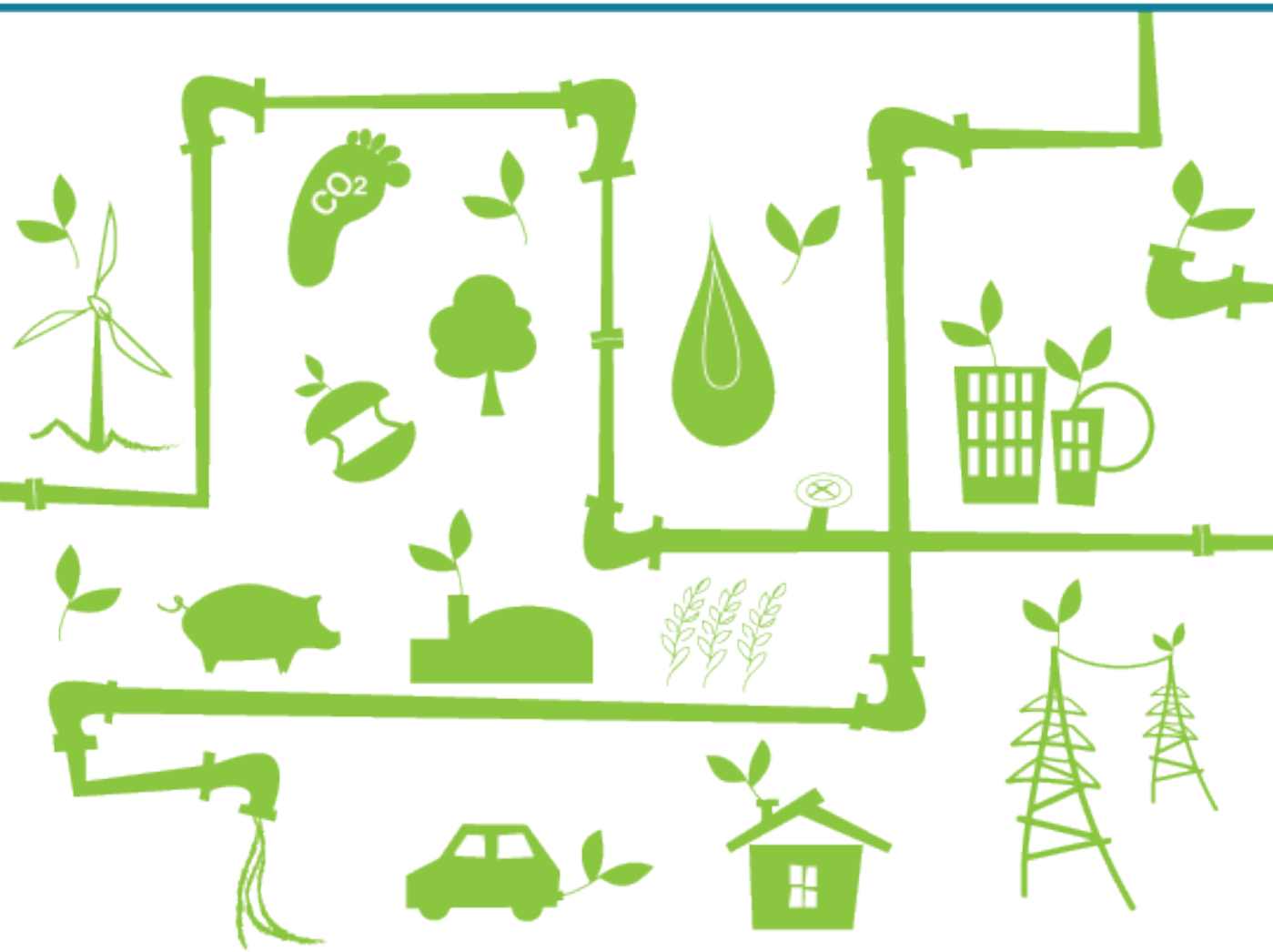
GEODE The Voice of Local Energy Distributors Across Europe



A Sustainable Europe

Green Gas
Green Grids
Green Future

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A. FOREWORD

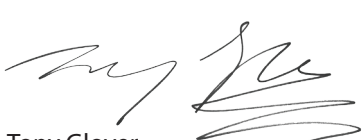
The GEODE Future of Gas Working Group has prepared this report to highlight the important role that Green Gas has to play in Europe's decarbonisation and future energy mix. It is clear that Green Gas should be a key ingredient in the recipe of solutions to the challenges policymakers face, including security of supply, sustainability and the needs of the consumer.

The report is intended to show how Green Gas can support the role of electricity but also where Green Gas has an advantage over renewable electricity. A common theme, I hope, is that Green Gas and electricity are complementary rather than conflicting, and that each should be deployed by policymakers where appropriate.

We believe that gas is undergoing an energy renaissance, redefining itself as a renewable energy source, potentially at the vanguard of a European energy revolution. Most importantly, the report stresses the central role the Distribution System Operators (DSOs) should play, given their key position sited between the high pressure Transmission System and the end customer.

I do not believe that this report offers all of the answers to this complex issue, but I am optimistic that policymakers will find something useful in its recommendations.

Finally I would like to thank the members of the GEODE Future of Gas Working Group who have kindly given their time and expertise; the Natural Gas Vehicles Association, the European Biogas Association and the Anaerobic Digestion and Biogas Association (UK) for taking the time to give their views; and Adrian McConnell & Agnieszka Eva Juszczyk for preparing this report.



Tony Glover
Co-Chairman
GEODE Future of Gas Working Group

B. EXECUTIVE SUMMARY

GEODE believes that Green Gas underpins the continued use of gas in a low carbon world. It creates an indigenous source of energy supporting security of supply by reducing reliance on imported energy, whilst offering the consumer the continued benefits that gas provides: flexibility, comfort, convenience and affordability.

We believe that the policymakers across Europe should take a proactive approach in developing Green Gas as a key part of the European Union's (EU) future energy mix. Gas is redefining itself as a Renewable energy source. The view of gas as a predominantly fossil fuel based energy source is changing.

Green Gas is unique amongst renewable energy sources in that it can continue to produce energy, regardless of the weather, a key advantage over renewable electricity sources such as solar and wind power.

RECOMMENDATION 1:
The European Commission should set an EU-wide target for sustainable gases, in TWh, or percentage of total energy consumption.

RECOMMENDATION 2:
European policymakers and Member States should take a holistic approach to the promotion of Green Gas, recognising the corollary benefits (i.e. local jobs, rural regeneration etc.) beyond the creation of an environmentally sustainable energy source.

For the majority of consumers in the EU, the cost of their energy is more important than its environmental impact. This provides a challenge for policymakers in firstly, making Green Gas more affordable, but also promoting and articulating the potential uses of Green Gas as a fuel. Green Gas will become more affordable when demand and consequently production increases.

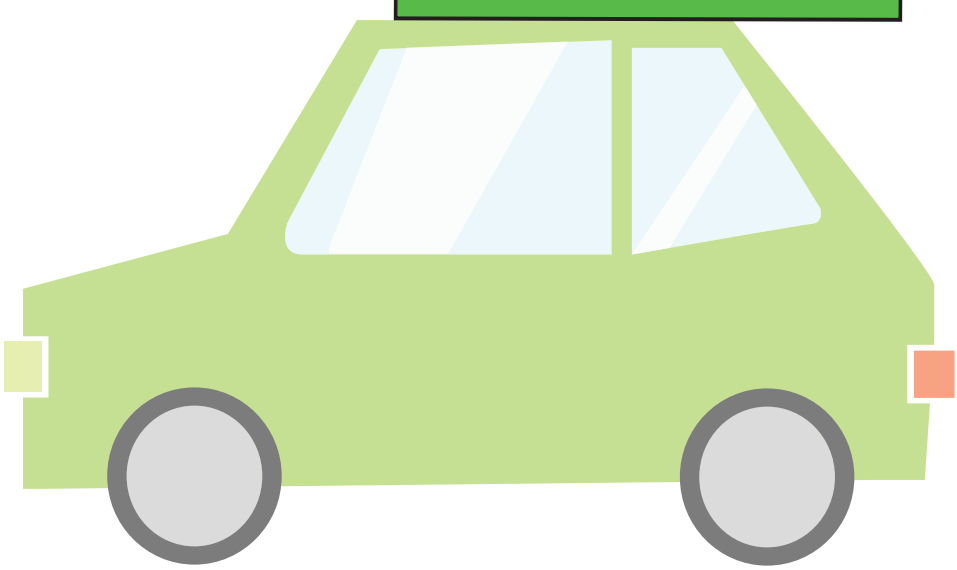
GEODE uses the term 'Green Gas' to describe all gas produced from renewable sources, which includes not only biogas/ biomethane derived from anaerobic digestion (AD) processes, but also gases produced by a range of other sustainable techniques.

One of the most exciting applications for Green Gas is its use in gas vehicles. Whilst electric vehicles have their advantages for small passenger vehicles, they are impractical for heavy good vehicles and larger public transportation vehicles.

In 2013, there were 1.1 million gas vehicles in use across the EU. Currently, 10 of the EU-28 produce biomethane for mobility and injection into the gas grid. GEODE believes that the EU should take urgent action to promote and incentivise these uses given that the use of Green Gas for vehicles and in the grid has much greater decarbonisation potential than its use for electricity production.

RECOMMENDATION 3:
The European Commission should recommend Member States include the development of Green Gas as part of their security of supply strategy, recognising the role an indigenous source can play in both mitigating supply shocks and creating domestic energy production.

