February 2016

The future of gas

Supply of renewable gas

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Foreword

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The government has important choices to make about how the UK maintains and delivers an energy supply to meet its affordability, security and sustainability targets. For example, the Climate Change Act 2008 commits the UK to reducing total emissions by at least 80% in 2050 from 1990 levels.

While the Department of Energy & Climate Change (DECC) Heat Strategy[1] has identified a long term need for natural gas for seasonal heat, its role will need to change if environmental targets are to be met. In this context, what contribution could renewable gas make?

Evidence suggests that in 2050 there will still be a demand for gas across heat, transport and power generation and we believe that renewable gas is a realistic option to help meet this demand while making a significant contribution to emissions reductions targets. Not only can it provide a way to deliver the same energy outcome without significant investment in new infrastructure, customers will not have to make any significant changes to their appliances for heating or cooking. However, during our discussions with industry experts and stakeholders to develop this series of publications, it has become clear that a number of misconceptions around renewable gas persist.

The gas industry has already shown that it can facilitate the development of a renewable gas market with anaerobic digestion (AD) and we are now in the process of demonstrating the next innovation in the form of Bio Substitute Natural Gas (BioSNG). The potential of this technology would secure low carbon heat to millions of homes and businesses in a cost effective way for between a third to a half of all domestic customers served today. We believe it has the potential to deliver 10 times the quantity of gas that can be generated from AD, as AD deployment is limited by both feedstock and rural gas grid penetration. It could also play an important role alongside other technologies such as carbon capture and storage, gas heat pumps and hybrid heat pumps in ensuring the heat and energy we derive from gas has the lowest carbon footprint possible.

Importantly, renewable gas requires little or no new infrastructure to replace fossil natural gas, and can be injected into the existing pipeline network – straight to people's homes. This is a sustainable, flexible, economic solution that could help the government meet its sustainability target.

If more renewable or low carbon gas can be piped through the gas network then the life and utilisation of the existing network, already substantially depreciated, can be extended and puts the UK on the right trajectory to meet its carbon reduction targets. Once on this path, we could then turn our attention to how we could move to a hydrogen economy, which would see gas networks adapt the system to transport hydrogen for heating, cooking, homes and transportation in a similar way to the supply of natural gas today.

National Grid has a long history of working within a framework of shifting demands to deliver innovation. Since the creation of the energy system in 1926 we have successfully overcome a series of challenges and opportunities because we are flexible and forward-thinking. This latest set of challenges – the energy trilemma of affordability, security, and sustainability – is being met with the same enthusiasm that helped bring about positive change in the past.

While the current and future direction of energy policy is an increasingly debated topic, the government is now beginning to recognise the potential for renewable gas. This paper addresses the benefits of renewable gas in relation to the energy trilemma; how the UK can secure the reliable feedstocks needed to generate it; and the policies required to help it significantly contribute to our 2050 targets.

David Parkin
Network Strategy Director

The challenge

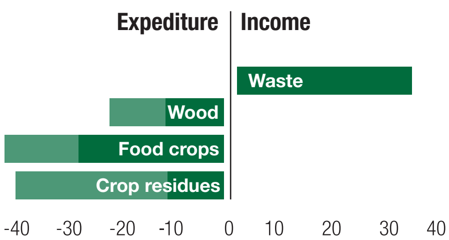
Addressing the demands of the energy trilemma is core to any change in policy, technology or investment decision and for the supply of renewable gas the challenges are complex. There are factors which need a much higher profile if we are to really understand the opportunity renewable gas offers, such as the real cost of production, the UK's ability to be self-sufficient with feedstocks and being realistic about what cannot be achieved by other routes.

Affordability

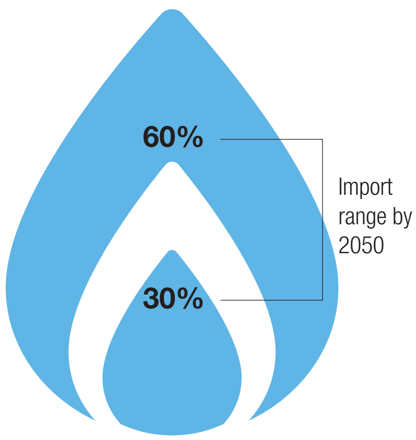
An affordable, renewable energy supply necessarily requires low or zero carbon energy sources. At the moment, a range of feedstocks is being used to produce renewable energy but their cost in both monetary terms and as potential long term sustainability needs to be considered. In the UK the lowest cost opportunity lies with household rubbish, (black bag waste) referred to in this document as Municipal Sourced Waste (MSW).

Every household in the UK produces nearly a tonne of MSW[2] a year. After recycling, this still represents around 530kg of residual, energy-rich waste. Business and industry produce substantially more and currently over 15 million tonnes goes to landfill. As you can see from the diagram below waste has a negative cost because it commands a gate price for disposal at landfill or has to be exported.

Feedstock income/expenditure (£ per MWh)[3]



Range of the percentage of gas imports by 2050



Security

By 2050, the UK's population is expected to have grown by 24%, making it the biggest country in the European Union[4]. So how can renewable gas ensure that households and businesses will have access to heat and power even at times of peak demand?

To determine future supply and demand, National Grid modelled sources of gas to 2050 as part of the Future Energy Scenario analysis. Even the most optimistic scenario (Gone Green) would require the UK to import 35% of gas from Norway, Russia and the Middle East at a time when worldwide demand for gas will be growing strongly. Quite simply, investment in renewable gas produced from UK feedstocks increases our energy security by reducing our reliance on imports.

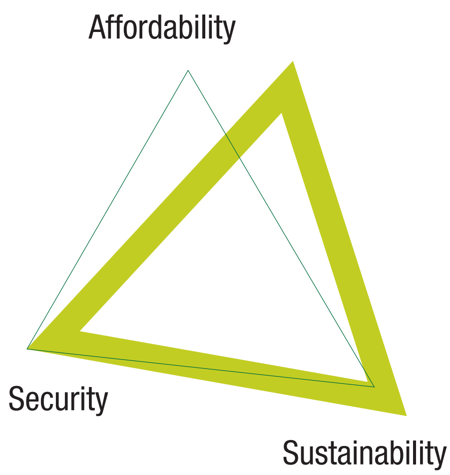
Sustainability

While fossil gas is plentiful but finite, renewable gas is a sustainable resource that can make a considerable contribution to decarbonisation.

So we need to consider how to make the best use of energy rich waste that cannot be reused or recycled.

Currently, some of the feedstocks that could be used to generate renewable gas are being used to make electricity. Given that there are many ways to produce renewable electricity, is this the most efficient use of this resource?

The energy trilemma



Our commitment

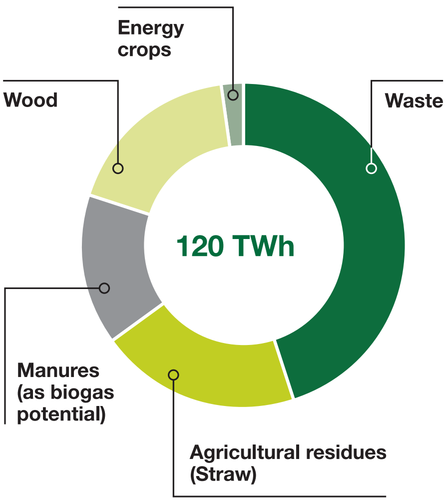
As an industry we need to better understand the opportunities gas can afford us in the UK, particularly in the context of four key priorities for customers; supply of renewable gas, domestic heat, transport and network capability. We are committed to seeking the lowest cost outcome to deliver our carbon reduction targets.

Current and future subsidies under RHI for biomethane

£76.20 MWh past
£58.70 MWh current

Figures based on Tier 1 plants up to 40,000 MWh production per annum.

