November 2016

nationalgrid

The future of gas

A Transmission Perspective

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01 Foreword

by Nicola Pitts
Head of Market Change – Gas

As the owner and operator of GB's gas transmission network, we ensure that gas flows to supply our businesses, heat our homes and drive our industry. In order to be ready for a changing energy future, we want and need to evolve the transmission system to ensure we are reducing the cost of our energy solutions, delivering what our customers want and contributing to a sustainable future.

There is a growing consensus that gas can continue to play a key role in the UK's energy mix out to 2050 and beyond, enabling us to meet our carbon emissions target in an affordable way[1]. Policy decisions are needed in the short term to keep overall energy system costs low and ensure that consumers get the best deal possible, but we recognise the complexity around the wide range of options. There is no simple whole energy system solution.

This document marks the launch of an engagement programme to develop insights on the future of gas from a transmission system perspective. We will pull together the wealth of information that already exists on this topic, including analysis by the GB gas distribution networks; our latest Future Energy Scenarios (FES 2016)[2]; and additional scenarios and reports produced by the energy industry and academics. Combining this with our system operator expertise and input from our customers and stakeholders, we believe we are well-placed to facilitate this debate and to provide an overall view of how gas can be a partner to electricity in a low-carbon future.

Through this Future of Gas (FOG) engagement programme, we will set out options for the role that gas can play out to 2050, supporting the achievement of the UK's 2050 carbon emissions target. We want to understand future market requirements and what they could mean for our transmission system. We will engage with stakeholders to understand what customers and end consumers value. This will allow us to identify optimal levels of future investment in the system and innovative ways to adapt our commercial arrangements. As our insights develop we will set out recommendations for no regrets actions that government, industry and National Grid may take, over the coming years, to ensure that the needs of GB consumers are met. Our aim is to identify options that ensure the optimum mix of security, affordability and sustainability.

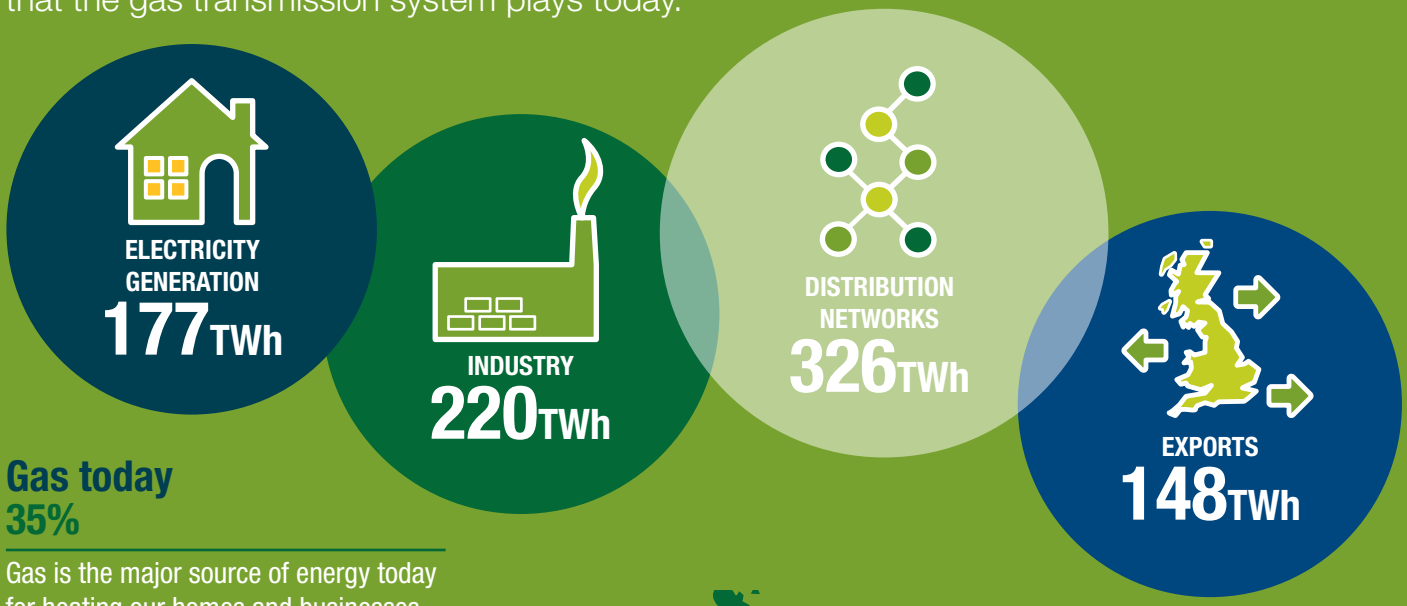
National Grid should not and cannot answer this alone – we would like to engage with the whole industry in looking for answers. The aim of this document is to set out, at a high level, the context and challenges faced in determining the future of gas; the fundamental questions we need to address; and our plan to do that through engagement with stakeholders. Over the next year we will publish further insights and recommendations as a result of this engagement and our developing analysis. It is essential that we get your input, views and feedback to ensure we make optimal decisions around the future of the transmission system, how we operate it and how the market framework needs to evolve.

"Gas plays a very important role in meeting UK energy demand. In the future, this role will change. Demand will need to reduce significantly if we are to meet our climate targets. This Future of Gas project is an important opportunity to explore some of the implications of this trajectory for consumers, producers and network operators."

Jim Watson
Director of the
UK Energy Research Centre

02 The role of gas and transmission today

In this section we will set out the context for how gas is currently used and the role that the gas transmission system plays today.



Gas today

35%

Gas is the major source of energy today for heating our homes and businesses and producing our electricity, providing 35% of the UK's total energy supply in 2015[3].

