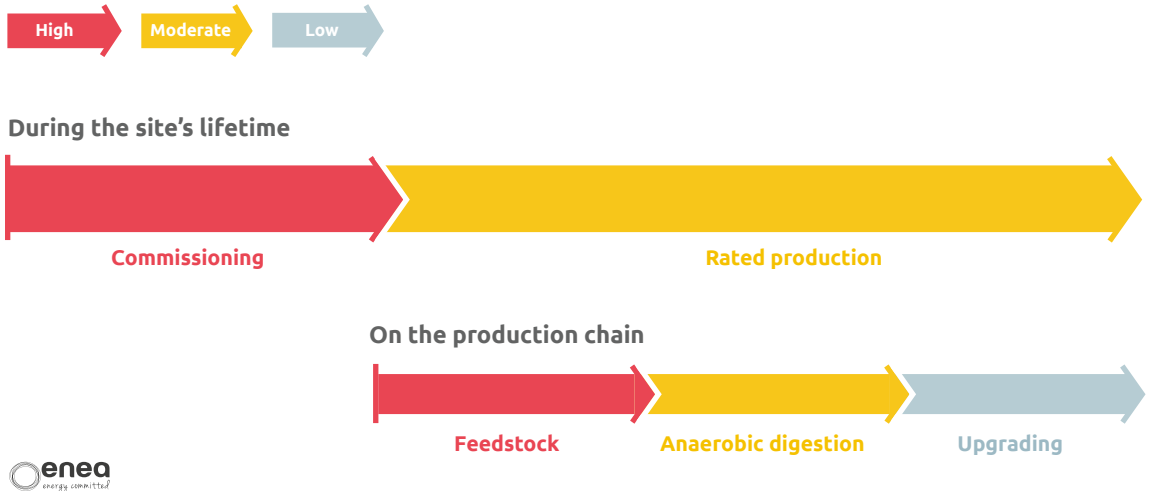
- **Equity investments by feedstock suppliers:** this strategy aims at getting feedstock suppliers to invest in order for them to have a financial stake in the success of the projects and thus encourage them to respect their commitments.

- **Feedstock contracting** over long periods: the supply of most feedstock could be secured for a minimum of 5 years by contract (and not a simple letter of intention) that stipulates heavy penalties should feedstock quality and quantity requirements not be met.

Figure 12

Securing feedstock supply, the main challenge for production

The risks perceived by financing bodies when investing in biomethane production facilities



For investors, securing feedstock quantity and quality is a key stage in financing biomethane production facilities.

THE FINANCING
Challenges and opportunities

ABOUT PROJECT FINANCING

« As this study demonstrates, the biomethane sector is a key component of the energy transition movement underway, but it's also key element of sustainable waste management, particularly agricultural waste. For long-term investors, the fairly limited unit size and the diversity of projects will require the adopting of platform-type logic, to pool together several projects while preserving the specific nature of each of them. Meridiam wants to continue to play an active role in the emergence of solid projects, whose profits will be shared by all of the stakeholders»

A forecast of future financing volumes was carried out on both trend-based fleet growth scenarios and national targets announced in Pluriannual Energy Program (PPE) and the Energy Transition for Green Growth Act (LTECV).

Biomethane sector financing needs are high but fragmented into small projects.

The financing volumes to be planned for production will be high in the coming years: from 1 to 2 billion euros from 2018-2023, and roughly €10bn to attain the LTECV targets for 2030 for the agricultural and territorial sub-sectors. This represents an opportunity for new types of investors, such as private investment funds or infrastructure funds, to become involved in the emergence of this sector: demand for equity financing could reach €500m in 2018-2023, and €4bn by 2030. The results of the evaluation of total financing volumes for production are presented in Fig.13.

These amounts are however distributed to many very diverse and low-capacity projects: the individual project financing needs are often much lower than the minimum amount investment funds require, which makes them of little interest to these funds.

The financing required to grow the NGV filling station network, which will also carry bioGNV, is also an investment opportunity for infrastructure funds.

