UK Biomethane

Market Report by the REA
April 2016

REA
RENEWABLE ENERGY ASSOCIATION

Biogas

GreenGas
CERTIFICATION SCHEME

REA Biomethane Market Report

Contents

www.r-e-a.net
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This report has been prepared by Renewable Energy Association (REA), with the support of CNG Services and Green Gas Certification Scheme, using REA's own market intelligence. Data correct as at 31st March 2016.

1 The size of the market

The Biomethane to Grid sector had a significant expansion in Europe over the past few years, reaching 282 plants across Europe with a total annual production of 1.3 billion m^3 of renewable gas in 2013, according to the latest report published by European Biogas Association[1]. There are currently over 100 biomethane projects operating in Germany, and very active markets in the Netherland and France.

In the UK, the Renewable Heat Incentive (RHI), introduced in 2011, is the primary policy which supports biomethane projects in the UK. The innovative nature of this technology allowed an attractive RHI tariff, which has helped kick-start the market for biomethane to grid.

Before the introduction of the RHI there were no full scale biomethane plants in operation in the UK. However, as shown in chart 1 below, the latest data indicates that 50 projects were completed by end of 2015, injecting approximately 2.5 TWh/year of biomethane into the gas grid, enough to meet the heating and cooking needs of around 100,000 homes. In 2015 the UK was the fastest growing biomethane market in the world.

Another 15 plants are expected to be completed in 2016, which will bring annual biomethane – or green gas - production in the UK to 3.5 TWh/year – representing around 240,000 tonnes of LNG that the country won't need to import from the Middle East or four 60,000-tonne LNG tankers not needing to dock at domestic ports.

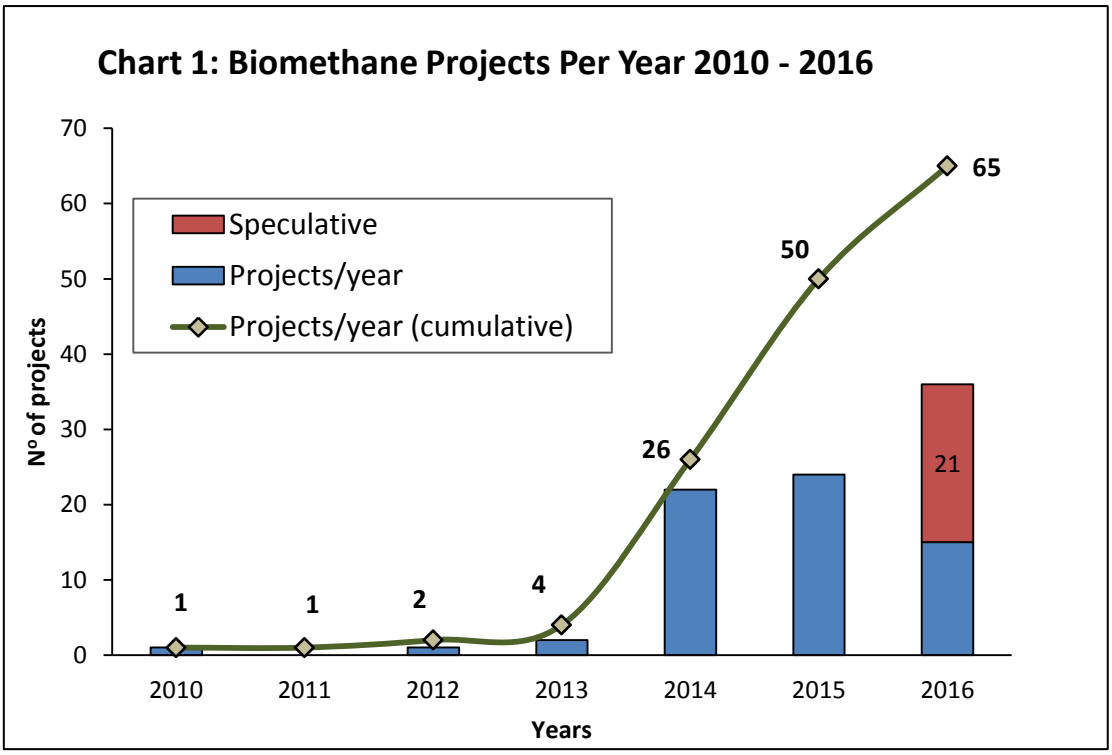
As shown in chart 2 below, most of the projects that have been and are being developed (61%) are agricultural plants that treat crop feedstocks, crop residues and livestock slurries/manures. 28% treat food wastes from municipal and commercial sources and only 9% treat sewage sludges.

On 3rd March 2016 DECC released a major consultation on the RHI reform[2]. In the consultation the Government acknowledges that biogas and biomethane[3] have an important role both now and in the longer term, in decarbonising heat and the gas grid, reducing greenhouse gas emissions from waste and agriculture, and supporting jobs in rural areas. The consultation sets out the Government's ambition is to see an annual deployment of 20 biomethane plants by 2021.