Potential source of renewable gas[5]



Expressed as energy per annum

Meeting demand

Looking at a range of scenarios the demand for gas could be between 300 TWh and 800TWh in 2050[6]. There is a consensus from the industry that UK sources of wastes and residues could generate 80-120 TWh of renewable gas, and this paper argues that producing renewable gas is the best use of this resource.

Energy policy

As well as being mindful of sustainability targets and the UK's future energy needs and supplies, we must also consider the complexities of Government policy-making, how spending decisions are made, and other external influences. How quickly we arrive at our goals, and how different they may be in reality will be the result of much debate, as this Future of Gas series demonstrates.

The Government needs to support production of all types of renewable gas within the structure of DECC's Renewable Heat Incentive. It also supports creation of transport fuels such as ethanol from the same feedstocks using the Department for Transport's (DfT) Renewable Transport Fuel Obligation, and production of electricity from those feedstocks through DECC's Contract for Difference Feed In Tariffs. Defra has responsibility for overall regulation of production and disposal of most feedstocks. We believe the gas industry can help join up the needs of Government across sectors to set a policy that ensures the UK makes the best use of its valuable resources. How soon should we expect to see a combined position on waste and energy across Government?

The Government must continue to support the development of new technologies through appropriate incentives in order to reap the rewards of establishing low cost, low carbon solutions.

Investment

While the last five years has seen more than £0.5bn of investment in the production of renewable gas, the industry will need to invest another £25bn for it to achieve its full potential. The economics of renewable gas production support this level of investment and what is more, it is a sector where new jobs can be created – not just to support the construction and operation of a new plant, but also within the supply chain. However, funders will require a clear policy framework from Government and strategic direction from the gas industry to give them the confidence to invest in the technology.

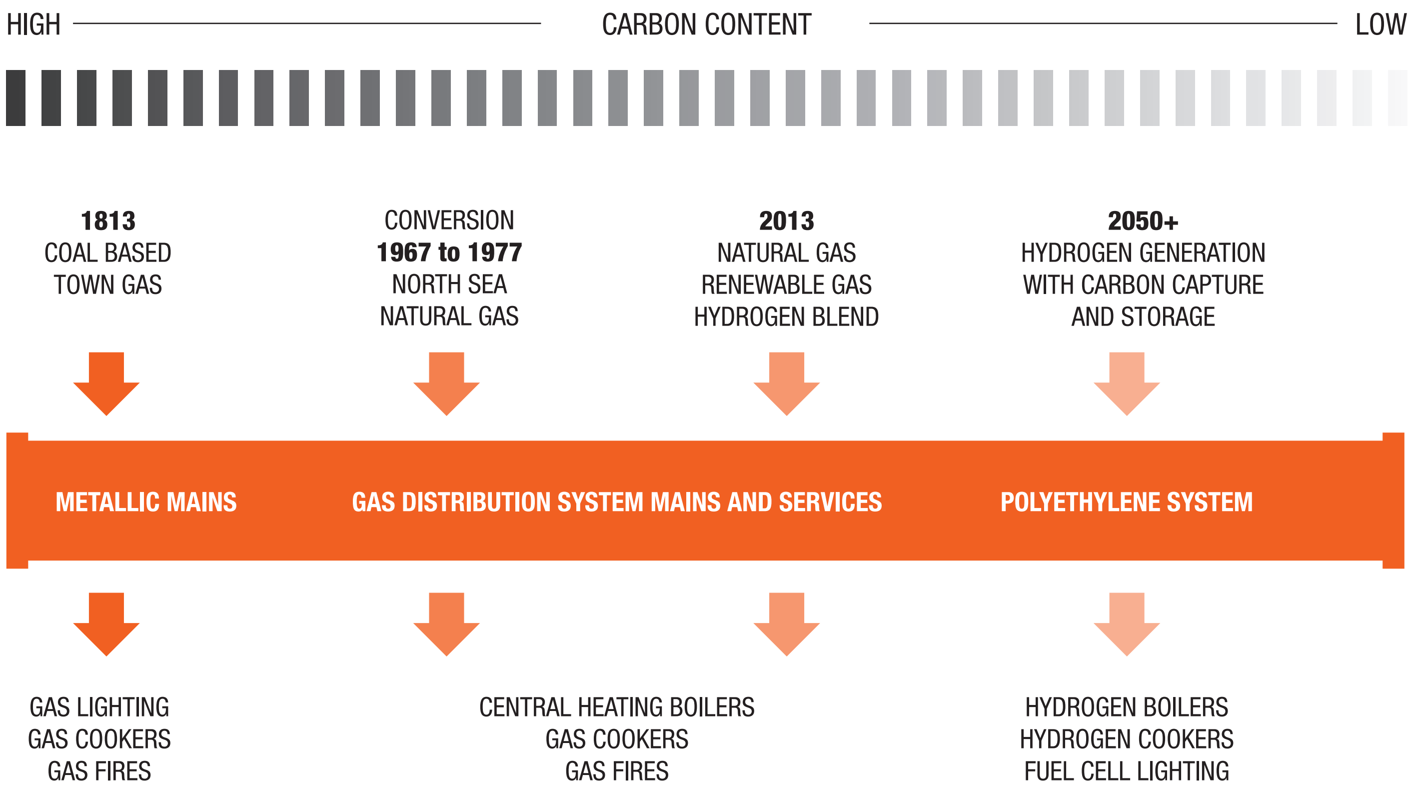
Chapter one of the Future of Gas series addresses five key questions posed in the introductory document:

- How can gas better contribute to meeting challenging sustainability targets?
- How do we integrate waste and energy policy?
- Can a more diversified supply ensure reliable sources of energy?
- At what cost should electrification be prioritised?
- How can renewable gas contribute to the local economy?

The potential for renewable gas

The majority of our energy still comes from fossil fuels – predominantly gas for heat and electricity, and oil for transport. Renewable and low carbon energy is growing in importance for electricity generation but in other sectors progress has been slower. Decarbonisation of heat and transport will be based on electrification but, as set out in the previous chapter of this series, electrification does not provide a solution for areas such as aviation, heavy goods transport, peak heat and high temperature industrial heating. These will continue to rely on fossil fuels or renewable gases and liquid fuels produced from biomass, collectively known as bioenergy.

The changing gas supply in the UK and its impact on the distribution network and customers



The Climate Change Committee, DECC, DfT and Defra have investigated bioenergy in detail and there is a consensus that it will play an important role in the UK's low carbon energy future. Currently, bioenergy is used in the following areas:

- Waste and wood is combusted to produce electricity in incinerators.
- Crops, waste oils and fats are converted to bioethanol and biodiesel which is blended with fossil fuels and used in transport.
- Crops, agricultural residues and some wastes are used in AD plants to produce electricity and biomethane.
- Wood is combusted to produce heat.

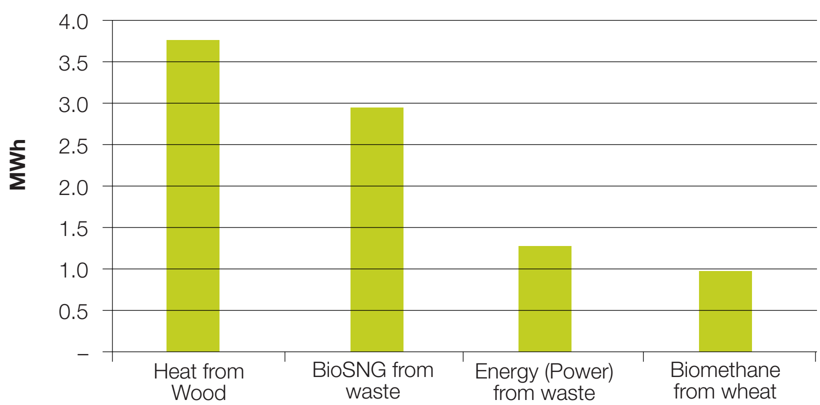
These applications are mature and are being utilised around the world, but recently, new technologies have been developed that produce biomethane, or liquid fuels, from a wide range of biomass. These rely on gasification, pyrolysis and upgrading to methane, or pre-treatment of materials to allow them to be used in mature processes such as AD or fermentation. The key advantage of production of renewable gas from biomass is the high conversion efficiency. Converting biomass to a fuel produces more useable energy than generating electricity from it. The efficiency of converting biomass to gas is reflected in the carbon footprint of processing one tonne of waste.