29%

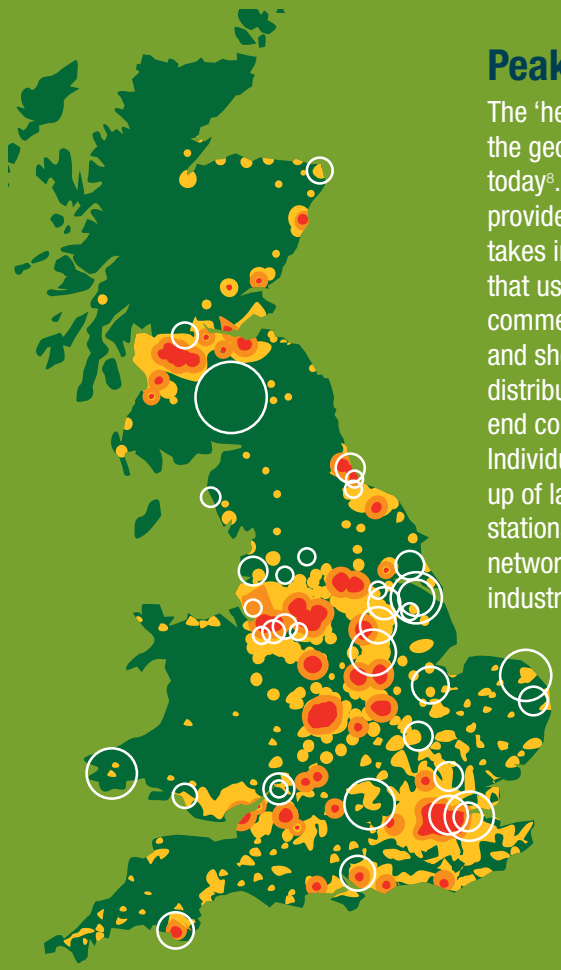
Gas is used to generate significant amounts of electricity at a lower cost compared to other sources of generation[4], mainly through Combined Cycle Gas Turbines (CCGTs); gas produced around 29% of the UK's electricity needs in 2015[5], more than coal, nuclear or renewables individually.

35%

It is also essential for our manufacturing industry, with some 35% of gas providing heat and feedstock for industrial processes such as chemical refineries.[6]

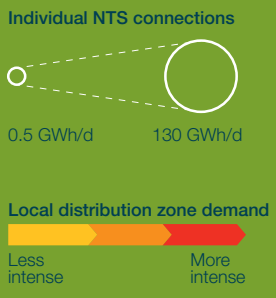
90%

Importantly for households, gas provides around 90% of our home heating, hot water and cooking needs[7].



Peak day gas demand

The 'heat map' on the left illustrates the geographical demand for gas in GB today[8]. It shows where the gas networks provide gas across the country. This takes into account all the sectors that use gas: domestic, industrial, commercial and electricity generation, and shows how the transmission and distribution systems are used to meet end consumer demands all over GB. Individual NTS connections are made up of large industrial sites and power stations, and the local distribution networks demand include commercial, industrial and domestic.



Transmission today

The National Transmission System (NTS) for gas is a series of high-pressure transmission pipelines transporting gas from import terminals and onshore fields to the lower pressure distribution networks that supply businesses, households and large users such as power stations. National Grid is responsible for the physical transportation of gas across GB, performing a similar function to the motorways on Britain's road network. The NTS is essential in ensuring gas is safely and reliably supplied to over 23 million end consumers connected to the gas networks today, with 60,000 new end consumers connecting every year[9]. The NTS is very resilient and provides significant amounts of storage that allows it to meet the very large swings in demand both during the day and across the seasons[10].

Underpinning the GB gas regime is one of the most liquid gas markets in Europe, known as the 'NBP' (National Balancing Point). This sets one price for all wholesale gas in GB, regardless of where it has come from. The NBP provides the opportunity for market participants to trade gas at any point from a number of years in advance right up until the end of each day. There is a high level of competition between traders within the NBP which ensures the best wholesale price, and therefore the best value for consumers.

GB has a number of diverse sources of natural gas supplies: from the North Sea, on and offshore storage, interconnecting pipelines with Europe and global supplies of liquefied natural gas (LNG) brought to GB by ship. A factor that determines the location of supply is the global and NBP gas prices: as NBP prices vary, NTS customers have the flexibility to decide what source of gas to use and the volumes to put in at each entry point in order to supply GB up to the limits of the transmission network's capability. National Grid, in turn, operates the network to balance the supply and demand mix between customers putting gas in and taking gas out of the NTS, and we undertake maintenance and improvements to our network to maintain security of supply for end consumers, while providing flexibility to our customers.

FES 2016 predicts a general reduction in overall demand for gas in the future, but the number of domestic gas connections is currently increasing each year which shows strong continuing consumer demand. FES 2016 still shows a need for gas to meet GB's energy demands at least out to 2050. We want to make sure we adapt the system and how we operate it so that it can enable and meet the needs of our customers and stakeholders in the future.

03 The challenge of decarbonisation

Decarbonising the UK's energy

A major challenge facing our energy system is the need to decarbonise. The Climate Change Act 2008 requires the UK to have reduced carbon emissions by at least 80% by 2050 from 1990 levels. This needs to be achieved while maintaining security of supply and providing energy at lowest cost to consumers.

In recent years the UK has seen rapid growth in renewable electricity sources like wind and solar. Progress to decarbonise the heat and transport sectors has been slower[11], even though carbon emissions from existing homes need to be significantly reduced by 2050. Gas, as the cleanest fossil fuel, releases 50% less carbon dioxide than coal and 20-30% less than oil[12]. However the carbon intensity of gas means there is a need to review the role it can play in delivering decarbonisation.

The decarbonisation of heat is a significant challenge and one that is likely to have a number of different potential solutions, even varying by region. We see the gas system as the network to facilitate and connect this patchwork of solutions.

Full electrification of heat is an option that could significantly reduce carbon emissions from heating, depending on further decarbonisation of electricity generation[13]. However, studies show that full electrification of heat is challenging[14] as it would have a high impact on consumers due to:

- The costs associated with the huge investment required to increase GB's electricity infrastructure. A recent KPMG study showed a total cost of £274-318bn, and estimated that the cost to consumers would be two and a half to three times more expensive than keeping gas within a decarbonised system[15];
- Higher consumer bills, as electricity costs around three times as much as gas (gas costs around 5p per unit whereas electricity costs around 15p per unit[16];
- The challenges associated with heat pumps, which take up more space than gas boilers, installations are disruptive and higher buildings efficiency is essential for them to work effectively; and
- The fact that electricity alone is unable to meet GB's peak winter heating needs based on predicted capacity levels.

