

CONNECTING REALITY WITH CLIMATE GOALS: CASE STUDIES OF GAS DISTRIBUTION SYSTEM PLANNING AND REGULATION

Country Report United Kingdom

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Background and objectives

- Fossil gas consumption in the EU must decline rapidly to meet energy and climate targets, as well as in the context of energy security concerns, and gas price volatility.
- Declining gas demand will lead to higher grid fees for remaining customers as fewer people use the gas infrastructure, with potential high increases of grid fees.
- Proposals to replace fossil gas with hydrogen face technical and economic challenges, with hydrogen being less efficient and more expensive for heating compared to electrification and district heating.
- Continued investment in gas infrastructure without a decommissioning plan risks stranded assets, as the long lifespans of gas grids do not align with decreasing gas usage and climate targets.
- Regulations are beginning to address these issues, with some countries taking steps towards orderly gas grid decommissioning to manage costs and transition to alternative energy sources efficiently.
- In view of these challenges ahead, the objectives of this country sheet are to
 - provide an overview the status quo of gas consumption and gas distribution networks
 - Outline how regulations related to the gas grid embrace this challenge and identify gaps
 - Highlight opportunities for stakeholders to interact in the process

Summary of the country report for the UK

- Fossil gas is used as fuel for 38% of total energy demand in the UK. Two-thirds of domestic demand is served by fossil gas. There are eight gas distribution networks in the UK, operated by four distribution system operators.
- There are some positive policy and regulatory features:
 - The energy regulator Ofgem regulates the gas distribution networks (GDNs) using a performance based regulatory framework, known as RIIO ((Revenue = Incentives + Innovation + Outputs). This framework provides the basis for periodic prices control that set that level of revenue that can be earned by the GDNs, and the levels of performance that the GDNs are required to deliver. Those revenues can be adjusted year-on-year depending on performance relative to pre-set targets.
 - Ofgem announced in July 2024 that they would switch to accelerated depreciation for all new gas grid investments so that new investments are fully depreciated by 2050 at the latest. The regulator also considers extending this to existing gas grid assets.
 - The Energy Act 2023 provides the powers for government to implement heat network zoning in England through regulations. Government is currently consulting on the further detail of heat network zoning.
 - From 2025 new buildings will no longer be able to be fitted with fossil fuel heating. Hydrogen-ready boilers are not allowed under the current plans.
- At the same time, important challenges are ahead:
 - The United Kingdom has been considering hydrogen for heating but cancelled three trials in two villages and one town. Government will make a decision regarding its role in 2026 after collecting additional information.
 - The depreciation rates in the UK are very long (45 years).
 - Network operators' scenarios in the UK are only partially consistent with the country's climate targets.

Content and structure of the country report

- 1. Development of Fossil Gas Consumption + Heating Market/Systems:** This chapter provides an overview of historical trends and current statistics regarding fossil gas usage and the evolution of heating systems.
- 2. Distribution Network - Development and Current State:** This section discusses the infrastructure that supports the distribution of gas, including an assessment of its development over time and its condition today.
- 3. Network Regulation and Costs:** Here, we analyze the regulatory framework governing the distribution network and detail the associated costs of maintaining and expanding this infrastructure.
- 4. Current and Anticipated Role of Alternative Gases:** This chapter evaluates the expected role of alternative gases like biogas and hydrogen in transitioning away from fossil fuels, including current applications and future projections.
- 5. Alignment with Climate Scenarios:** We explore how gas grid planning is aligned with national climate goals, examining scenarios that aim to reduce greenhouse gas emissions.
- 6. Transparency of Information and Stakeholder Input:** The final section discusses transparency and highlights opportunities for stakeholder engagement.

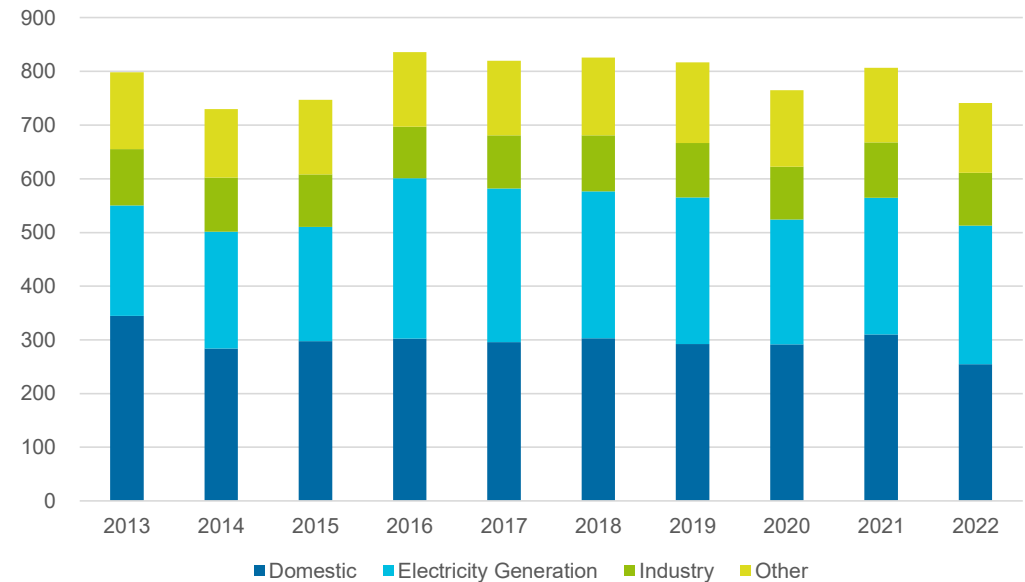
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- 1** Development of fossil gas consumption + heating market/systems
- 2** Distribution Network - Development and Current State
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- 5** Alignment with Climate Scenarios
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Development of fossil gas consumption

- Fossil gas is used as fuel for 38% of total energy demand in the UK.¹
- Two-thirds of domestic demand is served by fossil gas in 2022.¹
- The total consumption of fossil gas in the UK remained relatively consistent over the past 10 years although total demand dropped 7.9% in 2022 compared to 2021 due to it being the warmest year on record, high prices, and record renewable output.¹
- Domestic demand fell 18% from 2021 to 2022.¹
- Fossil gas plays a central role for electricity generation, and heat supply in private households, each of those categories comprising about a third of demand, with industry and other uses making up the remaining third.¹
- The UK gas system serves 22 million customers.²

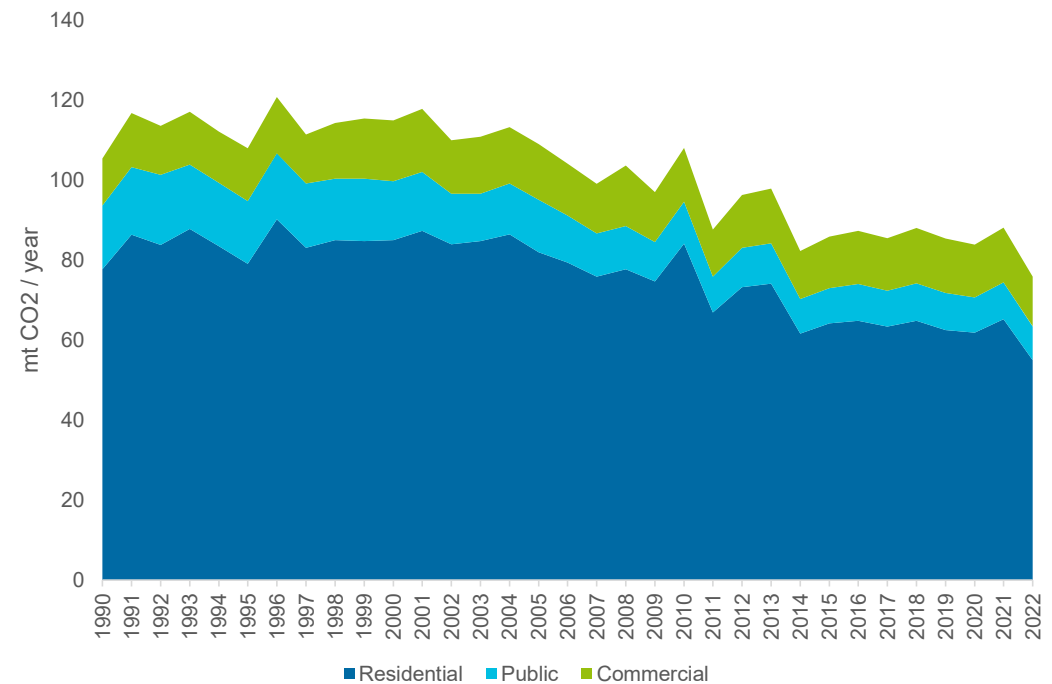
UK Fossil Gas Consumption (TWh/year) 2013-2022^{1,2}



