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# Natural Gas as a Gateway for Renewable Gas in Transport

*Eugenia Sillero Maté, Carla García, Paloma Martínez Ramos and Elena Martínez Calvo*

## Abstract

Mobility with biomethane is already a reality in many countries in Europe, while in others it is just the beginning. Biomethane is a green and clean fuel which is obtained from the biogas produced by the anaerobic decomposition of the organic matter present in urban waste, sewage water and agricultural, livestock and forest residues. To generate biomethane, the biogas undergoes a process called upgrading. It is a process of elimination of different components such as CO<sub>2</sub>, which can be used to obtain synthetic natural gas. Biomethane is perfectly compatible with natural gas; it can be injected in the pipeline grid or used directly as fuel in a vehicle, generating a null CO<sub>2</sub> balance or even negative depending on the type of residue it originated from. Biomethane represents a real solution to decarbonise transport. However, applying this solution depends mainly on public policies and the commitment at national and European level. This chapter will analyse the impulse models for the production of biomethane and its use as fuel for the transport sector. In addition, it will assess whether the development of this market would be possible without public support by creating a product ruled exclusively by the market.

**Keywords:** mobility, biomethane, decarbonisation, natural gas, green transport

## 1. Introduction

There are a lot of uncertainties about what decarbonised transport will be like in 2050; however, it is increasingly accepted that clean gas or low-carbon gas and hydrogen will form an essential part of the energy mix, especially in segments where electrification is difficult, such as heavy-duty transport and maritime transport.

At present, natural gas technology is mature and available for all kinds of transport, from light vehicles to vans, buses, lorries, trains and ships. The growth of the fleet of vehicles and the fleet of large ships continues to increase given that it is an alternative that guarantees air quality by significantly reducing the emissions of pollutants that affect health (nitrogen oxides, particulates and sulphur oxides) and helping to reach the targets thanks to a reduction of CO<sub>2</sub> emissions. However, this reduction is insufficient. The solution depends on the progressive incorporation of biomethane, hydrogen and power-to-gas technologies that do not require modification of distribution grids or the engines of users.

Conventional gas faces the major challenge of decarbonisation, and to do achieve this, there are obstacles it must overcome. Green gas, like other renewable energies, is more expensive than fossil fuels; stakeholders are not sufficiently prepared to invest, and, therefore, its development in Europe is taking place with aid policies.

The regulatory framework is another of the major drawbacks. It is obvious that this framework was not designed with the existence of renewable gases in mind and it needs to evolve at the same pace as technology.

The Agency for the Cooperation of Energy Regulators (ACER) recently indicated that “It seems clear that a sustainable future needs decarbonised gases and new technologies (such as P2G), but the current regulatory framework was not designed with these activities in mind and the lack of regulation for these areas may have unintended consequences, acting as a barrier or hindrance to their development” [1].

In this article we shall analyse the incentive schemes for the production and use of biomethane in different European countries. Before doing so, we shall begin with a description of the challenge that the mobility sector must face over the coming years, the obstacles that it must overcome and the contribution of green gas to this end.

## **2. The challenge of decarbonising transport**

The European Union, as a worldwide benchmark in the fight against climate change, has established a roadmap named the Climate and Energy Framework which represents a global strategy comprised of three main targets that involve all sectors of the economy at multiple levels. The targets for 2030 are as follows: 40% cuts in CO<sub>2</sub> emissions, in relation to 1990 levels, a market share of 32% share for renewable energy in final energy consumption and a 32.5% reduction of energy consumption.

With regard to mobility, different standards establish the specific targets for the decarbonisation of transport.

Europe has established a target for the share of renewable energy in transport through Directive (EU) 2018/2001. By 2030, 14% of the energy used in the sector must come from renewable sources, and 3.5% of this figure must be covered by biogas that does not come from crops.

CO<sub>2</sub> emission limits have also been regulated, establishing a deadline that is truly demanding and a long way from actual emissions at present.

The Regulation (EU) 2019/631 of the European Parliament and of the Council of 17 April 2019 setting CO<sub>2</sub> emission performance standards for new passenger cars and for new light commercial vehicles establishes a target to reduce CO<sub>2</sub> emissions for passenger cars by 37.5 and 31% for vans by 2030, in both cases in relation to the levels recorded in 2021. An intermediate target has also been set, according to which passenger cars as well as vans will have to emit 15% less CO<sub>2</sub> in 2025.

