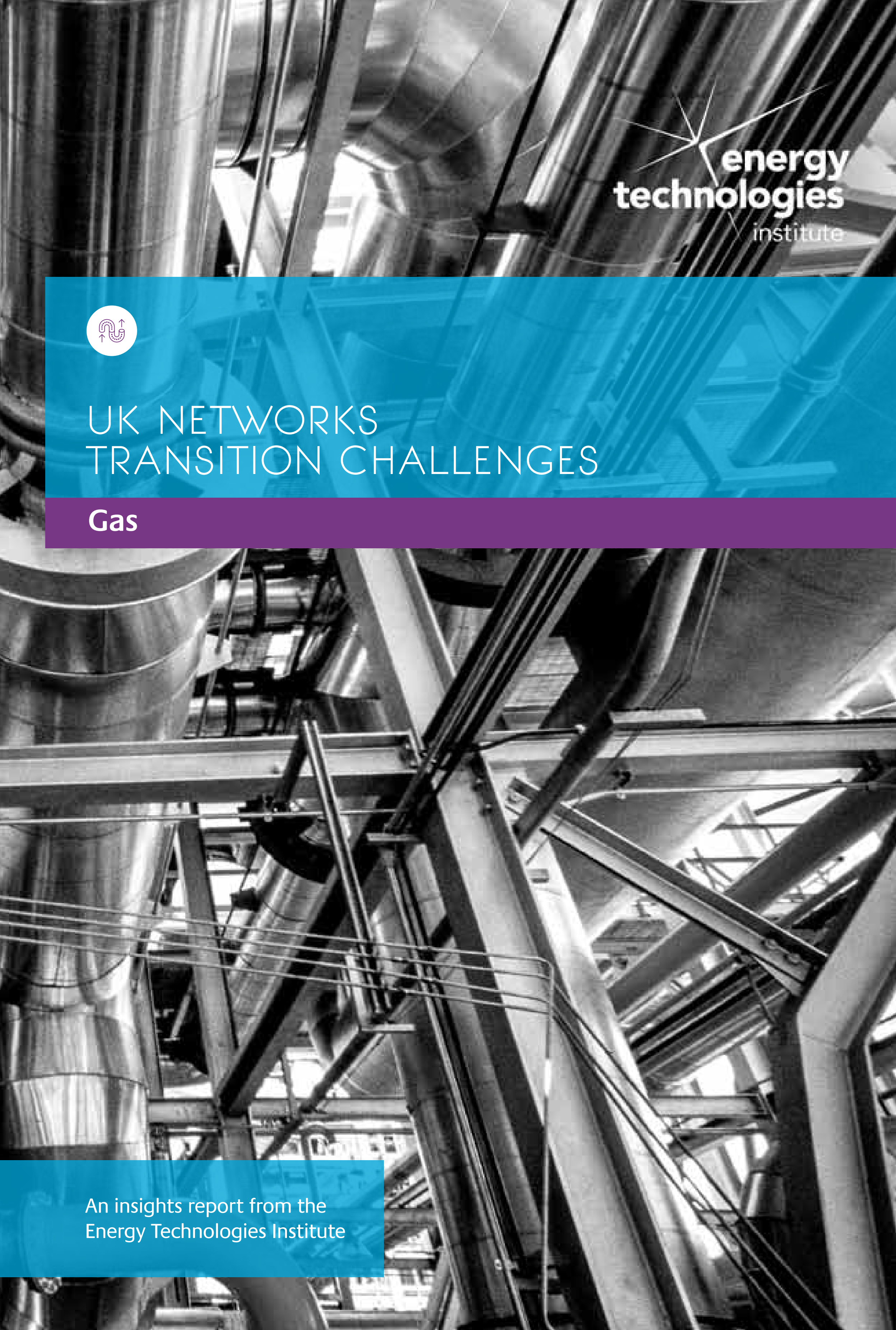
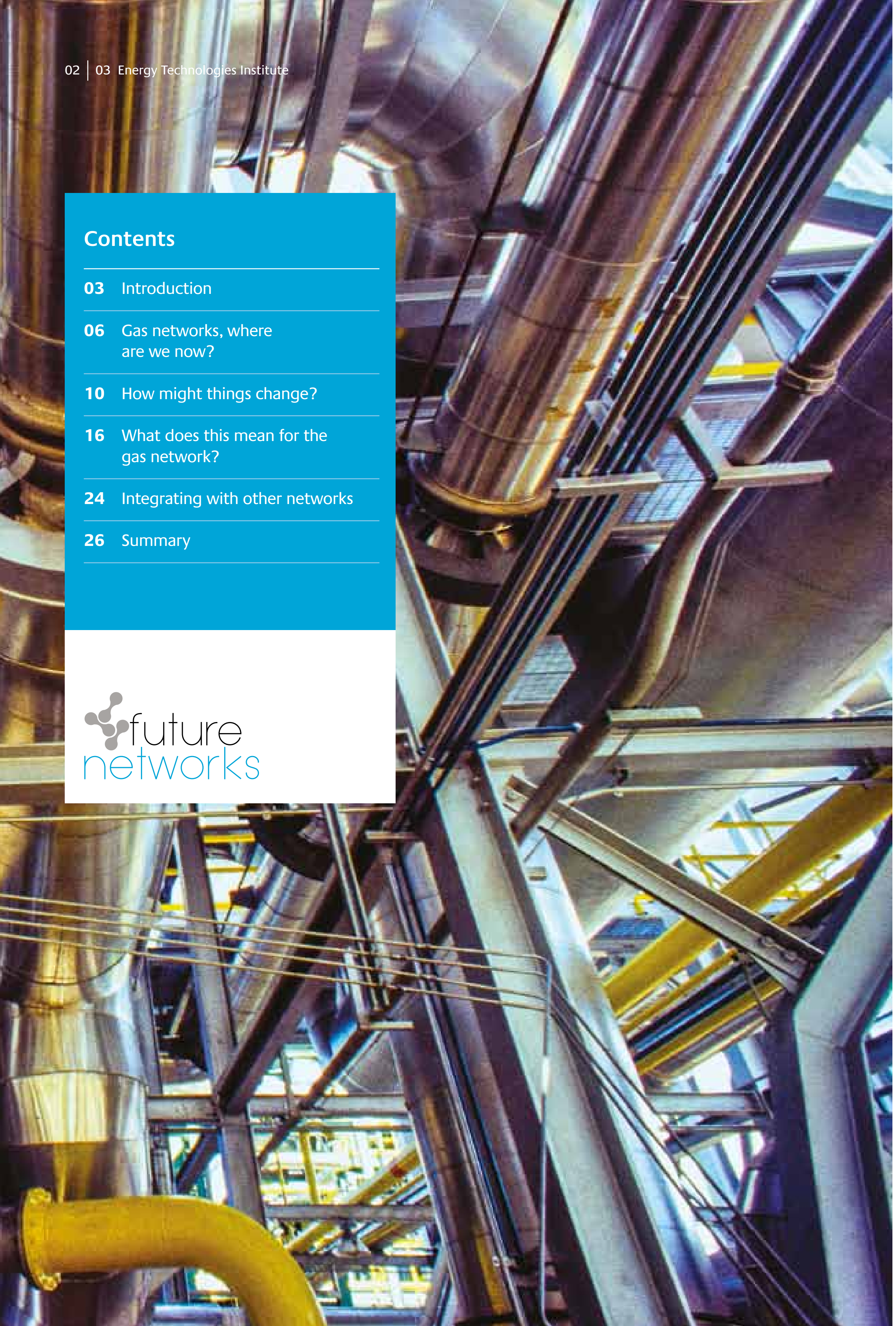