The development of the use of biomethane as a fuel will require the deployment of NGV filling stations for natural gas-powered cars. Two "main types" NGV stations will require financing: "territorial" stations and "market-specific" stations. These stations don't attract the same types of investors: "territorial" stations require the intervention of mostly public financing bodies (local authorities, etc.) while "market-specific" stations attract private investors Bib.17. Future financing volumes for NGV stations were evaluated to 2020 and 2025 according to two deployment scenarios, one trend-based and the other more proactive see Fig.14.

Figure 13

€10 bn required by 2030 to develop the sector

Future financing volumes for biomethane production to 2023 and 2030

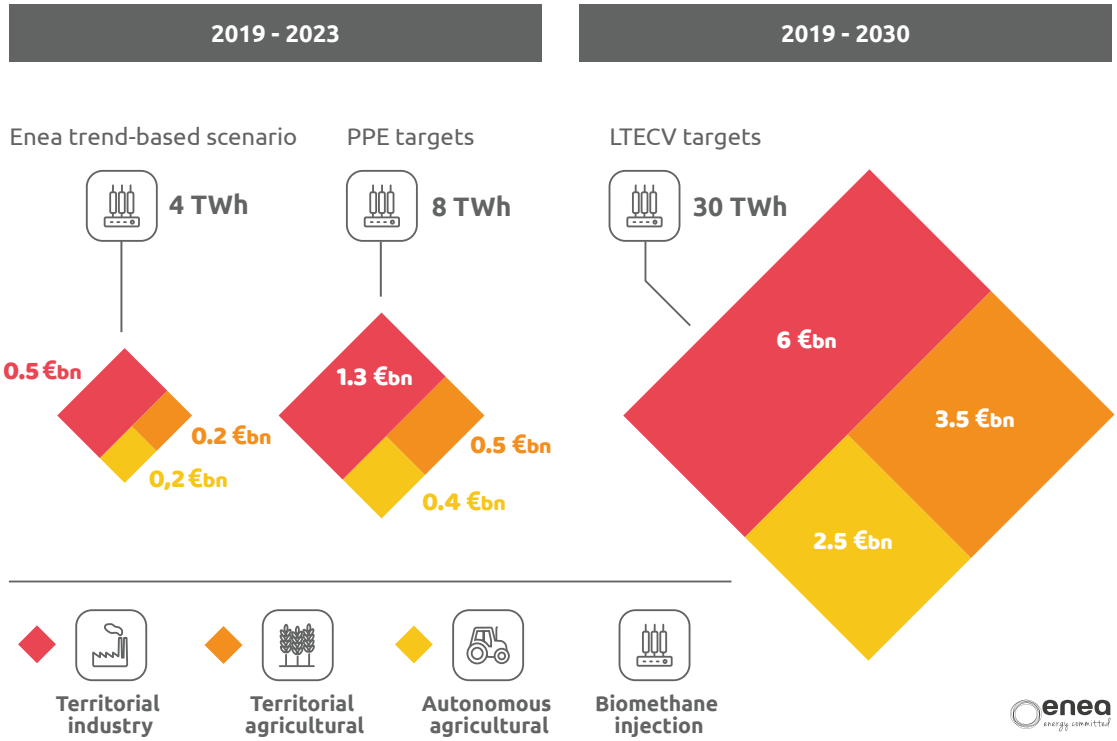
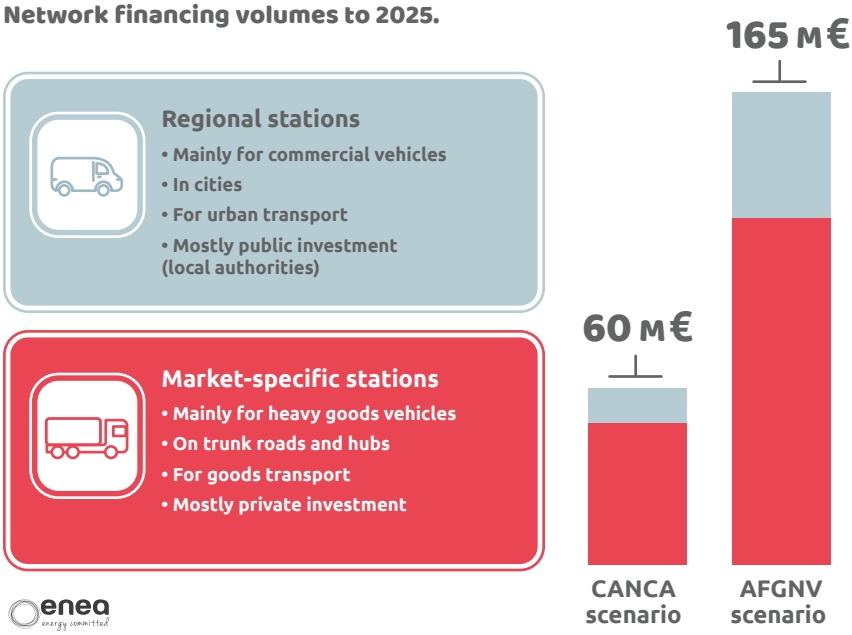


