PRESSURE IN THE PIPELINE

Decarbonising the UK's gas

Wilf Lytton and Ryan Shorthouse

bright blue

Pressure in the pipeline

Decarbonising the UK's gas

Wilf Lytton and Ryan Shorthouse

bright blue

Bright Blue is an independent think tank and pressure group for liberal conservatism. Bright Blue takes complete responsibility for the views expressed in this publication, and these do not necessarily reflect the views of the sponsor.

Design: Chris Solomons, Wilf Lytton

First published in Great Britain in 2019

by Bright Blue Campaign
ISBN: 978-1-911128-13-7

www.brightblue.org.uk

Contents

	About the authors	2
	Acknowledgements	3
	Executive summary	4
1	Introduction	20
2	Methodology	39
3	The history of and projections for decarbonisation of UK gas	41
4	Technological solutions for decarbonising UK gas	56
5	Minimising prices for consumers whilst decarbonising gas	74
6	New policies	88
	Annex: Written evidence	99

About the authors

Wilf Lytton

Wilf is a Senior Researcher at Bright Blue, covering energy and environmental policy. His work has been featured in *BusinessGreen*, *ConservativeHome*, *Der Spiegel*, *Euractiv* and *The Ecologist*.

Ryan Shorthouse

Ryan is the Founder and Chief Executive of Bright Blue. Under his leadership, it has grown significantly in size, reputation and impact. The organisation has been shortlisted for the 2016, 2017 and 2018 UK social policy think tank of the year and UK environment and energy think tank of the year in the prestigious annual Prospect Magazine awards. Ryan was named as 'One to watch' in 2015 by *The Observer*. Many of his policy ideas have been adopted by the UK Government over the past decade. Ryan was previously a Research Fellow for the think tank the Social Market Foundation and was part of the team that won *Prospect Magazine's* Think Tank of the Year in 2012.

Acknowledgements

This report has been made possible with the generous support of the Energy Networks Association. The views expressed in this publication do not necessarily reflect the views of the sponsor.

We would like to give special thanks to Philip Box and Sam Hall for their research and thinking for this report.

We would like to thank Matthew Hindle for his advice and support throughout. We are also grateful to Grant Wilson, Guy Newey and Paul Blacklock for their thoughts and advice on this report.

Executive summary

Today, the UK's gas network is instrumental in delivering a cheap and reliable source of energy to meet the needs of households, the power sector and businesses. It has played a significant role in enabling the transition away from coal-burning in the energy system.

The main type of gas that is used in this country's gas network is natural gas - a fossil fuel that consists primarily of methane. However, there is a very small proportion of biogas, which is entirely renewable.

As Chapter One explains in detail, the gas which enters the gas network comes from a variety of domestic and international sources, including: North Sea gas fields; liquefied natural gas imports; interconnectors from continental Europe; and, UK-based biogas plants.

Gas suppliers provide the gas that enters the National Transmission System (NTS), manged by National Grid. Branching off from the NTS, and managed by the Gas Distribution Network Operators, are regional gas distribution networks that deliver gas to homes, gas power plants and industrial premises where it is burnt to produce energy, or otherwise consumed in chemical processes. The Gas Distribution Network Operators charge energy suppliers - the companies that interface with energy consumers - a fee for maintaining the regional gas distribution network infrastructure.

In 2016, emissions from the combustion of natural gas were responsible for 35% of the UK's total greenhouse gas emissions, approximately half of which were associated with gas use in the heating sector. The UK's gas network contributes both directly (through a small amount of leakage in the gas network) and indirectly (via gas consumption) to greenhouse gas emissions. Deeper decarbonisation of the gas network is therefore essential if the UK is to meet its current greenhouse gas emissions reduction target of 80% by 2050 compared to 1990 levels, alongside its anticipated future net-zero emissions target.

Gas plays an enormous role in the UK energy system and decarbonising it will be a major undertaking, necessitating changes to the UK gas network on a scale not experienced since flammable gas first arrived in homes. Considering public and political concern with consumer energy prices, this deeper decarbonisation needs to be conducted while keeping gas prices affordable.

Focus of this research and methodology

In this report, we examine the case for and pathways to deeply decarbonise the UK gas network. In particular, the report assesses how to decarbonise both the supply of gas through the pipeline infrastructure and the demand for gas in the electricity and heat sectors. It also evaluates how the deeper decarbonisation of UK gas will impact on consumer gas prices.

This report seeks to answer the following four research questions:

1. Why and how should the supply of and demand for UK gas network be decarbonised?
2. Which technologies are supporting and will support deeper decarbonisation of UK gas?
3. What are the implications of deeper decarbonisation of UK gas on consumer gas prices?
4. Are there new policies that can support the decarbonisation of the UK gas network while minimising costs to gas consumers?

In order to answer these research questions, we employed a number of methods, described in detail in Chapter Two. First, we conducted an extensive literature review of published evidence and analysis pertaining to the gas network in the UK. Second, we consulted with a number of leading academics, experts, decision makers, and representatives of the gas and energy sectors. Third, we organised and hosted an invite-only policy roundtable discussion, which took place under the Chatham House Rule, with leading academics, chief executives, politicians, special advisers and civil servants to devise and brainstorm policies. Fourth, we put out a call for written evidence for our gas network project and received 24 submissions from a range of organisations, which we include in the annex of this report.

These research methods enabled us to identify: the history of and projections for decarbonisation of UK gas (Chapter Three); the technological solutions for decarbonising UK gas (Chapter Four); and, the impact of prices for consumers of deeper decarbonisation Chapter Five).

History of and projections for decarbonisation of the UK gas network

Since the UK's current greenhouse gas emissions reduction target was established in the 2008 Climate Change Act, there have been reductions in emissions associated with natural gas use. This has been achieved in three main ways. First, on the supply-side, the number of gas leaks has declined as a result of the HSE's Iron Mains Risk Reduction Programme (IMRPP). Second, the injection of relatively small volumes of low-carbon biomethane into the gas network from anaerobic digestion plants has marginally reduced the carbon intensity of UK gas. Third, on the demand-side, there has been a significant fall in gas demand in recent years with a 23% fall in annual gas demand across the UK economy since 2000.

Nonetheless, the emissions reductions that have been achieved to date represent a small fraction of the progress in decarbonisation of the gas network that is needed to meet even the UK's current greenhouse gas emissions target. The deeper decarbonisation of the gas network that is necessary is largely contingent on further progress towards decarbonising gas-using segments of the electricity and heat sectors, which are the largest gas-consuming sectors of the economy.

For the heat sector alone, the National Infrastructure Commission estimates that, under the existing greenhouse gas emissions target, annual emissions would need to fall by 90% from existing levels by 2050. To achieve this, a national programme to switch the gas network to low-carbon gas sources would need to begin by 2030 at the latest, according to the Climate Change Committee (CCC), requiring significant lead-in decisions by the mid-2020s.

Pathways to decarbonisation

There are two main pathways – related to gas supply and demand - for deeper decarbonisation of the UK's gas network. These two pathways are not mutually exclusive. They can and both should be pursued

1. **Reducing the carbon intensity of the supply of gas** in the gas network through replacing natural gas with low carbon gases.
2. **Reducing gas demand**, especially in the electricity and heat sectors, by improving the energy efficiency of buildings and gas appliances, and by enabling fuel switching as to shift demand away from the gas network.

Technological solutions will have a vital role in enabling both pathways for deeper decarbonisation of UK gas.

Supply-side technological solutions

On the supply side, low carbon or 'carbon negative' gases can reduce and potentially even eliminate the carbon intensity of gas flowing through the gas network. There are three varieties of low carbon gas in production in the UK today: biomethane, bio-synthetic natural gas (bioSNG) and hydrogen.

Of these, biomethane is the only one that is currently injected into the gas network. Indeed, the UK's biogas industry has seen considerable growth during the last half decade, helped by a supportive policy framework. Since 2013, a small but increasing quantity of biomethane has been injected into the UK's gas network – representing 0.3% of total gas supplied in the UK in 2017 – leading to a modest decrease in the carbon intensity of gas. Recent analysis suggests there is enough biomass feedstock to supply at least 10 terawatt hours (TWh) of biomethane per year to the gas network, although other analysis suggests the potential may be up to ten times this value. The main constraint to increasing the scale of biomethane production is the availability of suitable feedstock, which is largely based on food and agricultural waste, or specially-grown crops.

BioSNG is a product of biomass gasification. The UK currently has one bioSNG demonstration plant which opened in 2018 and is not at present connected to the gas network. The potential for bioSNG is similar to that of biomethane, as are the limitations on its expansion.

The injection of hydrogen gas into the gas network is currently precluded by multiple regulatory barriers and technical constraints within the existing gas network infrastructure. There are two likely scenarios that could emerge for using hydrogen in the UK's gas network: blending hydrogen with natural gas and other renewable gases, or repurposing parts of the gas network to carry up to 100% hydrogen. These are numerous trials taking place in the UK of these two scenarios. Nonetheless, hydrogen production is costly compared to natural gas, making it uncompetitive to use as a low carbon substitute for natural gas at present. However, the supply of renewable hydrogen is plentiful as it can be derived from water.

Biomethane and hydrogen are especially needed to decarbonise the gas network in the coming decades as the use of unabated natural gas becomes increasingly unviable.

Demand-side technological solutions

On the demand side, there are two principal technological options for reducing gas demand: energy efficiency measures and fuel switching.

Energy efficiency measures in residential, commercial and industrial buildings – as well as of gas appliances - can cut heat waste and therefore reduce gas demand. An array of materials and technologies exist to make buildings more energy efficient, most commonly solid wall insulation, cavity wall insulation, loft insulation and double glazing. The National Infrastructure Commission (NIC) identifies low-cost energy efficiency measures as generating potential energy savings of 30 TWh per year, equating to around 6% of total heat demand.

There has already been significant uptake of some energy efficiency measures in UK households, especially double glazing, cavity wall insulation and loft wall insulation. But considerably more progress is needed to achieve the Government's ambition for all UK homes to have a minimum Energy Performance Certificate (EPC) rating of C by 2035. Unfortunately, policies to support the adoption of energy efficiency measures are insufficient, especially since financial support for the Government's Green Deal was withdrawn and the Zero Carbon Homes Standard scrapped in 2015.

There is scope to shift a substantial proportion of demand away from gas through technologies that enable fuel switching, particularly in the heating sector. This includes electrification, district heat networks, biomass boilers, and, solar thermal systems.

- Electrification in the heating sector involves replacing heating appliances that run on gas with those that run on electricity. One common example is air-source and ground-source heat pumps. While these do not contribute directly to greenhouse gas emissions, the electricity they consume may have a carbon footprint. Since electricity prices cost some three to four times those of gas per unit of energy, direct electric heating is considerably more expensive than using gas central heating systems. The potential for this type of technology is limited by the UK's capacity to generate sufficient quantities of electricity and poor economics of electric heating.
- District heat networks function as a system of insulated pipes that distribute heat across a locality from a central source (for example, an industrial plant or combustion process). District heat networks currently supply around 2% of space and water heating demand. However, research by the Energy Technologies Institute suggests they could meet nearly half the UK's heat demand, assuming capital costs can be significantly reduced.
- Biomass boilers burn renewable organic material to produce heat. The upfront costs of installing biomass boilers can be high, ranging from £7,000 to £13,000. The costs and sustainability of biomass varies between different geographies. However, the National Infrastructure Commission (NIC) estimates there is 100 TWh per year of sustainable biomass potential. This is equivalent to a third of domestic gas demand.
- Solar thermal heating – commonly called rooftop solar thermal panels – collect and store the sun's heat energy in water flowing through them. Their installation costs vary between £4,000 to £6,000. However, the seasonal variation in solar gain means that solar heating systems are not a full substitute for other heating systems.

There is disagreement over the exact degree to which each of these technologies may be the most cost-effective alternative to using natural gas. Nevertheless, there is broad consensus that heat pumps will play a prominent role in decarbonising the heating sector, particularly in premises that are not connected to the gas network.

The costs of decarbonising UK gas

Sustained investment is necessary for developing and deploying the technologies for more deeply decarbonising the UK's gas network. This financing will need to be directed towards a portfolio of technologies, rather than just those that are currently the most mature or least costly.

The NIC estimates the cumulative additional costs of decarbonising the heating sector, compared to the status quo, are in the range of £120-£300 billion through to 2050.

Such investments are likely to yield substantial savings for consumers over a longer period, compared to alternative routes to decarbonisation (or inaction), while also providing a host of intangible benefits associated with reducing the impacts of climate change. The falling cost of renewable electricity generation demonstrates that investments paid for by energy consumers have the potential to lower bills in the near future.

However, deeper decarbonisation does raise the costs of the gas network the near-term. There are three principal routes to meet the projected costs of more deeply decarbonising UK gas: asking taxpayers to contribute more; asking billpayers to contribute more; and, broadening the demand for UK gas, which would potentially widen the number of end-users of gas to spread the costs of deeper decarbonisation.

Convincing billpayers and taxpayers to pay more for decarbonising the UK's gas network will be challenging when there is low public trust in energy suppliers. Indeed, the findings of Professor Dieter Helm's *Cost of Energy Review* and a 2016 Competition and Markets Authority (CMA) investigation into the energy market suggest that consumer prices for energy at present are higher than they should be. Political aversion to further energy price increases, as evidenced by the introduction of an energy price cap earlier this year, may also make it harder to pass on the costs of decarbonisation to consumers.

It is very important that policy support and incentives are put in place to reduce the financial impact on billpayers and taxpayers. Fortunately, there are numerous ways in which this can be done, particularly for low-income households for whom the consequences of price hikes are more pronounced. Chief among these are through promoting tariff switching and energy efficiency measures.

New policies

In Chapter Six, we make eight policy recommendations. These policies seek to provide the necessary investment and incentives from government to enable the technological soloutions for decarbonising the demand for and supply of UK gas, whilst mitigating price increases on billpayers and taxpayers.

The policies we propose stem from three fundamental principles. First, that they are evidentially grounded: policies must be introduced, implemented and adapted according to robust evidence. Second, that they are fiscally realistic: however, climate change is an urgent threat that has costly implications for the UK so this report does not shy away from proposing policies that carry a realistic cost. Third, that they support market-based solutions: in other words, they should not be too prescriptive as to create unintended consequences, such as market distortions, under-investment, reduced competition, or regulatory burden.

Policies to reduce demand for gas

Recommendation one: Make decarbonisation of UK gas a priority for Ofgem in the next price control framework from April 2021, including by increasing the available funding through the 'Network Innovation Competition' and 'Network Innovation Allowance'.

The Gas Distribution Network Operators are subject to a Regulated Asset Base (RAB) model, which is a form of economic regulation designed to ensure that relevant actors operate efficiently and deliver value for money to consumers. A key part of this model is the price control framework.

The price control framework for after the current period which ends in March 2021, RIIO-2, is currently under review. This presents an opportunity to realign incentives to support upgrades to gas network infrastructure that paves the way for low carbon gas. RIIO-2 should incentivise Gas Distribution Network Operators to invest in delivering infrastructure to support low carbon gas and installing smart pressure controls to optimise the distribution of low carbon gas.

RIIO-2 should promote and reward the provision of technologies that support fuel switching, both within the gas network and by consumers. It could do this, for example, by enabling the deployment of network-connected electricity-to-gas technologies by third parties. And through measures to incentivise hybrid heating systems in buildings.

Similarly, funding available for all organisations in the gas network through Ofgem's 'Network Innovation Competition' and 'Network Innovation Allowance' should be increased to a level that is appropriate to meet the requirements of a more deeply decarbonised gas network.

Recommendation two: Amend the Gas Safety (Management) Regulations and the Gas (Calculation of Thermal Energy) Regulations to enable a higher proportion of low carbon gases to flow in the gas network.

Under existing regulations, there are restrictions on low carbon gases – especially hydrogen – being used in the gas network. These restrictions arise from two regulations: first, the Gas Safety (Management) Regulations, which only permit up to 0.1% hydrogen (by volume) in the gas network. Second, the Gas (Calculation of Thermal Energy) Regulations, which include Calorific Value (CV) requirements regarding the composition and price of gas, limit the use of different low carbon gases in the gas network. Biomethane suppliers, for example, must add propane to their feed in order to increase the CV of gas they supply to the network.

A higher proportion of hydrogen in the gas network is highly likely to be permissible in the near-future, if a growing number of trials prove its safety and effectiveness. Currently, several European countries permit varying levels of hydrogen to be injected into their gas networks. Indeed, historically, the UK's gas network trans 'Town Gas', which included 50-60% hydrogen. Therefore, the current Gas Safety (Management) Regulations should soon be amended to reflect the technical capability of the gas network to accept higher intensities of hydrogen, as well as biomethane.

Furthermore, under the existing gas billing methodology, set out in the Gas (Calculation of Thermal Energy) Regulations, the Calorific Value (CV) of gas injected into the network must fall within a particular range. The CV requirements on composition and price of gas should be responsive to increased usage of low carbon gases. Over time, the requirement to blend hydrogen, and biomethane in fact, with additives to achieve compliance with CV requirements should be lessened. In the long-term, the price of low carbon gases should not exceed consumer prices to natural gas in order to achieve compliance with CV regulations. This will be challenging but it is likely that the costs of low carbon gases will fall over time as their production increases in scale.

The amended requirements set out in both regulations should be reviewed periodically to ensure they remain up-to-date.

Recommendation three: establish a 'low carbon gas obligation' on gas suppliers in the next price control framework from April 2021 to incentivise the injection of low carbon gas flowing in the UK gas network.

The UK Government should establish a national 'low carbon gas obligation', starting after April 2021, when the next price control framework, RIIO-2, is introduced. This would include a requirement for gas suppliers to deliver a steadily increasing proportion of low carbon gases – which includes biomethane, bioSNG and hydrogen - to the network. The proportion of low carbon gas injected into the gas network, and the trajectory for this over time, should be consistent with meeting the UK's current and likely greenhouse gas emissions reduction target. Compliance with, and implementation of, this new 'low carbon gas obligation' would be overseen by Ofgem.

Gas suppliers could achieve compliance either through including a minimum proportion of low carbon gas within their gas supply or through certified purchases of low carbon gas from third parties injected into the UK's gas network.

This 'low carbon gas obligation' would ensure continued and increasing demand for low carbon gas and provide a predictable signal to the market. It would also effectively guarantee a market for biomethane in the next decade, after the Renewable Heat Incentive (RHI) - which currently subsidises biomethane production - expires.

Policies to reduce the carbon intensity of the supply of gas

Recommendation four: The methodology for calculating the Energy Performance Certificate (EPC) rating of buildings should be changed.