National Grid aims to facilitate new connections to the gas distribution network that will enable biomethane producers to inject their renewable gas into it. The addition of biomethane into the grid will help the UK minimise its carbon footprint and avert from unsustainable fossil fuels, whilst increasing the security and diversity of energy supplies.

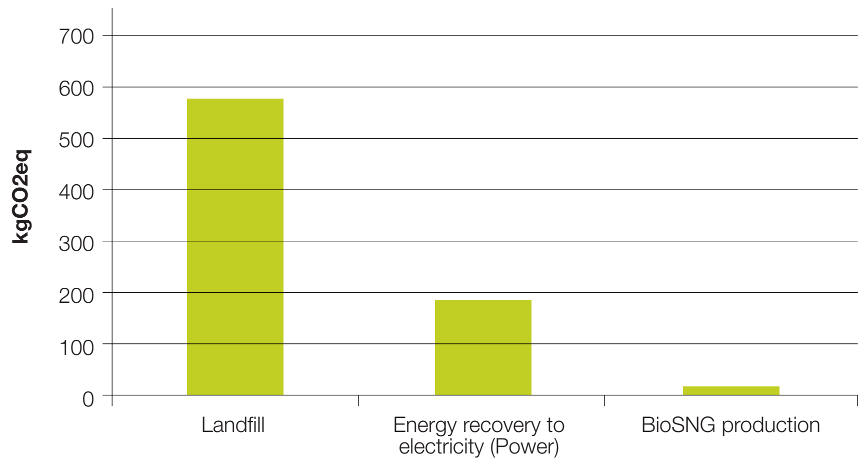
As you can see from the graph below (Greenhouse Gases Emissions from processing 1t MSW), the best performance in this analysis is achieved by production of renewable gas. Landfill performs worst as the impact of the methane produced by landfilled biomass results in a very high GHG footprint, even in a well manged landfill with energy recovery. Already production of biomethane offers better GHG performance than generating electricity, and as the carbon intensity of grid electricity reduces, the relative benefits of production of gas increase still further.

BioSNG process produces more than double the energy value compared to electricity from waste.

Useable energy produced from one tonne of feedstock[7]



GHG emissions per tonne of waste[8]



BioSNG

The BioSNG process

1 RECYCLE

Waste is collected and processed to remove recyclates and water. Waste that remains is taken to the plant.

2 GASIFICATION/PYROLYSIS

Waste materials are converted to a syngas using gasification or pyrolysis and tars are removed through thermal or physical treatment.

3 GAS, COOLING & CLEANING

The syngas is cooled so that contaminants can be removed and energy recovered from hot syngas.

4 WATER GAS SHIFT

The level of hydrogen in the syngas is boosted in a catalytic reactor by reacting syngas components with steam.

5 METHANATORS

The methanation catalytic reactors use syngas taken from the water gas shift and transform hydrogen and carbon monoxide components into methane.

6 REFINING

The Methanator gas contains methane and carbon dioxide. The refining stage separates these gases into the methane product gas and a carbon dioxide by-product.

7 THE PRODUCT - BIOSNG

The final product, BioSNG, is interchangeable with natural gas used to heat homes or power vehicles.

Key benefits of BioSNG

- It has the potential to increase the amount of renewable gas produced in the UK to 100 TWh perr annum (that's the potential to satisfy 30-50% of domestic gas demand in the future).
- Achieve savings to gas consumers through avoidance of costs associated with moving to other low carbon sources of heat.
- Ensure the long term future of the gas grid by providing a sustainable gas source, avoiding decommissioning costs.
- The ability to process a wide range of feedstocks, including mixed household waste.
- High conversion efficiencies of at least 60%.
- It's a local solution – the technology is designed to produce minimal waste emissions and to be acceptable to communities close to the facility.

CASE STUDY - Commercial BioSNG Demonstration Plant, Swindon, UK

National Grid is constructing a plant to produce renewable, low carbon methane (BioSNG), by the gasification of residual household waste, in order to encourage the roll-out of a large number of BioSNG plants across the UK. It will help address renewable targets and secure the long term future of the grid as well as develop a UK-owned technology which has the potential to generate significant exports.

The project addresses three interrelated problems:

- The UK has committed to increase renewable energy production to 15% by 2020 and reduce greenhouse gas (GHG) emissions to 80% of 1990 levels by 2050
- Cost effective sources of sustainable, low carbon gas at scale are required to secure the long term future of the gas network
- Commercialisation of the technology required to produce significant quantities of renewable gas.

The demonstration plant will be capable of heating 1600 homes or fuelling 75 heavy goods vehicles. It will enable the industry to better understand the contractual, commercial and engineering issues relating to the construction and operation of such facilities, the off-take of the fuel it produces and the supply of the waste feedstock.

Ultimately it will help inform policy and investment decisions so that engineering contractors are willing to supply BioSNG facilities under a fixed price. It will also help waste supply companies and fuel off-takes enter into long term take or pay contracts with plants and give assurance to banks and equity funders so they are willing to finance BioSNG projects.

The government must support the development of BioSNG plants and maintain its commitment to a Renewable Heat Incentive.

