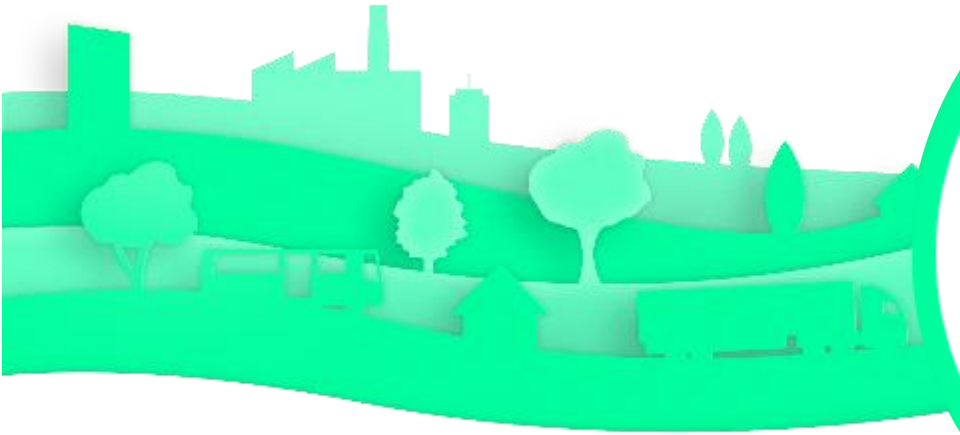

GAS GOES GREEN

Answering your questions about Gas Goes Green

November 2020

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What is Gas Goes Green & a zero-carbon gas grid?

What is Gas Goes Green?

Tackling climate change means we need to remove the carbon emissions from the gas that many of us rely upon for our heating, cooking and hot water.

The Gas Goes Green programme will help Britain meet that challenge by undertaking the work that's needed to switch over the country's network of gas pipelines from delivering carbon-emitting natural gas to zero-carbon hydrogen and biomethane.

When completed, it will deliver the world's first zero-carbon gas grid, here in the UK.

Who is involved in the programme?

Gas Goes Green brings together the engineering expertise of Britain's five gas network companies (Cadent, National Grid, Northern Gas Networks, SGN & Wales & West Utilities) with the wider energy industry, policymakers and academics.

We are supported by participation from policy makers, regulators, the energy industry and consumers groups. For more information on our Advisory Group and opportunities for stakeholder to get involved please contact us via gasgoesgreen@energynetworks.org.

What is a zero-carbon gas grid?

It is a gas network of pipelines and other supporting infrastructure that has been switched over from delivering carbon-emitting natural gas to our homes and businesses to delivering carbon-neutral green gases instead.

Gas Goes Green has developed a Pathway to 2050, authored by Navigant Research and independently reviewed by Imperial College, which acts as the 'greenprint' for delivering a zero-carbon gas grid in the UK.

That Pathway provides the information that is needed for decisions to be made that will turn that ambition in to reality; by the companies wanting to invest money in the grid infrastructure, by the experts and engineers making technical and operational decisions related to the running of that infrastructure and by the Government and the energy regulator who will decide how all of those things should happen.

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What would this mean for people's gas hobs and boilers?

People's existing cookers and boilers can operate as they do now with up to 20% of the gas in the network being hydrogen. More biomethane in the gas grid will also have no impact on the way people use their heating, hot water and cooking. Allowing gas networks to do this would take the equivalent of 2.5 million cars off the road, in terms of carbon emissions.

For more than 20% hydrogen in the gas grid, "hydrogen-ready" appliances are being now developed by manufacturers that can be converted to run at 100% hydrogen, being fitted ready as part of regular boiler replacement cycles. We think the law should say that from 2025 all new gas boilers should be 'hydrogen-ready'.

The biggest advantage of using these appliances instead of, for example, electricity powered heat pumps, is that they don't require people's whole heating system to be changed, and they don't require people to change the way they use their heating or cookers either.

For boilers, the switch to 100% hydrogen means an engineer to make some basic modifications. This process is expected to take around 1 hour which is less time than typical boiler servicing.

Once converted to 100% hydrogen, the boiler would be permanently switched to the new fuel. Manufactures believe that hydrogen-ready boilers can be developed at limited to no additional cost to the customer.

What are the different types of 'green' gas?