The methodology for producing EPC ratings is currently based on assumptions that do not necessarily lead to an accurate assessment of a building's energy efficiency. EPC assessment methodology uses data from a building's smart meter to assess running costs. But energy efficiency cannot reliably be determined from household energy prices alone, particularly when heat pumps are used.

Instead, the determination of energy efficiency should be based primarily on the standardised use of passive heat or temperature sensing equipment to determine the thermal mass of a building relative to its surroundings.

Recommendation five: Introduce 'Home Affordability Assessments' (HAAs) alongside a new HAA rating.

There is a need for high-quality information to be made available to buyers to help them understand how affordable a home is that takes into consideration factors in addition to the sale price.

We propose that 'Home Affordability Assessments' (HAAs) be introduced for new-build homes which takes account of a property's sale price and maintenance costs over its expected lifetime, including annual energy bills. It should also provide an overall HAA rating. By requiring this information only from newbuilds, private individuals who sell their property will not be encumbered by the costs of producing this additional documentation.

Energy Performance Certificate (EPC) do already provide information on the energy efficiency of a home, although this information is not routinely regarded as having an impact on affordability in the same way as mortgage costs are. HAAs would provide to prospective homeowners and mortgage providers fuller information about - and a more comprehensive and comparable rating on - how affordable a property is.

Disclosure of an HAA rating should be mandatory for newly built properties, making total costs more visible to potential buyers. This would encourage home builders to include measures that bring down the running costs of new homes, especially energy efficiency measures, in order to make them more attractive to potential buyers.

Recommendation six: Increase the requirement for domestic gas boilers to be 95% efficient.

The minimum Energy-related Products (ErP) requirement for domestic gas boilers should be raised from the existing level of 92% to 95% energy efficient as soon as possible.

Many new boilers are already more than 95% efficient. A more ambitious target for new boilers will ensure manufacturers continue to lead the market in high energy efficiency appliances and reduce consumers' energy bills.

Recommendation seven: Introduce carbon life cycle assessment as part of public procurement procedures to drive the market for energy efficiency and renewable heat technologies in public estates.

'Green public procurement' provides a means of leveraging government spending for environmental and public benefit. Government spending on government estates could be used to help create markets for more efficient energy consumption, without necessarily increasing costs to the taxpayer.

Maintenance spending on government estates runs to £20 billion per year, affording them considerable purchasing power. In addition to existing requirements for environmental compliance, the procurement criteria should also include a carbon life cycle assessment of a product or service, with theoretical carbon costs reflected in pricing. By including 'green' criteria as part of the standard tendering process, government estates could provide opportunities for energy efficiency measures and renewable heat technologies to gain a foothold in the market and, in doing so, bring down costs for installing those technologies in UK homes too.

Recommendation eight: establish a new district heat network regulatory unit in Ofgem.

There are existing regulations regarding the provision of energy via district heat networks. However, the approximately half a million UK homes supplied by district heat networks are not afforded the same protections and rights that gas and electricity customers receive. Indeed, the Competition and Markets Authority (CMA) has raised concerns over the monopolies created by district heat networks and the lack of transparency provided to customers of district heat networks.

A new regulatory unit should be established within Ofgem to oversee regulation of district heat networks and to develop suitable price controls for district heat networks. This will ensure that energy consumers supplied by district heat networks have adequate protection from uncompetitive pricing.

Conclusion

The supply of and demand for UK gas must be decarbonised deeply during the coming three decades if this country is to meet even its current and likely future legal target to reduce greenhouse gas emissions.

The gas network - including a major end-user of it, the heating sector - have been largely overlooked in government policymaking in recent years. Now - with time running out - a more ambitious raft of government policies – including a mixture of investments and incentives - is needed.

The policy ideas in this report would help to, for the first time, align decarbonisation of the gas network with the obligations that arise from UK's legal greenhouse gas emissions reduction target.

Chapter 1: **Introduction**

'Network industries' are businesses that provide an economic service to much of the population through network infrastructure. The core network industries are energy (gas and electricity), water, telecommunications (fixed and mobile), and public transport. They are vital for the functioning of the UK economy and are essential sources of economic growth in themselves.

The UK's network industries share several common characteristics. First, they comprise large-scale, distributed infrastructure that have a common function or platform. This results in network industries having high sunk, or irretrievable, costs. Second, as regulated entities, they are subject to government controls over how their services are delivered and priced. Third, they have a critical role in enabling the transition to a low carbon economy, in keeping with the UK's legal target under the 2008 Climate Change Act to reduce greenhouse gas emissions by 80% in 2050 compared to 1990 levels. A new, legal net-zero emissions target is likely to be adopted soon, necessitating even deeper decarbonisation of network industries.v

This report focuses on one network industry: energy, and even more specifically, the role of gas in it. The main type of gas that is used in this country's energy system is 'natural gas' - a fossil fuel that consists primarily of methane. It is ubiquitous in the UK's energy system due to it being a cheap and readily available source of energy. As a result, it has been a key ingredient in developing a secure and affordable energy system in this country. However, since the combustion of natural gas contributes to greenhouse gas emissions, which the UK is legally obliged to reduce, its unabated use is not sustainable in the long-term. Deeper decarbonisation of UK gas is therefore paramount.

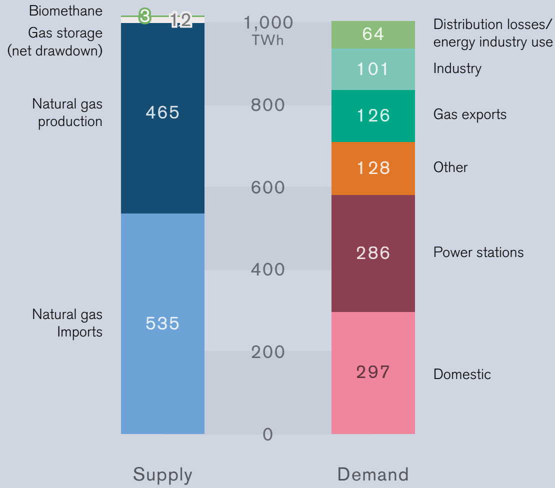
UK gas supply and demand

The gas that provides an important source of energy to the UK is delivered through the 'gas network'. The gas flowing through the gas network is overwhelmingly natural gas, but – as Chart 1.1 below illustrates - there is a very small proportion of biogas, upgraded to biomethane, which derives from anaerobic digestion and is entirely renewable.

The gas network delivers gas that is primarily used to: heat the vast majority of UK homes, providing warmth and hot water to householders on demand; supply the fuel for gas power plants which generate dispatchable electricity; and, deliver energy and feedstock used in a variety of industrial processes.

Chart 1.1 overleaf shows the relative breakdown of all the different sources of UK gas (supply) to the gas networks, and the consumers of gas (demand), in 2017. This is measured in terawatt hours (TWh) of energy.

Chart 1.1. Total UK gas supply and demand, 2017[1]



Source: BEIS, "Digest of UK Energy Statistics", 2017

As Chart 1.1 shows, natural gas dominated the supply of the gas network in 2017, with a majority (53%) of it imported and 46% produced domestically. A tiny proportion (0.6%) of biomethane flows through the gas network. There is a small proportion of gas storage, which holds gas in reserve in case of a national shortage in supply.

Gas which enters the network therefore comes from a variety of domestic and international sources, including: North Sea gas fields; liquefied natural gas imports; interconnectors from continental Europe; and, UK-based biogas plants. On imported gas, recent estimates point that most of this derives from Norway, with some from Holland,

1. 'Distribution losses' refers to gas that is lost through leakage from the gas network. 'Other' includes gas use in heat generation, public administration, commercial, and agricultural premises.

Belgium and Qatar.[2]

The largest UK gas consuming sectors in 2017 were homes (domestic) (30%) and the power sector (29%), followed by industry (10%). Other uses of gas such as heat generation and non-domestic buildings (13%), gas exports (13%), industrial consumption (10%), and energy industry use (6%) accounted for the remainder of UK gas outgoings.

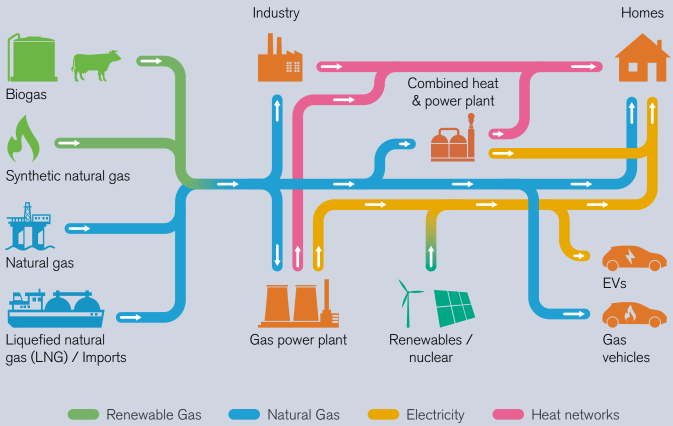
Significantly, gas dominates total energy provision in the UK, supplying 995 TWh of energy to consumers annually (after accounting for losses) in 2017, compared to 307 TWh delivered by the electricity network.[3]

The flow of gas through the gas network, from source to consumer, and the interaction with the 'electricity network', is illustrated to a large extent in Figure 1.1 overleaf. The different sources of gas are shown on the left. Gas consumers are shown in orange.

---

2. Simon Evans, "Factcheck: Less than 1% of UK gas supplies come from Russia", CarbonBrief, 16 March, 2018 https://www.carbonbrief.org/factcheck-less-than-1-per-cent-uk-gas-supplies-come-from-russia; BEIS, "Section 4: Gas", https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/720235/Gas.pdf, (2018) 41 (2018) 41, 42; BEIS, "Natural gas imports (ET 4.4)" https://www.gov.uk/government/statistics/gas-section-4-energy-trends (2018).
3. Ofgem, "The energy network", https://www.ofgem.gov.uk/ofgem-publications/126890.

Figure 1.1. Simplified schematic overview of the UK gas network and its interaction with the electricity network[4]



Source: BEIS, "Digest of UK Energy Statistics", 2017

As Figure 1.1 shows, the gas network provides for and interacts with the electricity network. The electricity network itself provides energy for an enormous variety of applications including lighting, electrical appliances (such as fridges and televisions), and air conditioning. Gas-fired power plants which generate electricity depend on the gas network for fuel supply.

The use of gas in electricity generation has declined since 2010, although 40% of electricity supply was still generated by gas power plants in 2017.[5] Gas use in the electricity network has experienced a shift from being used for baseload electricity generation - where gas

4. Wales and West Utilities, "Wales & West Utilities – supporting our customers now and into the future", http://es.catapult.org.uk/wp-content/uploads/2017/08/4.-Steve-Edwards-WWU-presentation-for-LA-Forum.compressed.pdf (2017), 17.
5. Simon Evans, "Analysis: Low-carbon sources generated more UK electricity than fossil fuels in 2017", Carbon Brief, https://www.carbonbrief.org/uk-low-carbon-generated-more-than-fossil-fuels-in-2017 (2017).

power plants run continuously - to instead providing a short-term boost to electricity supply during periods of high demand. Indeed, existing gas power plant have increasingly been used as 'peaking' assets for short-term balancing of the electricity network, along with smaller generators such as gas engines and combined heat and power (CHP) generators.

The prime destination of UK gas, as Chart 1.1 demonstrates, is homes. The latest evidence shows that approximately 85% of UK homes rely on gas to serve their heating needs.[6] The gas network is particularly well suited to delivering energy for heating homes as it can respond to short-term fluctuations in heat demand which are a frequent occurrence; peak demand for gas can be up to seven times higher than for electricity.[7] This is because the gas network can store significant quantities of energy within its pipeline infrastructure.

Overall, during the last two decades, there have been significant changes in gas supply and demand in the UK.

On supply, as Chart 1.2 overleaf shows, domestic natural gas production in the UK peaked in 2000 and output has since fallen by 63% as North Sea production has declined.[8] This has turned the UK from a net exporter of natural gas to relying on imports for meeting just over half its gas demand.[9] As Chart 1.1 showed, in 2017, domestic gas production accounted for nearly half of the UK's gas supply by TWh, with the remainder of UK gas supply largely supplied via pipelines connected to Europe and liquefied natural gas imports from overseas.[10] Prior to 2004, the UK produced more natural gas than was needed to

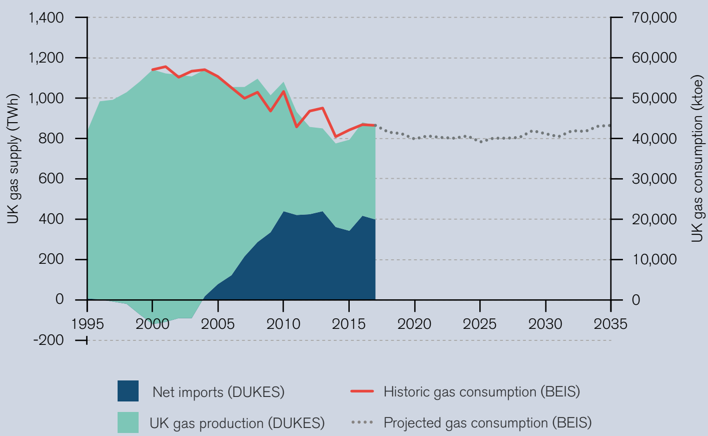
---

6. Energy Networks Association, "Gas Network Innovation Strategy", http://www.energynetworks.org/assets/files/Gas%20Network%20Innovation%20Strategy%20Final%202018.pdf (2018), 12.
7. UK Energy Research Council, "Heat decarbonisation challenges: local gas vs electricity supply", http://www.ukerc.ac.uk/publications/local-gas-demand-vs-electricity-supply.html (2018), 2.
8. BEIS, "Digest of UK Energy Statistics. Chapter 4: Natural Gas", https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/729395/Ch4.pdf (2018), 91.
9. BEIS, "Historical gas data: gas production and consumption and fuel input, 1920 to 2017", https://www.gov.uk/government/statistical-data-sets/historical-gas-data-gas-production-and-consumption-and-fuel-input (2017).
10. BEIS, "Digest of UK Energy Statistics: Natural Gas", https://www.gov.uk/government/statistics/natural-gas-chapter-4-digest-of-united-kingdom-energy-statistics-dukes (DUKES 4.2), (2018).

meet domestic demand and exported natural gas overseas. Gas imports, however, began to rapidly increase after this, especially between 2004 and 2010.

On demand, evidence from the Department for Business, Energy & Industrial Strategy (BEIS) show that the UK's total gas consumption has fallen by 23% since 2000, although forward projections by BEIS indicate demand will remain at near current levels out to 2035.[11] This is also shown in Chart 1.2 below. In this chart, demand for gas is calculated using kilotonne of oil equivalent (ktoe), but gas supply remains calculated using TWh.

Chart 1.2. UK gas historic and projected supply and demand, 1995-2035



Source: Historic gas supply data from BEIS/DUKES; historic and projected gas consumption data from BEIS

There are specific trends in gas demand which are worth noting.

11. BEIS, "Digest of UK Energy Statistics 2018. Chapter 4: Natural Gas" https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/729395/Ch4.pdf (2018), 3.

The consumption of gas in industrial processes such as chemicals and food and beverage production has, overall, remained largely stable this decade, although gas consumption in some industries has almost doubled (such as mechanical engineering) while in others it has halved (such as paper and textiles).

Meanwhile, utilisation of UK gas has also expanded into road transport, as Figure 1.1 indicated, such as in gas-powered vehicles. If compressed or liquefied natural gas is used as a vehicle fuel, it may be supplied locally from existing gas network infrastructure. While demand for gas in the road transport sector is currently low, several commercial vehicle fleet operators have introduced compressed natural gas-powered (CNG) vehicles in a bid to reduce costs and emissions.[12] In parts of Europe, the use of CNG in vehicles is much higher than in the UK, thanks in part to tax inducements.[13]

The infrastructure and operation of the gas network

The gas network comprises an extensive network of pipeline infrastructure that supplies gas across the UK. Most of the gas network infrastructure lies below ground. This makes it resilient to weather extremes that may interfere with above-ground network infrastructure, such as electricity cables.

'Gas suppliers' provide the gas that enters the 'National Transmission System (NTS)', a UK-wide network of high-pressure steel pipelines. The NTS is made up of approximately 7,660 kilometres (4,760 miles) of high-pressure pipe and 618 above-ground installations.[14]

---

12. CommercialFleet, "Waitrose launches fleet of CNG-fuelled trucks with 500-mile range", https://www.commercialfleet.org/news/latest-news/2017/02/09/waitrose-launches-fleet-of-cng-fuelled-trucks-with-500-mile-range (2017).
13. Transport & Environment, "CNG and LNG for vehicles and ships – the facts", https://www.transportenvironment.org/sites/te/files/publications/2018_10_TE_CNG_and_LNG_for_vehicles_and_ships_the_facts_EN.pdf (2018), 4-5.
14. National Grid, "Our networks and assets", https://www.nationalgrid.com/uk/about-grid/our-networks-and-assets (2018).

https://www.ofgem.gov.uk/ofgem-publications/126890 (2018).

The NTS transports gas to three main sources: 'Gas Distribution Network Operators', power plants, and large industrial users. Branching off from the NTS, and managed by the 'Gas Distribution Network Operators', are eight 'regional gas distribution networks' that deliver gas to homes, businesses, power plants and industrial users.

The whole gas network infrastructure is privately owned and operated. The NTS is managed by the 'System Operator' (SO), which is National Grid. The eight regional gas distribution networks are operated by the four Gas Distribution Network Operators: Cadent Gas, Northern Gas Networks, SGN, and Wales and West Utilities. These Gas Distribution Network Operators are not in direct competition with one another since each manages a different portion of the UK's gas network. Together, all these private companies manage a combined network comprising 284,000km of gas pipelines.[15]

The four Gas Distribution Network Operators deliver UK gas to end consumers. For this service, these companies charge 'energy suppliers' - the companies that interface with energy consumers - a fee for maintaining the regional gas distribution network infrastructure. These costs are passed on to consumers by the energy suppliers through energy bills. It is important to note that energy suppliers are not physically providing gas, but are responsible for issuing energy consumers with contracts for gas supply. While there are many energy suppliers operating in the UK, the market is dominated by British Gas, EDF, E.ON, npower, Scottish Power, and SSE. Together, they are known as the 'Big Six'. As of the fourth quarter of 2017, the biggest energy supplier was British Gas, with 31% of the market share for heat.[16]

15. Ofgem, "The Energy Network", https://www.ofgem.gov.uk/ofgem-publications/126890 (2018).
16. Ofgem, "Retail Market Indicators", https://www.ofgem.gov.uk/data-portal/retail-market-indicators#thumbchart-c23042756505310535-n120192 (2018).