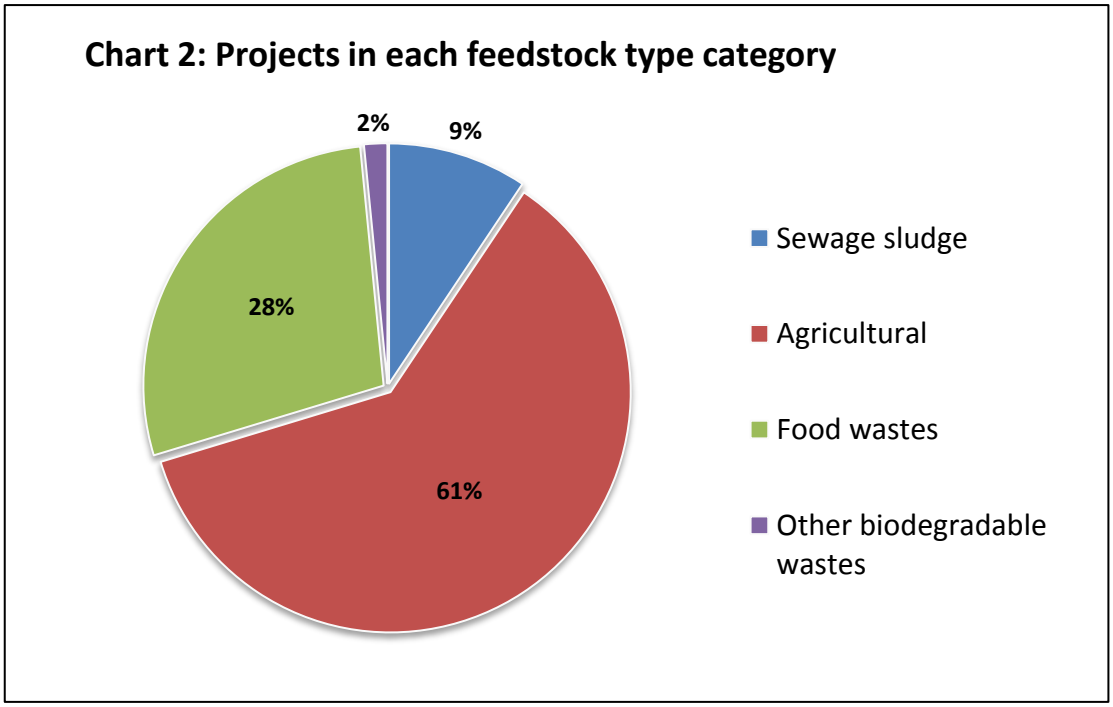
[1] EBA Biomethane and Biogas report 2015. Annual statistical report of the European Biogas Association on the European anaerobic digestion industry and markets (visit http://european-biogas.eu).

[2] DECC consultation on 'The Renewable Heat Incentive: a reformed and refocused scheme', 3rd March 2016.

[3] Biogas can be upgraded to grid quality gas (biomethane), and injected into the national gas network, where it can be stored until needed then used for heating, power or as a green transport fuel.

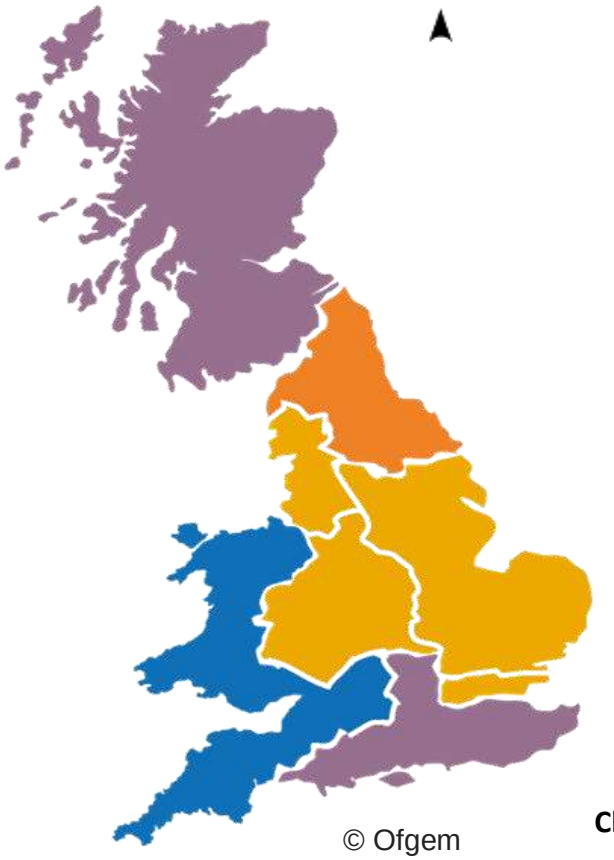


Note: 21 additional potential schemes could be developed in 2016, as identified by REA's market intelligence



2 Gas Distribution Networks (GDNs)

The figure below displays the UK's regional gas distribution networks (GDNs) and the number of biomethane projects that supply green gas into each GDN. These networks are owned and managed by the following companies:



© Ofgem

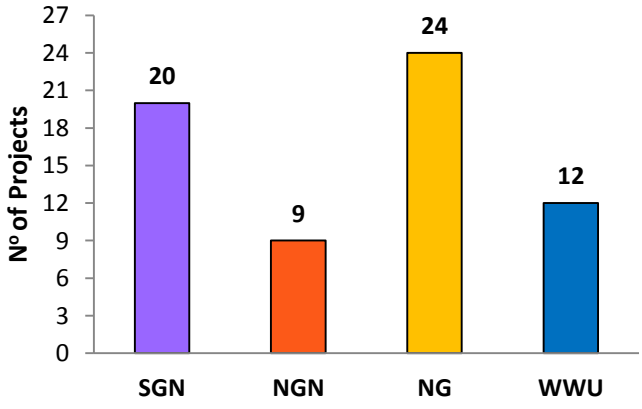
SGN **31%** of biomethane projects supply green gas to the Scotia Grid Network. The network runs through Scotland as well the South of England.