RECOMMENDATION 4:
Member States and National Regulatory Authorities should incentivise the development of innovative gas vehicle technologies by recognising them separately in their tax regimes to allow the market to develop, acknowledging the lower carbon footprint of gas (and especially Green Gas) and its potential to help to reach decarbonisation targets, by speeding up the introduction of biogas for transport.



As Green Gas is carbon neutral it has the potential to have a significant impact in helping the EU reach its greenhouse gas emission targets. Green Gas has the potential to meet 40 percent of domestic heat demand whilst lowering carbon emissions and making use of existing gas infrastructure and appliances.

A key advantage of Green Gas is the potential to maximise the use of our resources by utilising waste products. Over the course of the last century, the world increased its fossil fuel use by 12 times, whilst extracting more material resources by a factor of 34.

Today in the EU, 2.7 billion tonnes of waste is thrown away each year. It is GEODE's view that this provides a key opportunity for policymakers to meet their targets as set out in a number of EU Directives, including the Renewable Energy Directive (2009/28/EC),the Fuel Quality Directive (2009/30/EC), and the Landfill Directive (1999/31/EC). Furthermore, the localised use of waste for Green Gas production could mitigate the increase in international trade in waste and significantly reduce the carbon footprint of the industries that create it.

RECOMMENDATION 5:
The European Commission and European Parliament should require Member States to set out how they plan to recover energy via Green Gas from otherwise non-recyclable waste.

GEODE members' long-term strategy is to increase the volume of Green Gas entering their networks. They see biomethane as a clean and renewable source of energy, which can help the EU to meet its climate targets.

Greening the gas that passes through the Distribution System Operators' (DSOs) network is at the core of our members' vision for an enduring and sustainable gas network. We believe this innovative use of the gas network is a vital component of a sustainable energy future. However, in order for this to happen, there needs to be a clear steer from the European Commission and the European Parliament to support this nascent industry.

GEODE would like to see clearly defined support schemes that are transparent, easy to use and also have the regulatory certainty to encourage investment with the security of known payback periods.

GEODE Future of Gas Working Group believes that it is in the long-term interests of the DSOs to help to develop the potential for biomethane injection into the grid within their networks.

RECOMMENDATION 6:
Member States should set targets for the production of Green Gas, its use for transport, and injection into the grid.

RECOMMENDATION 7:
The European Commission and European Parliament should create clearly defined, easy to use and long-term support schemes that will encourage investment and allow Green Gas to reach its potential.

RECOMMENDATION 8:
Any support scheme for renewables introduced by the European Commission or Member States should recognise and reward Green Gases' flexibility and storage capacity, to allow it to complement renewable electricity (e.g. as a means to use and store excess electricity).

RECOMMENDATION 9:
A Europe-wide Green Gas registry should be established and appropriate steps should be taken to create a cross-border Green Gas market within the European gas grid.

C. INTRODUCTION

This report highlights the role that Green Gas should play in addressing what the World Energy Council calls the 'energy trilemma' – that is finding secure energy supplies and catering to rising demand without prices becoming unaffordable, whilst at the same time reducing greenhouse gas emissions.

GEODE believes that Green Gas underpins the continued use of gas in a low-carbon world, creating an indigenous source of energy supporting security of supply by reducing reliance on imported energy, whilst providing the consumer with the continued benefits that gas offers: flexibility, comfort, convenience and affordability.

One of the central issues is a lack of political recognition of Green Gas. It is rarely explicitly mentioned in legislation or policy documents and only a few Member States have set targets for Green Gas.

It is also key to note that Green Gas has a significant role in supporting the local economy, given it creates local jobs and provides a local energy source. Furthermore, it is the view of GEODE that the DSOs have a key role to play in this future given their presence across Europe and proximity to the customer.

In light of this, the European Commission needs to view the role of Green Gas in a holistic way as part of its wider energy and environmental policies.

C1. Who are the DSOs?

The Distributon System Operators operate the medium and low pressure pipes that deliver the gas, from the Transmission System Operator's (TSOs) high pressure network to the consumer.

Historically the role of the DSO has been well defined. The DSOs were, and continue to be, responsible for the safe and secure operation of the distribution system. They are also responsible for network planning and development, and in the majority of Member States, for investment decisions. Consequently, the role of the DSO in the market has always been largely passive, with the main interactions being with gas suppliers with the TSOs where the distribution system meets the transmission system; and with consumers for safety or supply interruption reasons.

The DSOs continue to have a critical role to play as a neutral market facilitator and ensuring the security of network operations. However, there are now new opportunities for DSOs to proactively deliver benefits to gas consumers and the energy sector in general.

The DSOs continue to have a critical role to play as a neutral market facilitator and ensuring the security of network operations.

Changes to the EU's energy system, including: retail liberalisation; new technologies; and distributed gas injection into the grid has meant that the role of the DSOs has evolved over the last 15 years and will continue to change in the future.

It is also important to note that whilst the way the DSOs function is broadly consistent, there are also significant differences across Europe. In particular, their scale of activity can vary drastically and there are key differences in the degree to which DSOs have been unbundled. There are also a number of structural and technical differences such as size, pressure levels, the degree of network automation and of penetration of distributed resources.

As such there is no "one size fits all" model- which describes gas DSOs across Europe, which means that Member States and EU policymakers need to think creatively when it comes to supporting the development of Green Gas and the role of the DSO.

Where the DSO sits in gas supply chain

C2. Background

It is clear that the EU faces and increasingly urgent challenge ensuring secure, sustainable, and affordable energy for all of its citizens. The EU imports 53 percent of its total energy consumption and six Member States are reliant on a single external supplier[1].

Given these import dependent Member States' reliance on limited gas sources (which can lead to supply disruption), together with the need to reduce carbon emissions whilst making sure energy prices are affordable and competitive, a proactive approach is needed by policymakers to address the concerns of consumers and ensure continued competitiveness.

There is one viable solution to the issues of security of supply, sustainability and consumer satisfaction that this GEODE report examines: Green Gas.

One potential solution to the issues of security of supply, sustainability and consumer satisfaction that this GEODE Report examines: Green Gas.

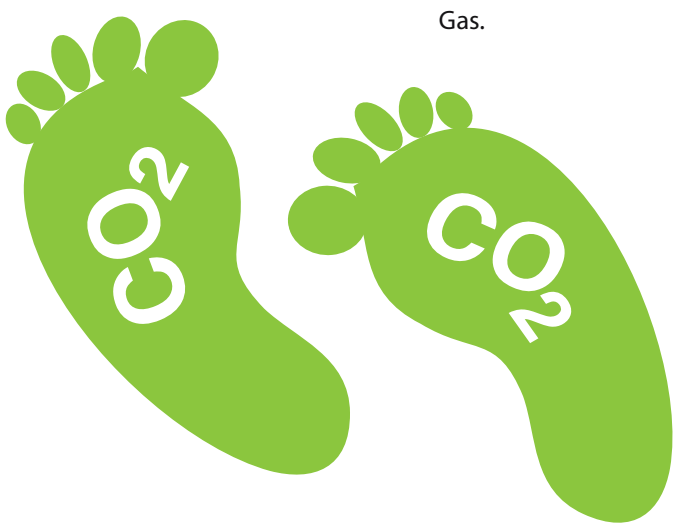
[1] *DODS EU Monitoring - The Balancing act of Energy Union briefing, March 2015.*

C3. Energy Union

Whilst the agreements on the 2030 Framework for Climate and Energy, and the European Energy Security Strategy in 2014 represent significant progress, it is GEODE's view that the EU needs to take further steps to address the challenges Green Gas faces.

The EU launched the Energy Union package[2] in February 2015. This was in response to the lack of a coordinated approach between Member States in a number of areas, including: national energy policies; relationships with non-EU countries; and the delays in implementing the internal energy market. In addition to dealing with the EU's import dependence, there are three other key areas that GEODE believes the Energy Union will need to address in order to deliver the modernisation the EU energy system needs:

- Firstly, setting the economy on a low-carbon pathway to meet EU climate objectives and creating new market opportunities in the EU economy; Green Gas should be at the heart of this process.
- Secondly, a stable investment framework which reassures investors and will fund the modernisation of energy infrastructure and development of new technologies including those that will encourage use of Green Gas as a renewable energy source.
- And thirdly, the completion of the internal energy market, supported by modern energy infrastructure.
  A market that works for households and businesses will reduce prices and boost competitiveness. This should include a Europe-wide single market for Green Gas.



[2] The Energy Union is based on the Commission's framework strategy and has five pillars: energy security, solidarity and trust; a fully integrated European energy market; energy efficiency contributing to moderation of demand, decarbonising the economy; and research, innovation and competitiveness.

GEODE argues this for three reasons:

- The focus on carbon reduction is increasing and requires urgent action.
- GEODE believes that the EU should move towards a competitive low-carbon economy that reconciles its climate objectives with competitiveness.
- A number of European countries, especially in the east, are vulnerable to energy supply disruptions and are overly reliant on individual sources for their gas.

GEODE recognises that energy supply shocks can impact livelihoods, economies and prices across Europe. An indigenous source of gas can mitigate short term supply shocks and ensure independent energy production. The EU still suffers from significant under investment in technology and innovation. GEODE is concerned that uncertainty around Europe's future energy mix is deterring investment and delaying the introduction and use of those new technologies.

GEODE believes that at the heart of the solution is the modernisation: the EU needs to both modernise infrastructure and technologies as well as modernising the investment framework.

