



**GAS GOES
GREEN**

**TOMORROW'S HEAT,
TODAY'S OPPORTUNITY**

**INTRODUCING BRITAIN'S
SMART GAS GRID**

CONTENTS

02	Foreword
03	Our part in delivering Net Zero
04	How we are using smart technology today
06	Using smart technology to deliver Net Zero
07	Flexible Generation Forecasting Project
08	OptiNet
09	Real Time Networks (RTN)
12	Freedom Project
13	Conclusion
15	References



FOREWORD

The way we all use our energy is changing.

New green technologies are opening up new opportunities for us all – in our homes, in our offices, in our factories, and on our roads, to reduce our carbon emissions in smarter, greener and quicker ways that are as cost efficient as possible.

Bringing together all five of Britain's gas network companies, Energy Network's Association Gas Goes Green (GGG) programme is our response to that challenge, delivering the infrastructure that will unlock green technology choice for customers, by preparing Britain's gas pipes for new green gases.

As part of the GGG Pathway to Net Zero, Britain's five gas networks are committed to building the world's first zero carbon gas grid here in the UK, using a combination of hydrogen and biomethane, working in partnership with increased electrification, to replace natural gas.

At the same time our energy system is becoming more interdependent than ever before, as we move from a relatively simple system where energy flows in just one

direction through one part of the system at a time, to a smarter, more complicated one where it flows in many different ones.

Data and digitalisation have become the watchwords of the day, as we seek to track a wider variety of energy sources moving through our energy system in new and different ways.

As we gradually replace natural gas with hydrogen, biomethane and electricity in the years to come, these trends will only accelerate. Instead of using just one type of gas in the future, there will be different blends which will behave in different ways, carrying different amounts of energy to our doorsteps.

To maintain our high standards of safety, security of supply and reliability, our gas grid must be smarter and more flexible than it has ever been before.

Chris Train ENA Green Gas Champion

OUR PART IN DELIVERING NET ZERO

As we build the evidence base for using hydrogen and biomethane as a replacement for natural gas, we will share the outcomes of gas network innovation projects, and support the wider development of best practice for the safe use of hydrogen. 'Our Expertise, Your Security', the **Gas Goes Green hydrogen safety commitment**, sets out how we will ensure we deliver hydrogen to Britain's homes in a safe and secure way, to reduce their carbon emissions.

Remote control and independently triggered autonomous safety devices have been features of the gas networks for decades. Section 1 of this report focuses on some of the smart technologies deployed or under development in the networks that will benefit consumers irrespective of the gases transported to their homes, businesses, and communities.

As we transition to a Net Zero energy system in 2050 the composition of the gases, where and how they are produced will change. Biomethane has been present in the networks for some years now and work is progressing to transition away from natural gas to low carbon gases. The 2nd section of this report will endeavour to describe some of the technologies the gas networks are developing and deploying today to unlock this Net Zero future.

What do we mean by 'smart'?

For the purposes of this report, we have defined smart as:

"The ability of a network to monitor and adjust to changing conditions in response to challenges in the socio-economic and dynamic energy supply and demand environment."

In other words, the ability of our networks to read and understand changing conditions on the networks that are supplying gas and electricity to peoples' homes and businesses, and take independent action accordingly.



HOW WE ARE USING SMART TECHNOLOGY TODAY

As responsible network operators we are committed to innovate and invest in our networks to improve their safety, security of supply and provide the value that customers expect whilst transitioning to new low carbon solutions for heat. Many of our smart tools also support a large supply chain of high-tech industries across the UK.

Today, robots are being deployed throughout our networks to improve the accuracy of our records and to monitor the condition of the pipes.

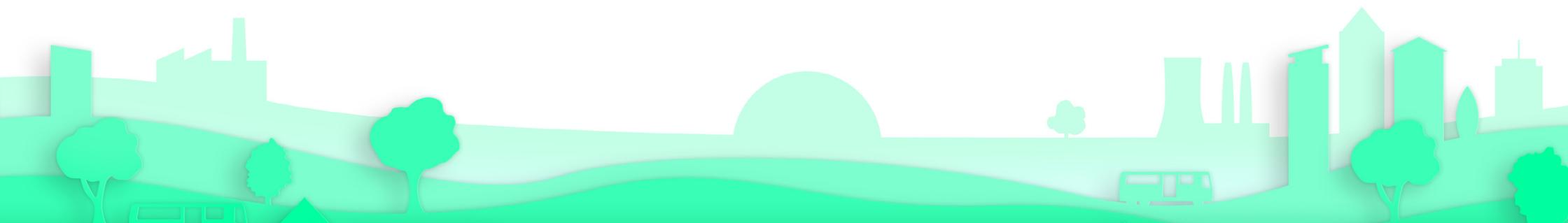
Sophisticated data analytics is being exploited to help improve the accuracy of our demand forecasting and to develop autonomous tools that reduce costs in network design.