Box. 1.1. The history of gas in the UK

The UK has a long history of gas usage stretching back as far as the 1600s. Rapid expansion of coal-mining throughout the eighteenth and nineteenth centuries gave rise to experiments in gas-lighting using methane released from coal mines. By the early twentieth century, an industry had developed around converting coal into 'town gas' which fed a growing number of industries and a nascent market for residential heating.

It was not until the middle of the twentieth century, following the nationalisation of the gas industry in 1949,[17] that large-scale gas infrastructure development began. Prior to that time, the numerous incohesive gas networks dotted about the country had been run by local authorities or small private entities. The establishment of state-run British Gas saw these providers merge under the organisation of 12 regional Gas Boards which managed both the distribution and sale of gas for their respective regions. At the same time, coal and electricity production were also nationalised.

In the early 1960s, with coal production in decline but demand for gas high, it became clear the UK would need to diversify its gas supply. A 200-kilometre long gas pipeline - the early beginnings of the NTS - was laid between Canvey Island gas import terminal in Kent and Leeds, allowing natural gas entering the UK to be distributed throughout the country. Compared to 'town gas', 'natural gas' was safer to use and of more consistent quality. By the late 1960s, the UK had started to develop indigenous natural gas supply from the North Sea continental shelf and, within a decade, natural gas effectively replaced town gas in the UK gas network.

17. Calliope Webber, "The Evolution of the Gas Industry in the UK", Instituto Argentino Del Petroleo Y Del Gas, http://www.iapg.org.ar/WGC09/admin/archivosNew/Special%20Projects/3.%20IGU%20GMI%20Guidelines/3.%20IGU%20GMI%20Guidelines%20FINAL%20-%20CD%20contents/UK%20Gas%20Market.pdf (date unknown), 3.

Natural gas began replacing coal for heat in buildings and industry during the 1970s.

In 1986, the Conservative Government under Prime Minister Margaret Thatcher sought to promote market competition and greater efficiency in the energy sector and introduced the 1986 Gas Act which led to the privatisation of British Gas. The 12 gas Area Boards became eight regional gas distribution networks and these were privatised in the decades that followed, finally completing in 1997. The regulatory body (Ofgas) was merged with that of the electricity industry to form the Office of Gas and Electricity Markets (Ofgem) in 2000. This was, and remains, the largest single sale of a previously state-owned company in the UK in terms of net proceeds and the number of initial shareholders.[18]

To open up the UK gas market to competition, a series of gas interconnectors were built to transmit gas to and from Continental Europe (in 1994 and 1998), Northern Ireland (1996), and via the South-North Gas Pipeline between Northern Ireland and the Republic of Ireland (in 2006). This increased the diversity of natural gas supply to the UK and market liquidity. Over the same period, the number of liquefied natural gas import terminals significantly increased too, allowing natural gas from further afield to enter the UK.[19]

A 1999 audit suggested that the benefits to consumers of increased domestic gas competition was around £1 billion a year to the consumer.[20]

18. Chris Rhodes, David Hough and Louise Butcher, "Privatisation", House of Commons research paper 14/61 (2014), 11.
19. Michael Bradshaw, "Future UK Gas Security: Midstream Infrastructure". http://www.ukerc.ac.uk/asset/E4F06E15-7EB9-4705-A3841CEA8540FEEE/ (2017).
20. National Audit Office, "Giving Customers a Choice – The Introduction of Competition into the Domestic Gas Market", https://www.nao.org.uk/wp-content/uploads/1999/05/9899403.pdf (1999), 2.

The UK's gas network has undergone a series of major changes in recent years. Notably, these include the replacement of the ageing iron gas pipelines, the connection of new sources of gas, and changes in seasonal gas storage capacity.

First, there is an ongoing process of replacing old iron gas mains infrastructure, mandated by the Health and Safety Executive (HSE). A significant portion of the UK's original gas pipeline infrastructure consists of iron pipes dating from the middle of the twentieth century, even before. Due to their age, these pipes are prone to leakage and therefore pose a safety risk. The HSE's Iron Mains Risk Reduction Programme (IMRPP), which began in 2002, has led to the accelerated replacement of more than half of these iron pipes with plastic ones and the programme is due to be completed by 2032. The cost of this upgrade work is being paid for through a levy on gas consumers' bills.[21] The scheme is expected to generate savings for consumers in the long-term due to lower network costs resulting from a reduction in operational costs and gas leaks.

Second, new sources of gas - in particular biogas (or biomethane) produced from anaerobic digestion plants - is contributing to a modest but increasing share of the UK's gas supply, as shown in Chart 1.1. Close to 100 biogas plants have reportedly been connected to the gas network since 2013,[22] largely driven by government policy incentives such as the Renewable Heat Incentive (RHI), which are described in further detail later in the report. The number of biogas plants is expected to grow, although this will be subject to whether the RHI continues. Biogas is highly desirable since it has significantly lower lifecycle greenhouse gas emissions compared to natural gas. It therefore has potential to reduce the carbon footprint of the gas network, along with bioSNG and hydrogen gas, as explained in greater detail in Chapter Four.

---

21. Nicholas Newman, Energy World, "Britain's gas mains replacement programme" https://www.nicnewmanoxford.com/wp-content/uploads/2018/04/Britain's-gas-mains-pdf.pdf (2018), 18-19.
22. Cadent Gas, "Biomethane: UK set for surge in plants producing 'green gas'. https://cadentgas.com/media/press-releases/2018/growth-in-uk-biomethane-plants-industry (2018).

Third, the gas network has recently undergone a significant reduction in upstream storage capacity. Early in 2018, the Rough gas storage facility - which at the time represented 77% of the UK's total seasonal gas storage capacity[23] - discharged the last of its stored gas and was closed.[24] This lost capacity has yet to be replaced and leaves the UK with dramatically reduced natural gas reserves to draw on compared to previous years. In March 2018, the UK experienced a severe cooling event caused by the convergence of Storm Emma and the 'Beast from the East', resulting in the highest gas demand in the UK for seven years. A number of upstream gas supply assets were affected by the sub-zero temperatures, causing National Grid to issue a 'Gas Deficit Warning' for the first time since the system was introduced in 2012. The resilience of the UK's energy system depends on having sufficient energy storage as a contingency for meeting peak demand. The gas network has historically, up to the present time, provided most of the UK's energy storage capacity. This storage capacity has proven to be particularly useful in dealing with sudden and severe periods of cold weather.

Box 1.2. Regulation of the Gas Distribution Network Operators

All organisations involved in the UK gas network are subject to regulation from Ofgem, but of particular relevance for this report is the regulation of the Gas Distribution Network Operators. The UK's four Gas Distribution Network Operators are subject to regulations that control their activities. These include performance and safety standards, as well as price controls.

To avoid non-competitive practices, the Gas Distribution Network Operators are subject to a Regulated Asset Base (RAB)

23. Chris Le Fevre, "Gas Storage in Great Britain", https://www.oxfordenergy.org/wpcms/wp-content/uploads/2013/01/NG-72.pdf (2013), 40.
24. Ian Staffell, Drax, "Running low on gas", http://electricinsights.co.uk/#/reports/report-2018-q1/detail/running-low-on-gas?period=1-year&start=2017-10-24&_k=8076mh (2018).

model, which is a form of economic regulation designed to ensure that relevant actors operate efficiently and deliver value for money to consumers. A key part of the RAB model is the price control framework.

A price control framework was established in 1986, when the gas network was privatised, in order to stimulate competition and investment. Indeed, by 2020-21, the private sector will have invested over £80 billion in the UK's gas and electricity networks since price controls were established.[25]

The current phase of price controls - known as 'RIIO' (Revenue = Incentives + Innovation + Outputs) - began in 2013 and is overseen by Ofgem, the energy regulator. It is designed to protect consumers from uncompetitive pricing and reward the Gas Distribution Network Operators for making investments that fulfil government policy objectives.

RIIO effectively caps the amount the Gas Distribution Network Operators can earn from charging energy suppliers to use their regional network. It does this by making the ability of the Gas Distribution Network Operators to retain revenues subject to their delivery of key outputs set by Ofgem over eight year periods. These include set targets for safety, reliability and availability, environmental impact, customer and stakeholder satisfaction, and customer connections. The current price control period for gas networks ends in March 2021 and consultations around its successor, RIIO-2, are ongoing.

RIIO provides stimulus for the Gas Distribution Network Operators to invest in new technologies that deliver low carbon gas or other environmental benefits through the 'Network Innovation Competition'. Ofgem provides the funding for this, which applies

25. Ofgem, "Infographic: the energy network", https://www.ofgem.gov.uk/publications-and-updates/infographic-energy-network (2017).

to both the electricity and gas network.[26] Of the funding available under the Network Innovation Competition, £70 million is available to the electricity network and £20 million to gas network per annum.[27,28]

A separate Ofgem fund, the 'Network Innovation Allowance', provides limited support to 'gas network licensees' (all organisations involved in the gas network that are licensed by Ofgem) for small-scale research, development and demonstration projects that have potential to deliver financial benefits for gas network customers, including both households and businesses.[29]

In addition to the price controls, all organisations involved in the gas network must also adhere to Gas Safety (Management) Regulations, known as GS(M)R, which were established in 1996. Equally, there are also regulations around the composition and price of gas according to its calorific value (CV), set out in the 1996 Gas (Calculation of Thermal energy) Regulations. CV is a measure of the energy released when a gas is fully combusted. It is used by the gas network to ensure consistency in the quality of gas flowing through the network. These regulations, among other things, limit the chemical composition of gas permitted in the gas network to ensure compatibility of network infrastructure and gas appliances.

As Chapter Four will explore in greater detail, these regulations make it difficult to decarbonise the gas network – the foremost challenge for UK gas.

---

26. Ofgem, "Making Britain's energy networks better", https://www.ofgem.gov.uk/system/files/docs/2018/11/competitions_brochure_2018.pdf (2018), 2.
27. Ofgem, "Electricity Network Innovation Competition" https://www.ofgem.gov.uk/network-regulation-riio-model/current-network-price-controls-riio-1/network-innovation/electricity-network-innovation-competition (2018).
28. Ofgem, "Gas Network Innovation Competition" https://www.ofgem.gov.uk/network-regulation-riio-model/current-network-price-controls-riio-1/network-innovation/gas-network-innovation-competition (2018).
29. Ofgem, "Gas Network Innovation Allowance Governance Document", https://www.ofgem.gov.uk/system/files/docs/2017/07/final_gas_nia_gov_doc_v3.pdf (2017), 5.

Deeper decarbonisation of the UK gas network

The foremost challenge facing the UK gas network today is the need for it to be more deeply decarbonised. This is essential if the UK is to meet its current greenhouse gas emissions reduction target of 80% by 2050 compared to 1990 levels, alongside its likely future net-zero emissions target. To avoid becoming a stranded asset[30] in future, the UK gas network must reduce its carbon footprint to a small fraction of current levels within the forthcoming decades.

Methane, the main component of gas transmitted through the gas network, releases carbon dioxide when combusted to generate heat. Both methane and carbon dioxide are potent greenhouse gases. So the UK's gas network contributes both directly (through a small amount of leakage in the gas network) and indirectly (via gas consumption) to greenhouse gas emissions. In 2016, combustion of natural gas accounted for 35% of the UK's total greenhouse gas emissions,[31] approximately half of which were associated with gas use in the heating sector.

Deeper decarbonisation of the UK gas network, however, will be challenging for three principal reasons.

First, as natural gas is the single largest source of energy in the UK, reducing its carbon footprint to meet current and likely greenhouse gas emissions targets will necessitate changes to the UK gas network on a scale not experienced since flammable gas first arrived in homes.

Second, of the technologies available to reduce the carbon footprint of the gas network, many are underdeveloped in the UK, require significant public and private investment, and will take time to effect

30. A 'stranded asset' refers to an asset that has undergone premature or unexpected write-downs for a variety of reasons, thereby losing its economic value. In this case, the value of a gas network that transmits carbon-intensive gas to the UK is reduced as the deadline for meeting 2050 greenhouse gas emissions targets nears.
31. BEIS, "2016 UK greenhouse gas emissions: final figures - data tables", https://www.gov.uk/government/statistics/final-uk-greenhouse-gas-emissions-national-statistics-1990-2016 (2018).

decarbonisation.[32] The nature and amount of government investment for decarbonising the gas network is unclear, which is in stark contrast to the electricity network.

Third, a relatively small number of government policies to drive deeper decarbonisation to date means that, unlike for the electricity network, there are few incentives or obligations to reduce the carbon footprint of the gas network.

This principal task of decarbonising the UK gas network will need to be achieved at the same time as minimising costs for gas consumers, which is a highly sensitive political issue with deep public concern. Consumer energy bills, of both gas and electricity, are a major cause of dissatisfaction.[33] Herein lies the problem for policymakers as, in seeking to decarbonise UK gas through investments that bring down costs in the long-term, there is a prospect that consumer gas prices may need to be raised in the near-term. Indeed, responding to public concern over consumer energy prices has been a priority across the political spectrum. The Labour Party, in its 2017 general election manifesto, pledged to nationalise energy provision through altering 'energy network operator' license conditions.[34] Both the Conservative Party and Labour Party have called for some form of an energy price cap for consumers. Indeed, the Government and Ofgem have implemented one at the start of this year. Further interventions of this nature risk having unintended consequences for the gas network, particularly if attempts to reduce energy bills in the short-term are at odds with the objective of cutting greenhouse gas emissions.

---

32. National Grid, "Future energy scenarios 2017", http://fes.nationalgrid.com/media/1253/final-fes-2017-updated-interactive-pdf-44-amended.pdf (2017), 52; Energy Networks Association, "Gas network innovation strategy", http://www.energynetworks.org/assets/files/Gas%20Network%20Innovation%20Strategy%20Final%202018.pdf (2018), 19.
33. The Ombudsman Services, "Energy Sector Report: January to December 2017", https://assets.ctfassets.net/46t2drav2f3e/2fTLGLYqHamM8iI2uQQ4cM/76c5f88c00f529e02b12f6351c81bde4/1118-energy-report-2017__1_.pdf (2017), 4.
34. The Labour Party, "The Labour Party Manifesto 2017", https://labour.org.uk/wp-content/uploads/2017/10/labour-manifesto-2017.pdf (2017), 20.

Focus of the report

In this report, we examine the case for and pathways to deeply decarbonise the UK gas network. In particular, the report assesses how to decarbonise both the supply of gas through the pipeline infrastructure and the demand for gas in the electricity and heat sectors. It also evaluates how the deeper decarbonisation of UK gas will impact on consumer gas prices.

This report seeks to answer the following four research questions:

1. Why and how should the supply of and demand for UK gas network be decarbonised?
2. Which technologies are supporting and will support deeper decarbonisation of UK gas?
3. What are the implications of deeper decarbonisation of UK gas on consumer gas prices?
4. Are there new policies that can support the decarbonisation of the UK gas network while minimising costs to gas consumers?

The report is structured as follows:

- **Chapter Two** outlines the methodologies used in developing this report, including a literature review, stakeholder consultation, a policy roundtable discussion, and a call for written evidence.
- **Chapter Three** outlines the history of, the current projections for and the challenges for the main pathways for decarbonising the UK's gas network.
- **Chapter Four** examines the technological solutions for decarbonising both the UK's gas demand and supply
- **Chapter Five** explains the composition of and trends in consumer gas prices, looking in particular at how the costs of deeper decarbonisation of the UK gas network can be managed.

- **Chapter Six** puts forward policy recommendations for decarbonising the UK's gas network.

Chapter 2: **Methodology**

This report seeks to outline the case for and potential pathways to deeper decarbonisation of both the supply of and demand for UK gas. This report concludes with policy recommendations to deliver deeper decarbonisation of the gas network in a cost-effective manner.

Research techniques

We employed four research techniques in this project:

- **Literature review.** We conducted an extensive literature review of published evidence and analysis pertaining to the gas network in the UK. We looked at relevant academic journals, think tank reports, publications from industry groups and trade bodies, and government studies and datasets.
- **Stakeholder consultation.** Bright Blue consulted a number of leading academics, experts, decision makers, and representatives of the gas and energy sectors.
- **Policy roundtable discussion.** We hosted an invite-only roundtable discussion with the Rt Hon Claire Perry (Minister of State for Energy and Clean Growth) and Ben Houchen (Mayor of Tees Valley) under the Chatham House Rule in July 2018 to devise and brainstorm policies. Attendees included leading academics, chief executives, politicians, special advisers and civil servants.

- **Call for written evidence** - Bright Blue issued a public call for written evidence on the future of the gas network. We received 24 submissions from a range of organisations. These are published in the annex of this report.

Chapter 3: The history of and projections for decarbonisation of UK gas

Chapter One detailed the structure of and trends in the UK gas network, concluding that the biggest challenge it now faces is the need to deeply decarbonise to meet this country's legal greenhouse gas emissions targets. This chapter outlines the history of, and the current projections and challenges for, the main pathways to the decarbonisation of the UK gas network.

Decarbonisation to date

As Chapter One outlined, UK gas consumption contributed just over a third to the UK's total greenhouse gas emissions in 2016,[35] both directly (through leakage in the pipeline infrastructure), but mainly indirectly (through consumption of electricity and heat).

Since the UK's current greenhouse gas emissions reduction target was established in the 2008 Climate Change Act, there have been reductions in emissions associated with natural gas use. This has been achieved in three main ways. First, on the supply-side, the number of gas leaks has declined as a result of the HSE's Iron Mains Risk Reduction Programme (IMRPP), described in Chapter One. Second, the injection of relatively small volumes of low-carbon biogas (or biomethane)

35. BEIS, "2016 UK greenhouse gas emissions: final figures - data tables", https://www.gov.uk/government/statistics/final-uk-greenhouse-gas-emissions-national-statistics-1990-2016 (2018).

into the gas network from anaerobic digestion plants has marginally reduced the carbon intensity of UK gas. Third, on the demand-side, there has been a significant fall in gas demand in recent years; as Chart 1.2 showed, there has been a 23% fall in annual gas demand across the UK economy since 2000.[36]

Nonetheless, the emissions reductions that have been achieved represent a small fraction of the progress in decarbonisation of the gas network that is needed to meet even the UK's current greenhouse gas emissions target. The deeper decarbonisation of the gas network that is necessary is largely contingent on further progress towards decarbonising gas-using segments of the electricity and heat sectors, which are the largest gas-consuming sectors of the economy.