energy technologies institute

UK NETWORKS TRANSITION CHALLENGES

Gas

An insights report from the Energy Technologies Institute



Contents

INTRODUCTION

Any move to a low carbon UK energy system that uses new and more varied sources of energy generation will require investment and an upgrade of the current energy network infrastructure.

At the ETI we see there are three key challenges to transitioning UK networks for a wider adoption of low carbon sources. These are:

1. A need to adapt and enhance the existing network infrastructure to absorb new forms of energy generation.
2. The creation of efficient and effective new network infrastructure to deliver new forms of energy generation.
3. The integration of energy networks so the UK can optimise the use and performance of energy generated across a number of different energy vectors, effectively and efficiently.

Our analysis in this area has pointed to the fact that we see there is real value in the UK employing a multi-vector approach to its energy supply, both from the perspective of transitioning to a low carbon energy system, but also in a manner that is convenient and affordable to the end consumer.

To make this a reality whole energy system thinking is critical. Analysing the interactions between networks (as well as with the wider energy system) and how today's network infrastructure will influence the infrastructure that will be needed in the future is central to this. The challenge is one of knowing where, when and to what extent to enhance the network.

Today, current governance and regulatory frameworks are simply not designed to enable and incentivise the radical transformation that will be needed to move to a low carbon solution.

Against this backdrop, the ETI recommends the following actions should be taken to effectively transition to a low carbon energy system with a network infrastructure that delivers for future generations.

1. The UK should incentivise and target investment to allow it to adapt and enhance existing networks.
2. Alongside this the UK needs to make clear decisions upon what and where they want new networks to operate and invest in them accordingly.
3. The UK should design network infrastructures to ensure that they work together efficiently across multiple vectors in real time – providing an economic and consumer solution to the delivery of low carbon energy.

Whilst we advocate the systems-wide approach, this insight report looks in more detail at the challenges that are facing the UK's gas network and how that network can adapt in the future to enable a low carbon solution and form a strong component of a multi-vector approach to UK energy infrastructure.

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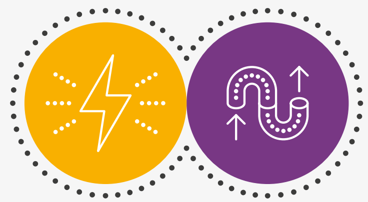
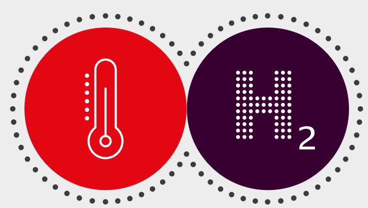
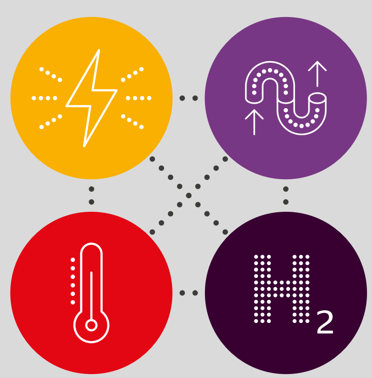
Challenge one
Adapting and enhancing existing network infrastructures



Challenge two
Enabling creation of efficient and effective new network infrastructures



Challenge three
Integrating new and existing networks to enable optimisation across vectors



GAS NETWORKS, WHERE ARE WE NOW?

As with the electricity network the gas network is well established. It offers national mainland[1] coverage, serving approximately 80% of homes in the UK (see Figure 1). Homes not connected to the gas grid tend to be either in more remote locations, where it is less cost-effective to provide a connection to the gas grid, or certain types of homes in urban areas which have electric heating (e.g. many apartment buildings).

Almost three-quarters of gas consumed in homes is for heating the homes themselves (see Figure 2). Over 20% is used for heating water and a small portion is used for cooking.[3]

As well as heating (and cooking) for domestic properties, the gas grid also serves:

- Commercial and public buildings, for the same purposes;
- The power sector, as a fuel for generating electricity; and
- Industry, mainly to produce high temperature "process" heat.

Between them, the buildings, power and industry sectors represent the bulk of gas consumption in the UK (see Figure 3).

Figure 1
Primary heating systems in UK homes[2]

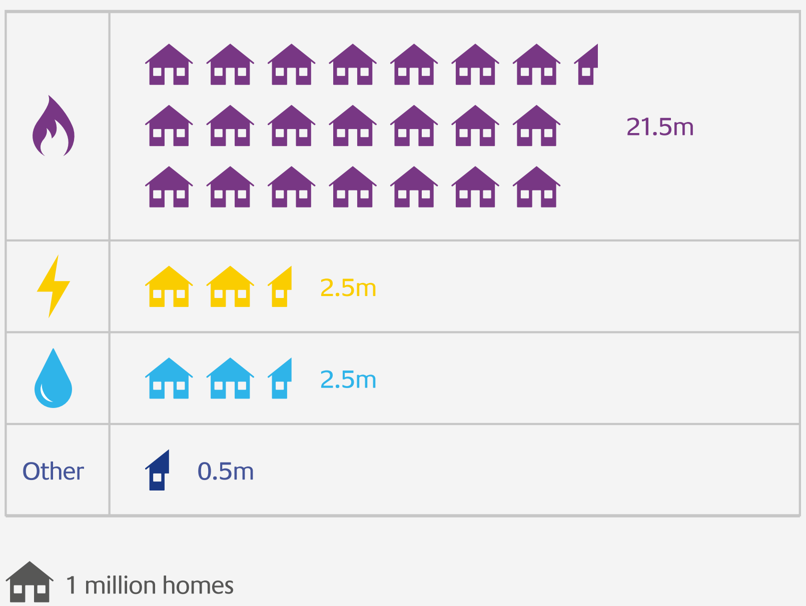


Figure 2
Estimate of total UK gas consumption in the home[4]