Figure 14

The involvement of private investors is essential for the development of the NGV filling station network

Network financing volumes to 2025.



Private investors, investing in the development of "market-specific" stations, will essentially be behind the deployment of NGV filling stations to 2020 and 2025.

The investment costs used for the NGV stations are taken from literature Bib.17 et 23The financing volumes have been estimated using the CANCA trend-related scenario set out by the government Bib.16, and the more proactive AFGNV scenario Bib.17.

THE FINANCING Recommendations

Three main recommendations emerge from these analyses to help generate more interest from the banking world and new financial bodies that are currently absent from this market:

The three main recommended actions focus on the public authorities, banks and project owners.

1. Provide additional guarantees to the banking world

The development of a guarantee fund model would reassure the banking world, whose role is essential for debt financing. Thought must go into the creation of a mechanism adapted to anaerobic digestion and biomethane injection (scope and duration of the coverage, ease of implementation, etc.). As an example, the French cluster GEODEEP, created in 2015 and regrouping international industrial groups, specialised companies, project developers and integrators, and professional organisations in the field of geothermy, proposes a guarantee fund financed by public and private funds to project owners to lower the risk they carry.

2. Engage new stakeholders in project financing

The systematic participation of substrate suppliers in equity investments would further secure feedstock supply and foster the emergence of territorial sites.

Local and national authorities could facilitate project financing by making equity investments in the sites, via the creation of mixed investment funds (public private partnerships) at the local scale.

Infrastructure funds could become more involved in anaerobic digestion projects. Beyond the provision of capital, their experience in long-term asset management could accelerate the professionalisation of the sector. For low-capacity projects such as autonomous agricultural projects, investment funds could study the feasibility of pooling projects via increased standardisation, thereby increasing the total investment amount to reach levels sufficiently high to make them worthy of investing. Investors could also work more closely together with project developers to create an investment pool to finance a project portfolio.

In the longer term, once the sector is more structured, the use of citizen and participatory financing tools (commonly used for PV and wind power financing) represents a new opportunity for civil society to reap local economic benefits. Participatory financing could moreover generate more interest in civil society and be a way of furthering social acceptability.

3. Structure the independent producer business model

Independents wishing to develop a biomethane production project would benefit from the support of specialised consulting and engineering firms to structure their business models. It would make it easier for them to find financing and to make the best technological choices.

Conclusion

Through this study, carried out with major stakeholders in the French biomethane sector, we were able to analyse the sector's market, technological, economic and financing aspects in detail in order to assess challenges and opportunities and to measure its development potential. Throughout this report, recommendations were made concerning actions to implement in order to foster the development of this sector.

This conclusion summarises the three main cross-functional focuses identified for the development of the biomethane sector in France.

The biomethane production sector is quite dynamic today and offers many opportunities for its stakeholders to take new positions that will contribute to its development.