Furthermore, the DSO networks are already throughout Europe and it makes sense to develop new ways to use these valuable assets, whilst at the same time diversifying the gas market. In GEODE's view, one simple way in which the EU can mitigate the challenges outlined above and meet its carbon reduction targets is through the promotion and increased use of Green Gas.

C4. An Energy Renaissance

Gas is redefining itself as a renewable energy source. The view of gas as a predominantly fossil fuel based energy source is changing. Green Gas is unique amongst renewable energy sources in that it can continue to produce energy, regardless of the weather, a key advantage over renewable electricity sources such as solar and wind power.

RECOMMENDATION 1:
The European Commission should set an EU-wide target for sustainable gases, in TWh, or percentage of total energy consumption.

D. GREEN GAS: WHAT'S IN IT FOR THE CONSUMER?

For the majority of consumers in the EU, the cost of their energy is more important than its environmental impact. Indeed O-Power estimates that the average consumer spends only 9 minutes each year interacting with their energy provider[3].

This provides a challenge for policy makers in firstly, making Green Gas more affordable, but also promoting and articulating the potential uses of green gas as a fuel. Green Gas will become more affordable when demand and consequently production increases.

GEODE believes that the EU could help this happen by encouraging and facilitating cross border trade in Green Gas which has the potential to stimulate production in those countries, especially in Eastern Europe, where there is significant and unexploited potential.

[3] *O-Power presentation, 2015 - opower.com*

D5. Local Economy

One of the key and often overlooked opportunities created by Green Gas is that it can create skilled employment opportunities within areas of unemployment, especially in rural areas. Waste from farming used as feedstock in biomethane production means that decentralised small-scale energy production can create jobs in areas where skilled jobs are at a premium.

Green Gas provides an almost unique opportunity to join up employment, environment, agriculture and energy policies, contributing to rural regeneration and arresting the knowledge drain caused by people relocating to urban areas in the pursuit of skilled employment.

The European Biogas Association notes that in 2013, according to the REN21 Report, there were 68,500 jobs in the European biogas sector representing 5.5 percent of the total jobs in the renewable energy business in Europe[4] (See Table 1). This demonstrates the importance of the industry, especially in rural areas, and up from 4 percent in the previous year.

RECOMMENDATION 2:
European policymakers and Member States should take a holistic approach to the promotion of Green Gas, recognising the corollary benefits (i.e. local jobs, rural regeneration etc.) beyond the creation of an environmentally sustainable energy source.

[4] *European Biogas Association – Biogas Report 2014*

TABLE 1

Countries	Jobs in the Renewable Sector	Jobs in the Biogas Sector
Germany	363,100	41,000
UK	939,254	2,650
France	N/A	1,700
Irleand	N/A	100
Spain	N/A	150
Slovenia	188	N/A
Italy	N/A	3,670
TOTAL		
REN21 Report	1,245,000	68,500
EuObserv'ER Report	1,218,230	68,895

Table 1: Source: EBA Biogas Report 2014 (NB "N/A" means numbers "not available")

D6. Security of Supply

Green Gas has distinct advantages over other renewable energy sources, such as solar and wind power, in that it is not intermittent. It can be used to produce energy regardless of whether the wind is blowing or the sun is shining. This consistency is especially important for industries that require a constant and reliable source of energy.

In addition to this, the nature of Green Gas means that it can be injected into the grid which efficiently transports the energy to where it is needed, or it can be stored in the grid as potential energy in a much more efficient, affordable and environmentally friendly way than storing energy as electricity in batteries. GEODE thefore believes that developing Green Gas markets within Member States will create an indigenous, reliable and renewable source of energy that can mitigate short term supply shocks and reduce dependency on imports from outside of the EU. The EU needs to help the development of the biomethane market in those European countries with significant potential, especially in Eastern Europe, to help diversify sources of supply.

The nature of Green Gas means that it can be injected into the grid to efficiently transport the energy to where it is needed, or it can be stored in the grid as potential energy.

RECOMMENDATION 3:
The European Commission should recommend Member States include the development of Green Gas as part of their security of supply strategy, recognising the role an indigenous source can play in both mitigating supply shocks and creating domestic energy production.

E. WHY GREEN GAS?

GEODE believes that Green Gas will play a vital role in achieving the Renewable Energy Directive's targets of 20 percent renewable energy consumption and 10 percent of transport fuel to come from renewable sources by 2020.

In addition this, Green Gas has an important role to play in meeting the renewable energy targets set by individual Member States. The Green Gas Grids[5] project estimated that the EU has a biogas potential of 41.6 Mtoe by 2020, one third of which (14 Mtoe) was assumed to be available for biomethane production.

[5] *www.greengrids.eu*

E7. What is Green Gas?

Green Gas is a clean and renewable source of energy that can help the EU and its Member States meet their carbon reduction targets. It can be produced from a number of sources including sewage, manure, food waste and fuel crops as well as chemical processes.

One type of Green Gas is biomethane, which is currently produced in 15 Member States, and injected into the gas grid in 10 countries. The majority of gas produced is used for combined heat and power purposes (CHP), but it is also increasingly used as a transport fuel and as a replacement for natural gas, which reduces emissions dramatically and is a more efficient use of the gas.

In Sweden, the use of biomethane for transport has overtaken compressed natural gas (CNG), taking more than 60 percent of the market[6]. Worldwide, the gas vehicle market currently consumes 2-3 billion (m^3)[7] with the Natural and Biogas Vehicle Association (NGVA) estimating this demand growing to 10-15 billion m^3 by 2020 (roughly 5 percent of the total market)[8]. According to the European Biogas Association[9], total Green Gas production in Europe corresponds to about 14 billion m^3 (natural gas equivalent) with production expected to double, based on the National Renewable Energy Action Plans, by 2020.

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E8. Making Green Gas

For most policymakers, gas is seen as a fossil fuel and therefore less environmentally desirable than, for example, solar or wind generated electricity. GEODE refutes this assertion and believes that gas is undergoing the 'energy renaissance' that electricity underwent in the 1990s and is developing its green credentials as a renewable energy source.

[6] *www.ngvaeurope.eu/european-ngv-statistics*
[7] *ibid*
[8] *ibid*
[9] *european-biogas.eu*

Biogas can be burned to produce both heat and electricity, or upgraded to biomethane which can be used as vehicle fuel or injected into the gas grid.

Central to this is the fact that natural gas and Green Gas (biomethane and synthetic gas) are the same molecule: methane (CH4).

The difference between natural gas and Green Gas is where they come from. Whilst natural gas is extracted from the ground, both biomethane and synthetic gas are created through renewable, sustainable technical processes.
A more detailed description of the processes involved can be found in Appendix 1, at the end of this report.

a. Anaerobic Digestion

Anaerobic digestion (AD) is the straightforward, natural breakdown of organic matter into carbon dioxide, methane and water, by micro-organisms (bacteria and archaea).

Since many of these micro-organisms are intolerant to oxygen, this process is anaerobic. These processes happen naturally, AD takes control of these processes and effects a significant reduction in carbon emissions.

At the end of the process there is a mixture of methane and carbon dioxide gases (biogas), water and some organic material (digestate). Biogas can be burned to produce both heat and electricity, or upgraded to biomethane which can be used as vehicle fuel or injected into the gas grid.

More Information in Appendix 1 (p.50)

It takes 5 cows or 30 pigs to heat a typical home in Denmark for one year.
Source: NGF Nature Energy

CASE STUDY 1

NGF Nature Energy, Holsted, Denmark

NGF Nature Energy[10] opened the Holsted Biogas plant in August 2015. The plant processes around 400,000 tons of waste per year, split roughly between 75 percent agricultural waste, mainly manure and deep litter, and 25 percent industrial waste. The biogas produced is cleaned, upgraded to natural gas quality equivalent and injected into the grid. Production of biomethane at the plant is 1,800 Nm3 per hour of pure methane, which equates to the annual consumption of circa 8,000 households in Denmark, or fuel for 17,500 gas vehicles per annum.

The choice of site highlights the importance of choosing an area with suitable agricultural intensity (for supply of feedstock), access to the gas grid for injection and other geographical practicalities concerning transportation of the feedstock to the site and removal of waste products for reuse.

Local farmers own around 30 percent of the plant, which not only gives them an extra income stream but also secures the plant's supply of feedstock. Total cost of the plant is circa 27 million Euro. The European Agricultural Fund for Rural Development and the Danish Ministry of Food jointly part funded the project with approximately 5 million Euro. The industrial waste component of the feed stock comes primarily from the abattoir next door to the plant that also reutilises food waste from supermarkets and large kitchens as fertiliser locally.

[10] *http://www.natureenergy.dk/*

b. Gasification

Gasification is a process where Green Gas is produced from the carbon in solid organic materials, which is environmentally friendly and can be used for a range of applications.
The process uses high temperatures to convert biomass (e.g. wood, carbon-rich waste) into gas that can be used in the same way as natural gas.

Like the gas created by AD, the gas produced by gasification can be used for heat and electricity generation, in industrial processes that require high temperatures (e.g. cement kiln, brick making and ceramic firing), in transport, in chemical processes and when upgraded to methane, injected into gas grids.

More Information in Appendix 1 (p. 51)

Göteborg Energi - GoBiGas – Göteborg, Sweden

GoBiGas[11] (Gothenburg Biomass Gasification Project) is a Göteborg Energi project which will produce biogas from forestry waste using gasification.
The aims of the GoBiGas project are:

- To demonstrate the possibilities of gasification technology.
- To build a plant that can fulfil the growing need for renewable biogas.

