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The role played by Biomethane within the European Energy Market

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Key Words:

Renewable gases, biogas upgrading, Power to Gas, Anaerobic Digestion, Gasification.

Abstract:

Natural gas plays an important role within the European energy market to meet the demand for heat, electricity and transport fuels. Moreover, the natural gas sector has already a well-developed infrastructure which could be used to take new and suitable projects forward.

Biomethane, defined as a high-calorific methane extracted from biogas, is a fully renewable, available and low carbon alternative fuel that can be used to produce energy using organic waste.

Biogas and biomethane production aims to move away from traditional municipal solid waste increasing production through digestion or co-digestion plants fed by selected organic matrices. Moreover, natural gas technology is fully compatible with renewable gas: this can be both directly used on vehicles and injected in the distribution grid.

After the Paris Agreement, some European Directives on renewable energy have been published and the reduction of greenhouse gas emission (GHG) plays an important role on them. One key driver for the application of biomethane is the reduction of GHG due to the substitution of fossil fuels. According to some studies and following best practices, it is possible to achieve GHG savings of over 80% when compared to the fossil fuel alternative.

In Europe, biomethane market is still at the very beginning. Therefore, an appropriate framework is needed to boost this challenging market, since today, the biomethane provision is linked to higher prices compared to natural gas.

Introduction. Biomethane characteristics

Biomethane is a naturally occurring gas which is produced by the so-called anaerobic diges-tion of organic matter such as dead animal and plant material, manure, sewage, organic waste, etc.

Biomethane production eliminates the release of a great deal of methane and other harmful gases into the atmosphere. This is since its production eliminates exposure of the decom-posing organic matter to the air which prevents methane and other gases from escaping into the atmosphere. In addition, biomethane reduces the need for fossil fuels by which it further reduces the emissions of greenhouse gases into the air.

This paper will be focus on the future of this energy, its production, grid injection and uses in different countries in Europe, concretely in Spain where biomethane is not as developed as in other countries in our continent. Its benefits are countless and its uses as a clean energy matches with the Paris Agreement policies, since the objective for renewable gas to account for 10% of gas consumption by 2030, was set with a view to limiting global warming to 2ºC by 2050.

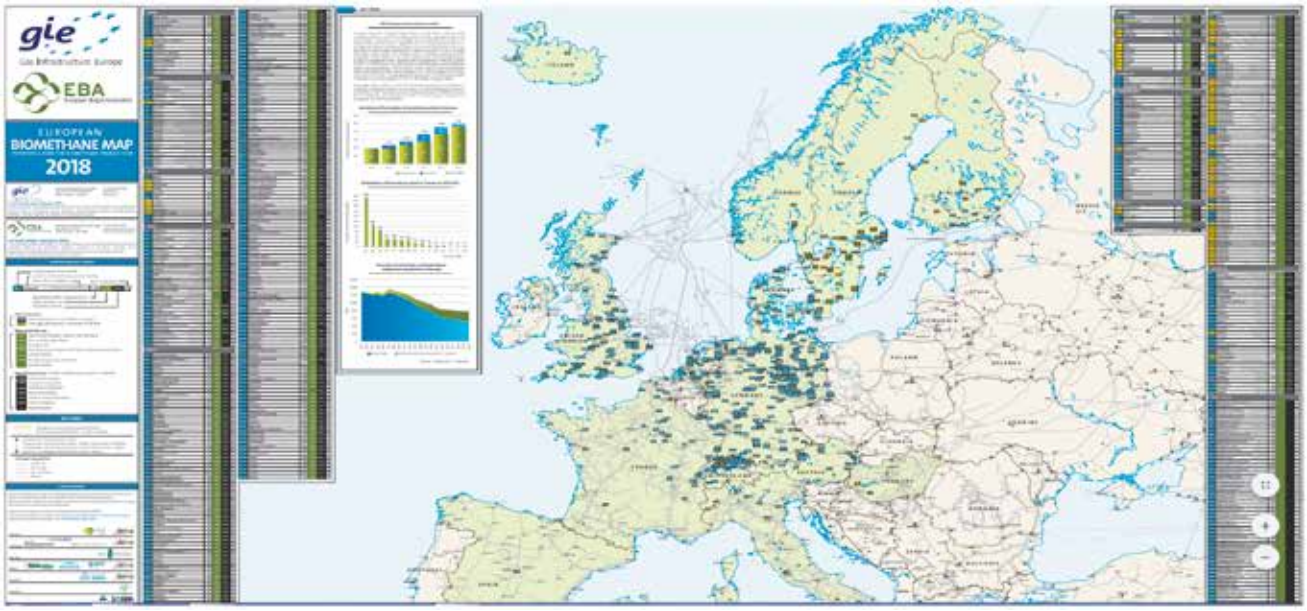
Biomethane has similar properties to natural gas and it is an important fuel to support the transaction from fossil fuels to renewables and to achieve the greenhouse gas emission reduction. This renewable gas could play an important role in energy provision helping natural gas to meet the demand for heat, electricity and transport fuels.The European Biogas Association and Gas Infrastructure Europe (GIE) locates and lists biomethane installations running in Europe in 500 units on the continent.