Many positioning opportunities are available for sector stakeholders, enabling them to diversify their activities and eliminate the technical, financing or economic constraints that project owners must face during the development and operation of anaerobic digestion units. Here below are some examples of identified opportunities:

- **Financial bodies and investors** would benefit from working more closely with project developers in order to study the feasibility of pooling low-capacity projects, such as autonomous agricultural ones. The "project pooling" solution would make it possible to increase the total investment amount thereby reaching an amount sufficiently high to be worthwhile to investors; it would also make it possible to share the associated risks.
- **Equipment manufacturers** have opportunities to diversify thanks to the development of the French biomethane sector, by proposing new services to biomethane producers, such as third-party financing, O&M services, technology leasing, etc.
- **Natural gas transmission and distribution system operators** can propose new injection guarantee services, such as backhauling or storage solutions, to biomethane producers. The fact that pilot projects are being set up to test these new technologies demonstrates the will of these operators to support the emergence of projects.

With clearer long-term visibility of usage support mechanisms, gas suppliers and consumers will be able to become more sustainably involved in the sector.

The encouraging growth dynamics of the stock of facilities could be boosted by developing demand for biomethane from suppliers and users; this is currently hindered by unclear support mechanisms. A clarification of the government's ambitions concerning usage support mechanisms would drive demand and thus boost the supply side to increase biomethane production volumes in France.

Firstly, from a usage support perspective, it would make sense to clarify the development strategy per usage type (heating fuel and vehicle fuel), by ranking them according to their energy efficiency and environmental performances compared with competing energy sources currently used for the same purposes.

Secondly, to give greater visibility to sector stakeholders, the sharing of a calendar concerning possible changes to all of the support mechanisms would be beneficial to the development of the sector.

Beyond the production of renewable energy, the biomethane sector generates positive externalities that must be taken into account, including the fact that the sector contributes to the development of a local circular economy:

- **It participates in organic waste treatment and recovery** in the region. Behind the cost of a biomethane production unit hides the avoided cost to the community of treating organic waste. The complexity of the waste value chains made it impossible in the framework of this study to carry out an in-depth examination of the cost breakdown between energy production and organic waste treatment that are inherent to a biomethane production unit.
- **It creates wealth for the agricultural sector** that has the possibility of generating additional revenue as well as rethinking its practices thanks to biomethane production.
- **The sector also creates local jobs** (1 to 2 full-time equivalents per production site[2])
- **Finally, biomethane production represents an opportunity** to consume locally-produced energy.

The local authorities therefore have a role to play in enhancing the positive impacts of biomethane production at the local scale, by developing their stock of facilities, modifying their gas supplies or reconsidering their energy mix.

At the national level, the sector also makes it possible to meet the targets set by the government:

- **Biomethane replaces natural gas** and makes it possible to reduce greenhouse gas emissions by 188 grams of CO2 equivalent for each kilowatt hour produced, injected and consumed Bib.24.
- **It creates value for existing gas transmission and distribution infrastructure** and ensures their long-term sustainability in a context of decreasing gas consumption.

Hence, the long-term evolution of support mechanisms must take into account these positive externalities by calculating them appropriately.

Finally, the sector contributes to the energy independence of France while producing local, non-intermittent and storable energy. It even becomes a source of industrial know-how and solutions that can be exported abroad.

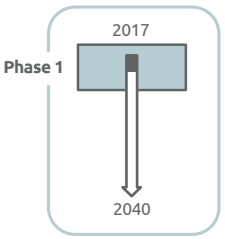
A development route for the biomethane of the future

The French biomethane sector is currently quite dynamic but is nevertheless new and must gain in maturity. In the short and medium term, government support will remain essential and its backing will allow biomethane to become a credible and sustainable part of the French energy landscape in the long term.

A possible development route for biomethane is proposed Fig.15. It will require milestones that are endogenous to the sector, contributing to maximising the intrinsic competitiveness of the projects: technological improvements to improve performance and productivity and significantly reduce production costs. In parallel, exogenous conditions must be present to ensure its development. These depend on the policies decided by the government but also on market evolutions (price of natural gas, deployment of NGV filling stations, etc.) see Fig.15.