The project has two phases:

- The first is building and evaluating a demonstration plant, producing biogas for use by 15,000 passenger cars. The plant opened in late 2014 and cost circa 150 million Euro.
- The project was partly funded through a grant of 22 million Euro from the Swedish Energy Agency.
- The second phase is a plant four to five times larger than the demonstration plant. This will be funded by a 59 million Euro from EU NER 300 grant.

Production from the two plants will be almost 1 TWh, which is enough biogas to fuel 100,000 passenger cars. This is equal to the total amount of biogas used in transport in Sweden today.

The project's aim is to ensure that at least 65 percent of the biomass' energy content is transformed to biogas and that the total energy output will be over 90 percent. In addition to this, the heat surplus is used in district heating and the ash generated by the plant will be used as fertiliser.

[11] *www.gobigas.goteborgenergi.se/*

Met NewEn - Olevano di Lomellina, Italy

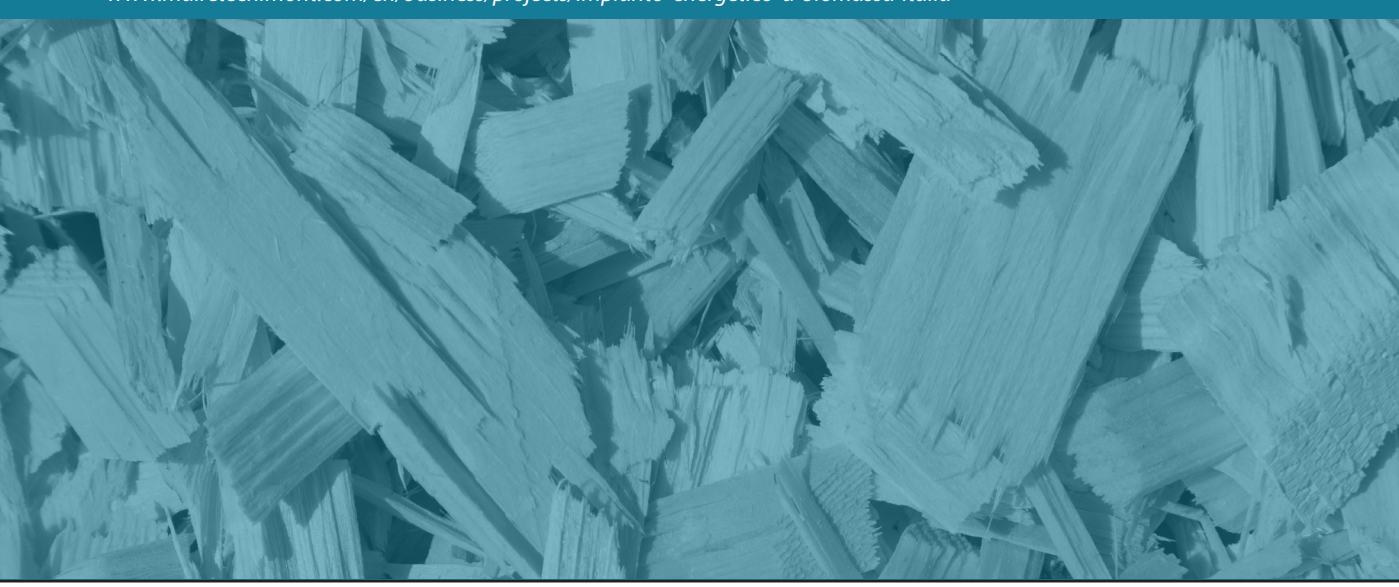
Met NewEn[12] has built its first wood biomass power plant in northern Italy. The 20 MW BiOlevano project cost 80 million Euro. A key feature is the development of the wood-chip supply chain.

A high proportion (more than 85 percent) of the plant's raw materials will come from a short supply chain. The BiOlevano unit features a very high conversion efficiency (more than 30 percent) and extremely low emissions, lower than any other biomass power plant in Italy.

The plant, designed to deliver 140 GWh per year of renewable energy, sufficient to meet the needs of about 50,000 families, will consume approximately 200,000 tonnes of wood chips per annum. The wood chips will come mainly from poplar trees grown according to the short rotation forestry (SRF) formula, defined as high-density plantations of fast-growing species to be used for energy conversion.

Taking into account the carbon capture cycle of its raw materials, the Olevano plant will reduce atmospheric emissions of CO2 by more than 100,000 tonnes per year by replacing electricity generated from fossil fuels.

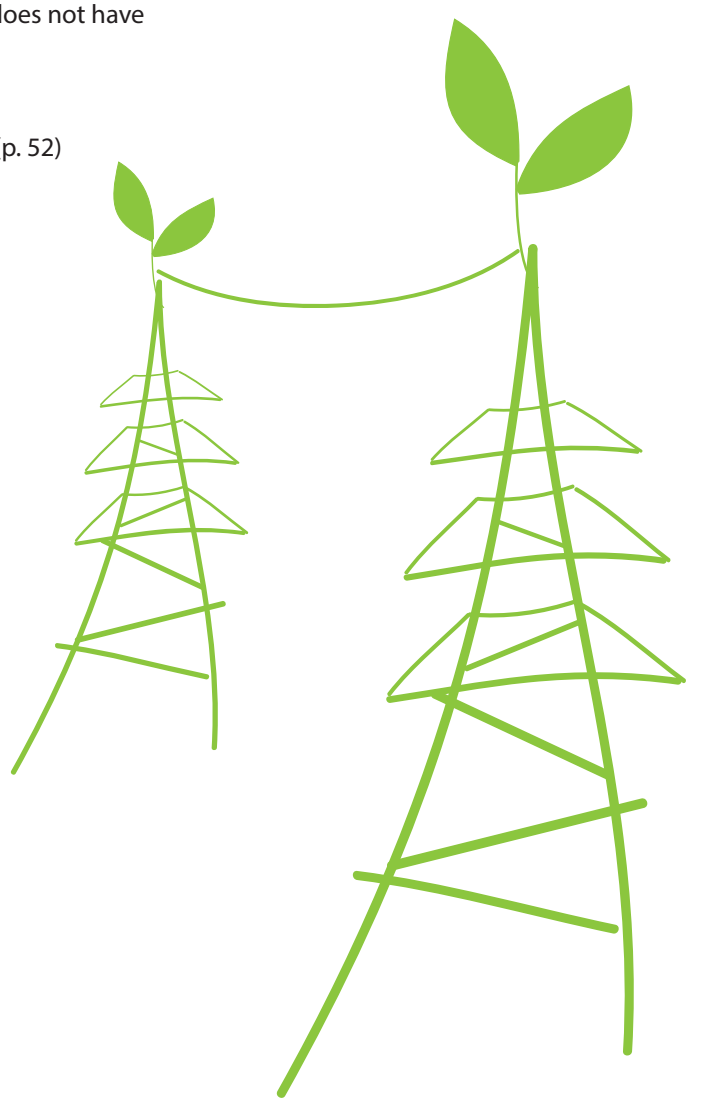
[12] *www.mairetecnimont.com/en/business/projects/impianto-energetico-a-biomassa-italia*



c. Gas to Power

Power to gas (P2G) is the conversion of electricity from renewable sources into hydrogen and carbon dioxide and then into synthetic methane, which can subsequently be fed into the gas infrastructure, stored and/or transported elsewhere. P2G is a relatively new technology that makes use of energy which would otherwise go to waste. For example, when a wind turbine continues to produce electricity but the electricity grid does not have the capacity to accept it.

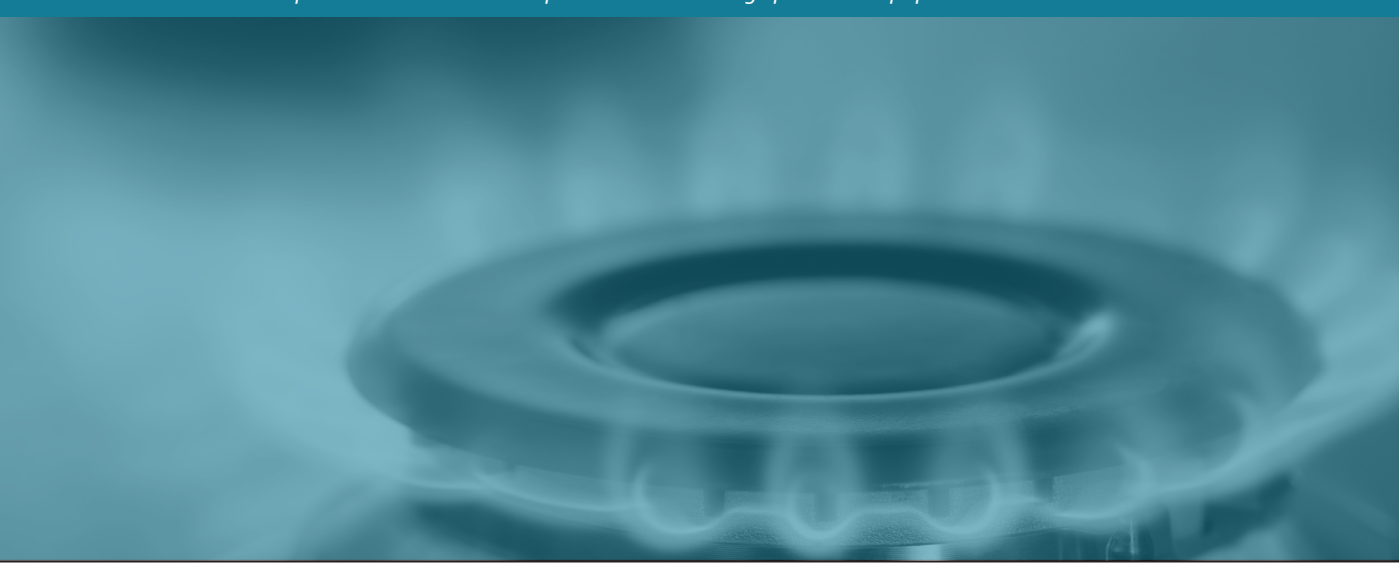
More Information in Appendix 1 (p. 52)