Anaerobic Digestion: the story so far

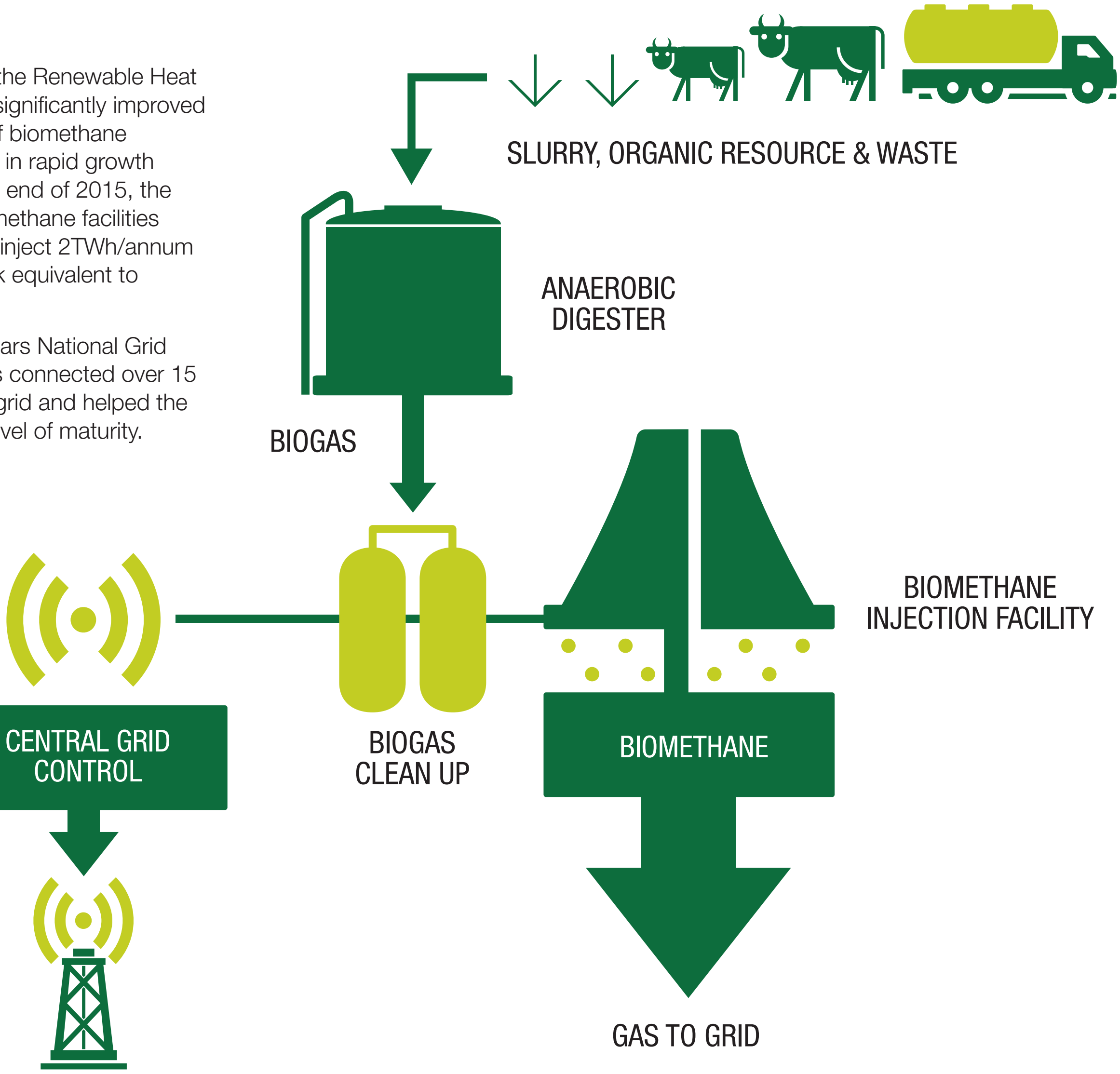
Anaerobic Digestion (AD) is a series of biological processes in which microorganisms break down biodegradable material in the absence of oxygen to produce biomethane. It is not a new technology, and has been widely applied in the UK for the treatment of sewage sludge for over 100 years. However, until quite recently it has not been used in the UK for treating other wastes or with purpose-grown crops and it is still limited to a small range of "feedstocks" such as food waste, manure, sewage and crops. The biogas produced is a mixture of carbon dioxide (CO_2) and methane. What's left from the AD process is a nutrient-rich bio-fertiliser.

Every tonne of food waste recycled by anaerobic digestion as an alternative to landfill prevents between 0.5 and 1.0 tonne of CO_2 entering the atmosphere.

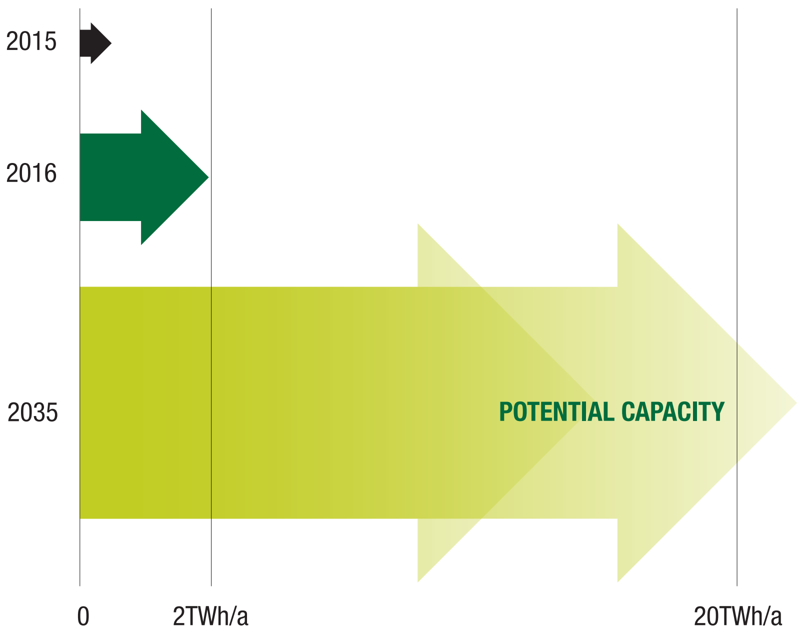
The AD process:

The introduction of the Renewable Heat Incentive (RHI) has significantly improved the attractiveness of biomethane production resulting in rapid growth in the sector. By the end of 2015, the established AD biomethane facilities had the capacity to inject 2TWh/annum into the gas network equivalent to 155,000 homes.

Over the last two years National Grid Gas Distribution has connected over 15 projects to the gas grid and helped the market to reach a level of maturity.



AD biomethane production capacity[9]



Key benefits of AD

- A proven, mature technology with a well-developed supply chain and investment community happy to support projects.
- Extremely well-suited to an agricultural setting as it can treat most farm wastes and residues and produces a valuable soil conditioner.
- Facilities have relatively small environmental footprints and are generally accepted by local communities.

Wider implications of AD

It is important to see AD as part of a soil management process, rather than purely as a route to generate biomethane. For example, a plant which uses 40,000 tonnes of waste may produce 34,000 tonnes of digestate. This can be used to condition and improve soils for crop production, reducing use of fossil fuel fertilisers, which have greenhouse gas impacts. However, the use of the digestate[10], and the transport issues around waste feedstocks that are suitable for AD, limit the size of AD facilities.

Production of biomethane via Anaerobic Digestion of appropriate, waste derived feedstocks such as food waste and slurries is widely recognised to be environmentally beneficial and should be encouraged. However, there are reservations about the benefits of using food and fodder crops for the production of biomethane because of the direct and indirect changes to the use of land and the carbon implications arising from these[11].

The future

The growing market of connecting gas supplies to the distribution network has resulted in new materials being used in the high pressure network and more market competition resulting in lower costs and faster connections to the gas grid. A number of these improvements will transfer to other new connections on to and out of the gas grid.

However, uncertainty over the future of the RHI in 2015/16 has resulted in a sharp fall in requests to connect.

There are challenges in enabling AD to increase its production to achieve the top end estimates of 35TWh/annum of biomethane from UK wastes and residues. Exploiting different feedstocks is technically more challenging than food and fodder crops such as maize. However, it should be encouraged because waste offers significantly better environmental benefits and ultimately lower costs of producing biomethane anaerobically.

