Cadent
future
Your Gas Network

The Future of the Gas Network

The crucial role gas networks will play in delivering net zero.

September 2024 / Revision 02

Foreword

The gas network will play a crucial role in the energy transition by enabling the delivery of net zero.

The UK's gas distribution networks provide energy to over 20 million homes and businesses, keeping them safe, warm and operating. The transition to clean energy will change the role of the gas network over time, as our customers shift their consumption to low carbon alternatives such as clean electricity and low carbon gases like hydrogen.

The scale and complexity of this transition is unprecedented. Cadent transports a third of all the energy supplied to UK homes, businesses and industry, nearly as much as all the electricity distribution networks combined. Even in 2035 our network is likely to still be providing at least 20% of all the energy demanded by UK homes and business.

The gas network that supplies the 11 million and more homes and businesses across the Cadent region is highly interconnected. So, even though each customer's decarbonisation journey might look different, the transition requires us to consider how we collectively get there.

We think the critical role the gas network will play in decarbonising the UK is not well understood and often simplified in the way it is described. We have therefore written this report, showing how we are supporting customers in the energy transition in three main ways:

Firstly, we **enable energy solutions** that provide flexibility, resilience and reduce consumption, such as access to gas for flexible power generation and for hybrid heating systems, by continuing to safely and reliably provide gas as we transition.

Secondly, we **drive reductions in emissions** while our customers still need gas so the gas that is used create as few emissions as possible. This includes our focus on reducing gas leaks and boosting biomethane.

Finally, we plan to **convert and develop the network** to distribute hydrogen to where it is needed when customers are ready – this includes hydrogen for industry and power and possibly for homes in the future.

Without the gas distribution network, the journey to net zero will be more difficult and costly. Deployment of clean energy technologies that require either gas as a feedstock or to provide wider energy system resilience would be slowed. Customers would not have the time they need to decarbonise using the clean energy technology most appropriate for their own circumstances. And we would make the option of using hydrogen for uses like industry, power and potentially heat, much harder.

As we head in to a process where the investment in the next five years will be agreed with our economic regulator Ofgem, we believed it was timely to set out the ways in which the current gas network provides customers with a safe and reliable gas supply today, the role that we will play in supporting customers transition to net zero tomorrow and therefore the need to maintain an efficient gas network into the future.

Steve Fraser
Chief Executive Officer

Executive summary

Getting to net zero means abating or replacing all methane use with low carbon alternatives by 2050. The scale of this challenge is huge. Even if we exclude methane's important role in generating electricity, methane still makes up two thirds of all the energy used by homes, businesses and industry today.

The gas network that distributes this methane connects many parts of the wider energy system. The future of the gas network therefore needs to be seen in context of the wider transition to net zero and the pathway we follow. Stood in 2024, that pathway is highly uncertain, with a variety of potential scenarios capable of playing out between now and 2050. Whilst these different pathways create uncertainty about the balance of roles the gas network will play over time, in all pathways it is clear they will be a need for a gas network of some description well in to the 2040s and beyond.

The role gas will play in delivering net zero.

We see Cadent playing three important roles to support the energy transition and help the UK reach net zero, regardless of the pathway we take.

Enabling energy solutions (Role 1) that provide flexibility and resilience to accelerate the rollout of renewables and heat electrification.

- The gas distribution network will play a key role in supporting the decarbonisation of the power sector by storing gas in pipes and providing gas to generate electricity when renewables are intermittent. This enables the UK to continue building renewables at a faster rate than would be possible if renewables growth needed to coincide with electricity grid reinforcement to guarantee constant supply.
- We will support the adoption of low carbon heating technologies like hybrid heat pumps which could reduce gas consumption by around 80%. This would enable emissions reductions whilst limiting the amount of investment needed in electricity network capacity.

Driving reductions in our emissions (Role 2) while our customers still need gas.

- We will reduce our methane emissions by around 27% by 2032 through replacing pipes and deploying new innovative technologies that reduce emissions – saving 900ktCO2e per year.
- We will increase the connection of biomethane and hydrogen on our network – blending these low carbon gases with methane will reduce the carbon content of our gas by 10MtCO2e each year.

Converting and developing the network (Role 3) to distribute hydrogen to where it is needed, as and when our customers are ready.

- We are undertaking a replacement programme of old iron pipework as a way of improving the safety and reliability of the network. As a result, the network will be 95% ready to transport hydrogen by 2032 with limited retrofitting.
- Hydrogen will undoubtedly play a role in decarbonising industry and power – but also potentially the heat and hot water we use in our homes and businesses. We are providing the evidence and analysis necessary for government to decide on this potential role in 2026.
- We will play a central role in constructing new hydrogen infrastructure to help make hydrogen a reality. For example, we are part of the consortium for the HyNet industrial cluster in the North West.

The use of the gas network will change over time as we deliver net zero. Whilst the pathway we will follow remains unclear, there is sufficient certainty across all scenarios to be clear the gas network is required for some time to come. This includes supporting customers through the transition with the provision of flexible energy, direct emissions reductions, and enabling a potential future shift to low carbon gases such as hydrogen.

Key takeaways

1 **The size of the challenge ahead is significant.**

The gas network transports huge amounts of energy, more than twice as much as the entire electricity network. Replacing that energy with low carbon alternatives like hydrogen, biomethane and electricity will be a challenge, and one that is not always recognised.

2 **The network today is highly interconnected.**

A single pipe on the gas network simultaneously supplies energy to multiple customers, including homes, local businesses, public buildings and industrial sites. Only around 5% of industry is within existing industrial cluster areas and much of industry outside of the clusters will need hydrogen to decarbonise too.

3 **The pathway we will follow is uncertain.**

There is uncertainty over which pathway we will follow in delivering net zero. Ultimately, it will depend on a multitude of factors, the critical one being the role of consumers and consumer choice.

4 **Regardless of the pathway we follow, we will still need a gas network in the 2040s – and beyond.**

Even under pathways where most demand is electrified, 6.3m domestic customers will still be connected to our network and using methane by 2040.

5 **A reduction in customer numbers doesn't mean a similar reduction in network size.**

Even if a small number of customers decide to remain on the network, the gas network that supplies them will largely need to remain – unless the government decides to remove people from the network in some way, for example through the banning of methane boilers from a certain date.

6 **The gas network will be needed to enable energy solutions that provide flexibility and resilience.** *(Role 1)*

The gas network provides both storage and resilience for intermittent renewable assets decarbonising the electricity sector. The presence of a gas network also allows the adoption of hybrid heating systems, which countries like the Netherlands are installing - and back up energy to industrial sites which need additional resilience.

7 **We will need to drive reductions in our emissions whilst customers still need gas.**
(Role 2)

Through replacing old iron pipes with new plastic ones, we are improving the safety and efficiency of the network and significantly reducing emissions. We will proactively find and fix leaks through the deployment of technology – and deliver other improvements to reduce methane emissions from today's level by 66% by 2032. We will maximise the potential for biomethane by facilitating connection to our network. Combining biomethane and blended hydrogen could make up 24% of the gas we distribute by 2035.

8 **We need to convert and develop the network to distribute hydrogen to where it is needed.**
(Role 3)

Hydrogen will play a critical role in the delivery of net zero, providing low carbon energy where electrification is either unfeasible or uneconomic, as fuel for power generation, a long-term store of energy and potentially even heat and hot water for our homes. By 2032 95% of our network will be ready to transport hydrogen due to the iron mains replacement programme.

9 **We need to drive innovation to achieve much of this.**

Deploying innovative technologies such as pressure management tools and digitalisation can help us respond more quickly and accurately to problems on the network, improving performance and reducing costs.