The Paris Agreement

The Paris Agreement aims to undertake some measures in order to face the climate change. This is a common cause mission of all nations (184 Parties have ratified of 197 Parties to the Convention) and each of them has the duty to build a framework with the goal to limit the impact of climate change[1].

One of the main points of this Agreement is to limit a global temperature rise this century well below 2 degrees Celsius above pre-industrial levels and to pursue efforts to limit the temperature increase to 1.5 degrees Celsius. Moreover, the Agreement drives to achieve zero emissions in the second half of this century. How will it be possible? It is mandatory to boostsome appropriate financial flows, a new technology framework and an enhanced capacity building framework.Throughout the following years, all parties must report, among others, their emissions and their implementation

Figure 1.



1 UNITED NATIONS 2015

efforts through this international agreement, known as their Intended Nationally Determined Contribution (INDCs)[2].

This study will be focused on how the "renewable gas" would help to achieve these ambi-tious goals since it requires a large focus on energy efficiency and a transition towards re-newable and low carbon energy.

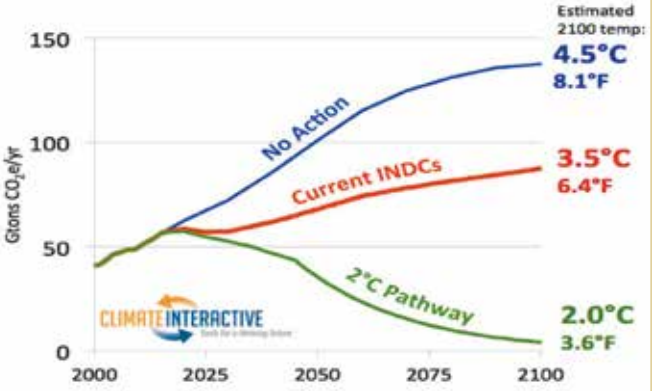
More specifically, it is going to be explained the contribution of the biomethane on the Paris Agreement policies, by reducing considerably green gas emissions or which environmental benefits would bring (reduction of agricultural or industrial wastes) among others.

Biogas and Biomethane: Renewables gases

Renewables gases are produced from a wide range of agricultural products and by products such as: energy crops, livestock manure and slurry, along with various types of biowaste (sewage sludge, municipal solid waste and industrial waste)[3].

Biomethane can be produced through different pathways:

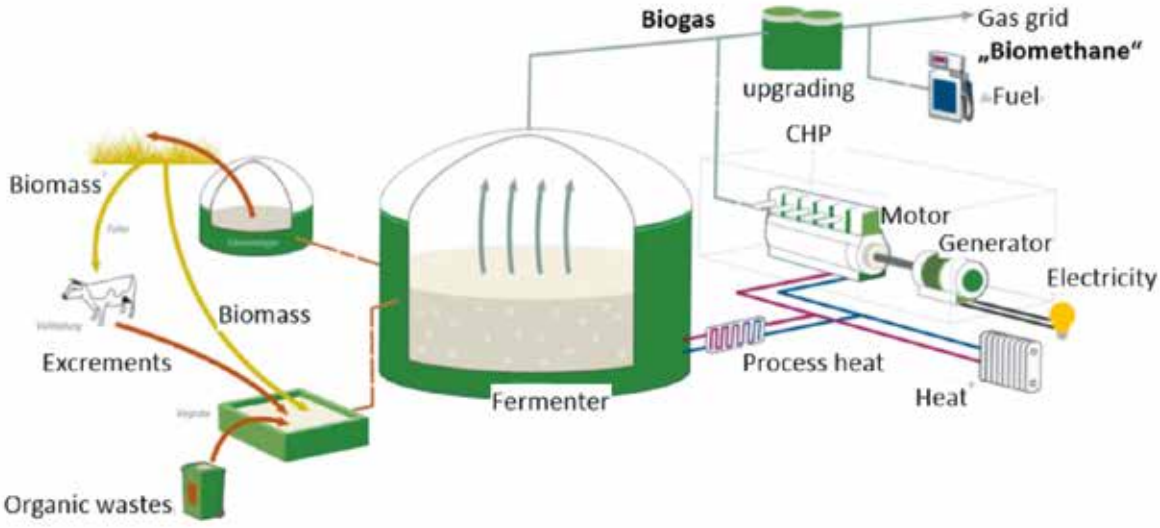
Figure 2. Global Greenhouse Gas Emissions



Source: ClimateScoreboard.org

Anaerobic digestion. Biogas is a result of a complex biological and chemical process known as anaerobic digestion (AD). Anaerobic means that it is oxygen-free and it consists in break-ing down

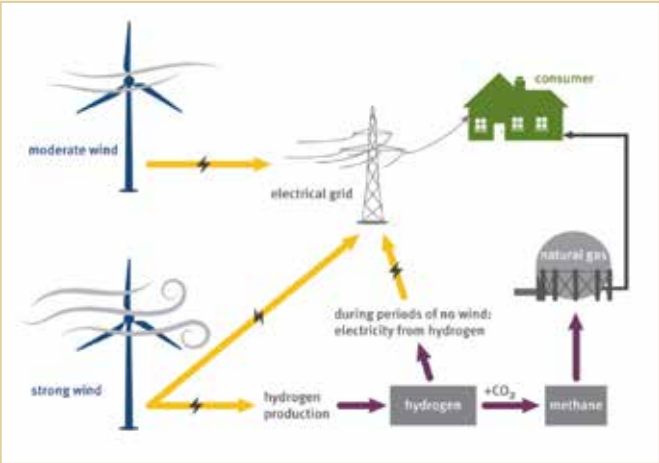
Figure 3.



Source: Agenter für Erneuerbare Energien, 2014

2 https://unfccc.int/process/the-paris-agreement
3 Florence School of regulations

Figure 4.



large organic polymers that build the organic feedstock into smaller molecules with help of chemicals and microorganisms. The final products of AD are: biogas composed mainly of methane (40-70%), carbon dioxide (30-60%) and various contaminants (ammonia, water vapor, hydrogen sulphide, nitrogen, oxygen, etc.) and digestate that can be used in agriculture as natural fertilizer[4].

Biogas can be used on-site, to generate heat and electricity in a combined heat and power (CHP) plant. It can also be injected into the natural gas pipeline system and then transported to more remote customers. Yet, first it is purified and upgraded to biomethane, meaning that the content of methane is increased, so that biomethane's quality is similar to the quality of the methane already in the gas grid. Once biomethane is injected into the grid, it blends with natural gas and has the same application.

Gasification. Biomethane can be generated through other processes namely: gasification and thermochemical liquefaction processes, such as pyrolysis. The gasification of biomass involves the heating of dry biomass feedstock with restricted supply of air. The product of such a process – synthesis gas (or syngas) is a mixture of carbon monoxide, hydrogen, and other components such as methane. In terms of pyrolysis, biomass is heated to a high temperature ranging from 400 to 600° C, and without oxygen. In both cases, the gas that is a product of gasification needs to be further processed before it can be injected into the gas grid.