	Gas (for heat)	Electricity
Annual energy delivered (TWh)	675	350
Peak demand (GW)	300	60
Storage duration (h)	900	9
Storable energy (GWh)	50,000	27
Storage cost (£/MWh)	30	>60,000 120,000 – 1,400,000

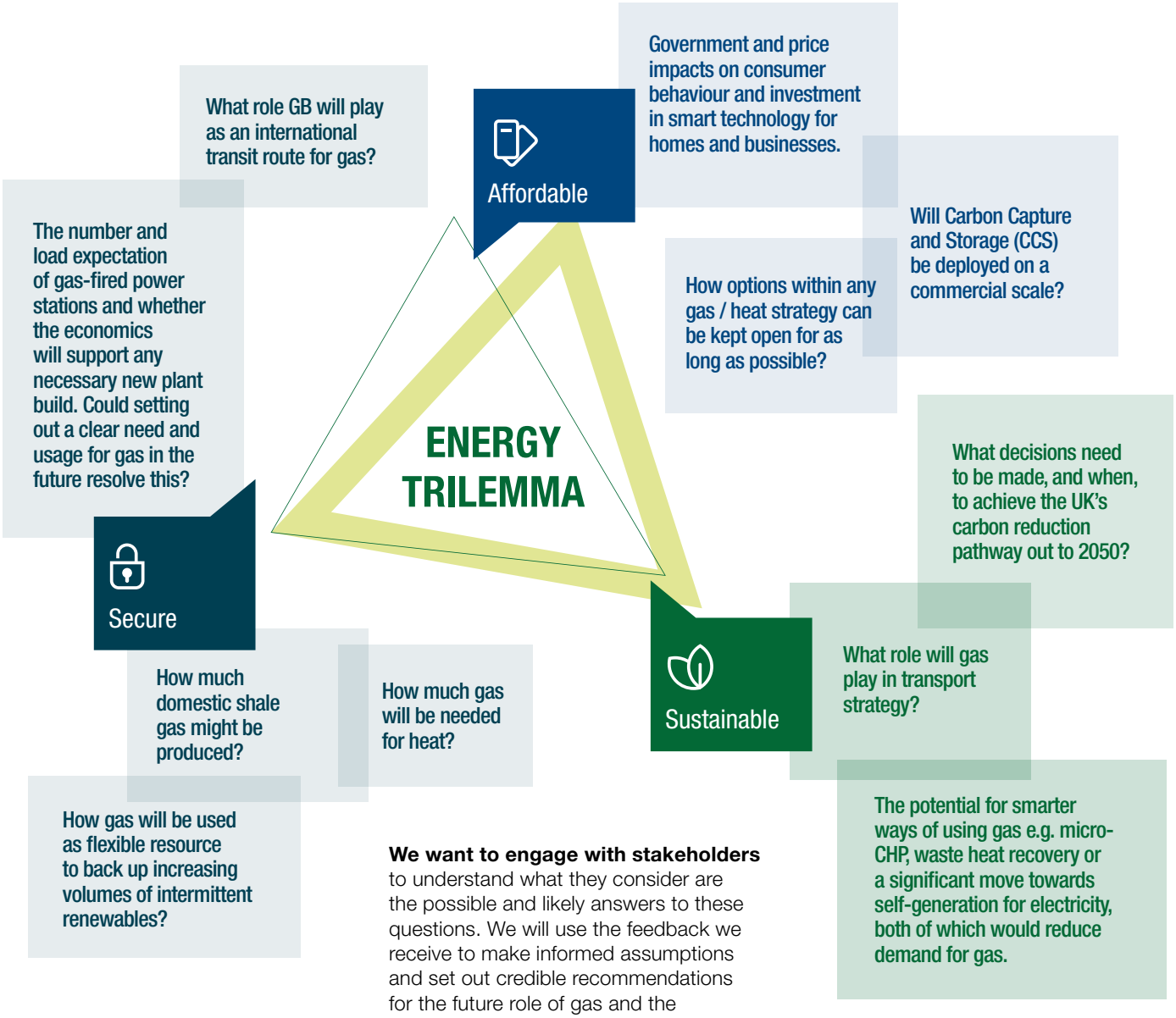
Table 1. Comparative statistics of the gas and electricity systems

This table, from a recent report by Imperial College London[10] shows that gas currently delivers around five times more peak demand than electricity. The table reflects the current costs if electricity storage was chosen to replace gas storage to balance, or partly balance supply and demand. There are other means of achieving this, although more limited for large scale or seasonal variations.

We therefore believe that the options for gas to continue to play a key role in the future need to be further explored.

The challenges for the energy industry

Despite the recognised need to clarify the future of gas, there are significant challenges for the Government, Ofgem, National Grid and the wider industry in agreeing the role that gas should play in the future. There are questions around:



We want to engage with stakeholders to understand what they consider are the possible and likely answers to these questions. We will use the feedback we receive to make informed assumptions and set out credible recommendations for the future role of gas and the transmission system.

04 Gas and transmission in the future

National Grid is committed to adapting its system to meet the needs of the future at the best value to end consumers. There are multiple reasons to support the idea that gas will be crucial for providing secure energy supply at the best value for consumers while we transition to a low-carbon future:

A: Supply of gas is abundant

Global gas supplies are cheap and plentiful (enough for 250 years of global gas demand)[17].

GB has sufficient gas infrastructure to supply around 128% of current peak forecast demand for this winter[18].

Additional domestic sources are emerging e.g. shale gas, hydrogen, biomethane and bioSNG.

B: Low gas wholesale price

In recent years the gas wholesale price has been low. Global supply has increased through shale and LNG exports and is expected to increase further. While many factors influence the wholesale cost of gas it is not expected that market conditions will result in increased priced in the short to medium term.

C: The NTS and supporting infrastructure is already available

Consumers have already invested significantly in each part of the network: from the NTS through to the heating system in their homes. Any alternative heating system would involve significant individual and collective costs.

Consumers are comfortable with gas and there is some opposition to moving away from it[19].

D: Gas provides a flexible source of electricity

Natural gas is flexible enough to produce electricity quickly to cover the variability of renewable generation.

E: Gas demand for transport

Gas is increasingly being used as a cleaner and more economical option for heavy goods vehicles, public transport, and marine and rail transport. Increased use of gas for transport rather than diesel will reduce nitrous oxide emissions and improve air quality[20].

F: Gas demand for specialist industries (e.g. chemicals, ceramics)

Gas will continue to be used by specialist industries while alternatives are being researched and developed.