10 **Securing this role for the gas network will require ongoing maintenance.**

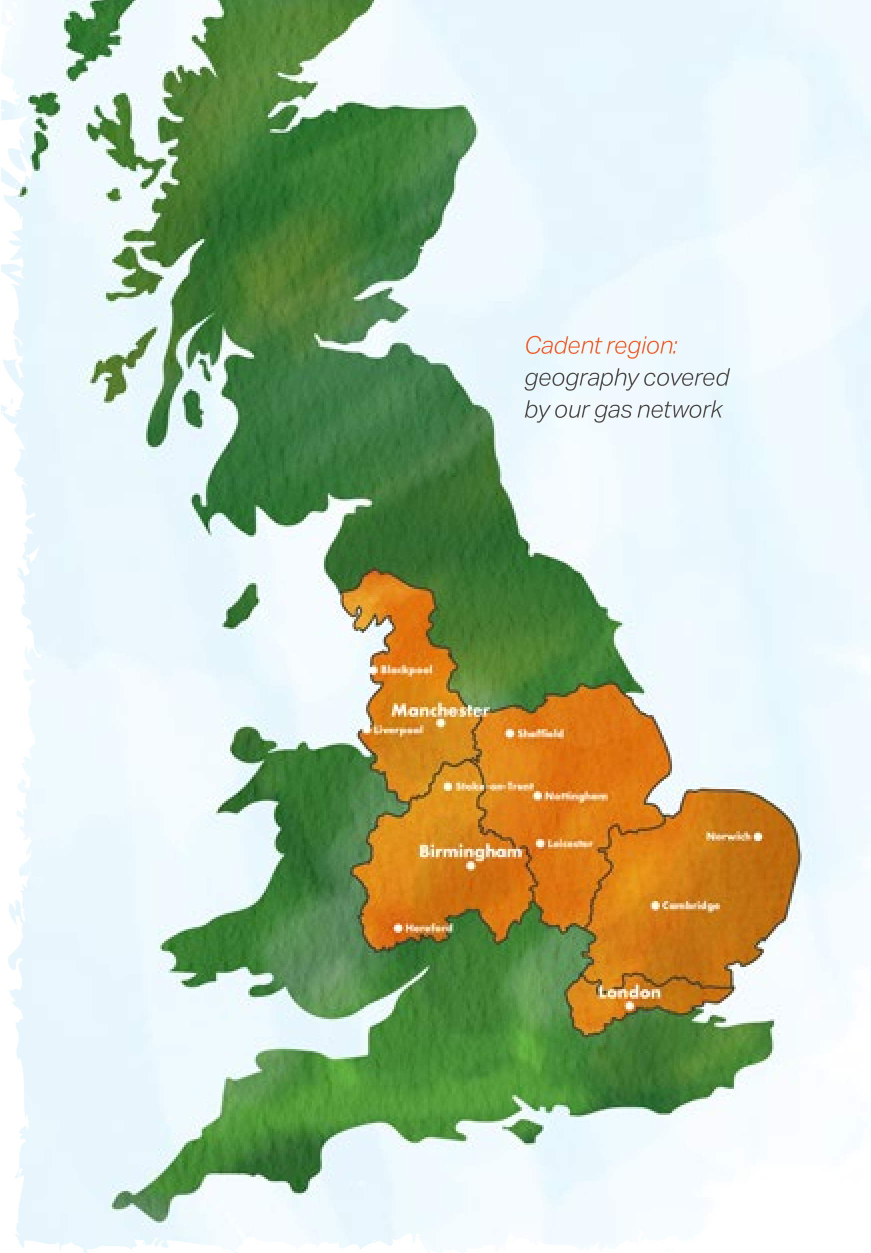
Delivering each of the roles the gas network needs to play in the future will require ongoing investment in the operation and maintenance of the network to ensure safety and reliability.

The gas sector today

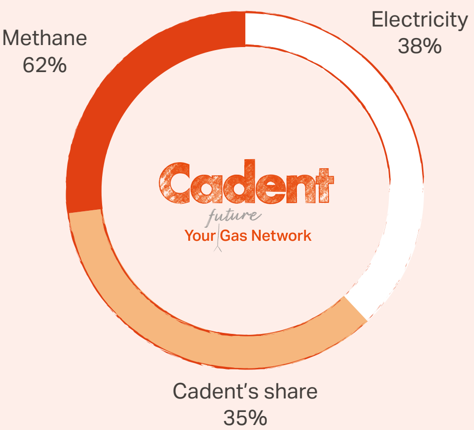
The gas network in the UK today is vast, totalling more than 280,000km in length.

This network delivers more than 242TWh of energy to homes, businesses and industry each year – more than double the amount of electricity those same customers demand[1] - and with a reliability record of 99.99%. It is also increasingly modern, with 75% of it having been installed in the last 22 years.

We are responsible for 135,000km of that gas network, covering half of the country and more than 11 million homes and 40,000 industrial customers – making us the largest energy provider to homes, businesses and industry in the UK today. Our network alone carries almost as much energy as the entirety of the UK's electricity network does today, and includes the three largest cities in the UK, London, Birmingham and Manchester, as well as big brands like Rolls Royce, British Sugar and Liberty Steel. Whilst we do not own the gas in these pipes, as an infrastructure provider, we ensure it is safely delivered to where it is needed.



Cadent region: geography covered by our gas network



A third of the pie: Our network supplies nearly one third of energy used by UK homes, businesses and industry in 2022.

The network: A map showing the extent of our high, medium and intermediate pressure pipelines

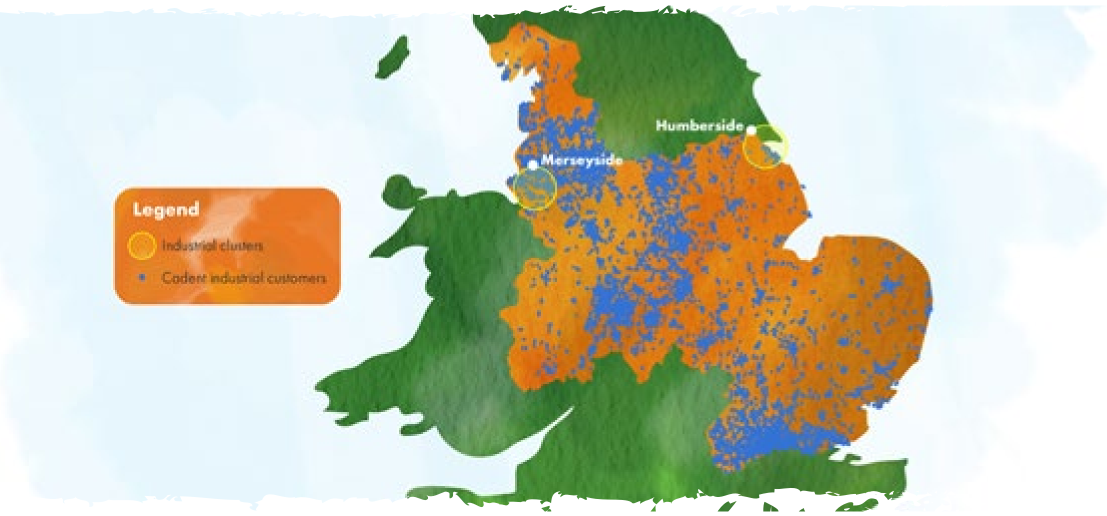
Our nearly 40,000 industrial customers are located across the network, often right alongside homes and businesses.

Our industrial customers span a wide range of sectors, from agriculture to steel, and often have processes that require very high temperatures. Production at these high temperatures, sometimes exceeding 1,000°C, can generally be economically run only by burning a gas in appliances such as furnaces or boilers. While some may think that industrial customers are concentrated in cities and clusters, they are actually dispersed widely across the UK.

In fact, **around 5% of industrial demand in the Cadent region is in defined industrial clusters,** meaning decarbonising hydrogen clusters alone will not be sufficient to decarbonise industry. [2]

Our network also provides flexible power at times of peak demand, helping keep the lights on for residential, commercial and industrial customers.

This is because 174 power generation assets, totalling 2.2GW in capacity – or 8% of UK gas power station capacity – are connected to our network. Gas provides the energy system with both resilience and flexibility on days when either demand is very high or renewable supply very low. Gas also provides round the clock back-up energy for customers who need a guaranteed supply of energy such as hospitals, as well as providing the energy needed to run combined heat and power systems.



Industry is everywhere: A map showing the location of our industrial customers

Each pipe on the network has multiple users and uses

A single pipe on the gas network **will simultaneously supply multiple customers with the energy they need,** often including homes, local businesses, public buildings and even nearby industrial sites. In the example shown below, in one region of Liverpool a small subset of the network simultaneously serves a wide variety of demand.

4,180 industrial sites, from the very small to the very large

250k different residential and commercial

Five hospitals, a prison, power generation sites and a university

Diverse: Our network of gas distribution pipes serve a wide variety of use cases across Liverpool

This network carries an enormous amount of energy.