NGN **14%** of biomethane projects supply green gas to the Northern Gas Networks. The network runs through Northern England.

NG **37%** of biomethane projects supply green gas to National Grid. The network runs through North West and Central England.

WWU **18%** of biomethane projects supply green gas to Wales and West Utilities. The network runs through Wales and South West of England.

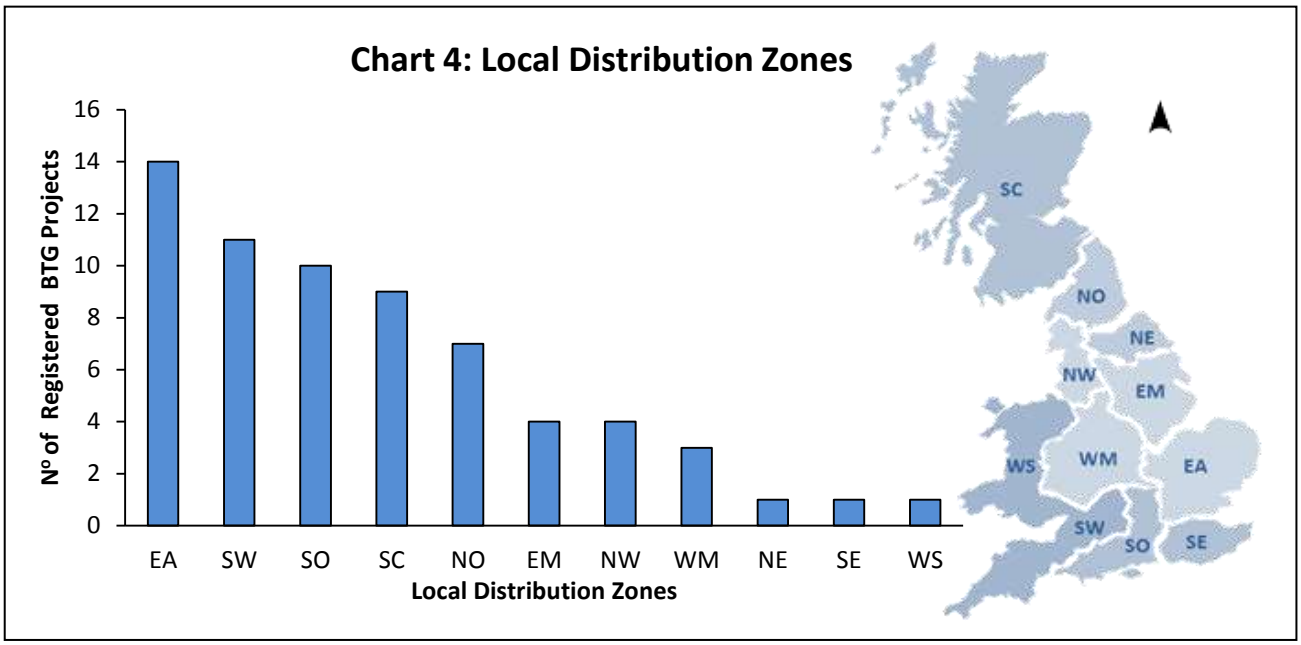
Chart 3: Biomethane Projects Delivering Green Gas to Gas Distribution Networks



The majority of biomethane projects deliver gas to the SGN and NG in England (68%). All biomethane production from Wales is delivered to WWU, accounting for approximately one fifth of all UK projects.

3 Local distribution

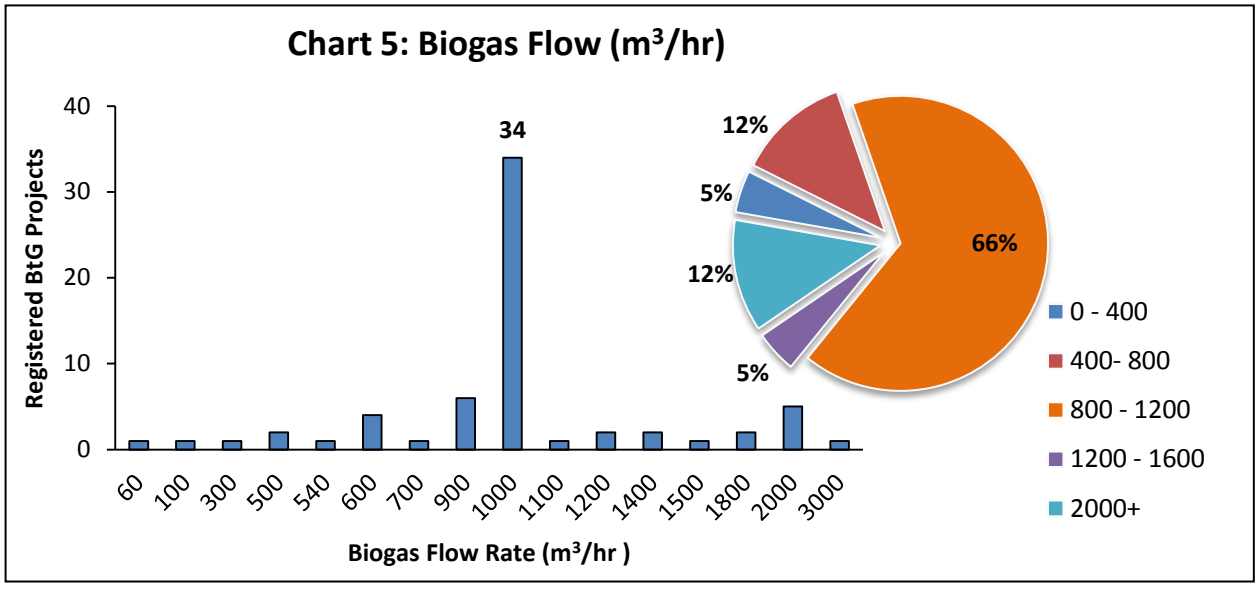
Local distribution zones (LDZs) within the GDNs deliver gas to approximately 10 million consumers. The number of projects injecting biomethane into each distribution zone is detailed in the Chart 4:



South Wales, North East and South East England have single projects supplying gas into their respective LDZ. All other regions have 3 or more biomethane projects operating, with East Anglia having the most at 14 projects, 13 of which use agricultural feedstock.

4 Biogas flow rates

Biogas flow rates range from 60 – 3,000 m³/hr, with most projects within the range 800 to 1,200 m³/hr. The most frequent flow rate of projects is 1,000 m³/hr, corresponding to a biomethane flow rate of 550 m³/hr. Approximately 47% of the biogas within the 1,000 m³/hr category flows at medium pressure.

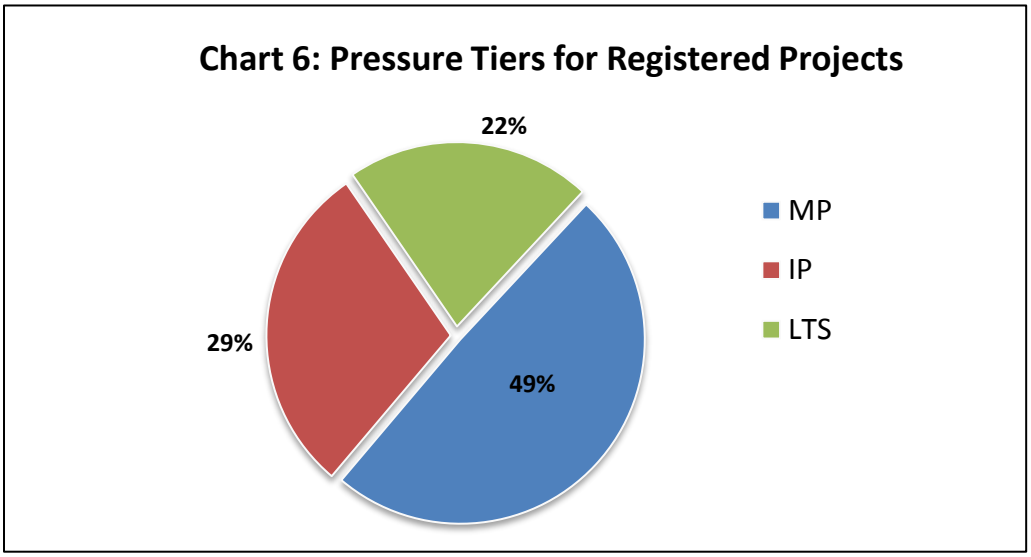


5 Pressurisation

Regarding gas pressure, three main networks are used for biomethane injection:

- Intermediate pressure (IP)- 2 to 7 bar
- Medium pressure (MP) – 75 mbar to 2 bar
- Local Transmission System (LTS) – 10 bar to 42 bar

Chart 6 highlights how approximately half of biomethane plants inject gas into the medium pressure system, with 22% injecting green gas into the LTS. The intermediate pressure network accounts for 29% of network delivery.