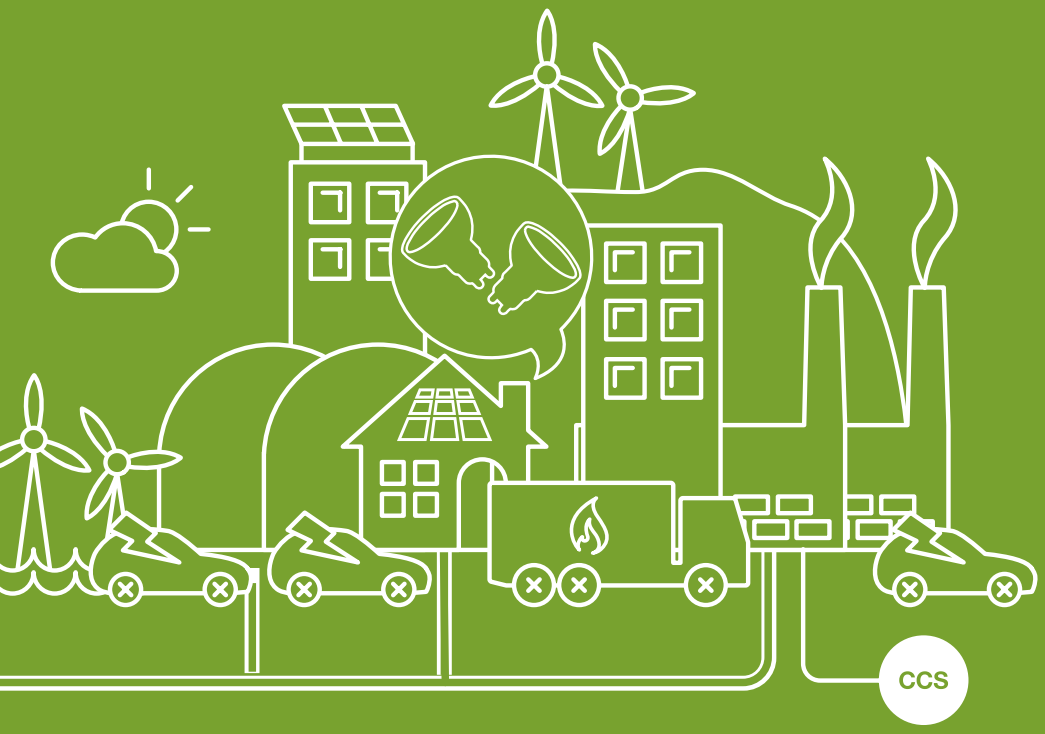
Our FES publication considers the potential changes to the demand and supply of energy out to 2050. The scenarios are created through data collection and stakeholder engagement, with 326 stakeholders contributing to FES 2016. While not all the scenarios reach the 2050 carbon emissions target, the stakeholder feedback underpinning the analysis suggests that gas will remain a significant source of heating out for decades to come. Approximately 90% of consumers would only be willing to change their heating if it makes financial sense, if there is funding available or if their system is coming to the end of its life[21], and we've already noted that around 60,000 new consumers connect to the gas networks every year, predominantly driven by new home developments. This suggests that the NTS will continue to be critical in ensuring the ability to move gas around the country to get to where it is needed.

As referenced in the foreword, there is a growing belief that gas can, and should, continue to play a significant role; and that, if planned correctly, it can help the UK to decarbonise in the most cost-effective way. For example, CCS is a technology that can enable the continued use of natural gas, as recognised in Lord Oxburgh's recent report[22]. Additional reports state that the costs of achieving the 2050 carbon emissions target will be 50-100% higher without CCS[23]. We would be interested in hearing your views on the role of CCS in the GB's future.

05 Innovation

Flexible for the future

Innovation is essential to ensure that gas and the transmission system can adapt to meet the needs of the future. In this section, we will set out a snapshot of the innovative projects that National Grid is already involved in to become more flexible for the future, as well as a summary of the key new and potential technologies that could have an impact on the role of gas and therefore an impact on the transmission system. As our insights develop we will provide an overview of stakeholder views on these innovations and what impacts they may have on the use of gas and the transmission system.



As National Grid looks towards the next decade and beyond, the NTS and our market frameworks and operation will need to be able to respond to and cater for an ever-evolving energy system, by:

- Enabling cheaper, faster and simpler connections for indigenous shale and biogas;
- Reducing unnecessary barriers to entry for new technologies, such as hydrogen, that can reduce our overall carbon footprint;
- Remaining an attractive and competitive market for imported gas;
- Being able to distribute gas across the country;
- Responding quickly to our customers' needs; and
- Continuing to provide an attractive route to deliver imported gas to mainland Europe and Ireland.

National Grid is already leading and supporting a number of projects to adapt our transmission system for the future:

Customer Low Cost Connections (Project CLoCC)

Through this project we are helping customers by minimising the time and costs required to connect to the transmission system. The objective is to halve the costs and reduce the time to connect from three years to one year.

We're fundamentally challenging every aspect of the connection process, so that we can deliver a better customer experience and offer more choice.

You can find out more at **www.ProjectCLoCC.com**

Gas quality

The current gas quality limits defined in UK legislation[24] were set in 1996. Since then there has been a significant shift in the sources of gas available to the GB market, with differing gas qualities that may need to be processed before it can enter the transmission system (e.g. LNG).

We are involved in an industry exercise to launch a review of the legal limits for GB gas quality, while ensuring it remains safe and of a high quality. The focus is on widening the set limits to open up our gas market to more diverse sources of gas.

A change to gas quality legislation is likely to deliver benefits to consumers through reducing costs in the GB market for imported gas; for example, it is likely to minimise costs associated with processing gas to meet our legal limits, which is currently the case. This would maximise the potential use of the transmission system, therefore reducing the risk of stranding assets that have already been invested in by GB.

Charging review

Building on Ofgem's Gas Transmission Charging Review (GTCR), concluded in November 2015, we are undertaking a gas charging review with the aim of:

- Achieving cost-reflective charging for network usage;
- Ensuring a clear and cohesive National Grid / industry approach to implementing changes to ensure the charging regime is fit for purpose for the next 10 years;
- Addressing multiple charging issues for industry in one broad review rather than on a piecemeal basis; and
- Developing and implementing an EU compliant framework, aligned with and potentially in advance of EU Tariffs Code changes (currently mandatory but dependent on Brexit negotiations).

We want to have a charging framework that fits with how the NTS is used and is expected to be used in the future; helping with the efficient access to, and use and operation of, the NTS for Network Users.

New and emerging sources of supply, innovations and technologies

Outlined below is an overview of some of the technologies that may have an impact on the NTS in the future. We want your views on the technologies you think will gain the most traction and to what scale; will they most likely be regional solutions or have more widespread adoption; what drivers may lead to a connection to the transmission or distribution system; what are the potential impacts on gas quality; and are there any implications for commercial charging regimes?