Much of the UK's electricity (40%) is generated by gas power stations,[37] as Figure 1.1 illustrated. Indeed, electricity currently accounts for close to a third of the UK's gas demand, as described in Chapter One. Chart 1.2 showed that gas consumption has fallen markedly in recent decades. And BEIS' projections indicate that gas use in the electricity sector will decrease by around two thirds by 2035[38] and may continue to decline thereafter. This significant decline for gas from electricity is strongly supporting decarbonisation.

By contrast, the heating sector has proven much more difficult to decarbonise due to the volatility of heat demand (peak heat demand is typically around five times greater than that of peak electricity.[39]), the sheer magnitude of energy involved, and the lack of cost-competitive alternatives to natural gas, which remains the cheapest option for the majority of consumers.

The National Infrastructure Commission (NIC) estimates that

---

36. BEIS, "Updated energy and emissions projections: 2017", Annex: F, https://www.gov.uk/government/publications/updated-energy-and-emissions-projections-2017 (2018).
37. BEIS, "Updated energy and emissions projections: 2017", Annex J, https://www.gov.uk/government/publications/updated-energy-and-emissions-projections-2017 (2018).
38. Ibid.
39. Ofgem, "Ofgem's Future Insights Series: The Decarbonisation of Heat", https://www.ofgem.gov.uk/system/files/docs/2016/11/ofgem_future_insights_programme_-_the_decarbonisation_of_heat.pdf (2016), 3.

the heating sector (which includes heating and hot water provision) currently accounts for 100 $MtCO_2$ (metric tons of carbon dioxide) per annum,[40] representing 22% of total UK greenhouse gas emissions.[41] Put another way, the heat sector contributes about two thirds of the greenhouse gas emissions that derive from the UK gas network.

The NIC estimates that, under the existing greenhouse gas emissions target, emissions from heat would need to fall substantially to 10 MtCO2 per year by 2050. To achieve this, a national programme to switch the gas network to low-carbon gas sources would need to begin by 2030 at the latest, according to the Climate Change Committee (CCC), requiring significant lead-in decisions by the mid-2020s.[42]

Ultimately, further progress on decarbonising the UK gas network is necessary, especially in the heating sector.

Pathways for deeper decarbonisation of the UK gas network

There are two main pathways – related to gas supply and demand - for deeper decarbonisation of the UK's gas network. These two pathways are not mutually exclusive. They can and both should be pursued.

1. **Reducing the carbon intensity of the supply of gas** in the gas network through replacing natural gas with low carbon gases.
2. **Reducing gas demand**, especially in the electricity and heat sectors, by improving the energy efficiency of buildings and gas appliances, and by enabling fuel switching as to shift demand away from the gas network.

40. E4tech & Element Energy, "Cost analysis of future heat infrastructure options", https://www.nic.org.uk/wp-content/uploads/Element-Energy-and-E4techCost-analysis-of-future-heat-infrastructure-Final.pdf National Infrastructure Commission, (2018), 3.
41. BEIS, "Updated energy and emissions projections: 2017", Annex A, https://www.gov.uk/government/publications/updated-energy-and-emissions-projections-2017 (2018).
42. Ibid, 105.

For much of the last decade, the Government's approach towards the energy system has been characterised by the so-called 'energy trilemma' of security of supply, cost and decarbonisation.

Since the late 2000s, considerable political attention and financial resources have been devoted towards decarbonising electricity. However, reducing greenhouse gas emissions for UK gas, which comprises the largest share of energy provision in the UK, has received much less attention.

Nonetheless, several recent high-profile government policies do help, even indirectly, to decarbonise the UK gas network, either through the adoption of low carbon gas on the supply-side or a reduction in gas demand. These are described in Box 3.1 below.

Box 3.1. Recent government policies that help with decarbonising UK gas

Renewable Heat Incentive (RHI)

The RHI helps reduce demand for natural gas for heating by providing financial incentives from government to residential and business energy users who install renewable heating technologies, such as biomass and biogas plant, air-source and ground-source heat pumps, and solar thermal systems. It was introduced in 2011 for the non-domestic sector and was subsequently expanded to domestic energy consumers in 2014. The RHI remains one of the few schemes that exists to help homeowners adopt low-carbon heating technologies.

The RHI started supporting a growing number of biogas (or biomethane) producers from 2014, with 27 new plants approved for support since May 2018.[43] As of September 2018, 22% of heating

43. Ofgem, "Tariff Guarantee applications", https://www.ofgem.gov.uk/publications-and-updates/tariff-guarantee-applications (2019).

capacity deployed as a result of the RHI was from biomethane injected into the gas network.[44] However, there has been a 45% fall in total accredited renewable heat installations since 2015,[45] an indication that support for RHI-eligible heat technologies generally is dwindling.

Renewable Transport Fuel Obligation (RTFO)

The RTFO scheme, which was introduced in 2007, encourages production of biofuels for the transport sector, including biomethane. The regulation requires that transport and machinery fuel providers include a certain proportion of biofuel in their supply.[46]

The RTFO supports demand for biomethane which can be used for a variety of purposes, including injection into the gas network.

The RTFO also includes a target for renewable fuels to account for 9.75% of total fuel supply by 2020,[47] thereby driving demand for low carbon gas in the transport sector.

Energy Company Obligation (ECO)

The ECO began in 2013 and established a requirement for energy suppliers to provide energy efficiency improvements to fuel poor residential dwellings. A household is defined as being in fuel poverty if it is on a low income and faces high energy costs.[48] By increasing

44. BEIS, "RHI deployment data: September 2018" https://www.gov.uk/government/statistics/rhi-deployment-data-september-2018 (2018).
45. BEIS, "Renewable Heat Incentive statistics", https://www.gov.uk/government/collections/renewable-heat-incentive-statistics (2018). 40% fall based on comparison of total installed capacity of full accreditations for first three quarters of 2015 and 2018.
46. Department for Transport (DfT), "Renewable Transport Fuel Obligation", https://www.gov.uk/guidance/renewable-transport-fuels-obligation#data-on-biofuel-supply (2012).
47. DfT, "Biofuels statistics", https://www.gov.uk/government/collections/biofuels-statistics (2018).
48. Department of Energy and Climate Change (DECC), "Fuel Poverty Energy Efficiency Rating Methodology", https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/332236/fpeer_methodology.pdf (2013) 4. A policy discussion around ECO can be found in Bright Blue's 2016 Better Homes report.

the efficiency of homes, ECO reduces gas demand for heating and, by implication, the cost of heating homes. The Government's 2017 Clean Growth Strategy proposed extending the scheme to 2028.[49]

Heat Networks Investment Project (HNIP)

HNIP began in 2018 and comprises a £320 million fund to support local authorities in rolling out heat networks. Heat networks distribute heat from a centralised source, such as an industrial plant or combined heat and power installation, to local buildings where it can be used for space heating. In the preliminary six months of the HNIP scheme, £24 million was awarded to nine local authorities and this investment is expected to yield emissions reductions of 0.2 megatonnes of CO2 (MtCO2) over a 15 year period.[50] The scheme will support up to 200 projects in total and is expected to leverage £1 billion in private investment.[51]

Current projections and challenges for the main decarbonisation pathways

In terms of the future of decarbonising the supply and demand of UK gas, there are several projections as well as challenges to consider.

Supply-side projections and challenges

On the first pathway, decarbonising supply, by 2050, as a result of the UK's greenhouse gas emissions target, there will be limited scope for

49. HM Government, "The Clean Growth Strategy", https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/700496/clean-growth-strategy-correction-april-2018.pdf (2017), 13.
50. BEIS, "Heat networks", https://www.gov.uk/guidance/heat-networks-overview (2018).
51. BEIS, "Heat Networks Investment Project (HNIP) pilot scheme", https://www.gov.uk/government/publications/heat-networks-investment-project-hnip (2018).

unabated natural gas use in heating and industrial or gas power plant.[52] So this will leave end users with a choice between decarbonised gas, electricity, renewable heat, or some bespoke solution to meet their energy needs. In the longer term, then, the gas network will only continue to be viable if demand for natural gas has been replaced by demand for low-carbon gases towards the middle of this century. That is why new investment to realise this supply-side pathway is particularly important. In particular, during the next price control period, described in detail on Box 1.2, which for the gas network will start in April 2021, it will be important for this to support the development of infrastructure that enables the gas network to decarbonise.

In addition, there are profound practical challenges: to decarbonise gas supplies, new equipment capable of handling low carbon gas is required. This includes connections to low carbon gas producing facilities and redesigning network assets and operations to better support distributed, low-carbon gas producers. The Gas Distribution Network Operators have the ability to make investments of this kind, but lack incentives to do so under the existing RIIO price control framework. New measures in the next gas price control framework, RIIO-2, are needed to create this imperative.

Linked to the need for better redistribution of gas in the network is the availability of gas storage. Gas storage capacity in the regional gas distribution networks will enable them to cope with new, low carbon gas inputs, as well as to provide energy storage to support the expansion of renewable electricity generation. Ofgem will need to consider how best to facilitate the development of gas storage assets, since Gas Distribution Network Operators are currently not encouraged to own or operate storage assets.

At the upstream end of the gas network, gas suppliers – who are the sources of gas to the UK's network – have an important role in

52. UK Energy Research Centre, "The future role of natural gas in the UK", http://ukercwww.ukerc.ac.uk/asset/9E5B1FD5-AB5D-4D36-AE83671E76E0E180/ (2016), 3.

delivering low carbon gas to the network. In the electricity network, there are government incentives such as the 'Capacity Market' and 'Levy Control Framework' which are designed to reduce the carbon intensity of electricity supply.[53,54] No similar incentive or obligation exists for gas suppliers to provide low carbon gases to the network, beyond the subsidies available for biomethane production under the RHI, as explained in Box 3.1. As a result, low carbon gas suppliers currently cannot compete on price with unabated natural gas without subsidy.

Demand-side projections and challenges

It is worth examining current gas use projections for some main end users to assess the potential to switch demand away from the gas network. Decarbonising the gas network raises a host of issues for sectors other than electricity and heating that rely on gas for supply of fuel or chemical feedstock. So, here, we focus on the heat and electricity sectors, as well as industry and transport.

Demand for gas in the heat and electricity sectors is projected to fall in the long-term. The CCC estimates that gas use will decline by 50% in 2050 relative to 2015.[55] Similarly, modelling of future energy demand by Wales and West Utilities suggests that annual gas demand in the UK will fall considerably, but peak gas demand will increase compared to current levels.[56] Accordingly, this is largely due to an anticipated drop

---

53. Committee on Climate Change, "Reducing UK emissions: Progress Report to Parliament, https://www.theccc.org.uk/wp-content/uploads/2018/06/CCC-2018-Progress-Report-to-Parliament.pdf (2018), 21.
54. The 'Capacity Market' was introduced by the UK Government as part of the 2013 Electricity Market Reform. Its function is to support continued investment in new UK electricity generation capacity. The 'Levy Control Framework' is a mechanism for supporting low carbon electricity generation through issuing Contracts-for-Difference to some forms of low carbon electricity generation capacity that provide a guaranteed return on investment.
55. Committee on Climate Change, "Next steps for UK heat policy", https://www.theccc.org.uk/wp-content/uploads/2016/10/Next-steps-for-UK-heat-policy-Committee-on-Climate-Change-October-2016.pdf (2016), 7, 8, 40.
56. Wales and West Utilities, "2018 Long Term Development Strategy Summary", https://www.wwutilities.co.uk/media/2844/2018-long-term-development-statement-summary.pdf (2018), 3.

in demand for gas in large gas power plants - due to the expansion of renewable energy, nuclear and small peaking gas plant - but more pronounced peaks in winter heating demand in the residential sector. In addition, a future renewables-rich energy system will result in more pronounced intermittency of electricity supply, leading to increased reliance on stored energy, potentially in the form of gas, to plug gaps in supply and help manage peak energy demand. Gas is therefore likely to provide a lower proportion of the UK's overall energy needs in the coming decades, although there are indications that the gas network will play an increasing role in supporting peak energy demand and providing energy storage. In relation to demand for gas particularly in homes, although this will depend on the relative cost of different low-carbon heating technologies, heat demand in homes is likely to be met by a variety of energy sources including gas – especially at peak times – alongside electricity and heat networks.

In relation to demand for gas for industry, due to the sheer variety of processes gas is used for in different industrial sectors, no clear trend has emerged. Gas is used especially by energy intensive industries and the chemicals sector. Industry is subject to 'carbon pricing', based on the amount of greenhouse gases emitted. The use of decarbonised gas would significantly reduce the financial impact of carbon pricing on energy-intensive industrial sectors, but it would also require changes to gas-handling equipment, process controls and production methods. The economics of using low-carbon gas, compared to natural gas or alternative sources of energy, depends on the level at which future UK carbon pricing is set and the evolution of energy prices overall. For steelmaking, which is an energy and emissions-intensive process, the use of hydrogen gas offers the only means of producing zero-emissions steel from virgin iron ore, while electrification may play an increasing role in the recycling of scrap steel. On the other hand, for chemical producers that rely on natural gas as a feedstock (rather than an energy source), biomethane, which is chemically similar to natural gas, is a viable route to decarbonising. In the medium term, there is likely to be increased demand for natural gas from hydrogen production via steam methane reforming or autothermal reforming with carbon capture and storage (CCUS). Seemingly, there is likely to be demand for some natural and low-carbon gas in industry. There are, however, various factors that will affect businesses' decisions on what energy source they use, making it difficult to ascertain whether overall there will be greater or lesser demand for gas from industry in the decades ahead.

In relation to gas demand in the transport sector, a number of gas-powered vehicle fleets are in operation – particularly in the freight sector where several commercial fleet operators have adopted compressed natural gas-powered trucks. However, demand is presently low and vehicle sales data from the Department of Transport (DfT) paint an uncertain picture of future demand for gas-powered vehicles.[57] The private vehicle market has shown a clear preference for electrification over gas, while the combined market share of sales of both types of vehicle stood at just 0.2% in 2017.[58] However, it is estimated that hydrogen vehicles may achieve a market share of between 20% and 50% by 2050.[59] More broadly, new sources of demand for low-carbon gas – specifically, biomethane or hydrogen - may emerge from aviation, rail and shipping as these sectors seek to decarbonise.

Overall, then, it is clear there will still be demand from key sectors from the gas network, whether that is for natural gas or low-carbon alternatives, in the decades ahead. But it is worth stressing that for the many sectors that rely on natural gas, a switch to using low carbon gas may still be challenging. Low carbon gas is at present more expensive to produce than natural gas since the costs of externalities, such as climate change impacts, are currently not priced into natural gas production and usage. And with industrial applications of natural gas, such as

57. Department for Transport, "Cars (VEH02)", dataset VEH0203, https://www.gov.uk/government/statistical-data-sets/veh02-licensed-cars (2018).
58. Ibid.
59. UkH2Mobility, "Phase 1 results", http://www.ukh2mobility.co.uk/wp-content/uploads/2013/08/UKH2-Mobility-Phase-1-Results-April-2013.pdf (2013), iii.

high temperature processes and chemicals manufacturing, suitable alternatives to it are limited. Nevertheless, as Chapter Four will make clear, innovations in product and processing technologies are lowering the barriers to transitioning away from natural gas.

Furthermore, it should be noted that there are profound implications for reducing gas demand by a complete shift of energy demand away from the gas network. Taken to the extreme, this could make decarbonising UK gas irrelevant. As unlikely as this scenario is, it does raise issues about the allocation of government focus and resources to the gas network in its energy policy. To avoid under- or over-investment in the UK's gas network, the Committee on Climate Change (CCC) has advised that future decisions from government about decarbonising the gas network should be taken in the next parliament.[60] Any policies proposed later in this report, therefore, should follow this timetable.

The potential for reducing gas demand via the second route – the installation of energy efficiency measures – is explored in greater detail in the next chapter. But there are limits to its overall impact on gas demand.

Box 3.2. The impact of convergence of energy provision

The convergence of energy provision also points to the major role gas should and will play in the UK's future energy system.

Generally, convergence refers to and involves different network industries becoming more closely integrated. For example, how the gas network is interacting with the telecommunications network, through the roll-out of smart meters and smart heating controls.

For the purposes of this paper, convergence refers to and focuses on closer integration of different energy networks, specifically the

60. Committee on Climate Change, "Next steps for UK heat policy", https://www.theccc.org.uk/wp-content/uploads/2016/10/Next-steps-for-UK-heat-policy-Committee-on-Climate-Change-October-2016.pdf (2016), 8.

gas and electricity network. The objective of convergence is to make energy networks function more efficiently with increased interoperability between them, supporting deeper decarbonisation and reducing costs for end users.

At present, the UK's gas and electricity networks operate largely independently of each other. However, flexible energy technologies are developing, such as smart infrastructure, hybrid heating systems that can draw energy from multiple sources (such as gas and electricity), and demand-side response technologies, such as power-to-gas and smart appliances. The deployment of technologies such as these could result in greater interaction between the gas and electricity networks.

Three attributes of the UK's gas network are particularly desirable in such an integrated energy system: network flexibility, resilience, and energy storage.

First, as the UK meets an increasing proportion of its energy needs from low or zero carbon energy sources, the energy system will need to become more resilient to intermittency in electricity supply. Flexibility between the electricity and gas networks both at a network level and in end-user energy equipment will help in managing peak heat demand and intermittent electricity supply in a renewables-dominated energy system. Since the UK gas network has greater flexibility in responding to fluctuations in heat demand compared to the electricity network, it will play a major role in delivering this sort of flexibility to the energy system in future.

Second, gas network infrastructure is largely below ground and is inherently less vulnerable to damage from storms or other extreme weather events which cause disruption to overground infrastructure. Conversely, much of the electricity network is above ground and susceptible to storm damage. The gas network is also required to withstand events that may occur on a one in 20-year timescale, such as extremely high levels of demand or disruption to supply. This ingrained reliability makes the UK gas network well-suited to balancing electricity network intermittency in future, as well as peak heat demand.

Third, energy storage, and the ability for the gas network to provide seasonal storage capacity, will become an increasingly valuable commodity for security of supply, providing essential backup at times of low renewable energy output. At present, the gas network has far greater capacity to store energy over the duration of the winter season than the electricity network. Without gas storage, it would be extremely difficult to meet current peak winter heating demands and the gas network is therefore likely to continue providing energy storage for the foreseeable future. Indeed, to cope with increased rates of low-carbon gas, additional gas storage capacity may be required at the regional gas distribution level.