That is to say, the average of the emissions from fleets of new vehicles should not exceed 95 grammes of CO<sub>2</sub> per kilometre in 2021, 81 grammes of CO<sub>2</sub> per km in 2025 and 67 grammes of CO<sub>2</sub> per kilometre in 2030.

Some experts believe that the wide gap that exists between actual emissions and targets could result in a cataclysmic disaster for the automotive industry. According to a report by JATO [2], which analyses the emissions of different manufacturers in 2018, the difference is so vast that it could generate penalty payments of up to 34 billion Euros.

Inevitably, new heavy-duty vehicles will also have to considerably reduce their emissions. Regulation (EU) 2019/1242 establishes a 15% reduction of CO<sub>2</sub> emissions for heavy-duty transport by 2025 and 30% by 2030, in comparison with the levels recorded in 2019.

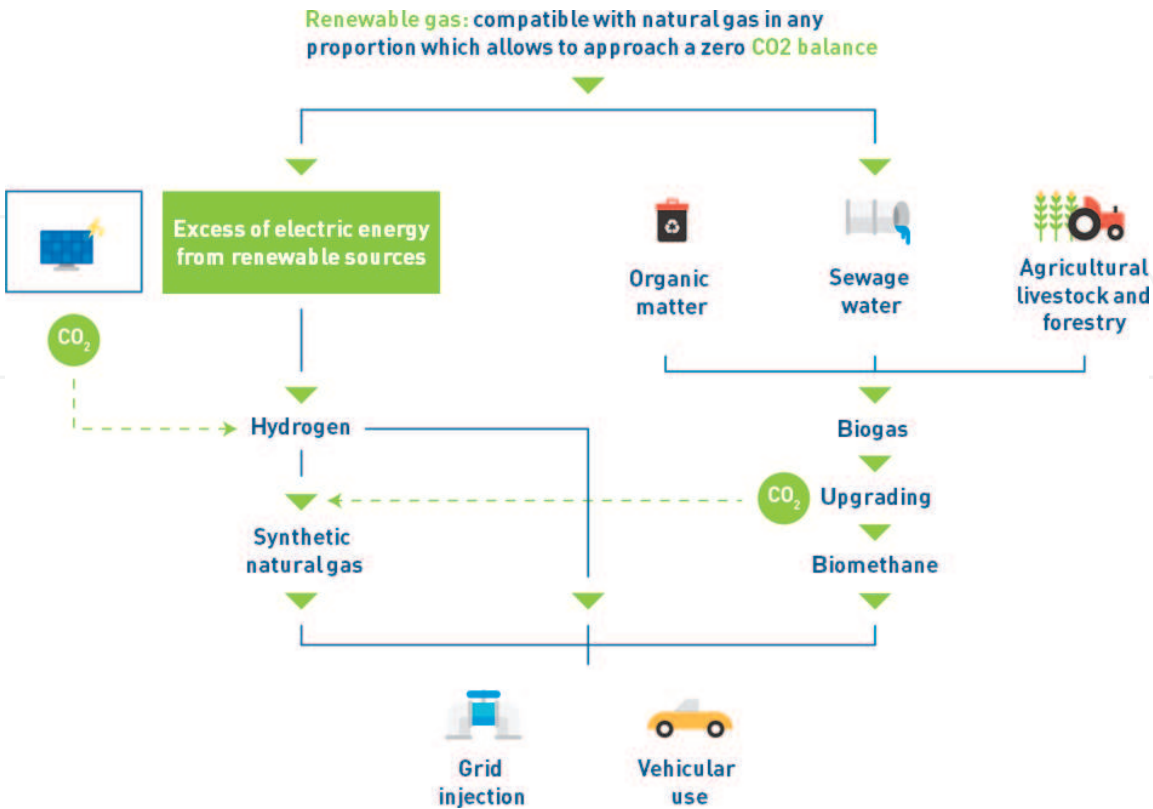
There is even greater complexity in this case than with light vehicles, given that the electrification of heavy-duty vehicles with batteries is an issue that has not yet been resolved and the same applies to maritime transport.