2TWh of AD equates to 155,000 homes

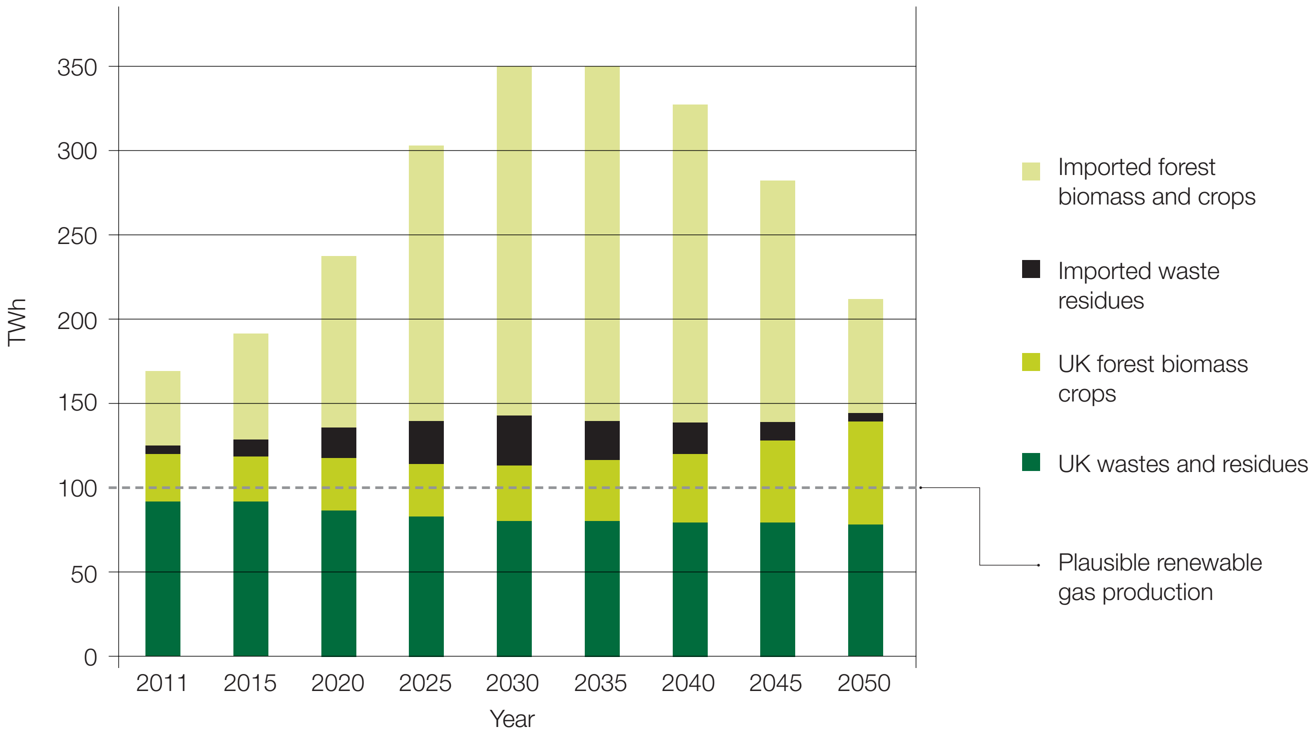
In policy terms, is it right that the supporting financial regime reflects this balance as well? These issues are well understood in the transport fuel sector, and the Renewable Heat Incentive should recognise it too. Indeed, it is important that AD shows a clear pathway to operating without any subsidy if it is to offer affordable energy in the longer term.

AD is a proven technology with a clear role to play in meeting carbon and GHG targets and therefore striking the balance is key for its development and use in the longer term. Industry and Government must focus on the development of technology to utilise waste and ensuring that the RHI, or any alternative subsidy, encourages the construction of plants where they can take best advantage of available feedstocks.

Feedstocks

Renewable gas plants can utilise a wide range of feedstocks. The question for the UK is which feedstock is most appropriate, abundant and commercially viable to generate energy that will contribute to filling the energy gap in future?

UK share of potential sustainable bioenergy supply[12]



Various experts have reviewed the availability of sustainable biomass feedstocks including the Climate Change Committee. In their report on Bioenergy[13], they concluded that "Scenarios for global land use which take account of required food production suggest that a reasonable UK share of potential sustainable bioenergy supply could extend to around 10% (200 TWh) of primary energy demand in 2050."

The dominant source of indigenous biomass is from wastes and agricultural residues. These are seen to be reliable feedstocks into the future as waste generation is unlikely to reduce significantly, even with increased recycling, as that will be countered by population growth.

Over time, sustainable 'second generation' energy crops are seen to play an increasing role, a view also reflected by DECC, more than compensating for the elimination of the use of feed and fodder crops for energy, which is rightly seen as less desirable.

The establishment of international supply chains provides further potential sources of sustainable bioenergy for the UK, although it is recognised that this is less supply secure as other countries demand for biomass increases to help them meet climate change commitments.

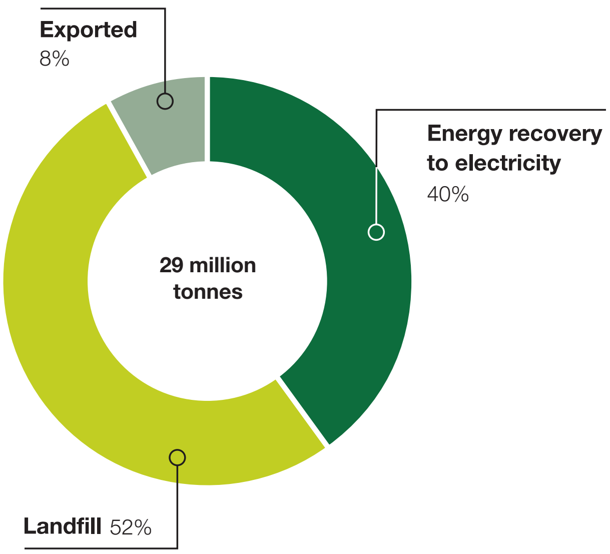
Whilst each of the different feedstocks present advantages and disadvantages and there are still significant uncertainties over how they will evolve, it is vital that pathways for conversion of each feedstock are developed now to ensure that the UK is well placed to produce biomethane going forward – no matter which feedstock offers the best solution.

At present there has been good progress in some areas, but limited successful deployment of renewable gas production from mixed residual waste, cellulosic residues and woody material. These feedstocks represent more than 80% of UK biomass and we believe it is essential that support is given to develop and deploy the technologies for utilising them.

Key benefits of using waste as a feedstock

- Waste is the UK's largest source of biomass at around 100TWh.
- Waste has a negative cost which means it is the only feedstock that can produce gas at a cost that matches current fossil fuel prices.
- Currently, 17 million tonnes of waste is sent to landfill or exported to Europe. This valuable UK resource is sorely underutilised.
- The long term price for gas is around £18-26/MWh without subsidy and depending on scale compared to £92/MWh for nuclear.

Where our non-recycled waste goes[14]



Key attributes of different feedstocks

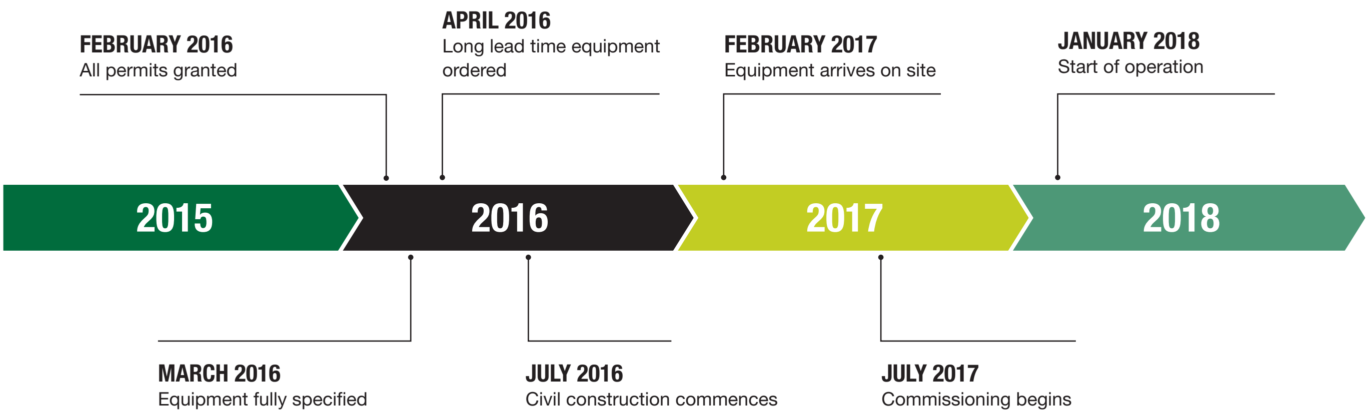
	CROPS	RESIDUES	WASTE/MANURES	WOOD
Affordability	High cost.	Medium Cost.	Very low (negative) cost.	High cost.
Security	Good security if generated within the UK. Concerns over imported feedstocks, particularly as demand for low carbon fuels increase.			
Sustainability	Sustainabilty of UK sources good. Care required with imports.	Sustainable supplies from the UK.	Reduction in waste arising likely to be balanced by increase in population.	Sustainabilty of UK sources good. Care required with imports.
GHG Emissions	High because of cultivation GHG emissions, land use change factors.	Low for most UK residues.	Low, particularly in comparison to landfill.	Variable depending on land use change factors.
2020 UK Renewable Gas Potential	1 TWh/a	28 TWh/a	73 TWh/a	18 TWh/a