Automation and independently triggered safety devices have been features of our networks since the 1970's. These technologies are being upgraded and modernised all the time and within the last decade new technology that can self-diagnose issues and take actions in the event of a control system outage have been deployed.

By and large the majority of this technology is designed for the existing gas network. Evidence shows that today's gas network can be safely converted to transport green gases like hydrogen and biomethane, so is equally relevant today as it would be in a future Net Zero network. The following table lists a small number of these technologies, either already in place or currently under development:



Sophisticated data analytics is being exploited to help improve the accuracy of our demand forecasting and to develop autonomous tools that reduce costs in network design.



HOW WE ARE USING SMART TECHNOLOGY TODAY

Technology	Type	Summary	Status
Automatic Safety Overrides	Autonomy	Gas networks can take 'final resort' control and perform certain safety actions autonomously without human interaction.	Implemented
Control of the gas networks in the event of a communications failure	Autonomy	If remote control is lost, the gas network can autonomously take control of outstations and control them to a predetermined set of rules until remote control is restored.	Implemented
Asset management optimisation	Big Data	Technology being developed to automatically analyse system and asset performance to inform Maintenance and Asset Management decisions	In Development
Digital twins	Big Data	Digital twins offer the ability to simulate potential scenarios and predict network conditions in order to optimise a response ahead of the event.	In Development
Distribution Network Information Modelling (DNIM)	Robotics	Tetherless robot using artificial intelligence to create a 'digital twin' of gas network infrastructure and perform Simultaneous Location and Asset Mapping (SLAM) that will help us develop more detailed records of what infrastructure we have and in what location.	In Development

USING SMART TECHNOLOGY TO DELIVER NET ZERO

Our energy system is changing as we decarbonise the gas and electricity that we all rely upon. It is becoming more integrated and more interconnected than ever before, as we adopt a far wider range of new green technologies that behave in different ways to our energy networks, as well as new more dispersed energy sources in a wider variety of locations than in the past.

Developing new smart technology is absolutely vital to not only managing this change, but also to ensure that we maximise the opportunities it creates to run our energy system in a smarter, cleaner way that will help us all reaching our Net Zero emissions target.

Britain's gas networks are rolling out four flagship projects that help ensure that is the case. These projects demonstrate how we are facilitating the required growth in green power generation, optimising our networks for the new demands placed upon them, and laying the groundwork so that the UK's homes and businesses can continue to have their energy needs met in a reliable, responsible and cost effective way.

The **Gas Goes Green Pathway to Net Zero** sets out the actions that need to be taken to deliver the world's first zero carbon gas grid. The following features align with a series of "low regrets actions" outlined in the report.



Flexible Generation Forecasting Project

Background

The growth in new flexibly operated gas fired electricity generators is changing the once predictable daily demand profile our networks and systems were designed to meet. These generators play an important role in supporting the connection of more intermittent forms of renewable electricity generation, such as wind or solar farms, because they ensure that our electricity supplies stay on those days when the sun doesn't shine, or the wind doesn't blow.

Under the Gas Goes Green Pathway to Net Zero, we expect that these flexible generators will run on biomethane or converted to hydrogen, as a replacement for natural gas. As the cost of producing 'green hydrogen' from those times of day when we have too much renewable electricity falls, there is every chance that the same wind and solar farms that these generators support will also create the hydrogen that they need to do that.

The normal daily gas demand profile of a breakfast and teatime peak load is now being replaced with less predictable profiles including double breakfast peaks or high demands that last throughout the day. To continue to meet this changing demand pattern new technology is required to predict when these new flexible generators are expected to run.

How does it work?