For example, in 2020, our network supplied 43.5 GWh of energy to Broadgreen Hospital, located in the mapped area, equivalent to the annual gas demand of around 4,000 homes. By way of comparison, electricity supply to the same hospital was only 0.8GWh in the same year.[3]

Our network is highly interconnected, contributing to its overall reliability and, because so many customers are connected to it, enables the costs of operating to be spread thinly, reducing the cost per customer through high levels of utilisation.

Due to the diversity of customers on the network and different decarbonisation pathways for each sector, the amount of gas pipeline needed will not reduce in parallel with gas demand.

The relationship between customer disconnections and the network needed to support the remaining customer base is not proportional. Two features of the network cause this:

1. For a particular pipe to be removed, all customers relying on that pipe must no longer require a gas supply. This means that unless customers are at some future point forced to disconnect from the gas network, for example through a ban on replacement boilers and boiler repairs, **we will not be able to remove pipes until the final customer at the end of the pipeline is disconnected** – even if all other customers on the pipe have already ceased their demand.
2. Other customers, connected to different parts of the network, may rely on a pipe further up the network to:
   a) Transport the gas they need to the part of the network where they are.
   b) Provide the capacity necessary to support their peak demand.
   c) Ensure gas can still reach them even if a different pipe elsewhere in the network should fail.

This highlights the importance of coordinated planning of gas and electricity networks, with each disconnection from the gas network implying a need for increased electricity network capacity. Whilst this coordination has been lacking to date, the introduction of central planners at the regional and national level is designed to address this issue.

The newly created National Energy System Operator (NESO), the independent, public corporation responsible for planning the whole system, will consider the connections between gas and electricity and their relationship with the wider system. Their work will be supported by up to thirteen different Regional Energy Strategic Planners (RESPs) who will work with local governments, regional authorities and gas and electricity networks to establish how energy infrastructure can help deliver decarbonisation at the local level.

The role gas will play in delivering net zero

Our customers are decarbonising. This includes reducing their energy use and switching to lower carbon technologies and energy sources. The pace at which this happens will, however, be different for different customer groups and in different regions.

We have a duty to continue to serve all customers throughout the transition to clean energy. We will supply customers with methane until they no longer need it whilst also supporting other customers with the switch to low carbon technologies – either through conversion of our asset, provision of new infrastructure or through eventual disconnection. This critical role is often not well understood yet is essential for us to deliver net zero.

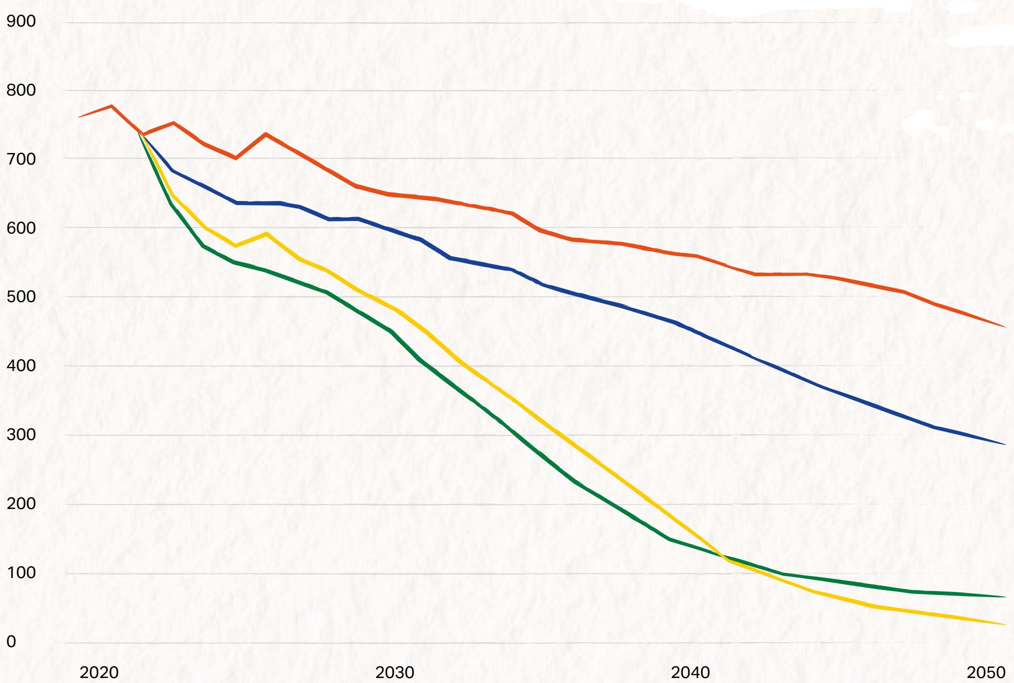
What pathway are we on?

There is a good deal of uncertainty as to ultimately what path we will follow in delivering net zero, and a wide range of pathways are assumed across the different institutional parties. The pathway we find ourselves on will ultimately determine the role the gas network will play in delivering net zero.

On the one hand, the National Infrastructure Commission's Second National Infrastructure Assessment assumes that in delivering net zero we will not need a gas grid for heating people's homes, assuming that all homes will be heated by either a heat pump, heat network or other electric solution. That of course depends on whether consumers across the UK can be persuaded to change how they heat their homes, at a reasonable cost and the market dynamics and incentives for doing so. The Energy System Operator's (ESO's) Future Energy Scenarios (FES) Holistic Transition and Electric Engagement Transformation pathways show substantial falls in methane demand by the late 2030s and early 2040s.

The Climate Change Committee (CCC) Balanced Pathway shows methane use dropping by 70%, while from the 2030s a hydrogen economy develops "to a scale that is comparable to existing electricity use by 2050". Much of this again depends on the widespread uptake of alternative heating technologies like heat pumps, and an assumption that we will see 500k heat pump installations per annum by 2026.

On the other hand, FES' Hydrogen Evolution pathway sees a significant increase in hydrogen demand, to 393 TWh in 2050 or 60% of today's methane demand. The FES Hydrogen Evolution pathway still has significant methane demand in the 2040s, falling to 266TWh – mainly for hydrogen production, in 2050. At the extreme, there is also a scenario where we fail to deliver net zero by 2050, described by FES in the Counterfactual pathway, where we still have more than half of today's gas demand by 2050 and virtually no change from now until the mid-2030s.



The uncertain path ahead: *Methane demand by FES 2024 decarbonisation pathway (2020-2050, TWh)*

– *Counterfactual*
– *Hydrogen Evolution*
– *Electric Management*
– *Holistic Transition*

Methane use falls across the four FES scenarios, broadly aligning with the CCC's view of 2050. The FES Counterfactual pathway is perhaps more reflective of reality today however, as shown by the lack of alignment between historic FES forecasts and observed outcomes. The ultimate pathway we follow will depend on a multitude of factors, the critical one being the role of consumers – something that is often overlooked through an over technocratic view of the world today.

Regardless of which pathway plays out, 6.3m domestic customers will still be connected to our network and using methane by 2040, even under the most ambitious electrification scenarios. This suggests there will need to be access to gas pipelines for some time to come – with ongoing duties for Cadent to safely and efficiently manage the networks to the benefit of customers.

We have some visibility of how access to and use of the gas network will change over time for different customer groups (see below). Hydrogen production and distribution is already planned in industrial clusters, areas which will need pipelines for hydrogen distribution and methane pipelines for hydrogen production.

This is in addition to new CO2 pipelines that will transport the carbon captured across the area to where it can be safely stored. We expect this infrastructure to be developed from 2030 onwards.

Away from industrial clusters, industries that cannot electrify will need access to either hydrogen or methane networks, and CO2 pipelines of their own. The development of this infrastructure is likely to occur later than in industrial clusters.

For homes and buildings, the methane network will need to be available until the switch to alternative low carbon sources can be completed – regardless of whether that is hydrogen, heat networks or heat pumps. There will likely be disconnections from the gas network from now until the 2040s – and possibly beyond. With a proposed opt-out from electrification for 20% of homes there could be future options for both hydrogen and hybrid heating systems, both indicating a future role for a gas network.

Biomethane connections to the gas network are supported by government policy through to 2043, with potential for this to be extended in future as the UK's green gas strategy is reviewed.

The changing of the network: Timeline of when different gas infrastructure will be needed, and for what purpose.