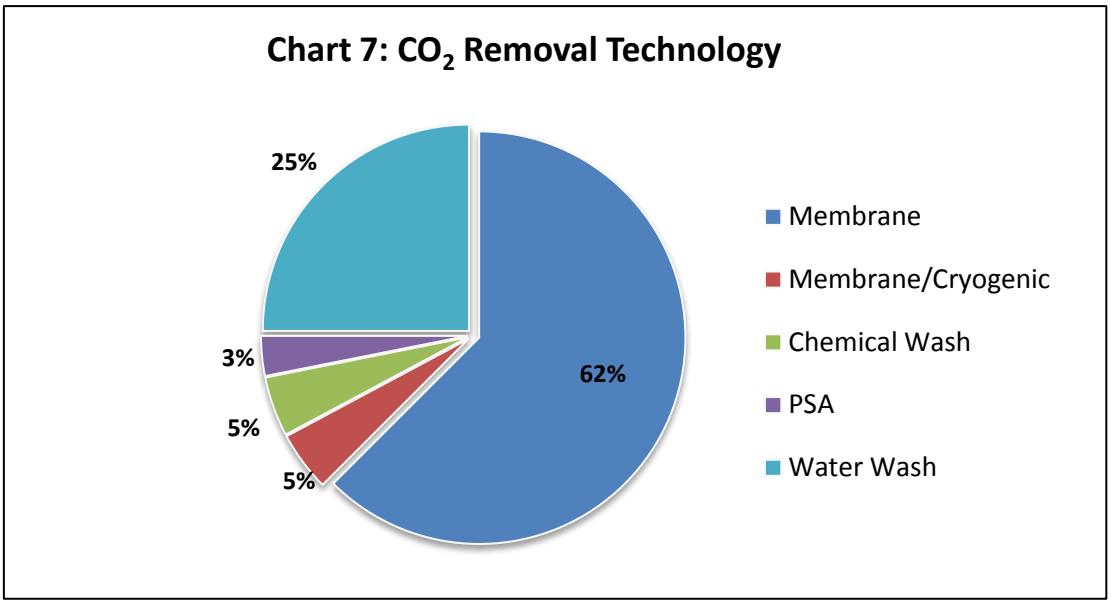
6 Carbon dioxide removal

CO_2 removal is required to upgrade biogas to grid quality biomethane. A range of technologies for CO_2 removal is currently available, which follow four principles:

- Absorption techniques, including Water Wash and Chemical Wash
- Adsorption, which utilises Pressure Swing Adoptions (PSA) processes
- Permeation, involving the use of membranes to separate CO_2 from the gas
- Cryogenic upgrading, which condenses biogas, allowing liquid extraction of CO_2

Permeation is the most commonly used principle in upgrading technologies, incorporating high or low pressure membrane separation systems.

Chart 7 shows the technologies utilised in the biomethane sector and their relative proportions.



Membranes are the most widely used technology across biomethane plants accounting for 62% of CO_2 removal processes. Water wash represents close to a quarter of the industry with the other technologies accounting for the remaining 18%.

7 Biomethane market potential

The biomethane sector has only just started to develop and has significant scope to increase the production of the UK's green gas resource. There is continuing interest in the field, with a number of projects under consideration. Industry estimates that another 100 BtG projects as a minimum could be developed by end of 2020. However, for the sector to continue to develop and grow, the industry needs a stable support framework from Government.

National Grid's 2015 Future Energy Scenarios[4] report highlights the potential for a 10-fold increase in the number of green gas connections to the grid over the next decade, indicating a possible 416 connections by 2025 and 700 connections by 2035. This equates to approximately 30 TWh of green gas (which, in addition to biomethane, includes Bio-substitute natural gas (Bio-SNG), and Power to Gas (P2G)) injected to the grid by 2035, around 5% of the total UK gas demand and around 10% of the UK domestic gas demand. More recent industry estimates suggest that the full potential may be over twice this level. Additionally, as UK gas demand continues to decrease, this proportion could become much higher.

8 Delivering carbon savings

The REA has supported the introduction of sustainability criteria to be applied to biomethane as it is vital to be able to demonstrate that public funds are being spent to

[4] Future Energy Scenarios 2015, National Grid, July 2015.

deliver real environmental benefits. The UK is leading the way in Europe with the introduction of sustainability criteria for biomethane with the introduction of mandatory sustainability criteria under the RHI[5] from 5 October 2015, which states that only biomethane that delivers 60% GHG savings compared with the EU fossil fuel average can receive RHI support. Emission savings are likely to be even more significant as the fuel that biomethane will increasingly displace is higher carbon intensive imported fossil Liquefied Natural Gas (LNG). Boosting the development of biomethane to grid schemes can not only diversify the UK's security of energy supply, but also support the Government's 2020 target to meet 15 per cent of final energy demand from renewables, and the achievement of the UK's carbon budget targets[6].

9 Green Gas Certificates

Founded in 2011, the Green Gas Certification Scheme (GGCS) is a not-for-profit, industry led initiative that tracks biomethane through the supply chain to provide certainty for those that buy it. The GGCS tracks each unit of green gas from its injection into the distribution grid, to any trades, to its sale to a consumer, or group of consumers. It tracks the contractual rather than physical flows to ensure there is no double-counting from production to end use.

Each kWh of green gas is labelled electronically with a unique identifier known as a Renewable Gas Guarantee of Origin (RGGO). This identifier contains information about where, when and how this gas was produced. When consumers buy green gas the RGGO is their guarantee that the gas is authentic and has not been sold to any-one else.

Anyone involved in the biomethane supply chain can take part in the Green Gas Certification Scheme. The key participants are green gas producers who register the gas they have injected in to the grid, and suppliers and other traders who register the gas sale contracts they have agreed.

In contrast to EU markets where Green Gas Certificates have been used for some time, the UK market is only just now developing. The GGCS has seen rapid growth in its membership over the past year[7] with over 20 biomethane schemes now registered with the scheme and increasing interest in green gas products from both the energy market and end consumers. In addition, areas of interest where Green Gas Certificates use is now being explored include:

- Since 2014 Green Gas Certificates can be utilised by bus operators to access funding under the Department for Transport's Low Carbon Emission Bus (LCEB) Bus Service Operators Grant (BSOG)[8].
- All UK quoted companies are required to report on their GHG emissions as part of their annual Directors' Report[9]. In February 2014, Defra consulted on proposals to amend their guidance for this GHG reporting allowing companies to report purchases of biomethane provided they hold certificates showing that this gas has been injected into the grid. Defra has not, however, published its final decision to this consultation[10].