Power-to-Gas. Renewable gas may also be used to store electricity by converting it into hydrogen or methane via power-to-gas. In most of the cases, renewable gas – similarly to conventional natural gas – is mostly composed of methane. While natural gas was formed over millions of years in deep underground wells, renewable gas is mostly a product of bio-chemical processes, which take up to a few days[5].

This method has some advantages that should be considered. According to Paul Scherrer Institute (Switzerland), it is essential to study how quickly power-to-gas facilities would achieve load balancing when pressure on electricity supplies threaten to destabilize the grid – either as a result of peak demand or peak production[6].

Biomethane advantages

Burning biomethane for electricity generation, heat production or fuel emits carbon dioxide and some other greenhouse gases as well, but it does not increase carbon dioxide levels in the atmosphere. This is since the same amount of carbon dioxide would be released into the atmosphere if organic matter (from which biomethane is produced) would simply be left to decompose naturally[7].

Natural gas blended with biomethane or synthetic gas (power-to-gas) from renewable sources can reduce CO_2 emissions significantly, up to 95%.

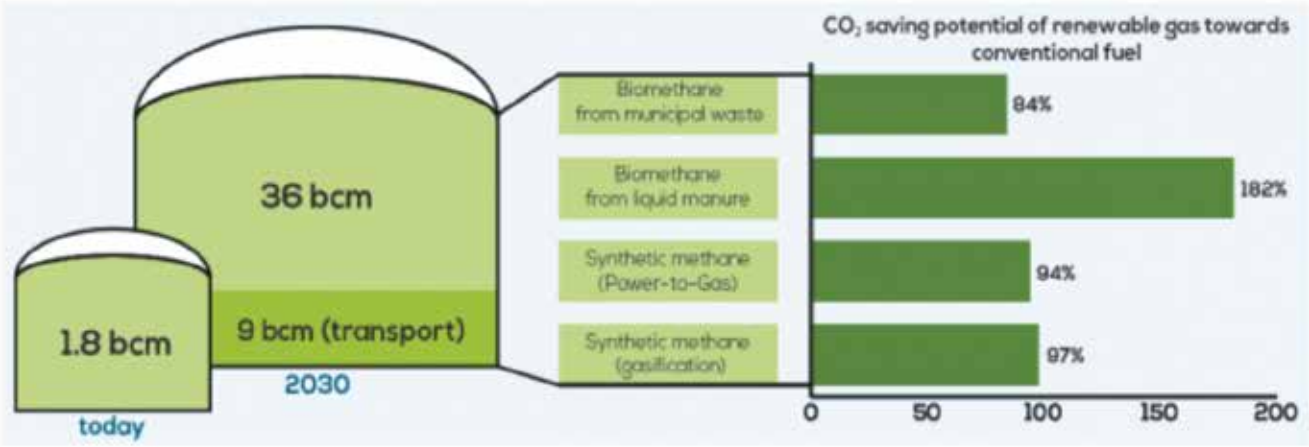
Biomethane and synthetic gas (from the gasification and power-to-gas processes) are renewable energy sources with very low carbon footprints; when applied as fuels, they allow gas vehicles to run carbon-neutral.

It creates direct jobs with maintenance of agricultural operations, local recycling of waste, return of digestate soil as natural fertilizer. As a result, we can see a decarbonation of energy and agricultural systems, and the dynamism of rural regions[8].

Biomethane is a commercially viable fuel under condition that it is exempt of tax and/or granted with other financial incentives: it can

4 IEA Bioenergy
5 Florence School of regulations
6 Paul Scherrer Institute of Switzerland
7 Our World in Data
8 NGVA Europe

Figure 5. Renewable gas production / Greenhouse gas saving



rely on existing natural gas infrastructure and the upgrading technology is mature and proven.

Preservation of forests. Firewood remains the leading source of heat in most parts of the world. The use of wood for heating is not problematic as long as it comes from sustainably managed forests but unfortunately, it often does not. In addition, the population growth puts an increased pressure on natural resources which threatens ecosystems and biodiversity, while uncontrolled logging dangerously raises carbon dioxide emissions. Since the trees absorb the harmful greenhouse gas, its concentration in the atmosphere increases with each fallen tree. Purchase recycled and reclaimed wooden products which do not use freshly felled trees. As an alternative source of both heat and electricity, biomethane helps preserve forests and biodiversity[9].

