Gas Network Innovation Strategy

Draft for Consultation

ENA Gas Members

Purpose of this document

This document describes the Gas Network Innovation Strategy, including the current challenges and how we will manage the uncertainties applicable to the gas transmission and distribution networks. It is published to enable the public, industry and other interested parties to have a meaningful input into the proposed innovation strategy.

Gas network innovation strategy stakeholder consultation

We (Cadent, National Grid, Northern Gas Networks, SGN, Wales & West Utilities) have worked together to develop this Gas Network Innovation Strategy. The work has been managed through the Gas Innovation and Governance Group (GIGG) of the Energy Networks Association (ENA). Independent consultants DNV GL have been commissioned through an open tendering process to support the development of the Strategy and the stakeholder consultation.

The importance of stakeholder consultation on the draft strategy forms a crucial part in its development. It is essential that the views of wider industry stakeholders are considered. We believe that the ideas contributed by other parties during the consultation will strengthen the content, structure and style of the document.

The consultation can be accessed online at http://www.energynetworks.org/gas/futures/gas-innovation.html until 22nd December 2017, giving all interested parties adequate opportunity to review the draft strategy and provide valuable feedback. In addition, the draft strategy will be presented at the ENA's Low Carbon Networks and Innovation (LCNI) conference, alongside the Electricity Network Innovation Strategy. An interactive session will give attendees the opportunity to give feedback directly and ask questions. This will enhance the opportunity for whole systems thinking on innovation and the future of the energy networks.

Introduction

Our commitment to innovation

The gas industry is facing its greatest challenge since the introduction of natural gas in the 1960s, with new technological developments and the need to greatly reduce carbon emissions before 2050. To meet this challenge, we must evolve the current energy networks to meet the needs of the future customer. Successful innovation will be a vital part of this process.

> We are embracing the challenge of delivering secure and sustainable energy supplies, and guiding the country's progress toward a low-carbon economy. We are innovating in what we do and how we do it, since this is the only way to decarbonise heat and meet our climate change targets.

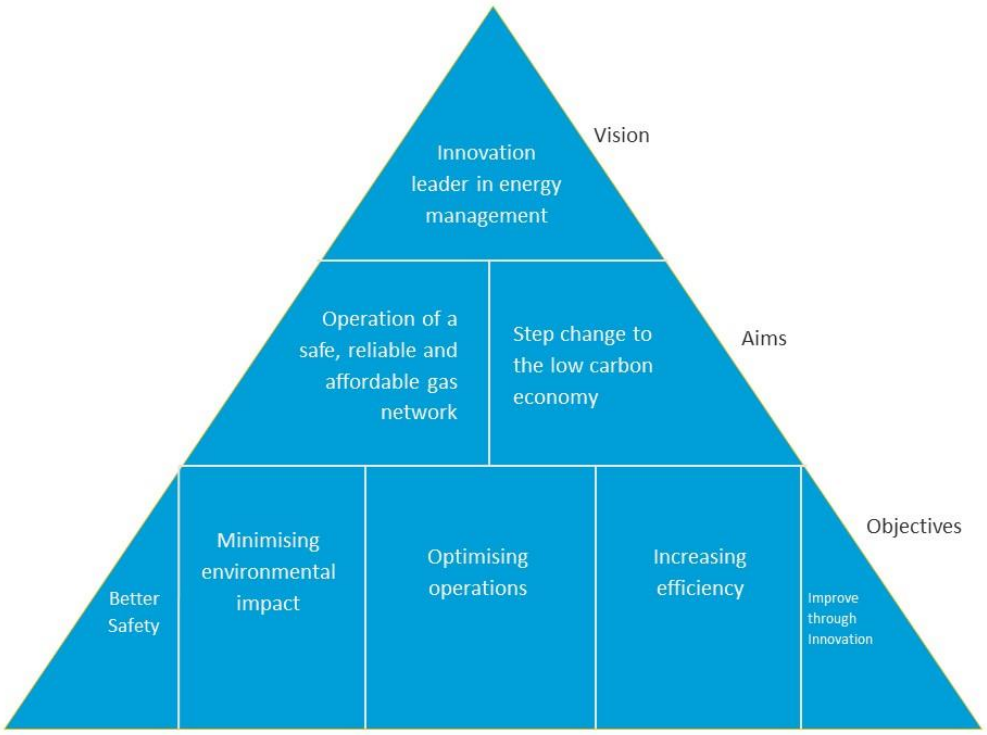
Our vision is to be an innovation leader in energy management.

Our innovation strategy is twofold. Innovation is key to the:

- Continued operation of a safe, reliable and affordable gas network, whilst
- Developing solutions for the step change to the low-carbon economy that consumers need.

We use innovation (which is the development new and useful things) to improve our business processes, our use of technology and the security of supply of gas to consumers. We will manage the flexibility of our innovation project portfolios so we address future uncertainties. We will aim to deliver value to consumers through:

- Prioritising improvements to safety
- Minimising environmental impact
- Optimising operations
- Increasing efficiency, and
- Enhancing through innovation



We will continue to build on the success of our innovation activities to date and increase the value delivered for our stakeholders by building our culture of innovation and strengthening our cross-industry collaboration.

Our commitment to collaboration

We are listening to our stakeholders and focusing our efforts on innovative solutions to meet their needs. Our people generate ideas and scan the technology landscape with suppliers to identify opportunities.

We will continue to build a more innovative culture within our organisations to make sure we achieve our vision. We will give our people the tools and time to investigate different innovative solutions, and foster an environment where this is the norm rather than the exception.

We recognise that, using only our own resources, we cannot make the best use of funding available for innovation, nor identify all the solutions to our challenges. We also recognise there will be gaps in our current innovation portfolio, and that new challenges will appear that need to be addressed. We are listening to our stakeholders and focusing our efforts on innovative solutions that meet their needs.

This strategy has been published by the Energy Network Association (ENA) in fulfilment of the licence conditions of the following gas networks:

- Cadent
- National Grid
- Northern Gas Networks
- SGN
- Wales & West Utilities.

We want to continue to build strong links with academia, suppliers, manufacturers, and other organisations through the gas value chain, and from related industries, to help us innovate.

This strategy, and the implementation of the ideas and projects within it, will ensure we achieve our vision for the consumers of today and tomorrow.

Structure of the document

In this next section, we set out the main themes of our innovation strategy, namely:

- Future of gas
- Safety and emergency
- Reliability and maintenance
- Repair
- Distribution mains replacement
- Security
- Environment and low carbon.

Under each theme we first provide the context, innovation requirements and the areas requiring further development. In doing so we aim to assist our stakeholders in understanding our current needs, without restricting the ideas and technologies that they may wish to bring to our attention.

This innovation strategy supersedes the ‘Gas Network Innovation Problem Statements’ document[1] that the ENA published in March 2017.

Getting in touch

If you have any questions or would like to discuss the innovation strategy in more detail, please get in touch at:

gas@energynetworks.org

and use ‘Gas Network Innovation Strategy’ in the subject field.

[1] Gas Network Innovation Problem Statements, Energy Networks Association, March 2017

Future of gas

The gas network plays a vital role in transporting energy to consumers securely and cost-effectively. It can adapt to support the decarbonisation of heat, transport and energy toward 2050 and beyond. It is a high-value asset that can transport all gases that comply with the *Gas Safety (Management) Regulations* (GS(M)R), and can respond to the significant daily and seasonal swings in demand for heat and energy. The disruption and cost to consumers will be critical factors in the successful decarbonisation of heat, transport and energy in Great Britain. These consumer issues will be the focus of our gas innovation strategy in this respect.

> The gas network delivers 995 TWh of energy through 284,000 km of pipes to industry, homes and businesses in Great Britain.
>
> This compares with 307 TWh of electricity transported along 818,000 km of cables.
>
> —Ofgem

Gas for heat

The Committee on Climate Change,[2] an independent body set up under the UK *Climate Change Act* to advise the government on building a low-carbon economy and preparing for climate change, reports that heating and hot water for buildings make up 40 per cent of our energy consumption and 20 per cent of greenhouse gas emissions. These emissions will need to be reduced if we are to meet our target, under the *Climate Change Act*, of an 80 per cent reduction in greenhouse gases by 2050.

The option of changing to electrical power has been proposed, but recent energy industry reports[3,4,5] indicate that using electricity for heating could cost up to £300 billion in broad terms.

The gas network provides about 80 per cent of heat demand. It can help decarbonise a lot of our heat and energy load by 2050 using a range of initiatives to maximise the use of renewable gases and support the use of hydrogen. Other reports[6,7,8] predict that global warming targets cannot be achieved without further work on decarbonising gas-powered electricity generation using carbon capture and storage.

Gas for transport

About 25 per cent of total greenhouse gas emissions come from transport. About a quarter of this is produced by heavy goods vehicles (HGVs) and buses. The concern in the transport sector is not just decarbonisation but also improvements in air quality. Natural gas engines produce fewer emissions – they out-perform Euro VI emissions standards for diesel engines on nitrogen oxides (NOx), sulphur oxides, particulates and carbon dioxide emissions.

The use of compressed natural gas (CNG) and liquefied natural gas (LNG) for HGVs and buses is not new but it has not reached its full potential. A lack of infrastructure means current fleet owners tend to build their own refuelling stations to realise the benefits. The potential of gas as a road transport fuel is incorporated in the Low Carbon Vehicle Partnerships infrastructure road map to

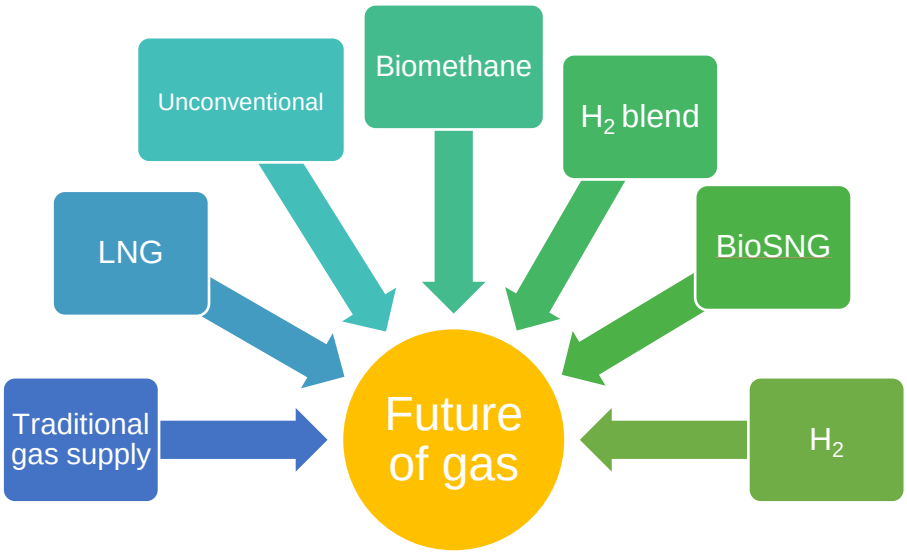
[2] Next steps for UK heat policy, Committee on Climate Change, October 2016
[3] 2050 Energy Scenarios - The UK Gas Networks role in a 2050 whole energy system, KPMG, July 2016
[4] Too Hot to Handle? How to decarbonise domestic heating, Policy Exchange, 2016
[5] A Greener Gas Grid: What are the Options?, Imperial College London, July 2017
[6] The Future Role of Natural Gas in the UK, UKERC, February 2016
[7] Energy Roadmap 2050, European Commission, December 2011
[8] Energy Transition Outlook, DNV GL, September 2017

2050.[9] At the heart of this roadmap is innovation in policy, collaboration, information assessment and technology for hydrogen and methane networks. Innovation will also be required to develop hydrogen-natural gas blends for transport.

The City CNG[10] project led by Northern Gas Networks is exploring the first scalable compressed natural gas fuelling station for city-based vehicles. The Leyland project[11] led by Cadent developed the first commercial high-pressure refuelling station for HGVs – after the first year of operation there was an 84 per cent reduction in carbon dioxide emissions from the vehicles.

A wider range of gases

The gas network also has the potential to transport gases outside the current GS(M)R range, which include hydrogen, hydrogen blend and un-ballasted LNG. There are exciting challenges ahead relating to the different gases entering the network. For example, the network will need flexibility to match consumer demand with the varying energy content of these gases. Ongoing innovation and technology developments are focused on understanding the impact of a wider range of gases on the gas network and our domestic, commercial and industrial consumers.



Introducing a wider range of gases into the gas network is a country-wide challenge that requires industry collaboration. We are working together with the Institution of Gas Engineers and Managers (IGEM) to develop standards to enable the safe delivery and use of these new gases. Two examples of this collaboration are the:

- Gas Quality Working Group, which aims to change GS(M)R to enable a wider range of gases to be safely delivered by the gas network
- Hydrogen Working Group, which is developing standards for hydrogen networks.

Integration of gas and electricity networks

The gas and electricity networks are already integrating more closely in response to increasing consumer choice, the availability of renewable energy technologies and energy pricing. For decarbonising domestic heat, for example, hybrid systems offer a solution combined with hydrogen in cities or biomethanes in smaller communities. Examples include:

[9] Transport Energy Infrastructure Roadmap to 2050 - Methane Roadmap, Low Carbon Vehicle Partnership, June 2015
[10] The City CNG Project, Northern Gas Networks
[11] Revolutionising fuel for transport - Leyland CNG filling station, Cadent Gas

- Increasing numbers of small local gas-powered generators
- Combining intermittent renewable energies and gas
- Combined heat and power
- District heating schemes
- Power-to-gas to store renewable energy in the gas network.