New sources of gas

Renewable gas

Biomethane and BioSNG are renewable gases. Biomethane is generated from organic material via anaerobic digestion, and is predominantly methane. BioSNG takes waste and processes it to make a gas that can be used the same way as natural gas is for heating and cooking. A National Grid distribution project is underway to test this concept[25]. Typically, Biomethane connects at the lower pressures associated with the distribution networks (DNs) and therefore offsets the demand for transportation through the NTS. However, Biomethane gas supply is currently very low at 0.1%[26] of total gas supply and it is not expected to increase at a rate that will change the role of the NTS as the predominant supplier of gas.

The BioSNG process allows for waste to be stockpiled for use at a later date: one tonne of waste is able to generate 2.8MWh of BioSNG. This is similar to how coal-fired power stations have created large quantities of coal reserves which can be easily converted into energy when required to meet demands.

Shale gas

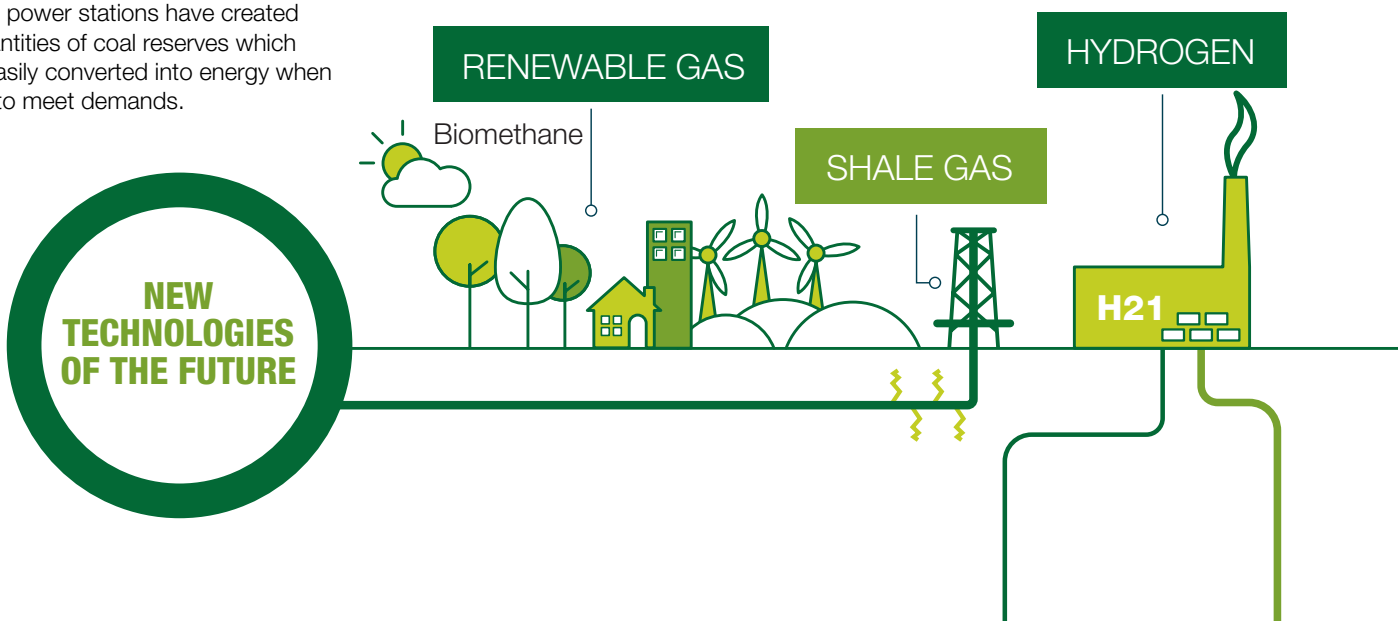
Shale gas is a natural gas found in shale rock. It is extracted by injecting water, sand and chemicals into the rock to create cracks or fractures so that the shale gas can be extracted. There is significant uncertainty as to the size, timing and likely location of connection of shale to the GB gas networks. There is potential for shale to connect into both the transmission and distribution networks (DNs). If the DNs convert to hydrogen in the future then shale would have to connect to the NTS.

Hydrogen

Significant research is already underway in the industry around the viability of hydrogen as a fuel to provide heat and hot water to homes and businesses. The H21 project[27] run by Northern Gas Networks has looked at the potential to convert Leeds from natural gas to hydrogen.

Burning hydrogen leaves no carbon footprint and therefore the only by-product at the point of use is water. However, hydrogen is not naturally occurring so has to be industrially produced. The two most popular ways of producing hydrogen are steam methane reforming and electrolysis.

Steam methane reforming takes natural gas (supplied through the transmission system) and steam to produce hydrogen. Carbon dioxide is a by-product of this process, so CCS is needed for hydrogen to be an option for decarbonising gas (CCS is explained on p.13). Leeds H21 demonstrates how combining these technologies could be an effective method of completely decarbonising gas going directly to consumers through the distribution networks. Electrolysis is a process that splits out oxygen and hydrogen from water; it doesn't require CCS, but it is a very expensive process.



Heat Provision

District heat networks

The majority of GB housing stock currently has a traditional heating system, where each home has a unit capable of generating its own heat and hot water. In a heat network a number of buildings and homes are provided with heat and hot water from one central source.

The UK Government has set aside £320m in this Spending Review to stimulate development: £300m for district heat networks; £20m for recoverable heat (e.g. from waste). Currently such networks can run on a range of heat sources including geothermal, industrial heat waste, biomass, heat pumps, and Combined Heat and Power (CHP) plants, so they could have a heating source that is not natural gas.

Heat networks currently provide around 2% of heat demand for buildings in the UK[28], and there are questions around how much more they could provide.