The natural gas currently used in around 85% of homes and businesses around the UK is methane-based and produces carbon emissions when burned. We think that the best way to reach our net zero emissions target is to replace that natural gas with green gases, that are zero carbon.

The two main types of green gas that we propose replacing natural gas with are hydrogen and biomethane:

- Hydrogen is a gas that can be burnt in a way that produces no greenhouse gas emissions. It can be produced by using renewable electricity and water ('green hydrogen'), or by converting methane natural gas ('blue hydrogen').

- Biomethane is created from the anaerobic digestion of waste material from household waste, sewage, farm material, and byproducts. It is molecule for molecule the same as natural gas. It is carbon neutral as the carbon released during combustion has been recycled by the waste materials used

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What are 'blue' and 'green' hydrogen?

Hydrogen can be produced several different ways, but the two main ones are described as being either 'blue' and 'green':

- Blue hydrogen is produced by taking methane natural gas, which made of carbon and hydrogen molecules, and using steam to split off the carbon which is then captured and stored or used by industry (rather than being emitted into the air), leaving the hydrogen.

- We expect this type of hydrogen to have an important role to play in the next ten to twenty years in particular, as a way of providing enough hydrogen for our energy system whilst we reduce carbon emissions as rapidly as possible.

- Green hydrogen is produced from renewable electricity, which might be excess electricity produced by wind or solar farms when demand from customers is low or electricity specifically produced for the purpose of producing hydrogen.

This uses a process called electrolysis, where the electricity combined with water generates a chemical reaction that separates the water's hydrogen molecules from its oxygen molecules.

Green hydrogen is currently quite expensive, Once more wind or solar farms are built, the costs of producing green hydrogen fall then we expect this to become the main way of producing hydrogen, from the 2030s onwards.

What are the environmental benefits of using hydrogen and biomethane to replace natural gas?

When hydrogen is burned it doesn't produce carbon dioxide, just water and heat. This means that it offers a net zero energy solution, providing it can be produced without creating carbon emissions.

Biomethane is also a carbon-neutral solution as when burned it only releases recycled carbon that was captured by organic materials as they grew.

If the UK's gas network converted to hydrogen, this would decarbonise as much as 70% of the UK's total heat. As a first step, replacing just 20% of natural gas with hydrogen across the UK would prevent 6 million tonnes of carbon dioxide from being released to the atmosphere each year; that's the same as taking 2.5 million cars off our roads.

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Why don't we just switch from gas to electricity?

We need to use both zero carbon gas and electricity to reach our net zero emissions target. Gas Goes Green's Pathway to 2050 sets the roles both can play, working together in a 'whole systems' way.

The costs of running our energy system solely using electric technologies to decarbonise are estimated at £13 billion more a year by 2050 than repurposing our gas grid – that's almost £500 per household, according to research undertaken by consultants Navigant.

We need to take an integrated approach that uses both electrification and decarbonisation of the gas network, along with other new technologies for greener homes and transport, to ensure that we can continue to deliver heat and power to homes and businesses around the UK while reducing environmental impact. And we need to do that in a way that works with people and communities.

Fast facts: The challenge of reducing emissions from our homes

- To achieve Net zero by 2050:
  - The required annual rate of UK carbon emissions reduction is 50% higher than under the UK's previous 80% emissions reduction 2050 target
  - …And 30% higher than has been achieved on average since 1990
  - Britain's annual average household carbon emissions need to drop from 2.7 tonnes to 135kg.
- Heat contributes toward a third of the UK's annual CO_2 emissions
- 83% of domestic homes currently use natural gas for their heating and cooking.
- Households' carbon emissions from heating alone will need to drop from an average 2.7 tonnes a year to just 138kg by 2050.

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What is the role of Britain's gas networks?

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What is the current role of gas in the UK energy system?

We need to find a way to get replace the natural gas we currently rely upon, but we also need to recognise the important, strategic role it currently plays in meeting our energy needs. That is important if we are to find a way to do that in a way that is realistic, achievable and cost-effective.

With 85% of properties in Great Britain connected to it, our country's network of gas pipelines and support infrastructure allows us all to reliably access large amounts of our energy quickly and easily, often when we need it the most. It guarantees people's comfort in our homes whilst providing the lifeblood that our businesses need to grow.

Therefore, the challenge we face is to transition to different sources of gas that are able play a similar strategically important role in energy system, whilst being zero carbon.