This innovation project provides a new, innovative statistical model that will help energy networks to better understand and forecast the operation of these flexible generation loads. These sites generate electricity to balance the power network when renewable generation is unable to and the numbers connecting to the gas networks are set to continue to rise. This project has utilised relevant data including real time data held across both gas and electricity networks to develop a model that will help us all better manage flexible generation. The model will be used in the control rooms for day ahead and within day forecasting rather than longer term planning activities. Data from National Grid ESO, SP Energy Networks and Wales & West Utilities has been utilised to produce the models, use cases were based on flexible generation in North Wales due to the involvement of SPEN with a high degree of accuracy being achieved with the models.

Benefits

FlexGen improves the energy networks capability to model and predict demand and supply associated with flexible electricity generation. This is key to enabling the gas networks to operate efficiently in support of the growth in renewable generation.

- For the local Gas Distribution Networks (GDNs) this improves forecasting accuracy that will ultimately lead to the networks being run more efficiently.
- For National Grid Gas Transmission, increased accuracy in GDN forecasts and access to Electricity System Operator (ESO) data could save time when forecasting.

- National Grid ESO will benefit from improved visibility of and forecasting of local gas generation, as they have responsibility for ensuring enough electricity is transmitted to the right places around the country, 24 hours a day, 7 days a week, 365 days a year.
- The model can be integrated into System Operation systems and processes. Increased data sources and inputs from the industry will improve future modelling outputs.
- By allowing us to better forecast when flexible electricity generation is and isn't needed, this will also help us to plan more accurately for when new infrastructure, such as hydrogen or biomethane storage sites need to be built, as well as allowing us to operate existing infrastructure more efficiently, such as the gas compression equipment that ensures the gas is transported at the right pressure.
- Provide data which can be used to determine whether flexibility services (currently interruption terms in Network Exit Agreements) need to be invoked.

How the project supports Britain's Hydrogen Network Plan

This model contributes to **Britain's Hydrogen Network Plan** by building in new forecasting requirements into existing processes and systems, required due to a change in demand on the gas network and supply to the electricity network in support of renewable energy.



Background

The growth of local green gas generation, principally in the form of biomethane production brings with it many challenges and opportunities – both technical and economic.

When demand for gas is low, then gas network capacity is limited because the grid stores the gas not being used. That means that new green gas connections may not be able to connect into the network or may be 'constrained' (paid not to feed green gas into the grid) during the low demand periods.

One of the "low regret actions" identified in the [Gas Goes Green Pathway to Net Zero report](#), demonstrated the role of smart pressure management as a way round this, to find new ways to allow biomethane to continue to be injected even when capacity is limited.

How does it work?

The OptiNet project aims to prove the concept of a network solution that can be replicated in capacity-restricted areas to enable the wider connection of locally produced green gas. The solution comprises a smart pressure control system and a compressor field trial along with a review of the storage options that

can be utilised in support of green gas entry. The smart system trial is being led by Wales & West Utilities and will automate control of a distribution network in response to green gas entry and extremity pressures.

This will mean that where there is demand for gas, it will be fed by green gas whilst still maintaining security of supply. The compressor trial is being led by Cadent to increase demand on the network by compressing gas up the pressure tiers to areas of higher demand. Application of these proven solutions will maximise the opportunity to decarbonise the gas network and support the energy system transition to Net Zero.

Benefits

- Successful field trials will provide a proven method for automating distribution network control utilising our existing SCADA infrastructure management system and a proven in-grid compression solution. This will in turn maximise green gas entry to the distribution network offsetting fossil gas.
- Improved customer experience and environmental benefits from a reduction in the number of times that entry sites are unable to inject.
- The combined solution aims to provide a cost-efficient and reliable way to manage green gas injection whilst maintaining security of supply to existing customers.
- It will also support the requirements of new exit demands such as the increase in flexible power generation or gas for transport also connecting to the same distribution networks.

In addition to the key project benefits listed previously:

- The smart Pressure Control System will reduce the number of engineer callouts to adjust pressures at natural gas sites and will contribute towards reducing network shrinkage keeping pressure as low as possible.
- The Compressor will result in significant CO₂e savings, for this project, the additional green gas entry capacity of 5,000 SCMh will result in a CO₂e saving of 88,666 tCO₂e pa. (Calculated using the Ofgem NIA Projects Benefits Guide).