Rolling out renewable gas

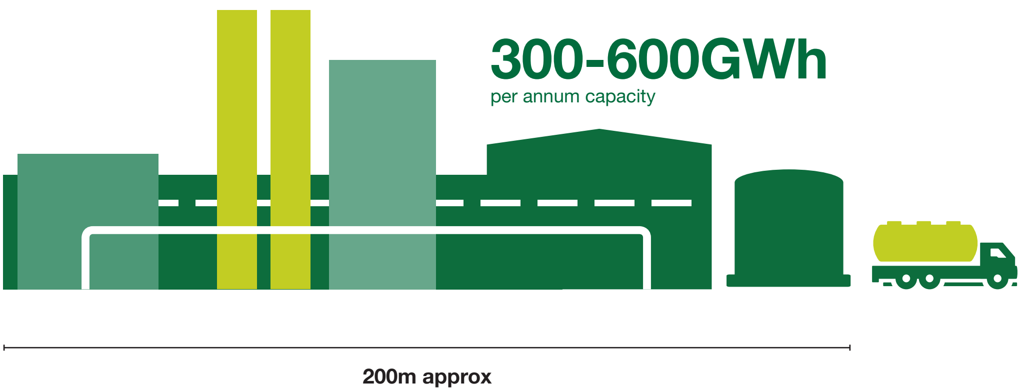
Gasification offers a cost effective, efficient, low carbon pathway for converting any waste or biomass feedstock to biomethane. National Grid believes that the development of this pathway is an important step on the road to a sustainable, low carbon gas supply and as such we have been working with partners (Progressive Energy and Advanced Plasma Power) for more than five years to help commercialise the technology.

Biomethane gasification facilities are starting to enter service around the world and the Gobigas facility in Sweden, which began operating in 2014, now produces 149GWh/a of gas from forest residues. The first UK commercial scale demonstration plant is under construction in Swindon and will operate on waste. It is important to understand what a plant actually looks like, how big it would be and the impact it could have on the local economy.

Timeline for development of a BioSNG demonstration plant in the UK



BioSNG plant



Plant capacity of BioSNG

Commercial plant will be between ~300-600GWh per annum capacity.

The long term price for gas is around £18-26/MWh without subsidy and depending on scale.

In the shorter term, the first wave of commercial plants would depend on RHI support.

Key facts about renewable gas

- Waste to energy plants have a number of advantages over traditional incinerators in terms of their physical size, efficiency and transport demand. They can be typically 50% smaller than an incinerator of the same feedstock capacity.
- A typical commercial waste to energy plant will process between 150,000 & 300,000 tonnes of feedstock to produce 0.3-0.6TWh per annum of gas.
- The total waste from a city the size of Coventry could produce enough gas to meet a quarter of its current gas demand.
- BioSNG plants are relatively small at 8 hectares, and can fit into the industrial estates typically found around the edges of cities.
- The only emissions to air from the process are a high purity carbon dioxide stream, which can be sequestered to further improve GHG emissions.
- The majority of any hazardous material in the waste will be vitrified into a stable, glassy material that can be used as a building aggregate.
- The small amount of effluent generated in the process will be cleaned to allow it to be sent to the sewer.
- Odour should be far lower than current landfills and emissions to air far cleaner than facilities that combust waste to generate electricity.
- BioSNG plants will cost around £100m to build and would last 25 years. The majority of the investment is likely to be spent with UK companies, increasing economic activity and generating tax revenue for the Government.
- Around 100 jobs will be created during the two-year construction period and in many cases the facility will help regenerate run down areas and create a new local industry.
- Around fifty full time, skilled engineers will work in a BioSNG facility once up and running.
- More jobs will be created in the supply chain. For example, the treatment of waste using BioSNG creates more jobs than landfilling the waste or producing refuse derived fuel (RDF) and exporting it to incinerators in Northern Europe.

The future: Hydrogen

Similar to electricity generation, the gas industry is looking at ways to turn the resources we have today into renewable energy in the future.

Carbon Capture and Storage (CCS) allows us to use fossil fuels like gas and capture the carbon that is produced. This therefore delivers low carbon and reliable energy for electricity generation or heat delivery via hydrogen.

Hydrogen creation

Hydrogen is produced effectively today with existing technology. The most common approach is Steam Methane Reforming, which allows natural gas to be turned into hydrogen and the carbon extracted. Combined with carbon capture and storage the hydrogen produced under this process would be equivalent to other renewable sources and could continue to be used for heating and cooking without a significant change from the approach today.

Hydrogen is different from natural gas in that the energy value is a factor of 3 lower than that of natural gas. For the gas distribution low pressure (75 mbar and below) polyethylene system, adjustments can be made to the operation of the network in terms of pressure to adjust for the majority of the difference. The gas industry is currently assessing the impact of a move to a hydrogen network and are considering potential impacts that the current replacement processes would have on a potential change. This could result in taking some 'no regret' decisions to ensure if and when we do wish to transition, the building blocks are in place to facilitate the changes.

Hydrogen for our heating and cooking

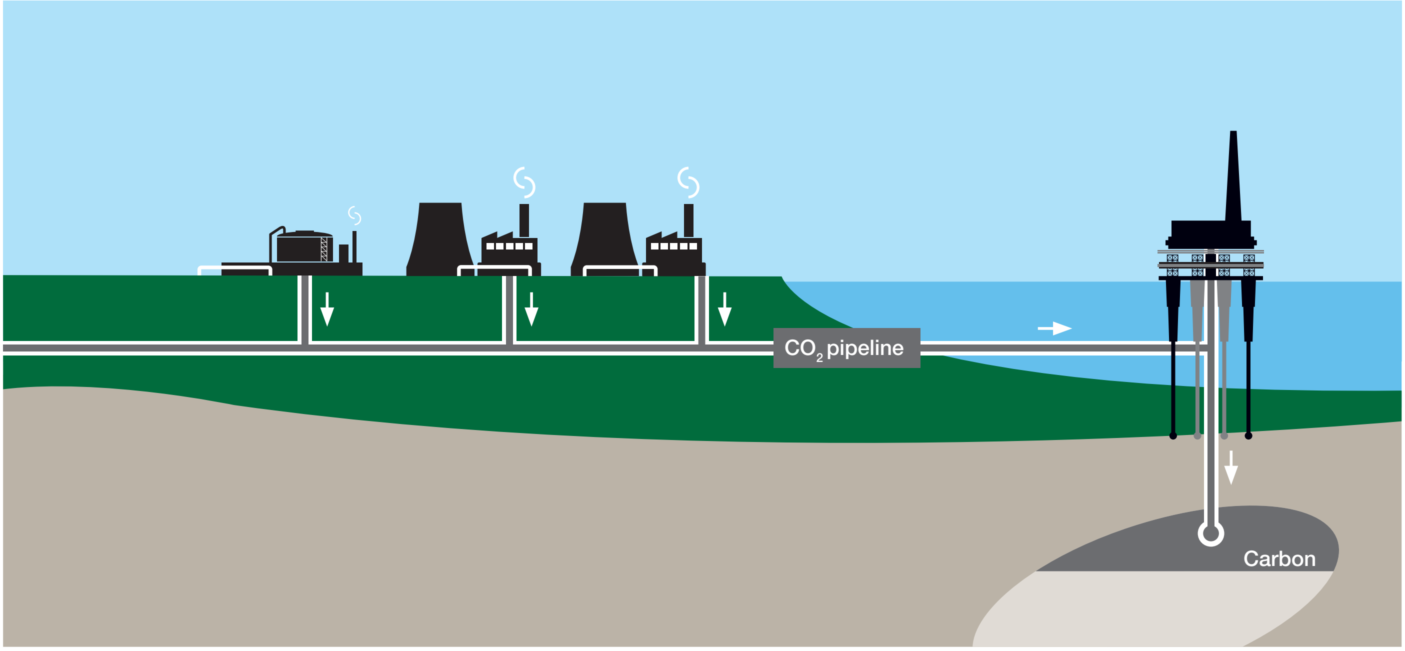
Applying the same principle to a gas network, we can look to generate hydrogen from natural gas, shale gas and renewable gas processes with CCS to meet our future heating and cooking requirements. There are a number of advantages:

Flexibility – future flexibility would remain as it is today regarding when to generate or supply customers with energy. Should there be a need to store the hydrogen, we already have tried and tested underground storage of gases that could be expanded further. In addition, the gas network has significant storage capacity delivered by the pipeline infrastructure and we have the ability to increase pressures, which allows greater storage across the Local Transmission Network.

Decarbonised – running a full hydrogen network would achieve the decarbonisation of heat and cooking for customers that currently use natural gas. To meet our domestic demand needs we would be looking to generate 200 and 300 TWh of gas but equally hydrogen could be fit for purpose for Industrial and Commercial use.

The gas industry is currently assessing the impacts of introducing hydrogen into the network.

The principle of the Carbon Capture and Storage (CCS) process



Security – at present we rely on two sets of infrastructure to deliver our energy demands covering heating, cooking, lighting, entertainment and electrical devices. With hydrogen, the diversity would be the same as we currently have, with the added potential of using hydrogen to generate electricity at point of use in hydrogen fuel cells. This would allow significant consumer choice and network flexibility for different geographic locations.

Minimise disruption – with all technologies there will be a need to make changes to consumers' energy use. With some alternative technologies this can lead to the installation of new appliances which take up space in gardens, such as air source heat pumps or require new or adapted radiators within the home. With potential hydrogen appliances, the changes will be limited to either the modification or exchange of existing boilers and cookers. The remaining infrastructure, location of metering systems, and internal pipe work will stay in place.

Infrastructure disruption – one alternative technology is district heat networks that would generate heat at a central source and distribute the heat to individual homes via the installation of pipelines under our roads. This technology would require significant Streetworks to deploy, with significant disruption to the general public.

Repurposing the gas network for hydrogen would only require small specific changes and would not require significant modifications in customers' properties other than the adaptation or replacement of an appliance.

Key benefits of hydrogen

- Once decarbonised at source the gas is zero carbon.
- Hydrogen production is proven technology and would utilise carbon capture and storage to decarbonise.
- Hydrogen can be transported through a polyethylene pipe network.
- Existing gas appliances can potentially be used with modifications depending on the level of hydrogen introduced. If not a similar style like-for-like appliance would be installed.
- Generation flexibility and usage by customers can be delivered in the same way as it is today.

List of activities we are working on for Hydrogen

- 'Hyready' – Study being funded by UK and European transporters to draw together the research on hydrogen to inform network owners.
- European – CEN work on hydrogen standardisation.
- Hydrogen blending - Germany is currently blending 2% by volume into their existing gas network to demonstrate network potential. Germany could inject hydrogen at up to 10% by volume.

Opportunity for UK plc and call to action

The UK is uniquely placed to take advantage of waste to energy plants to produce renewable gas – the technology is proven and the commercial case for new plants looks strong. What is lacking is a long term policy commitment to renewable gas and joined up thinking between waste and energy policy makers in order to create a clear pathway for investment. We have the opportunity to take the lead in the global market and export our skills around the world as well as tackling carbon reduction, landfill and any future need to import energy.

Commitment to, and investment in renewable gas offers a number of benefits against the challenges of the energy trilemma:

Sustainability

- Waste from a city the size of Coventry could produce enough gas to meet one quarter of current domestic demand.
- Using waste to generate renewable gas could prevent three million tonnes of waste going to the Continent and 15 million tonnes of waste to landfill each year.
- Keeping gas as gas is far more efficient: waste to BioSNG is two or three times as efficient as waste to electricity.
- We could deliver carbon reduction for customers in heating their homes – almost halving from 185gCO2 per kWh (total savings from landfill diversion and reduction in fossil gas use).