The gas network will underpin the decarbonisation of electricity and act as an energy store that can respond quickly, flexibly and efficiently to peaks in consumer demand.

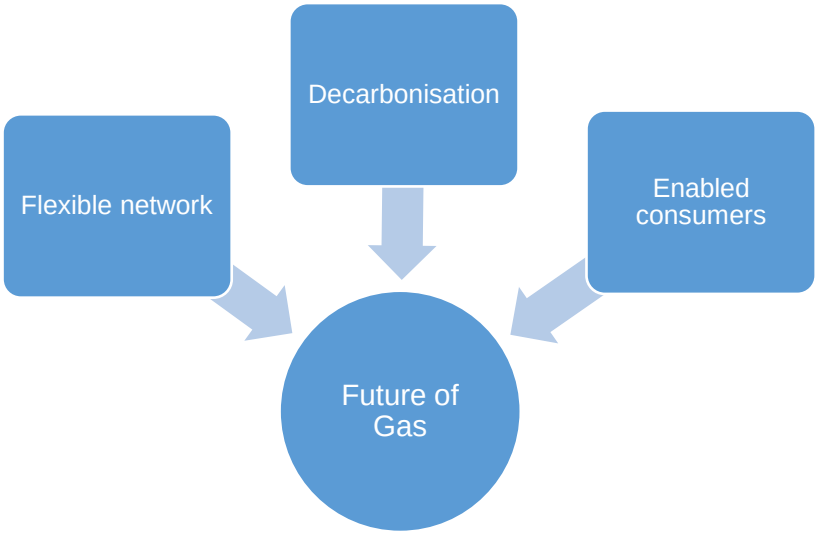
> People's well-being, industrial competitiveness and the overall functioning of society are dependent on safe, secure, sustainable and affordable energy. The energy infrastructure which will power citizens' homes, industry and services in 2050, as well as the buildings which people will use, are being designed and built now. The pattern of energy production and use in 2050 is already being set.
>
> —European Commission

Innovation into the integration of gas and electricity has recently begun: two examples are the FREEDOM[12] project, which is a large-scale trial to demonstrate smart hybrid heating systems, and InTEGRel,[13] which is a research, development and demonstration test site for integrated energy systems.

There are many potential opportunities for innovation by integrating renewable energy with the gas network. In Scotland, for example, there are 175 GW of power generated by offshore wind installations, plus energy from tidal schemes, which could be integrated with the well-developed gas transmission and distribution infrastructure.

Future of gas innovation

We have developed our own scenarios for the future of gas. It is important that the overall innovation strategy for the gas network maintains its flexibility rather than using a single vision of the future. The challenges we have identified have been combined under three themes, which are developed below.



[12] FREEDOM - Flexible Residential Energy Efficiency, Demand Optimisation & Management, Western Power Distribution and Wales & West Utilities

[13] Integrated Transport Electricity Gas Research Laboratory (InTEGRel), supported by Northern Gas Networks and Northern PowerGrid

Flexible network

The future gas network will transport gases from renewable and sustainable sources while maintaining current or improved levels of safety, reliability and affordability. The flexible network theme covers the provision of low cost and simplified access to the gas network for new gas sources.

Past and current innovation projects have greatly helped the process of connecting biomethane and high Wobbe number[14] gas to the gas network. Standards and guidance issued by IGEM clarify and simplify the requirements for biomethane producers. We are now contributing to work by the European Committee for Standardisation (CEN) on a harmonised European biomethane specification. Similar guidance for connecting unconventional gas sources is also being developed.

Decarbonisation

Decarbonisation of heat is essential to meet the Committee on Climate Change carbon budget targets. At present, the primary fuel for domestic and industrial heat is natural gas. We wish to support and encourage new sources of low-carbon gas, in particular the use of hydrogen either alone or as a blend with gases containing methane. Innovation in this area is intended to allow the transport of low-carbon alternatives to natural gas while maintaining the current standards of safety, reliability, affordability and customer service.

We have initiated many projects that explore transporting hydrogen or hydrogen blends. Projects have also looked at the impact on consumers and industrial users and the changes to energy measurement and billing required for a low-carbon network. Planned projects include trials for hydrogen distribution networks and continuing contributions to the IGEM working groups on hydrogen standards. The use of the high-pressure National Transmission System (NTS) for hydrogen transportation is an area for further work.

Enabled consumers

It is important to us that consumers share the benefits of moving toward a low-carbon future. This may be accomplished by using suitable billing arrangements and enabling consumers to select from a flexible range of energy options that suit their needs. For this to work, the gas network will need to better predict demand and monitor the use of gas, preferably on a near real-time basis.

Completed innovation projects have improved demand forecasting and understanding of the system constraints for the high-pressure gas network. Projects have also reviewed options for decarbonising domestic and industrial heating and their implications for stakeholders. Studies are under way which explore the technical and economic benefits of improving energy flexibility for consumers and the operation of a real-time network.

Future of gas innovation strategy

A timeline in Figure 1 shows possible future developments on the future of gas theme and how these relate to the Committee on Climate Change carbon budgets.[15] This is only one possible scenario and others are possible:

- 2020 – Facilitating change (to support delivery of the third carbon budget)
- 2030 – Carbon decreasing (to support delivery of the fifth carbon budget)
- 2050 – Decarbonised energy system.

[14] The Wobbe number describes the way in which the gas burns and is calculated as a factored ratio of calorific value and specific gravity (otherwise known as relative density).
[15] Carbon Budgets, Department for Business, Energy & Industrial Strategy, July 2016

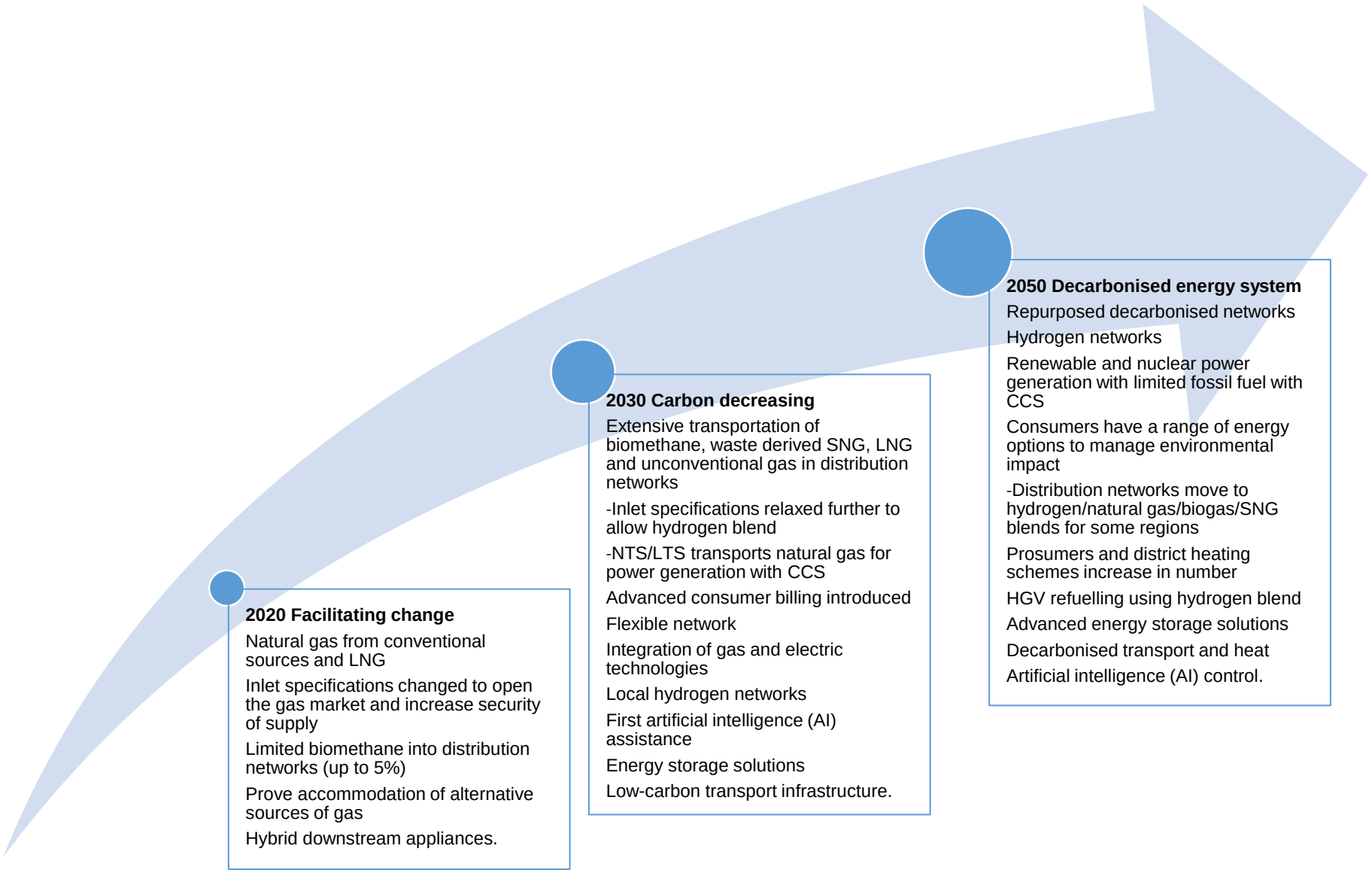


Figure 1 Future of gas timeline from 2020 to 2050.

Safety and emergency

Historically, accidental damage from third parties digging and excavation has been a major threat to the safety and performance of the gas network. We seek to continually improve and wish to invest in new technologies, and improved processes and procedures: for example solutions that better highlight where the pipelines are, or they could be solutions that physically protect the pipelines.

In addition, much of the gas network has already reached the end of its original design life. Safe operation is maintained by replacement and repair work. As the materials used in pipelines degrade, and components wear out, there is an opportunity to introduce new materials and techniques to maintain world class levels of safety.

> There are now more companies involved in digging holes across the UK than ever before. Latest figures estimate around 4 million holes dug by utility companies annually and this excludes any excavations made as part of construction projects. Third party damage to underground services of all types continues to be a source of danger and financial loss to workers, members of the public, utility companies and contractors
>
> —Health and Safety Executive

Currently, we must robustly plan for how to respond to anything that could occur on the gas network that might have significant implications for safety and/or loss of supply. With the move toward decreasing the use of carbon in energy supplies, our emergency response may need to be modified or extended to take account of changes in the gas being transported; for example, the increased use of hydrogen.

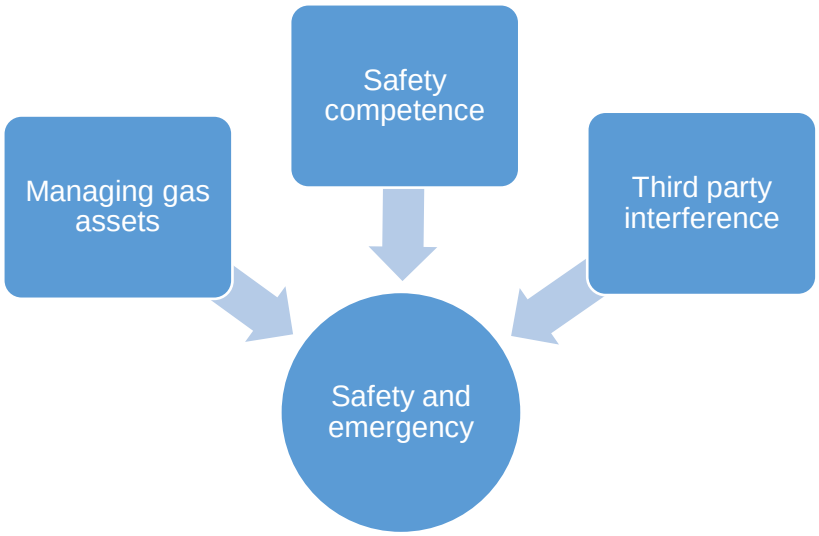
Integration of gas and electricity networks

Innovation projects to improve third-party knowledge of where utilities are buried will be of interest to us but could also be of value to electricity network operators who use underground cables.

Projects that develop ways to target where asset failure is most likely and/or has the most significant consequences for safety or loss of supply will be of benefit to all network operators. This is particularly important as routes for all utilities become more congested.

Safety and emergency innovation

We have developed our own scenarios for the future of safety and emergency. It is important that the overall innovation strategy for the gas network remains flexible rather than using a single vision of the future. The challenges we have identified have been combined under three themes, which are developed below.



Managing gas assets

To efficiently manage the risks associated with ageing assets, we need solutions that allow us to better understand their true condition. With an understanding of these issues, we can then prioritise and target measures to reduce the risks, or in some cases replace pipes and fittings where the likelihood of failure is highest and/or the potential consequences of failure most severe.