The role of the gas network

We will play three crucial roles through the energy transition.

1. **Enable energy solutions** that provide the flexibility and resilience necessary to accelerate the rollout of renewables and heat electrification by continuing to provide gas as we transition;

2. **Drive reductions in our emissions** while our customers still need gas; and

3. **Convert and develop the network** to distribute hydrogen to where it is needed, when customers are ready.

Role One

Enabling energy solutions that provide the flexibility and resilience necessary to accelerate the rollout of renewables and heat electrification.

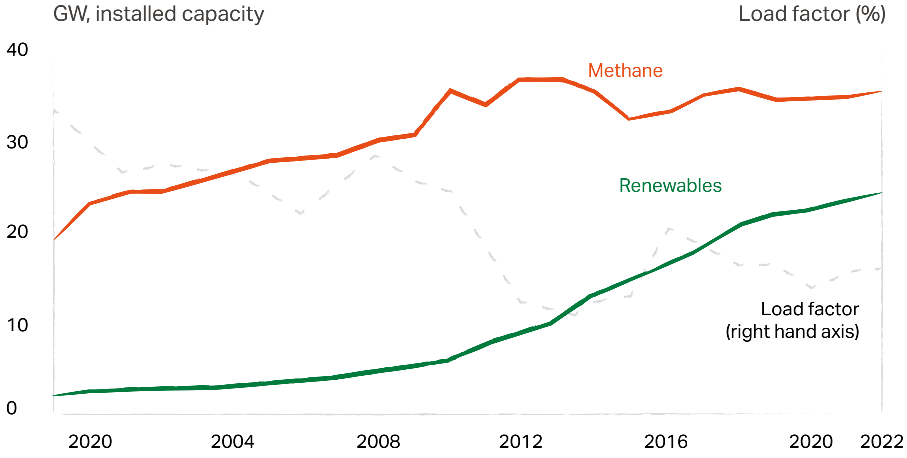
The gas network will continue to provide a reliable supply of methane to those who need it as we transition to clean energy. The network can, however, also support the roll-out of low-carbon technologies, for example:

- Renewable sources of electricity produce energy intermittently and therefore need complementary technologies to balance the system and meet demand, such as dispatchable gas-to-power energy or energy storage.
- Heat pumps reduce in efficiency as the temperature falls, meaning their performance is lowest when heat demand is highest. Gas as a secondary heating source, typically as part of a hybrid heat pump installation, can benefit customers by providing additional heat in peak demand conditions and reduce the cost of upgrading the electricity network to meet increases in demand.
- Some electrified heating systems and industrial processes will require secondary energy sources in case of system outages, for example heat networks and critical infrastructure such as hospitals.
- These examples highlight how the transition to clean energy will require deployment of a portfolio of low carbon technologies designed to complement each other. The gas network will play a critical role in this.
- Taking each of those examples in turn, we see how gas is integral to decarbonisation of our energy system.

The gas distribution network will play a key role in supporting the decarbonisation of the power sector by both storing gas in pipes and providing energy to generate electricity when renewable output falls

Our future power system will necessarily be based around large amounts of renewable power, such as wind and solar. These technologies are not dispatchable; we cannot simply turn on the wind or sun whenever we need more electricity.

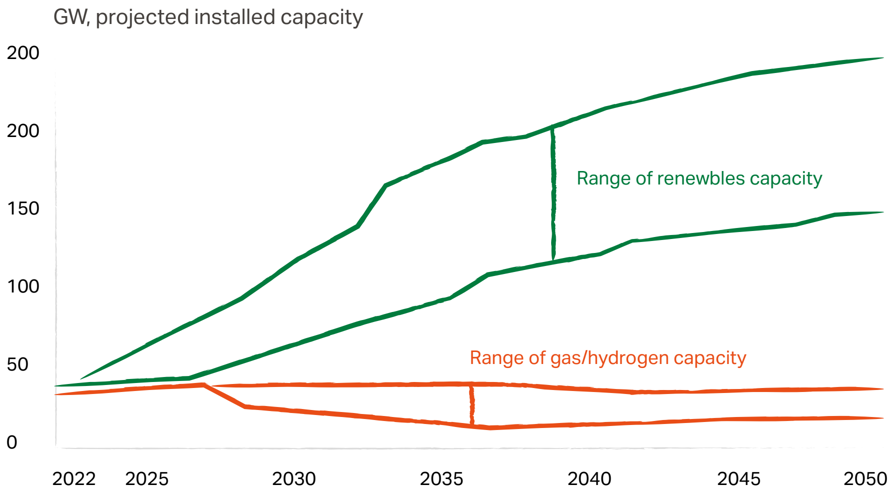
The inherent intermittency of renewables creates a need for low carbon sources of flexibility that can step in and balance demand and supply when renewable production either exceeds demand or is insufficient to meet demand. This includes solutions such as batteries, vehicle to grid and demand side response – but it also includes the use of low carbon gas like hydrogen, which can provide both a long-term store of energy and generation power capacity that can be used to meet peaks in demand.



Loading up:
Gas capacity grows whilst we increase renewables.

As the UK both decarbonises its electricity supply and increases its electricity demand, we will see more renewable power generation assets deployed across the country. As we do this, the amount of gas capacity we build to provide back-up electricity will also grow. Despite gas providing a decreasing share of electricity production over time, the amount of gas capacity connected has actually grown by 15 GW since 2000[4], with an increasing amount of it connected to the distribution network. At the same time, load factors fell to around 40% where they have stayed since.

This was recognised by Labour in their election manifesto where they set out an intention to maintain a strategic reserve of gas power stations, even once the electricity system had been decarbonised.[5]



An ongoing role:
There will still be a need for gas and / or hydrogen capacity to back up renewables.

Gas can provide a secondarily heating source for hard to electrify homes through hybrid heating systems.

Whilst heat pumps have been identified as a key technology in the decarbonisation of home heating, there are several challenges to their deployment in all homes. Some homes have either limited internal space for hot water storage, poor levels of insulation or limited outside space for the heat pump unit itself. These limitations were acknowledged by the government when they announced that no homes will be forced to replace gas boilers.[6]

Other European countries such as the Netherlands and France are increasingly investigating the role of hybrid heating systems as a way to both address these challenges and reduce overall investment needed in the electricity networks to meet peak heat demand. These hybrid heating systems combine a heat pump with a gas boiler, typically meeting most heating demand through the year with the heat pump and using the gas boiler to provide additional 'top-up heat' when required. Indeed, the Climate Change Committee's Sixth Carbon Budget Balanced Pathway assumes 13% of homes have hybrid heating systems in 2050.[7]

Used in this way, these systems could reduce gas consumption by around 80%[8]. Hybrid heat pumps also provide the option of biomethane or hydrogen conversion at some future point – a solution that could be least disruption and cost for some customers. Indeed, deploying up to 1.9m[9] hybrid heat pumps envisioned by the FES by 2050 could save 3.1 MtCO2e annually in our region the same as taking 1.9m cars off the road. Hybrid heat pumps help solves three key problems, both for customers and for the wider energy system:

1. They can be installed in homes that are either costly to insulate, space constrained or otherwise hard to economically retrofit with a larger electric heat pump only solution.
2. The gas boiler provides a supplement to the electric heat pump when the ambient temperature is low, ensuring temperatures in the home remain consistent regardless of external conditions and characteristics of the home.
3. Because gas boilers can provide additional heat in the winter, hybrid systems reduce the amount of peak electricity demand. This reduces the overall size of the electricity infrastructure we need to build – from generation capacity to transmission and distribution networks and dispatchable back-up power. A recent report from Imperial College estimated that an energy system that had some hydrogen for heat in it could save £5.4bn per year, precisely because it helps meet this peak heat challenge.[10]

These systems enable significantly lower use of methane, provide resilience to the system and enable a future shift to lower-carbon alternatives such as biomethane or hydrogen. We can see these benefits in action in the Netherlands, which is typified by a similar climate and historical reliance on methane for heat.

How the Dutch are decarbonising heat with hybrid heating systems[11]

The Netherlands has adopted a different approach to the decarbonisation of heating through looking at the incorporation of hybrid heating solutions to their wider strategy. The systems involve the installation of small heat pumps in existing properties alongside gas boilers. Given the similarities between the UK and the Netherlands in their reliance on methane for home heating, this is worthy of further exploration in the UK.