Siemens – Mainz Power to Gas project – Mainz, Germany

Siemens, alongside the public utilities of Mainz, Linde and the Rhein Main University of Applied Sciences, have started a project that will develop a new type of energy storage system[13]. On 2 July 2015, a hydrogen production plant was opened at the Energiepark Mainz. This 17 million Euro project has been part funded by the German Federal Ministry of Economics and Technology as part of the Energy Storage Funding Initiative. The system, equipped with an electrolyser, will convert surplus electricity from wind farms to hydrogen. Using this method it will be possible to store electricity from renewable sources over longer periods of time. With a peak rating of up to 6 MW the plant is the largest of its kind in the world. The principle of electrolysis has been tried and tested for decades. What is unique about the Mainz system is that it involves highly dynamic proton exchange membrane (PEM), high-pressure electrolysis which is particularly suitable for high current density and can react within milliseconds to sharp increases in power generation from wind and solar sources. In this electrolyser, a PEM separates the two electrodes at which oxygen and hydrogen are formed. On the front and back of the membrane are precious-metal electrodes that are connected to the positive and negative poles of the voltage source. This is where the water is split. The system in Mainz will have capacity to use excess power during bottlenecks in the electricity grid and from small wind farms.

[13] *www.siemens.com/press/en/feature/2014/corporate/2014-05-energiepark-mainz.php*



F. GREEN GAS: PRACTICAL APPLICATIONS

One of the key contributions Green Gas can make towards Member States meeting their carbon reduction targets is the decarbonisation of Europe's transportation and heating & cooling sectors.

As a vehicle fuel, Green Gas has the potential to reduce noxious and particulate emissions by around 90 percent, which Public Health England calculate could increase the average life expectancy by six months. Green Gas also reduces carbon dioxide levels by 20-30 percent. That progress is set to continue: the European Commission recently outlined a new regulatory framework that could require Member States to ensure publicly accessible refuelling points every 400km by the end of 2025.

Similarly, one of the challenges Europe faces in meeting its long-term emissions targets is decarbonising its heating system. For example, heating accounts for 45 percent of all energy use in the UK[14], with the majority used for cooking, and to heat homes and hot water. Consequently the UK has one of the most extensive gas grids and largest gas boiler markets in Europe.

If Europe is to decarbonise its heating system, low carbon heating technologies need to be as effective as traditional fossil-fuel options in meeting consumer needs.

[14] *DECC Energy Consumption in the UK (2014) www.gov.uk/government/statistics/energy-consumption-in-the-uk*

F9. Fuelling Transport

One of the most exciting applications for Green Gas is its use in gas vehicles. Whilst electric vehicles have their advantages for small passenger vehicles, they are impractical for heavy good vehicles and larger public transportation vehicles.

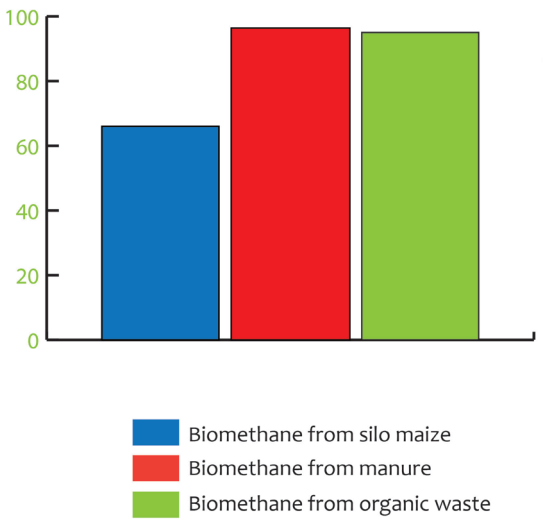
In 2013, there were 1.1 million gas vehicles in use across the EU. In Italy, there are over 850,000 gas vehicles in use, which represents a significant share of the market, whilst Germany has almost 100,000 gas vehicles. Elsewhere, countries like Belgium, the Netherlands, Croatia, Hungary and the Czech Republic have seen significant growth in the number of gas vehicles on the road since 2009 (+41 percent, +30 percent, +65 percent, +17 percent, 22 percent respectively)[15].

The Natural and Gas Vehicle Association (NGVA) predicts that 50 percent of public transport will be fuelled by natural gas by 2030, whilst as many as 30 percent of heavy goods vehicles will be run on liquefied natural gas (LNG) by the same point in time[16]. Given this, there are significant carbon savings to be made by Member States incentivising the transition from diesel to gas for heavy goods vehicles. Currently, 10 of the EU-28 produce biomethane for transport and injection into the gas grid[17].

GEODE believes that the EU should take urgent action to promote and incentivise these uses given that the use of Green Gas for vehicles and in the grid has much greater decarbonisation potential than its use for electricity production. NGVA says that if 20 percent of vehicles were run on biomethane, it would make a carbon saving of 40 percent.

[15] *www.ngvaeurope.eu/european-ngv-statistics*
[16] *Ibid*
[17] *Ibid*

Greenhouse emissions' reduction potential (well-to-wheel) of biomethane in % compared with diesel/gasoline[18]



It is critical to note that in terms of vehicle technologies, diesel engines are at a mature stage and there is limited potential for them to be developed to be more efficient, whilst gas vehicle technologies are still at a relatively early stage and it is likely that advances in those technologies will only provide greater carbon savings. With this in mind, GEODE urges Member States to provide funding and incentives for the development of these innovative gas vehicle technologies.

Gas vehicle technologies are still at a relatively early stage and it is likely that advances in those technologies will only provide greater carbon savings.

Furthermore, the development of biomethane as a vehicle fuel is hampered in some Member States by low taxation on diesel, which makes it difficult for gas to compete. GEODE therefore calls on Member States to recognise vehicle gas separately within their tax regimes.
Under the Directive on Alternative Fuels Infrastructure (DAFI) (2014/94/EC), Member States have to submit their alternative fuel deployment strategy to the EC by November 2016, which will outline each country's national targets for putting in place new refuelling points as well as strategies for promoting the use of alternative fuels.

Consequently, GEODE believes it is essential that Member States work closely with the DSOs in their country to make sure the use of these valuable assets is maximised.

[18] The data does not include the avoided emissions of raw manure storage, landfilled organic waste and the benefits of the produced digestate, which can replace mineral fertiliser. Source: Environment Agency, Austria

TABLE 2

CNG/LNG Stations in Europe		
Country	CNG	LNG
Austria	175	0
Belgium	26	2
Bulgaria	109	0
Czech Republic	85	0
France	40	2
Germany	851	1
Italy	1071	1
The Netherlands	150	13
Spain	36	17
Sweden	161	6
Switzerland	136	1
UK	2	9

Source: NGVA: Natural Gas Vehicles Catalogue, October 2015

RECOMMENDATION 4:
Member States and National Regulatory Authorities should incentivise the development of innovative gas vehicle technologies by recognising them separately in their tax regimes to allow the market to develop, acknowledging the lower carbon footprint of gas (and especially Green Gas) and its potential to help to reach decarbonisation targets, by speeding up the introduction of biogas for transport.

CASE STUDY 5

Green Transport – Stockholm, Sweden

The city of Stockholm has sought to increase the use of biogas as a vehicle fuel for a number of years. The supply of biogas from the sewage treatment plants has made investments in a greener city possible.

Most of the biogas produced from sewage plants is used in Stockholm's buses. Some of the biogas is pumped into a new network of vehicle gas to which more filling stations and bus depots are connecting.

The demand for biogas in Stockholm is much higher than supply. To cope with this demand, biogas is mixed with natural gas.

Stockholm is now starting to use food waste to produce biogas. A new plant processing household waste will help boost biogas supplies in the region.

Eco-friendly Transport

Private transport companies have been quick to take advantage of the city's investment in the environment. A large taxi company is replacing its petrol and diesel-driven fleet with gas vehicles. Its investment has paid off financially and to the benefit of the environment.

The city of Stockholm has run a successful project to get more HGVs on the road with eco-friendly technology. The city also has the world's first vehicle gas-driven ambulances.

Another example is the city's airport Arlanda, which has invested heavily in fossil fuel free vehicles on the site: there is a biogas filling station; taxis running on gas take priority at taxi stands; and even snow clearance is carried out by biogas-driven snowploughs. Overall, these moves help the airport reduce its emissions.

There are now over 20 gas filling stations in the Stockholm area, and HGVs can even fill up with liquid gas.

F10. In the Home

As Green Gas is carbon neutral it has the potential to have a significant impact in helping the EU reach its greenhouse gas reduction targets. Green Gas has the potential to meet 40 percent of domestic heat demand[19] whilst lowering carbon emissions and making use of existing gas infrastructure, and appliances.

Unlike other low carbon heat options, the use of biomethane requires no expansion of gas or electricity networks or the installation of new domestic appliances, saving money for consumers.

Domestically, heating and cooling amount to 46 percent of the EU's final energy consumption of which gas (currently mainly natural gas) comprises 47 percent across Europe[20], albeit with considerable variety across different Member States.