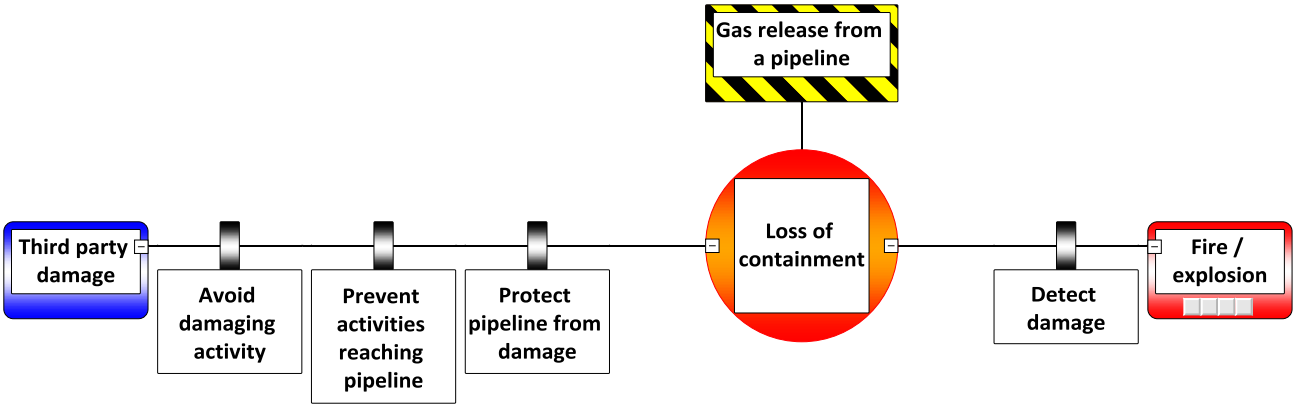
Safety competence

The current age profile of our workforce means there is a significant challenge to maintain competence levels into the future. We need to find innovative ways of passing on knowledge to new gas engineers and appropriate ways to plan the successful succession of personnel who are approaching retirement. We are also carrying out projects in automation and the creation of decision support tools, to aid our workforce in safely carrying out their duties.

The move toward lower-carbon energy supplies will probably bring changes in the composition of the gas being transported through the distribution (and potentially the transmission) network. We're likely to see an increased use of hydrogen either as an additive to natural gas or as a replacement for it. To maintain or reduce safety risks, we'll need to develop new approaches to emergency response. This may involve developing new instrumentation for detecting leaks on the distribution network. We may also need to train operatives to use new detection equipment, and to adopt new or adapted procedures for responding to leaks from a network transporting gas with a lower carbon content, whether it is added hydrogen or even pure hydrogen.

Protecting against third-party interference damage

We have both physical and non-physical methods, and technologies to protect our pipelines from the threat of damage.



We use four general methods to protect pipes and associated equipment; innovative solutions could be developed in any of the following areas:

- Avoidance – preventing potentially damaging activities taking place near our pipelines, for example: through liaison schemes to increase awareness that a pipeline is present and the potential consequences of damaging it; improved third-party access to records of where pipelines are located or methods for detection of non-metallic pipes
- Prevention – solutions that stop a damaging activity from reaching the pipeline may include different types of surveillance or in-ground indicators such as marker tapes
- Barriers – physical protection against the damaging activity such as slabs, increased wall thickness or increased depth of cover
- Damage detection – solutions to identify that damage has occurred before the pipeline fails; examples could include CP monitoring for metallic pipelines or acoustic surveillance.

Safety and emergency innovation strategy

A timeline in Figure 2 shows the safety and emergency theme and how these relate to the Committee on Climate Change carbon budgets.[16] This is only one scenario; others are possible:

- 2020 – Facilitating change (to support delivery of the third carbon budget)
- 2030 – Carbon decreasing (to support delivery of the fifth carbon budget)
- 2050 – Decarbonised energy system.

[16] Carbon Budgets, Department for Business, Energy & Industrial Strategy, July 2016

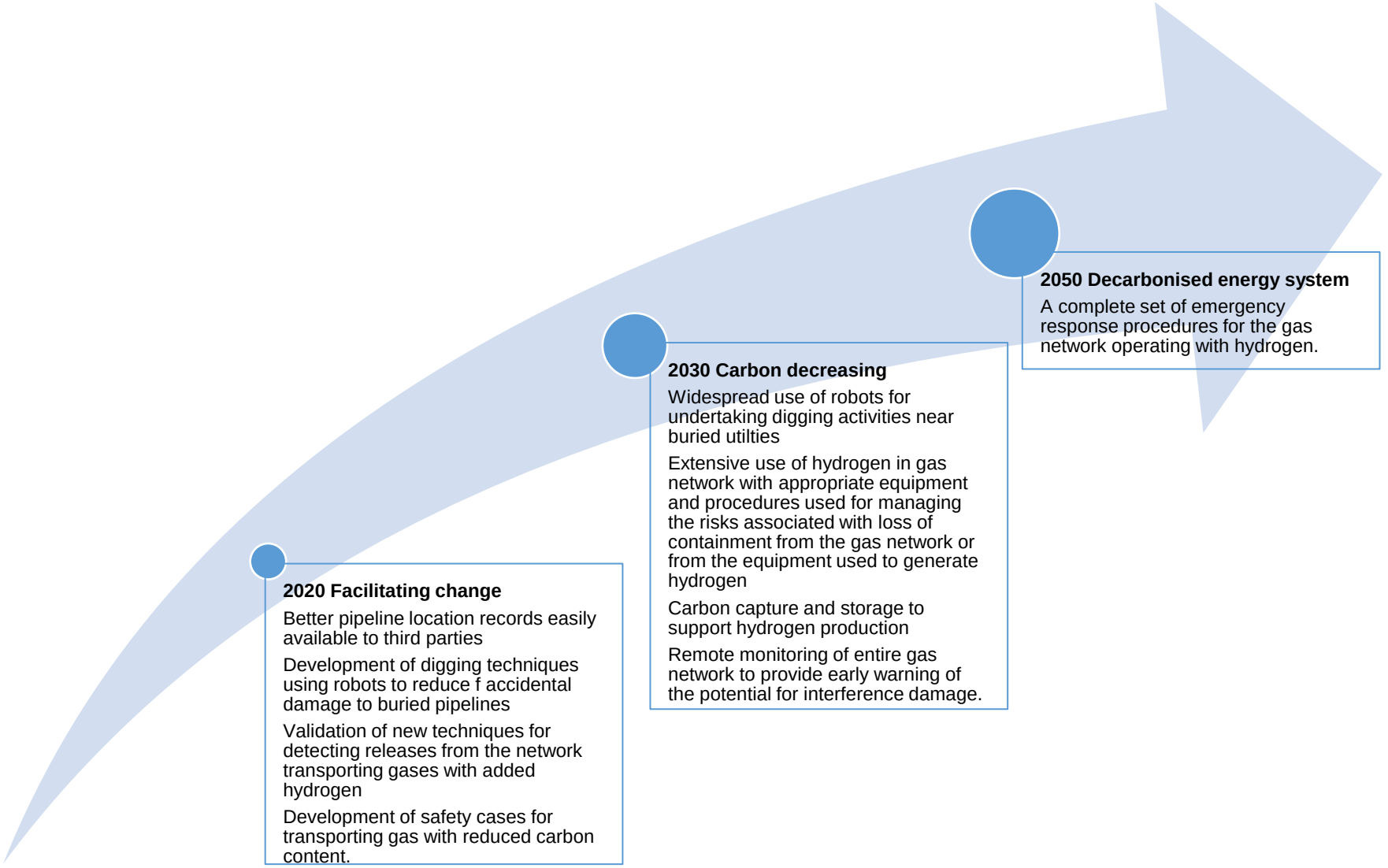


Figure 2 Safety and emergency timeline from 2020 to 2050.

Reliability and maintenance

The gas network is at the heart of the British energy transportation system. It has always evolved to meet challenges. This has included the construction of the National Transmission System (NTS) in the 1960s to deliver natural gas from the North Sea, and the current programme to replace old iron distribution pipes.

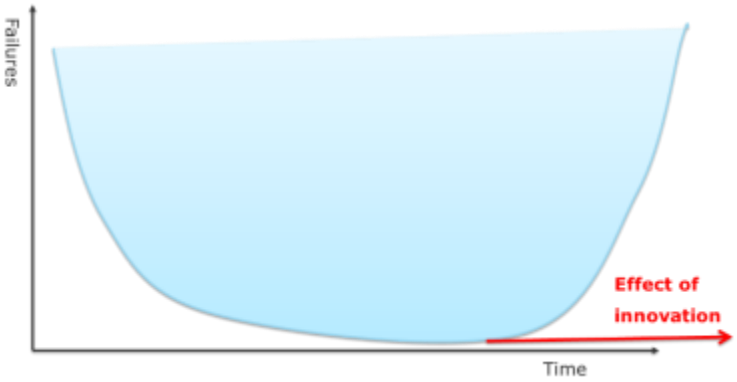
The current gas network provides 99.999 per cent supply reliability. Consumers seldom lose their gas supply, even in the worst winters. This standard must be maintained as the gas network transitions to a range of low-carbon gases.

> The maintenance of the gas network is not just an economic argument. Homes and families need safe, secure heat in the winter and these factors also need to be taken into account.
>
> —Energy Networks Association

A maturing network

Most industrial systems follow the 'bathtub' curve for reliability against time (age). There is a rush of failures after construction, followed by a long period of reliability, and then another increase in failures as the system approaches the end of its working life. This means older systems require more maintenance to maintain their reliability.

The pipes within the gas network are inherently reliable. Inspections have shown that even 100-year-old pipe can be in excellent condition, so pipes can last a long time. However not all pipes can be inspected and so corrosion remains a threat. We still need to maintain and improve our corrosion control and inspection methods. Parts such as valves, pressure reduction devices, filters and governors are likely to be less reliable the older they get.



This suggests that we will need to invest more in maintenance and asset integrity to keep the current reliability standard. Innovation is needed to make maintenance and inspection more efficient and to extend the reliable life of the gas network.

Materials and corrosion control

Corrosion of underground and above-ground assets has become an area of focus for the gas network. The direct and indirect cost of corrosion to USA gas pipelines was estimated to be more than $5 billion per year, and we can assume the UK will be proportionately the same.[17]

The gas network is made of metallic and polymeric materials that were state of the art at the time they were built. The high-pressure NTS was provided with highly effective corrosion control systems using a combination of cathodic protection and coatings. We're replacing the iron pipes in the distribution network with plastic ones that do not corrode.

The cost of corrosion can be controlled with innovative corrosion detection and prevention, the use of new materials with built-in corrosion resistance, and improved paints and coatings.

[17] Corrosion costs and preventative strategies in the United States, US Federal Highway Administration, Report No FHWA-RD-01-156, 2002

Digitalisation

The gas network faces a regulatory challenge to control and reduce costs while maintaining asset integrity and operating safely. The increased use of smart systems, cognitive computing and automation is essential to meet this challenge.

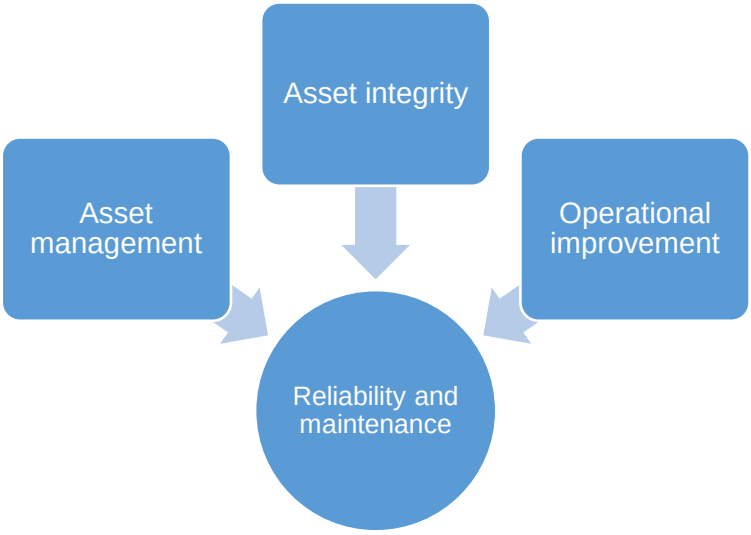
Examples of areas where digitalisation could influence reliability and maintenance include predicting when equipment needs maintenance, using remote controlled or autonomous vehicles for inspection, predicting corrosion, and improvements in the accuracy and accessibility of asset records.

Integration of gas and electricity networks

Gas and electricity networks have some of the same challenges in reliability and maintenance. They both need regular surveys to detect problems such as third-party interference or ground movement. Joint development of innovative survey platforms has already begun. An example is the Beyond Visual Line of Sight Aerial Inspection Vehicle[18] project which aims to set rules for the use of unmanned aerial vehicles (UAVs or drones) for pipeline and power line surveys.

Reliability and maintenance innovation

We have developed our own scenarios for the future of reliability and maintenance. It is important that the overall innovation strategy for the gas network maintains its flexibility rather than using a single vision of the future. The challenges we have identified have been combined under three themes, which are developed below.



Asset management

We will need to continue to manage our assets effectively and in the interests of consumers. This includes aspects such as data management, maintenance scheduling and managing risk. We have effective asset management systems certified to the ISO 55000 standard and innovation is intended to support this by providing improved accuracy, efficiency and value.

We've made considerable progress in asset management of the gas networks. Projects have investigated the use of field data for improved asset records, intelligent 3-D modelling, considering climate change impact and the development of asset health 'criticality index' (the relationship

[18] Beyond visual line of sight aerial inspection vehicle, Northern Gas Networks, Northern Powergrid, Scottish and Southern Electricity Networks, Scottish Power Energy Networks, Scotia Gas Networks, and UK Power Networks

between the probability of failure and the consequence of that failure) Work continues improving digital systems for capturing and working with asset data.

Asset integrity

Maintaining the integrity of the gas network will remain essential in the future. The asset integrity theme covers the continued performance of the network's primary function of transporting gaseous fuels cost-effectively and safely. This includes aspects such as pipeline surveillance, corrosion control and inspection.