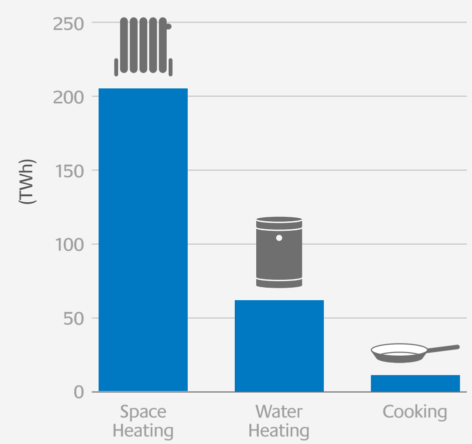
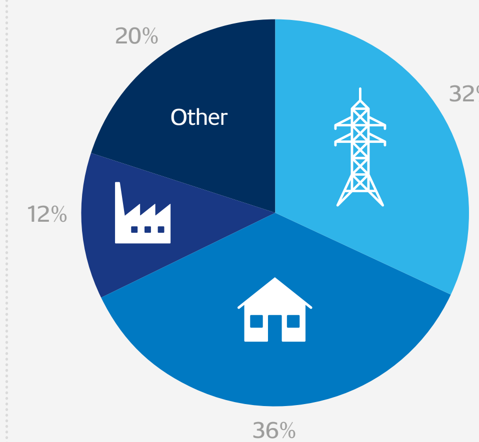


Figure 3
Consumption of gas across different sectors in the UK[5]



1 There is more limited gas network coverage in Northern Ireland
2 Based on data from DECC and 2011 Census
3 Douglas, J. (2015). Decarbonising Heat for UK Homes. [online]. Available at: http://www.eti.co.uk/insights/heat-insight-decarbonising-heat-for-uk-homes
4 Based on data from DECC's Digest of UK Energy Statistics (2015) and DECC's The Future of Heating: Meeting the Challenge (2013)
5 Department of Energy and Climate Change. (2015). Digest of United Kingdom Energy Statistics (DUKES)

GAS NETWORKS, WHERE ARE WE NOW?

Continued ›

Many of the larger power stations and industry sites connect directly to the transmission part of the gas grid. This is responsible for transporting gas from import sites on the coast and moving gas between regions of the UK (Figure 4 shows the route of the transmission system across England, Scotland and Wales). Crucially, it also connects to the distribution network which serves the domestic sector and other smaller sites.

Whilst the national gas transmission system is approximately 6,600km in overall length, the distribution network totals 275,000km in length[6], though it uses much smaller pipelines and operates at lower pressures than the transmission network. In its entirety, whilst it is less than a third of the length of the electricity network, it is a significant amount of infrastructure, and as it stands actually carries more than twice the energy (see Figure 5).

As can be seen in Figure 6, gas use varies enormously across the year, driven largely by changes in heating demand. This places a lot of emphasis on balancing supply with demand. This is partly managed through control of supply, partly by dedicated storage facilities in the UK and partly through the inherent storage capability of the gas grid itself. Between these mechanisms the gas network is able to cope with large amounts of variability in demand.

Figure 4

The "National Transmission System" for gas, covering England, Scotland and Wales

Figure 5

Total amount of electricity[7] and gas[8] consumed in the UK in 2014[9]

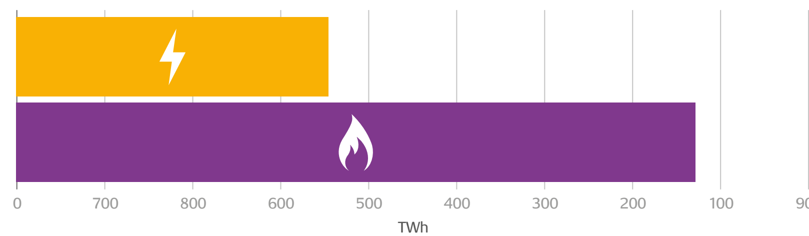
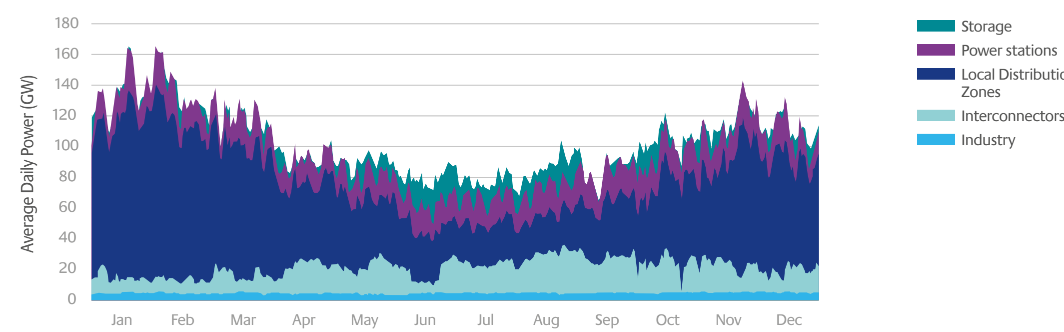


Figure 6

UK gas consumption during 2015[10]



6 To put this in context, if laid end-to-end, this would encircle the Earth almost 7 times

7 Estimate based on final consumption, use in the energy industry and network losses

8 Includes network losses and gas used to produce electricity

9 Department of Energy and Climate Change. (2015). Digest of United Kingdom Energy Statistics (DUKES)

10 From National Grid gas transmission operational data (2016)

HOW MIGHT THINGS CHANGE?

In this report we have used the ETI's published scenarios, which illustrate how the wider energy system might evolve, as a basis for exploring how we might need to adapt and invest in the gas network. The scenarios themselves have been developed from extensive analysis of the overall energy system and how it might have to develop out to 2050 in order to meet the UK's greenhouse gas emissions targets. The underlying analysis covers, amongst other things: how technologies might develop; how they would need to interact with each other as part of an overall energy system; practical roll-out timeframes for those technologies; potential constraints on energy resources; operational constraints and, not least, changes in energy demands and customer expectations.