The green gas provides Europe with several advantages: it contributes to the European climate targets by reduced CO_2 eq emissions and improved air quality (while fossil fuels are replaced, particulate (< PM10) and NOx emissions are massively reduced), and it advances security of supply and European energy independency from (unstable) third countries.

Future of Biomethane in Europe

Only a small quantity of biomethane is being produced in the EU today. Increasing this significantly in a sustainable way is feasible, as it is possible to scale up renewable hydrogen production.

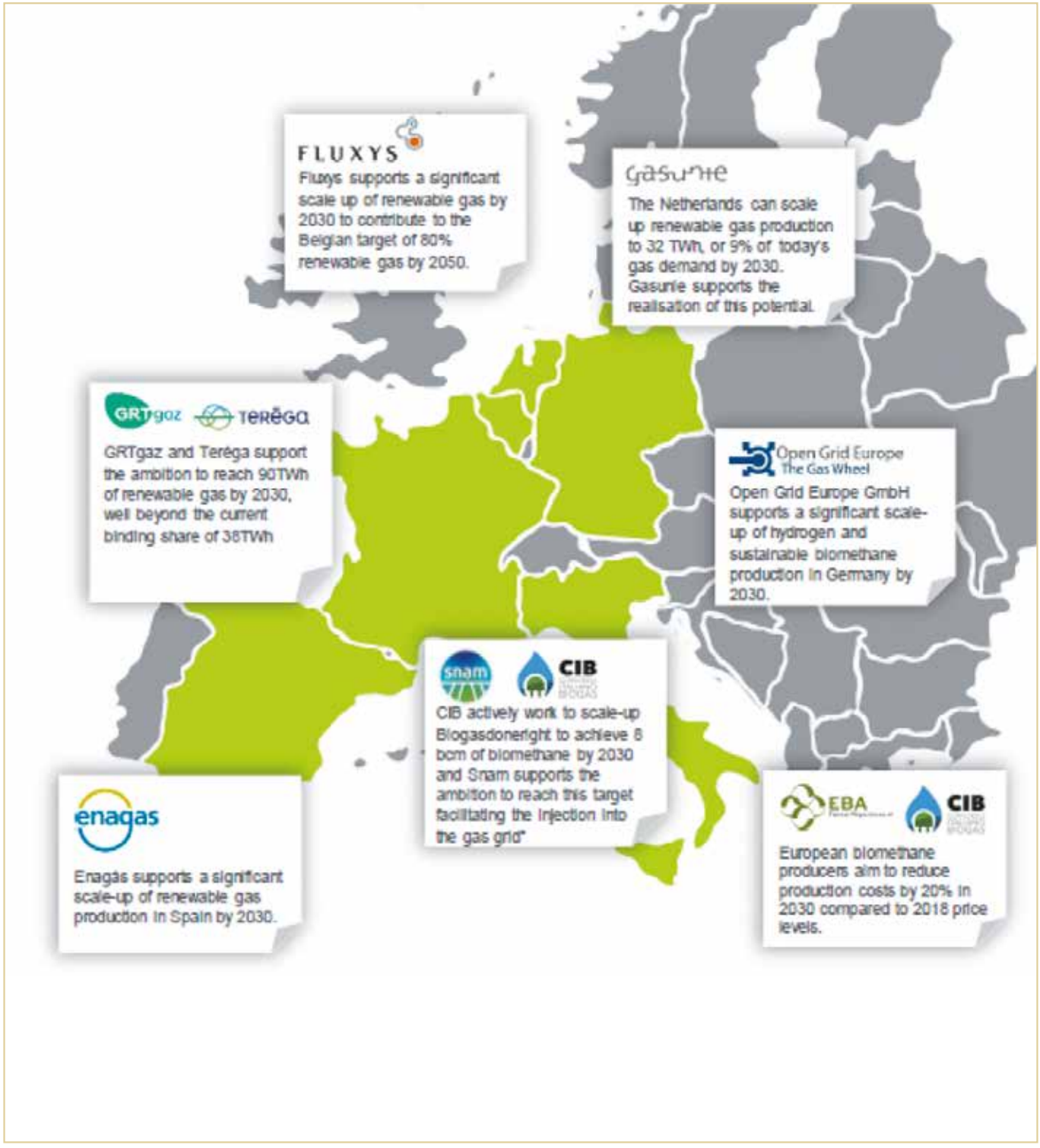
Yet this requires efforts from companies, farmers and policymakers to improve production technologies, reduce costs, apply new agricultural concepts and reward renewable gas for the societal benefits it delivers in full decarbonization of the energy system in a smart combination with renewable electricity.