Figure 15.1

Ideas for a sustainably competitive sector



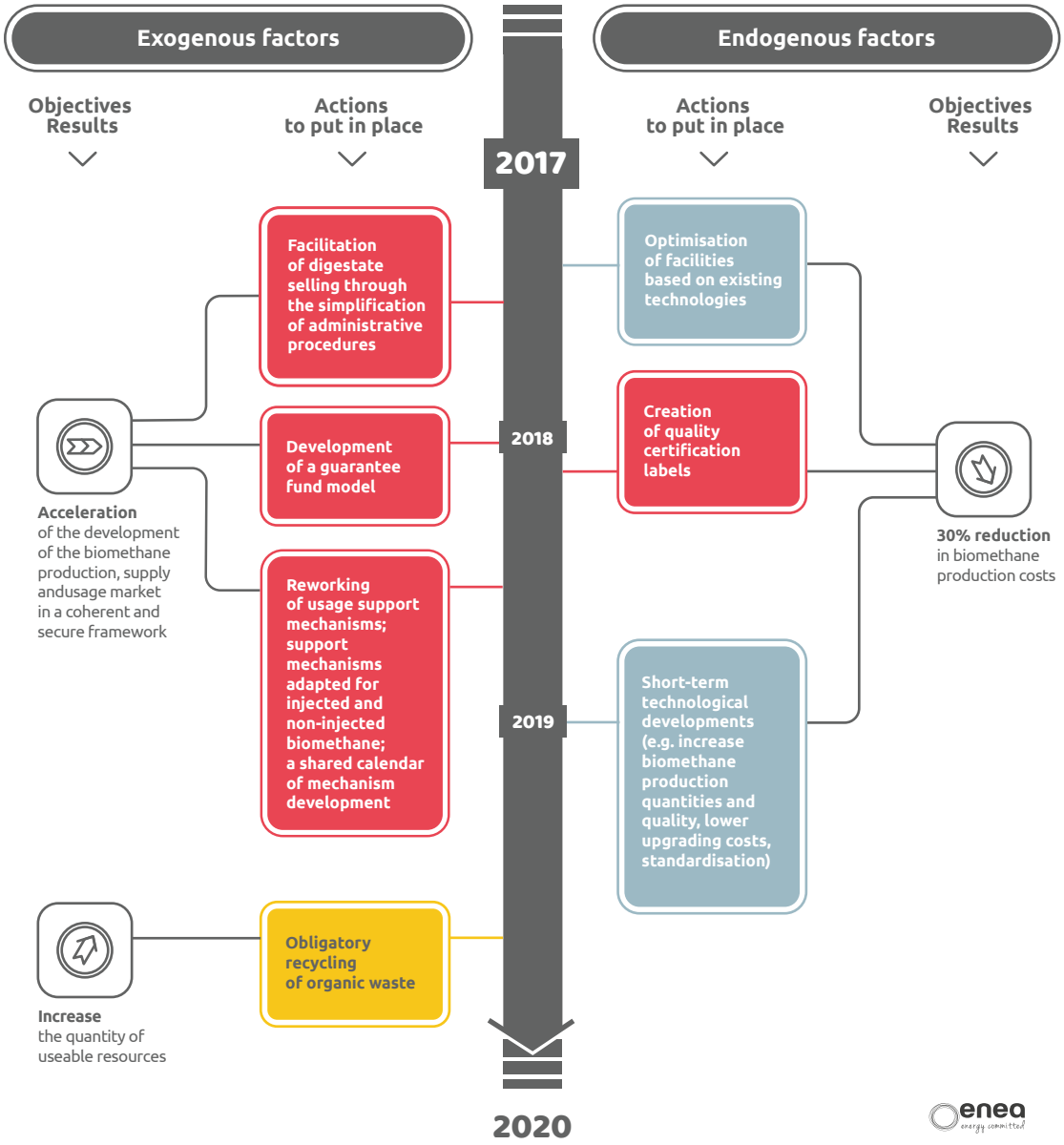
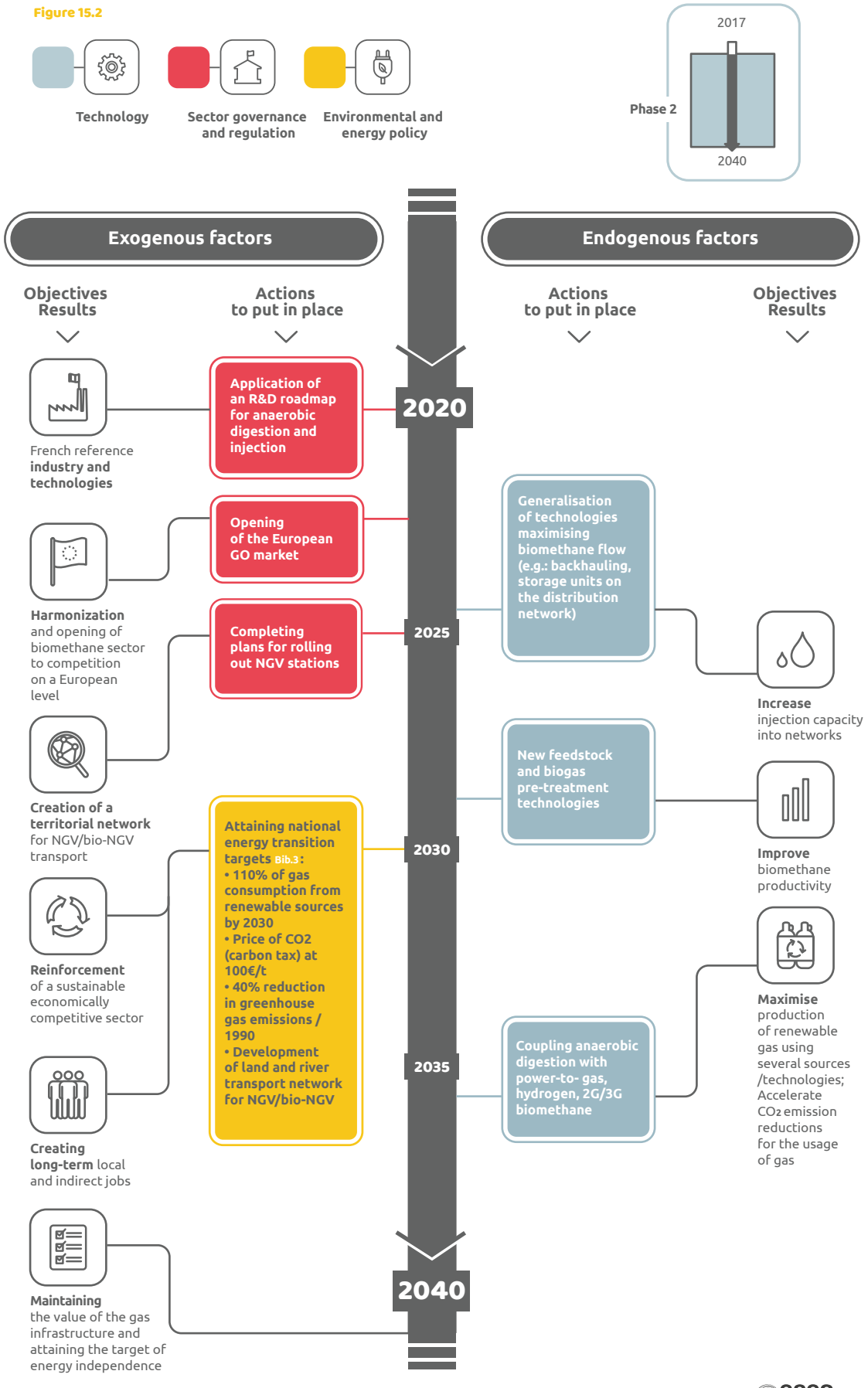