Two scenarios are depicted which offer contrasting pictures of the UK energy system evolution to 2050. These are referred to as **clockwork** and **patchwork** and are plausible and self-consistent examples of how the energy system might evolve to meet the UK's 2050 greenhouse gas emissions targets. They are not forecasts but portray distinct (yet not exhaustive) ways in which the gas network could need to evolve, offering a means to explore a range of challenges that it might face.


Source: National Grid

HOW MIGHT THINGS CHANGE?
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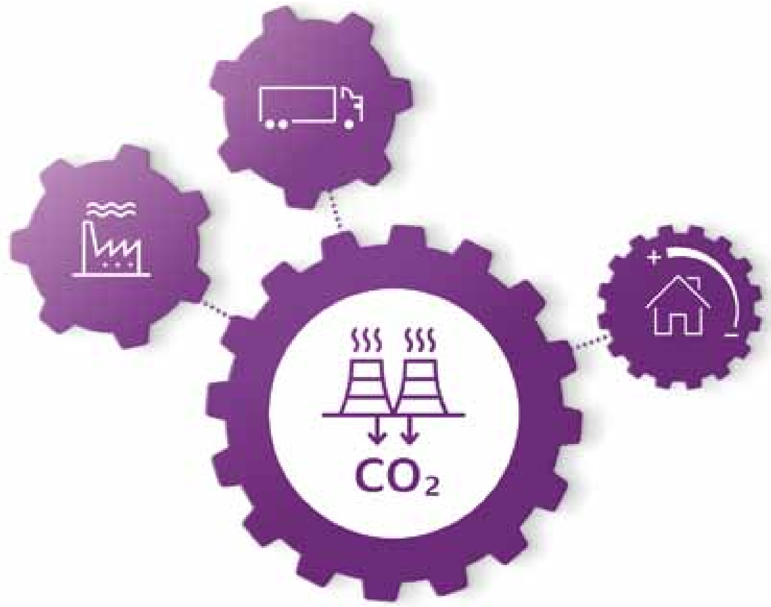
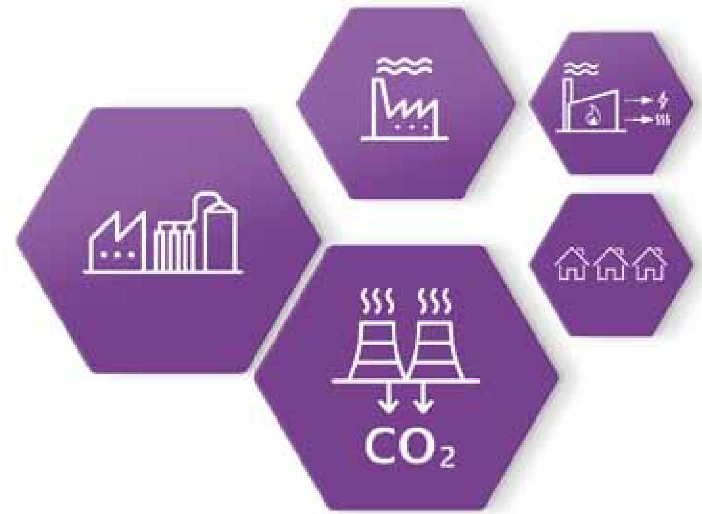


CLOCKWORK

For the clockwork scenario, with a move away from gas for home heating a phased shut-down of the local gas distribution network is required. This would need to take place over a similar timeframe both in the towns and cities where heat networks are deployed and also in rural areas where the electrification of heat begins to take hold. With gas continuing to play a role in both the power sector and industry, along with the emergence of transport as a new demand sector, the gas transmission system will still be required. However, this will need to evolve to meet supply and usage requirements. With the power sector seeing a near-term increase in demand for gas, followed by a decline as older gas plants close and those that remain need to operate at lower utilisation (for example, with large seasonal variations), the infrastructure will need to accommodate these developments. Overall industry demand stays relatively flat, meanwhile, but the gas supply networks may still need to adapt to accommodate any changes to the nature and locations of the industries. The use of gas to help to decarbonise heavy duty transport requires the network to supply to vehicle refuelling stations, primarily to transport hubs and along major transport routes.



PATCHWORK

For patchwork, in the near term, a reduction in gas consumption in the domestic sector is partly offset by supply to gas-CHP systems in urban areas where heat networks are deployed. Gas network connections to homes in these areas will need to be decommissioned whilst major trunk lines able to supply the CHP systems are initially retained. An electrification of heat in rural areas may necessitate disconnection of homes from the network there too or call for a radically different operating model, where gas is used as a backup. In some locations local efforts drive a switch to alternative types of gas (such as bio-SNG and hydrogen) allowing the network itself to be operated in a similar fashion to today. Longer term, as heat networks move away from gas CHP supply, the gas supply to these particular networks also need to be decommissioned. Gas supply to the power sector initially increases alongside growing renewable deployment and limited build of CCS-connected and nuclear power stations. A subsequent decline in gas consumption in this sector, as gas takes on more of a peaking role, will require the gas network to be able to adapt to manage these changes. The role of storage, for example, would take on greater emphasis in the longer term. The network also needs to adapt to the gradual decrease in gas consumption in industry as emissions constraints start to take effect.