The European Biogas Association and Gas Infrastructure Europe (GIE) locates and lists biomethane installations running in Europe in 500 units on the continent[10].

According to a study by Ecofys, showed that, using conservative assumptions, it is possible to scale up renewable gas production within the EU to 122 billion cubic metres (bcm) by 2050 (1.200 TWh), using both hydrogen and biomethane[11]. This renewable gas can be transported, stored and distributed in existing gas infrastructure and the synergies offered by renewable electricity and renewable gas allow the EU to achieve a net zero carbon en-

9 Biomethane.org.uk
10 GIE Europe
11 Ecofys study

Figure 6. The overview below shows the 2030 ambitions for each Gas for Climate member organisation



ergy system by 2050, while saving €138 billion annually compared to a scenario without any gas.

Estimations about the European Natural Gas Vehicles (NGVs) market evolution show a potential in reaching a fleet of 13 million units in 2030, which means growth by factor 10 compared to today's situation. In parallel, the production of renewable gas will increase, too: in 2030 a conservative estimation shows a production potential close to 45 bcm (we are at approximately 2 bcm today). This will theoretically be enough to overcome the entire fuel demand of the 13 million units' fleet (around 30 bcm).

Nevertheless, NGVA Europe and EBA estimate that in 2030 the average value of renewable gas used in the transport sector in Europe will be around 30%. Main sources for renewable gas production will be from anaerobic digestion, such as municipal waste and liquid manure. Gasification and Power-to-Gas will be playing a more significant role to produce renewable gases from 2025 on.

How could the EU boost the biomethane implementation?

• Companies:

– Improve gasification technologies including enabling feedstock flexibility (quality, consistency, dryness) and post-production gas treatment (particulate and tar removal, enrichment for grid injection)[12].

– Improve conversion efficiencies of biomass to biomethane, electricity to hydrogen and hydrogen to methane.

– Increase research on biogas done right. Farmers and biogas producers can take the lead, assisted by agricultural institutes and universities.

• Governments:

– Finance gasification plants from the EU Innovation Fund.

– Support for innovative gasification demonstration projects from Horizon Europe.

– Enable grid connection and tariff discounts for green gas injections into the transmission network.

– Tax exceptions: Biomethane can be exempted from a tax or be subject to a reduced tax rate compared to fossil fuels (e.g. natural gas). This is one of the most common support schemes, and is applied e.g. in Austria, Germany, Sweden, Switzerland and Slovakia.

– Direct feed-in tariff for biomethane. Similar to the feed-in tariff for electricity, injection in the natural gas grid or direct delivery to a fuel station can be supported by a feed-in tariff for biomethane. This is applied in France, Denmark and the U.K. as well as in the Netherlands, where a feed-in subsidy covering the difference between production costs and income is implemented.

– Investment incentive. A biogas or biomethane plant can be supported by a reduced interest rate for a loan or a fixed share of the investment cost. This is applied e.g. in Austria, Sweden, Denmark, Hungary, Slovakia and Poland.

• Policies to enhance renewable gas transport and trade:

– Injection in DSO (European distribution system operators) grid should be counted as gas made available at a virtual trading point (at TSO level) to improve renewable gas tradability.

– DSO and TSO (Transmission system operators) technical guidelines and gas quality specifications should be harmonized.