Without doubt, UK gas should and will play a critical role in energy provision which is more converged. These three attributes are why it is necessary and desirable for politicians and policymakers to focus on facilitating investments and providing incentives for UK gas to decarbonise in the decades ahead.

While Gas Distribution Network Operators are obliged to provide infrastructure to meet peak demand levels, it is not within their legal remit to develop new capacity for network flexibility or gas storage. Moreover, such flexibility is not currently incentivised; a combination of policy and regulatory measures is needed to overcome the barriers to developing technologies that enable convergence.

The costs of the different decarbonisation pathways

There have been studies on the projected costs to government and consumers of these different pathways to deeper decarbonisation. First, recent modelling by Imperial College London, on behalf of the CCC, forecasts that the building of a hybrid gas, electric and heat network-based heating system is a more cost-effective route to decarbonising the heat sector compared to either full electrification (converting heating systems to run on electricity only) or repurposing of the gas network to carry 100% the low-carbon hydrogen.[61] This analysis suggests that a particular approach to reforming demand for UK gas would be the most cost-effective route to deeper decarbonisation.

Contrastingly, analysis by the NIC finds that repurposing the gas network to deliver low-carbon hydrogen on a large scale is the least costly route to decarbonising heat,[62] suggesting that supply-side reforms should be the focus of deeper decarbonisation of UK gas.

The different conclusions of these two leading reports are indicative of the sensitivity of cost estimates to modelling assumptions. Indeed, though this rigorous modelling has been undertaken, there are still numerous cost uncertainties inherent to all potential routes to decarbonisation. Nevertheless, all credible studies rely on deeper decarbonisation of the gas network, or parts thereof, for meeting the UK's current greenhouse gas emissions reduction target cost-effectively. As highlighted in a recent report by Frontier Economics,[63] an approach that balances securing long-term investment in the UK gas network while keeping options open for focussing on decarbonising other parts of the UK's energy system reduces the risk of turning parts of the UK's energy infrastructure into 'stranded assets'.

---

61. Imperial College, "Analysis of Alternative UK heat decarbonisation pathways (Imperial), https://www.theccc.org.uk/publication/analysis-of-alternative-uk-heat-decarbonisation-pathways/ Committee on Climate Change, (2018), 84.
62. E4tech & Element Energy, "Cost analysis of future heat infrastructure options", https://www.nic.org.uk/wp-content/uploads/Element-Energy-and-E4techCost-analysis-of-future-heat-infrastructure-Final.pdf National Infrastructure Commission, (2018), 8-9.
63. Frontier Economics, "market and regulatory frameworks for a low carbon gas system", https://www.frontier-economics.com/media/2250/beis-low-carbon-gas.pdf BEIS, (2018), 132-133.

Conclusion

The report thus far has shown that deeper decarbonisation of the UK's gas network is both a necessary and desirable aim of government policy. Though there are challenges, both of the two main pathways to decarbonisation - reducing the carbon intensity of the supply of gas and reducing gas demand – should be pursued.

There has been some progress in decarbonisation, especially in reducing leakage from the pipeline infrastructure and gas demand from the electricity sector. Nonetheless, much more needs to be done, especially in reducing demand from the heating sector. The most recent UK strategy for decarbonising heat was produced in 2013, under the Coalition Government by the then Department of Energy and Climate Change (DECC). The context in which the strategy was developed has been superseded by more recent technological developments. A more recent document was published by BEIS in December 2018, collating up-to-date evidence on decarbonising heat.[64] Nevertheless, the Government's approach, as outlined therein, remains a somewhat fragmented collection of measures rather than a strategic plan.

This chapter has argued that there are clear government incentives for decarbonisation in the electricity sector. There are, however, no equivalent regulations or schemes to promote decarbonisation of the gas network, and especially the heating sector, despite their more significant role in energy provision. New policies are needed, especially for when the next price control framework, RIIO-2, starts in 2021. That is the focus of Chapter Six. Technological solutions, however, will also have a vital role in enabling both pathways for decarbonising UK gas. The key technologies that can support the two different decarbonisation pathways are described in the next chapter.

64. BEIS, "Clean Growth – Transforming Heating", https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/766109/decarbonising-heating.pdf (2018), 3-5.

Chapter 4: Technological solutions for decarbonising UK gas

The last chapter outlined the history of, projections for and challenges of two pathways to decarbonising UK gas. In particular, it outlined some of the practical challenges to, as well as the lack of government incentives for, reducing the carbon intensity of the supply of gas, and shifting consumer demand away from the gas network. This chapter examines the technological solutions that could support the decarbonisation of the supply and demand of UK gas.

Supply-side technological solutions

As Chapter One outlined, natural gas – which comprises the vast majority of gas flowing through the network - emits carbon dioxide when burned. It therefore contributes substantially to greenhouse gas emissions through its consumption and, to a much lesser extent, through leakage from gas pipes. There are, however, low carbon, and even 'carbon negative' gases, that can reduce the carbon intensity of gas as an energy carrier. Low carbon gases have lifecycle greenhouse gas emissions that are considerably lower than natural gas. 'Carbon negative' gases, in fact, lead to a net reduction in greenhouse gas emissions.

An increased usage of these alternatives gases would thus strongly support decarbonisation of UK gas. In fact, as Chapter Three stated, if the UK is to meet its legal greenhouse emissions target, there will be limited scope for natural gas usage in the heating and power sectors especially by 2050.

There are three varieties of low carbon gas in production in the UK today: biomethane, bio-synthetic natural gas (bioSNG) and hydrogen. Of these, as Chart 1.1 much earlier illustrated, biomethane is the only one that is currently injected into the gas network.[65] No carbon negative gases are currently being produced in the UK on a commercial scale.

The processes for producing low carbon gases are well-established but, without government subsidy or incentives, they are more expensive to produce than natural gas.

Table 4.1 below shows the 'carbon footprint' of two of the low carbon gases, using different production methods, relative to natural gas on a per unit energy basis. Carbon footprint refers to the lifecycle emissions of a particular gas, which includes any greenhouse gas emissions arising from its production and combustion. There is no available data for bioSNG, and there is one plant for this currently operating in the UK.

Table 4.1. Estimated carbon footprints of natural and low carbon gases, using different production methods

Gas	Carbon footprint (gCO_2eq/kWh)[66]
Natural gas	232
Biomethane	-50 to 450
Biomethane injection, RHI eligibility	<125
Hydrogen (steam methane reformed (SMR), no carbon capture and storage (CCS))	300
Hydrogen (SMR with CCS)	80
Hydrogen (electrolysis)	Typically <100

65. BEIS, "Energy Trends: gas", https://www.gov.uk/government/statistics/gas-section-4-energy-trends (2018). Natural gas production and supply (ET 4.2). Calculated from 2017 data on biomethane injection and gross gas production.
66. Figures in grams of carbon dioxide (equivalent) per kilowatt hour.

Hydrogen (biogasification, no CCS)	110
Hydrogen (biogasification with CCS)	Negative

Source: Parliamentary Office of Science & Technology[67]

As Table 4.1 shows, the carbon footprint of alternatives to natural gas is strongly dependent on the method of production. These different production methods are described below. With certain production methods, biomethane and hydrogen can have a significantly lower carbon footprint than natural gas. For both biomethane and hydrogen, there is in fact the potential for it to be a carbon negative gas.

The future of biomethane

Biomethane is extracted from biogas produced by the anaerobic digestion of biodegradable waste, which would have otherwise been sent to landfill. Biomethane is at present the only form of low carbon gas that is eligible to receive subsidies (under the RHI, described in Box 3.2) for commercial production. It is also the only form of low carbon gas injected into the gas network, albeit only a relatively small amount. In 2017, 2.8 TWh of biomethane was injected into the gas network, representing 0.3% of total gas supply.[68]

Biomethane can have significantly lower carbon footprint than natural gas but it is not carbon negative unless carbon capture and utilisation or storage (CCUS) is used to sequester greenhouse gas emissions emitted by the anaerobic digestion process. CCUS is a technology that involves capturing carbon dioxide from a carbon-intensive process, compressing it, and permanently storing it either through reaction to chemically bind the carbon dioxide or injecting it underground to

67. Parliamentary Office of Science and Technology, "Decarbonising the Gas Network", https://researchbriefings.parliament.uk/ResearchBriefing/Summary/POST-PN-0565 (2017), 2.
68. BEIS, "Digest of UK Energy Statistics: natural gas", (DUKES 4.2), https://www.gov.uk/government/statistics/natural-gas-chapter-4-digest-of-united-kingdom-energy-statistics-dukes, (2018), 100.

prevent it from escaping into the atmosphere. An advantage of using biomethane to replace natural gas is that it is already compatible with the existing gas network infrastructure and is one of the lowest cost routes to reducing the carbon intensity of the gas flowing through the pipeline infrastructure.

There are reportedly 98 biomethane plants injecting biogas into the UK's gas network at present, with many more biomethane plants supplying local facilities without injecting into the gas network. Owing to the distribution of anaerobic digestion plants, biomethane is, for the most part, injected directly into more local parts of the gas distribution network, often far away from the NTS.

As biomethane production expands, dominance of the gas market will shift away from large, vertically-integrated gas suppliers towards small-scale suppliers. But many of these small-small gas suppliers will require new connections to the gas network. In addition, having localised production presents a hurdle for increasing biomethane injection rates into the gas network, as there is currently no means of transferring gas from one local part of the distribution network to another. While technically possible, new infrastructure would be required to achieve this.

Since most biomethane plants inject into distal and lower pressure parts of the gas network, where gas storage capacity is limited, they are sometimes required to choke supply to the gas network during periods when local demand for gas is low. A project led by Wales and West Utilities and Cadent Gas is exploring the use of smart pressure controls within the gas network to allow low-carbon gas to be diverted to parts of the network where there is storage capacity.[69]

There are very differing estimates of the potential contribution biomethane can make to the UK's gas supply. The NIC's recent analysis of heat infrastructure suggests there is enough biomass feedstock

---

69. Wales and West Utilities, "2018 Long Term Development Statement", https://www.wwutilities.co.uk/media/2845/2018-long-term-development-statement.pdf (2018), 31.

to supply at least 10 TWh per year to the gas network,[70] while other modelling suggests potential biogas capacity of between 80 TWh and 108 TWh by 2050, which would represent 10% of current UK gas demand.[71] Nonetheless, alternative estimates indicate that biomethane may only be capable of supplying up to 5% of current UK gas demand.[72]

The future of bio-synthetic natural gas (bioSNG)

Bio-synthetic natural gas (bioSNG) is methane produced from biomass gasification. The UK currently has a single bioSNG demonstration plant in the west of England which opened in 2018[73] and uses municipal waste as a feedstock. The Government's growing determination and plans to reduce waste[74] are likely to make it increasingly difficult to source suitable feedstocks for bioSNG production.

Though representing a small proportion of gas supply at the moment, it has been estimated that bioSNG output could reach 100 TWh per annum by 2050, equating to roughly 10% of total gas supply in the UK, and become cost competitive with natural gas from 2030.[75]

70. E4tech & Element Energy, "Cost analysis of future heat infrastructure options", https://www.nic.org.uk/wp-content/uploads/Element-Energy-and-E4techCost-analysis-of-future-heat-infrastructure-Final.pdf National Infrastructure Commission, (2018), 5.
71. Anaerobic Digestion and Bioresources Association, "Heat decarbonisation and the role of new AD feedstocks", http://adbioresources.org/news/heat-decarbonisation-and-the-role-of-new-ad-feedstocks (2017); REA, "REA response to Bright Blue Call for Evidence", https://static1.squarespace.com/static/56d9b584f8baf31e9937bd55/t/5b72dff5562fa741a1d67601/1534255094903/REA.pdf (2018).
72. Parliamentary Office of Science and Technology, "Decarbonising the Gas Network", https://researchbriefings.parliament.uk/ResearchBriefing/Summary/POST-PN-0565 (2017), 2.
73. Bioenergy Insight, "UK's first BioSNG plant to use Saxlund technology", https://www.bioenergy-news.com/display_news/12841/uks_first_biosng_plant_to_use_saxlund_technology/ (2017).
74. HM Government, "Our waste, our resources: a strategy for England", https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/765914/resources-waste-strategy-dec-2018.pdf (2018).
75. Cadent, "BioSNG Demonstration Plant: Project Close-Down Report", http://gogreengas.com/wp-content/uploads/2015/11/BioSNG-170223-1-Project-Close-Out-Report.pdf (2015), 35.

The future of hydrogen

Hydrogen is a gas that burns without producing any greenhouse gas emissions. However, the production of hydrogen gas is not intrinsically low carbon. As Table 4.1 earlier demonstrated, its carbon footprint will vary depending on the method used. There are numerous methods for producing hydrogen, but those which are most appropriate for injection into the gas network include: electrolysis of water; steam methane or autothermal reforming of natural gas; and, coal or biomass gasification.

First, production of hydrogen by electrolysis involves a process of splitting water into oxygen and hydrogen using electricity. In order for hydrogen produced in this manner to have a low carbon footprint, the electricity used must be have a low or zero carbon footprint. It is estimated that to produce hydrogen from electricity with a lower net carbon footprint than natural gas requires marginal electricity grid carbon intensity of below 150 gCO_2/kWh.[76]

Since electricity consumer prices track well above gas consumer prices, hydrogen produced via electrolysis tends to be more expensive than the other production processes for hydrogen. However, the technology can be more environmentally sustainable than these alternative production methods, particularly if seawater is used as a feedstock. Moreover, electrolysis can allow electrical energy to be converted into gas during periods when there is excess electrical energy available on the electricity networks.

Second, in the steam methane reforming (SMR) or autothermal reforming (ATR) process for hydrogen production, natural gas is chemically converted into hydrogen at high temperature and pressure. This is at present the most commonly used method for producing hydrogen on a commercial scale, accounting for 48% of global

76. Energy Research Partnership, "Potential role of hydrogen in the UK energy system", http://erpuk.org/wp-content/uploads/2016/10/ERP-Hydrogen-report-Oct-2016.pdf (2016) 28.

production.[77] Large quantities of carbon dioxide are also produced as a by-product. So, in order to make this hydrogen production process low carbon, this carbon dioxide must be captured and permanently sequestered or mineralised using CCUS.

Third, in coal and biomass gasification, there is a production process of converting coal or biomass to hydrogen-rich syngas in a controlled reaction. As with SMR, carbon dioxide is produced in this production process, alongside hydrogen and methane (or, bioSNG).[78] Since biomass is a natural carbon sink, using CCS with biogasification provides a carbon negative route to producing hydrogen.[79]

There are two likely scenarios that could emerge for using hydrogen in the UK's gas network: blending hydrogen with natural gas and other renewable gases, or repurposing parts of the gas network to carry up to 100% hydrogen gas.

Technologies for blending hydrogen with natural gas, and converting the gas network to carry 100% hydrogen, are being actively researched and piloted, for example through schemes such as INTEGREL, H100, H21, Hy4Heat, HyDeploy, and HyNet.[80] INTEGREL is a project which includes the development of a 50-100MW electrolyser to convert electricity into hydrogen.[81] H100 is a project that is exploring the viability of using hydrogen in the gas network on a commercial scale.[82] H21 is a project to examine the feasibility of converting part of an existing gas network to 100% Hydrogen. Hy4Heat is a programme which aims to establish the safety parameters for hydrogen blended with natural gas in domestic appliances. HyDeploy is a programme to

---

77. Parliamentary Office of Science and Technology, "Decarbonising the Gas Network", https://researchbriefings.parliament.uk/ResearchBriefing/Summary/POST-PN-0565 (2017), 2.
78. US Department of Energy, "Hydrogen Production: Biomass Gasification", https://www.energy.gov/eere/fuelcells/hydrogen-production-biomass-gasification.
79. Parliamentary Office of Science and Technology, "Decarbonising the Gas Network", https://researchbriefings.parliament.uk/ResearchBriefing/Summary/POST-PN-0565 (2017), 3.
80. HyDeploy, "About Hydeploy" https://hydeploy.co.uk.
81. Gridchangeagent.com, "UK one step closer to first large-scale power-to-gas project", https://gridchangeagent.com/uk-one-step-closer-to-first-large-scale-power-to-gas-project/ (2018).
82. Scottish Gas Networks, https://www.sgn.co.uk/Hydrogen-100/

determine whether existing domestic cooking and heating appliances are compatible with gas that contains 20% hydrogen at a small number of households near Keele University.[83] HyNet is a project that aims to combine hydrogen production from natural gas (using SMR) with CCUS to create low carbon gas that might in future be injected into the gas network. None of these technologies have yet been developed on a commercial scale.

Moreover, neither hydrogen blending nor full conversion to hydrogen in the gas network is permitted by the current Gas Safety (Management) Regulations, explained in Box 1.2 earlier. These regulations permit only up to 0.1% hydrogen (by volume) in the gas network.[84] These regulations were established more than two decades ago at a time when the gas network was predominantly supplied by North Sea gas.

Evaluations, however, suggest that blending up to 20% hydrogen with natural gas is possible using existing infrastructure.[85] Indeed, it may be possible to inject this level of hydrogen without compromising the safety or integrity of the gas network or end user appliances. If HyDeploy is successful, this project will provide evidence to support amendments to Gas Safety (Management) Regulations with respect to permitted hydrogen content.

Subject to changes in the Gas Safety (Management) Regulations, blending small amounts of hydrogen with natural gas in the regional gas distribution networks could provide a route to reducing the carbon footprint of UK gas supply with minimal disruption for consumers. Under these hydrogen blending scenarios, there would be little need for changes to consumer gas equipment since existing domestic gas heating appliances can be safely used with these types of low concentrations of hydrogen gas.

---

83. HyDeploy, "About HyDeploy", https://hydeploy.co.uk.
84. DNV GL, "Hydrogen and other routes to decarbonization of the gas network", https://www.birmingham.ac.uk/Documents/college-eps/chemical/fuel-cells/FCH2-2018-Presentations/k-4-Andy-Williams-DNV-GL-Hydrogen-Presentation-for-FCH2.pdf (2018), 15.
85. Health and Safety Executive, "Injecting hydrogen into the gas network - a literature search", http://www.hse.gov.uk/research/rrhtm/rr1047.htm (2015), v.

In contrast, repurposing the gas network to carry 100% hydrogen raises the prospect of more disruptive changes to the both the network infrastructure and consumer equipment. Hydrogen is not currently compatible with the high pressure gas mains of the NTS, due to there being increased risk of leakage.[86] This poses a hurdle for short-term gas storage in a 100% hydrogen network since the NTS, at present, provides most of the gas network's daily storage capability.[87] Furthermore, hydrogen conversion is not a process that will happen of its own accord or because the market wills it: a planned conversion is necessary for attracting investment to where it is needed and ensuring different actors in the gas network coordinate actions to achieve this.