How the project supports Britain's Hydrogen Network Plan

If we are to achieve the high levels of green gas required to reach our Net Zero targets, then network solutions like OptiNet project will have to be employed to ensure that we can manage large amounts of green gas production sites that are connected to the gas grid at a variety of different locations. Compression, smart systems and storage will have to be utilised to balance supply and demand.

OptiNet contributes to 2 of the 4 Tenets of Britain's Hydrogen Network Plan, by ensuring security of supply by adjusting gas pressures in the gas network, keeping the extremity pressure above the system low limit and by support customers by accommodating green gas injection.



Problem

Consumer behaviour, properties and appliances have changed significantly since existing demand profiles were established. As we transition to Net Zero and the volume and mix of low carbon gases in the networks increases, the networks will require the capability to model where those gases are and how they will be used, in real time, to ensure the maximum volume of low carbon gases can be distributed in a flexible, secure and cost-effective way.

The Real Time Networks (RTN) project sets out to provide an ongoing and iterative definition of a consumer's demand profile, intelligently retraining the model iteratively with real network and consumer data. This sophisticated modelling enables the gas network to meet future gas demand from homes and businesses and to distribute low carbon gases in greater quantities.

Background

Network modelling is used to analyse the gas network and inform infrastructure design, investment planning and operations. The existing modelling method is based on having one centralised supply of natural gas, with little to no entry of alternative gases. All gas in the network was correctly assumed to be the same in terms of quality and it was subsequently modelled this way.

However, progress in bringing greater quantities of low carbon gas onto the networks, from diverse supplies, multiple locations and a greater variety in gas composition, coupled with changes to the way we use the gas as homes and appliances become more energy efficient, has meant that these models need to evolve and be more agile than previously was the case.

The **Gas Goes Green Pathway to Net Zero** emphasises the need to update gas safety, metering and billing regulations to facilitate and enable greater supply and use of low carbon and renewable gases.

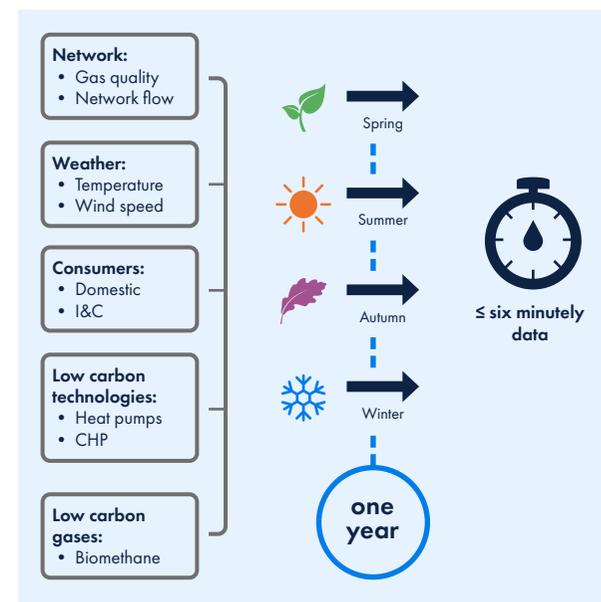
How does it work?

Network modelling is used to analyse the gas network and inform infrastructure design, investment planning and operations. Our current model is based on calculations made during the 1980's when there was one centralised supply of natural gas, with little to no entry of alternative gases. All gas in the network was correctly assumed to be the same in terms of quality and it was subsequently modelled this way.

However, driven by decarbonisation and a greater variety in gas supply, where our gas comes from, the type of gas we use and the way we use it is continually changing. As a result, we will use different types of gas, such as hydrogen and biomethane, which behave in different ways when we transport it. Homes and appliances are becoming more energy efficient and the use of low carbon solutions such as renewable technologies, hydrogen and biomethane, are accelerating.

Progress

Since the project started in 2016, RTN carried out the most extensive and meaningful gas demand research the industry has seen for decades. Our project is leading the way in gas innovation through the installation and demonstration of sensing technologies, associated hardware, software and infrastructure in a statistically representative section of Great Britain (GB). Novel use of technologies installed at key points along the network have enabled monitoring of gas performance and consumption data every six minutes.