Gas offers European consumers an affordable, adaptable, efficient and flexible heating and cooking solutions. The price of gas across Europe is approximately one third that of electricity[21]. Also, consumers are offered a wide choice of gas appliances, of which the costs, both of installation and use, tend to be the most competitive option for domestic users.

Furthermore, gas appliances can be combined with renewables such as solar panels, or with integrated hybrid systems combined with an electric heat pump, which creates flexibility for both the consumer and the whole energy system.

Residential buildings in the EU are the largest proportion of European building stock (60 percent)[22] and have the largest potential to drastically reduce energy use and carbon dioxide emissions.

[19] *www.eurogas.org/uploads/media/2015_-_July_-_15PP203_-_Eurogas_contribution_towards_the_EU_strategy_for_Heating_and_Cooling.pdf*
[20] *www.eurogas.org/uploads/media/2015_-_July_-_15PP203_-_Eurogas_contribution_towards_the_EU_strategy_for_Heating_and_Cooling.pdf*
[21] *www.europarl.europa.eu/meetdocs/2014_2019/documents/itre/dv/acer_market_monitoring_r eport_2014_/acer_market_monitoring_report_2014_en.pdf*
[22] *www.eurogas.org/uploads/media/2015_-_July_-_15PP203_-_Eurogas_contribution_towards_the_EU_strategy_for_Heating_and_Cooling.pdf*

Heat 4U project – Gas Absorption Heat Pump pilot – Europe-wide

Gas Absorption Heat Pumps[23] (GAHP) brings together the benefits and efficiencies of the two most common existing heat technologies, that of the condensing boiler and electric heat pumps. This technology has already been identified in the UK Heating Strategy and German Energy Roadmap.

The Heat4U project is a Europe-wide consortium with testing of GAHP being carried out in UK, France, Italy, Germany and the Netherlands.

Each of these Member States has specific characteristics:

- UK has the largest target market for GAHP, given the large share of gas use, family homes, and the ease of retrofit.
- Germany, although it has a smaller gas market, has great potential for similar reasons to the UK. France and the Netherlands see a 50/50 split between new and existing buildings as a target market.
- Deployment in Italy would be predominantly focussed in the North, due to climate reasons.

GAHPs address a number of Europe's key heating needs as they:

- Have a large potential market.
- Are ideal for retrofit in existing buildings.
- Are reliable.
- Are high performing.
- Are economically competitive.
- Are sustainable.
- Are compliant with current and future regulations.
- Align with European strategies on energy and environment.

[23] *Heat4U project - www.heat4u.eu*

G. GREEN GAS: MAKINGTHE BEST USE OF OUR RESOURCES

A key advantage of Green Gas is the potential to maximise the use of our resources by utilising waste products. GEODE has identified a number of areas which are promising. Waste products with potential include:

- **Agriculture:** Pig, poultry, dairy and arable farming.
- **Municipal:** Waste food collected / other appropriate feedstock.
- **Commercial**: Appropriate sources of catering / food preparation feedstock.
- **Industrial:** Food preparation & manufacturing feedstock.
- **Waste Water**: Sewage treatment.

It is GEODE's view that this provides a key opportunity for policymakers to meet their targets as set out in a number of EU Directives, including the Renewable Energy Directive (2009/28/EC), the Fuel Quality Directive (2009/30/EC) and the Landfill Directive (1999/31/EC).

GEODE notes that whilst the use of fuel crops will have a significant impact on the volume of Green Gas that can be produced, it is a contentious issue in some Member States and takes the view that their use is a decision for each country to take.

At the same time, GEODE and its members are keen to support the use of waste for Green Gas production as it is both environmentally responsible and has broad public acceptance.

Furthermore the localised use of waste for Green Gas production could mitigate the increase in international trade in waste and significantly reduce the carbon footprint of those industries.

G11. Circular Economies

Another application for Green Gas is to be a part of a circular economy system for food, energy, fuel, waste and water. This can be done by upgrading raw biogas to produce 98 percent pure biomethane and 98 percent pure carbon dioxide.

Biomethane can be used:

- For energy storage in combined heat and Power.
- To fuel farm vehicles and other vehicles.

Whilst the carbon dioxide can be used:

- By greenhouses for further crop production.
- For cold storage for food preservation.
- For second generation biomethane via P2G.

The raw biogas is produced via AD at farms using waste from greenhouses and farm waste. The digestate slurry from the AD process can be re-used as bio-fertiliser on the farm which will reduce the demand for water used for irrigation.

CASE STUDY 7

Wales and West Utilities - Spring Hill Farm - Pershore, UK

Spring Hill Farm[24] makes the most of agricultural waste. Upgraded biogas is injected into the gas grid, while the carbon dioxide by-product goes straight to the farm's tomato greenhouses.

Since August 2013, Spring Hill Farm has delivered biomethane to the Wales and West Utilities gas grid.

At full capacity, the system produces 225 Nm3/h of biomethane 24/7, which is enough to supply 1,000 households with their annual natural gas consumption.

In addition to this, Spring Hill Farm uses 25 percent of the gas produced to meet its own heating and power needs.

[24] *www.wwutilities.co.uk*

CASE STUDY 8

JV Energen LLP/Scotia Gas Networks - Rainbarrow Farm Anaerobic Digester Plant – Poundbury, UK

JV Energen LLP's Rainbarrow Farm Anaerobic Digester Plant was the UK's first commercial Biomethane to Grid plant on Duchy of Cornwall land in Dorset, UK[25].

The plant uses a range of waste products as feedstock. Current feed ration is 20 tonnes of maize, 50 tonnes of grass, seven tonnes of potato waste and 18 tonnes of food waste/day with about one tonne each per week of chocolate waste and muesli. It produces 850 m^3/hour of biogas, which is used for CHP as well as upgraded for injection into the gas grid.

The plant produces circa 10 MW of electricity every day, of which, around 5 MW is used to power the plant, the rest being exported, which is enough electricity for 500 three-bedroom homes, averaging usage of 3,300 kWh per year. The plant produces enough gas for the annual requirements of 3,200 new build houses. The gas is spread through the distribution network to around 4,000 homes in the winter and 56,000 homes in the summer. Most importantly, the plant not only makes use of waste products but also efficiently makes use of its own waste.

[25] *www.biogaspartner.de/fileadmin/biogas/documents/Kurznachrichten/2012/engl/Poundbury_Scotia_Gas_Networks.pdf*

G12. Using Waste

Today in the EU, 2.7 billion tonnes of waste is thrown away each year.

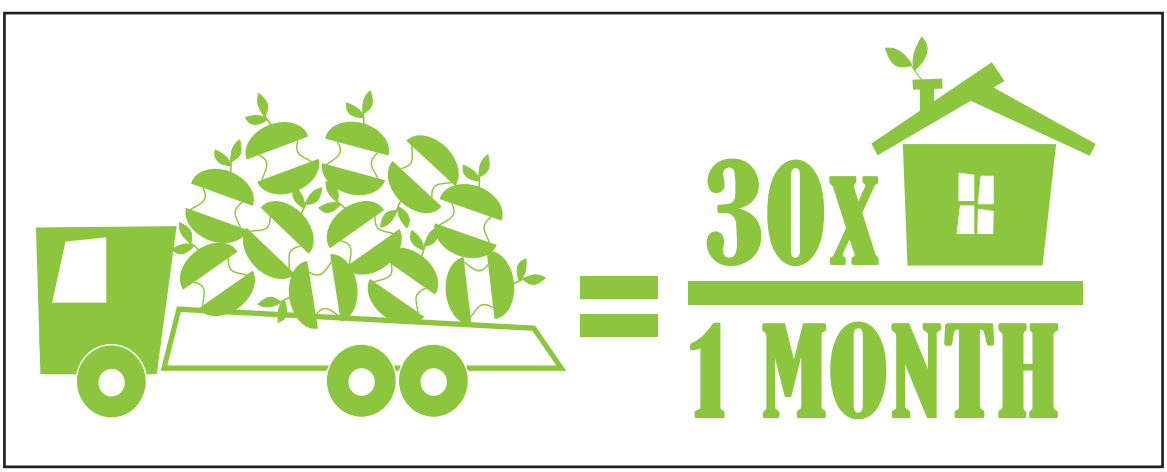
Over the course of the last century, the world increased its fossil fuel use by a factor of 12, whilst extracting more material resources by a factor of 34.

Today in the EU, 2.7 billion tonnes of waste is thrown away each year. Each person consumes 16 tonnes of materials annually, of which 6 tonnes are wasted, with half going to landfill. The environmental impact of this is dismaying and it is essential that steps are taken to minimise the amount of waste material that is not re-utilised.

RECOMMENDATION 5:
The European Commission and European Parliament should require Member States to set out how they plan to recover energy via Green Gas from otherwise non-recyclable waste.

Critically, Member States should ensure that energy is recovered from non-recyclable waste. Given the clear advantages of gas as a method of storing and transporting energy, it is clear that this waste should be used to produce Green Gas (BIO-SNG), which then has a number of applications.

As mentioned elsewhere, gas is not only a fossil fuel but has huge potential as a renewable energy source that can be used to produce energy for electricity, heat or transport, or be injected directly into the grid. Not only will this provide a way of utilising domestic and industrial waste but also provide a practical solution for disposing of sewerage and manure.