While full conversion of the gas network infrastructure for 100% hydrogen has not been proven on a commercial scale, the H21 project, which is supported with a £8.9 million grant from Ofgem, demonstrates this is at least possible for some parts of the network. Indeed, hydrogen blending and conversion are not mutually exclusive and, with careful planning, different parts of the gas network may operate on different gas compositions.

Ultimately, the potential for hydrogen to decarbonise the gas network, while promising, remains uncertain because of technological and regulatory barriers. But the CCC's central scenario for 2050 indicates that around 60% of demand for heat from domestic, commercial and industrial consumers could come from hydrogen in the gas network. This would reduce greenhouse gas emissions from the residential sector from 29 to 3 MtCO2 a year, equal to a tremendous 90% reduction.[88]

Overall, there are various technological solutions for decarbonising the UK gas supply, each with different associated costs, timescales for development and practical limitations. The processes for producing

---

86. Parliamentary Office of Science and Technology, "Decarbonising the Gas Network", https://researchbriefings.parliament.uk/ResearchBriefing/Summary/POST-PN-0565 (2017), 3.
87. Ibid., 3.
88. E4tech, "Hydrogen and fuel cells: opportunities for growth a roadmap for the UK", http://www.e4tech.com/wp-content/uploads/2016/11/UKHFC-Roadmap-Final-Main-Report-171116.pdf (2016), 9.

low carbon gases are well-established, although they are currently more expensive to produce than natural gas without government support and intervention. Low carbon gases can and should be used as a transition fuel to reduce the carbon footprint of the UK gas network, while carbon-negative solutions are commercialised.

Demand-side technological solutions

As Chapter Three outlined, reducing gas consumption represents the second major pathway to deeper decarbonisation of the gas network. This can be achieved in two main ways: by improving the efficiency of gas usage; and, by encouraging fuel switching as to shift demand away from the gas network.

Improving the energy efficiency of gas usage

Energy efficiency enhancements in residential, commercial and industrial buildings – as well as of gas appliances - can cut heat waste and therefore reduce gas demand, particularly during peak periods. An array of materials and technologies exist to make buildings more energy efficient, most commonly solid wall insulation, cavity wall insulation, loft insulation and double glazing. These are not discussed exhaustively here. A detailed overview of different energy efficiency measures can be found in Bright Blue's recent report, Better Homes.[89]

The degree to which these different energy efficiency measures can reduce gas demand cost-effectively in the UK varies across buildings of different ages and geographies. Recent constructions tend to be more efficient than those predating the advent of modern building standards. However, creating new and more efficient buildings is only part of the solution. Around 80% of the UK's existing housing stock will remain

89. Sam Hall and Ben Caldecott, "Better homes", https://brightblue.org.uk/wp-content/uploads/2017/03/Betterhomes.pdf (2016).

in use by 2050[90] and these buildings too will need improvements to increase their efficiency during the interim.

A recent report by the UK Energy Research Council estimated that installing 'cost-effective'[91] energy efficiency measures up to 2035 could cut energy use in the domestic sector, the biggest consumer of gas, as Figure 1.1 earlier showed, by a quarter.[92] Similarly, the NIC identifies low-cost energy efficiency measures as generating potential energy savings of 30 TWh per year, equating to around 6% of total heat demand.[93]

The widespread use of energy efficiency measures is therefore highly important to reducing demand for gas. There has been good progress in the uptake of some of the main energy efficiency measures, especially double glazing, cavity wall insulation and loft wall insulation. However, on solid wall insulation, which has the greatest energy savings potential, the progress in uptake has been much slower.[94]

As of 2013, the average Energy Performance Certificate (EPC) rating - a measure of how energy efficient a building is - for all UK homes was D.[95] The Government's 2017 Clean Growth Strategy sets out an ambition for all UK homes to have a minimum EPC rating of C by 2035. Indisputably, much more progress is needed on the uptake of energy efficiency measures.

---

90. Brenda Boardman (for The Co-operative Bank and Friends of the Earth), "Home Truths: A low-carbon strategy to reduce UK housing emissions by 80% by 2050", https://friendsoftheearth.uk/sites/default/files/downloads/home_truths.pdf (2007), 6.
91. The measure of cost effectiveness used by the authors is based on criteria used by the UK government to appraise public policies and projects. Measures are cost effective when the discounted sum of all benefits exceeds the associated capital costs. The term 'cost effective' should not be interpreted to imply that improvements considered as such are affordable to energy consumers.
92. Dr. Jan Rosenow, Professor Nick Eyre, Professor Steve Sorrell, Pedro Guertler (for UK Energy Research Council), "Unlocking Britain's First Fuel: The potential for energy savings in UK housing. http://www.ukerc.ac.uk/news/unlocking-britains-first-fuel.html (2017), 1.
93. E4tech & Element Energy (on behalf of the National Infrastructure Commission), "Cost analysis of future heat infrastructure options", https://www.nic.org.uk/wp-content/uploads/Element-Energy-and-E4techCost-analysis-of-future-heat-infrastructure-Final.pdf (2018), 4.
94. Sam Hall and Ben Caldecott, "Better Homes", https://brightblue.org.uk/wp-content/uploads/2017/03/Betterhomes.pdf (2016), 8.
95. Department of Energy and Climate Change, "Energy Efficiency Statistical Summary 2015", https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/395007/stats_summary_2015.pdf (2015), 19.

At present, though, it is not clear whether government policy measures currently in place, such as the Energy Company Obligation (ECO) (see Box 3.1), will be sufficient to incentivise retrofitting of energy efficiency measures on the scale required to achieve this. This is especially the case since the Government recently abandoned other relevant policies. First, it withdrew financial support for the 'Green Deal', launched in 2013 to incentivise and finance retrofitting in the domestic sector, in mid-2015, as a result of low take-up, failure to leverage private investment, a high cost to the taxpayer, and poor interaction with the ECO.[96] Indeed, only 15,600 loans were ever issued under the Green Deal.[97] Second, in 2015, it cancelled the 'Zero Carbon Homes Standard', which was introduced with the aim of requiring all new homes to be highly energy efficient from 2016. Since these flagship policies have been scrapped, no successor schemes have been put in place. Essentially, though the uptake of energy efficiency measures is essential to reduce gas demand, there are currently a lack of policies from government to support this technological solution. In 2017, the Government consulted on creating a market for energy efficiency, but has not yet released its plans.

Encouraging fuel switching to shift demand away from the gas network

Chapter Three outlined current projections of gas use by different consumers, such as the electricity and heat sectors, industry and transport, concluding that gas – including decarbonised forms of it - will and should still be an important source of fuel for them. Nonetheless, there is scope to shift a substantial proportion of demand away from gas among these different consumers through technologies that enable

96. Sam Hall and Ben Caldecott, "Better Homes", https://brightblue.org.uk/wp-content/uploads/2017/03/Betterhomes.pdf (2016), 11-12.
97. MoneySavingExpert.com, "The Green Deal Mythbuster", https://www.moneysavingexpert.com/utilities/green-deal/ (2015).

fuel switching, specifically substituting natural gas with lower carbon alternatives.

Fuel switching provides a means of reducing the use of natural gas in the heating sector in particular. The main potential technological solutions to enable fuel switching away from gas in the heating sector include: electrification; local heat networks; biomass boilers; and, solar thermal systems.

Electrification of heating

Electrification in the heating sector involves replacing heating appliances that run on gas with those that run on electricity. Electric heating technologies do not contribute directly to greenhouse gas emissions. They may, however, lead to them indirectly, depending on the marginal source of electricity used to power them. The main electrical heating technologies are direct electric heating and pure electric or hybrid heat pumps.

Widespread use of electric heating technologies in the UK would increase annual and peak demand on electricity networks, particularly during winter months. The marginal electricity used to power electric heating equipment at peak times would therefore need to be sourced from dispatchable sources such as gas plant, hydroelectric power or battery storage. This would require a significant increase in electricity generation, storage, transmission and distribution infrastructure, along with changes to consumer heating systems, most of which presently run on gas.

Direct electric heating can provide space heating and hot water. Nonetheless, at current average electricity grid carbon intensity levels, direct electric heating often has higher (albeit indirect) greenhouse gas emissions, compared to using a natural gas-boiler,[98] particularly when used at times of peak electricity demand. They are also a relatively

98. ICAX, "Direct Electric Heating", https://www.icax.co.uk/Direct_Electric_Heating.html.

expensive form of heating compared to gas boiler-powered central heating systems. Direct electric heating is, therefore, unlikely to provide a scalable alternative to natural gas use in the heating sector.

Heat pumps work by transferring ambient atmospheric or ground source heat to warm or cool the interior of buildings, much in the same way that air conditioning systems do. These air-source and ground-source heat pumps work most efficiently when providing low-grade space heating in well-insulated buildings, but are less suited to providing hot water. They also work less efficiently in winter due to there being less ambient heat to draw upon.[99]

The CCC has recommended that one in five of all new homes be retrofitted with pure electric heat pumps by 2030.[100],[101] Pure electric heat pumps can be up to 25% cheaper than conventional gas boilers over a lifetime,[102] but have significantly higher upfront costs, making them an unattractive proposition for consumers that do not face particularly high energy costs. For example, ground-source heat pumps cost between £9,000 and £17,000 and air-source heat pumps cost between £3,000 and £10,000.[103] Moreover, heat pumps do not have high flow temperatures, meaning that to provide a home with sufficient heat, the property must be very energy efficient. This can require the expensive retrofitting of more energy efficiency measures, together with more radiators.

---

99. ICAX, "Air Source Heat Pumps", https://www.icax.co.uk/Air_Source_Heat_Pumps.html.
100. Committee on Climate Change, "Next steps for UK heat policy", https://www.theccc.org.uk/wp-content/uploads/2016/10/Next-steps-for-UK-heat-policy-Committee-on-Climate-Change-October-2016.pdf (2016), 52.
101. Mike Hemsley, "Cleaning up the UK's heating systems: new insights on low-carbon heat", https://www.theccc.org.uk/2018/09/10/cleaning-up-the-uks-heating-systems-new-insights-on-low-carbon-heat/ Committee on Climate Change, (2018).
102. WSP, "Delivering cleaner air, carbon savings and lower costs for property owners with heat pumps", http://www.wsp-pb.com/PageFilesn/83555/WSP_Carbon%20Free%20Heating%20and%20Cooling.pdf (2017), 9.
103. Sam Hall and Ben Caldecott, "Better Homes", https://brightblue.org.uk/wp-content/uploads/2017/03/Betterhomes.pdf (2016), 9.

Box 4.1 Hybrid heat pumps

Hybrid heat pumps can operate interchangeably using electricity or gas, therefore overcoming to a degree some of the limitations associated with electric heat pumps at the same time as potentially reducing heating costs. The opportunity to use gas also avoids being wholly dependent on electricity supply.[104] The CCC has estimated that hybrid heat pumps could result in up to 85% of UK consumers' heat demand being met by low-carbon electricity by 2050, resulting in significant reduction in gas use. However, the same report acknowledges that gas would still be required for meeting peak heat demand.

District heat networks

District heat networks function as a system of insulated pipes that distribute heat across a locality from a central source, therefore requiring a new, localised distribution network.

The heat source might be a facility that provides a dedicated supply to the heat network, either a gas plant or combined heat and power unit; or heat recovered from industry and urban infrastructure, canals and rivers, or energy from waste plants.[105] Greenhouse gas emissions associated with district heat networks will vary depending on the source of heat.

District heat networks currently supply around 2% of space and water heating demand. Deployment of heat networks requires new pipeline infrastructure to transport heat from its source to nearby buildings. They are therefore better suited to installation in new developments,

104. Jenny Love et al., "The addition of heat pump electricity load profiles to GB electricity demand: evidence from a heat pump field trial", Applied Energy 204 (2017), 332-342.
105. Department for Business, Energy and Industrial Strategy, "Heat networks", https://www.gov.uk/guidance/heat-networks-overview (2018).

rather than being retrofitted into existing buildings which is disruptive.

Research by the Energy Technologies Institute suggests they could meet nearly half the UK's heat demand, assuming capital costs can be significantly reduced.[106] The NIC estimates a less ambitious roll-out is feasible, with heat networks potentially supplying between 10% and 25% of the UK's heat demand, while reducing overall annual greenhouse gas emissions from the heating sector by 10 MtCO2/year by 2050.[107] It is important to note that the degree to which the use of district heat networks results in greenhouse gas emissions reductions varies according to the source of energy used to generate the heat.

Biomass boilers

Biomass boilers burn renewable organic material to produce heat. Unlike heat pumps, they are able to provide similar flow temperatures to condensing gas boilers.

Biomass boilers provide space heating and, in some cases, hot water. Biomass is not a carbon-neutral fuel, but it can be a lower carbon alternative to natural gas heating if emissions from processing and transport are minimised. They are standalone, meaning it does not require network infrastructure to supply energy that is used to operate them.

The upfront costs of installing biomass boilers can be high, however, ranging from £7,000 to £13,000.[108] The running costs of biomass heating systems vary by geography. Many rural areas have access to large quantities of woody biomass at very low cost, although there is limited

106. Energy Technologies Institute, "New ETI report highlights how the capital costs of UK heat networks could be reduced by 30-40%", https://www.eti.co.uk/news/new-eti-report-highlights-how-the-capital-costs-of-uk-heat-networks-could-be-reduced-by-30-40 (2018).
107. E4tech & Element Energy, "Cost analysis of future heat infrastructure options", https://www.nic.org.uk/wp-content/uploads/Element-Energy-and-E4techCost-analysis-of-future-heat-infrastructure-Final.pdf National Infrastructure Commission, (2018), 4.
108. Sam Hall & Ben Caldecott, "Better homes", https://brightblue.org.uk/wp-content/uploads/2017/03/Betterhomes.pdf (2016), 9.

availability of sustainable biomass that doesn't compete with food crops and increase overall carbon emissions. In metropolitan areas, biomass as well as space to store it are at a premium. Furthermore, air quality regulations prevent the burning of solid fuels, such as biomass, in some urban areas.

The NIC estimates there is 100 TWh per year of sustainable biomass potential.[109] This is equivalent to a third of domestic gas demand.

Solar thermal systems

Solar thermal heating – or, more commonly, rooftop solar thermal panels on a building - uses the sun's energy to heat and store water carried in pipes that are exposed to sunlight. Solar thermal systems produce no direct greenhouse gas emissions. Like biomass, they are standalone. It also has, relative to the other heat technologies detailed in this chapter, low installation costs, ranging from £4,000 to £6,000.[110]

However, a drawback of these systems is the variability of solar gain throughout the year, which makes them less productive during winter months when hot water is in greater demand. As such, the role of solar thermal is limited to complementing other heating systems, rather than a significant substitute for gas use in heating.

Conclusion

This chapter explored technological solutions for the two main pathways to the decarbonisation of UK has. On the supply-side, there are renewable, low-carbon forms of gas which could be injected into the gas network, but government regulation and incentives do not sufficiently support this at present. New policy measures are needed

109. E4tech & Element Energy, "Cost analysis of future heat infrastructure options", https://www.nic.org.uk/wp-content/uploads/Element-Energy-and-E4techCost-analysis-of-future-heat-infrastructure-Final.pdf National Infrastructure Commission, (2018), 5.
110. Sam Hall and Ben Caldecott, "Better Homes", https://brightblue.org.uk/wp-content/uploads/2017/03/Betterhomes.pdf (2016) 9.

in order to expand renewable gas production to a scale such that it can make a significant dent in the carbon footprint of the gas network.

On the demand-side, there are technological solutions both to improve the energy efficiency of gas consumption in the heating sector and provide alternative fuel to gas for homes.

There has been some progress in the uptake of some energy efficient measures, especially air-source heat pumps, thanks in part to the subsidy available from the RHI. But there needs to be much greater deployment of them if this to be a technology that leads to substantial fuel switching in the heating sector.[111]

Energy efficiency measures and fuel switching can also incur high upfront costs and practical barriers. Again, these technological solutions have insufficient support or subsidy from the government. It is often assumed that consumers are the sole beneficiaries of energy efficiency, however, consumers who invest in energy efficiency also provide stability to the energy system through reducing their energy consumption. The focus of Chapter Six is to provide new policy ideas both to better support the adoption of these technological solutions. But, before this, the next chapter examines how deeper decarbonisation will impact on a sensitive political issue: consumer gas prices.

111. Sam Hall and Ben Caldecott, "Better Homes", https://brightblue.org.uk/wp-content/uploads/2017/03/Betterhomes.pdf, (2016) 9.

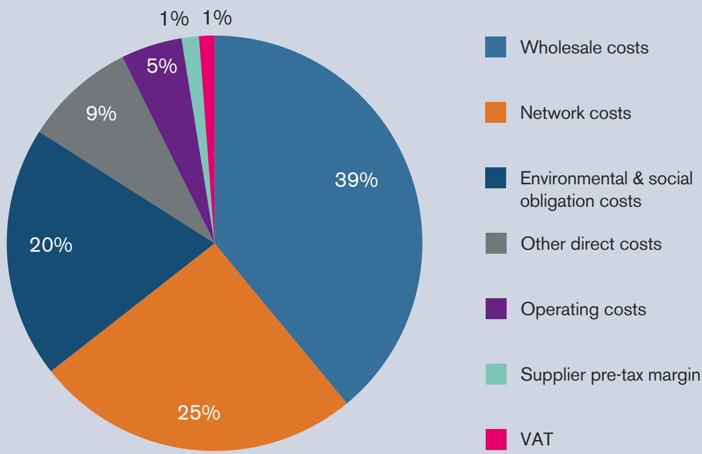
Chapter 5: Minimising prices for consumers whilst decarbonising UK gas

The previous chapter outlined the different technologies that could support deeper decarbonisation of both the supply and demand of UK gas, concluding that there was currently insufficient support and incentives from government to enable the necessary and widespread use of these technologies. This chapter explores a key challenge of deeper decarbonisation of UK gas: namely, the impact on consumer energy prices, specifically consumer gas prices. Indeed, if deeper decarbonisation of the gas network is to succeed, then dissatisfaction with consumer gas prices will have to be mitigated.

What drives consumer gas prices?

Consumer gas prices are influenced by a number of factors, including wholesale gas prices, the gas network costs, operating costs, policy measures, taxes, and profit margins., the gas network operating costs, policy measures and taxes. This is illustrated in Chapter 5.1 overleaf.