Development of heating systems

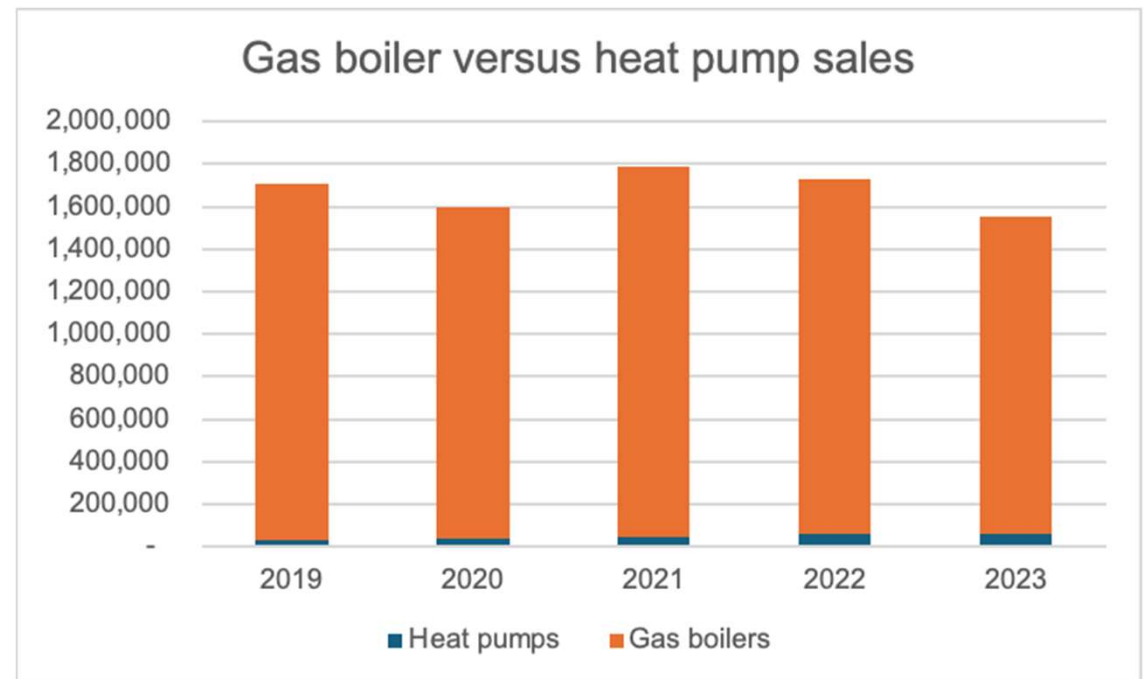
- Residential heating accounts for 13% of the United Kingdom's greenhouse gas emissions.¹
- Heating systems in the United Kingdom are predominantly gas boilers, about 85%.¹ With an average lifetime of 20 years, this technology will continue to play a significant role.
- Similarly, more than 85% of all new heating systems in the United Kingdom are fossil gas boilers.¹
- Heat pumps made up 4% of all new heating systems in 2023.²

Direct Emissions from Heat in Buildings (1990-2022)¹



Development of heating systems

- Gas boilers make up the vast majority of heating systems in the UK.¹
- Currently heat pumps make up only 1 percent of heating system in the UK, but Heat pumps sales have increased in recent years and are expected to increase further.²
- In the existing stock, gas boilers had a 86% share of heating systems in 2020. With an average lifetime of 20 years, this technology will continue to play a significant role.¹
- The UK is not addressing the gas distribution questions immediately, instead deferring a great deal of the issue until 2026 when the government will make a decision about whether hydrogen will be used for heating purposes
- The UK regulator, Ofgem, has stated” ”We do not anticipate that there will be large-scale, systematic changes to the gas networks during the RII0-3 price control period [2026-2031].”³

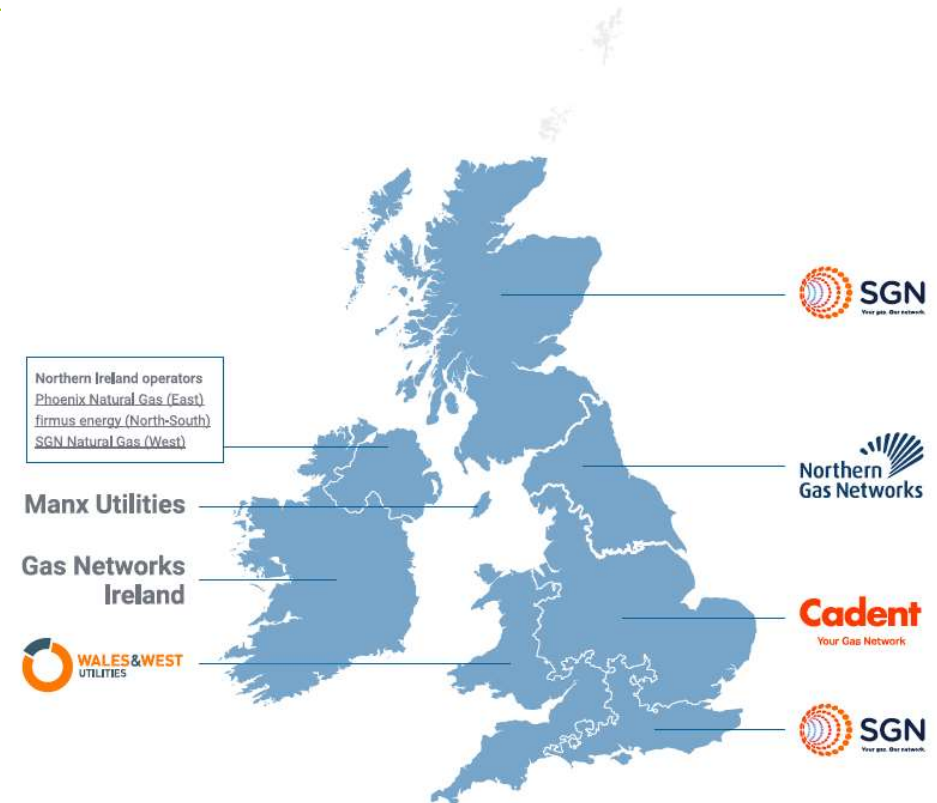


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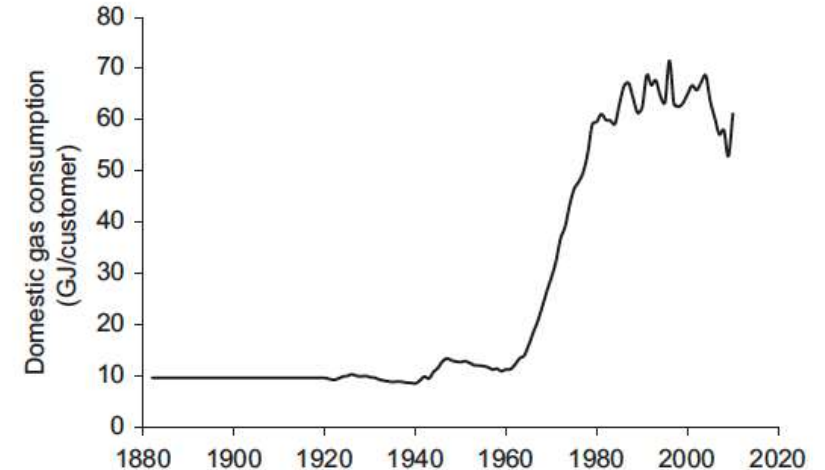
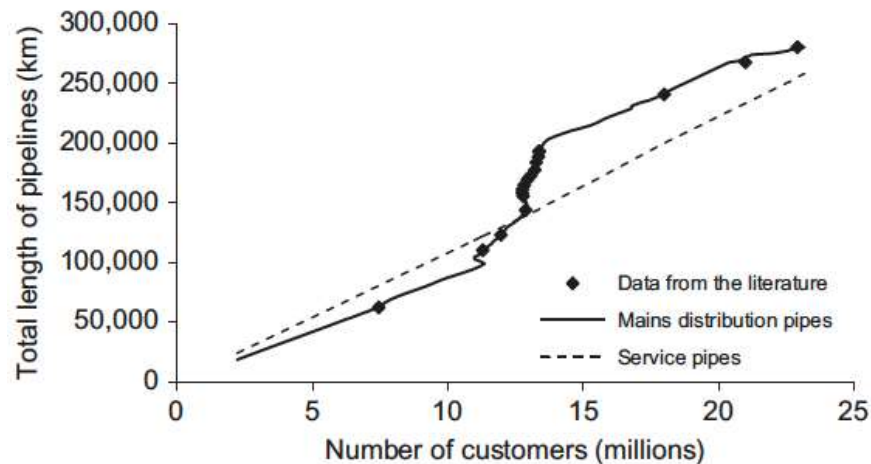
Gas network operators