### 3. Green gas—biomethane, hydrogen and P2G—, a solution

Biomethane is obtained from methane emissions resulting from the anaerobic digestion of organic matter found in urban waste, waste water and agricultural, livestock and forestry waste. To produce biomethane, these emissions from the decomposing organic matter, which would otherwise be emitted into the atmosphere and contribute to the greenhouse effect, are captured and used to produce fuel for vehicles. For this reason, biomethane acts as a sink, and the greenhouse gas emissions of a vehicle powered with this fuel are considered neutral (**Figure 1**).

Another way of decarbonising gas is through hydrogen or synthetic natural gas (power-to-gas).

Hydrogen is set to play an important role in the energy mix of the European Union, and this is reflected in the National Energy and Climate Plans of a significant number of Member States. “Green hydrogen”, produced through electrolysis of water using renewable energy, offers high decarbonisation potential when used in a fuel cell in order to power a vehicle or if it is injected into the gas grid. It is widely accepted that at least 10% of hydrogen can be mixed into the natural gas system without the need to make changes to the grid or modifications to the engines of users.



**Figure 1.**  
Process to generate renewable gas.

It is also possible to combine this green hydrogen with the CO<sub>2</sub> extracted and stored by the industrial sector in order to generate synthetic gas which, at a practical level, is the same as natural gas and can be used in vehicles or injected directly into the pipeline grid as a replacement for natural gas.

4. Real analysis of the emissions of a vehicle

When it comes to addressing the sustainability of transport, today’s society faces two major challenges; on one hand, it must guarantee air quality in order to safeguard the health of citizens, and, on the other, it must protect the planet from climate change.

Air quality is determined by the local emissions of nitrogen oxides, sulphur oxides (SO<sub>x</sub>) and particulate matter (PM). All are local pollutants, harmful to health, and therefore they are measured as they come out of the exhaust.

The same does not apply with the emissions responsible for global warming, which are largely responsible for causing devastating consequences for our planet: an increase in average temperature, melting of ice, rising sea levels and extreme weather events with the damage this entails.

Making an assessment of the impact of climate change on transport while limited to observing the exhaust emissions of a vehicle is totally insufficient; a comparison in fair conditions necessarily requires an analysis of the product life cycle or at least with a well-to-wheel approach.

With regard to the impact of the use of natural gas on air quality, according to a report produced by the Foundation for the Promotion of Industrial Innovation of the Polytechnic University of Madrid [3] which analyses scientific studies that have used proven methods of measuring atmospheric emissions from different types of vehicles, under real conditions of urban and interurban traffic, it is seen that natural gas guarantees air quality by reducing NO<sub>x</sub> emissions by up to 97% and particulates by up to 70%.

As we mentioned, when we talk about reducing CO<sub>2</sub> emissions, it is not enough to analyse the effluent from the exhaust pipe. The Greenhouse Gas Intensity from Natural Gas in Transport report prepared by Thinkstep [4] assesses emissions from a wide range of fuels with a well-to-wheel approach, that is, considering emissions throughout the process from the generation of energy to its use in the vehicle (**Figure 2**).

In this study we observe that the greenhouse gas emissions of a vehicle powered by biomethane are 83% lower than those of a vehicle powered by gasoline and 79% lower than a diesel vehicle.

Recently, the French Institute of Petroleum (IFP Energies Nouvelles) [5] in France published a study evaluating the emissions of CO<sub>2</sub> in different means of road transport in two time horizons (2019 and 2030) taking into account the life cycle of