Both face challenges of electricity grid constraints and cost barriers to conversion in heat decarbonisation.

Comparators	United Kingdom	Netherlands	Germany	France
Energy mix Top 3 sources[12, 13, 14, 15]	Methane 39% Oil 35% Nuclear 8%	Methane 37% Oil 38% Coal 9%	Methane 24% Oil 33% Coal 21%	Methane 16% Oil 31% Nuclear 37%
% of households using methane for heat in 2021[16, 17, 18, 19]	80%	92%	50%	36%
2023 heating days[20, 21, 22, 23]	297 Data from Heathrow Weather Station	297 Data from Schiphol Weather Station	285 Data from Berlin Dahlem Weather Station	254 Data from Charles de Gaulle Weather Station
Climate targets	Achieve net zero by 2050 Reduce emissions by 68% by 2030	Achieve net zero by 2050 Reduce emissions by 49% by 2030	Achieve net zero by 2045	Achieve net zero by 2050 Reduce emissions by 55% by 2030[26]

To support their climate targets and address these practical challenges, the Dutch are taking an approach that involves both hybrid heat pumps and fully electric heat pumps, with three key targets:

1. Install fully electric heat pumps for new and younger housing stock.
2. Install hybrid heat pumps for older or electricity grid-constrained stock, with an overall target of 1 million by 2030.
3. Phase-in installation for the remaining housing stock in line with natural renovation and replacement cycles and as heat-pumps gain maturity in the Dutch market.

Low carbon gas assets also enable the electrification of critical infrastructure as they can provide insurance where loss of heat poses a significant risk.

Some of our commercial and industrial customer base, including over 400 hospitals, require an uninterrupted source of heat. This is equally true of heat networks, which are likely to grow from providing around 3% of heat demand today to as much as 20% in future.

For these customers, an ongoing connection to the gas grid provides a valuable insurance policy, providing a secondary source of heat should the electricity supply fail. It also can supply combined heat and power units which provide local back up sources of electricity in case of power cuts.

How Rotherham is considering heat networks.

Heat networks could provide heat and hot water to as much as 20% of the UK's homes and businesses by 2050. Whilst some of these properties will be new build, some will be retrofits of existing properties, replacing the source of heating there today. Key to market development will be the establishment of 'heat network zones' where customers within a designated area will be obligated to connect if they meet certain criteria.

In Rotherham, the firm 1Energy are planning to **deliver low carbon heat generated by water source heat pumps** to public, commercial and residential buildings across the town centre in the proposed heat network zone.

Construction is due to start at the beginning of 2025 with heat delivered by 2027. Until a net zero solution is put in place in 2030, **gas boilers will be installed alongside heat pumps to provide resilience and top-up heat** when demand is especially high or in the event of heat or power failure.

The gas network will therefore support the delivery of 1Energy's heat network, and others across the country, by providing a back-up source of energy to ensure customers on the network will always have heat whatever happens.

The NHS is the world's sixth largest employer, handling 1.6million patient interactions every day across thousands of different sites in the UK. Whilst electrification will play a role at some NHS sites, for other sites the cost, need for upgraded electrical connections and a lack of electricity network capacity mean **hydrogen also features in the NHS' decarbonisation plans.**

Specifically, we have identified opportunities for some hospitals to replace natural gas with hydrogen in **hydrogen-ready combined heat and power units (CHPs)**, helping them decarbonise without the financial and practical implications of electrification.

More crucially, conversion to low carbon gas helps **avoid the disruption** that can accompany the enabling works for heat electrification, works that can be disruptive in an hospital environment, therefore maintaining levels of care for patients.

The gas distribution network can provide gas to industrial customers, allowing them to begin their decarbonisation journeys earlier, even as low carbon alternatives remain nascent.

We supply a wide variety of industrial customers. Some of these industries, such as steel and plastic manufacturers, rely on processes that are hard to abate due to their high heat requirements or energy intensive nature. In response to such constraints, some customers are considering hydrogen as an option to decarbonise their operations. However, these industrial customers are unlikely to start transitioning to hydrogen, given uncertainties around early-stage consistency of supply, unless they can rely upon methane as a back-up to plug these gaps.

The gas network therefore acts as an accelerator to industrial decarbonisation, allowing these customers to start the process now instead of waiting until they can be guaranteed a fully resilient and reliable hydrogen supply.

Role Two

Reducing emissions while our customers still need gas.

Methane is a fossil fuel and greenhouse gas. Transporting it through a network of pipes, combusting it in end use processes and any leakage which occurs along the way create emissions which we endeavour to understand and reduce as part of our work in supporting decarbonisation. Ultimately this could be achieved by replacing the methane in our network with low carbon alternatives such as hydrogen, or displacing gas demand with alternatives such as electrification. Until each use of gas is decarbonised however, we have a responsibility to reduce the emissions of the gas we use. We plan to achieve this in two main ways:

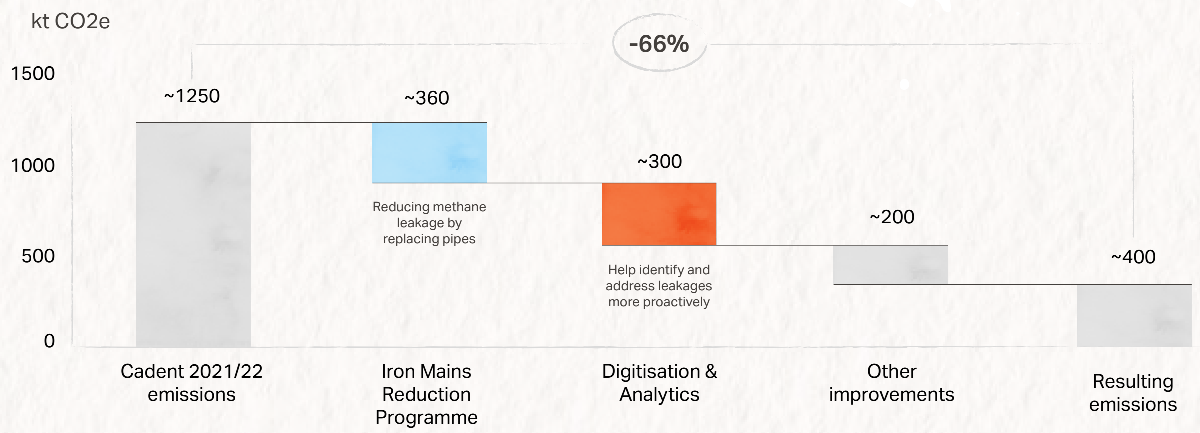
1. **Reduce the carbon emissions associated with the operation of our network.**
2. **Reduce the emissions of the gas our network supplies by blending methane with low carbon gases, like biomethane and hydrogen.**

Methane is a potent greenhouse gas and has a global warming potential 56x more than carbon dioxide over a 2-year period.[27] The main source of emissions from our network is via the leakage of methane as it is transported around, largely because of wear and tear on the network. Through the planned Iron Mains Risk Reduction Programme, a legal obligation set from the Health & Safety Executive to replace iron mains with newer plastic mains, we are not only improving the safety and efficiency of the network but also significantly reducing leaks.

We also intend to reduce leakage through the deployment of new and innovative technologies such as pressure management tools and digitalisation. For example, we plan to implement new digital and analytical tools, alongside other operational improvements, to more accurately and quickly pinpoint leakages. This would allow us to respond quickly and specifically to the problem, as opposed to today's more investigation and maintenance led approach.

By 2032, we estimate that these activities will have collectively reduced emissions from the network by around 66%, or around 850ktCO2e a year – roughly the equivalent of the emissions from around 100,000 homes.

A more efficient network: We plan to reduce emissions on the existing network by ~66% by 2032.



How we are reducing leakage in North London through Picarro analysers.

Digitisation is presenting energy utilities with new tools to improve the resilience, effectiveness and efficiency of the network. Historically, leaks have been detected by through visual inspections by engineers of our pipeline, or through public reported gas leaks. We are now working with organisations like Picarro and Bohr who offer digital technology solutions which are already widely adopted by European and US organisations such as Italgas and ConEdison to proactively address leaks within their network.

Picarro is a digitalised way of monitoring the gas network for leaks, 1,000x more sensitive than traditional approaches. This provides remote, continuous real-time measurements that do not require vehicles to follow the underground pipeline, enabling coverage across ~100x larger range.