Figure 15.2


Technology
Sector governance and regulation
Environmental and energy policy
2017
Phase 2
2040
Exogenous factors
Endogenous factors
Objectives Results
Actions to put in place
Actions to put in place
Objectives Results
French reference industry and technologies
Application of an R&D roadmap for anaerobic digestion and injection
2020
Harmonization and opening of biomethane sector to competition on a European level
Opening of the European GO market
Generalisation of technologies maximising biomethane flow (e.g.: backhauling, storage units on the distribution network)
Completing plans for rolling out NGV stations
2025
Increase injection capacity into networks
Creation of a territorial network for NGV/bio-NGV transport
Attaining national energy transition targets Bib.3:
• 110% of gas consumption from renewable sources by 2030
• Price of CO2 (carbon tax) at 100€/t
• 40% reduction in greenhouse gas emissions / 1990
• Development of land and river transport network for NGV/bio-NGV
New feedstock and biogas pre-treatment technologies
2030
Improve biomethane productivity
Reinforcement of a sustainable economically competitive sector
Creating long-term local and indirect jobs
2035
Coupling anaerobic digestion with power-to- gas, hydrogen, 2G/3G biomethane
Maximise production of renewable gas using several sources /technologies; Accelerate CO2 emission reductions for the usage of gas
Maintaining the value of the gas infrastructure and attaining the target of energy independence
2040

About the partners

The ambition of Biogaz Vallée® is to give biogas its rightful place in the French energy mix. A national professional association, Biogaz Vallée® federates, moderates and supports the anaerobic digestion sector, in order to accelerate its construction and grow its value for the French regions. Created in November 2011 by industrial companies and the Département de l'Aube (10), Biogaz Vallée® has several objectives: to structure the emerging biogas sector in France, spread best practices, facilitate access to financing, support the creation of qualified industrial jobs in France, boost innovation to improve competitiveness, differentiate French companies and eliminate the need for subsidies.

biogazvallee.com **@BiogazVallee**

Cryo Pur is a manufacturer specialised in the supply and maintenance of modular biogas upgrading units and biomethane and CO2 liquefaction units. Cryo Pur technology, protected by 7 international patents, is used to treat biogas and landfill gas for flows ranging from 100 to 2000 Nm³/hr. Following the validation of its technology in the framework of the BioGNVal project, Cryo Pur began marketing its solutions on the European market. Cryo Pur has a headcount of 28 people and has raised €9 M from Xerys funds.

www.cryopur.com **@Cryo_Pur**

ENEA is a strategic advisory consulting firm contributing to the advancement of energy and environmental transition and the development of energy access worldwide, with offices in Paris, Melbourne and Hong Kong. Since 2007, ENEA has been advising and supporting leading private sector companies and public authorities around the world on the topic of energy transition sectors and markets.

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The main natural gas distributor in France, GRDF operates and develops natural gas distribution networks in more than 9500 municipalities. Owned by the municipalities, this almost 200,000 km long network stimulates the emergence of biomethane. By working with all project owners, GRDF concretises its commitment to develop innovative solutions serving regional energy transition. GRDF performs feasibility studies and services for biomethane injection into the network (metering, quality control and pressure regulation). What's more, the company has been in charge of the guarantee of origin register since December 2012.

www.grdf.fr **@GRDF**

GRTgaz is one of the leading European operators in natural gas transmission and a global expert in gas transmission system and network management. In France, GRTgaz owns and operates 32,450 km of underground pipes and 28 compression stations to transport gas between suppliers and consumers (distributors or industrial companies directly connected to the transmission network). Committed to energy transition, GRTgaz is investing in innovative solutions to adapt its network and reconcile competitiveness with security of supply and the protection of the environment.

www.grtgaz.com @GRTgaz

Founded in 2005 by Thierry Déau, Meridiam is an independent investment firm specialised in the development, financing and management of long-term and sustainable public infrastructure projects. Its model is based on the conviction that the alignment of interests between the public and private sectors can lead to the development of solutions that are vital for the needs of society. With offices in Paris, New York, Toronto, Luxembourg, Istanbul, Vienna, Addis-Abeba and Dakar, Meridiam manages 6 billion euros of assets and is involved in more than 60 development, construction or management projects.