- There is one transmission system operator (TSO), National Gas, which owns and operates the gas transmission network in Great Britain and another four TSOs in Northern Ireland.
- There are eight gas distribution networks in the UK, operated by four distribution system operators: East of England, London, North West, West Midlands (all owned by Cadent, previously National Grid Gas), Northern (owned by Northern Gas Networks), Scotland, Southern (both owned by Scotia Gas) and Wales and West (Wales and West Utilities).
- In addition to distribution network operators, there are Independent Distribution Network Operators (IDNOs) that are connected to the distribution network. These operators do not have a specific geographic service area but are regulated by Ofgem.
- The UK gas transmission network has a total length of 7,666 km² and the distribution system is around 284,000 km². Gas leaves the transmission network at 175 locations.
- In total, more than 23 million homes, businesses, industry and power stations are connected to the gas grid.³
- More than 60,000 new customers are connected each year.⁴



Development of the gas transmission and distribution network

- The length of the distribution network remained proportional to the number of customers until about 1960.
- At that point, the construction of high pressure pipes began to reconfigure what had been a fragmented network.¹



Iron Mains Replacement Program

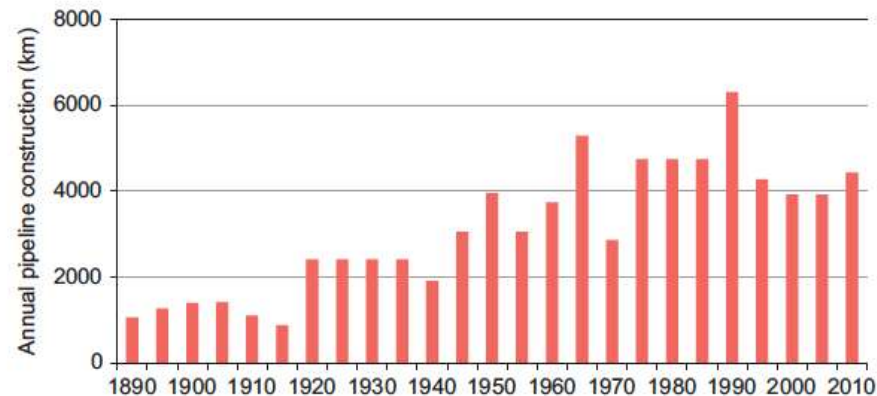
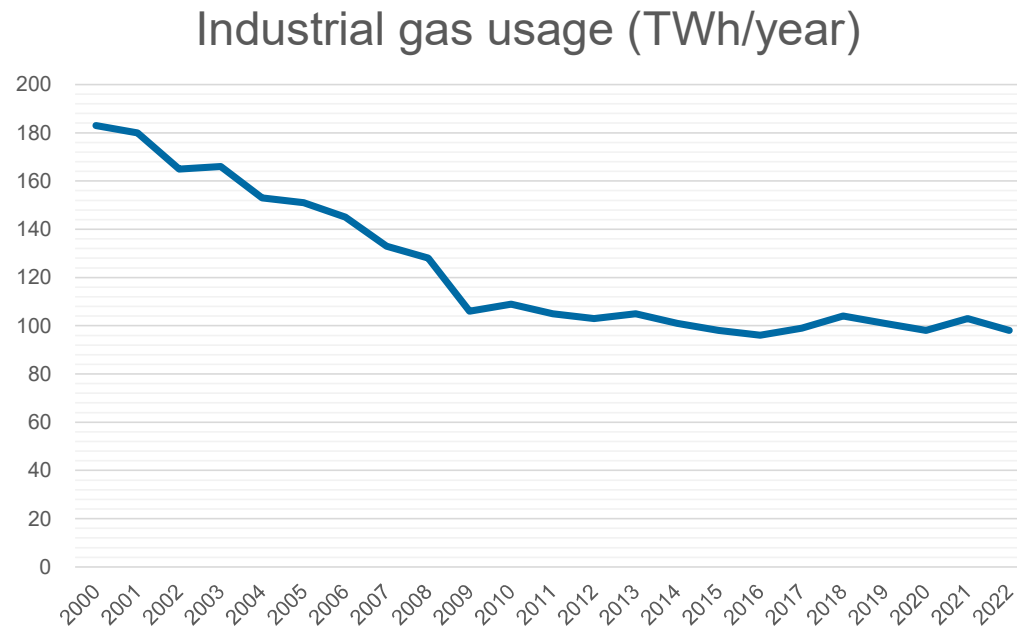


Fig. 3. Estimated annual pipeline construction rates over 5-year periods from 1890 to 2010. Both new and replacement pipelines are included in these data.

- In 1996, the HSE mandated that all iron mains within 30m of buildings are to be replaced by 2032, based on safety considerations.¹
- Iron mains replacement programme (IMRP) is continuing with targets for utilities to replace around 100,000 km low-pressure iron distribution and attached service pipes with polyethylene pipes.²
- Although justification for IMRP is safety, a study commissioned by the National Infrastructure Commission and Ofgem states that currently, 83% of pipelines are ready for hydrogen and after the IMRP is finished in 2032, that will increase to 99%.³
- Given expected lifetimes of replaced pipelines (assumed 50 years), if gas is curtailed by 2050 per climate targets, replacement pipelines will not be fully paid off given current depreciation.

Industrial Gas Usage



- Industry usage currently makes up about 13% of fossil gas in the United Kingdom.¹
- Industry has used on average around 100 TWh/year over the last 10 years, having dropped most around 2009.¹
- This drop in industrial demand has been a large part of the overall 18% drop of UK gas demand since 2010.¹
- Demand decreased some in the last year, with the largest decreases in the chemicals and the paper and printing sectors.¹

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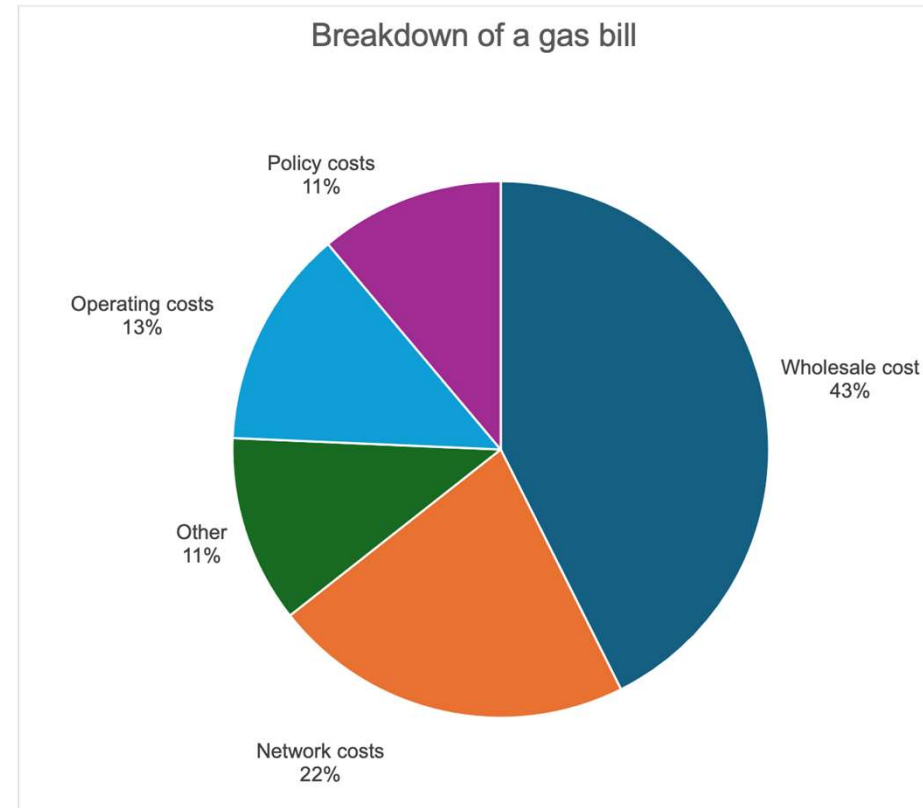
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Regulation – gas networks