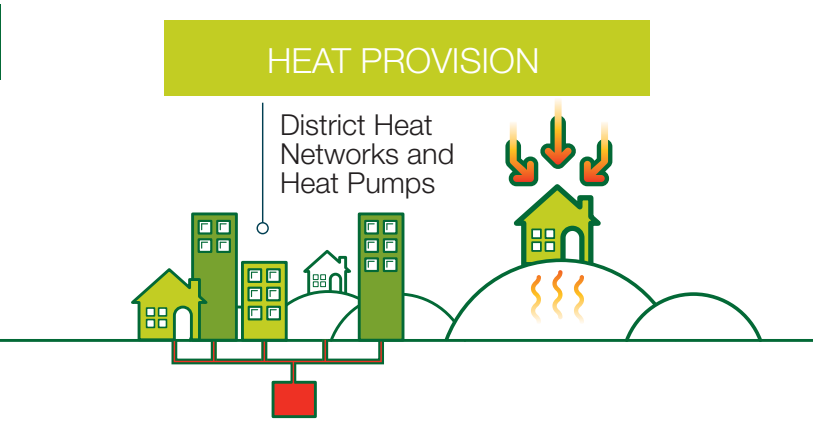
Heat pumps

Heat pumps can be either air source or ground source. Air source heat pumps absorb heat from the outside air, and this heat can then be used to produce hot water or space heating; ground source heat pumps absorb heat from the ground.

Ground source heat pumps are highly energy efficient systems using electricity to generate heat. However, while low cost to run, they tend to come with a high upfront cost and they require energy efficient buildings to be effective. The government has provided businesses and homes with support to install this technology through the Renewable Heat Incentive (RHI), which helps with the cost of installing and running the system. Nevertheless, take up for the technology has been low to date.

Air source heat pumps are typically cheaper to install than ground source and have therefore seen a greater uptake. Even with their efficiencies, a backup heat source is still likely to be needed for the coldest days.

Hybrid heat pumps are heating systems that use a combination of an electric heat pump and a gas-fired boiler to supplement heating requirements at peak times.



Emerging technologies

Carbon Capture and Storage (CCS) / Utilisation (CCU)

CCS is a technology that can capture the carbon dioxide emissions produced from the use of fossil fuels in electricity generation and industrial processes, preventing the emissions from entering the atmosphere. CCS consists of three parts: capturing the carbon dioxide, transporting the carbon dioxide, and securely storing the carbon dioxide underground. While CCS at scale is not yet developed in the UK, it is proven at large scale in a number of countries and for different purposes.

CCU converts carbon dioxide into commercially viable products such as bio-oils, chemicals, fertilisers and fuels. These could replace fossil fuel based products further reducing greenhouse gas emissions and improve waste treatment. The technology is not yet commercialised on a large scale and therefore needs more research and development.

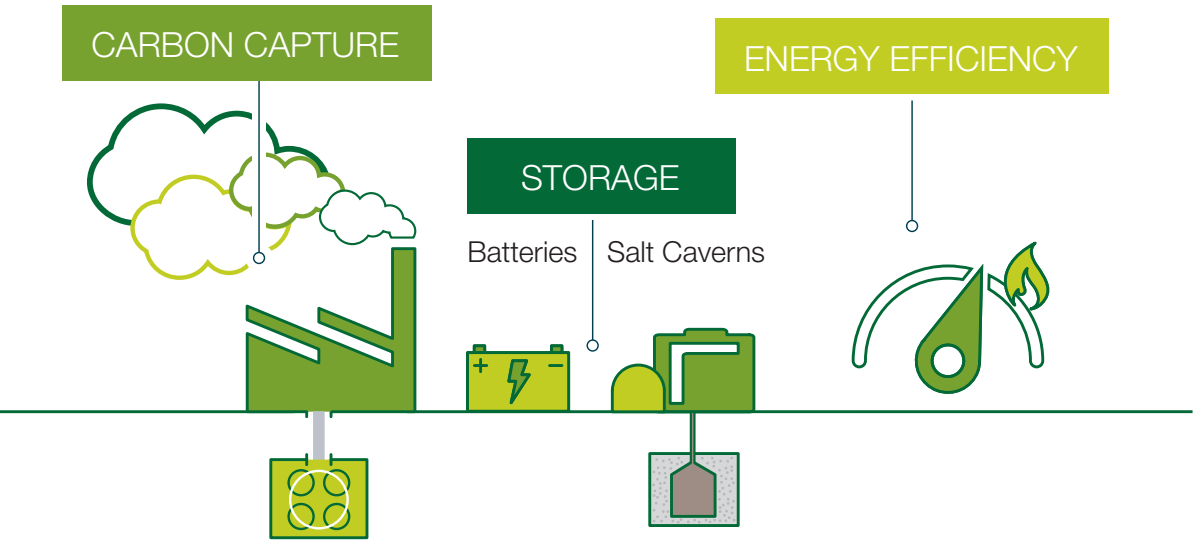
Batteries

Electricity storage technology is an area that has the potential to change the energy market. If a solution is found to make large-scale storage economic, it will likely allow greater storage of renewable energy, meaning it can be used when it is needed rather than purely at the time of generation. This technology has the potential to reduce the need for gas-fired generation to smooth the intermittency of renewable generation, although it is uncertain how rapidly this technology will be deployed.

There are a number of developments within the home battery market, with commercial products becoming available to store solar power generated in the day for discharge through periods of high demand and during the evening. The technology has the future potential to enable home owners to move off the electricity grid and manage peak heat demand. The implications of this emerging technology on domestic gas heating is uncertain at this stage, but it has the potential to reduce demand either from existing connections or in terms of new gas connections.

Smarter usage of gas

In respect of heat, the introduction of low-carbon alternatives are likely to be more expensive than the energy delivered through the gas market today, so focusing on energy efficiencies for housing and industry would reduce low-carbon supply requirements and reduce energy costs to consumers. The introduction of energy-saving initiatives could be achieved through promoting progressive A++ standards (dis-incentivising energy-intensive products), progressive building regulations and advances in smart metering and intelligent appliance technologies.



The potential for these new technologies and sources of gas means that National Grid needs to understand all the different local solutions that may develop across GB. National Grid's role is to ensure consumers have continued access to affordable, reliable and sustainable energy sources. As our analysis develops we will be looking at a range of innovation options and will provide further views in later reports, including where we feel there is a role for National Grid to lead or support projects.

06 Optimising the transmission system

As the previous sections make clear, the transmission system needs to adapt in order to meet the different requirements of the future. Through this engagement programme we aim to identify solutions for our future assets, system operability and commercial arrangements that fulfil the requirements of our customers and keep costs as low as possible.

Assets

The gas transmission assets are aging. With all assets there comes a point where it is more economical to replace them rather than maintain. To determine that point, there is a need for any asset management company or industry to assess the expected needs of customers in the future in terms of demand, service and performance of its assets.

The actual sources of supply and demand points on the network will be vital in determining when and where to invest.