HOW MIGHT THINGS CHANGE?
Continued ›

Clockwork	Patchwork
From the mid-2020s onwards, a planned, phased shutdown of the gas distribution network takes place as home heating transfers to other fuel sources.	In the 2020s and 2030s the emergence of viable smart energy solutions and changes to regulation accelerates heat pump and DHN uptake affecting the gas distribution network in multiple ways.
This starts both at the extremities of the gas network in the most expensive-to-supply rural areas and in those urban areas that are first to adopt heat networks.	In some locations, the gas distribution network is decommissioned. In some other areas it is retained, but at much lower utilisation.
Over the course of the next few decades decommissioning of the gas distribution network accelerates in line with the adoption of heat pumps and heat networks.	In some urban areas where heat networks are deployed the gas network is partially retained to fuel combined heat and power (CHP) systems, until the gas CHP systems are eventually replaced by lower carbon alternatives.
The gas transmission system, meanwhile, is retained to supply both the power and industry sectors.	In some locations local efforts drive a switch to alternative types of gas (such as bio-SNG and hydrogen) allowing the network itself to be operated in a similar fashion to today.
The availability of CCS allows over 300TWh of gas a year to be used for power generation in the mid-2020s but restricts where new power stations can be sited and thus where the gas transmission network must serve.	In the power sector, with CCS unavailable until the 2030s, short-term growth in gas use is mainly limited to supplanting retiring coal stations – with the gas network delivering over 200TWh by the mid-2020s.
Over subsequent decades, gas usage in the power sector declines as older gas plants close and those that remain need to operate at lower utilisation, for example, with large seasonal variations – with less than 200TWh a year of gas used in the sector by 2050.	The eventual emergence of CCS allows gas to remain in the power sector, with it taking on more of a peaking role and seeing a steady decline to 150TWh a year.
Overall gas use in industry stays relatively flat out to 2050 as efficiency improvements and the availability of CCS offset growth in the sector. Some sites switch from gas to hydrogen.	Overall gas use in the industry sector halves between now and 2050 as the sector shrinks and emissions constraints take effect, alongside the availability from 2040 of hydrogen as an alternative fuel for the sector.
A growing use of gas in the heavy duty transport sector from the 2030s onwards has the gas network adapting to supply refuelling facilities at depots and eventually along major highways nationwide.	

Source: National Grid

WHAT DOES THIS MEAN FOR THE GAS NETWORK?

In both of the scenarios there is a changing role for gas, particularly in the domestic sector. The emissions from boilers in people's homes and the lack of practical options for capturing and storing CO_2 there, means that there needs to be a substantial reduction in the use of gas for home heating for the carbon targets to be met. This in turn affects the role of the gas distribution network. Where and in what way it is affected depends on the options that would replace gas.

Gas is a very effective means of delivering heat to homes and there are only a few options that can realistically replace it. These options are limited further by the nature of the homes themselves and the local environment they inhabit.

The scenarios reflect this with natural gas replaced, over time, with varying degrees of heat network and heat pump deployment (typically in urban and rural areas, respectively) or through the integration of lower carbon gases. The latter case would see retention of the gas network. For either of the other two options, this could involve complete replacement of the gas distribution network. There is also the possibility that gas will still be needed to support either of the alternative technologies. Each of these outcomes presents its own challenges.

ETI Project:
Infrastructure Cost Calculator

This tool provides data on costs of key types of fixed energy infrastructure and can be used to assess the relevant merits of different infrastructure options given different energy generation and demand scenarios

future networks

ETI Project:
Energypath Networks

A software tool to design cost-effective local energy systems for the UK.

Designed in partnership with local authorities.

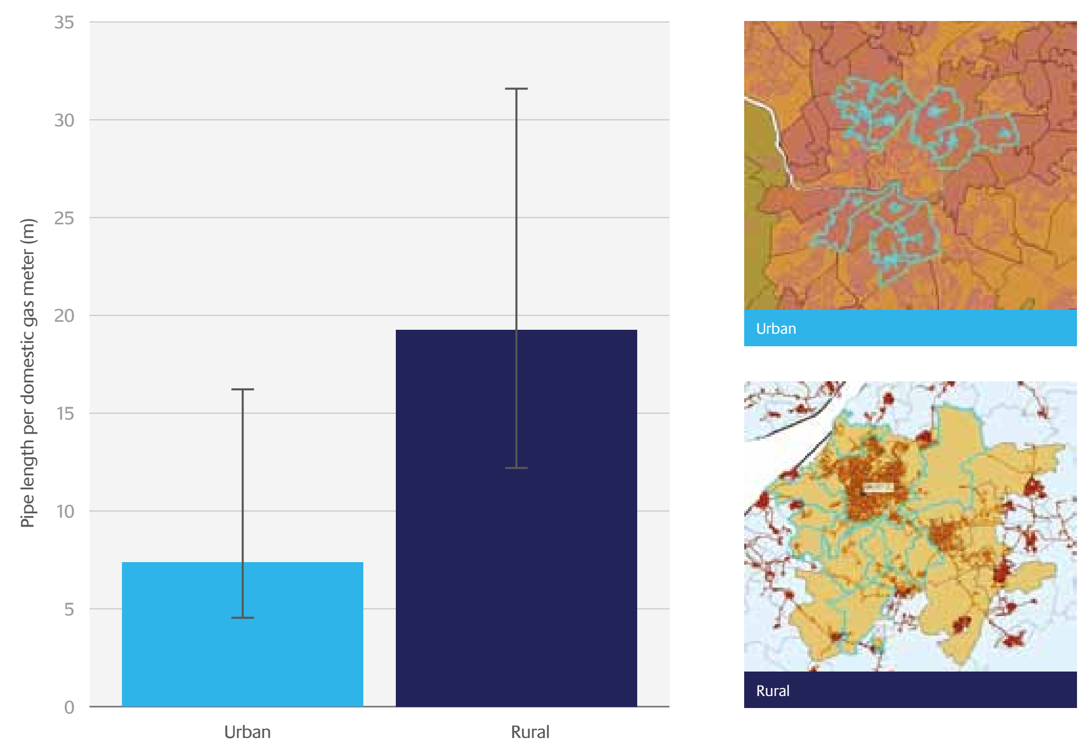
Demonstrating the capability to create future-proof and economic local heating solutions for the UK.

EnergyPath

Decommissioning

Where gas is no longer needed for homes, the gas distribution network for those homes will need to be decommissioned. A major part of this is the buried gas pipework itself. This can either be sealed off and left buried or removed. Care will need to be taken with either approach as the gas will need to be purged from the decommissioned parts of the network. Clearly there are safety implications for this but there are also emissions implications, given the very high global warming potential (GWP) of methane[11]. Beyond the pipework, the most appropriate process would also need to be established for disconnecting the homes themselves. Minimising disruption will be paramount in all of this and is likely to be most acute in more urban areas, whilst in more rural areas, the more dispersed nature of properties will mean the decommissioning of more pipework per building disconnected (see Figure 7).

Figure 7
A comparison of pipework requirements for supplying rural and urban areas[12]



11 Methane, the major constituent of natural gas, has a GWP more than 30 times that of CO_2
12 Calculated using data from DECC's MSOA Domestic Gas Consumption (2014)

WHAT DOES THIS MEAN FOR THE GAS NETWORK?

Continued ›

Which energy network takes over from the gas network in a given area will affect the nature of the decommissioning that takes place there. Where electricity fully replaces gas, the distribution network in that area would need to be fully decommissioned. By contrast, where a heat network initially fed by a gas CHP system replaces the gas home heating, a supply to the CHP system will still be required, so a part of the gas distribution network would need to be retained.