Chart 5.1. Breakdown of a typical UK consumer's gas bill, August 2018[112]



Source: Ofgem

Chart 5.1 shows that wholesale costs are typically the largest contributor to overall consumer gas prices. The CCC found that changes in wholesale gas costs accounted for 79% of overall consumer gas price increases between 2004 and 2013.[113] Gas consumers are exposed to volatility in global wholesale gas costs due to the liquidity of global gas markets.

Next, network costs - the portion of consumer gas bills that is diverted towards maintaining the UK's gas network - typically account for a quarter of consumers' gas bills.[114] Ofgem found that network costs fell by almost half in the first 15 years of privatisation. Between 2000

112. Ofgem, "Breakdown of a gas bill", https://www.ofgem.gov.uk/data-portal/breakdown-gas-bill (2018).
113. The Committee on Climate Change, "Energy prices and bills - impacts of meeting carbon budgets", https://www.theccc.org.uk/wp-content/uploads/2014/12/Energy-Prices-and-Bills-report-v11-WEB.pdf (2014), 33.
114. OVO Energy, "Wholesale energy prices", https://www.ovoenergy.com/guides/energy-guides/wholesale-energy-prices.html.

and 2014, these network costs reportedly rose, although recent data by Ofgem shows they have remained stable since then.[115] 'Environmental and social obligation costs', a designation that includes policy measures to decarbonise UK gas, typically accounts for a fifth of consumers' gas bills. This includes policies such as the ECO and the RHI, explained earlier in Box 3.1.

Consumer gas prices fell by 15%-17% in real terms between 1990-91 and 1997-98, although analysis differs as to the primary driver for these savings.[116] More recently, consumer gas bills have fallen over the last decade, in spite of rising unit costs (pence per kilowatt hour).[117] This has been achieved in a large part through a reduction in gas consumption, as shown in Chart 1.2 much earlier, mainly through the adoption of energy efficient measures.

However, the future trajectory of consumer gas prices is uncertain. Projections published by BEIS anticipate consumer gas prices will rise on average by 40% out to 2030.[118] However, the underlying assumptions of this analysis have been challenged by the government-commissioned *Cost of Energy Review*, led by Professor Dieter Helm, which suggests the future evolution of energy costs is far from clear.[119] Nevertheless, the *Cost of Energy Review* does claim that consumer prices for energy at present are higher than should be necessary to meet the UK's greenhouse gas emissions reduction target.[120]

Despite the drop in the average consumer's gas bill in recent decades,

---

115. Ofgem, "Infographic: Bills, prices and profits", https://www.ofgem.gov.uk/publications-and-updates/infographic-bills-prices-and-profits (2018).
116. NAO, "Giving Customers a Choice – The Introduction of Competition into the Domestic Gas Market", https://www.nao.org.uk/wp-content/uploads/1999/05/9899403.pdf (1999), 2.
117. Committee on Climate Change, "Energy Prices and Bills - impacts of meeting carbon budgets", https://www.theccc.org.uk/wp-content/uploads/2017/03/Energy-Prices-and-Bills-Committee-on-Climate-Change-March-2017.pdf (2017), 5.
118. https://www.gov.uk/government/publications/updated-energy-and-emissions-projections-2016, Annex: M. Change in average gas prices for industrial, residential and services for 2018, compared to 2035.
119. Dieter Helm, "Costs of Energy Review", https://www.gov.uk/government/publications/cost-of-energy-independent-review (2017), 12-13.
120. Ibid., ix.

energy bills remain a major cause of consumer dissatisfaction.[121] Data compiled by the Competition Market Authority (CMA) found that problems related to billing, customer services and payments accounted for the majority of energy customers' complaints, with numbers rising six fold between 2008 and 2014.[122]

Current measures to reduce consumer gas prices

At present, the retail energy market is not delivering competitive prices for the majority of consumers who do not switch tariff. As a result, consumers that remain loyal to energy suppliers tend to end up paying higher consumer prices. Certainly, a Competition and Markets Authority (CMA) investigation suggested the 'Big Six' energy suppliers were overcharging their customers.[123] However, it should be noted that this does not implicate gas distribution network operators.

Energy price protection for consumers largely falls within the remit of Ofgem, the energy regulator. The role of Ofgem includes promoting "security of supply and sustainability, for present and future generations of consumers".[124] Ofgem also has a role in ensuring the wider energy supply chain acts to reduce energy prices and delivers on government policy. It oversees regulations on the Gas Distribution Network Operators such as the price control framework, described earlier in Box 1.2, for example.

In some cases, however, consumer protections in the energy market are mandated by direct government regulation, rather than via Ofgem.

121. The Ombudsman Services, "Energy Sector Report: January to December 2017", https://assets.ctfassets.net/46t2drav2f3e/2fTLGLYqHamM8iI2uQQ4cM/76c5f88c00f529e02b12f6351c81bde4/1118-energy-report-2017__1_.pdf (2017), 4.
122. Competition and Market Authority, "Energy market investigation", https://assets.publishing.service.gov.uk/media/5773de34e5274a0da3000113/final-report-energy-market-investigation.pdf (2016), 6.
123. Patrick Wintour and Frances Perraudin, "Ed Miliband targets energy firms with proposed price-cut powers for Ofgem",
https://www.theguardian.com/business/2015/mar/13/ed-miliband-energy-firms-price-cut-powers-ofgem-labour-freeze-bills The Guardian, (2015).
124. Ofgem, "Who we are", https://www.ofgem.gov.uk/about-us/who-we-are.

Energy performance requirements on rental properties are one example. In April 2018, the Government introduced minimum energy efficiency standards (MEES) for rented accommodation in England and Wales. The current minimum Energy Performance Certificate (EPC) rating for rented accommodation is E,[125] and this is expected to be raised in future. Energy efficiency upgrades have significant potential to reduce consumer gas prices and thus fuel poverty in the private-rented sector. Also, the Government has set a minimum target for a EPC rating of C for all types of homes by 2035. However, with no rules or incentives from government currently in place to support widespread retrofitting for energy efficiency measures, as Chapter Four argued, it will be difficult to achieve this.

For its part, Ofgem administers schemes that are designed to protect vulnerable consumers from high gas prices. This includes the Energy Company Obligation (ECO), explained in Box 3.1 much earlier, which is a scheme that requires energy suppliers to install energy efficiency measures in fuel poor homes. Ofgem also oversees the Fuel Poor Network Extension Scheme (FPNES), which helps low income off-gas grid households to be connected to the gas grid.

Ofgem previously administered the Warm Homes Discount, which reduced consumer energy prices during winter months for low income households, and the Safeguard Tariff, which was an effective cap on consumer energy bills that applied to some five million economically vulnerable households. Both these schemes ended in January 2019, when the energy price cap took effect. Ofgem oversees this new high-profile and contentious policy.

Originally, an 'energy price freeze' – where consumer energy bills can decrease but not increase - was proposed in the Labour Party's 2015 general election manifesto. This was in response to public concern over

125. BEIS, "The domestic private rented property minimum standard - landlord guidance documents", https://www.gov.uk/government/publications/the-private-rented-property-minimum-standard-landlord-guidance-documents (2018).

energy costs and revelations that large energy suppliers had not passed on falling energy wholesale costs to consumers. To placate concerns around the cost of consumer energy, the incumbent Conservative Government adopted in their 2017 general election manifesto an alternative version of this Labour Party proposal: the energy price cap.

The energy price cap is designed to mitigate consumer energy bill increases when customers are moved from attractive introductory tariffs onto more expensive standard variable tariffs by energy suppliers. The energy price cap will function in a similar way to the aforementioned Safeguard Tariff but will apply to all UK households. It means the energy bill of a typical houshold on the most expensive energy tariff will be capped at £1,137 per annum. The Government's energy price cap is expected to eventually lead to a reduced price differential between standard variable tariffs and cheaper introductory tariffs, as energy suppliers take a revenue-neutral approach, raising the price cheaper tariffs to pay for the loss in revenue from standard variable tariffs. The result will be little or no net change in average consumer energy bills, although the distribution of prices is likely to be less punitive for those who do not switch energy tariffs. However, the energy price cap affords little protection to consumers from rising wholesale gas prices, which comprise a major propotion of gas bills as outlined in Chart 5.1 earlier in this chapter. Indeed, in February 2019, Ofgem announced that the price cap would rise in April, due to an increase in wholesale energy costs, affecting some 11 million households.[126]

This energy price cap was introduced as a temporary solution. Higher rates of tariff switching would result in more immediate savings for consumers and would likely reduce variability between introductory tariff rates and standard variable tariffs as energy suppliers would have greater incentive to retain customers. But, for the foreseeable future,

126. Priyanka Shrestha, "Energy bills to rise for millions as Ofgem raises price cap", https://www.energylivenews.com/2019/02/07/energy-bills-to-rise-for-millions-as-ofgem-raies-price-cap/, *Energy Live News*, (2019).

consumer switching is likely to stay low.

Box 5.1. Renationalising the gas network?

Recent polling shows a majority (77%) of British adults support renationalising the gas network.[127] Polling by YouGov likewise found 53% of the British public in favour.[128]

In a nationalised gas network, different actors would largely be in public hands. Governments would be able to manipulate and reduce consumer gas prices. However, as the *Cost of Energy Review* led by Profesor Dieter Helm pointed out, nationalisation of energy networks deals with issues that attract public ire such as executive pay, without addressing underlying problems.[129] Nationalisation does not of itself cut the costs of energy supply. Any shortfall in revenues a public company receives from billpayers would thus need to be made up by additional public spending.

It is therefore not clear how re-nationalising the gas network would reduce overall costs. Moreover, doing so would lead to the creation of much larger energy monopolies, accompanied by a loss of accountability to consumers. Returning the gas network to public ownership would also cause significant disruption in the short-term with no guarantee that network costs or quality of service would be improved in future.

127. Matthew Elliot and James Kanagasooriam, "Public opinion in the post-Brexit era: Economic attitudes in modern Britain", https://lif.blob.core.windows.net/lif/docs/default-source/default-library/1710-public-opinion-in-the-post-brexit-era-final.pdf?sfvrsn=0 (2017), 15.
128. YouGov, "YouGov Survey Results 17-18th May 2017" https://d25d2506sfb94s.cloudfront.net/cumulus_uploads/document/uufxmyd8qm/InternalResults_170518_nationalisation_privatisation_W.pdf (2017).
129. Dieter Helm, "RIP RPI-X Regulation - OFWAT and OFGEM nail down the coffin", http://www.dieterhelm.co.uk/regulation/regulation/rip-rpi-x-regulation-ofwat-and-ofgem-nail-down-the-coffin/ (2018).

The costs of deeper decarbonisation

Ultimately, decarbonisation of the gas network is necessary for meeting the UK's legally binding greenhouse gas reduction target. However, deeper decarbonisation of the gas network – and, indeed, the energy system as a whole – will mean increased costs. But this needs to be considered alongside higher long-term costs – especially for consumers – of not pursuing deeper decarbonisation.

Indeed, for many sectors of the economy, gas is at present the cheapest form of energy available to them, and sometimes the only suitable energy source. It is important that the financial impact of the decarbonisation of UK does not lead to an outcome that sees gas end-users switching to more carbon-intensive coal or oil.

The NIC estimates the cumulative additional costs of decarbonising the heating sector, compared to the status quo, are in the range of £120-£300 billion through to 2050.[130] That is equivalent to between £4 billion and £10 billion per year of additional spending on the infrastructure needed to decarbonise heat consumption. The extent to which taxpayers or billpayers will pick up the bill for this is unclear; but it is forecast that decarbonising the heat sector – which is just one route, albeit a major one, to decarbonising the whole of UK gas - will raise consumer heating prices by just under 10%. There is also a need, as outlined in Chapter Four, for investment in new infrastructure to make the gas network compatible with more decentralised biomethane and hydrogen inputs.

130. E4tech & Element Energy, "Cost analysis of future heat infrastructure options", https://www.nic.org.uk/wp-content/uploads/Element-Energy-and-E4techCost-analysis-of-future-heat-infrastructure-Final.pdf National Infrastructure Commission, (2018), 3.

There are three principal routes to meet the projected costs of more deeply decarbonising UK gas:

- **Asking taxpayers to contribute more.** Government could fund schemes and investments that leverage private capital. An example is the Renewable Heat Incentive (RHI), described in Box 3.1 much earlier, which provides businesses and homeowners with taxpayer-funded discounts on the cost of purchasing low-carbon heating equipment. Similarly, the Government's 2018 Budget included a new £315 million fund to support the installation of energy efficiency measures for energy-intensive businesses; it is possible this could be directed to lowering gas demand for commercial heating too.
- **Asking billpayers to contribute more.** For instance, through a levy on energy bills. This has been the case in the electricity sector, through for the Levy Control Framework, as described in Chapter Three, which supports the deployment of renewable technologies.
- **Broadening the demand for UK gas.** Government could help develop new markets for low-carbon gas by creating new sources of demand for gas, for example in transport. This could potentially widen the number of end-users of gas to spread the costs of deeper decarbonisation.

Convincing billpayers and taxpayers that paying more for decarbonising the UK's gas network is a prudent, cost-effective strategy in the long-term will be challenging. Relatively recent polling found low appetite among the general public for policies to reduce greenhouse gas emissions commitments if it increased energy prices. Only 30% agreed the UK should stick to its commitments on reducing greenhouse gas emissions even if it means higher prices for households, versus 43% who disagreed.[131] Other evidence shows that consumers

131. Ibid.

are concerned by the environmental impacts of their energy usage, but tend to be less inclined to support decarbonisation efforts if it leads to higher prices.[132]

Box 5.2. Energy consumers in fuel poverty

It has long been a central aim of the UK Government, and by extension Ofgem, to reduce and protected individuals living in fuel poverty.

In general, households are considered to be 'fuel-poor' if they cannot afford to keep warm at reasonable prices relative to their income. The specific criteria for what constitutes fuel poverty varies in different regions of the UK. Accordingly, the latest estimates suggest there are 3.6 million households in the UK experiencing fuel poverty: 2.5 million in England;[133] 613,000 in Scotland;[134] 291,000 in Wales;[135] and, 160,000 in Northern Ireland.[136]

Evidence shows that fuel poverty is more common in rural households, those where heating costs are high, and for dwellings with poor energy efficiency.[137] The rate of fuel poverty is also particularly high in the private rented sector and in rural areas – hence the introduction of FPNES, as described earlier in this

132. Joel Rogers de Waal, "Public attitudes to the household energy market" https://yougov.co.uk/topics/science/articles-reports/2014/04/11/british-attitudes-household-energy-market (2014).
133. BEIS, "Annual fuel poverty statistics reports, 2017 (2015 data)", https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/639118/Fuel_Poverty_Statistics_Report_2017_revised_August.pdf (2017), 3.
134. Energy Action Scotland, "Fuel Poverty Overview", https://www.eas.org.uk/en/fuel-poverty-overview_50439/.
135. Welsh Government, "Fuel poverty", https://gov.wales/topics/environmentcountryside/energy/fuelpoverty/?lang=en (2018).
136. Northern Ireland Housing Executive, "House condition survey report", https://www.nihe.gov.uk/house_condition_survey_main_report_2016.pdf (2016), 15.
137. BEIS, "Annual fuel poverty statistics reports, 2017 (2015 data)", https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/639118/Fuel_Poverty_Statistics_Report_2017_revised_August.pdf (2017), 41.

chapter.[138]

If and when consumer gas prices rise as a result of the decarbonisation of UK gas, there is a prospect that a greater number of households will fall into fuel poverty. It is highly important that public policy is in place to ensure this does not happen during deeper decarbonisation of UK gas in the decades ahead, and that it drives the most cost-effective approach to decarbonisation.

Neither increases in taxation nor higher energy bills are evidently popular. However, the impact of potential energy prices rises can be mitigated if measures are introduced that lead to a reduction in demand for energy. That way, the inevitable mixture of the principal routes listed above necessary to fund decarbonisation of the gas network need not have a significant impact on consumers.

But, without doubt, to adopt a business-as-usual approach would result in the UK failing to meet its legal greenhouse gas emissions target and increasing consumer energy prices in the long-term. Indeed, it is more sensible to consider the forecast costs of decarbonising UK gas in relation to the costs of alternative ways for meeting the UK's greenhouse gas emissions target. Moreover, a significant body of evidence, including from the most recent Intergovernmental Panel on Climate Change (IPCC) report, shows that the costs of decarbonisation are far outweighed in the long-term by its benefits.[139] Nevertheless, the falling cost of renewable electricity generation demonstrates that investments paid for by energy consumers have the potential to lower bills in the near future. Deeper decarbonisation of the UK gas network

138. BEIS, "The domestic private rented property minimum standard", https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/749021/Domestic_Private_Rented_Landlord_Guidance_-_June_18.pdf (2018), 9.
139. Damian Carrington, " Hitting toughest climate target will save world $30bn in damages, analysis shows", https://www.theguardian.com/environment/2018/may/23/hitting-toughest-climate-target-will-save-world-30tn-in-damages-analysis-shows The Guardian, (2018).

is not a question of if but how.

The projected costs of more deeply decarbonising gas supply and demand are significant. It will lead to costs that are borne by households, as billpayers or taxpayers. Government-supported investments in the gas network could be recovered from Gas Distribution Network Operators over time, returning invested funds back to the taxpayer. But, it is also very important that policy support and incentives are put in place to reduce the financial impact on billpayers and taxpayers, such as supporting energy efficiency measures.

There are several ways households can take advantage of existing technologies, many of which were outlined in Chapter Four, to reduce their energy consumption and bills. However, not all consumers are able to benefit from, or have access to, these technologies.

The installation of energy efficiency measures is the most effective lever for counteracting consumer gas price rises associated with deeper decarbonisation of the gas network. Nevertheless, as Chapter Four argued, upfront costs often pose the biggest barrier to making such improvements in residential properties.

Box 5.3. The role of hybrid heating systems in reducing consumer energy prices

Hybrid heating systems, an example of the ongoing convergence of energy networks outlined in Box 3.1 earlier, also provide an option to reduce consumer energy prices in the long-term. Hybrid heating systems include hybrid heat pumps that involve retrofitting of a heat pump to an existing gas boiler system, with added 'smart controls'.

Hybrid heating systems that can run on either gas and electricity offer energy consumers greater flexibility to use the least cost source of energy for regulating the temperature of their buildings. Compared to pure electric or gas systems, hybrid heating systems are also less at risk of becoming ‘stranded assets’ should the market show a strong preference for either electrification or low-carbon gas pathways.