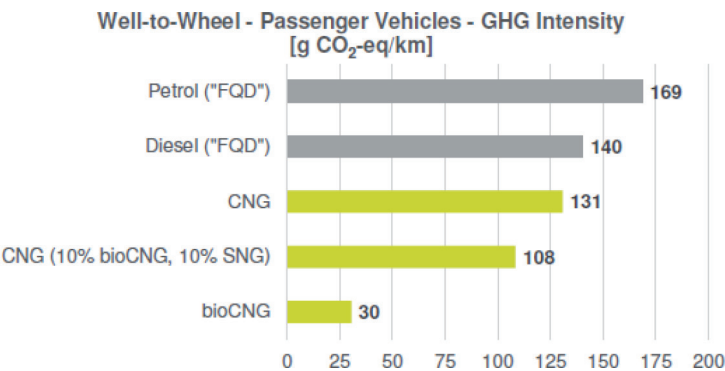
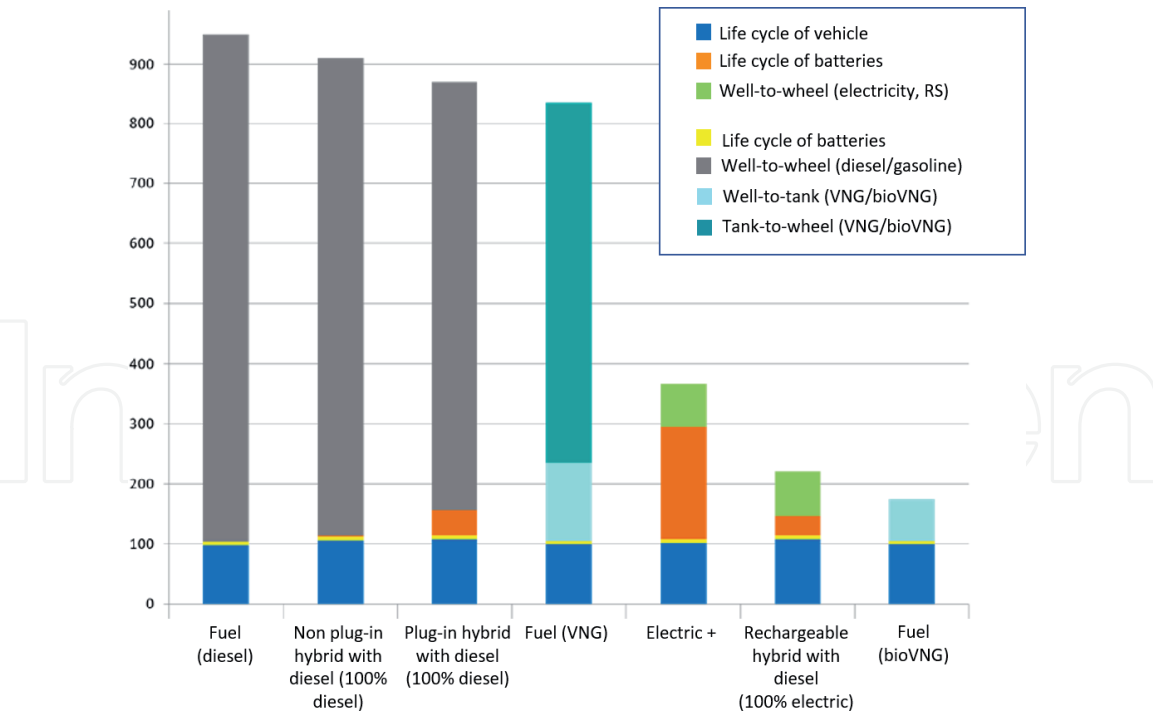
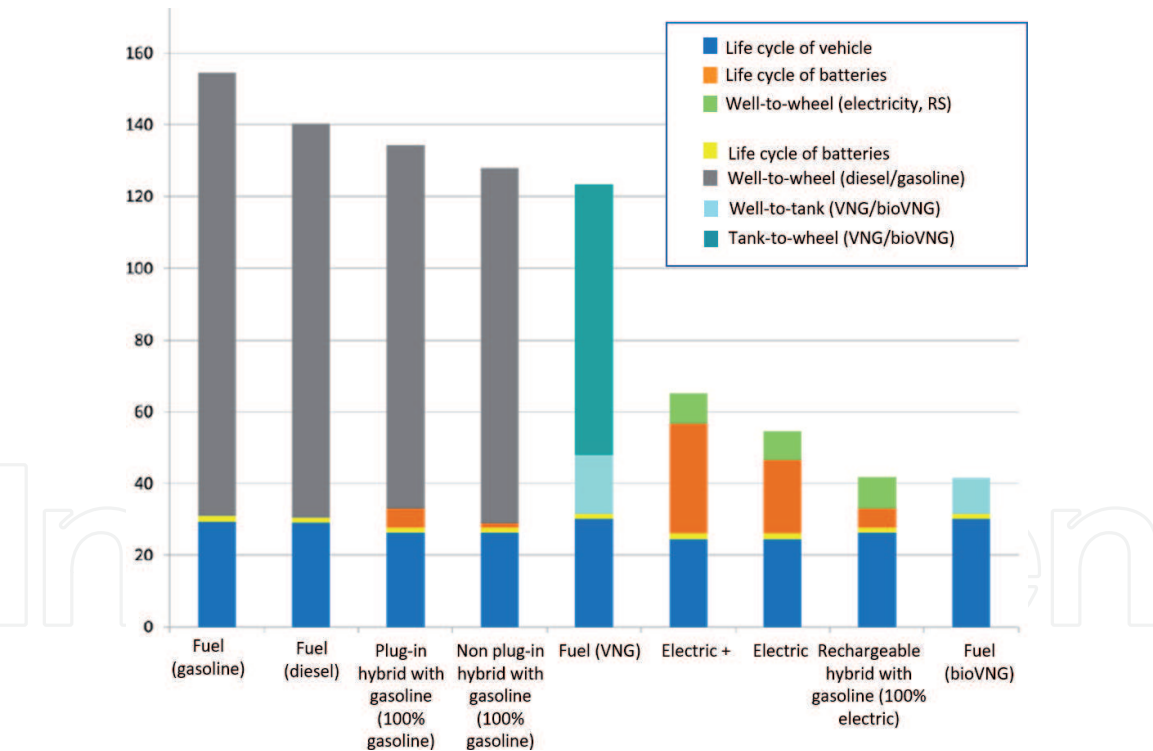