Several projects have looked at replacing the current helicopter pipelines surveys with alternative platforms and sensor suites. Work continues to explore the use of UAVs for pipeline surveys and inspections. Remote inspection using robotic systems is a focus area. Some projects have explored the potential of new coating and anticorrosion technologies, along with using more composite materials.

Operational improvement

Several projects have investigated more efficient methods of gas preheating, which is needed in some situations before gas can be reduced in pressure, and some trials are under way. Other work has examined more flexible compressor installations, wireless sensor technology and improving the efficiency of actuated valves. Moving toward smart operation, we need to see more innovation to link sensors and remote operation across the gas network.

Reliability and maintenance innovation strategy

A timeline in Figure 3 shows the reliability and maintenance theme and how these relate to the Committee on Climate Change carbon budgets.[19] This is only one possible scenario and others are possible:

- 2020 – Facilitating change (to support delivery of the third carbon budget)
- 2030 – Carbon decreasing (to support delivery of the fifth carbon budget)
- 2050 – Decarbonised energy system.

[19] Carbon Budgets, Department for Business, Energy & Industrial Strategy, July 2016

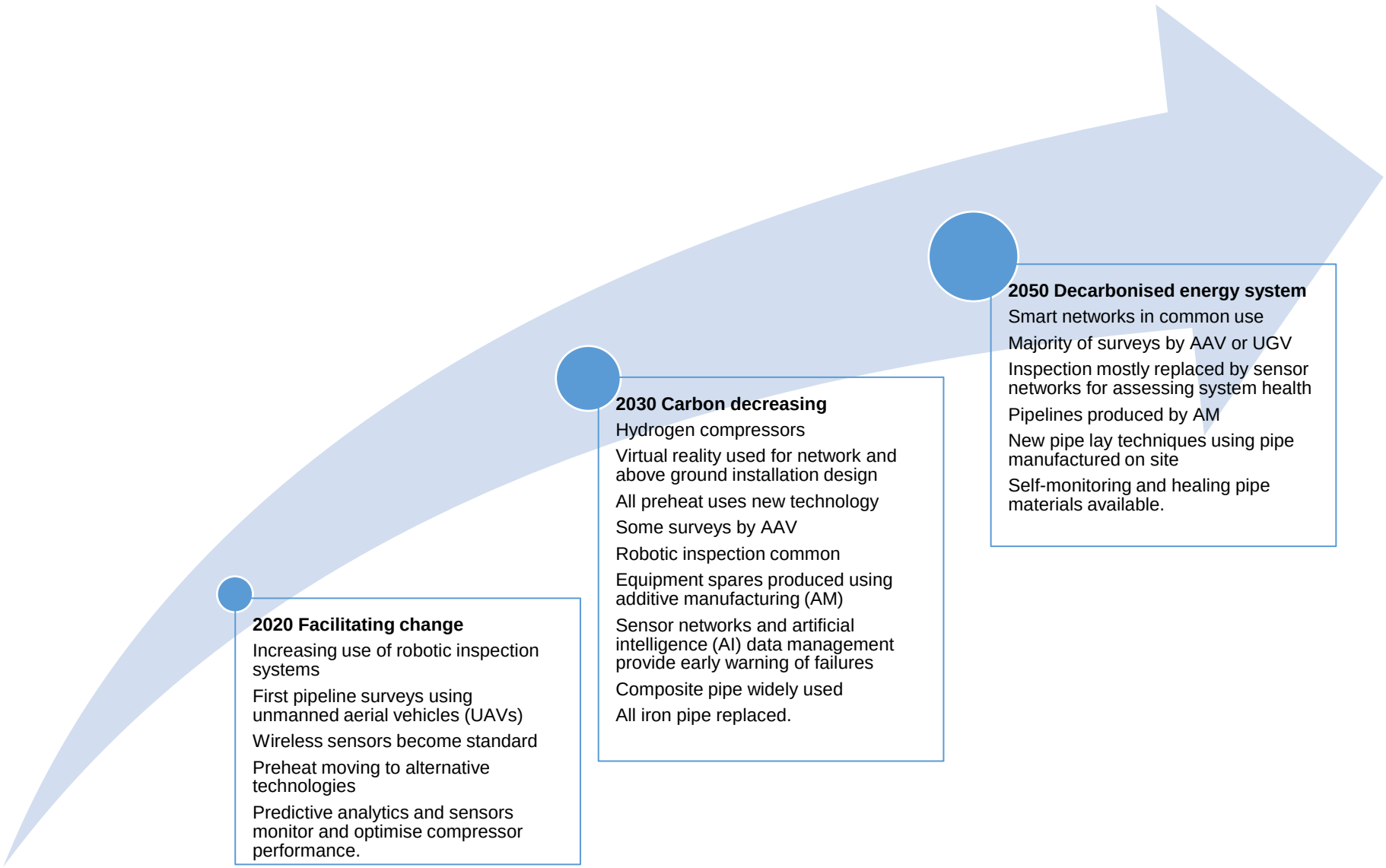


Figure 3 Reliability and maintenance timeline from 2020 to 2050.

Repair

Reducing the country's dependency on natural gas for heat will be a critical factor in meeting the 2050 targets for greenhouse gas emissions, set out in the Climate Change Act. Currently more than 80 per cent of buildings are heated by gas transported through the gas network.[20]

The gas industry has recognised for some time that the gas network has a role to play in the future of Britain's energy mix.

> Despite being the source of the majority of the emissions from heating today, by transporting low-carbon gases (instead of natural gas) the gas grid could still play a critical role in a decarbonised future.
>
> —Policy Connect

Parts of the distribution network are more than 100 years old and need repairs if we are to continue using them safely. We are modernising the gas network under the Health and Safety Executive's enforcement policy for the replacement of iron gas mains 2006–2013[21] and will continue to do so for the next 15 years.

Sometimes repairs are also required on the higher pressure gas transmission networks. Current methods are effective but there are innovation opportunities for the use of new materials or repair tools to improve capability and efficiency.

Asset data

We need good data on assets to be able to manage and maintain our gas network. Current innovation projects have helped us acquire large amounts of asset data, but we can do more.

Increased digitisation and a single platform approach to asset data management will improve:

- Understanding of the gas network's condition and risk management
- Flexibility of access to the gas network
- Third party planned interaction and interference prevention
- Efficient usage of network capacity.

Asset life

When we monitor the condition of the gas network, we normally focus on the metallic pipework, typically cast iron, ductile iron and carbon steel, to ensure these assets remain fit for purpose. In the timescale covered by the carbon budgets we will also need to begin monitoring polyethylene (PE) pipe. This will drive the need to develop risk registers and health indices further.

It is reasonable to expect that shrinkage from the gas network (gas used within the network or lost) will reduce over time to very low levels. The replacement of the iron gas mains, along with the refurbishment of reliable metallic sections of the network, will provide us with the flexibility to increase pressure, and reduce our reinforcement and service replacement activities.

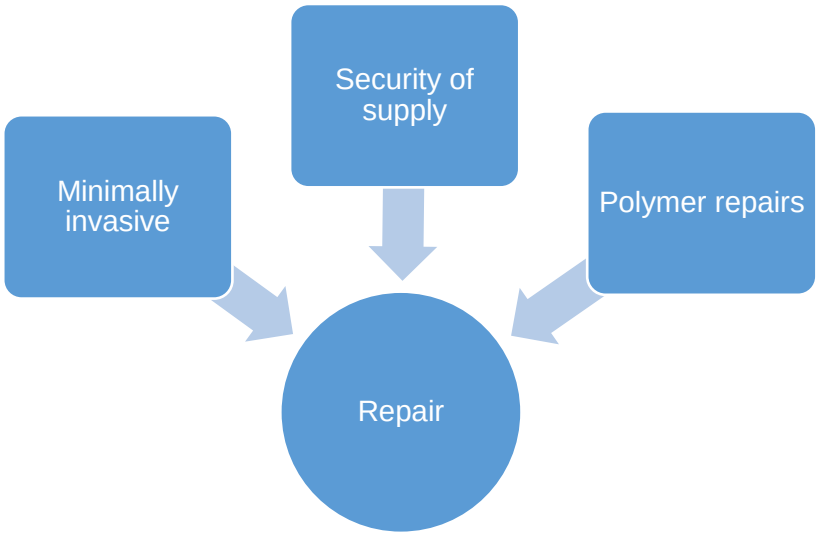
Integration of gas and electricity networks

There are similar challenges to repairing gas and electricity networks. They are buried in towns and cities and we have to dig to reach them. We can minimise the disruption this causes to consumers through cooperation between the gas and electricity networks. Innovations that have resulted in benefits for electricity projects could create similar benefits for gas projects, and vice versa.

[20] Future gas series – Part 1 - Next steps for the gas grid, Policy Connect, September 2017
[21] Enforcement Policy for the replacement of iron gas mains 2006-2013, Health and Safety Executive, December 2005

Repair innovation

We have developed our own scenarios for the future of repair. It is important that the overall innovation strategy for the gas network remains flexible rather than using a single vision of the future. The challenges we have identified have been combined under three themes, which are developed below.



Minimally invasive

We have seen a dramatic move away from open-cut pipeline installations over the past 20 years. We have new, less intrusive methods of accessing the gas network. Keyhole technology gives us opportunities to move further along this path, with mains insertion techniques currently being developed.

The techniques we use for repairing the network will need to adapt to new technologies. For example, we would like to see robotic internal repair of PE pipes using the direct injection of polymers. Another example is the increased use of corrosion resistant composite materials for repair of higher pressure transmission pipe and fittings and innovation will contribute to the effectiveness of these techniques.

Security of supply

The industry is moving away from the use of squeeze-off tools for stopping PE pipe flow. The use of bags and stopple techniques, traditionally for metallic pipework, has been successfully adapted. We would like to see further developments, such as patch repair electrofusion techniques on live gas leakage.

Polymer repairs

As the gas network becomes increasingly PE or advanced high pressure capable composite pipes, we need to expand our focus from inspection and repair techniques on metallic parts of the network alone to include techniques applicable for use on plastics and composites.

Repair innovation strategy

A timeline in Figure 4 shows the repair theme and how these relate to the Committee on Climate Change carbon budgets.[22] This is only one scenario and others are possible:

- 2020 – Facilitating change (to support delivery of the third carbon budget)
- 2030 – Carbon decreasing (to support delivery of the fifth carbon budget)
- 2050 – Decarbonised energy system.

[22] Carbon Budgets, Department for Business, Energy & Industrial Strategy, July 2016

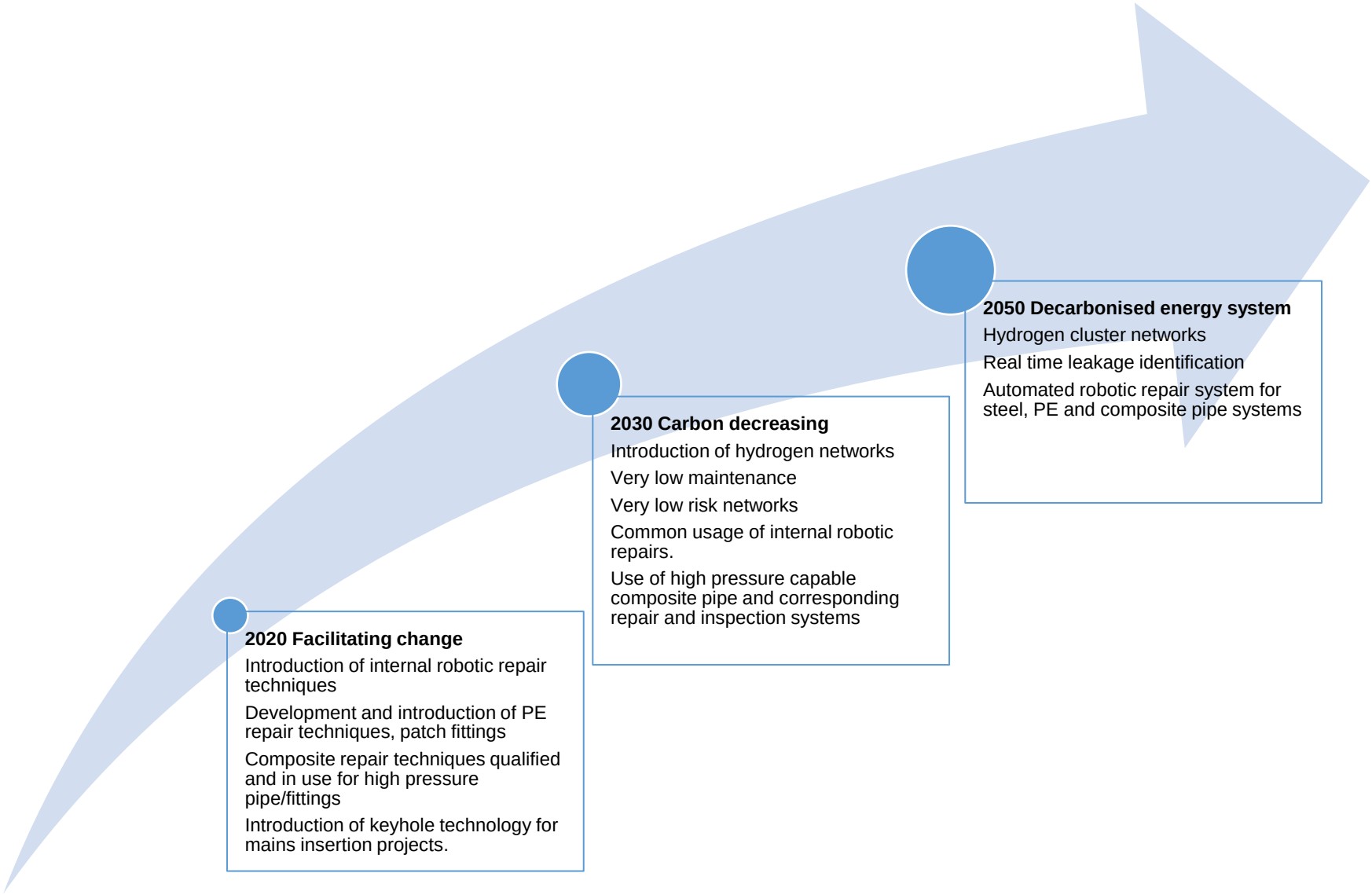


Figure 4 Repair timeline from 2020 to 2050.