- The eight gas distribution networks (GDNs), managed by four companies, are regulated by the National Regulatory Authority, Ofgem.¹
- Ofgem regulates the GDNs using a performance based regulatory framework, known as RIIO ((Revenue = Incentives + Innovation + Outputs). This framework provides the basis for periodic prices control that set that level of revenue that can be earned by the GDNs, and the levels of performance that the GDNs are required to deliver. Ofgem sets the baseline revenues that the GDNs can earn at the start of the price control. GDNs must deliver on certain outputs associated with the baseline revenues either annually or an eight-year basis. Those revenues can be adjusted year-on-year depending on performance relative to pre-set targets.¹
- Under the RIIO price control, the GDNs' output performance is regulated in six categories, each with specific metrics: 1. Safety – which includes Iron Main Risk Reduction and Emergency Response; 2. Reliability – which includes Loss of Supply; 3. Connections; 4. Customer Satisfaction; 5. Social Obligations; 6. Environmental Outputs.¹
- In addition to output performance, Ofgem considers GDN Innovation, which is made up of two categories: operational innovation, which focuses on improving operational effectiveness, efficiency, and safety, and network innovation, which focuses on exploring and defining the future of gas.¹
- Ofgem takes a totex approach in the GDN price controls, which seeks to incentivize GDNs to deliver outputs at the lowest total cost. Totex includes Capital Expenditure (Capex), Iron Mains Replacement Expenditure (Repex) and Operational Expenditure (Opex).¹
- Ofgem uses a Rate of Regulatory Return on Equity (RoRE) to estimate financial benefits and to assess the financial penalties for underperforming in output performance.¹
- As part of the price control, Ofgem's tariff methodology provides an estimate of the overall cost of domestic energy bills.¹
- In its Future Systems and Network Regulation: Framework Decision Overview, Ofgem provided a framework for upcoming price controls, focusing on a case for change, and whether a different regulatory approach is needed as the energy system transforms.²

Gas grid charges – domestic customers

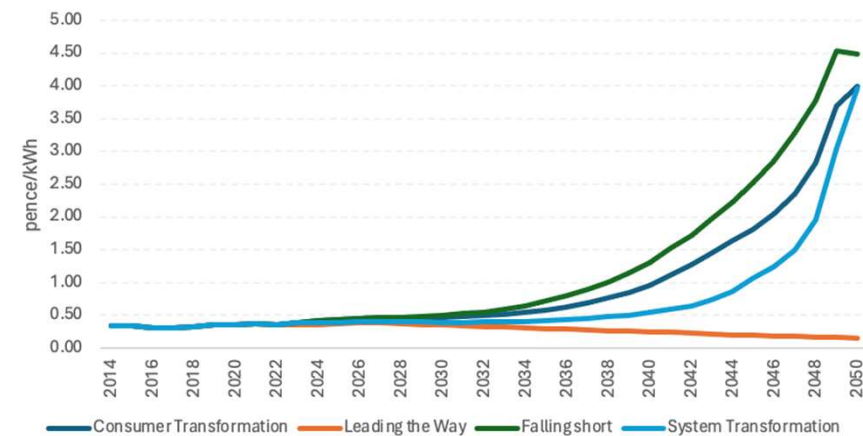
- From April to June 2024 network charges accounted for 22% of the total gas price for domestic customers.¹



Possible future development of network charges

- By switching from fossil gas to renewable energy sources or heat pumps driven by green electricity, the energy demand for gas and the number of users will continuously decrease.¹ Accordingly, grid charges may increase significantly in the future.¹
- The following figure shows a forecast of the development of average grid charges from 2014 to 2050, if there were no changes to the regulations on grid expansion and cost calculation. This results in a more than tenfold increase in grid charges. Ofgem has estimated that network charges could reach 1p/kWh by 2040 and 4p/kWh by 2050, up from less than 0.5p today.¹
- Using National Grid's FES data, Ofgem created a high-level estimate of the likely direction that customer bills will take on a volumetric unit basis. In most scenarios, the average forecast gas charge starts to increase significantly in the mid-2030s. This is because gas demand is forecast to fall significantly faster than the combined allowed depreciation and allowed return revenue building blocks. In this scenario, the cost of the regulated asset value is being paid for by fewer consumers – leading to increasing charges per remaining consumer.
- Ofgem announced in July 2024 that they would switch to accelerated depreciation for all new gas grid investments so that new investments are fully depreciated by 2050 at the latest. The regulator also considers extending this to existing gas grid assets.²

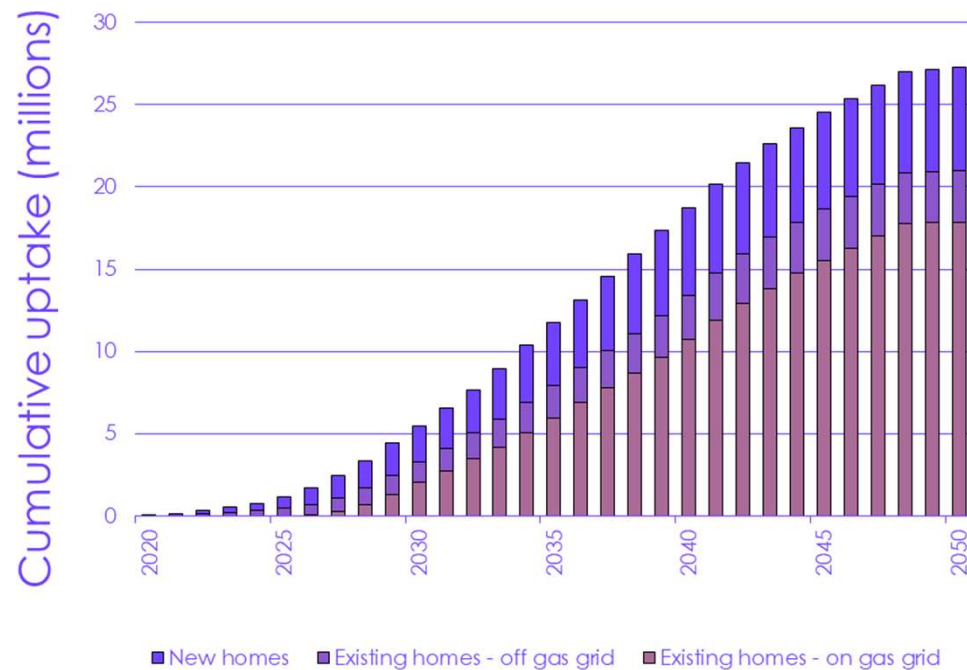
Development of gas grid charges without adjustments to the regulatory framework¹



Regulation – Heat planning

- The United Kingdom's Heat and Buildings Strategy focuses on transitioning to high efficiency and low-carbon buildings with a goal of decarbonising buildings, to include phasing out the installation of new fossil gas boilers from 2035.¹ In October 2023 the government modified this ambition stating 20% of homes would be exempt without specifying which homes.²
- The United Kingdom's plan includes targets for the installation of 600,000 heat pumps per year – around 200,000 for new build and 400,000 in retrofits.
- The Boiler Upgrade provides grants of £7,500 towards the installation and capital costs of heat pumps.³
- The United Kingdom has been considering hydrogen for heating but cancelled three trials in two villages and one town.⁴ Government will make a decision regarding its role in 2026 after collecting additional information.¹
- The Energy Act 2023 provides the powers for government to implement heat network zoning in England through regulations. Government is currently consulting on the further detail of heat network zoning.

Heat pump development in the United Kingdom

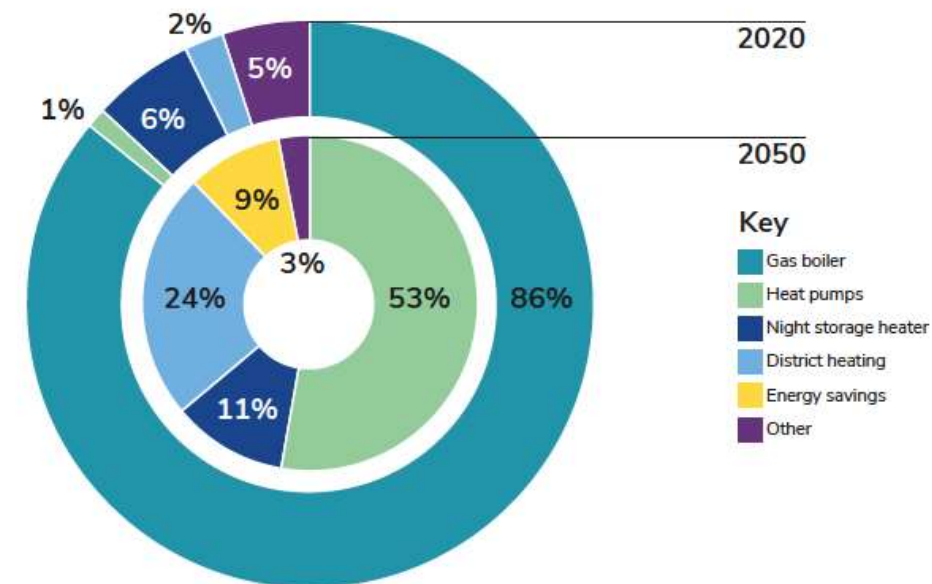


- The CCC Balanced Net Zero Pathway implies that by 2030, low-carbon heat installations in homes could represent up to around 80% of sales. Of these low-carbon heat installations, 75% are heat pumps (including hydrogen hybrids), 19% are low-carbon heat networks, and 5% are other flexible electric heating with space heat storage or solar thermal.¹