Figure 2.  
Comparative analysis of different fuels.





**Figure 3.**  
*CO<sub>2</sub> emissions (g/km) in light commercial vehicles in 2019 scenario.*



**Figure 4.**  
*CO<sub>2</sub> emissions (g/km) in passenger cars in 2019 scenario.*

the vehicle and the fuel. The report concludes that, in both light and utility vehicles and even in 12 tonne lorries, the use of biomethane provides the best results in terms of greenhouse gas emissions.

However, electric vehicles with high capacity batteries are penalised by the significant amount of CO<sub>2</sub> emitted during the manufacturing of batteries, largely deriving from the extraction and refining of the metals used such as lithium, cobalt and nickel and due to energy-intensive processes used for the manufacturing and assembly of the cells (**Figures 3 and 4**).

These reports reach a clear conclusion: The European legislative framework should also consider analysis methods that make it possible to establish homogeneous comparisons regarding the environmental impact of different technologies, so that the effect of biomethane can be considered in order to accredit compliance with the environmental targets. However, the regulation published recently to mitigate the effect of transport on climate change only deals with exhaust emissions.

The last regulatory package has made a first step in this direction. The aforementioned Regulation (EU) 2019/1242 outlines, in a review clause for 2022, the development of a methodology that analyses the cycle of fuel from the point of production and not only the direct emissions from the vehicle.

## **5. Natural gas: vector for the entry of green gas in mobility**

At present, natural gas technology is mature and available for the entire range of vehicles, from heavy-duty vehicles to vans, passenger cars and ships. As we have mentioned, it is an alternative that guarantees air quality and reduces CO<sub>2</sub> emissions, making it possible to reach a neutral balance of emissions when renewable gas is used.

In accordance with demanding European regulation, sectors such as heavy-duty transport and maritime transport have mature technology in order to reduce their emissions through the use of natural gas and the progressive incorporation of renewable gas.

In Europe there are already 1,331,000 vehicles on the roads that are powered by natural gas, and the forecast for 2030 is 13 million vehicles. The same applies to the supply infrastructure. At present, in Europe there are 3684 gas stations for compressed natural gas and 228 for liquefied natural gas which will rise to 10,000 in the case of CNG and 2000 in the case of LNG by 2030 [6].

The maritime sector also continues to progress; according to data from DNV, there are currently 170 LNG-fuelled ships in operation worldwide, another 112 are ready to use this fuel, and 35 are currently being built.

The current development and consolidation of the use of natural gas in mobility facilitates the progressive penetration of renewable gas in different means of transport, and it could be an important resource for meeting the demanding targets that the automotive sector faces over the coming years by reducing the foreseeable sanctions.

Below, an analysis has been carried out of the support systems that are being implemented to assist this transition.

## **6. The main mechanisms through which renewable gas has been incentivised in Europe**

In order to give a boost to renewable gas to enable it to offer all of its potential to the decarbonisation process, the different Member States have developed incentive mechanisms that make it possible to create a suitable ecosystem for the development of renewable gas.