Fast facts: The role of gas in our energy system

- 85% of homes and businesses are connected to 284,000km of gas pipelines in Great Britain.
- The peak heat demand for gas from London alone is equivalent to the output of eight Hinkley Point C nuclear power stations.
- At its peak, Britain's gas network transports up to five times more energy than the electricity networks.
- In 2018, natural gas accounted for 39% of the UK's primary energy demand.
- About 30% of gas demand is from domestic consumption, with the remainder being used for industrial, commercial and other uses.
- It is also used to generate about 40% of our electricity

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Why bother converting the gas network?

The need for action has never been greater – the climate emergency is now upon us. Ensuring that homes and businesses across the UK are connected to the world's first zero carbon gas network is the one of the quickest ways that we can take that action.

With 85% of Britain's properties connected to our gas networks, decarbonation of natural gas with new, greener gas forms is a critical ingredient of meeting the government's net zero targets and addressing climate change.

The replacement of natural gas with hydrogen in particular has been cited by the Committee on Climate Change is being necessary for the UK to hit its net zero target.

At the same time, simply casting aside a world-leading piece of critical national energy infrastructure and relying solely on electricity, would cost consumers as much as £13 billion more a year by 2050, according to Navigant Research – if that approach was even achievable in the first place.

If we can decarbonise the gas network and convert Britain's it to zero carbon hydrogen and biomethane, we can reduce the UK's carbon emissions by 260 million tonnes of CO2 per year by 2050 - the equivalent of taking 56.8 million cars off the road.

What's your plan?

Decarbonisation of the UK's gas network will mean repurposing the UK's gas network to carry hydrogen and biomethane rather than natural gas. This process will use technology and infrastructure already in place in the UK and around the world today.

Our Gas Goes Green Pathway to 2050 is based around six steps, independently commissioned and peer-reviewed by Imperial College.
These steps are to:

- **Undertake planning & research (2020-2024)** – not to just tackle the technical and operational challenges with switching the gas grid from running on natural gas to hydrogen and biomethane, but to identify the opportunities that it creates too.

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- **Create new sources of green gas (2026-32) –** first of all through projects that use carbon capture, utilisation & storage (CCUS) in local 'clusters' around the country that gradually expand outwards, to create hydrogen that can be used by industry and transport.

- **Expand the use of green gas (2030 onwards)** – by expanding from industry and transportation to commercial and residential consumers near the first hydrogen projects, initially via low blends (up to 20%) but developing into 100% hydrogen clusters.

- **Join up hydrogen clusters (2030s-40s)** - hydrogen clusters spread and connect to become extensive hydrogen zones, enabled by an evolving, carefully managed National Transmission System.

- **Deliver the world's first zero carbon gas grid (by 2050)** – this expansion continues until zero carbon gases fully integrated across the GB energy system, with distinct regional solutions tailored to local needs.

What would the cost be?

Reaching net zero by 2050 will require significant investment by the UK government and industry, with an annual cost of 1-2% of GDP according to the Committee on Climate Change.

The total cost of investment in switching our gas network over to hydrogen would be around £182bn – but aside from the environmental benefits of that, the benefit of that approach is that billpayers would start to see a return five years before we reach our Net zero target, in 2045. By the time we reach the target just five years later, we forecast that they will have already saved £89bn in total. And that's before we even account for the wider economic benefits that investment could deliver in terms of new jobs, innovation and technology.

Decarbonisation of the UK's gas network is one such area that will require investment; however, this investment will be offset in the future by the significantly lower running costs of continuing to use gas for energy versus converting to a single source such as electricity.

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The costs of running our energy system solely using electric technologies to decarbonise are estimated at £13 billion more a year by 2050 than repurposing our gas grid – that's almost £500 per household. This is why a balanced approach is required, where hydrogen and biomethane are used alongside more electricity, energy efficiency measures and carbon capture & storage.

What examples are there of gas decarbonisation already underway in the UK?

Since 2008, gas network companies have invested £265 million in 536 innovation projects. Over 100 green gas production plants are now connected across the country and it is estimated that green gas could be used to heat up to 15m homes by 2050. Notable projects include HyDeploy, the UK's first live pilot to inject zero carbon hydrogen into a gas network to heat homes and businesses. This project has proven that that a 20% hydrogen/natural gas blend can cut CO2 emissions without the need to change gas appliances. Backed by Ofgem's Network Innovation Competition, this £7 million project is led by

Fast facts: The costs & benefits of a hydrogen-based economy

Published in June 2020, Gas Goes Green research has found that:

- If investment into zero carbon hydrogen infrastructure began today then the country would be a net beneficiary of that investment before 2045, five years ahead of its 2050 net zero carbon emissions target

- The £182 billion of investment needed to create a zero carbon gas grid using hydrogen would save British bill payers £89 billion by 2050, compared to the continued use of natural gas.