USING SMART TECHNOLOGY TO DELIVER NET ZERO

- To establish consumer demand, the project installed gas data loggers on 1200 domestic, commercial and industrial meters to record gas consumption. For this, the RTN team engaged with thousands of our customers and invited them to take part in the project by volunteering their gas consumption data for two years. Participating properties were carefully selected to ensure the data set was statistically representative of GB.
- RTN designed and installed new weather stations to collect live temperature, wind speed and humidity data of finer granularity than the network currently uses. Gas demand is directly linked to environmental conditions, therefore, having real-time weather data is important to improving accuracy and confidence in modelling. The project benefited from valuable, extreme peak demand data during the 'Beast from the East' and near record-breaking UK heat wave temperatures during summer 2018.
- RTN monitored gas network performance through novel sensor technology, installed in our six bespoke constructed sites. The sensors are recording gas quality, flow, temperature and pressure data. The site designs required complex planning and vigilant construction for safe installations on a range of pressure tiers. The designs also ensure a reliable and accurate transfer of data is achieved. Each site is being powered by innovative, low carbon sources such as solar panels, wind turbines and connecting to existing street lighting. The completed site in Rochester had gas quality, pressure and temperature monitors, alongside a flow meter

installed on a gas pipe underground with above ground kiosks storing sensors, solar panels and a wind turbine powering the equipment.

- In addition to the sensor technology data collection, gas pressure data was collected using SGN's Abriox Osprey Pressure Validators, typically used for network planning, installed at evenly distributed key points along the Medway network in residential areas.

The streams of big data were wirelessly transferred and managed by our bespoke and innovative real-time Cloud Data Solution. This system securely stores, processes and analyses the live data as it communicates with the real-time network model. This presents a far cheaper option than creating the equivalent "hardware" solution capable of dealing with this intensity of data flow from multiple sources, an approach which had not been practiced on this scale within the industry previously.

The UK's drive to decarbonise heat has encouraged the emergence of downstream renewable technologies, which may impact gas consumption. As a key aim of the project is to prepare the network for changes in demand, additional research was performed to establish the potential impact of renewable appliances on future gas demand. 172 laboratory tests were carried out on the technologies (some novel and others commercially available) used in homes, measuring their performance in various conditions. The study determined that decarbonising heat requires a carefully considered solution for each property type and not a "one-size-fits-all" solution.