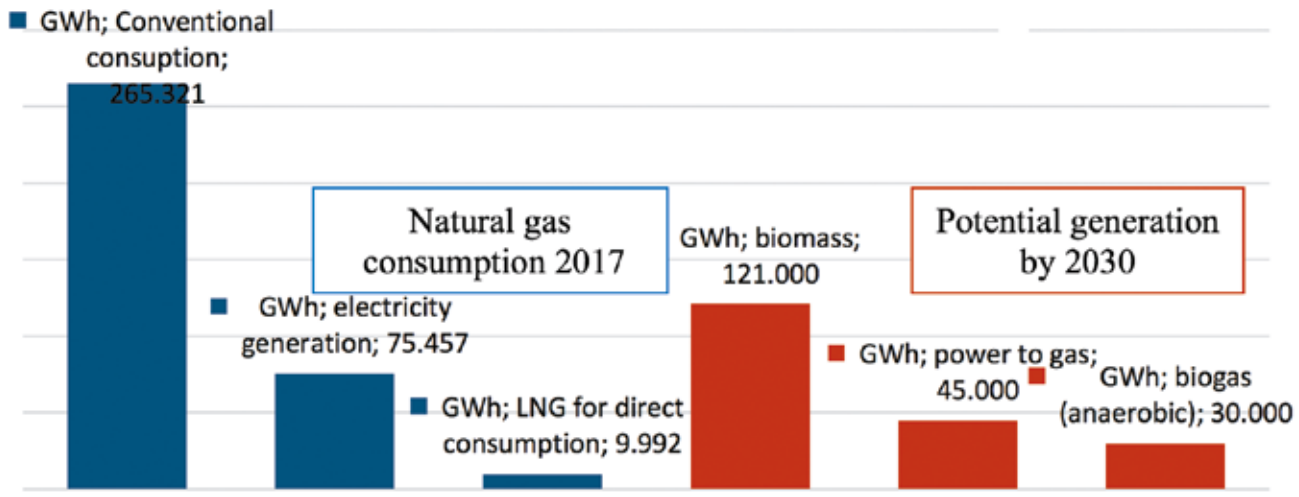
– European recognition of renewable gas certificate trading schemes to enable proof of origin and proof of sustainability by an EU harmonized certification scheme (already implemented in some European countries).

Biomethane in Spain. Perspectives

Today, there is one biomethane plant (Valdemingomez) in Spain. In 2017, the total quantity of biomethane generated and injected to the grid by this installation was 92 GWh[13] equivalent to 10.000 homes gas consumption. As a result, it reduced 467.273 tons of CO_2 emission[14].

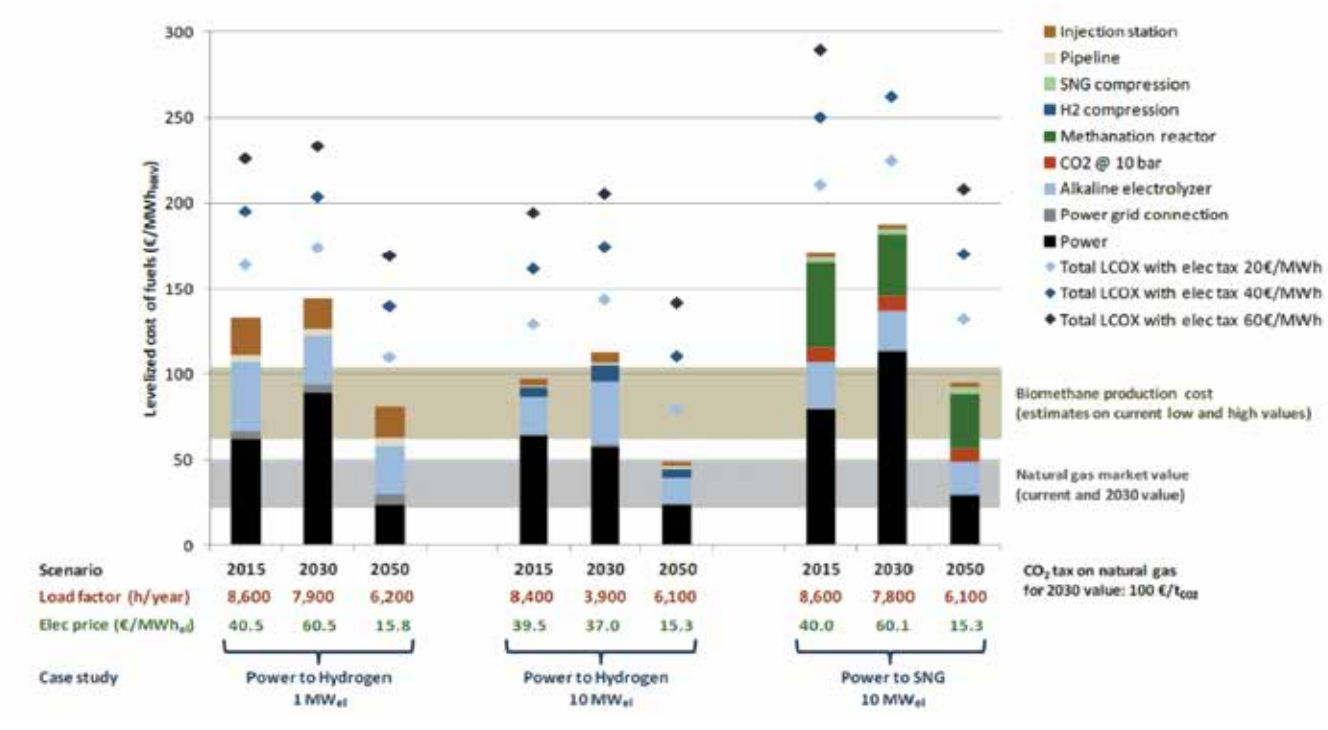
12 Action Plan 2030. Gas for Climate
13 CORES. Corporación de Reservas Estratégicas de Productos Petrolíferos.
14 Sedigas