Feed-in tariff [7]: Feed-in tariff is an incentive linked to the type of production technology. In this case, the producer ensures the price of the renewable gas for the next 10–20 years, as well as access to the grid. An example of the benefit of these kinds of tariffs is reflected in the pricing structure for the purchase of renewable gas in France. This price depends on the characteristics of the production plant and promotes sustainable projects by adding premiums according to the origin of the waste. In this case, for 15 years, the producer sells all of their biomethane production to the supplier they choose, thus encouraging the long-term vision that this type of technology offers.

**Feed-in premium:** Feed-in premium is a premium on top of the market price of the production costs in accordance with the characteristics of the project.

**Tax incentives:** The most common incentive is the exemption from taxes on emissions or fossil fuels.

**Guarantee of origin:** This is both a regulatory mechanism and a support mechanism. These certificates document the chain of custody of the renewable gas injected into the natural gas grid. Their objective is to certify the renewable character of the gas and its main characteristics and to provide traceability.

## **7. European experience with renewable gas**

The biogas market is very heterogeneous; it varies greatly from one country to the next. This analysis aims to provide a comparative analysis of the national experiences of different countries, assessing the current situation in the biomethane sector and evaluating possible development trends in terms of mobility.

The analysis was carried out in seven European countries that are benchmarks for the production of biogas given that they represent 90% [9] of total EU production. This analysis is based on a study by KPMG, Regulatory benchmarking of renewable gas in Europe [8], carried out by Gasnam, Sedigas and Aebig.

### **7.1 France**

The support system for renewable gas in France involves a feed-in tariff for the injection of biomethane into the gas grid. The French system also has guarantees of origin.

Natural gas suppliers and biomethane producers establish bilateral contracts for the purchase and sale of renewable gas. Producers inject this biomethane into the grid, after which, the suppliers receive the renewable gas along with a guarantee of origin that accredits the renewable origin of the gas.

There is a maximum period of 1 year to create this guarantee of origin after injecting the biomethane, as well as a maximum of 2 years to use it after its creation. The main use of the certificates is to report on compliance with the targets for reducing emissions and the market share of renewable energies in transport.

Any consumer can obtain biomethane through their supply contract; however, it is necessary to emphasise that France incentivises the use of biomethane in transport, given that suppliers only keep 100% of the profit resulting from the economic transaction of the certificate in the event that the sale is made for use in mobility and only 25% if it is intended for heating or gas.

France has committed to ambitious targets in terms of the production of biogas, established in the Energy Transition Law, which entail making 10% of the natural gas consumed renewable by 2030.

In accordance with the Distribution Grid for Natural Gas in France (GRDF) [9], the production of biogas in 2016 was 3.6 TWh/year [10] of which 215 GWh/year were recovered as biomethane through its biomethanation plants.

This development goes hand in hand with the great growth of biogas recovery plants, which have increased from a total of 4 in 2013 to 30 in 2017, which means that this country has positioned itself as one of the most promising future markets.

### **7.2 Italy**

Italy has a support system based on the creation of guarantees of origin for the use of biomethane in mobility. The fuel distributors are the final recipients of the



certificates, given that they have to use them to accredit compliance with the targets for renewable energies in transport [11].

These certificates are obtained at the time when the projects inject the biomethane into the grid. Italian biomethane producers and fuel distributors establish bilateral contracts for the purchase and sale of renewable gas. Thus, when the producers make deliveries of renewable gas, the fuel distributors receive gas and certificates. The economic incentive reflected in the certificate depends on the biomethane production technology.

Italy currently has seven biomethane plants with a production of 50GWh, in contrast to the two plants it had in 2013.

### **7.3 Germany**

Germany is an atypical case given that it does not have a feed-in tariff for the injection of biomethane into the gas grid, so the economic benefit only occurs due to the transaction of the guarantee of origin certificate.

The production of biomethane has tax incentives that result in the discount of tolls for injecting into the natural gas distribution grid.

The biomethane producers sell natural gas on the wholesale market through bilateral contracts for the purchase and sale of gas. The producer receives a certificate for each kWh at the time of the injection of renewable gas and transfers it to the suppliers in accordance with the amounts of renewable gas contracted [12].

The supplier sells the consumer the natural gas along with the certificates; furthermore, any consumer, whether industrial, individual or collective, can request green gas through their supply contract.

Transactions on the market of guarantee of origin certificates are only possible between gas suppliers, but not for end consumers. However, any consumer can request green gas through their supply contract.