Distribution mains replacement

The gas distribution network is complex and has a 200 year history. Some of it was built in Victorian times, and continues in use today. Older cast iron gas pipes can fail through corrosion and fracture. Newer parts of the network are built from polyethylene plastic (PE), with a design life of 80 years, while old iron mains are now being replaced with PE. Although this work began nearly 40 years ago, the start of the Iron Mains Risk Reduction Programme (IMRRP – also known as the '30/30 Programme') in 2002 accelerated that work to a level that was estimated to be as fast as practicable at that time given the potential risk and the resources required.

The work is driven not only by health and safety considerations, but also by a desire to reduce leakage of natural gas into the atmosphere where it contributes to climate change. Additionally, PE pipe also future proofs the gas network, leaving open the option of using existing infrastructure long into the future.

With these three benefit areas in mind we continue to review our mains replacement strategy.

The current 30 year Mains Replacement programme replaces enough metallic pipe every year to stretch from London to Adelaide and back.

Mains replacement prioritisation

Mains replacement was a huge undertaking when it started in the late 1970s due to the extent of the network. We have developed statistical and analytical methods, culminating in the Mains Replacement Prioritisation Scheme (MRPS) which estimates the likelihood and impact of failure by looking at the history of the gas main, including earlier failures, and its surroundings. The combination of these factors gives an indication of the risk that can then be used to prioritise higher-risk mains for replacement earlier than lower-risk ones. MRPS is invaluable for selecting mains for replacement within a large population, to achieve maximum reduction in risk as efficiently as possible. All iron mains of diameter less than or equal to 8 inches (20 centimetres) that are within 30 metres of a property will be replaced over a 30 year period, which ends in 2032.

Construction methods

Typically, when we replace an iron main with PE, we replace the full length of the gas main. We can use insertion (which is where the new pipe is pushed into and through the old one) to avoid digging up roads. Live insertion can reduce the time that consumers are without gas during the process. We have now replaced a large proportion of the Tier 1 (≤8 inch diameter) gas network. Some larger diameter pipes in Tier 2 (8 inch to 18 inch diameter) have also been replaced, with the largest category, Tier 3 (≥18 inch diameter), being identified by localised risk assessment and economic considerations.

Replacement by PE is usually straightforward, but we recognise that the standard of jointing of PE is critical and can compromise the integrity of the gas network if it is not done correctly. Simpler methods of making joints would help reduce the cost and improve the integrity of the gas network.

Improved management, control and audit of joint operations has the potential to drive up quality and increase confidence in the PE assets.

Integration of gas and electricity networks

There are similar challenges to replacing gas and electricity networks. They are buried in towns and cities and we have to dig to reach them. We can minimise the disruption this causes to consumers through cooperation between the gas and electricity networks. Innovations that have resulted in benefits for electricity projects could create similar benefits for gas projects, and vice versa.

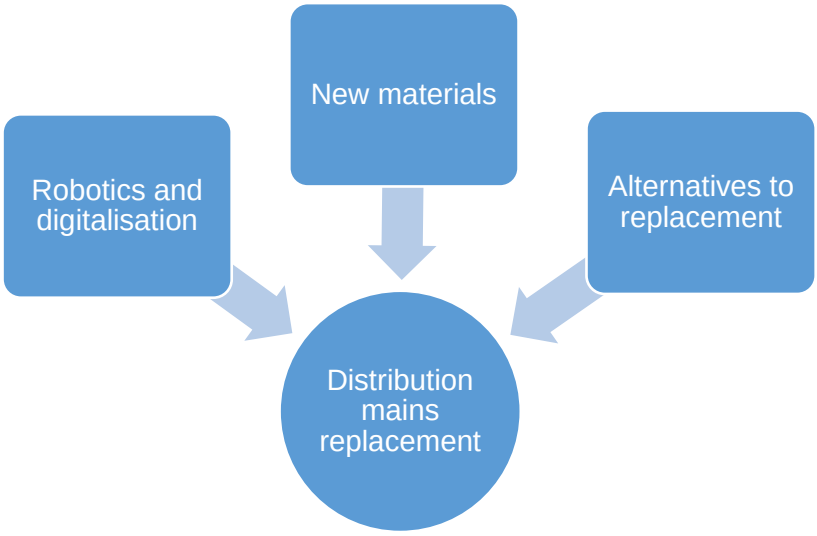
There is a synergy between gas and water distribution networks in the area of asset condition assessment and PE jointing quality. Both have been persistent issues in the water industry, and there is clear scope for both industries to co-operate more closely to improve iron main asset monitoring and intervention, and improving PE network construction quality, to ensure the design life is met and ideally exceeded.

Operational challenges

There are operational challenges facing the distribution mains replacement programme which innovation could help us meet. These include a general reduction in the number of large scale mains replacement projects and labour market pressures. Smaller projects mean more frequent mobilisation and demobilisation of engineering teams, equipment and support services and result in adverse cost pressure and increase the number of main to main connections. An increase in the number of utility and other infrastructure developments across the country is increasing pressure on resources due to increasing demand for skilled labour.

Distribution mains replacement innovation

We have developed our own scenarios for future distribution mains replacement. It is important that the overall innovation strategy for the gas network maintains its flexibility rather than using a single vision of the future. The challenges we have identified have been combined under three themes, which are developed below.



Robotics and digitalisation

Advances in in-pipe inspection have been made with robotics that is allowing us to measure the remaining pipe wall of old iron mains over a much greater area without widespread excavation and coupon extraction. The results from these investigations have provided a snapshot of their condition. Coupled with an understanding of time in service and corrosion mechanisms, the results could help assess the rate of deterioration against in-service life. This may enable us to defer the cost of mains replacement by enabling interim measures, such as condition monitoring, to be used instead. The improved data quality may also allow us to focus on the targeting of the higher-risk parts of the gas main with much greater accuracy, leaving in service the parts of the main that are in

good condition. We would like to develop the technology to include larger mains (≥12 inch), and to be able to accurately map the stress in the pipe wall at critical locations.

These initiatives could be leveraged to obtain maximum benefit from the data being produced. We would like to see better coordination of data from various sources, an industry-wide portal/data repository for interrogation at high level, and new methods of analysis that will not only identify but also predict problems.

New materials

We are currently replacing mainly iron mains with PE. Plastics that could be used other than PE are of interest, as are new ways of connecting pipes that do not include fusion or mechanical joints. Using alternatives to PE pipe could remove the need to hold a large stock of PE pipe, and could be laid more quickly on site.

Alternatives to replacement

Whilst exploring new materials PE remains our preferred material at this time for replacing low and medium-pressure gas mains. It has a 80 year minimum design life, although this is likely to be an underestimate. A small proportion – mainly above ground pipe, is replaced in steel. More detailed analysis of gas mains condition could enable us to rate the gas main condition at a much higher level of granularity than previously. This could be used to determine a preferred strategy ranging from replacement, through selective replacement, joint repair, or putting an enhanced monitoring regime in place for the medium term.

We would like to develop decision support tools based on detailed survey data, for more efficient management of asset condition. Being able to detect leaks more effectively would allow us to repair pipe in a more efficient and targeted way.

Where the iron mains population appear to be in reasonable condition after many decades of service, and their condition assessment is favourable, replacement may not be value for money. The greatest remaining risk is leakage from the joints between each pipe section. Proven remediation methods using anaerobic sealant injection have been found to reduce joint leakage, but these require excavation of the road at each joint location. We would like to consider other risk reduction methods such as large-diameter joint sealant, and cured in place linings, as alternatives to mains replacement and asset life extension. These technologies could also help us more efficiently remediate gas riser pipes within buildings.

Distribution mains replacement innovation strategy

A timeline in Figure 5 shows the repair theme and how these relate to the Committee on Climate Change carbon budgets.[23] This is only one scenario and others are possible:

- 2020 – Facilitating change (to support delivery of the third carbon budget)
- 2030 – Carbon decreasing (to support delivery of the fifth carbon budget)
- 2050 – Decarbonised energy system.

[23] Carbon Budgets, Department for Business, Energy & Industrial Strategy, July 2016

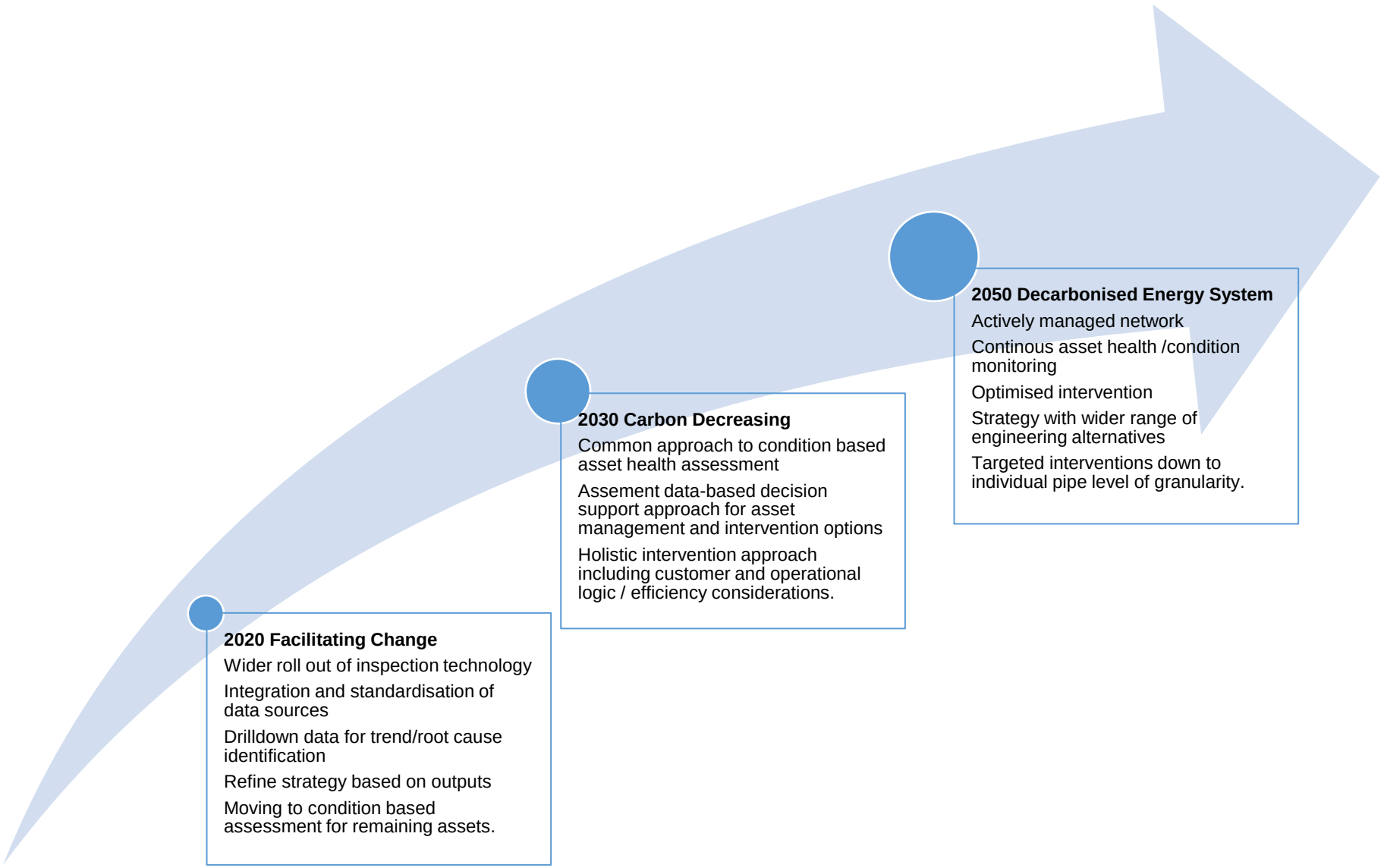


Figure 5 Distribution mains replacement timeline from 2020 to 2050.

Security

Cyber and information security is rarely off the top of the news agenda. With progress towards a smart energy future and ever increasing connectivity there is an opportunity for those wishing to do harm to our critical national infrastructure. We will face an increasingly sophisticated threat in coming years and need to continually innovate to improve both our physical and cyber security.

> In 1999 attackers used a Trojan Horse tool delivered by an insider to assume control of the Russian Gazprom gas pipeline network for several hours.
>
> —5th European Conference on Information Warfare and Security

Organised crime or state sponsored attacks

In the coming years, methods traditionally seen limited to nation states will become increasingly available to organised criminals. In 2015, attacks on three Ukrainian electricity distribution network operators resulted in power outages to more than 225,000 people. That incident demonstrates the impact and effectiveness of multi-tiered attack in accessing business networks, stealing security credentials and overwriting control device firmware. It highlighted the need for energy networks to be resilient and able to fend off prolonged and varied attacks whose true scope and intent may not be apparent even after a breach is discovered.