Regulation – Gas boiler

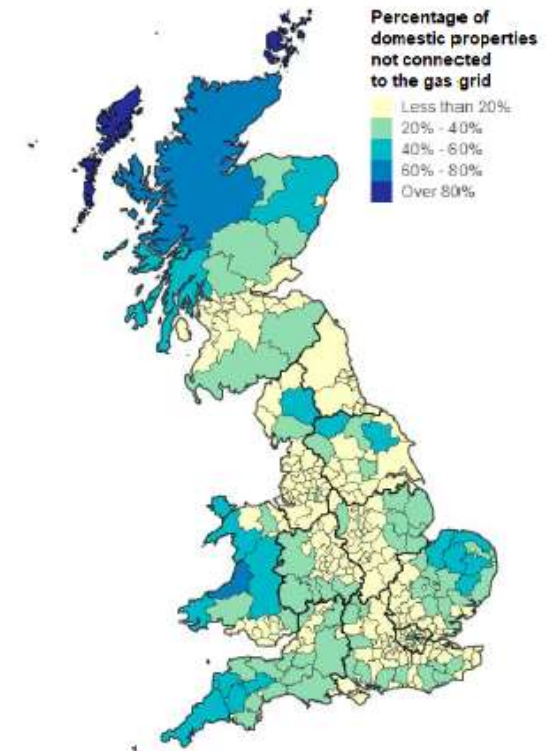
- The government intends to phase out gas boilers from 2035 for 80% of homes, with Scotland proceeding at a faster pace, with a phase-out of new fossil gas boilers from 2025 in off-gas-grid areas and from 2030 in on-gas-grid areas.¹
- This target is set to align phase-out with a goal of ensuring that all heating systems are low-carbon by 2050 although it remains unclear how the 20% of homes exempt from the phase-out plans will be decarbonised.
- Under plans for the Future Homes Standard, new buildings will no longer be able to be fitted with fossil fuel heating. Hydrogen-ready boilers are not allowed under the current plans.¹

Heating system usage



Connection the to gas network

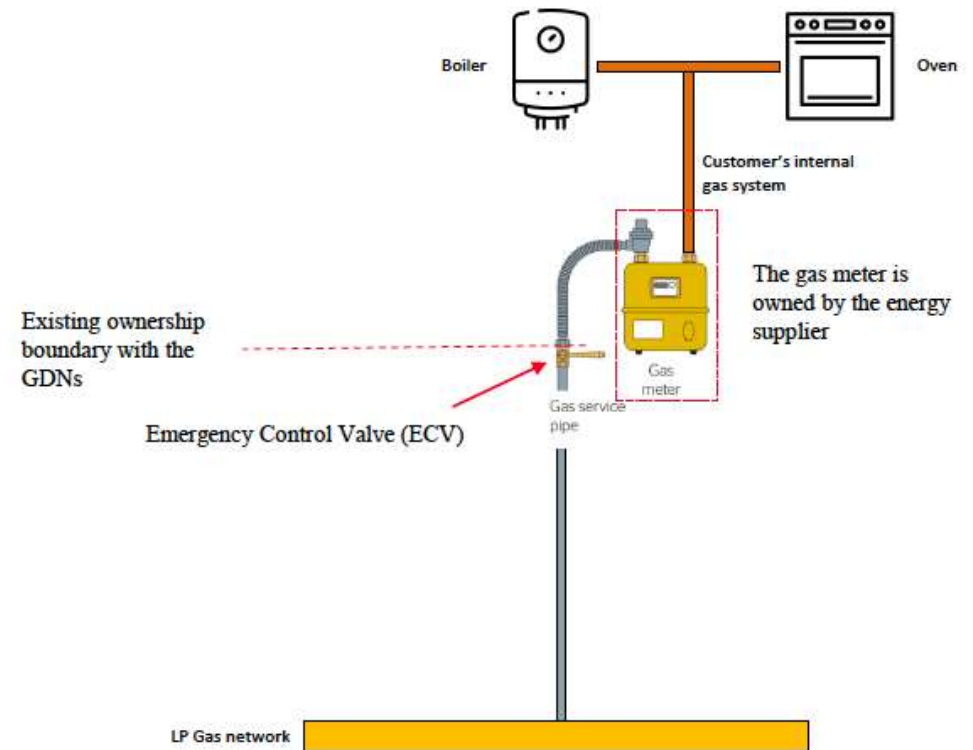
- The gas system operator has a duty, in its authorized area, to develop and maintain an efficient and economical pipe-line system for the conveyance of gas.¹
- The operator also has a general duty to connect any customer who requests a connection to the gas network.¹
- This requirement applies to any customer situated within 23 meters from the relevant main of the gas transporter, or a customer that could be connected via a pipe supplied and laid by the owner or occupier of a premises.¹
- Once a connection has been made, generally a gas transporter must maintain that connection until such time as it is no longer required by the owner or occupier of the premises.¹
- The gas transporter may be allowed to have the owner or occupier defray the costs to supply and lay pipe for connection.¹



Percentage of domestic properties not connected to the gas grid
Source: BEIS Subnational Consumption Data

Disconnection from the gas network

- For customers wishing to disconnect from the gas grid, a customer can request disconnection from their energy supplier.¹
- The gas pipe will be sealed at the emergency control valve. If a new gas meter is not fitted within 12 months, the gas distribution network operator may remove the pipe.¹
- The gas distribution network operator will not charge for this disconnection work, but the energy supplier may charge for meter removal.¹



Gas infrastructure around the customer premises

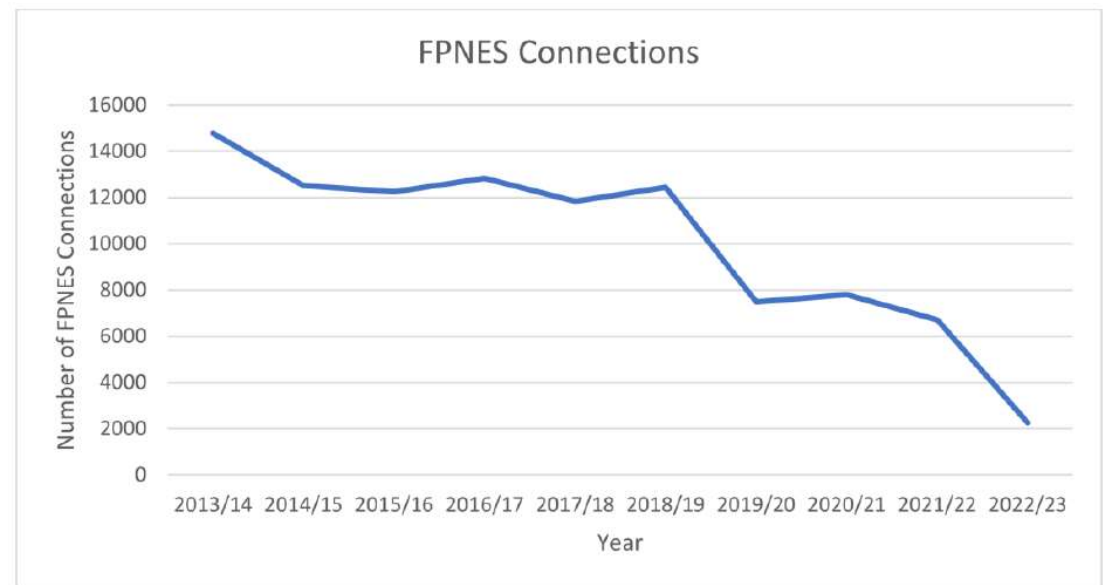
Source: Arup analysis

Addressing vulnerable energy consumers and broader social justice concerns

- Ofgem developed a Consumer Vulnerability Strategy to address the needs of vulnerable energy users. The strategy runs until 2025.¹
- Ofgem determined in RIIO-GD2 that gas distribution networks have an important role in addressing vulnerability and should:
 - assist consumers in vulnerable situations during outages;
 - recognise and take proactive measures to address vulnerability when responding to emergencies;
 - provide subsidised connections to fuel poor households;
 - recognise and appropriately take vulnerability into account through their customer service functions; and
 - identify consumers in vulnerable situations and offer them some additional assistance free of charge.^{2,3}
- In the RIIO-GD3 consultation document, Ofgem noted that local governments have the primary role in addressing fuel poverty, and encouraged gas DSOs to coordinate with local governments.⁴

Addressing vulnerable energy consumers in the energy transition

- Fuel Poor Network Extension Scheme (FPNES)¹
 - Incentivized networks to connect fuel-poor households to the gas grid to assist with energy security.
 - Proposal to discontinue scheme, given anticipated changes in the energy system and heating approaches.
 - Ofgem: “We consider there to be a risk in connecting additional fuel poor households to the gas network and facilitating the installation of natural gas central heating systems while such uncertainty remains.”