System operability

Our customers are changing the way they want to use the NTS as they require increased flexibility. In order to accommodate these changes we need to understand and quantify the opportunities and risks that these changes, in the form of requirements, may have on NTS capability and operability.

We are beginning to see a number of operability challenges, such as changes in sources and volumes of gas supplies at different GB entry points causing changes to the direction of gas flows in the system. We are also aware that customer requirements are going to continue to change. For example, the way CCGT generators' operate is expected to become more unpredictable as their requirement to generate will be increasingly linked to more variable renewable generation (wind, solar etc.).

Regulatory and commercial arrangements

The current commercial and governance arrangements in GB's gas market are structured in a way that facilitates long-term growth and investment. FES 2016 and other industry studies indicate that, as demand for gas is unlikely to increase, the level of significant additional entry investment required could be low. In the changing energy landscape the existing gas market regime and commercial framework may no longer accurately reflect our customers' behaviours, and therefore may not be providing National Grid with the operational signals that best reflect the network services and products that our customers are looking for.

Moving towards investing in a more dynamic and flexible gas network would represent a potentially significant move away from the way the gas industry operates and interacts with the electricity market today. We need to consider how we align the gas regime and commercial arrangements to best meet GB's future energy needs, and to provide the services that customers want and are willing to pay for. Project CLoCC demonstrates our commitment to facilitating improved services and reduced costs in the area of connections, with potential for further projects in the future.

Gas Future Operability Planning (GFOP)

In order to aid us in understanding and adapting the operability of the network to meet our customers' needs we are introducing a process called **Gas Future Operability Planning (GFOP)**. We are publishing our first edition of the GFOP on 30 November 2016 alongside our annual Gas Ten Year Statement (GTYS). Our first edition is a building block for future GFOPs and provides an outline for what the document could look like.

The GFOP document will:

- Provide a route for our customers to tell us what they think might happen in the future and how their use of the NTS might change;
- Enable us to better articulate the longer-term physical capability requirements and operability opportunities / challenges that National Grid sees could affect the wider energy community; and
- Provide a focus on longer-term uncertainty and the possible impact(s) on the transmission network.

http://nationalgrid.com/gtys
http://nationalgrid.com/gfop

Questions we want your help in considering

The way we use and source gas is changing and expected to change further. New domestic sources of gas are developing such as shale, biomethane and hydrogen, and there is potential for increasing interaction between electricity and gas. This means that we need to consider a number of fundamental questions to ensure we deliver solutions that meet consumers' needs:

- How should the gas market develop?
- What gas assets will we need in the future?
- How do we manage the changing requirements of assets, commercial frameworks and arrangements to ensure that the NTS and the gas market frameworks are fit for future options?
- What commercial arrangements do we need to consider that encourage the right long term investment from industry parties?
- What services do customers want from the NTS and are willing to pay for?
- What might we need to consider around the option of decommissioning parts of the network?
- Where is it National Grid's role to provide solutions?
- What role does gas transmission play in the future?

Through engagement with interested parties, we are seeking to tackle these questions and produce recommendations to take forward that will best meet the needs of consumers. To do this we will develop four sensitivities, which suggest four potential futures of varying gas demand, and assess the impacts they may have on the transmission assets, system operability and commercial and regulatory rules. This will help us to understand how the operation of the NTS may need to change to meet GB's future energy needs.

07 Sensitivities

We are developing four FOG sensitivities that meet the UK's 2050 target. These build on FES 2016, but aim to show greater variation of gas demand projections to enable us to test the NTS with a wider range. While developing these we want to engage with stakeholders to validate and further enhance the assumptions; to understand what impact they would have on customers and the services customers would require e.g. would there be a requirement for more flexibility and what form could this take? We can then work with you to see how best your future needs could be met through regime change, policy changes or physical investment.

Electric Transformation

Electric Transformation sees the lowest level of gas demand across the transmission system. Within this sensitivity, gas demand is constrained by low investment in CCS. Nearly all gas demand is eliminated from power stations by 2050. The industrial sector significantly reduces their demand for gas too; cleaner light industry that doesn't require high thermal delivery dominates while heavy industry declines. There is a significant drop in gas demand from residential heating: heating is replaced with electrification or more efficient gas appliances, removing two-thirds of demand. This assumes that consumers are willing to change to alternatives. This route to decarbonisation requires significant additional renewable electricity generation and nuclear power to provide a guaranteed baseload.

Balanced Pathway

In this sensitivity CCS-enabled generation is deployed along with nuclear and renewable technologies. There is electrification of heat as in Electric Transformation, but this is supported by more renewable gas, reducing the total requirements for electrification in order to hit the 2050 target.

Carbon Capture

Within this sensitivity, investment in CCS technology is at its most effective, allowing for an abundance of CCS-enabled power generation from gas as well as continued use of gas within the industrial sector. High levels of green gas capitalise on the strength of a well-supported gas network to allow for the lowest penetration of electrification of heat in the residential sector compared to the other sensitivities. Gas is used in the transport sector as a lower carbon alternative to petrol and diesel vehicles, especially for heavy goods.

Hydrogen

Hydrogen production becomes a significant component of the future energy system. Building upon the work undertaken through such projects as Leeds H21 Citygate, hydrogen displaces natural gas in the distribution networks and therefore becomes the main fuel for heating people's homes. This hydrogen is produced at NTS offtakes from natural gas that is transported by the NTS. The methane is converted to hydrogen to feed into the distribution networks to supply homes, once gas appliances have been replaced with hydrogen versions. Industrial demand either uses hydrogen from the gas distribution network or continues to use gas at large sites connected to the NTS. This method also allows for hydrogen vehicles to be easily refuelled across the country. Two key technologies are required to enable this: one is steam methane reforming (already established in the UK) to create hydrogen from natural gas; the other is CCS.

08 Next steps and timeline

This document launches our Future of Gas engagement programme. Its purpose is to provide a high-level view of the challenges and opportunities that need to be considered when determining the role gas can play within an integrated energy future where the UK meets its 2050 carbon emissions target. The intention of the document is to promote discussion on the future role of gas transmission with our customers and stakeholders, in order to help us understand what customers and end consumers' value. These discussions will enable us to identify whether investments are required, and the nature of any investments; this will enable us to identify innovative ways to adapt our commercial arrangements.

Our customer seminar on 29 November 2016 will focus on the Future of Gas. Following that, we will set up a series of workshops to test our analysis as it develops and get input from customers and stakeholders, to inform our sensitivities and development and publication of further insights.