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TIGF (Transport et Infrastructures Gaz France), a major player in the world of energy, has been located for more than 70 years in southwestern France. Between the gas reserves in the North Sea and those in North Africa, it occupies a strategic position in Europe. TIGF is aware that natural gas has an essential role to play in energy transition and wants to accelerate this green revolution through greater implication in the biomethane, NGV and Power-To-Gas sectors.

www.tigf.fr

Total is a major energy operator with a global footprint, a leading international oil and gas company and a major player in solar power via SunPower and Total Solar. Its 98,000 employees are committed to delivering better, safer, cleaner, more efficient, more innovative energy to the greatest number of people possible. Present in over 130 countries, Total does its utmost to ensure that its activities generate positive effects in the economic, social and environmental spheres.

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Bibliography

Bib. 1 Powernext, "PEGAS" *powernext.com.*

Bib. 2 Ministry of Environmental and Solidarity-based Transition, *"Indicators: biomethane injected into gas grids – second quarter of 2017"*, 2017.

Bib. 3 Legifrance, *"Law n° 2015-992 dated 17 August 2015 concerning energy transition for green growth"*.

Bib. 4 GRDF, GRTgaz, SPEGNN, SER and TIGF, *"Renewable Gas French Panorama in 2016"*, 2016.

Bib. 5 *"Annual report of the register of guarantees of origin 2015"*, 2016.

Bib. 6 BIOSURF and G. B. Association, *"Biomethane Roadmap in Germany"*, 2016.

Bib. 7 7 Legifrance, *"Decree n° 2011-1595 dated 21 November 2011 Compensation of public services charges relative to the purchase of biomethane injected into natural gas grids"*.

Bib. 8 Legifrance, *"Article 26 of Law n° 2016- 1917 dated 29 December 2016 for the 2017 budget"*.

Bib. 9 Legifrance, *"General tax code"*.

Bib. 10 DGEC, *"PPE – French Pluri-annual energy plan"*, 2016.

Bib. 11 Solagro and ADEME, *"Estimate of potential substrate resources usable for anaerobic digestion in France"*, 2013.

Bib. 12 Greenbirdie, CRIGEN, GRDF and ADEME, *"Evaluation of biomethane production potential from urban waster water treatment plant sludge"*, 2014.

Bib. 13 AFGNV, *afgnv.info.*

Bib. 14 ADEME, *"ADEME Forecast exercise – Vision 2030-2050"*, 2012.

Bib. 15 *"Environmental Regulations RE 2018"* *reglementation-environnementale-2018.fr*

Bib. 16 Ministry of Environmental and Solidarity-based Transition, *"National action framework for the development of alternative fuels in the field of transport and the deployment of the corresponding infrastructures"*, 2016.

Bib. 17 AFGNV, *"NGV Infrastructure in France 2020- 2025"*, 2016.

Bib. 18 GRDF and GRTgaz, *"Biomethane injection in France – Feedback from facilities in operation and network evolutions"*, 2016.

Bib. 19 ADEME, *"Technical, economic and environmental monitoring of production facilities and biomethane facilities for injection into natural gas networks"*, 2017.

Bib. 20 S3D and ADEME, *"Technical, economic and environmental study of the remote injection of biomethane into gas networks"*, 2017.

Bib. 21 AILE, *"Different digestates and their agronomical uses"*, 2015.

Bib. 22 Legifrance, *"Decree dated 13 June 2017 approving specifications for the sale and use of digestates from the anaerobic digestion of farm materials for use as fertilizers"*.

Bib. 23 FNCCR and GRDF, *"Vehicle natural gas: how to manage a project for a filling station open to the public"*, 2016.

Bib. 24 GRDF, *"Evaluation of greenhouse gas emissions from biomethane injection"*, 2015.

Bib. 25 GRTgaz, *"Open Data"* opendata.grtgaz.com.

Bib. 26 France biométhane, *"White paper on biométhane"*, 2016.

Bib. 27 AFG, *"Gas demand in France to 2030, AFG scenario"*, 2016.

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