The UK government has committed to implementing the Network and Information Systems (NIS) Directive from May 2018. The EU's General Data Protection Regulations (GDPR) framework also comes into force in May 2018. These changes in legislation will require us to find innovative ways to reduce the threat to the gas network.

Convergence of Information and Operational Technology

The gas network increasingly relies on data acquisition and control devices and systems to manage plant and equipment. Operational technology (OT) systems have traditionally been isolated from information technology (IT) systems by a physical 'air-gap', but as the demand for operational data and remote maintenance increases, supervisory control and data acquisition (SCADA) and distributed control system (DCS) hierarchies are becoming interconnected. This provides opportunities for exploitation.

Our increasing need for interoperability (the ability for devices and systems to communicate) and interchangeability (the ability for devices to be exchanged without losing or degrading service) means more devices and systems are based on standardised application and networking technology. This standardisation presents an opportunity for organisations and individuals with malicious intent.

Gas and asset theft

Security of plant, equipment and gas is an increasingly common issue that impacts gas network operations, competition, privacy, safety and, ultimately, the cost to consumers. Securing sites and equipment requires more sophisticated protection measures and near real-time monitoring to deter, prevent and detect theft.

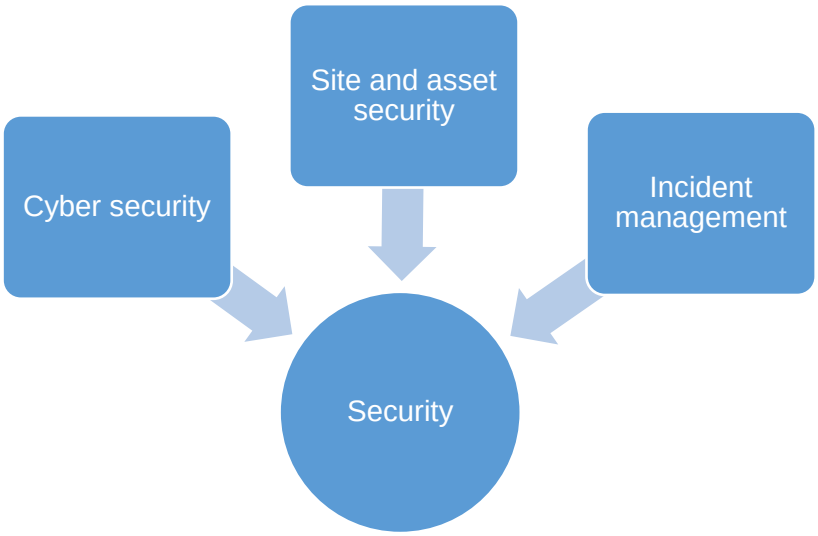
Integration of gas and electricity networks

These challenges are not unique to the gas network, and are at least as important to the electricity network and all other parts of the transmission and supply chain. Decentralised generation in the electricity market is already giving criminals more ways to attack electrical systems. The aggregation of distributed sources of renewable generation, decarbonisation of heating, electric vehicles, and the proliferation of energy storage present their own cybersecurity challenges for the electricity market. It will take a collective effort to deploy smart grids and smart meters to ensure

organisations, systems and people are sufficiently prepared for a dramatic increase in the volume and ingenuity of attempted attacks.

Security innovation

We have developed our own scenarios for their future security requirements. It is important that the overall innovation strategy for the gas network maintains its flexibility rather than using a single vision of the future. The challenges we have identified have been combined under three themes, which are developed below.



Cyber security

The release of so-called exploits that target vulnerabilities in standard systems (such as computer operating systems) will become more widespread, requiring more focus on ensuring that systems are up to date. We will need to install patches quicker to reduce the time when our systems are vulnerable. More detailed reference systems (on which updates can be tested) and greater use of automated testing will help us achieve this.

The existence of such exploits, targeting traditional IT systems, makes it even more important to segregate IT and OT systems, to limit the extent of any compromise. We must be careful to maximise usability while minimising the opportunity for attackers to access all parts of a network.

Advanced attacks will drive the need for smarter monitoring of networks which, in turn, will promote better analytics relating to monitoring and logging. A smarter gas network will generate massive amounts of data which must be securely acquired, validated, stored and processed. Big data sets will require artificial intelligence (AI) techniques to assist in their analysis.

Site and asset security

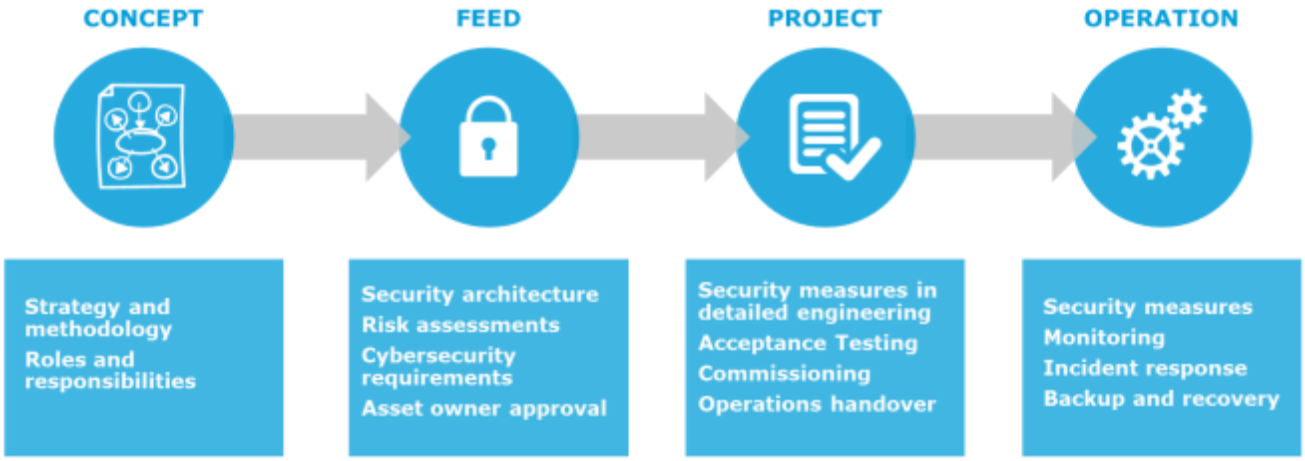
Smart grid presents opportunities to improve the protection of physical assets and data from unauthorised access, loss and malicious damage. Intelligent and connected site security and electrical and instrumentation (E&I) technology will help us develop more effective detection and prevention of illicit activities that compromise our equipment and data centres.

Incident management

The government's most recent figures[24] show that only 10 per cent of businesses have a cyber security incident management plan in place. As part of our national infrastructure, we realise the need for effective incident response and recovery of security events that, if uncontained, can cause mass disruption of operations, disclose sensitive data, and increase the risk of harm to life.

[24] Cyber Security Breaches Survey, Department for Culture, Media and Sport (April 2017)

Organisations operating an industrial automation and control system (IACS) should have a cyber security management system (CSMS) in place. Emerging security standards will help us implement, manage and operate IACS management systems typically based on established practices including ISO 27001.



Security innovation strategy

A timeline in Figure 6 shows possible future developments on the security theme and how these relate to the Committee on Climate Change carbon budgets.[25] This is only one scenario; others are possible.

- 2020 – Facilitating change (to support delivery of the third carbon budget)
- 2030 – Carbon decreasing (to support delivery of the fifth carbon budget)
- 2050 – Decarbonised energy system.

[25] Carbon Budgets, Department for Business, Energy & Industrial Strategy, July 2016

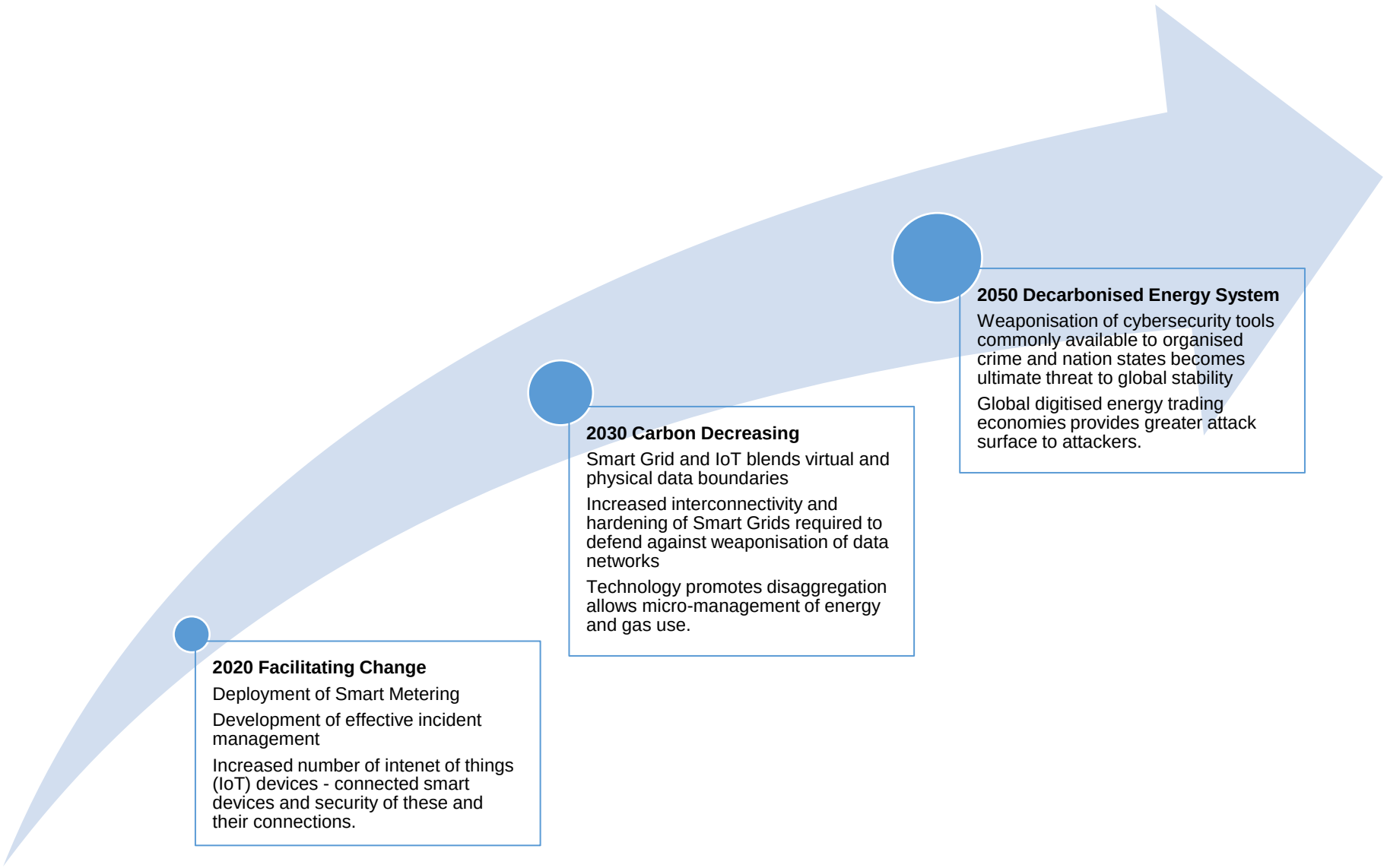


Figure 6 Security timeline from 2020 to 2050.

Environment and low carbon

Improving our environmental performance is more important than ever for us. The impact of the gas network on the environment must be managed from both a local and global perspective, considering issues such as gas leakage and venting during field operations to dealing with contamination during decommisioning and remediation of legacy gas industry sites. Sustainability is fundamental to the future of the gas network and reducing environmental impact and costs, for example if we treat spoil from excavations and use it in place of raw materials.

> The total amount of greenhouse gas (GHG) emissions caused by the methane emissions from natural gas transmission and distribution networks is estimated to be between 0.5 per cent and 0.9 per cent of the total of anthropogenic GHG emission (CO_2 equivalents) in Europe (EU28).
>
> —Marcogaz

Emissions

Methane, the primary constituent of natural gas, has a global warming potential twenty-five times that of carbon dioxide (CO_2),[26] which means gas emissions are a significant part of our carbon footprint. Our gas emissions may come from planned events such as venting pipes for routine maintenance, emergency activities, or through small leaks in joints, valves and other equipment.

We consider noise from operational gas equipment, such as above-ground installations and compressors, an environmental nuisance for our neighbours. If our sites cannot control their noise emissions, we could find future asset development held up or even rejected at the planning stage.

Use of natural resources

Natural resources are finite. We are committed to reducing the amount of raw materials we use through reducing, reusing and recycling materials wherever possible.

Contaminated assets

When assets – like gasholders and the sites of old gasworks – are no longer needed, we want to see the land they occupy put to other uses. First the equipment needs to be removed and the land cleaned. Current decommissioning techniques are often not efficient or cost-effective and we must be careful not to expose our workforce to health hazards from contaminants such as hydrocarbons, heavy metals and volatile organic compounds. There is also an environmental risk from water that may have accumulated in the assets. We need new methods to treat and dispose of this efficiently while continuing to protect the local environment.