Data loggers were installed on meters



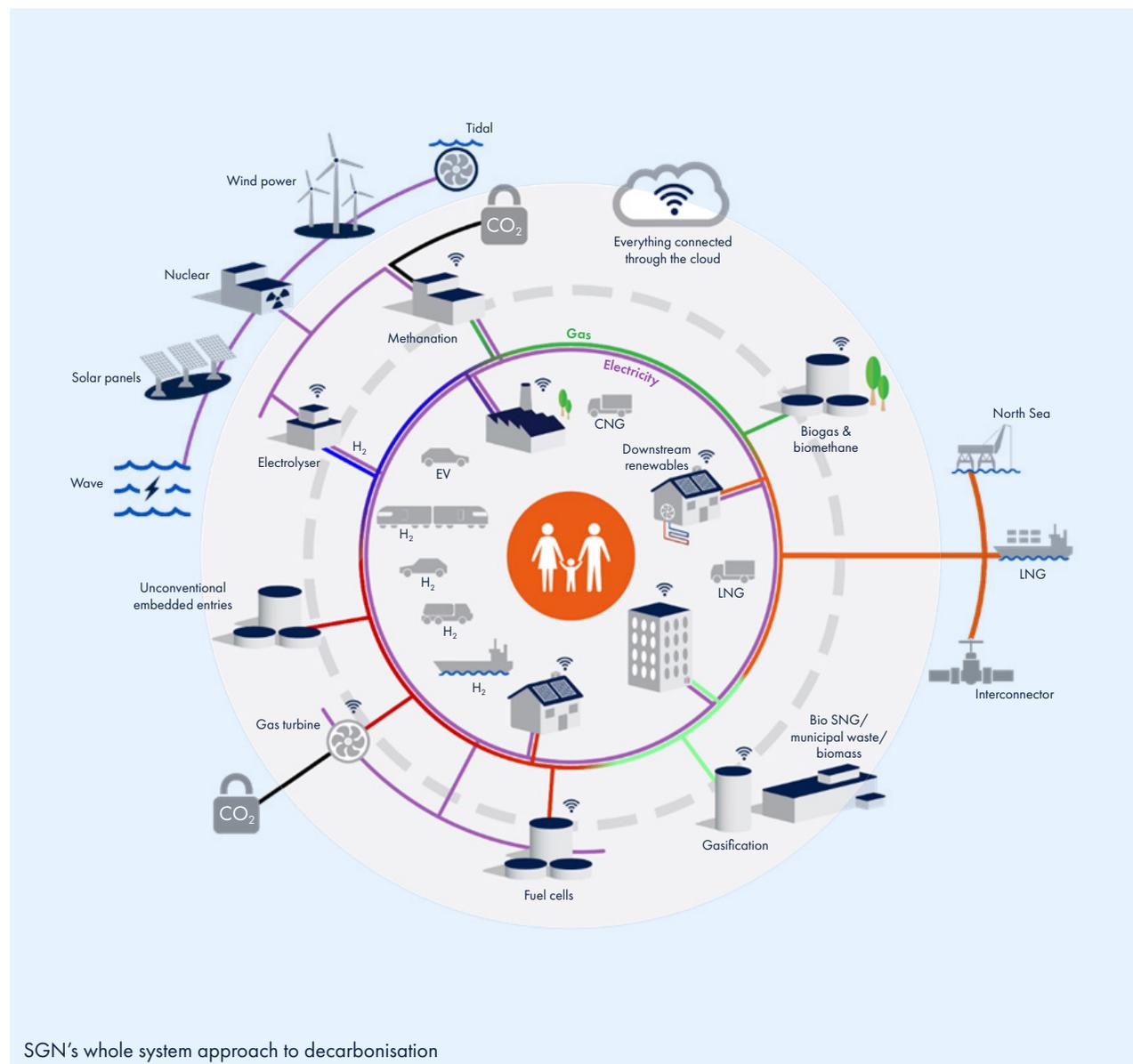
Completed site in Rochester

How the project supports Britain's Hydrogen Network Plan

RTN contributes to maintaining security of supply by delivering a platform for modelling both blended and 100% hydrogen networks, ensuring all systems can be appropriately designed and reinforced to facilitate these network changes in a timeously manner.

It does this in the following ways. It:

- Allows us to be more confident about reliable gas supplies. by it allows us to adjust our forecasting, rather than having to use one fixed model. This is because it allows gradually make the forecasting of customer gas demand more accurate.
- Allows us to plan infrastructure investment more accurately based on advanced scenario modelling including networks running on both blended and 100% hydrogen.
- Allows us to improve the way we control the gas networks using real-time data feeds.
- Provides advanced 'bottom up' demand forecasting.
- Supports modelling of unprocessed embedded entries such as biomethane.
- Gives us better understanding of individual and whole system impacts of downstream renewable appliance technologies such as hybrid systems and micro-CHP.
- Provides a modelling system to support changes to customer billing developed **Future Billing Methodology** project (pragmatic and composite solutions).





Problem

In the UK, about 70% of all energy used is in the home, of which space heating and hot water production account for the bulk of the energy use. With the majority of the homes in the UK being heated by combustion of fossil fuels, a heat generating system that could improve domestic energy efficiency significantly has the potential to deliver dramatic reductions in primary energy consumption and CO₂ emissions.

The **Gas Goes Green Pathway to Net Zero** highlights the importance of testing and certification of Hydrogen Ready appliances and undertaking large scale demonstration of hybrid heat systems using both methane and hydrogen.

How does it work?

The Freedom Project integrated small air source heat pump alongside an existing boiler central heating system with smart controls. The smart controls essential and enable switching between gas and electricity based on the affordability and carbon intensity of each vector. The hybrid installation is retrofitted to the existing system with minimal disruption.

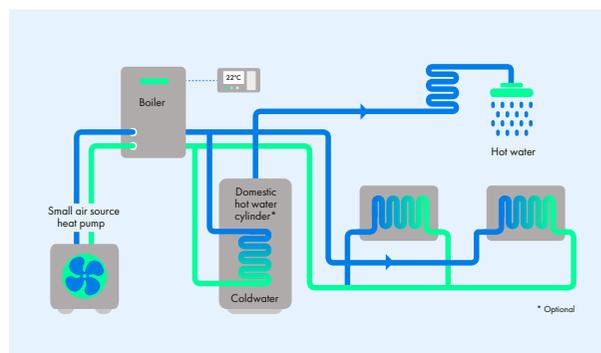
Further developing the technology explored in the Freedom Project, the HyCompact project aims to demonstrate the efficiencies of installing a single-unit hybrid heating system to further develop customer acceptability, minimise disruption, improve cost efficiency and enhance smart controls with boiler modulation. The project is a collaboration with UK Power Networks and is expected to demonstrate system benefits of large-scale deployment of such low cost, integrated hybrid heating systems with an aggregated control system. The project has successfully installed these hybrid heating systems in consumers' homes and has been testing innovative smart switching signals, including marginal carbon intensity forecasts and minimum COP thresholds.