We aim to publish our developing analysis and thoughts from this engagement in a Spring document.

9 Have your say

In developing our understanding of what role gas transmission should play in the future of energy in GB, it is important to us that we fully consider our customer and stakeholders' future energy needs and concerns. To this end we hope that our FOG customer and stakeholder engagement programme will provide the opportunity for you to share your views and expertise, to inform the development of a clear view of how gas transmission may need to change to meet GB's future energy needs.

We are holding a customer seminar on 29 November to mark the launch of our engagement programme. In preparation for the seminar we have compiled six high level questions (detailed to the right), which reflect a range of topics we have covered within this document and which we would be very interested to hear your thoughts on.

During the following months we would like to schedule further workgroups and 1:2:1 development and discussion groups to test our developing analysis and recommendations.

We have also launched a microsite to act as a hub and bring views on this topic together in one place. It will include links to relevant studies and reports and will regularly feature articles from various commentators, not necessarily reflecting National Grid's views. We want to facilitate an open discussion about the future of gas in order to inform our plans for the gas transmission system.

Customer seminar discussion questions

1. **How do you expect supply of gas to change? How do you expect demand for gas to change?**
   - How will this impact your business?
   - How can we help?
2. **How do you think the way you use gas transmission might change in the future?**
   - How do you see the wider role of gas transmission changing?
   - How will new technologies impact the way you operate?
   - Will this change the way you want to use the NTS?
3. **How do we ensure that the GB gas market remains attractive into the future?**
   - How will we compete with the European and global markets?
   - How should the market change to support security of supply in the future?
4. **How can we decarbonise gas?**
   - Are there alternatives to CCS?
   - For how long will gas remain relevant?
5. **Will our current commercial arrangements for gas be fit for purpose in a future energy market?**
   - In the future what services and products do you want from the NTS?
   - What changes in our commercial arrangements are needed to deliver the products and services that you want?
6. **Where do you need certainty to make investments?**
   - What Government policies and commercial arrangements need to be considered that encourage the right long term investment from industry parties?

Continuing the Conversation

If you would like to get involved in the FOG customer and stakeholder engagement programme or share your views on any of the questions we have asked in this document please contact: *www.futureofgas.uk/contact #futureofgas*

To get involved in the debate on the Future of Gas join our Linkedin group at: *'Future of gas' https://www.linkedin.com/groups/8435517*

Access our National Grid Future of Gas documents and industry-wide Future of Gas related documents, data and multimedia at the microsite: *http://futureofgas.uk/*

References

1. http://www.eti.co.uk/insights/the-evidence-for-deploying-bioenergy-with-ccs-beccs-in-the-uk

https://policyexchange.org.uk/wp-content/uploads/2016/11/PEXJ4810_Too_hot_to_handle_09_16-V2-WEB.pdf

https://www.theccc.org.uk/wp-content/uploads/2016/10/Next-steps-for-UK-heat-policy-Committee-on-Climate-Change-October-2016.pdf

http://www.energynetworks.org/gas/futures/the-uk-gas-networks-role-in-a-2050-whole-energy-system.html

2. http://fes.nationalgrid.com/

3. https://www.gov.uk/government/statistics/energy-chapter-1-digest-of-united-kingdom-energy-statistics-dukes ("Primary Energy Demand" from "1.1 Aggregate energy balance 2015" in "Aggregate energy balances – alternative units, petajoules & terawatt hours (DUKES 1.1-1.3au)")

4. Gas (CCGT) with a 50% load factor is about 33% cheaper than Nuclear, 40% cheaper than offshore wind and 50% cheaper than Solar PV

5. https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/540135/UK_Energy_in_Brief_2016_FINAL.pdf

6. https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/541163/ECUK_2016.pdf

7. http://fes.nationalgrid.com/ p.46

8. Internal data from 20th January 2016 (highest gas demand day over winter 15/16)

9. National Grid, 'The Future of Gas: Delivering for our Customers' (December 2015), http://www2.nationalgrid.com/UK/Industry-information/Future-of-Energy/Gas/

10. http://provpol.com/wp-content/uploads/2016/05/Heat-infrastructure-paper.pdf

11. https://www.theccc.org.uk/wp-content/uploads/2016/06/2016-CCC-Progress-Report.pdf

12. https://www.eia.gov/tools/faqs/faq.cfm?id=73&t=11

13. http://www.icax.co.uk/Decarbonising_the_Grid.html

14. https://policyexchange.org.uk/wp-content/uploads/2016/09/too-hot-to-handle-sept-16.pdf

15. http://www.energynetworks.org/news/press-releases/2016/july/kpmg-report-analyses-long-term-role-of-gas-network-in-the-future-of-heat.html

16. https://www.fortisliving.com/saving-energy (Sept 2014 figures)

17. http://www.worldenergyoutlook.org/media/weowebsite/2011/WEO2011_GAG_FactSheet.pdf

18. This depends on the configuration of supply and demand. Data from National Grid's Winter Outlook 2016 http://www2.nationalgrid.com/UK/Industry-information/Future-of-Energy/FES/Winter-Outlook/

19. http://www.energynetworks.org/assets/files/gas/futures/Delta-ee_ENA%20Final%20Report%20OCT.pdf

20. http://www.cleanairpower.com/about.html

21. http://www.smarternetworks.org/Files/Bridgend_Future_Modelling_%E2%80%93_Phase_2_150910144351.pdf

22. http://www.ccsassociation.org/news-and-events/reports-and-publications/parliamentary-advisory-group-on-ccs-report/

23. http://www.eti.co.uk/programmes/carbon-capture-storage

https://www.theccc.org.uk/2016/09/12/ccc-welcomes-renewed-interest-in-carbon-capture-and-storage-ccs-technology/

24. Gas Safety (Management) Regulations 1996 http://www.legislation.gov.uk/uksi/1996/551/contents/made

25. http://www2.nationalgrid.com/UK/Our-company/Innovation/Gas-distribution-innovation/NIC-Projects/BioSNG-Process-Diagram/

26. FES 2016 underpinning analysis

27. http://www.northerngasnetworks.co.uk/wp-content/uploads/2016/07/H21-Report-Interactive-PDF-July-2016.pdf

28. https://www.gov.uk/government/consultations/consultation-on-ensuring-regulation-encourages-innovation

For more information about how to get involved please contact us at **www.futureofgas.uk/contact**

The papers will be published online at **www.futureofgas.uk**

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