If decommissioning of the gas network needs to take place on a mass scale, it will be important to determine the best way to do this. Given the extent of the gas distribution network this would be no small task. It will be necessary to identify, for example, which areas to transition from gas first. Processes and protocols will need to be established. A supply chain of sufficient size and capability will need to be deployed to undertake the work. This will need to be scaled up to meet the requirements of the transition and in line with, for example, the level of decarbonisation of the relevant parts of the rest of the energy system. The logistical aspects of switching over homes from one type of supply to another will need to be considered, such as coordinating utility works and establishing the windows within which work can be carried out.

Whichever approaches are taken, careful planning will be required to ensure people are not left without the means to heat their homes for any meaningful period of time and are willing and able to change their cooking appliances to electric alternatives.

Operating at much lower utilisation

In the situation where gas is still needed to support heat pumps, this would see (in order to achieve the emission reduction targets) the majority of heat provided electrically via the heat pump but at certain times gas augmenting or possibly even supplanting the electricity supply[13]. The nature of this situation – for example, there being insufficient capacity in the electricity network or insufficient electricity generation available to meet the heat demand at that time (the reasons behind this are covered in more detail in the electricity network insights paper[14]) – means the gas would only be needed infrequently, typically during the coldest winter mornings and evenings, but the demand for it at these times could be considerable.

This is a substantially different way of using gas to today. A usage profile where gas is used infrequently would drastically alter the economics of the gas network. There would still be a cost to maintaining and managing the network to ensure it worked safely when it was needed. However, there would be significantly less gas being used from which to derive revenue. An appropriate business model would need to be developed to accommodate this. Options for this include:

- An increase to the unit price of the gas – Consumers would thus pay high costs for usage. Given that this would be to meet needs at the coldest times of the year this heavily penalises necessary usage and has the potential to disproportionately affect those least able to afford it.
- Pay for access rather than usage – This limits the opportunity for consumers to save money by reducing consumption as well as reducing the incentive not to use too much gas, which could be detrimental to efforts to decarbonise
- A combination of price change and usage cap measures – As with any option but particularly so when combining measures, it is important that tariffs and mechanisms are effective and not too complicated, to avoid unintended consequences and allow consumers to affordably access the utility they require. There will need to be enough interest from service providers to ensure there is a competitive market.
- Greater management of overall energy usage by suppliers or third parties – This would require effective regulation and market structures to ensure operation for the benefit of consumers and the wider environment as well as effective integration across networks. Utilising the gas network in this way lends itself well to the adoption of a more integrated service provision model between gas and electricity which will require system control across the two networks.

If it is feasible, it may be that it becomes more economical to make gas available in bottled form rather than to continue to maintain the gas distribution network. Under these circumstances, as above, the gas distribution network in these locations would need to be decommissioned. Deciding what is the best solution for each location is likely to come down to economics and consumer preferences. Basing that decision on informed and reliable analysis both of the local factors and of the wider energy system provides the best opportunity to deliver a successful outcome.

ETI Project:
Energypath Networks

A software tool that will allow designers to better understand the information and communications technology (ICT) solutions that will need to be implemented to deliver new home heating solutions. Increases ETI's capability to provide comprehensive local area energy system designs

ETI Project:
Enabling Efficient Low Carbon Networks

A project to build understanding of options for reforming governance, market and regulatory arrangements to enable efficient investment in low carbon energy network infrastructures

13 The gas could, for example, be used in boilers or the heat pumps could be hybrid systems able to run on electricity and gas

14 Lidstone, L. (2016). Electricity Network Transition Challenges. [online] Available at: http://www.eti.co.uk/insights/network-electricity

WHAT DOES THIS MEAN FOR THE GAS NETWORK?
Continued ›

Integrating low carbon fuels at significant levels

Reducing the carbon intensity of the gas[15] carried in the gas grid is a third option for decarbonising heat supply and would allow retention of the gas network infrastructure and potentially less disruption. This involves substituting a portion or all of the gas with an alternative gas that would either emit less CO_2 when burned (e.g. in a boiler) or consume CO_2 when it was produced to offset emissions when it was burned. There are two main options:

- Hydrogen
- Lower carbon methane replacement

Whilst small percentages of hydrogen can be blended into the gas grid with little effect, more meaningful amounts would require changes to both the infrastructure and, for example, heating systems. Estimates vary but it is expected that issues would start to arise once blends exceed around 5-20%[16 17 18]. Blends would need to be substantially greater than this, however, for CO_2 emissions to meaningfully reduce. Hydrogen has a (volumetric) energy density around a third that of natural gas. This means that even if blends were to reach the upper end of estimated limits, i.e. 20%, emissions (for the same level of output) would reduce by less than 8%[19].

At higher blends hydrogen's properties affect how it can be used. Hydrogen causes embrittlement of the steel grades commonly used in gas pipelines. This is not an issue for those pipelines in the distribution network that have been replaced with polyethylene in recent years. Further work is needed to assess the impact on gas network components, such as compressors. The small molecular size of hydrogen means that it is more prone to leakage than natural gas, which is an issue both in terms of lost energy and safety.

The above also apply if hydrogen were to fully replace natural gas in the gas network. For the same level of energy delivery to be maintained, the lower energy density of hydrogen means that flow rates would need to be tripled. How much of an effect this would have on operating pressures, components, leakage rates, etc. needs to be more fully established and there are several projects[20 21] that have been commissioned to look at issues with repurposing the gas grid.

How appropriate it is to adapt the gas grid to carry larger amounts of hydrogen will depend on the degree of physical adaptation needed and public acceptance, as well as the availability of a sustainable source of hydrogen and how much of the network to adapt. For example, a regional rather than national conversion would not require adaptation of the transmission network other than for those distribution networks that are converted to be disconnected from it.