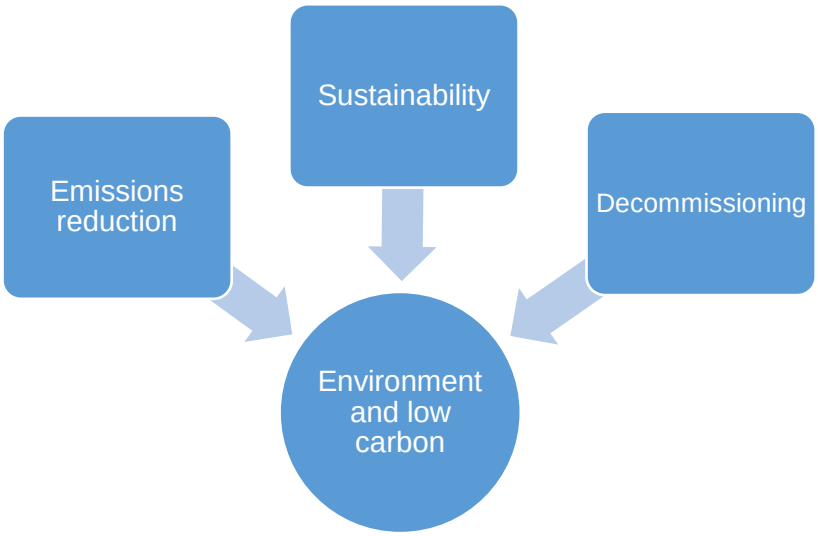
Integration of gas and electricity networks

We see opportunities to minimise both the disruption to consumers and the environmental impact of projects through cooperation between the gas and electricity networks. For example, we might reuse materials from a gas holder demolition on a new electricity asset, or coordinate excavations to repair both types of assets simultaneously. Innovations that have produced environmental and low-carbon benefits for electricity projects could create similar benefits for gas projects, and vice versa.

Environment and low-carbon innovation

We have developed our own scenarios for the future of environment and low carbon. It is important that the overall innovation strategy for the gas network remains flexible rather than using a single vision of the future. The challenges we have identified have been combined under three themes, which are developed below.

[26] Climate change 2007: Working group I: The physical science basis, IPPC, 2007



Emissions reduction

Innovation over recent years has focused on reducing gas emissions and projects have made progress in capturing vented gas and identifying small leaks. However, these new techniques are expensive and some come with lifecycle carbon costs. We need further innovation to reduce gas emissions in a more cost-effective and sustainable way.

To avoid planning application delays or rejections because of complaints about the noise of the gas network's existing operations, we're looking for innovative ideas for making our operations run quieter without putting up obtrusive structures. This could be through novel sound barriers or silencers on noisy equipment or processes.

Sustainability

Sustainability is high on our agenda. The benefits of minimising the social, economic and environmental impacts of our projects are well-known, and form a core part of the recently revised ISO 14001 environmental management system standard to which we are certified. By using sustainable resources, we can minimise the impact of our projects on the environment. However, we need further innovation to improve the sustainability of routine network operations, from the use of onsite renewable power generation for remote installations, to reuse of materials such as excavated spoil during replacement and repairs.

We have made progress in reusing materials, but we need more ideas to drive sustainability throughout the project lifecycle, and to improve the quality of recycled materials used for excavation reinstatement. The use of renewable power generation onsite (especially in remote locations) requires further innovation to ensure the power sources are reliable in all conditions.

Decommissioning

We are currently decommissioning gas holders and other assets will require dismantling, treatment and disposal to return the land to other use. Current techniques are often labour-intensive and risky. For example, when desludging a gas holder before demolition, we often need to enter the gas holders and manually scrape the sludge into bags. We have made progress in this area but further innovation is needed to reduce risks and improve efficiency in decommissioning, including wastewater treatment and disposal, demolition and remediation of the contaminated land.

Environment and low-carbon innovation strategy

A timeline in Figure 7 shows possible future developments on the environment and low-carbon theme and how these relate to the Committee on Climate Change carbon budgets.[27] This is only one scenario and others are possible:

- 2020 – Facilitating change (to support delivery of the third carbon budget)
- 2030 – Carbon decreasing (to support delivery of the fifth carbon budget)
- 2050 – Decarbonised energy system.

[27] Carbon Budgets, Department for Business, Energy & Industrial Strategy, July 2016

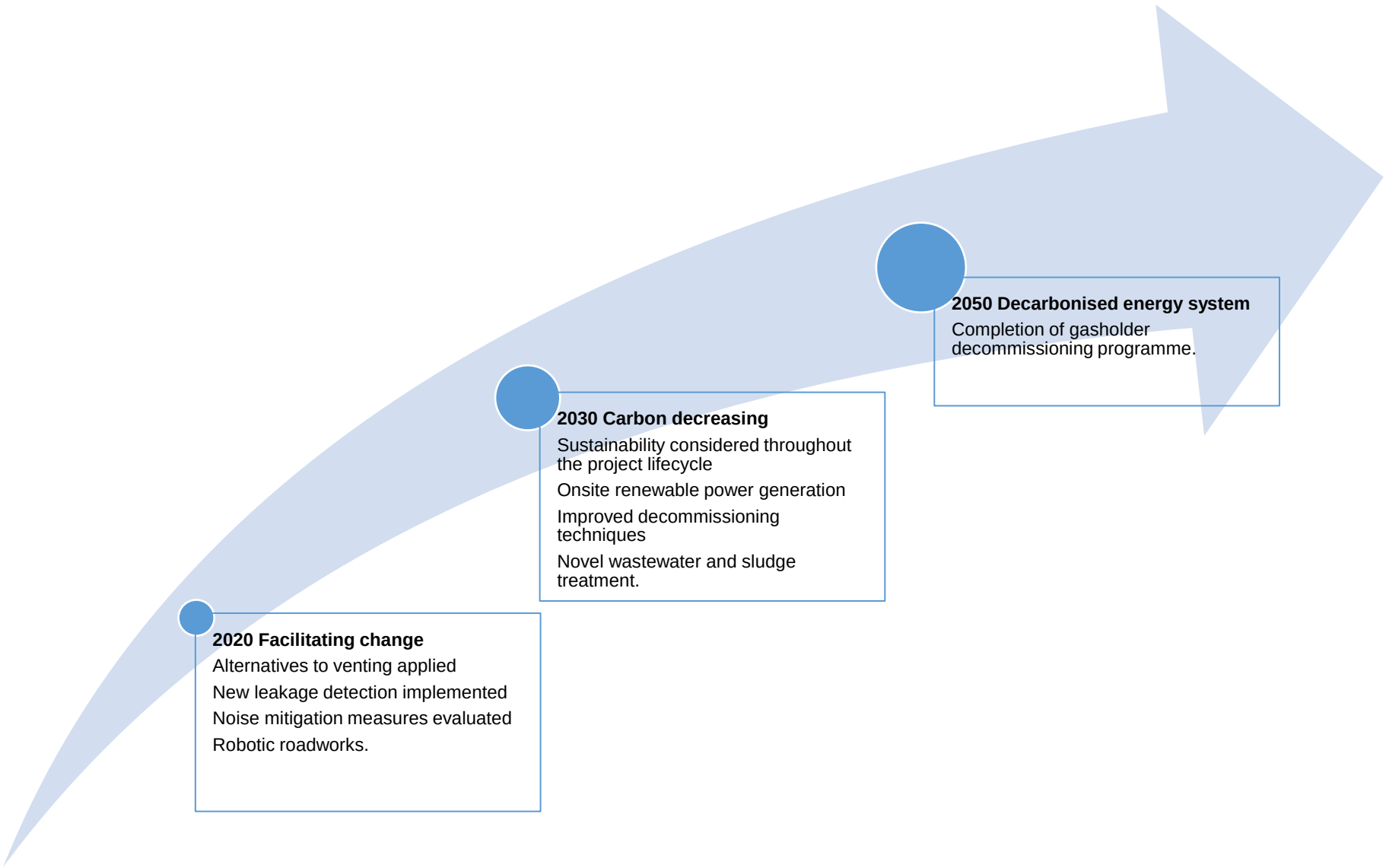


Figure 7 Environment and low-carbon timeline from 2020 to 2050.

Conclusion

To achieve these objectives, we must coordinate our activities on innovation projects. We will continue to work closely together and share what we learn from our innovation activities with the rest of the energy industry. We look forward to hearing from you with your ideas for projects and any feedback you may have on our strategy.

Coordination and sharing learning

We will:

- Embrace our obligation to keep our innovation projects open and transparent
- Ensure transparency of value for money, knowledge dissemination and direct partnership
- Support the ENA's Innovation Governance Group as a collaborative forum
- Look to develop the ENA Smarter Networks Portal
- Respond quickly and positively to requests for innovation project information and learnings
- Encourage the sharing of information and learning through publishing papers, articles and by presenting at conferences
- Collect, store, share and reuse datasets generated through innovation projects wherever possible
- Continue to look for new ways to share our innovation activities and learning.

Addressing gaps and new challenges

We will:

- Regularly review the technological, social, environmental and economic drivers that may affect the gas network
- Keep our innovation project portfolios under review so we address gaps wherever possible
- Manage the flexibility of our innovation project portfolios so we address future uncertainties
- Engage with our workforce, the wider industry and academia to identify opportunities for innovation
- Engage with our supply chain, partners, universities and others to identify opportunities for innovation
- Regularly call for innovative solutions to specific challenges
- Jointly hold regular reviews of this strategy to ensure it remains up to date and relevant.

Smarter networks portal

The ENA's Smarter Networks Portal includes a complete list of all current and previous innovation projects that have been funded under the Network Innovation Allowance (NIA) and Network Innovation Competition (NIC) mechanisms and can be found at: http://www.smarternetworks.org.

Exemplar projects

Future of gas

Flexible network

Project CLoCC

The objective of project CLoCC is to minimise the cost and time of connections to the National Transmission System (NTS), with a focus on unconventional gas connections. This will be achieved through fundamentally challenging every aspect of the current connection process, building on worldwide 'best in class' technology and practice.

Biomethane connection guidelines

This project developed guidelines for biomethane producers to clarify the requirements for connection to the gas distribution network. The guidance contained best practice recommendations for aspects such as gas quality, dryness, flow rates and monitoring methods.

Opening up the gas market

Two key concerns for British energy consumers are price and security of supply; together with the need to reduce carbon emissions, these form the energy trilemma. Opening Up the Gas Market, a project for the Network Innovation Competition, sought to demonstrate that it is safe to distribute and use gas meeting the specification of the European Association for the Streamlining of Energy Exchange (EASEE) but sitting outside GS(M)R. Moving to the higher Wobbe number gas makes 90 per cent of the global LNG supplies available, a significant improvement over the 10 per cent currently suitable. This project has been completed and work on changing the GS(M)R limits continues.

Real-time networks

The Real-Time Networks project will demonstrate how a flexible gas network is more efficient for the evolving energy market and for meeting changing consumer demands and behaviour. Unconventional and green gases increase security of supply but the demand and supply calculations we use need to be updated to reflect the continuously changing energy content of the gases flowing in the network.

Decarbonisation

H21 Leeds Citygate

The H21 Leeds City Gate project is a study to determine the technical and economic feasibility of converting the existing natural gas network in Leeds, one of the largest UK cities, to 100 per cent hydrogen. The project has shown that the network has the correct capacity for conversion and the existing heat demands of Leeds could be met utilising steam methane reforming technology, supported by salt cavern storage for high peak demands.

HyDeploy

This project is intended as a practical demonstration of using hydrogen blends within a closed gas network at Keele University. It will include engagement with local industrial and domestic consumers, testing of appliances, development of operational and safety procedures and staff training. The project will include a quantitative risk assessment to gain an exemption from the GS(M)R regulations and will include making billing arrangement acceptable to Ofgem. Later phases will include the installation of hydrogen production plant and finally the live trial of the hydrogen network.

Future billing methodology

This project explores options for a new type of billing methodology for the gas industry that will provide consumer benefits in a lower-carbon future. The current flow-weighted average calorific value (CV) billing regime restricts entry to unconventional gases that comply with GS(M)R. Additional expensive processing is required to match the CV of the primary inputs. The project explores options for assigning CV at a more specific level, to avoid processing, and could provide a more robust attribution of gas energy to consumers.

Enabled consumers

FREEDOM project

The FREEDOM (Flexible Residential Energy Efficiency, Demand Optimisation and Management) project is a large-scale demonstration trial of smart hybrid heating systems to understand the benefits of transitioning domestic heat into a demand-side response market. It is the first collaborative project between the electricity and gas networks. The objectives are to:

- Use smart switching between gas and electric load to combine the simultaneous purchase of fuel and the sale of heat – so-called fuel arbitrage – to create value and offer highly flexible services that match energy supply with consumer demand for heat
- Demonstrate and record the potential consumer cost, carbon emissions and energy system security benefits from the large-scale deployment of hybrid heating systems
- Gain insight into balancing the interests of ourselves, our consumer, and our suppliers.

Bridgend future modelling

Using Bridgend, a typical town in South Wales, researchers carried out a series of case studies to model future energy demand, potential ways to meet that demand and the ability of the residents to pay for the changes. The projects used a bottom-up approach to examine the best options for moving to low-carbon heating for the town's consumers. The study found that electric heat pumps increase emissions and costs to consumers, compared with the continued use of the gas network. Research shows that renewable gas such as biomethane require lower investment than other renewables and can help to keep cost to the consumer down while working to meet carbon targets. The project highlighted further areas for innovation, including more research on the impact of widespread combined heat and power (CHP) roll-out, the role of biomethane and other distributed sources of gas, hydrogen and power-to-gas.

The research has been shared with policy makers to support investment in a low-carbon energy future.

Safety and emergency

Managing gas assets

Asset health modelling

This project developed a risk-based condition model to determine the probability of failure of pressure reduction and governor assets.