[5] Non Domestic RHI Sustainability Self-Reporting Guidance, Ofgem, 5 October 2015.

[6] https://www.ofgem.gov.uk/sites/default/files/docs/2011/07/biomethanearenewablegassourcefs.pdf

[7] See www.greengas.org.uk for further information.

[8] See Certification of dedicated gas buses as low carbon emission buses, DfT, December 2013.

[9] As part of the Companies Act 2006 (Strategic Report and Directors' Report) Regulations 2013.

[10] See https://consult.defra.gov.uk/climate-change/ac04ad33

- The Greenhouse Gas Protocol[11] is the most widely used international accounting tool to quantify and manage GHG emissions. The GGCS has recently commissioned Ecofys to explore opportunities for Green Gas Certificates in the GHG Protocol in response to recent changes to the guidance, which now specifically reference the use of biomethane to grid[12].
- New build developments are also examining the potential of using Green Gas Certificates as part of their carbon and energy strategies, especially where Combined Heat and Power (CHP) and/or district energy systems are being proposed.

The Green Gas Certification Scheme is continuing to work with industry and Government to highlight the huge potential that exists for biomethane to grid across a wide range of economic sectors.

10 Biomethane in transport

Biomethane could play an important role in the transport sector, where it can deliver significant carbon savings and reductions in NOx and particulate emissions to help decarbonise transport fuel as well as help improve air. The REA has been asked to lead on supporting the development of Advanced Fuels/Renewable Gases policy with the Department for Transport (DfT) and are working closely with all stakeholders to ensure that the role biomethane can play in the transport sector - in particular in displacing the use of diesel in HGVs and buses - is fully recognised with the right policy framework is put in place to support the greater deployment of biomethane to transport. The REA has published a report on the *Use of Gaseous Fuels in Transport*[13] which argues that the supply of renewable gases in the sector has been underestimated and that the UK needs a clear and long-term strategy for the use of renewable biomethane in transport, as well as support for the development of appropriate vehicle technology.

11 Conclusions

The Biomethane to Grid sector has grown significantly over the past few years, with a huge as yet untapped potential in the UK, as has been demonstrated by its rapid growth. A dynamic new UK industry has been established around the innovative production of renewable gas, which is actively supported by major businesses in the gas distribution sector.

Further opportunities are now being explored around the production of Bio-SNG and Power to Gas (P2G) – and there exists significant potential for the use of green gas in the transport sector to help decarbonise emissions, and help tackle air quality pollution. The production of green gas has the potential to provide significant benefits to the UK economy, this is dependent on a stable Government support mechanism, particularly over the period to 2020, at the right level, to ensure the market continues to grow with confidence.

[11] http://www.ghgprotocol.org/

[12] See WRI Press Release http://ghgprotocol.org/node/458, 20th January 2015.

[13] Currently available to REA Members at www.r-e-a.net. The report is to be published on UK Biomethane Day (20 April 2016).

About the REA

The REA was established in 2001, as a not-for-profit trade body, representing British renewable energy producers and promoting the use of renewable energy in the UK.

The REA endeavours to achieve the right regulatory framework for renewables to deliver an increasing contribution to the UK's power, heat, transport and renewable gas needs. It is influential in helping shape UK energy policy and has a track record in delivering high quality events on a wide range of energy related topics. REA aims to help its members build commercially and environmentally sustainable businesses.

REA Expertise

REA Biogas is the established voice for the UK AD and biogas industry.

The Renewable Energy Association has been representing the anaerobic digestion (AD) sector since its launch in 2001. REA Biogas was formed in 2004. The objective of REA Biogas is to promote the widespread uptake of Anaerobic Digestion and other technologies for the generation of biogas for renewable energy and transport fuels and for the sustainable redeployment of organic residues. Having worked hard to promote AD for many years, the sector is finally being recognised as a major contributor to renewable energy in the UK.

Over the past nine years REA Biogas has worked to convince successive Governments of the benefits of biomethane injection, resulting in the introduction of the Renewable Heat Incentive in 2011. The Green Gas Certification Scheme (GGCS) is run by REAL, a subsidiary of the REA.

www.biogas.org.uk

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REA - Growing the renewable energy economy

Case Study

Wyke Farms

Site location:	Wyke Champflower, Bruton, Somerset, BA10 0PU
Project developer:	Tom Clothier and Jason Fewell (Wyke Farms)
Biomethane injection:	46,197,380 (kWh/annum)
CHP:	2 x 499 kWe

Build dates: November 2012
First gas to grid: 28th November 2014

Overview

Biomethane generation at Wyke Farms forms an integral part of the company's sustainability plan. Wyke Farms is the first national cheddar brand to solely operate on renewable energy. The accomplishment has led to a series of sustainability awards, and Wyke Farms have recently been selected as the National Champion in the European Business Awards, in the Environmental and Corporate Sustainability category. The company will represent the UK in the 2015/16 European Business Awards.