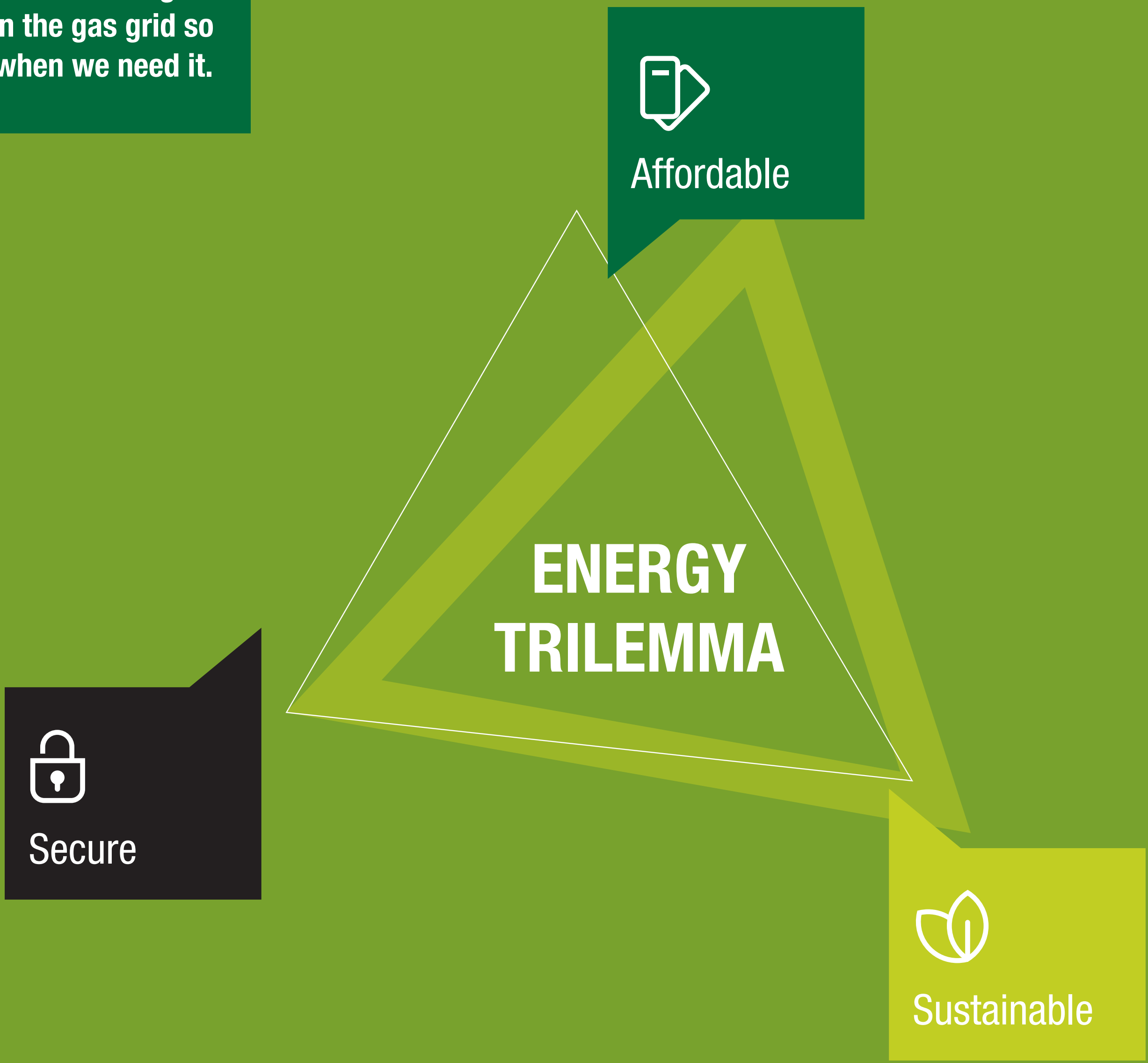
Affordability

- Waste has a negative cost and is the only feedstock that can produce gas at a cost that matches fossil fuel prices.
- The gas distribution network of the future is the network of today – no significant new infrastructure is needed.
- New BioSNG plants could support 100 jobs during construction and 50 when up and running.
- BioSNG does not require customers to make changes to their appliances.
- BioSNG ensures the long term future of the gas grid – avoiding decommissioning costs.

Security

- Renewable gas will help meet the UK's needs for a diverse energy supply to meet customer demand, with a growing population.
- Every household produces more than half a tonne of waste a year after recycling.
- Domestic waste and residues could generate 80 – 120 TWh of renewable gas.
- The technologies to support AD and BioSNG are tried and tested and low risk.
- BioSNG has the potential to satisfy 33% of domestic gas demand in the future.
- Renewable Gas could produce 35 MWh per annum by 2035.
- BioSNG is a local solution, designed to produce minimal waste emissions and so can be located close to the communities they serve.

Government and the energy sector need to support the role of renewable gas as an important part of the energy mix – now and in the future – including storing it in the gas grid so it's ready when we need it.



Glossary

Anaerobic Digestion (AD): a series of biological processes in which microorganisms break down biodegradable material in the absence of oxygen to produce biomethane. The biogas produced is a mixture of carbon dioxide (CO2) and methane. What's left from the process is a nutrient-rich bio-fertiliser.

Biomass: organic matter derived from living, or recently living organisms. Biomass can be used as a source of energy and it most often refers to plants or plant-based materials which are not used for food or feed, and are specifically called lignocellulosic biomass. Biomass can either be used directly via combustion to produce heat, or indirectly after converting it to various forms of biofuel.

Biomethane: a naturally occurring gas produced by anaerobic digestion and defined as a green source of energy.

BioSNG: typically produced via an initial gasification step followed by gas conditioning, Synthetic Natural Gas synthesis and gas upgrading. BioSNG can be used in a similar way to biomethane (biogas) generated via anaerobic digestion. Syngas may also be converted into liquid advanced biofuels.

Carbon capture and storage (CCS): an innovative technology that can reduce levels of CO2 emitted to the atmosphere by fossil fuel power stations and heavy industry by capturing the CO2 at source so that it can be stored safely and permanently offshore deep under the seabed.

Climate Change Act: In November 2008, the Government passed the Climate Change Act, making the UK the first country in the world to have a legally binding commitment to cut greenhouse gas emissions, including CO2. The aim is to reduce emissions by at least 80% by 2050 from 1990 levels.

Conversion 1967 to 1977: Industry conversion from Town Gas to Natural Gas that required conversion of customers' appliances.

DECC: Department for Energy and Climate Change.

Defra: Department for Environment, Food & Rural Affairs.

DfT: Department for Transport.

Digestate: the material remaining after the anaerobic digestion of a biodegradable feedstock. Anaerobic digestion produces two main products: digestate and biogas.

Gasification: a process that converts organic or fossil fuel based carbonaceous materials into carbon monoxide, hydrogen and carbon dioxide. This is achieved by reacting the material at high temperatures (>700 °C), without combustion, with a controlled amount of oxygen and/or steam. The resulting gas mixture is called syngas (from synthesis gas or synthetic gas).

GHG: Greenhouse gas.

GWh/a: Gigawatt hours per annum.

Ha: symbol for hectare, a metric unit of square measure, equal to 2.471 acres or 10,000 square metres.

Incinerators: apparatus for burning waste material, especially industrial waste, at high temperatures until it is reduced to ash.

Hydrogen: made (in this context) by processing natural gas through Steam Methane Reforming and extracting the carbon. This produces hydrogen equivalent to other renewable sources, which could be used for heating and cooking.

Indirect Land Use Change (ILUC): relates to the unintended consequence of releasing more carbon emissions due to land-use changes around the world induced by the expansion of croplands for ethanol or biodiesel production in response to the increased global demand for biofuels.

Municipal Sourced Waste (MSW): Waste mainly produced by households, though similar wastes from sources such as commerce, offices and public institutions are included.

National Grid Future Energy Scenarios National Grid Future Energy Scenarios: visit http://fes.nationalgrid.com/

Refuse derived fuel (RDF): a fuel produced by shredding and dehydrating MSW with a waste converter technology. RDF consists largely of combustible components of municipal waste such as plastics and biodegradable waste.

Renewable Heat Incentive (RHI): £76.20 per MWh is based on the period of 1 April 2015 to 1 July 2015. £58.70 per MWh applicable from 1 January 2016. Figures based on Tier 1 plants up to 40,000 MWh production per annum.

TWh/a: Terawatt hours per annum.

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Other publications in this series

The Future of Gas series seeks to address the challenges and opportunities to help the UK move towards a low carbon economy. These include efficiency measures that customers can take to reduce their consumption, and new sources of gas that could deliver energy in a more sustainable way. Look out for the following publications:

Introduction to the Future of Gas
Overview of the challenges in meeting the UK's carbon reduction targets

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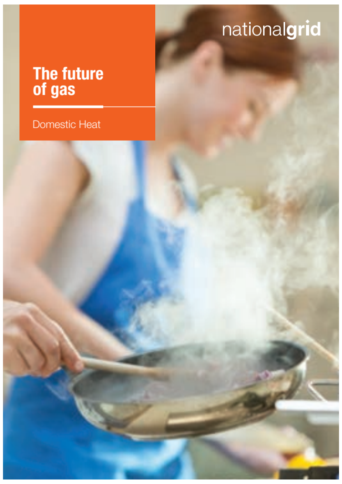

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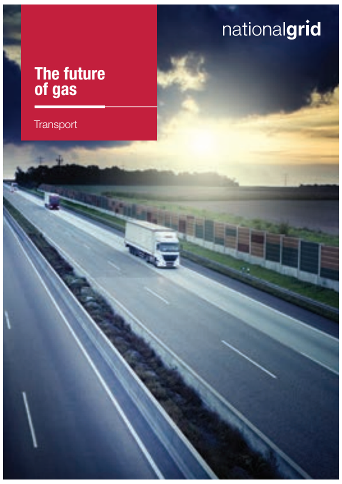
How gas networks can help deliver low carbon solutions to heat our homes

Coming March 2016



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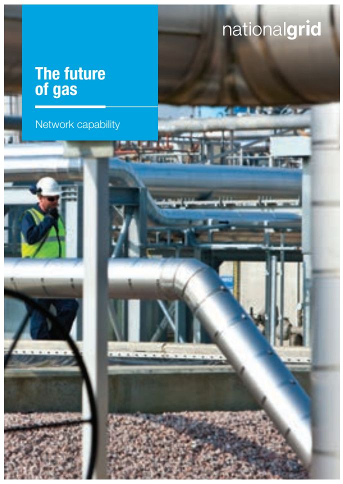

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