The energy content of one lorry full of organic waste (40m³) will heat around 30 homes in Denmark for 1 month.
Source: NGF Nature Energy

CASE STUDY 9

Großfurtner Biogas Plant - Großfurtner, St. Martin, Austria

This biogas plant in the village of St. Martin is directly integrated into the largest abattoir in Austria. The company Großfurtner[26] slaughters 550,000 pigs and 50,000 cattle per year.

It is the first biogas plant in the world that exclusively uses slaughterhouse waste as substrate for biogas production. All in all 10,000 tons of blood, rumen content, colon content and grease separation materials are used to produce 3.6 Mio. kW/h electricity and 3.6 Mio. kW/h heat per year.

The aim of the project, which costs 1.8 million Euro, was the improvement of the economic and ecological performance of this abattoir. Two cost intensive areas in the company are the energy costs (natural gas, electricity) and the disposal costs for the slaughterhouse waste.

By using the slaughterhouse waste as substrate for biogas production Großfurtner can reduce the disposal costs and can cover approximately 33 percent of their electricity demand and 75 percent of their heat demand with renewable energies.

[26] *www.grossfurtner.at*

H. THE ROLE OF POLICY – MAKING GREEN GAS HAPPEN

The purpose of this report is not only to highlight the key role that Green Gas has to play in Europe's future energy mix and decarbonisation, but also to suggest ways that the European Commission and European Parliament, together with Member States may be able to support its development.

The end game for GEODE is to increase the volume of Green Gas entering its members' networks but also to highlight the 'energy renaissance' that gas is currently experiencing.

Critical to this is the introduction of targets, creation of support schemes and encouraging cross border trade.

H13. Targets

GEODE members' long-term strategy is to increase the volume of Geen Gas entering their networks. They see biomethane as a clean and renewable source of energy, which can help the EU to meet its climate change targets. Greening the gas that passes through the DSOs' network is at the core of our members' vision for an enduring and sustainable gas network. We believe this innovative use of the gas network is a vital component of a sustainable energy future.

However, in order for this to happen, there needs to be a clear steer from the European Commission and the European Parliament to support this nascent industry. GEODE would like to see clearly defined support schemes that are transparent, easy to use and also have the regulatory certainty to encourage investment with the security of known pay back periods.

Each Member State should be encouraged to set targets for the industry, demonstrating a commitment to the development of the market, which would encourage innovation and the deployment of newer and more innovative ways to produce, refine and inject Green Gas into the DSOs' networks.

RECOMMENDATION 6:
Member States should set targets for the production of Green Gas, its use for transport, and injection into the grid.

RECOMMENDATION 7:
The European Commission and European Parliament should create clearly defined, easy to use and long-term support schemes that will encourage investment and allow Green Gas to reach its potential.

H14. Support Schemes

For Green Gas projects and innovation to develop and thrive, investors and developers require certainty, and so therefore it is essential that Member States and the EU create stable support schemes and implement long-term policies, that recognise the importance of Green Gas in the energy mix and also that in the current market it cannot yet financially compete with natural gas.

Broadly speaking these schemes support either production or consumption, examples include:

Supporting production through:

- Direct investment through grants or low interest loans.
- Subsidising the cost of grid connections.

Encouraging consumption through:

- Feed-in tariffs for Green Gas.
- Obligatory quotas for the consumption of Green Gas.
- Subsidies for gas vehicles.
- Taxation (relief, exemption or refund) relating to energy, vehicle fuel etc. duties.
- Revenues from carbon dioxide emissions trade.

GEODE believes that Member States should create an environment where the risks and revenues are shared by all, and that the combination of support schemes in place is complementary rather than competitive. One example is in the UK where there is a fund, the AD Loan Fund, which supports the construction of new AD plants via low cost loans of between 65,500 Euro and 1,25 million Euro for up to 5 years, alongside the Renewable Heat Incentive (RHI), which is paid as a premium on the top of the price of natural gas injected into the grid and is guaranteed for 20 years. The RHI works in the same way for electricity produced from biogas or biomethane.

Most importantly GEODE stresses that it is essential that any support scheme recognises and rewards Green Gases key characteristics, namely flexibility and storage capability. This will allow it to complement renewable electricity sources such as solar and wind, within a suite of support schemes for renewable energy.

RECOMMENDATION 8:
Any support scheme for renewables introduced by the European Commission or Member States should recognise and reward Green Gases' flexibility and storage capacity, to allow it to complement renewable electricity (e.g. as a means to use and store excess electricity).

H15. Cross Border Trade

To maximise Green Gas' potential to contribute to security of supply and carbon reduction targets, GEODE believes that it is essential that it can be traded across national borders.

Central to this is that the "green" aspects (renewable, environmentally friendly and carbon reducing) of the gas should be recognised by the importing country, and that the gas should be counted towards the national quotas or targets of that country. The green certification of that gas should be provided by the country of origin to the importing country.

A successful pan-European biomethane market is predicated on a transparent and reliable system of comprehensive information transfer between Member States.

GEODE believes that the establishment of national biomethane registries in every European country and cooperation between them will be the first important step towards creating the conditions for a free cross-border biomethane market within the European gas grid. This requires a standardised set of data to be exchanged with involvement of the national registries whenever biomethane is transferred across borders. To guarantee this, it is essential that this data is recognised by the corresponding registry in the receiving country.

The document, entitled "European Biomethane Guarantee of Origin" will contain all information needed for the imported biomethane to qualify as "green" in the receiving country, thus enabling cross-border trade and also transactions running through the territories of several countries.

To date six European biomethane registries have agreed to cooperate, to make progress in this direction. These six registries are:

Austria:
Biomethane Register Austria
www.agcs.at

Denmark:
Energinet
www.energinet.dk

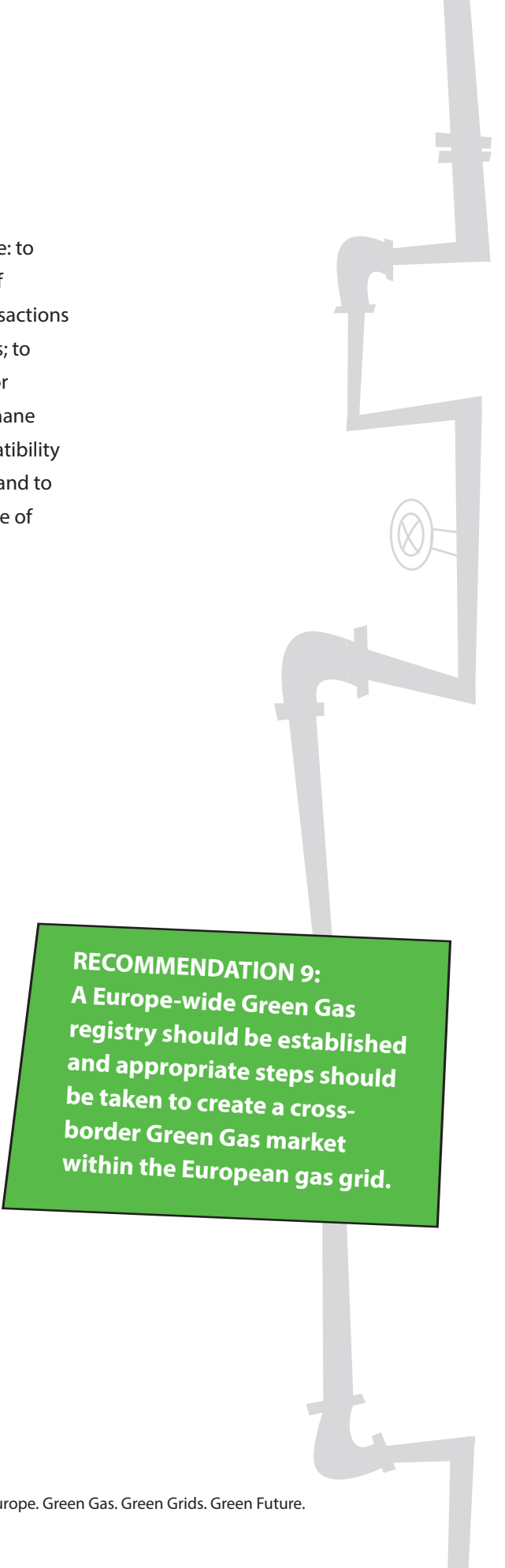
France:
Gaz Réseau Distribution France
www.grdf.fr

Germany:
Biogasregister
www.biogasregister.de

Switzerland:
VSG (Federation of Swiss Gas Industry)
www.erdgas.ch/biogas/clearingstelle

United Kingdom:
Green Gas Certification Scheme
www.greengas.org.uk

The key aims of this collaboration will be: to create the best conditions for transfer of information related to biomethane transactions between national biomethane registries; to establish a harmonised methodology for information transfer relating to biomethane between each registry; to ensure compatibility between national registration systems; and to set the conditions for mutual acceptance of guarantees of origin for biomethane.



RECOMMENDATION 9:
A Europe-wide Green Gas registry should be established and appropriate steps should be taken to create a cross-border Green Gas market within the European gas grid.

I. RECOMMENDATIONS

RECOMMENDATION 1:
The European Commission should set an EU-wide target for sustainable gases, in TWh, or percentage of total energy consumption.

RECOMMENDATION 2:
European policymakers and Member States should take a holistic approach to the promotion of Green Gas, recognising the corollary benefits (i.e. local jobs, rural regeneration etc.) beyond the creation of an environmentally sustainable energy source.

RECOMMENDATION 3:
The European Commission should recommend Member States include the development of Green Gas as part of their security of supply strategy, recognising the role an indigenous source can play in both mitigating supply shocks and creating domestic energy production.