'Smart heating controls' used on hybrid heating systems automatically switch between electricity and gas supply depending on preferences set by the user and price incentives offered by energy suppliers. They give consumers flexibility to use the cheapest source of energy for their needs. For example, a 'smart meter' on a hybrid gas-electric heating boiler can help consumers automatically switch to the cheapest energy source. In addition, energy usage data from millions of consumers will allow Gas Distribution Network Operators (and electricity distribution network operators) to manage demand and allocate energy resources more efficiently, with the potential to reduce the costs and carbon footprint of gas supply.[140]

Clearly, hybrid heating systems have potential to reduce consumer prices. Hybrid heating systems are actively being explored through initiatives such as Freedom Project.[141] However, the upfront cost of installing hybrid heating appliances can be costly. But, as the NIC estimates, that greater use of smart technologies could save energy consumers up to £8 billion a year by 2030.[142]

This chapter explained the composition of and trends in consumer gas prices. There is higher consumer disaffection with consumer energy prices, to which the Government has responded to with some policies such as the energy price cap. Deeper decarbonisation of the UK's gas network will, in the near-term, increase energy prices, with

140. The Data Communications company, run by Ofgem, and, to a lesser extent, the Information Commissioner's Office (ICO) are responsible for overseeing protocols for energy data exchange and enforcing energy consumer's rights.
141. Western Power Distribution, "FREEDOM", https://www.westernpower.co.uk/projects/freedom.
142. National Infrastructure Commission, "Smart power", https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/505218/IC_Energy_Report_web.pdf (2016), 4.

a risk that billpayers and taxpayers face the prospect of an ever-more costly energy system. However, this need not be the case. Indeed, the Government can help mitigate the extent rise in consumer gas prices by introducing new policies to support energy consumers in adopting more energy efficient measures. That is, in part, the focus of the next and final chapter.

Chapter 6: **New policies**

The previous chapters argued that efforts by the Government to more deeply decarbonise the supply of and demand for UK gas is both necessary and desirable, as long as increases in consumer gas bills can be minimised. Some progress has been made in decarbonising UK gas, especially in reduce gas demand in the electricity sector. But, undeniably, such progress has been insufficient, both on the supply-side and demand-side: low carbon alternatives to natural gas are not yet cost competitive, and there is a dearth of policies to promote energy efficiency in buildings. There are technological solutions available, but investment and incentives from government to enable their widespread usage have been lacking. This chapter proposes new policies to support deeper decarbonisation of the supply of and demand for UK gas in the decades ahead.

Policy approach

In developing policy recommendations, we applied three key tests that had to be met:

- **Evidentially grounded.** A body of evidence shows that climate change is causing profound damage to this country's economy and environment. Ambitious investment and incentives from government to significantly reduce greenhouse gas emissions in the UK gas network to meet this country's current and likely future legal emissions target are thus essential. But such policies must be introduced, implemented and adapted according to robust evidence.

- **Fiscal realism.** Since the Government still plans to reduce the structural budget deficit, policies that significantly raise government expenditure have less chance of being adopted. Nevertheless, climate change is an urgent threat that has costly implications for the UK. So, this report does not shy away from proposing policies that carry a realistic cost.
- **Supporting market-based solutions.** Policy proposals should not be too prescriptive as to create unintended consequences, such as market distortions, under-investment, reduced competition, or regulatory burden.

Our proposed policies support either of the two pathways to decarbonise UK gas: reducing the carbon intensity of the supply of gas, and reducing gas demand. The policies we propose are not exhaustive. But they do offer original and credible policy ideas that need to be considered alongside many others to support and achieve deeper decarbonisation of the UK gas network in the decades ahead.

Policies to reduce the carbon intensity of the supply of gas

Recommendation one: Make decarbonisation of UK gas a priority for Ofgem in the next price control framework from April 2021, including by increasing the available funding through the 'Network Innovation Competition' and 'Network Innovation Allowance'

The price control framework for after the current period which ends in March 2021, RIIO-2, is currently under review. This presents an opportunity to realign incentives to support upgrades to gas network infrastructure that paves the way for low carbon gas. RIIO-2 should incentivise Gas Distribution Network Operators to invest in delivering infrastructure to support low carbon gas and installing smart pressure controls to optimise the distribution of low carbon gas.

RIIO-2 should promote and reward the provision of technologies that support fuel switching, both within the gas network and by consumers. It could do this, for example, by enabling the deployment of network-connected electricity-to-gas technologies by third parties. And through measures to incentivise hybrid heating systems, as explained in Box 5.3 in the last chapter, in buildings.

Similarly, funding available for all organisations in the gas network through Ofgem's 'Network Innovation Competition' and 'Network Innovation Allowance' – explained in Box 1.2 earlier in the report – should be increased to a level that is appropriate to meet the requirements of a more deeply decarbonised gas network. This would ensure that projects that deliver emissions reductions continue to be supported from their early stages to commercialisation.

Recommendation two: Amend the Gas Safety (Management) Regulations and the Gas (Calculation of Thermal Energy) Regulations to enable a higher proportion of low carbon gases to flow in the gas network

As previously explained in Box 1.2, under existing regulations, there are restrictions on low carbon gases – especially hydrogen – being used in the gas network. These restrictions arise from two regulations: first, the Gas Safety (Management) Regulations, which only permit up to 0.1% hydrogen (by volume) in the gas network. Second, the Gas (Calculation of Thermal Energy) Regulations, which include Calorific Value (CV) requirements regarding the composition and price of gas, This limits the use of different low carbon gases in the gas network. Biomethane suppliers, for example, must add propane to their feed in order to increase the CV of gas they supply to the network.

A higher proportion of hydrogen in the gas network is highly likely to be permissible in the near-future, if a growing number of trials prove its safety and effectiveness. Currently, several European countries permit varying levels of hydrogen to be injected into their gas networks.[143] Indeed, historically, the UK used 'Town Gas', which included 50-60% hydrogen.[144] Therefore, the current Gas Safety (Management) Regulations should soon be amended to reflect the technical capability of the gas network to accept higher intensities of hydrogen, as well as biomethane.

Furthermore, under the existing gas billing methodology, set out in the Gas (Calculation of Thermal Energy) Regulations, the Calorific Value (CV) of gas injected into the network must fall within a particular range. Also, customers are charged less for a gas which has a lower CV (such as hydrodgen) since they will need to burn more of it to generate a given amount of heat compared to the use of gas with higher CV (such as natural gas). Although fair to customers, this regulation has the unintended consequence of diminishing the incentive of supplying low carbon gas to the network. The existing CV requirements therefore limit the usage of low carbon gas in the gas network.

The CV requirements on composition and price of gas should be responsive to increased usage of low carbon gases. Over time, the requirement to blend hydrogen, and biomethane in fact, with a certain amount of natural gas to achieve compliance with CV requirements should be lessened. And, in the long-term, the price of low carbon gases should not exceed consumer prices to natural gas in order to achieve compliance with CV regulations. This will be challenging but it is likely that the costs of low carbon gases will fall over time as their production

143. Ofgem, "Future insights series: the decarbonisation of heat", https://www.ofgem.gov.uk/system/files/docs/2016/11/ofgem_future_insights_programme_-_the_decarbonisation_of_heat.pdf (2016), 7.

144. E4tech, "Scenarios for deployment of hydrogen in contributing to meeting carbon budgets and the 2050 target", 7 ; Carbon Connect, "Future Gas Series: Part 1: Next steps for the gas grid", https://www.policyconnect.org.uk/cc/sites/site_cc/files/report/676/fieldreportdownload/nextstepsforthegasgridweb.pdf (2017), 14.

increases in scale.

The amended requirements set out in both of these regulations should be reviewed periodically to ensure they remain up-to-date.

Recommendation three: establish a 'low carbon gas obligation' on gas suppliers in the next price control framework from April 2021 to incentivise the injection of low carbon gas flowing in the UK gas network

The UK Government should establish a national 'low carbon gas obligation', starting after April 2021, when the next price control framework, RIIO-2, is introduced. This would include a requirement for gas suppliers to deliver a steadily increasing set proportion of low carbon gases – which includes biomethane, bioSNG and hydrogen - to the network. The proportion of low carbon gas injected into the gas network, and the trajectory for this over time, should be consistent with meeting the UK's current and likely greenhouse gas emissions reduction target. Compliance with, and implementation of, this new 'low carbon gas obligation' would be overseen by Ofgem.

Gas suppliers could achieve compliance either through including a minimum proportion of low carbon gas within their gas supply or through certified purchases of low carbon gas from third parties injected into the UK's gas network. Sufficient financial resources would need to be made available to Gas Distribution Network Operators under the RIIO-2 framework in order to upgrade their infrastructure such that this new 'low carbon gas obligation' could be met.

This 'low carbon gas obligation' would ensure continued and increasing demand for low carbon gas and provide a predictable signal to the market. It would also effectively guarantee a market for biomethane in the next decade, after the Renewable Heat Incentive (RHI) - which currently subsidises biomethane production, as explained in Box 3.1 earlier in the report - expires.

A 'low carbon gas obligation' has several advantages. First, setting a target provides a non-prescriptive mechanism for reducing the carbon intensity of gas in the network, allowing actors in the market to find the lowest-cost solution. Second, it will create value in producing low carbon gases for injection into the gas network, which is crucial for supporting investment in the production of decarbonised gas. Third, a target for low carbon gas supply, rather than a price-driven mechanism such as carbon pricing, avoids some of the uncertainty around setting such prices at the right level to deliver on policy objectives.

Care should be taken to avoid creating incentives for biogas production that conflict with other environmental objectives such as avoiding the planting of monoculture feedstocks for biogas plants.

Policies to reduce demand for gas

As Chapter Four outlined, the main two routes to reducing demand for gas are improving the efficiency of gas usage, and encouraging fuel switching as to shift demand away from the gas network. The focus of our policy recommendations here is on improving energy efficiency in residential, commercial and industrial buildings. A previous Bright Blue report, *Better homes*, outlined new policies to increase the uptake of energy efficiency measures in homes, especially after the UK Government ended its financial support for the Green Deal in 2015.[145] This included new government-backed loans, called *Help to improve* loans, to help households finance the high upfront costs of many energy efficiency measures, repaid through future energy bills. Alongside this, we proposed the introduction of a new legal, minimum EPC rating for properties at the point of sale. We do not repeat these policy suggestions in this report. But we would urge the adoption of those ideas alongside further original policy ideas detailed below.

---

145. Sam Hall and Ben Caldecott, "Better Homes", https://brightblue.org.uk/wp-content/uploads/2017/03/Betterhomes.pdf (2016).

Recommendation four: The methodology for calculating the Energy Performance Certificate (EPC) rating of buildings should be changed

The methodology for producing EPC ratings is currently based on assumptions that do not necessarily lead to an accurate assessment of a building's energy efficiency. EPC assessment methodology uses data from a building's smart meter to assess running costs.

But energy efficiency cannot reliably be determined from household energy prices alone, particularly when heat pumps are used.

Instead, the determination of energy efficiency should be based primarily on the standardised use of passive heat or temperature sensing equipment to determine the thermal mass of a building relative to its surroundings.

Recommendation five: Introduce 'Home Affordability Assessments' (HAAs) alongside a new HAA rating

Previous attempts to require disclosure of detailed information about properties being sold – notably the Home Information Pack (HIP) – were met with opposition due to the additional burden compiling such information, often with the requirement of a paid expert, placed on sellers.

Nevertheless, there is a need for high-quality information to be made available to buyers to help them understand how affordable a home is that takes into consideration more than the sale price.

We propose that 'Home Affordability Assessments' (HAAs) be introduced for new-build homes which takes account of a property's sale price and maintenance costs over its expected lifetime, including annual energy bills. It should also provide an overall HAA rating. By requiring this information only from newbuilds, private individuals who sell their property will not be encumbered by the costs of producing this additional material.

It should be noted that while Energy Performance Certificate (EPCs) do provide information on the energy efficiency of a home, this information is not routinely regarded as having an impact on affordability in the same way as mortgage costs are. HAAs would provide to prospective homeowners and mortgage providers fuller information about - and a more comprehensive and comparable rating on - how affordable a property is.

Disclosure of an HAA rating should be mandatory for newly built properties, making total costs more visible to potential buyers. This would encourage home builders to include measures that bring down the running costs of new homes, especially energy efficiency measures, in order to make them more attractive to potential buyers.

Recommendation six: Increase the requirement for domestic gas boilers to be 95% efficient

The minimum Energy-related Products (ErP) requirement for domestic gas boilers should be raised from the existing level of 92%[146] to 95% energy efficient.

The current ErP requirement for new boilers sold in the UK was incorporated into Building Regulations in April 2018. It has helped save energy and reduce bills for consumers. Previous regulatory requirements around performance standards for boilers, such as those introduced in Building Regulations in 2005, have proven to lead to reductions in greenhouse gas emissions from the buildings sector.[147]

However, many new boilers are already more than 95% efficient. A more ambitious target for new boilers would ensure manufacturers continue to lead the market in high energy efficiency appliances and reduce consumers' energy bills.

146. BEIS, "Heat in buildings", https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/651853/Boiler_Plus_final_policy_and_consultation_response.pdf (2017), 4.
147. Ibid.

Recommendation seven: Introduce carbon life cycle assessment as part of public procurement procedures to drive the market for energy efficiency and renewable heat technologies in public estates

'Green public procurement' provides a means of leveraging government spending for environmental and public benefit. The EU, for instance, has produced voluntary green public procurement guidelines for EU Member States. Some countries have adopted the guidelines to varying degrees, but many have not.

The UK has developed Government Buying Standards (GBS) as part of its public procurement policy. However, these largely refer to environmental compliance and minimum efficiency standards. They do not include a lifecycle assessment of greenhouse gas emissions.[148]

Government spending on government estates could be used to help create markets for more efficient energy consumption, without necessarily increasing costs to the taxpayer. Maintenance spending on government estates runs to £20 billion per year,[149] affording them considerable purchasing power. By including 'green' criteria as part of the standard tendering process, government estates could provide opportunities for energy efficiency measures and renewable heat technologies to gain a foothold in the market. In addition to existing requirements for environmental compliance, the procurement criteria should also include a carbon life cycle assessment[150] of a product or service, with theoretical carbon costs reflected in pricing. Incorporating such information would encourage competition - based on emissions savings - for government contracts to supply heating services or

148. HM Government, "Sustainable procurement: the GBS for construction projects and buildings", https://www.gov.uk/government/publications/sustainable-procurement-gbs-for-construction-projects (2015).
149. Cabinet Office, "Government's Estate Strategy", https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/209484/Government_s_Estate_Strategy_-_June_2013_v1.pdf (2013), 4.
150. A carbon life cycle assessment is designed to establish the carbon footprint of a product or service, taking into account emissions associated with production, usage, and disposal.

equipment, helping to bring down costs for installing low-carbon heating technologies in UK homes too.

Recommendation eight: establish a new district heat network regulatory unit in Ofgem

There are existing regulations regarding the provision of energy via district heat networks, which were explained in detail in Chapter Four. However, the approximately half a million UK homes supplied by district heat networks are not afforded the same protections and rights that gas and electricity customers receive. Indeed, the Competition and Markets Authority (CMA) has raised concerns over the monopolies created by district heat networks and the lack of transparency provided to customers of district heat networks.

A new regulatory unit should be established within Ofgem to oversee regulation of district heat networks and to develop suitable price controls for district heat networks. This will ensure that energy consumers supplied by district heat networks have adequate protection from uncompetitive pricing.

Conclusion

The supply of and demand for UK gas must be decarbonised deeply during the coming three decades if this country is to meet even its current legal target to reduce greenhouse gas emissions by 80% in 2050, relative to 1990 levels. Efforts to decarbonise the gas network to date have yielded results that fall well short of what is required to meet that target. Indeed, once the UK adopts a legal, net-zero emissions target, as was advocated by Bright Blue and is expected, the challenge to decarbonise UK gas will become even greater.[151]

The gas network - including a major end-user of it, the heating

151. Sam Hall and Philip Box, "Hotting Up", https://brightblue.org.uk/wp-content/uploads/2018/05/Hotting-up.pdf (2018).

sector - have been largely overlooked in government policymaking in recent years. Now - with time running out - a more ambitious raft of government policies – including a mixture of investments and incentives - is needed.

The policies put forward in this report are not exhaustive, but do present some necessary and realistic initial ideas to reduce the carbon footprint of the UK's gas network. The policy ideas would help to, for the first time, align decarbonisation of the gas network with the obligations that arise from UK's legal greenhouse gas emissions reduction target.

Annex:
Written evidence

Evidence from the Aldersgate Group
Click here to read the submission

Evidence from the Anaerobic Digestion and Bioresources Association
Click here to read the submission

Evidence from the Association for Decentralised Energy
Click here to read the submission

Evidence from the Campaign to Protect Rural England
Click here to read the submission

Evidence from Canetis
Click here to read the submission

Evidence from The Carbon Capture and Storage Association
Click here to read the submission

Evidence from Meysam Qadrdan et al. (Cardiff University)
Click here to read the submission

Evidence from Citizens Advice
Click here to read the submission

Evidence from CNG Services
Click here to read the submission

Evidence from the Decarbonised Gas Alliance
Click here to read the submission

Evidence from E3G
Click here to read the submission

Evidence from the Energy and Utilities Alliance
Click here to read the submission

Evidence from Grant Wilson
Click here to read the submission

Evidence from Greenpeace
Click here to read the submission

Evidence from the Institute of Mechanical Engineers
Click here to read the submission

Evidence from ITM Power
Click here to read the submission

Evidence from National Grid
Click here to read the submission

Evidence from Providence Policy
Click here to read the submission

Evidence from the Renewable Energy Association
Click here to read the submission

Evidence from the Scottish Hydrogen and Fuel Cell Association
Click here to read the submission

Evidence from the Sustainable Energy Association
Click here to read the submission

Evidence from the University of Exeter, Energy Policy Group
Click here to read the submission

Evidence from Wales and West Utilities
Click here to read the submission

Evidence from WWF and Sandbag
Click here to read the submission

Decarbonising the UK's gas network presents one of the most significant political and economic challenges facing the UK. Natural gas delivered by the network has been a mainstay of our energy system for more than 50 years. However, the continued use of unabated natural gas is inconsistent with meeting the UK's legally binding greenhouse gas emissions target.

This report examines the key issues concerning deeper decarbonisation of the gas network. It concludes by recommending new policies for the UK to reduce natural gas use and decarbonise the gas network affordably and with minimal disruption.

Bright Blue Campaign
brightblue.org.uk

ISBN: 978-1-911128-13-7

bright blue