Germany is the European leader in terms of biomethane production plants, with 194 units that generate 9.4 TWh/year. Also, the country has 103 gas fuel stations that supply 100% biomethane [13].

### **7.4 The Netherlands**

In the Netherlands there is a feed-in tariff for the injection of biomethane into the gas grid and guarantees of origin. On the other hand, all of the biomethane projects and some biogas projects have subsidies for investment costs through corporate tax as producers of renewable energy.

The renewable natural gas market in the Netherlands has one peculiarity that distinguishes it from the other European countries as the injection of each m<sup>3</sup> of biomethane into the transport grid results in a tradable certificate, which can be sold among registered traders in the gas system, and it does not have to be linked to a physical flow of gas. For sales of biomethane outside of the gas grid, a non-tradable certificate is generated, whose recipient is the end consumer; it is not separable from the physical flow of gas.

The current biogas market in the Netherlands amounts to 1.1 TWh/year, although most of this biogas, thanks to different support systems such as feed-in premium, is recovered through cogeneration plants for use in electricity and heat. Only 15% of this production is recovered as biomethane for its injection into the grid and for obtaining guarantees of origin.

In total, there are 26 biomethane plants in the Netherlands which supply 91 gas fuel stations with 100% biomethane; they represent more than half of the country's supply infrastructure grid.

The Netherlands National Renewable Energy Action Plan [14] establishes the targets for the use of biomethane in mobility. It is expected that the road map will offer great potential to biomethane as a fuel. The main gas producers in the country are already offering the supply of renewable gas to users, although most of it is through the import of renewable gas certificates from the United Kingdom.

## **7.5 The United Kingdom**

The injection of biomethane into the gas grid in the United Kingdom has a feed-in tariff, but it does not have specific incentives for mobility.

Producers sell biomethane by injecting it into the natural gas transport grid, or they sell it directly liquefied or compressed for transport. The producer receives the certificate at the time of the injection of biomethane into the grid, and they either transfer it to the suppliers in accordance with the contracts signed for the purchase of green gas or they transfer it without depending on physical gas flows.

The suppliers can sell certificates and gas to an end consumer or to other suppliers. Once the certificate reaches the end consumer, it cannot be exchanged again, and it is redeemed.

These transactions are possible with suppliers and/or consumers from outside the United Kingdom, always through interconnections and verifying that the physical gas flow took place between both countries.

The production of biomethane has increased significantly since 2013, reaching 3.75 TWh/year in 2017, which are produced in a total of 85 biomethanation plants.

In general, significant growth of the injection of biomethane is expected in order to achieve the targets set: an increase of 60% in the injection of biomethane into the grid, as well as an increase of the installed capacity to 5 TWh/year [15] due to new projects that are undergoing development.

## **7.6 Denmark**

Denmark has a support system that is very favourable for the injection of biomethane into the gas grid through a feed-in premium scheme, which consists of three tariffs:

Tariff 1: Variable tariff. It began to be used in 2016, and its value drops by 1/5 each year, so it will be eliminated in 2020.

Tariff 2: Variable tariff. It is inversely proportional to the price of natural gas.

Tariff 3: Fixed tariff. Mainly, priority is given to injection into the grid and transport as the only viable decarbonisation option.

Additionally, in Denmark there is another feed-in premium scheme for the sale of biomethane for direct consumption in the transport or industrial sectors.

Denmark attained biomethane production of 898 GWh/year, with 50% injected into the grid. Although there is certain uncertainty over the future development of regulation after 2020, there is no reason to believe that trends are going to change as the Danish Energy Agency calculates that 5 TWh/year will be injected into the grid in 2022.

7.7 Sweden

Sweden has not implemented any certification system for biomethane and nor does it have feed-in tariff or feed-in premium systems [16]. Nevertheless, the total production of biomethane during 2016 was 1.3 TWh.

The national operator of the natural gas transport grid has implemented the Green Gas Principle, a virtual balancing point for renewable gas through bilateral agreements, which acts as an initial phase due to the lack of guarantees of origin.

The incentive scheme strongly supports biomethane for transport purposes through tax exemptions for vehicles, as well as exemptions from the CO<sub>2</sub> quota for biomethane as a fuel. All of this explains why Sweden is one of the most promising countries for the use of and harnessing of biomethane in mobility. An example of this is that almost all of its gas fuel stations supply 100% biomethane.