- There is no realistic scenario whereby the UK can achieve net zero carbon emissions by 2050 without hydrogen playing a key role in the decarbonisation of large carbon emitting sectors such as industry, transport and heat.

Cadent in partnership with Northern Gas Networks, Keele University, the Health and Safety Executive, hydrogen energy systems manufacturer ITM-Power, and independent clean energy company Progressive Energy.

Another significant project is H21, led by Northern Gas Networks, which proved that conversion of the existing gas grid to carry 100% hydrogen is technically possible and can be delivered at a realistic cost. The 2016 H21 Leeds City Gate report used Leeds, the UK's fourth largest city, to confirm that the UK gas networks are the correct capacity to be converted to 100% hydrogen, the pipes being installed across GB are suitable to transport hydrogen, low carbon hydrogen can be credibly sourced at scale, conversion of UK cities can be achieved incrementally, appliances can be converted to operate on 100% hydrogen, and hydrogen can be stored to manage intraday and interseasonal swings in demand.

Finally, the H100 project has looked at the risk assessments in a number of areas, including polyethylene (i.e. plastic) materials and jointing techniques, odorant to ensure people can small hydrogen, gas detection, characteristics of hydrogen and consequence testing.

These are just some of the projects that are helping to build the evidence base required to satisfy consumers and stakeholders that hydrogen can be safely transported within the gas network.

What are the wider benefits?

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What role would a zero-carbon gas grid play when it comes to reducing emissions from transport?

For transport, biomethane is proving an increasingly popular option for heavy duty vehicles today and hydrogen fuel cell vehicles could also play an important role for decarbonisation of buses, trains and lorries, and potentially for longer-range journeys in lighter vehicles.

Green gases may also have a role in decarbonising shipping as well, with hydrogen becoming an option if international markets develop for low-carbon hydrogen or ammonia.

All of these exciting developments mean that a zero-carbon gas grid will take on new responsibilities to support reducing carbon emissions from transport, such as connecting hydrogen refuelling stations for cars and trucks.

How would it benefit the economy and jobs?

With the gas network connected to 85% of properties in all corners of the country, decarbonisation would create significant economic benefit to the UK, rebalancing the economy across the regions, creating significant new export opportunities and creating jobs. The gas networks are members of the Energy & Utilities Skills Partnership to consider the training and competencies to operate the network of the future.

Estimates are that a world-leading UK hydrogen economy could add up to £18bn a year to the UK economy by 2050 and could create 221,000 jobs by 2050, according consultancy Element Energy.

How does hydrogen a benefit the production of renewable electricity?

The Gas Goes Green Pathway to 2050 is based on a 'whole systems approach', which means it is designed with all the different parts of the UK's energy system and how they can better work together in mind, not just the gas networks.

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This includes generators of renewable electricity. The UK is now a superpower of renewable energy, with a world-leading offshore wind sector that has ambitious growth targets, backed by Government policy. The number of onshore wind and solar farms has grown significantly in recent years, with that growth expected to continue as the cost that technology continues to fall.

At the same time, the UK has a very open gas market, buying and selling from countries all over the world. This creates major export opportunities for green hydrogen.

To reach its net zero target, the UK will need major quantities of green hydrogen, produced using renewable electricity via electrolysis. This is particularly useful at times when there is more renewable electricity being generated than is required. Hydrogen can also be produced from other sources too, such as via interconnections with Europe or battery storage.

Ensuring that the people, homes & businesses have a choice in decarbonisation: The role of a zero-carbon gas grid.

Only by using both our gas and electricity infrastructure can we give households, businesses and communities the greatest possible choice of low carbon technologies, to allow them to pick the ones that best suit their needs.

For example, for some people an electric vehicle might be the best option for personal transportation whilst for others a hydrogen fuel cell vehicle might be better suited. Some householders might prefer to use electric air source heat pumps combined with solar panels and batteries, whilst others might prefer to use hydrogen-fuelled boilers and cookers.

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