15 Natural gas predominately comprises methane
16 Altfeld, K and Pinchbeck, D. (2013). Admissable Hydrogen Concentrations in Natural Gas Systems
17 Dodds, P. E. and McDowall, W. (2013). The future of the UK gas network
18 Melaina, M. W. et al. (2013). Blending Hydrogen into Natural Gas Pipeline Networks: A Review of Key Issues
19 Equally, if blends were to reach 50%, emissions (for the same level of output) would only be reduced by around 25%
20 DECC – Comparison of the costs and other practicalities of converting a town to alternative heating solutions including hydrogen
21 Northern Gas Networks. (2016). H21 Leeds Citygate. [online] http://www.northerngasnetworks.co.uk/wp-content/uploads/2016/07/H21-Report-Interactive-PDF-July-2016.pdf

Using a replacement gas more similar to natural gas, such as bio-SNG (biomass-derived substitute natural gas), reduces the level of adaptation needed, both for the network and boilers, etc. in the home. Adaptations could be limited to expanding the network to connect new sources and/or integrate injection points. With any substitute gas of this nature, however, CO_2 is still emitted at the point of consumption (e.g. the boiler). So to deliver a net reduction in CO_2 emissions, sufficient CO_2 consumption needs to happen elsewhere in the lifecycle, e.g. in the growth of the bioenergy used to produce the bio-SNG. Assessment of the overall lifecycle emissions is critical. To meet decarbonisation targets there would need to be sufficient bio-SNG to replace all natural gas in the long term.

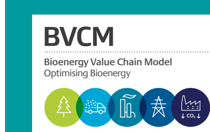
A sustainable source of the substitute gas would be needed to make this viable. Inevitably, and as with hydrogen, constrained resources and the ability for these to be used in other sectors will mean there is competition for its use. Full system level analysis offers the best opportunity to decide where to deploy constrained resources. For example, ETI analysis[22] has concluded that with limited biomass resource, what is available is most effectively utilised in the power sector and industry in conjunction with CCS to create so called "negative emissions".

ETI Project:
Biomass Systems Value Chain Modelling

This project developed a spatial model that links bioenergy crop production with the technology options required for logistics, pre-processing and final use as heat, power or transport fuel.

A value chain optimisation framework examines the economic and carbon impact of sustainably developing UK biomass resources whilst converting these to various energy vectors.

The project analysed the relevant agronomic, techno-economic and geographic factors associated with the cultivation, collection, processing, transmission and utilisation of biomass.



22 Newton-Cross, G. (2015). Insights into the future UK Bioenergy sector, gained using the ETI's Bioenergy Value Chain Model (BVCM). [online] Available at: http://www.eti.co.uk/insights/bioenergy-insights-into-the-future-uk-bioenergy-sector-gained-using-the-etis-bioenergy-value-chain-model-bvcm

WHAT DOES THIS MEAN FOR THE GAS NETWORK?

Continued ›

Changes for the power sector

The decisions taken with regard to the domestic sector will affect the wider gas network. In the power sector, there is the potential for gas consumption to climb in the near term before reducing in the longer term. Whether the existing gas network will be able to manage the near term increase will in part depend on where any additional gas power plants are built. Those that are built in locations already served by the gas network are unlikely to require major changes to the transmission network as there should be sufficient capacity. This may not always be possible since there may be constraints both from an electricity network perspective (further details on this are covered in the electricity network insights paper[23]) and from a CCS network perspective[24]. Those built elsewhere, however, would require new gas pipeline infrastructure. This is not a significant challenge in its own right but, when coupled with an expectation of a subsequent decline in gas use in this sector, may make these pipelines and the power stations themselves a less attractive investment.

In the longer term, gas being used in more of a peaking role reduces its emissions impact but calls for an appropriate set of structures, processes and market and business models to ensure the network can be sustainably operated in such a way. In addition, such a role will benefit from the development of a strategic gas storage capability to manage variable demands and hedge against uncertain global influences. It is reasonable to assume that sufficient storage could be built in the UK but this needs to be considered alongside the needs for hydrogen storage, which not only offers competition for the same sites but the prevalence of which also affects the need for gas to be used in this way in the power sector.

ETI Project:
CCS Next Generation Gas Capture Technology

This project seeks to accelerate the development of advanced carbon capture technologies for gas-fired power stations.

It has focused on post combustion examining designs to be used on new build or retrofitted onto combined cycle gas turbine power stations.

The findings will be used to inform the extent to which gas-fired power generation could cost-effectively contribute to decarbonisation and in turn the gas infrastructure needed to supply it.

Changes for the industry sector

As is the case for the power sector, the prevalence of hydrogen and carbon capture and storage (CCS) will also affect the extent to which gas is used in industry. The establishment of a CCS network able to take CO_2 from industry sites, for instance, would provide the opportunity for gas to continue to be used there at similar levels and still meet tightening emissions limits[25]. By contrast, the availability of low carbon hydrogen in sufficient quantities would offer an alternative to gas. Again, tightening emissions limits would be the driver here and (along with efficiency gains and any weakening of industrial output) the cause of any decline in gas usage in the sector. Of course gas can be used to produce hydrogen (and is currently the predominant means of doing so via steam methane reforming), which could compensate for a reduction in direct gas use in industry[26].

As a result, the gas network would need to adapt to this changing usage with any reduced demand meaning lower gas flows through the relevant pipelines. As with other sectors it will be important to ensure the network and equipment can reliably operate at these reduced loads. This is unlikely to be as challenging as for the domestic or power sectors as it's not expected that the temporal usage profile would also be changing at the same time.

A further consideration, however, is the need for the network to be able to supply to any new industry sites. With a reducing overall level of gas consumption and the possibility of having to invest in decommissioning existing pipelines that fall into disuse, the prospect of investing in new pipelines may become more difficult.

Changes for the transport sector

One market that may emerge to bolster the gas industry is in transport. Beyond efficiency improvements, the opportunities for reducing emissions in the heavy duty vehicles sector is limited. Gas is one option that could yield positive results, providing the lifecycle emissions associated with its use in this way make sense. Supplying this market would require serving depots of return-to-base fleets as a minimum but could lead to the development of a national refuelling infrastructure if it were necessary to support the majority of heavy duty vehicles. The gas network would need to be adapted to both connect up these sites and manage the particular gas flows that would be required. Whilst the volume of gas use that would be needed for this is small in comparison to current gas usage in the domestic or power sectors, if taken up, in the long term this could be a material proportion of overall gas consumption.

ETI Project:
Gas Well to Motion

This project will build knowledge of natural gas as a heavy duty vehicle fuel.

A software tool will be developed to calculate the well-to-motion greenhouse gas emissions of natural gas powered vehicles.

The findings will be used to understand the implications of gas use in heavy duty vehicles and the need for developing a gas supply for the transport sector.