Deploying these in North London has allowed us to reduce overall emissions by proactively identifying and addressing gas leaks while they are still small. An initial pilot identified 8 mains outside of the scope of the Iron Mains Replacement Programme for replacement, highlighting how investment in these new tools is not just improving the safety and efficiency of the network, but also reducing the emissions of it as well.

We are reducing the carbon intensity of the gas we supply by maximising biomethane and hydrogen potential to blend these low carbon gases with methane.

We're helping to decarbonise our customers' supply by blending methane with low carbon biomethane today, and hydrogen in the future. Both these gases have substantially lower carbon intensity than methane.

Biomethane is renewable methane, with a carbon intensity approximately 16% that of methane.[28] As a result, it is considered strategically important by government and therefore supported through the Green Gas Support Scheme.

Biomethane is made by refining the biogas produced in the decomposition of organic materials such as agricultural or landfill waste. We have 45 biomethane sites connected to our network today, providing 3TWh of low carbon gas, enough to heat 250,000 homes.

We're working to ensure the total UK potential for biomethane can at least meet the potential set out by the Renewable Energy Association[29] and others – around 30TWh by 2032, or double that if the emerging potential from bio-synthetic natural gas can be realised.[30] This would be equivalent to around 14% of the gas UK homes, businesses and industry use today.

We are also working to support the wider biomethane market across the UK, by:

- Investing in increasing network capacity.
- Operating the system to promote biomethane injection.
- Utilising smart pressure management controls.
- Installing new pipework to reinforce the network.
- Deploying reverse compression so we can move gas back up a pressure tier.
- Aligning connection charging rules for gas entry with electricity to ensure consistency in supporting low carbon technologies.

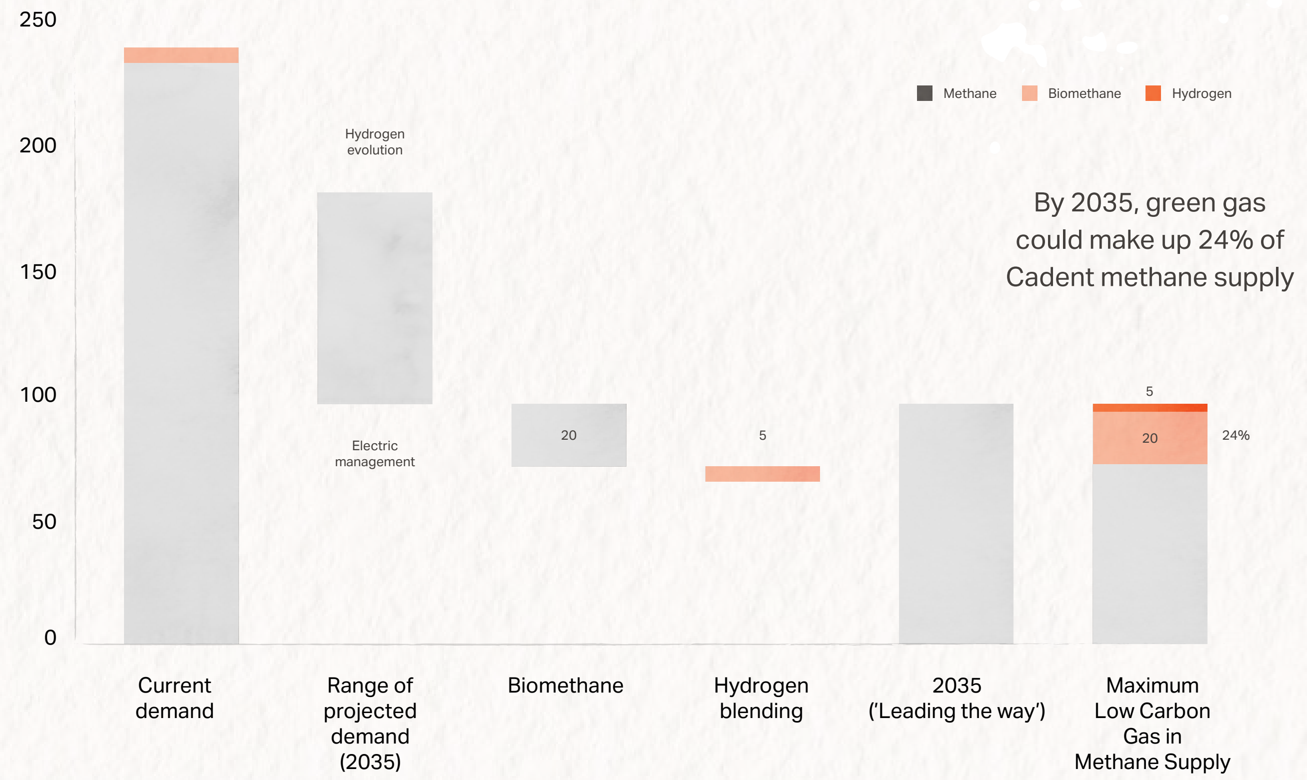
The blending of **hydrogen** in the existing methane network to 20% by volume has been demonstrated to be both possible and safe.[31] Doing so has the potential to reduce the overall emissions from ongoing use of the gas network by around 6% - equivalent to taking 550,000 cars off the road.

The government made a strategic decision in 2023 to financially support some hydrogen blending, in recognition of the benefits that has in promoting the development of the hydrogen economy, including:

- **Stimulating demand** - hydrogen blending helps break the 'chicken and egg' problem that exists between hydrogen supply and demand by helping producers manage the volume risk that contracting with offtakers can represent.
- **Promoting investment** - blending makes projects more investible as it helps de-risk off-taker demand for producers.
- **Building social acceptance** - hydrogen blending acts as a strategic test case of social acceptance and market frameworks.

The balance of low-carbon gas supplied will change as methane demand reduces and green gas supply increases. Methane demand across our network is forecast to reduce by 40-60% by 2035 according to National Grid's Future Energy Scenarios (FES).[32] At the same time the supply of biomethane on our network could possibly grow up to 20TWh with a further 5TWh of hydrogen also being blended.[33] Under the FES Leading the Way scenario this would mean 24% of the fuel supplied by Cadent was low-carbon gas – biomethane or hydrogen – reducing our emissions by 20%.[34]

In the mix: Biomethane and hydrogen blending projections in our network



Role Three

Converting and developing the network to distribute hydrogen to where it is needed, when customers are ready.

Electrification will play an important role in full decarbonisation, however hydrogen will also be critical - as set out in the government's 2021 Hydrogen Strategy.[35]

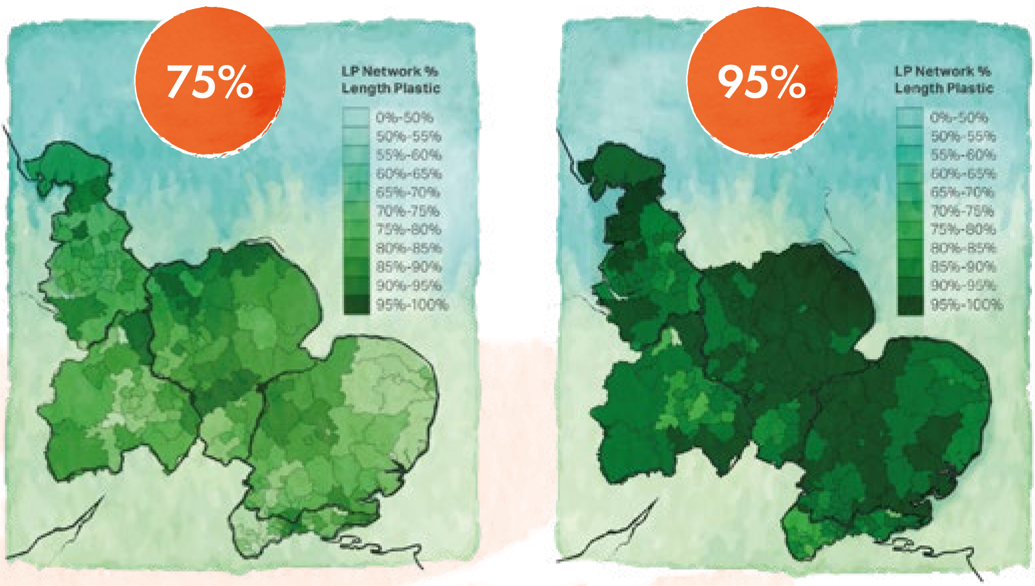
Hydrogen will complement electrification, being used where electrification is either unfeasible or uneconomic in applications such as high-temperature industrial processes, as fuel for dispatchable power generation and potentially space heating.