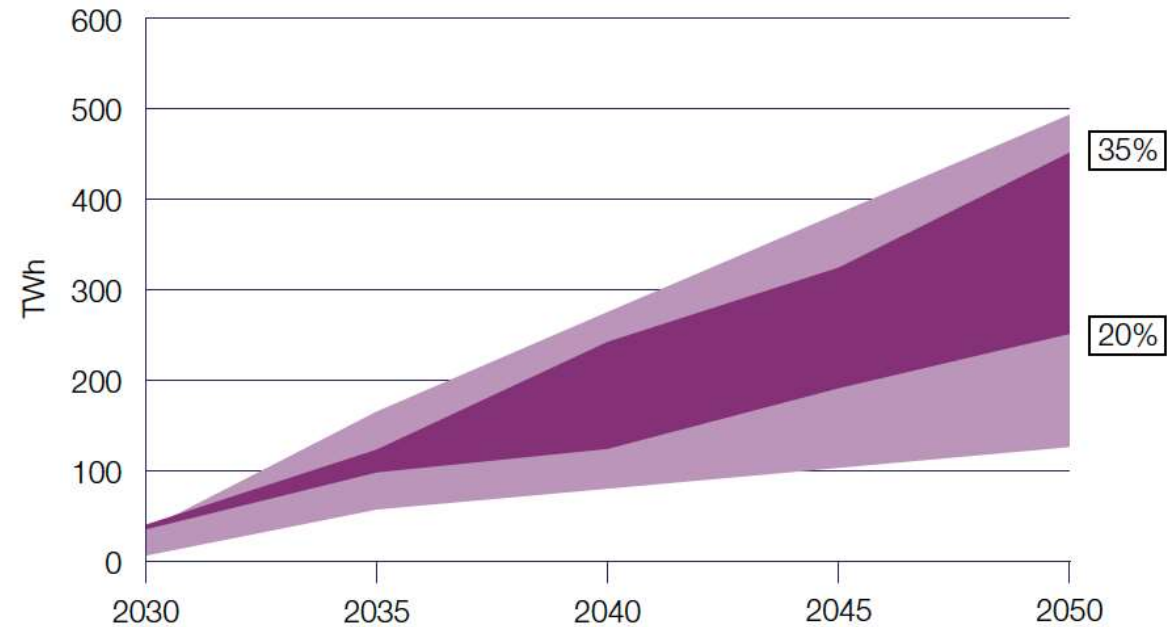


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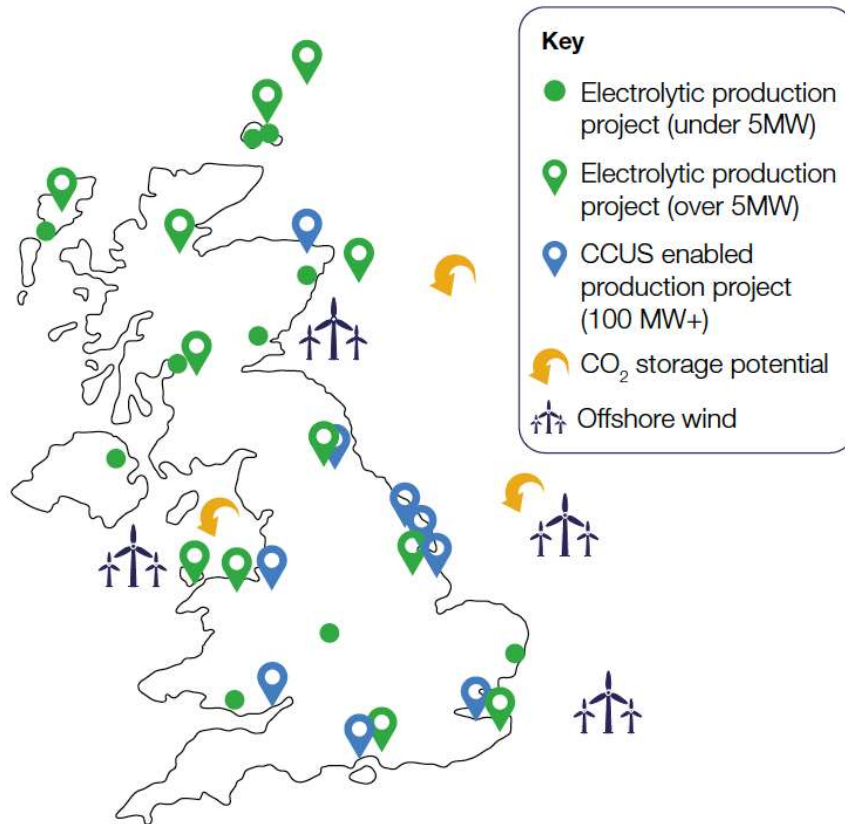
UK Hydrogen Strategy

- UK's Hydrogen Strategy notes that low-carbon hydrogen will be essential for meeting the UK's climate targets, and could meet 20-35% of the UK's energy needs.¹ Fossil gas currently meets about 38% of the UK's energy needs.
- To meet this hydrogen goal, 250-460TWh of hydrogen would be needed in 2050.¹
- Because hydrogen is a less energy dense molecule, if hydrogen were to deliver the same amount of energy to customers, the network throughput would have to increase three times by volume.
- This could be achieved by increasing the flow rate of the gas in the system, increasing system pressure, or by increasing the size of the network for reinforcement.
- Even in a high network scenario, the gas network will likely transport less energy in the future.²



% = hydrogen as proportion of total energy consumption in 2050

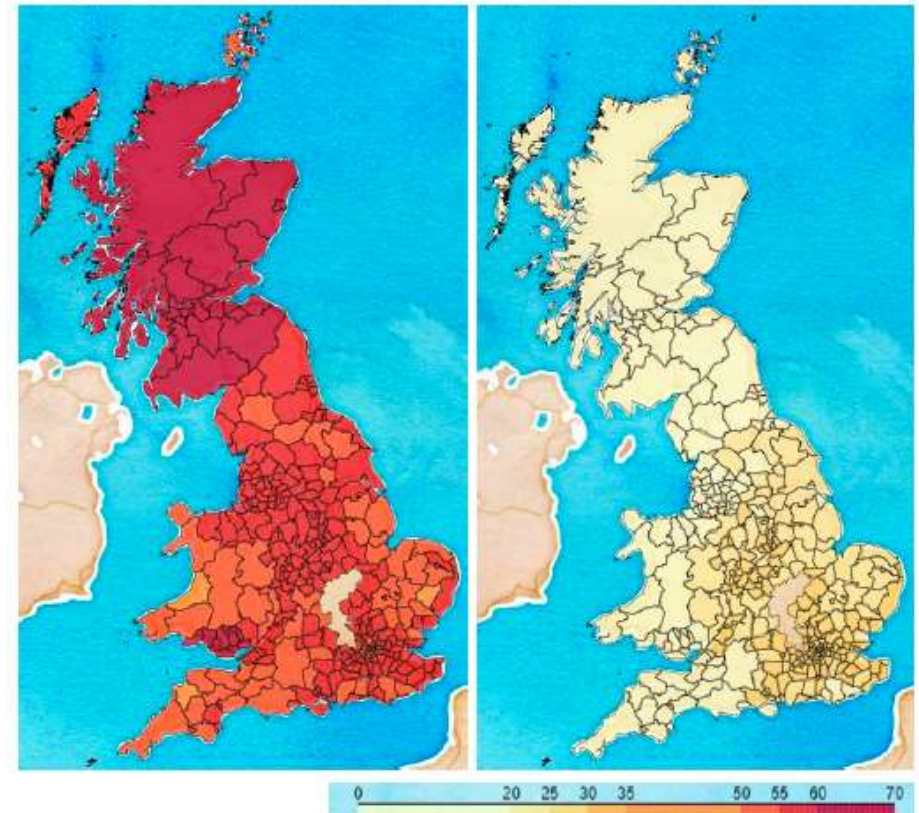
UK Hydrogen Strategy



- The UK's Hydrogen Strategy anticipates that the UK will build up hydrogen production for use in multiple sectors.¹
- The UK's strategy foresees production on a 'twin track' of producing "both electrolytic 'green' and CCUS-enabled 'blue' hydrogen."
- The initial strategy set forth a goal of 5 GW of low carbon hydrogen production by 2030, but that goal was doubled in 2022, so the goal is now 10 GW of hydrogen production by 2030, with at least half of that coming from electrolytic hydrogen production.
- In addition to domestic use, the strategy seeks to develop hydrogen for export to other markets, including continental Europe.