PE asset life research

This project will develop methods to assess the condition of polyethylene (PE) pipes and fittings, and determine their remaining service life. The project aims to develop a scheme to manage and rank ongoing risks to the PE distribution network which demonstrates to regulatory authorities that control of these primary assets is being maintained in a safe and planned manner.

Development of a risk based approach for safe control of operations

This project developed an innovative approach to the selection of suitable methods of control such as permits to work, non-routine operations, routine operations and method statements based upon a consistent application of the health, safety and environment risk criteria, within a practical risk based framework.

Advanced gas detection

The objectives of the project are to produce a portable gas detection device to detect methane and carbon monoxide gases, and determine if readings detected on site are from a natural gas leak. Development of digital capture of site investigation data and inventory management will also be developed as part of the project.

Safety competence

Incident management

This project reviewed the emergency action levels and trigger points that result from leaks or loss of supply to consumers. Trigger points were established to consider various stages of an incident, for example notification of the incident, initiating a response and escalation of the response as required.

Protecting against third party interference damage

Highly portable GPR

This project aims to develop a ground-penetrating radar to improve accuracy in locating buried utilities.

Risk methodologies

As part of this broader project, we work with European pipeline operators to quantify the benefit of different types of physical protection used on pipelines, for example developing the design and assessment of the effectiveness of PE slabs.

Reliability and maintenance

Asset management

Asset health and criticality modelling

This project involved the distribution network and was led by Wales & West Utilities. It developed an asset health model for pressure control and storage equipment, and was intended to provide a common reporting methodology for asset health across the gas distribution network. The model covered both the current health and predicted future deterioration using reliability engineering principles.

The project preceded a series of three projects that developed the network outputs measure risk trading methodology. The models built were embedded into licensee operations to allow reporting of risk to the required standard and format as part of the annual regulatory reporting cycle starting in 2017.

Building information modelling (BIM)

This highly successful project looked into producing designs using intelligent 3-D models to reduce the time and resources needed by traditional approaches. The study found savings of between 4 and 11 per cent at the conceptual phase, and the potential for greater savings with smart survey techniques such as laser scanning. The innovators shared their results with the electricity sector, and follow-up projects are improving the scope and use of the technique.

Wireless instrumentation field trial

This project investigated whether wireless technology could be used to monitor pressure across a pressure regulating station. The project assessed reliability, security and integrating the wireless system into the current telemetry systems, policies and procedures. It was found that operational improvements and reduced costs could be achieved by moving to wireless instrumentation.

Asset integrity

Corrosion mapping system

The Orpheus regulator system is buried and protected from corrosion using cathodic protection (CP); however, there have been occasions where the CP has failed, resulting in the need to physically inspect the buried Orpheus module. This project aimed to develop an inspection device that could measure wall thicknesses from the inside of the module, thus avoiding time-consuming excavation and surface preparation before inspections. The project successfully developed an inspection device that was demonstrated on several regulator types.

Fracture monitoring using acoustics

This project was a joint initiative by NGN, Cadent and SGN to develop a system for remote detection of a pipeline failure. On detecting a failure the system send a text message to a central location to trigger a response. Three field trials successfully showed that fracture monitoring could be used within a gas network.

Composite repairs to complex shapes

For many years, damaged or corroded higher pressure steel pipelines have been repaired using epoxy filled steel shells that enclose the pipeline. Advances in composite technology have led to the successful introduction of composite wrap repair systems that have been successfully demonstrated as temporary repairs for bends in an IFI programme. This ongoing project is a joint programme sponsored by NGGT, Cadent, SGN, NGN and WWU that aims to qualify the technology for permanent repairs on complex shapes such as bends or tees.

In-line robotic inspection of high-pressure installations (Project GRAID)

This Network Innovation Competition project, aims to develop a robotic in-line inspection device which can operate at high pressures. No technology currently available can perform in-line inspection of below-ground pipework at high pressure. The device will allow us to inspect critical high-pressure installations that we can't currently inspect through inline techniques and monitor according to their condition, as well as ending the need to excavate to assess potential problems.

Development of guidance for reinforced thermoplastic pipelines

Reinforced thermoplastics (RTP) may be used at higher pressures than the polyethylene pipes currently used in the distribution network. This guidance covered the design, construction, inspection, testing, operation and maintenance of RTP pipelines for natural gas transmission. A draft management procedure for using RTP pipe at pressures more than double the current polyethylene limit was created.

Operational improvement

Low carbon gas preheating

This project for the Network Innovation Competition involves a trial of two alternative low-carbon gas preheating technologies across six sites. The new technologies' efficiency will be compared to the current methods using smart metering. An additional benefit of the project is to measure the quantity

of gas used for system preheating, which will allow better estimates for costs and encourage improved efficiency.

Immersion tube preheating

This project aims to design, construct and install two innovative pre-heaters with heat output capacities of around 100 kW and 326 kW, compliant with UK legislation and standards. We hope that they will have better thermal efficiencies than current pre-heating systems and produce less carbon dioxide.

GPS enabled video for walking surveys

The aim of this project is to improve the current walking surveys by automating how we plot asset or risk locations onto a pipeline route map. It will develop and demonstrate technology that combines the video and GPS capabilities of smart phones with modern geographic information systems to plot a route from the video taken by the phone and project it onto a map.

Mobile virtual reality modelling

Virtual and augmented reality systems are being trialled by many industries to see if they can assist with operations and training. This project examined whether the modelling of work procedures in augmented or virtual reality could be used within the gas network to help engineers complete complex operations. The project showed the benefits of using augmented reality for training engineers and measuring improvements in efficiency.

Repair

Minimally invasive

Mains and service replacement through keyhole (iCORE)

The objective of this project is to develop a solution to use with keyhole excavation techniques, and to allow the trenchless replacement of PE pipes and services by both live and dead insertion methods.

Olympic rings for RIIO

The scope of this project is to test and develop a solution for multiple coring within highways to reduce the requirement for conventional excavation, allowing existing equipment to be used within core and vac (trenchless) excavations.

PRISM - Pipe replacement in situ manufacturing

This project will trial the PRISM system in an underground environment to develop and test mains end connection and service connection solutions.

Security of supply

PE Flowstop (up to 10 barg)

The objective of this project is to prove the suitability of using PE flow stopping equipment up to 10 barg on the gas network.

Digital MRPS solution

This project improved efficiency by developing an electronic data transfer tool with in-built validation to remove the need for extensive administration work. The tool allows for real-time data transfer that is GPS tagged, and date and time-stamped to provide evidence of when and where the survey was undertaken.

Polymer repairs

Development of specification for PE repair systems

The aim of this project, which is supported by Cadent, NGN and SGN, is to look at potential repair techniques for PE pipes that could provide an alternative to traditional cut out and replacement methods.

Management of brittle plastic materials

The objective of this project is to develop tools and techniques that can be used on leaks from non-standard materials instead of cut out and replace methods. As excavations will be smaller, there will be less time without gas and so less disruption to consumers.

Distribution mains replacement

Robotics and digitalisation

Remote service pipe replacement (TORS)

This project developed remote service connection technology for use when an iron main was replaced with PE or lined with PE. The technology enabled replacement of mains and services within a street via two single excavations rather than needing a separate excavation for each service connection.

Utilisation of the modular NIC robotics platform for service line rehabilitation

The aim of the project was to carry out a feasibility study to utilise the NIC Robotics platform for serv ice line rehabilitation. The NIC Robotics Project developed a modular robotic repair and inspection system that can be deployed within a large diameter gas main. The project considered seven concepts for installing a service line, ranked them and produced a plan for a commercial trial.

New materials

Non-fusion/mechanical PE jointing methods

The primary method of joining PE pipe is using electrofusion joints. These joints need careful surface preparation and rigid adherence to procedure to assure a quality joint. This project examined alternative jointing methods that could improve productivity and reduce costs.

CIPP for services

This cured in place pipe (CIPP) project is intended to demonstrate that CIPP is fit-for-purpose as a permanent repair and replacement technique for gas service pipes. The first stage will develop a performance specification for use of the technology within the gas industry.

Alternatives to replacement

Investment prioritisation in distribution systems

This project considered investment planning and prioritisation of mains replacement within the gas distribution network. Investment planning is the development of plans to deliver stable or improving levels of service to customers. These plans are justified based on current and future risk of service failure. Prioritisation of mains replacement was based on the implementation of investment plans.

Security

Cyber security

Smart meter implementation programme

As part of the government's vision for a low carbon future, energy retailers are deploying more than 50 million smart meters to every home and small business in the Great Britain. Smart meters will help consumers better manage their energy use and provide access to a range of new products and

services. We are key stakeholders in the rollout of smart meters. The wealth of operational data provided by meters will help us increase efficiency and develop new innovative services.

Smart Data Communications Company (Smart DCC) has developed a new centralised communications infrastructure to provide secure access to smart meters. A complex security architecture backed by rigorous assurance processes has been developed to protect the smart meter infrastructure against malicious attack and ensure sensitive consumer data remains private.

Site and asset security

Remote monitoring device for flammable and toxic gases

The project seeks to prove through trialling that such devices offer a viable, cost-effective means of monitoring potential gas escapes from assets. A primary goal was to prove that the devices can monitor areas of high risk by providing real-time data.

SMART pressure sensor device

The project aims to evaluate, produce and test a smart pressure-sensing device that will allow accurate measurement of test and installation pressures across the gas distribution network and storage of a digital record as evidence that a pressure test has been undertaken.

Environment and low carbon

Emissions reduction

Alternatives to venting

The project aims to provide comprehensive experimental and design information relating to the behaviour of large-scale gas recovery using adsorbed natural gas (ANG) technology. The results have confirmed whether ANG is viable and will provide valuable design information.

Noise mitigation tool

This project involved research and development of a tool and process to evaluate and compare options for noise mitigation and abatement. We expect the benefits to include an evaluation of pipework noise abatement techniques with the potential to reduce the whole-life cost of assets.

Sustainability

Robotic roadworks

This project will develop a robotic platform that can vertically launch into live tier two and three gas pipes. The platform will accommodate a module which can travel 150 metres in either direction from the single launch excavation point, and install mechanical seals within the pipe. A launch tube system will prevent gas from escaping during the process.

This innovative approach with reduce the amount of excavation and reinstatement needed. This in turn will cut cost and streamline the process by reducing the need for permits to excavate the road; reducing disruption for the public and traffic; avoiding disruption to the gas service by preventing the need to decommission the gas pipe during the repair, and creating a much smaller carbon footprint than conventional repair methods.

3-D volume scanner

This technology calculates the volume and dimensions of excavations, and the type of material used in each layer. The scanner will help engineers working on reinstatement works do their job as quickly and accurately as possible, and will therefore reduce our impact on our stakeholders.

Decommissioning

Clean to green

This project aims to develop technology to use in a gas holder before draining to provide data to accurately determine the decommissioning cost and inform our business decisions. It will also develop technology to decontaminate gas holders without putting our people in the tank or working at heights.

Management of wastewater

This project reviews technologies that can be used to characterise, treat and dispose of wastewater and identify opportunities for prevention, re-use and recycling. It will help us develop an improved operational decision matrix for use by engineering teams to identify the actions they must take for treatment, handling and disposal of wastewater.

Soil and groundwater remediation technologies for gasworks and gasholders sites

This project will determine the key issues and contaminants that the gas network face when remediating gasworks and gasholder sites, and produce a report that can be used for future reference material giving insight into new and emerging approaches for this problem area.

Treatment and re-use of gasholder sludge

This project aims to develop a cost efficient, sustainable solution for the management of gasholder sludge.

Stakeholder consultation questions

Your score	1	2	3	4
Response	Strongly disagree	Disagree	Agree	Strongly agree

Q	Gas Network Innovation Strategy Stakeholder Consultation	Score			
		1	2	3	4
1	The structure and content of the strategy document is easy to understand				
	Please add your comments – if you have scored 1 or 2 please let us know what you think we could do to improve that score				
2	The seven themes contained within the strategy clearly and sufficiently describe the challenges and uncertainties facing the gas network				
	▪ Future of gas				
	▪ Safety and emergency				
	▪ Reliability and maintenance				
	▪ Repair				
	▪ Distribution mains replacement				
	▪ Security				
	▪ Environment and low carbon				
	Please add your comments – if you have scored 1 or 2 please let us know what you think we could do to improve that score				
3	The seven themes clearly identify the challenges which are not currently being addressed through existing industry projects or plans				
	▪ Future of gas				
	▪ Safety and emergency				
	▪ Reliability and maintenance				
	▪ Repair				
	▪ Distribution mains replacement				
	▪ Security				
	▪ Environment and low carbon				
	Please add your comments – if you have scored 1 or 2 please let us know what you think we could do to improve that score				
4	The strategy contains a clear and sufficient description of the innovative projects and plans that the gas networks intend to progress to address the challenges and the gaps				

Q	Gas Network Innovation Strategy Stakeholder Consultation	Score			
		1	2	3	4
	▪ Future of gas				
	▪ Safety and emergency				
	▪ Reliability and maintenance				
	▪ Repair				
	▪ Distribution mains replacement				
	▪ Security				
	▪ Environment and low carbon				
	Please add your comments – if you have scored 1 or 2 please let us know what you think we could do to improve that score				
5	The strategy clearly defines the plans the gas networks will make to co-ordinate their innovation activities to minimise unnecessary duplication of effort				
	Please add your comments – if you have scored 1 or 2 please let us know what you think we could do to improve that score				
6	The strategy clearly describes how the gas networks will share the learning that they have gained through innovation projects				
	Please add your comments – if you have scored 1 or 2 please let us know what you think we could do to improve that score				
7	Please add any further comments about how we could improve our strategy				