Figure 7.



Source: Own made. IDAE estimates

Figure 8.



According to CORES, the natural gas consumption in 2017was 351 TWh. Considering that Spain must achieve the objective of renewable gas consumption of 10% of the total natural consumption by 2030, the country is still far from the objective.

Some studies carried out by IDAE, show a potential of biogas generation between 20 TWh and 34 TWh considering organic wastes through the construction of 490 plants which would create between 15.000 and 25.000 jobs[15].

Spain is the largest European producer on the pig-farming industry with around 28 million heads of pigs, generating 50 pig-slurry-tons per year. Therefore, the potential of renewable gas in Spain is important as shown on the graph in Figure 7.

Costs of production

According to The Oxford Institute for Energy Studies, costs of production of biomethaneare likely to be in the range of €100-150/MWh for methane by 2030 and €100/MWh by 2050. These ranges are broad because of the early stage of development and uncertainty regarding the extent to which economies of scale may be achievable. The price of power-to-methane is higher than the price of biomethane derived from anaerobic digestion as shown below in Figue 8[16].

On the other hand, according to Sedigas and CREARA studies, the upgrading process (from biogas to biomethane) would cost around 56€/MWh (grid injection 10 bar) considering that it could be decreased to 35€/MWh by 2030, after technological developments.

Conclusions

The results of this paper prove that the European production of biomethane and the injection into the gridis a negligible value compared to the Paris Agreement policies that must be implemented by 2030.

However, European countries are perusing these goals with the intention to produce renewable energy in order to reduce carbon dioxide emissions that are responsible for climate change.

Renewable gases eliminate the release of a great deal of the methane and other harmful gases into the atmosphere. Moreover, according to some energy consulters studies, the combination of renewable gas potential with renewable electricity would save almost €140 billion per year compared to such a system without any gas.

On the other hand, biogas and biomethane production aims to move away from traditional municipal solid waste increasing production through digestion or codigestion plants fed by selected organic matrices. Moreover, natural gas technology is fully compatible with renewable gas: this can be both directly used on vehicles and injected in the distribution grid. In order to facilitate the implementation of this energy system, governments should apply some measures with the aim to enable the development of such technologies.

With regard to the Spanish biomethane development, it is required to ensure a regulated and sustainable market. Possibility to trade biomethane between countries, taxes exceptions for renewable gases, recognition of renewables gas certificates, support schemes with regard of reliable and long-term conditions should be applied within the following years. ■

15 IDAE
16 The Oxford Institute for Energy Studies