Hydrogen for heating

- The UK government's hydrogen strategy includes a role for hydrogen in heating, alongside electrification and heat networks.¹
- The strategy anticipated that pilot projects would provide testing grounds for hydrogen heating, including investigation of the safety of using existing networks to transport hydrogen.
- Most of these pilot projects have been abandoned, however, due to local opposition and safety concerns.
- The UK government is expected to make a decision in 2026 about the role of hydrogen for heating. But the government more recently confirmed that it did not see a major role for hydrogen in heating.
- The government is also expected to make a decision about blending up to 20% hydrogen into the existing gas supply.
- In the consultation for the upcoming price control, Ofgem notes that these decisions will impact decisions about the distribution network. Because of the uncertainty, however, Ofgem notes that there will not be large-scale changes to the gas network during the RIIO-3 price control, which runs from 2026 to 2034.²

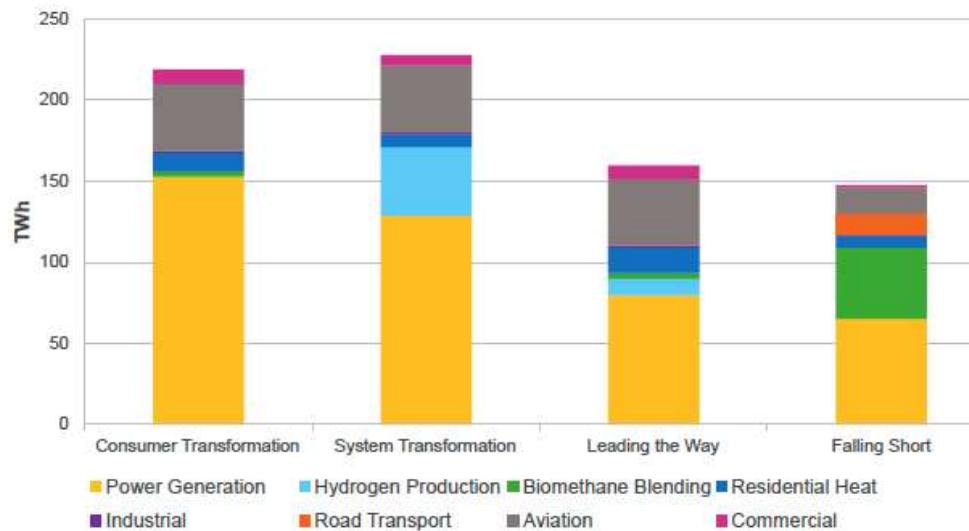


Percentage of homes with hydrogen in 2050 in System Transformation (left) and Leading the Way (right)

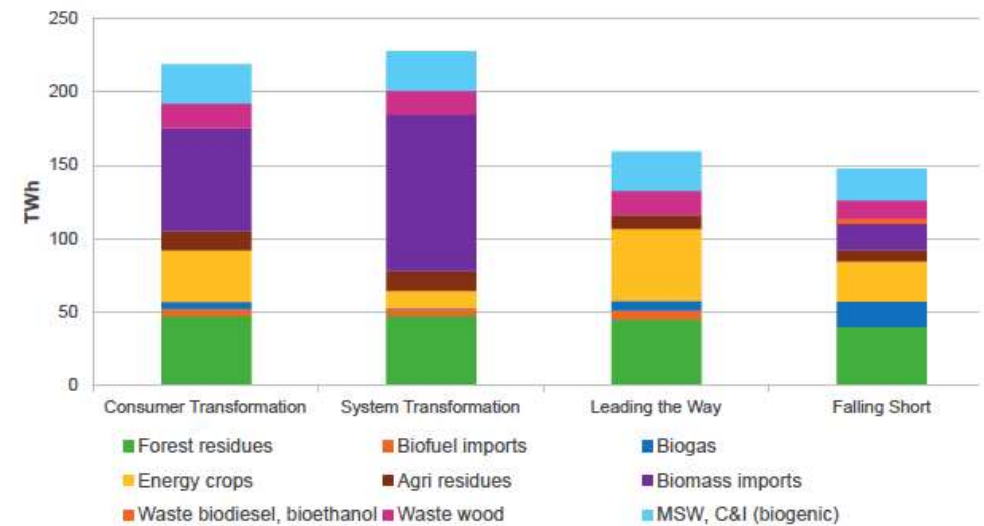
Source: FES & Arup Analysis

Biogas in the gas network - development

Total Bioenergy Demand, 2050



Total Bioenergy Supply, 2050



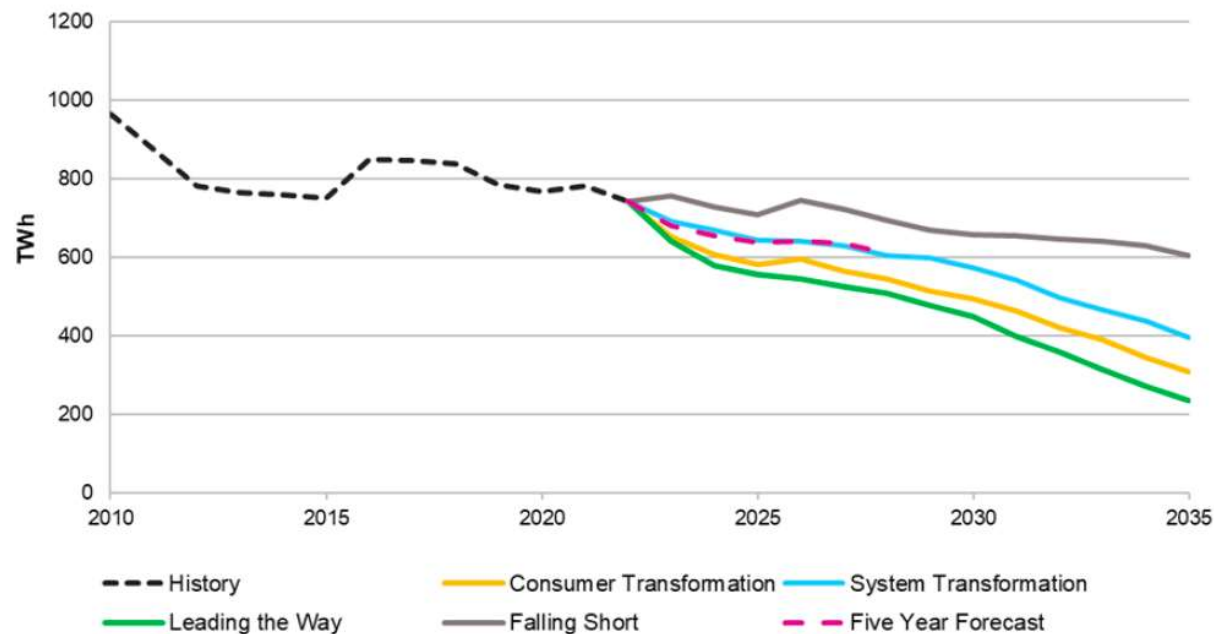
- The Energy System Operator's (ESO) Future Energy Scenarios include biogas as having a role in decarbonisation.¹
- The ESO recognizes the limited availability of bioenergy, and the need to ensure that it is achieving negative carbon emissions, and notes that it should therefore only be used for the most optimal applications.¹
- The scenarios anticipate its use in power production and low-carbon hydrogen production.
- The UK government set out priorities for biomass in its 2021 Biomass Policy Statement updated in the Biomass Strategy 2023.²

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Future Energy Scenarios gas forecast

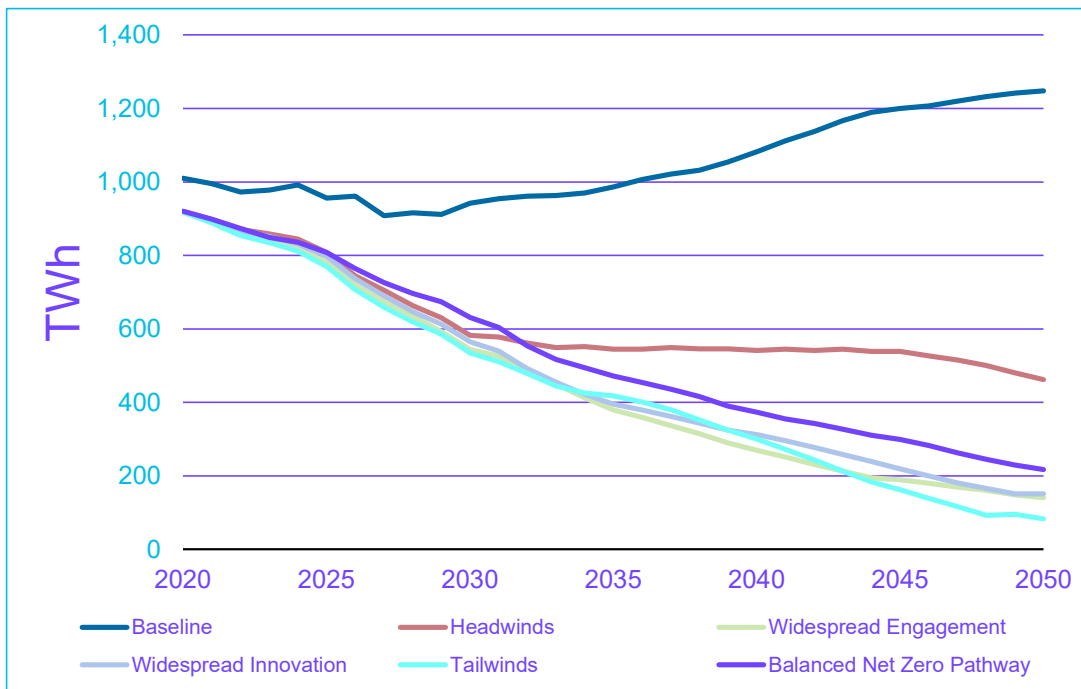
Figure 1: Historical and FES 2023 forecast gas demand