In addition to cow and pig slurries from the company's own farms along with whey permeate from the cheese dairy production process, a range of solid biodegradable waste such as bakery wastes from local supermarkets, apple pomace from local cider mills, cereal wastes from grain processing mills and agricultural wastes are diverted from landfill and used to generate biogas in three 4,600 cubic metre anaerobic digester vessels. The biogas produced is combusted in a 499 kWe CHP engine on site and another 499 kWe CHP engine a mile away, at the cheese factory site, providing heat and power for production processes and AD plant operations. The energy is used directly on site or within close proximity. Biogas is also upgraded for injection into the Wales and West Utilities gas grid network. 46,197,380 kWh of biomethane is delivered into the LTS annually at an hourly flow rate of 550 m^3 (maximum capacity gas into the grid is 800m^3 per hour).

Wyke Farms has recently signed a major new deal with Sainsbury's to supply the company with green gas generated at its dairy farm in Somerset.

Digestate is produced and used as an organic fertiliser for local farm use, recycling nutrients and organic matter back to the soil.

The table below shows details of biomass inputs and energy outputs.

Feedstock type	Annual throughput	Annual biomethane injection (kWh)	Combined Heat Power (kWe)
Cow and Pig slurry	51,907 m^3/a		
Whey Permeate	16,683 m^3/a		
DWC Permeate	5,324 t/a		
Waste Maize/silage	2,009 t/a	46,197,380	2 x 499 kWe
Rapestraw	757 t/a		
Apple Pomace	708 t/a		
Cereal and Bakery Waste	411 m^3/a		

Biogas Upgrading

Carborex MS membrane technology was supplied by DMT and is used for removing CO_2 from biogas. The dry multi-stage process system contains a preliminary pre-treatment section for the removal of H_2S and water. Biomethane at 98% availability is retained and less than 0.8% concentration of methane is lost.

Propane stored above ground is added through a vaporiser injection system and is compressed up to 16 bar on site. Biomethane flows through polyethylene pipes and is analysed at the entry unit supplied by Elster. Biomethane from Wyke Farms is delivered into the LTS, with Wales and West utilities providing the network into the LDZ. Barrow Green Gas transports and supplies Wyke's biomethane through the gas grid. The agreements for gas supply are long term.

Certification and Support Schemes

Biomethane production is certified and tracked through the Renewable Energy Assurance Limited's Green Gas Certification Scheme (GGCS).

With energy generated from CHP and Photovoltaics cells, Wyke Farms qualifies for receiving RHI and FiTs.

Carbon Reductions and Savings

The use of Wyke Farms biomethane as a renewable energy source will reduce carbon emissions by approximately 24,000 tonnes per year.

Case Study

Minworth Water Treatment Plant

Site location:	Kingsbury Lane, Minworth, Sutton Coldfield, B76 9BL
Project developer:	Severn Trent Water
Biomethane injection:	63,000,000 (kWh/annum)
CHP:	8,500 kWe

Build dates: October 2013 - September 2014
First gas to grid: 25th September 2014

Overview

Minworth is the first UK plant to inject sewage sludge derived gas at a commercial scale. The injection plant was commissioned on 25th September 2014 and is the largest works of Severn Trent Water. With an annual biomethane production of 63,000,000 kWh at 98% availability, Minworth is the first connection of unconventional gas into the LTS. This accomplishment was achieved with the cooperation of the National Grid, also stating Minworth as the first biomethane project to not require propane injection.

Over 1.7 million people within in the greater Birmingham area contribute to the sewage sludge treated on site, at Sutton Coldfield. A total daily biogas production of 80,000 m^3 is produced through mesophilic anaerobic digestion within 16 sludge digesters. CHP engines utilise some of this biogas to provide power and heat for the site throughout the year. The table below shows details of biomass inputs and energy outputs.

Feedstock Type	Total input (tonnes per annum)	Annual biomethane injection (kWh)	Combined Heat Power (kWe)
Sewage Sludge	1,825,000	63,000,000	8,500

Biogas Upgrading

After preconditioning, the methane content within the biogas is increased from 63% to 98% with the use of Malmberg biogas water scrubbers. CO_2 readily dissolves in water and is removed as the product gas passes through 6 bar pressurised columns. Hydrogen sulphide is also removed during the CO_2 removal process due to its low absorption pressure.

Energy blending eliminates the requirement for propane addition. However, the autonomous detection of blended gas outside legal tolerances results in liquid propane injection from a 12 tonne reserve stored above ground.

Pressurisation of biomethane occurs on site with the use of a single phase Wartsila oil free compressor. A compression of up to 20 bar is achieved prior to delivery into the lower transmission system.

Biomethane flows at a rate of 750 m^3/hr in a network of stainless/carbon steel pipes. The composition is tested at the entry unit supplied by Elster. The National Grid is contracted to deliver biomethane into West Midlands Local Distribution Zone.

Certification and Schemes

With a supply agreement of two years, the pathway of biomethane production to its consumer use is tracked by the Renewable Energy Assurance Limited's Green Gas Certification Scheme (GGCS). Approximately 90,000,000 kWh from Minworth has been registered under the GGCS, with each unit displacing an equivalent unit of natural gas from fossil fuels.

Registering with Ofgem qualifies Severn Trent Water to receive Renewable Heat Incentive (RHI) payments. The CHP engines are accredited under the Renewable Obligation scheme for the renewable electricity produced.

Carbon Reductions and Savings

The high energy demands of sewage and water treatment processes account for over 90% of carbon emissions from Severn Trent Water works. Severn Trent Water, through the use of GGC, delivers its entire gas consumption as a business from Minworth and exports the surplus to the National Grid.