23 Lidstone, L. (2016). Electricity Network Transition Challenges. [online] Available at: http://www.eti.co.uk/insights/network-electricity

24 New gas power stations should be located such that CCS can be retrofitted at a future date

25 Day, G. (2014). Potential for CCS in the UK. [online]. Available at: http://ow.ly/Vl8x302IUCY

26 This would require the steam methane reforming plants to be both connected to the gas network and to a viable CCS network in addition to relevant hydrogen infrastructure

INTEGRATING WITH OTHER NETWORKS

Integrating with electricity networks

Gas networks already interact with the electricity network to a certain degree with gas being a major source of electricity production and the gas transmission network, in particular, having to be able to respond to changes in electricity demand. Developments could lead to greater interaction at a more local level.

As described earlier, with the need to decarbonise the domestic sector and heating in particular, one solution that could emerge is gas being used as a backup to electric heating systems to help meet peak heat demands. To sufficiently decarbonise there would be a limit to how much gas could be used in this way but the gas system would have to be able to respond when it was needed. Greater integration between gas and electricity networks, particularly where this is driven by electricity network capacity constraints, will ensure this is as effective as possible. Smart energy solutions enabling greater cross network control have the potential to play a major role here.

ETI Project:
Multi-Vector Integration

This project aims to understand the opportunity for, and implications of moving to, more integrated multi-vector networks. This will include:

- Identifying the ways in which different networks could interact, e.g. one network providing peak capacity support for another;
- Determining how prominent these interdependencies could be;
- Examining what the effects on each of the networks would be; and
- Identifying any technology and/or operational opportunities that would facilitate any increased integration between vectors that may emerge

future networks

Integrating with heat networks

Unlike for heat pumps, in the situation where gas is needed to support heat networks the gas doesn't have to be delivered all the way to homes. Instead the requirement here is for it to feed the energy centres that supply the hot water to the heat network. As such, in these locations, the "last mile" of the gas distribution network still needs to be decommissioned. In the energy centres, combined heat and power (CHP) systems and back-up boilers use the gas to generate hot water. Here the usage profile might initially be similar to how gas is used for home heating now.

For this to be possible there will need to be a pipeline of sufficient capacity to serve the energy centre. The availability of one may actually be a factor in the siting of the energy centre in the first place. Otherwise a new supply pipeline to connect to the appropriate point in the gas network will need to be installed.

As described in the heat network insights paper[27], part of the benefit of heat networks is their ability to make use of a variety of heat sources and enable a transition to lower carbon heat supply. Over the longer term a transition away from gas-fuelled heat sources is required, as even with the overall efficiency benefits that CHP systems bring, further decarbonisation will be necessary. At this time the gas supply to the energy centres would need to be decommissioned. There is the possibility that gas will still be needed as a backup but this will very much depend on how the wider energy system (including both the electricity and heat networks) evolves. As with the support of heat pumps, appropriate policy and business models will be required to make this viable.

Integrating with hydrogen networks

Gas is currently the predominant means of producing hydrogen, through the use of steam methane reforming. If hydrogen demand were to increase and steam methane reforming were to continue to be the most cost-effective way of producing hydrogen then there would need to be sufficient gas supply to the increased number and size of plants. Whether new gas network infrastructure is needed for this will depend upon the siting of the plants. This will be influenced by: where the hydrogen will be used and so any hydrogen network they would need to be connected to; the location of any hydrogen storage that was needed[28]; the location of CO_2 pipelines (which the plants will need to connect to ensure the process is sufficiently low carbon); as well as the gas network itself. Once connected the operation of the gas network will be affected by the demand profile for the hydrogen, which in turn will depend on the particular demand sector(s) it serves and the availability of hydrogen storage.

If hydrogen were to be used as a replacement for gas supply in the domestic sector, it would be necessary to manage the switchover in those locations where it was adopted. This would involve the disconnection of the gas supply to the relevant regions (or parts of regions) as the supply of hydrogen was brought online, with logistics of this accounting for any changes needed to in-home gas using appliances as well as any adaptations to the gas distribution network itself. With gas use much higher in the winter, switchover is likely to be most plausible in the summer to minimise interruptions in critical heating supply, which limits the available window. Even in summer, however, gas is still used for providing hot water and cooking for many homes, so this will need to be factored in.

27 Lidstone, L. (2016). Heat Network Transition Challenges. [online] Available at: http://www.eti.co.uk/insights/network-heat

28 Salt cavern storage is the most cost-effective way of storing large quantities of hydrogen but only certain parts of the UK have the geology to support this

SUMMARY

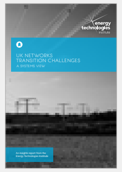
Changes to the way gas is used have the potential to profoundly affect the gas network, both in terms of where physical assets are needed and how they are operated.

With decarbonisation as the major driving factor the pressure is to reduce gas consumption, in particular in the domestic sector, the largest consuming sector. However, there could be short-term increases in gas consumption in other sectors and even the emergence of new gas consuming sectors.

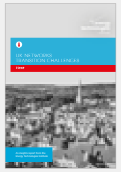
There are numerous implications for the gas network with the potential requirement for decommissioning of major parts of the network, building new assets and radical changes to the way the network that emerges operates.

These changes bring a focus on the investment and policy decisions that will be needed to ensure that the most cost-effective choices are made in each location for what needs to be built, what needs to be decommissioned and how the continuing gas network integrates with the wider energy system.

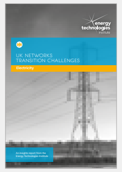
FURTHER READING



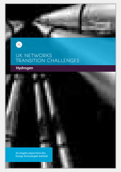
UK Networks Transition Challenges – A systems view
http://www.eti.co.uk/insights/network-transitions



UK Networks Transition Challenges – Heat
http://www.eti.co.uk/insights/network-heat



UK Networks Transition Challenges – Electricity
http://www.eti.co.uk/insights/network-electricity



UK Networks Transition Challenges – Hydrogen
http://www.eti.co.uk/insights/network-hydrogen

ABOUT THE AUTHOR

Liam Lidstone
BEng, EngD, MIMechE, CEng

Strategy Manager – Energy Storage and Distribution

Liam Lidstone joined the ETI in 2009 and has worked as Strategy Manager across the Smart Systems and Heat, Buildings, Distributed Energy and Marine programmes. He now has responsibility for Energy Storage and Distribution and Light Vehicle Integration.

01509 202055
liam.lidstone@eti.co.uk

energy technologies institute

Energy Technologies Institute
Holywell Building
Holywell Way
Loughborough
LE11 3UZ

01509 202020
www.eti.co.uk
info@eti.co.uk
@the_ETI