RECOMMENDATION 4:
Member States and National Regulatory Authorities should incentivise the development of innovative gas vehicle technologies by recognising them separately in their tax regimes to allow the market to develop, acknowledging the lower carbon footprint of gas (and especially Green Gas) and its potential to help to reach decarbonisation targets, by speeding up the introduction of biogas for transport.

RECOMMENDATION 5:
The European Commission and European Parliament should require Member States to set out how they plan to recover energy via Green Gas from otherwise non-recyclable waste.

RECOMMENDATION 6:
Member States should set targets for the production of Green Gas, its use for transport, and injection into the grid.

RECOMMENDATION 7:
The European Commission and European Parliament should create clearly defined, easy to use and long-term support schemes that will encourage investment and allow Green Gas to reach its potential.

RECOMMENDATION 8:
Any support scheme for renewables introduced by the European Commission or Member States should recognise and reward Green Gases' flexibility and storage capacity, to allow it to complement renewable electricity (e.g. as a means to use and store excess electricity).

RECOMMENDATION 9:
A Europe-wide Green Gas registry should be established and appropriate steps should be taken to create a cross-border Green Gas market within the European gas grid.

APPENDIX I

For most policymakers gas is seen as a fossil fuel and therefore less environmentally desirable than solar or wind generated electricity for example. GEODE refutes this assertion and believes that gas is undergoing the 'energy renaissance' that electricity underwent in the 1990s and is developing its green credentials as a renewable energy source. Central to this, is the fact that natural gas and Green Gas (biomethane and synthetic gas) are the same molecule: methane (CH4). The difference between them is where they come from. Whilst natural gas is extracted from the ground, both biomethane and synthetic gas are created through renewable, and sustainable processes.

a. Anaerobic Digestion

Anaerobic digestion (AD) is the straightforward, natural breakdown of organic matter into carbon dioxide, methane and water, by micro-organisms (bacteria and archaea). Since many of these micro-organisms are intolerant to oxygen, this process is known as anaerobic. Given these processes happen in nature, AD takes control of these and effects a significant reduction in carbon emissions.

There are four key stages to the AD process that break the matter into smaller and smaller components, until the only remaining substances are methane, carbon dioxide and water, three very simple molecules.
The stages are:

- **Hydrolysis** – which breaks down the complex organic matter – carbohydrates, fats and proteins – into simple sugars, fatty acids and amino acids
- **Acidogenesis** – those single sugar molecules, fatty acids and amino acids are further broken down into alcohols and volatile fatty acids (like ethanol and propionic acid), with by-products of carbon dioxide, ammonia and hydrogen sulphide.
- **Acetogenesis** – where those volatile fatty acids and alcohols are converted again, this time into hydrogen, carbon dioxide, and acetic acids.
- **Methaogenesis** – methanogenic archaea convert the remaining hydrogen and acetic acid into methane, and more carbon dioxide.

At the end of the process there is a mixture of methane and carbon dioxide gases (biogas), water and some organic material (digestate). Biogas can be burned to produce both heat and electricity, or upgraded to biomethane which can be used as vehicle fuel or injected into the gas grid.

Gas is undergoing the 'energy renaissance' that electricity underwent in the 1990s and is developing its green credentials as a renewable energy source.

Gas produced by gasification can be used for heat and electricity generation, in industrial processes that require high temperatures, in transport, in chemical processes and when upgraded to methane injected into gas grids.

Digestate is a stable, nutrient-rich substance and can be used for a range of products and purposes: most usefully as a fertiliser, rich in nutrients, but also as feedstock for ethanol production, and in low-grade building materials, like fibreboard. Water, after treatment within the AD process, may be returned to the watercourses.

b. Gasification

Gasification is a process where Green Gas is produced from the carbon in solid organic materials, which is environmentally friendly and can be used for a range of applications. The process uses high temperatures to convert biomass (e.g. wood, carbon-rich waste) into gas that can be used in the same way as natural gas.

Examples of the feedstock used for gasification include wood chips, pellets or wood powder, or agricultural waste such as straw or husks. The produced gas is often known as synthesis gas (syngas). The gasification of the feedstock takes place at 700° – 1600°C in the presence of a gasification medium. The gasification media used are air, oxygen, steam or a mixture of these. Gasifiers range in size from just a few kW up to several hundred MW.

Like the gas created by AD, the gas produced by gasification can be used for heat and electricity generation, in industrial processes that require high temperatures (e.g. cement kiln, brick making and ceramic firing), in transport, in chemical processes and when upgraded to methane injected into gas grids.

From the initial feedstock approximately 70-80 percent of the energy is transferred to the chemical energy of synthetic gas (remaining 20-30 percent is accounted for by heat and other losses). Small-scale biomass gasification is found worldwide, especially in India to supply electricity in rural areas. Improved gasifier designs, producing cleaner gas, have recently become available in Europe. A few large-scale biomass gasification plants have come online during the same period.

c. Power to Gas

Power to gas (P2G) is the conversion of electricity from renewable sources into hydrogen and carbon dioxide and then into synthetic methane, which can subsequently be fed into the gas infrastructure, stored and/or transported elsewhere.

P2G is a relatively new technology that makes use of energy, which would otherwise go to waste. For example, when a wind turbine continues to produce electricity, but the electricity grid does not have the capacity to accept it.

Like biomethane, methane produced from P2G processes can make a useful contribution to reducing carbon dioxide emissions when the gas produced from renewable sources replaces the use of fossil fuels for transport; in industry; heating and cooking; and electricity generation.

P2G can also play a role in storing electric power and balancing out fluctuations in the volumes of electricity generated by wind or solar power.

It can also make such power available over longer periods of time when large volumes of renewable energy cannot be fed directly into the electricity grid. In this way, P2G can potentially help achieve higher levels of green electricity and support the construction of more wind and solar power.

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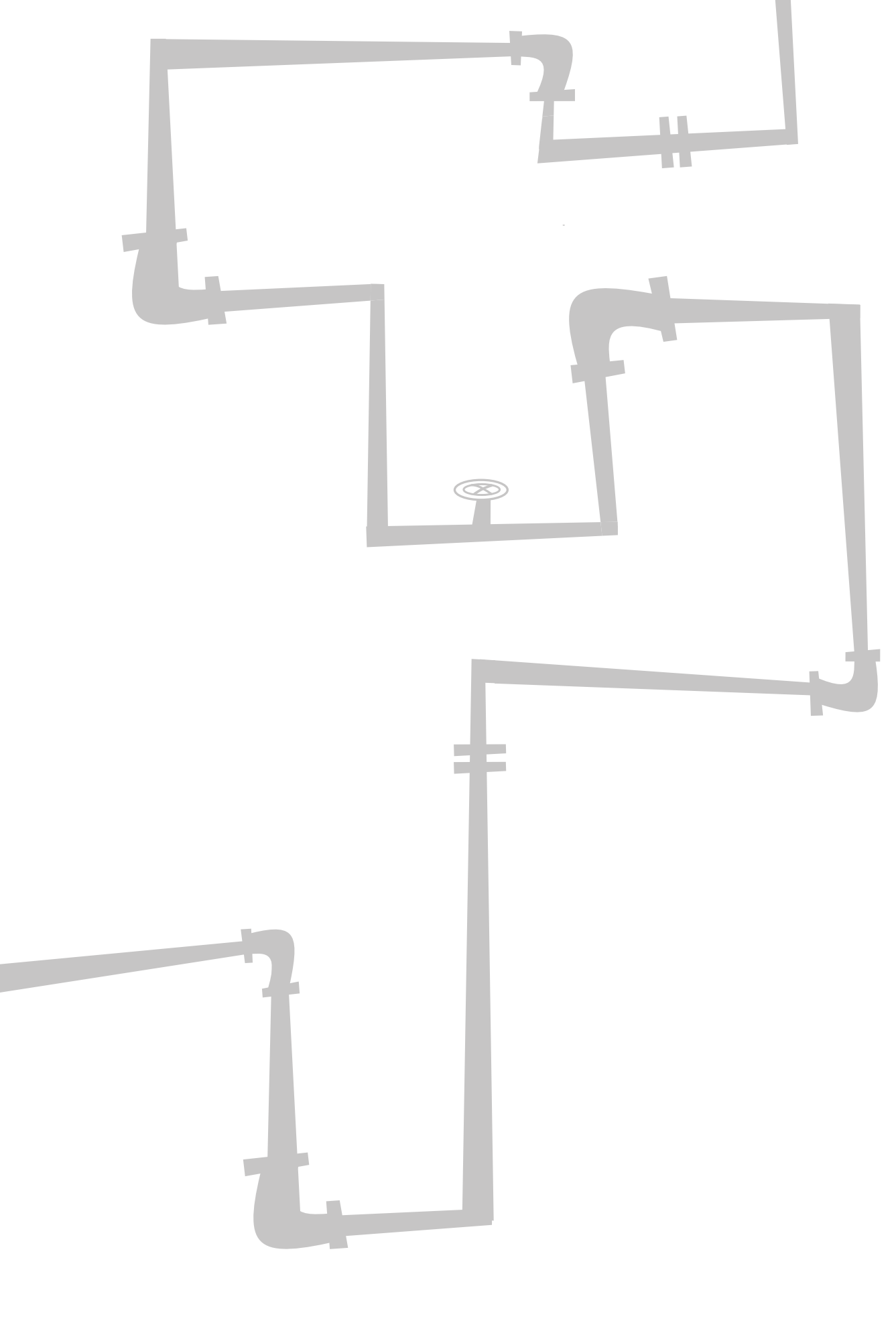

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