- With the Future Energy Scenarios, the UK's Energy System Operator (ESO) modelled four different pathways to achieve the United Kingdom's goal of net zero by 2050.¹
- With a Falling Short pathway, gas would continue to be used for power generation and residential heating and demand would decrease by only 6% to 2028.¹
- In Leading the Way, greater heat pump production and off-shore wind allows for a 30% reduction in gas demand by 2028.¹
- The Five-Year forecast represents the best view of the ESO of supply and demand in the short term. It represents an 18% gas demand reduction by 2028.¹

Climate Scenarios and gas demand

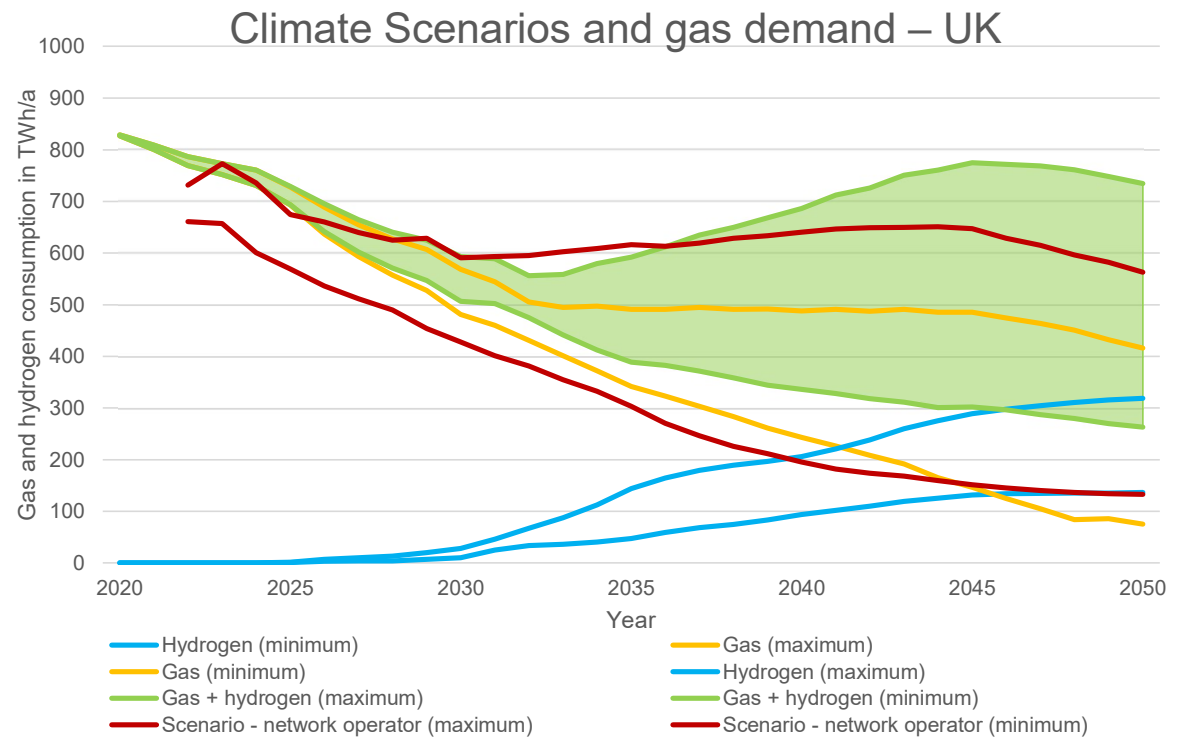
UK Gas Demand



- The United Kingdom's Climate Change Committee (CCC), in its Sixth Carbon Budget to run from 2033-2037, sets out recommendations for the needed path to achieve net zero by 2050.¹
- According to the CCC's carbon budget, gas must fall significantly to meet the Balanced net Zero pathway.
- Other than the Headwinds' pathway, the Future Energy Scenarios anticipate less gas demand than the CCC scenarios.

Climate Scenarios and gas demand

- UK climate scenarios and network operator projections show a significant range in gas and hydrogen demand development to 2050. Climate scenarios range from 260 TWh/a to 730 TWh/a by 2050, with a difference of more than 2.5 times between the minimum and maximum.
- The uncertainty raises questions about the future path, whether there will be more reliance on electrification or more reliance on hydrogen, biogas or synthetic gases.
- Grid operator scenarios consistently show demand below the climate scenarios, ranging from 130 to 560 TWh/a by 2050.
- The considerable variability in the projections indicates a high level of uncertainty in UK gas and hydrogen infrastructure planning.



Future gas and hydrogen demand in the Netherlands based on different scenarios that aim to achieve the climate targets of the country and projected developments of the gas network operators. (The values in the green corridor do not correspond solely to the sum of the maximum values for gas and hydrogen. Instead, the green corridor represents the range of the total sum of hydrogen and gas within the same scenario for different scenarios. Included scenarios: Tailwinds, Headwinds, Widespread Engagement, Widespread Innovation, Balanced Net Zero Pathway, Tailwinds¹ and for the network operators all scenarios from the National Grid ESO 2023²)

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Public information and transparency

- Ofgem provides a significant amount of information about ongoing proceedings and consultations.¹
- These documents are difficult to find, however, and the Ofgem website is difficult to search. As a result, it can be hard to find information without knowing fairly precisely what the document sought is. For example, although there is significant information available pursuant to each price control, that information is not easily found on Ofgem's website, and even then can be unclear as to whether all of the information is in one place.
- More general data about the network, such as its size or customer breakdown, is very difficult to find, if not impossible.
- Ofgem consultations allow for input, but do not necessarily provide access to sufficient data to allow for meaningful input.
- Comments offered via the consultation process are compiled but not summarized into useful input.
- GDN filings do not seem to be available on the Ofgem website and thus are available only as the GDN deems appropriate on its own platform.

Opportunities for stakeholder involvement

- Ofgem frequently consults on the price control framework for gas networks. These consultations can be found on the Ofgem website.¹
- Ofgem established a RIIO Challenge Group to²
 - a) "provide an independent challenge to, and scrutiny of, all proposed network company business plans for all sectors in RIIO-2 from the perspective of existing and future consumers, with a focus on affordability and the protection of consumers in vulnerable circumstances, and on sustainability (including but not limited to impact on the environment and the low carbon transition) and
 - b) participate in the public hearings run by Ofgem
- The current members of the challenge group can be found on the Ofgem website.³
- There are also working groups feeding into Ofgem's decisions on gas network regulation. There are working groups both on gas distribution³ and gas transmission⁴.
- Those interested in attending any upcoming working groups are invited to contact RIIO2@ofgem.gov.uk

Opportunities for stakeholder involvement

- The next UK gas distribution price control review is expected to start in April 2026. Because of the significance of this decision for gas regulation Ofgem suggested that in that upcoming price control review, long-term risks associated with the use of the gas grid could be managed through depreciation rates/asset lives with the potential for ‘re-openers’ which give the option to modify the price control if a major event occurs. Alternatively, Ofgem suggested that the price control framework could be delayed, perhaps by two years. Both options protect the gas network owners but offer limited upside for consumers. Ofgem suggests that this updated timeline is lower risk than a shorter two-year review in advance of 2028. But clearly there are risks. Delay leads to an increase in potential stranded assets and increases the financial exposure of UK citizens, not just to gas network costs, but to energy insecurity and climate change costs.¹ To address this, we make these recommendations to the UK government:
 1. Ofgem should implement its recent decision for allow for accelerated depreciation ensuring new gas grid investments are fully paid off by 2050. Ofgem should also extend accelerated depreciation to existing gas grid assets as currently considered.
 2. Take steps to gain a thorough understanding of the required process and costs of decommissioning the gas grid in order for this risk to be properly considered.
 3. Ofgem and the UK Department for Energy Security and Net Zero should work together with other parties to develop a plan which equitably allocates the multi-billion-pound risks associated with stranded gas assets and decommissioning, considering the value of accelerated depreciation, evolutionary regulation and renationalisation.
 4. Consider whether the Iron Mains Risk Reduction Programme continues to offer consumers value for money as a major capital investment programme — and if not, intervene as soon as is practicable.
 5. Ensure that approaches to heat and local area energy planning, and wider clean heating policy, are coordinated with the issue of gas grid decommissioning and that consumer protection is central.

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