Hydrogen has several advantages as an energy vector:

- It has many production methods and can be produced from low-carbon electricity, methane or biomass with carbon capture and storage.
- Through storage of excess renewable energy generation, hydrogen bridges the gap between supply and demand fluctuations, maximising renewable generation utilisation and minimising curtailment.
- Hydrogen offers a versatile and long-duration energy storage solution, enabling efficient management of energy demand over extended periods.
- Hydrogen can provide the sort of high-temperature process heat required by some industries, that can be too costly using electrification.
- Hydrogen power generation offers firm and dispatchable capacity, boosting the overall resilience and responsiveness of the energy system.
- The cross-vector flexibility enabled by hydrogen paves the way for cost-effective investment and operational planning within the future energy system.

Our network will be 95% ready to transport hydrogen by 2032.

We are in the process of replacing the iron mains in our network with plastic pipes that could transport hydrogen. This work is being done to maintain safety and resilience, regardless of whether hydrogen distribution is needed. But it does mean that our network could be converted to one that safely transports hydrogen to our existing customers.[36] In addition, we are continuing to explore the plans and practices required to effectively plan a network conversion to hydrogen.



Hydrogen ready: The proportion of our network that will be ready to transport hydrogen.

In addition to conversion of the existing network, we will play a leading role in the construction of new infrastructure to enable the hydrogen market to develop.

An integrated distribution network will unlock the whole system benefits of hydrogen. Distributed green hydrogen production will help maximise the output from wind and solar generation. Any excess energy that is produced can be stored for when needed rather than curtailed, providing long duration flexibility. Peak power generation from hydrogen completes the power-to-gas-to-power cycle – demonstrating the value of a connected hydrogen distribution system. The UK has already established a strategy that is enabling the first hydrogen networks to emerge, joining the places where hydrogen is produced with sites where it is demanded and the storage assets supporting it all.

HyNet North West

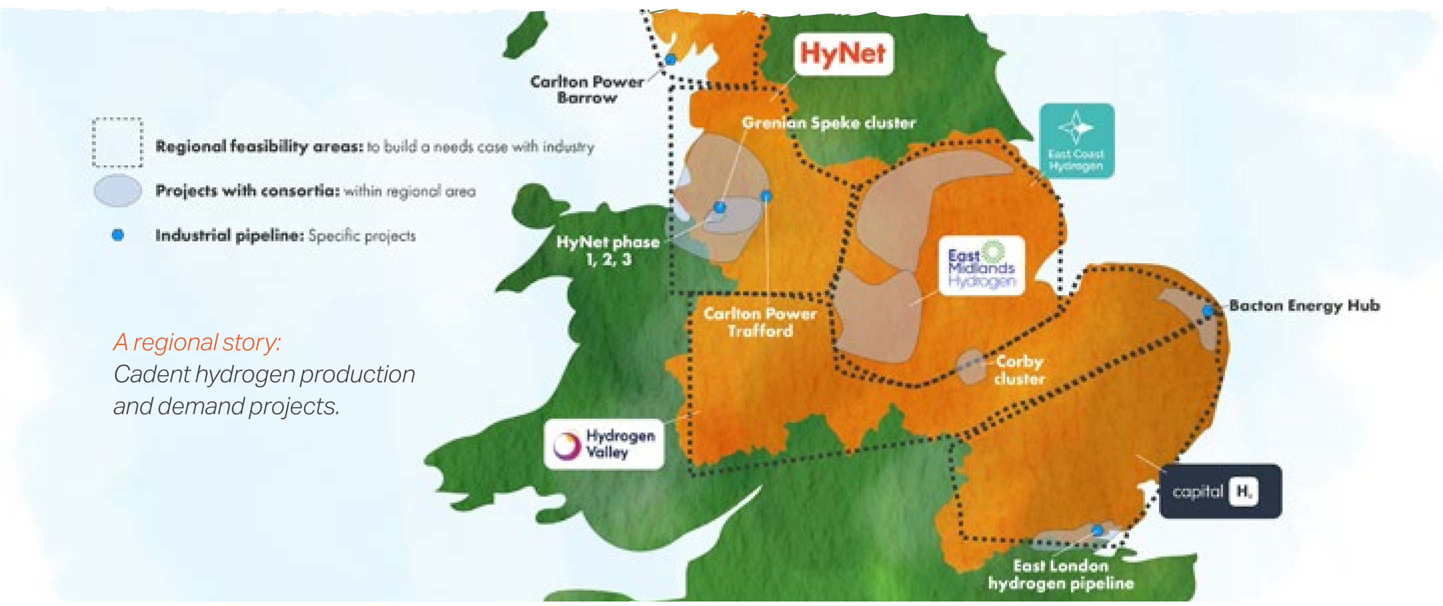
HyNet is where hydrogen infrastructure is happening first.

HyNet is the UK's leading industrial decarbonisation project, unlocking a low carbon future across the North West of the UK, creating new roles, safeguarding existing jobs, growing a skills base and attracting investment into the region.

We are partnering with others right across the value chain to join producers and storage provides to those who need hydrogen to decarbonise. These include names such as Encirc, Pilkington and ESB-Carrington who have identified hydrogen as important to their decarbonisation plans. In doing so we are unlocking wider development across the region – and potentially enabling decarbonisation of wider use cases there in the near future.

HyNet could reduce carbon emissions by 10MtCO2e per year by the early 2030s – the equivalent of taking four million cars off the road. It will also create 6,000 local jobs and generate £17bn in value for the local economy.

Whilst the goal is to repurpose the current gas network this cannot happen unless either domestic heat is also converted, or customers are forced to disconnect. There is therefore an option to plan early hydrogen pipelines now that can provide industry with the hydrogen they need. We have created a series of regional projects (HyNet, East Coast Hydrogen, Capital Hydrogen, Hydrogen Valley, Cumbria) to develop these plans, focused on hydrogen production and industrial and power demand. As production scales we can connect hydrogen with the customers who are decarbonising their businesses. Once a reliable hydrogen supply to these first customers is established, then the wider gas network could be re-purposed depending on need.



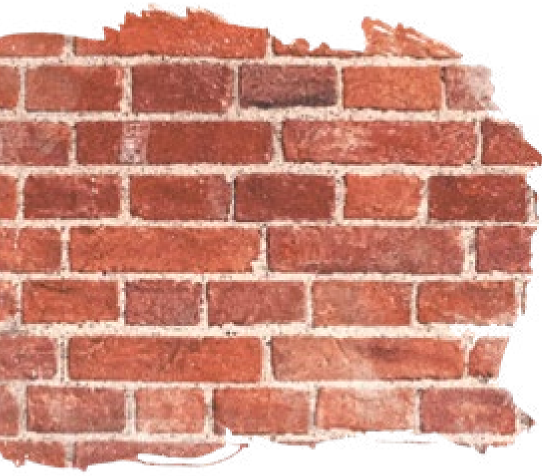
A regional story:
Cadent hydrogen production and demand projects.

How Encirc will decarbonise glass production.

Glass furnaces require very high temperatures of around 1,600°C, approximately the same temperature a space shuttle reaches as it re-enters earth's atmosphere. Today that heat is provided by combusting methane, a fossil fuel - something that will need to change as we transition to clean energy.

Encirc manufacture 40% of the glass bottles and jars found in the UK. Full electrification isn't possible on the size of furnaces that Encirc needs, meaning glass will continue to be made using gas into the future.

Encirc are planning to do this by testing a blend of hydrogen and methane on its furnaces during this decade, before linking to our HyNet project via a hydrogen pipeline from 2027/28 to help decarbonise existing and future furnaces. This will help keep them making the glass we need, right here in the UK.



How Forterra can decarbonise brick production.

Forterra make the bricks, blocks and other materials that keep Britain building across 17 different sites, with operations in the UK dating back to the 19th century. Their bricks are made by combusting methane in kilns until the temperature reaches over 1,000°C. This is a carbon intensive process today, consuming around 170 GW of methane a year.