Previous operations of biogas for on-site CHP generation had total production efficiencies of approximately 40% due to the lack of heat recovery. By exporting biomethane into the National Grid, total system efficiency is greater as consumer utilisation is up to 98% of the energy is available..

Case Study

Egmere Energy Limited - Holkham

Site location: Bunkers Hill, Wells Road, Egmere, Walsingham, NR22 6AZ

Project developer: Future Biogas Limited

Biomethane injection: 40,000,000(kWh/annum)

CHP: 499 kWe

Build dates: August 2013 – August 2014
First gas to grid: 13th November 2014

Overview

The Egmere project, developed and operated by Future Biogas, was commissioned on 13th November 2014 in Norfolk. The AD facility is the first to connect to the gas network in the county and with the cooperation of the National grid. Egmere features the first self-lay pipeline over 7 bar and the first high pressure connection. Over 2,500 houses and local businesses utilise the 40,000,000 kWh production of biomethane injected into LTS.

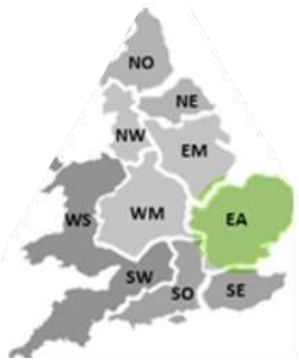
Electricity generated from CHP engines is used by adjacent facilities and production processes on site. The feedstock for anaerobic digestion derives from local agricultural break crops. Approximately 96 tonnes of maize, rye and grass are treated every day. The biomethane produced is injected into the grid at an hourly flow rate of 500 m^3. The table below shows details of biomass inputs and energy outputs.

Feedstock type	Annual throughput (tpa)	Annual biomethane injection (kWh)	Combined Heat Power (KWh)
Maize Rye Grass	35,000	40,000,000	499

Technology supplied by Agraferm allows the separation of solid and liquid digestate during biogas production. Solid digestate is collected and used as an organic fertiliser. Nutrients and organic matter are recycled back into the soil, helping to reduce inorganic fertiliser reliance.

Biogas Upgrading

CO_2 is removed from biogas with the use of AirLiquide membrane technology. The highly efficient membranes allow a 99% recovery of biomethane with a slip of ≤ 1%. Propane storage is above ground and is added through a liquid injection system to increase the calorific value of biomethane. Gas compressors owned by Future Biogas are located on site and operate between 7 to 19 bar.



Biomethane composition is examined at the entry unit supplied by Elster prior to exportation and delivery. The self-lay exportation pipeline was a CNG Services Ltd construction, allowing the flow of biomethane at a rate of 500 m^3/hr into the LTS at pressures above 7 bar. The National Grid is contracted to deliver biomethane into the East Anglia distribution zone.

Certification and Support Schemes

Approximately 40,000 MWh of biomethane is registered under the Biomethane Certification Scheme. The independent certification scheme is run by the Green Gas Trading Ltd. By generating electricity and injecting biomethane into the grid, Egmere Energy qualifies for receiving RHI and FiTs.

Carbon Reductions and Savings

Egmere Energy displaces the use of natural gas by using and injecting 100% certified green into the grid system. Energy generated from CHP is also utilised within close proximity to the site.

The emissions from consignments of biomass fall within the GHG sustainability criteria. An overall saving of over 70% is achieved from biomethane utilisation when compared to fossil fuel use.

Case Study

CNG Fuels – Leyland Station

Site location: Junction 28, M6, Leyland, Lancashire PR25 5XW

Project developer: CNG Fuels

Biomethane supplier: Barrow Green Gas

First date of operation: March 2016

Overview

Leyland filling station is the first CNG facility connected directly to the high-pressure local transmission system. The partnership between CNG Fuels and National Grid allows a constant availability of 100% renewable biomethane, capable of refuelling over 500 HGVs a day. Commitment to maintaining a sustainable logistics operation to by displacing diesel with biomethane has led to John Lewis Partnership as the first major consumer to utilising the Leyland CNG facility.

CNG Station Properties

The new station is operational 24 hours a day without the requirement of on site management. Fuel dispensing is quick and easy with a fill time of up to 4 minutes. The two compressors have a combined capacity of approximately 4,000 kg/hour and a total annual capacity above 25,000,000 kg. Properties of the facility are listed below.

- 2 CNG compressors
- 2 HGV refuelling lanes
- 2 trailer loading bays
- 4 refuelling dispensers
- CCTV monitoring
- Remote diagnostic control
- Cascade storage

Certification and Schemes

The biomethane delivered to consumers originates from biodegradable waste. Evidence of this is provided by the gas suppliers, Barrow Green Gas. Biomethane title transfers held by Barrow Green are tracked through the Green Gas Certificate Scheme (GGCS).

Carbon Reductions and Savings

CNG has the lowest carbon footprint of any natural gas fuel in the UK and running HGV fleets on bio-CNG reduces CO_2 emissions by more than 20%. Carbon emissions are reduced by more than 70% in comparison to diesel fuel. The high pressure LTS connection increases the compression efficiency and reduces the energy demand required. In addition to the lower particulate emissions and reduced noise pollution, bio-CNG from Leyland is also 30% cheaper than the equivalent price of a litre of diesel.