7.8 Comparative analysis

The European countries analysed have different levels of development of the renewable gas industry in terms of plants, infrastructures and technical requirements.

There are different formulas for carrying out the injection and connection to the grid, which differ in terms of the party that is required or responsible for the different phases of the injection and the existing obligations in order to prioritise, or not prioritise, biomethane over conventional natural gas.

Between 2013 and 2017, several support mechanisms for biomethane were implemented in most of the countries analysed, and consequently major growth is observed both in terms of the number of plants and the GWh produced between those years [17] (Table 1).

		France	Italy	Germany	Netherlands	United Kingdom	Denmark	Sweden
2013	Biomethane plants	4	2	154	23	6	3	54
	Biomethane production (Gwh)	20	15	7231	900	n/a	n/a	900
2017	Biomethane plants	30	7	194	26	85	22	63
	Biomethane production (Gwh)	215	60	9400	1100	3750	898	1297
	Number of CNG stations	87	1246	857	175	20	17	181
	No. of 100% Bio stations	6	1	103	91	2	14	141
	Obligatory quotas (%)	10% Achieved. NG End 2030	10% bio transport 2020	20% VNG (achieved)	100% bio transport 2020	n/a	No	30% Achieved NG end 2030
	Tax exemptions			Discounts on tolls in	Corporate tax		For use in heating	Exempt from taxes
	Subsidies, soft loans, investment grants and/or OPEX	Incentives depending on project						Investment incentives depending on project

Table 1. Level of development of renewable gas industry (2013–2017).

		France	Italy	Germany	Netherlands	United Kingdom	Denmark	Sweden
Incentives for consumption	Injection incentives	BIOMETHANE						
		FIT/FIP for biomethane	✓	✓	✗	✓	✓	✗
		Tax incentives (biomethane)	✗	✗	✓	✓	✗	✓
		Extra incentive for use in mobility	✓	✓	✓	✗	✗	✓
Integrated model		Biomethane certificates	✓	✓	✓	✓	✓	✗

Table 2. International experience of support mechanisms.

We have analysed the different systems from the point of view of cost recovery for biomethane producers. While in France producers only receive FiTs for the sale of biomethane, in Germany they only receive the profit generated by the certificates, and in Denmark, Italy, the Netherlands and the United Kingdom, they receive FiTs plus the profit generated through the sale of certificates (**Table 2**).

## 8. Conclusions

The sustainable transport of the future depends on incorporating decarbonised gases that make it possible to achieve the demanding climate targets.

Biomethane, synthetic gas or power-to-gas and hydrogen are the technologies that we can avail of in order to decarbonise conventional gas, but for that purpose, we need to overcome a significant number of drawbacks such as the reluctance of stakeholders in the current market to invest in decarbonised gas and a regulatory framework that has not been designed with this new reality in mind.

However, not everything is an obstacle; the use of natural gas as fuel is a mature technology for all kinds of vehicles that is gaining real momentum, especially for heavy-duty transport and maritime transport. These sectors do not have an environmentally friendly and efficient alternative for replacing conventional fuels. The only technologically mature option at present is natural gas and the progressive incorporation of renewable gas, biomethane, hydrogen or synthetic gas.

Additionally, the use of biomethane does not entail any risk to the system and nor does it require making any change to the vehicles or users, and it is an option that will make it possible to fulfil the obligations arising from the new Directive on renewable energies and reduce the foreseeable impact of the sanctions that will be faced by vehicle manufactures that do not manage to meet the targets set by Europe.

This chapter has offered an analysis of the incentive schemes of seven European countries that make it possible to overcome the aforementioned obstacles in order to make biomethane a reality, and although we have seen that there are different formulas we can see that there are numerous common policies.

It seems internationally accepted that the essential step towards introducing biomethane in transport is the definition of a system of certificates or guarantees of origin for the injection into the grid that is similar to the existing one for renewable electricity.

We also see that most of the countries analysed accompany the certificates with subsidies for biomethane producers and with tax benefits.

However, these subsidies could be reduced by providing the certificates with sufficient value in order to overcome the resistance of investors.

In a context where vehicle manufacturers face paying fines worth millions, the certificate could acquire an important value provided that it could be used to accredit compliance with the emission levels.

To do so, the methodology that the European Union bases its regulation on would have to be updated with a well-to-wheel approach, which takes into consideration the origin of the fuel and not only exhaust emissions.

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