No electric kilns large or powerful enough to provide a feasible alternative to methane currently exist on the market. As Forterra decarbonise their operations they are therefore planning to convert over time to running on low carbon gas. Gas has the added advantage of being able to utilise the existing network, enabling decarbonisation of Forterra's often rural locations that lack existing industrial scale electricity grid connections.

Dispatchable gas power operators are already thinking about hydrogen to decarbonise.

As we decarbonise the electricity sector, power stations that use low carbon gas and gas with carbon capture will be important in balancing the intermittency of wind and solar power assets.

Carrington is one such power station. It has capacity of 910 MW and can power over 1 million homes and businesses. The turbines require gaseous fuel so ESB, who own and operate it, is planning to convert it to run on low carbon hydrogen.

This will retain the flexibility of the power station, allowing Carrington to keep the UK's lights on when the wind is not blowing, helping the UK decarbonise the power sector by 2035.

We continue to innovate to enable hydrogen to be an option for home heating.

To upgrade the insulation and heating system in almost every home in the UK, as well as providing the infrastructure necessary to deliver the energy, is a significant task, the scale of which has never been delivered before. This will require huge levels of investment. The CCC estimate a total of £250bn will be needed by 2050.[37] As we set out in our Green Print: Future Heat for Everyone publication[38] consumers will need to be at the forefront of our minds if we are to have a chance of success.

We will need a range of solutions to achieve this. Heat pumps and heat networks will play a material role, but the government are also investigating how low carbon hydrogen could help, with a decision due to be made on this by 2026.

Hydrogen for heat has several potential advantages for some customers, in particular reduced disruption during the conversion process, better affordability and deliverability, as well as increased energy resilience for the wider system.

- **Reduced disruption:** Unlike heat pumps which may require significant changes for some homes, hydrogen boilers and appliances work just like natural gas ones, giving consumers a familiar and less disruptive experience.
- **Affordability:** The costs of decarbonising heat in a particular home depends on the characteristics of that home and how heat is used. For some customers, the lower capital costs of a hydrogen boiler are likely to be a cheaper option than a heat pump, even if the ongoing running costs of that system will be higher. And at a UK-wide level, Imperial College has shown that an energy system that has some hydrogen for heat will reduce the overall cost to customers of the energy system by around £5.4bn per year by reducing the amount of electricity infrastructure necessary to ensure resilient heat supplies even when renewable output drops.[39]
- **Deliverability:** Existing plastic pipes can deliver hydrogen to homes and businesses. Plastic pipes currently make up approximately 75% of our network, 60,000km of which has been installed since 2014, and this percentage is increasing as the mains replacement programme continues.
- **Energy resilience:** Hydrogen can be stored for use in the peak of winter, adding to energy resilience and energy security. By providing hydrogen to some homes, the capacity needed in the electricity network and the requirement for back up generation is lower. A whole systems approach is therefore required.

We believe that due to the inherent challenges with full electrification it is important to maintain the optionality of hydrogen for heating. We are working with government, other gas networks and appliance manufacturers to test the technical and safety aspects of a possible hydrogen conversion, providing input to government's decision on its role in 2026. And by continuing to invest in the safe operation of the asset today, we are also ensuring we will have the option of hydrogen for heat in the future should we need it.

Key takeaways

The UK's gas networks fulfil a crucial role in today's energy system, supplying two thirds of the energy demanded by over 20 million homes and businesses, keeping them safe, warm and operating. We have three crucial roles to play in the energy transition. These roles will change over time as we deliver the transition to clean energy, with customers shifting their consumption to low carbon alternatives such as clean electricity and possibly low carbon gases like hydrogen. In doing so, ten things are clear.

1

The size of the challenge ahead is significant.

The quantum of energy the gas network transports is large, delivering more than twice as much energy than the entire electricity network does today. Replacing all that energy with low carbon alternatives like hydrogen, biomethane and electricity will require change inside more than 20m homes, business and industrial sites, with all existing methane assets replaced alongside the installation of energy efficiency measures. This will require significant initial investment and will not happen without disruption.

2

The network today is highly interconnected.

Decarbonising industry cannot operate in isolation from homes. Only around 5% of industry is within existing industrial cluster areas and much of industry outside of the clusters will need hydrogen to decarbonise too. A single pipe on the gas network will simultaneously supply multiple customers with the energy they need, often including homes, local businesses, public buildings and even nearby industrial sites. This contributes to its overall reliability and enables the costs of operating it to be spread thinly.

3

The pathway we will follow is uncertain.

There is a good deal of uncertainty as to ultimately what path we will follow in delivering net zero, and a wide range of pathways are assumed across the different institutional parties. Whilst methane use falls in all net zero scenarios, what replaces it and at what rate differs widely between each. Ultimately, the pathway we follow will depend on a multitude of factors, the critical one being the role of consumers and consumer choice.

4

Regardless of the pathway we follow, we will still need a gas network in the 2040s – and beyond.

Even under pathways where most demand is electrified, 6.3m domestic customers will still be connected to our network and using methane by 2040. Other scenarios where there is more of a mix of low carbon technologies have more need for a gas network. This suggests an ongoing requirement for gas infrastructure under any scenario.

5

A reduction in customer numbers doesn't mean a similar reduction in network size.

While network usage will decline as some people electrify their heat and hot water, there is not a linear relationship between a decline in usage and the size of the network. Indeed, under the current legislative framework gas networks have a duty to provide gas to whomsoever wants it. So, if even a small number of customers need gas, the gas network that supplies them must remain - unless the government decides to remove people from the network in some way, for example through the banning of methane boilers from a certain date.

6

The gas network will be needed to enable energy solutions that provide flexibility and resilience (Role 1).

Even if a small number of customers decide to remain on the network, the gas network that supplies them must remain – unless the government decides to remove people from the network in some way, for example through the banning of methane boilers from a certain date. The presence of a gas network would allow the adoption of hybrid heating systems, which countries like the Netherlands are installing. These provide additional heat in peak demand conditions and reduce overall investment required in the electricity system. Deploying up to 1.9m[40] hybrid heat pumps envisioned by the FES by 2050 could save 3.1 MtCO2e annually in our region, the same as taking 3.5m cars off the road. The gas network also provides security and resilience to industrial sites, and critical infrastructure such as hospitals and heat networks.

7

We will need to drive reductions in our emissions whilst customers still need gas (Role 2).

The main source of emissions from our network is via the leakage of methane as it is transported around. Through the planned Iron Mains Risk Reduction Programme, we are replacing iron mains with newer plastic pipes, improving the safety and efficiency of the network and significantly reducing leaks. We are using Picarro technology to digitally detect leaks, we estimate by 2032 we will have reduced emissions by around 850ktCO2e a year - roughly the equivalent of the emissions from 100,000 homes.[41] We also need to maximise the potential for biomethane by facilitating connection to our network. Combined with the blending of hydrogen by 2035 green gas could make up 24% of the gas we distribute.

8

We need to convert and develop the network to distribute hydrogen to where it is needed (Role 3).

Hydrogen will play a critical role in the delivery of net zero, providing low carbon energy where electrification is either unfeasible or uneconomic, as fuel for power generation, providing a long-term store of energy and potentially even providing homes with heat and hot water. By 2032 95% of our network will be ready to transport hydrogen due in large part to the iron mains replacement programme. According to an Imperial College study, the total societal cost for an energy system with hydrogen and gas will cost 6% less (£5.4bn per year) than a fully electrified one.[43]

9

We need to drive innovation to achieve much of this

As we modernise the network with new pipes there is also an opportunity to use new digital tools and other innovations to improve our ability to detect leaks and more intelligently schedule maintenance ahead of need – reducing both emissions from the network and costs for consumers.

10

Securing this ongoing role for the gas network will require further development

Delivering each of the roles the gas network needs to play in the future will require ongoing investment in the operation and maintenance of the network to ensure safety and reliability. Failing to do so not only risks slowing down the deployment of other low carbon technologies but will also undermine our ability to directly decarbonise sectors such as industry and lose the future optionality of hydrogen in sectors like home heating.

End notes

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39. The Role and Value of Hydrogen in Future Zero-Carbon Great Britain's Energy System, Imperial College London (2023)
40. Overall heating technology mix, 2050, National Grid ESO Future Energy Scenarios (2024)
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Cadent

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September 2024