Benefits

- The Freedom project contributes directly to the UK's Net Zero target. The system can use renewable electricity when it is available, cheap and mild, and then hydrogen or biomethane when renewable generation is low and/or it is very cold weather.
- Uses the ability of smart switching between gas and electric load to allow the buying of fuel & the sale of heat simultaneously – called fuel arbitrage.

How the project supports **Britain's Hydrogen Network Plan**

Contributes to 3 of the 4 tenets set out in the Hydrogen Network Plan; Safety – utilises existing technologies and can be retrofitted to existing boiler system; Customer – potential saving of £700 a year in energy bills; Supply chain – creating business opportunities to manufacture, supply and install equipment.



CONCLUSION

Over the last 50 years the UK's gas networks have continually developed and deployed new technologies across our networks to keep the 22million homes and business connected to our networks warm and safe.

Because most fuel gases are interchangeable, the technology we have developed and deployed over this period is, mostly, equally well suited for the transport of green, Net Zero gases as it is for the natural gas for which the networks are currently used to. We are continuing to invest where we do need new technology to enable the UK's transition to Net Zero.

As such the UK's gas networks represent a quick, straightforward and relatively cost-effective route to large scale decarbonisation of the UK industry and domestic heating. The infrastructure already exists, its operation is well understood and the technology to continue to deliver [55%] of the UK's non-transport energy needs is either in place or under development.

There are 4 projects currently underway which are considered both smart and whose purpose is specifically to enable decarbonisation and the transition to Net Zero by 2050.

CONCLUSION

Britain's Hydrogen Network Plan sets out 4 tenets to delivering a 100% hydrogen network. The table below shows how the 4 projects highlighted in Section 2 fulfil these tenets:

Project	Summary	Safety – ensuring people's safety	Security – maintaining security of supply	Customers – focussing on people's needs	Supply Chain – delivering jobs and investment
Flexible Generation Forecasting (Flex Gen)	Forecasting demand from new wave of intermittent gas fired electricity generators		✓	✓	
Real Time Networks (RTN)	Domestic demand forecasting		✓	✓	
OptiNet	Using technology to increase the capacity for green gases in the existing gas networks		✓	✓	✓
Freedom	Exploring domestic heating technologies to reduce carbon emissions			✓	✓

REFERENCES

- Energy Networks Association. 2021. *What you need to know about Britain's Hydrogen Network Plan*. [online]. Available at: <https://www.energynetworks.org/newsroom/what-you-need-to-know-about-britains-hydrogen-network-plan> [Accessed May 2021].
- Energy Networks Association. 2019. *Pathway to Net Zero: Decarbonising the gas networks in Great Britain*. [Online]. Available at: <https://www.energynetworks.org/assets/images/Resource%20library/ENA%20Gas%20decarbonisation%20Pathways%202050%20FINAL.pdf> [Accessed May 2021]
- Energy Networks Association. 2021. *Hydrogen safety commitment*. [Online]. Available at: <https://www.energynetworks.org/assets/images/Resource%20library/ENA%20Gas%20Goes%20Green%20Safety%20Commitment.pdf> [Accessed May 2021]
- Future Billing Methodology. 2021. *About FBM*. [Online] Available at: <https://futurebillingmethodology.co.uk/>
- Smarter Networks Portal. 2021. *Flexible Generation Forecasting*. [Online]. Available at: https://www.smarternetworks.org/project/nia_wvu_068/print [Accessed 25 May 2021]
- SGN. 2021. *Real Time Networks*. [Online]. Available at: <https://www.sgn.co.uk/about-us/future-of-gas/hydrogen/real-time-networks> [Accessed May 2021]
- Wales & West. 2021. *OptiNet*. [Online] Available at: https://www.wutilities.co.uk/media/3924/p14_optinet_nia-2020_standalone.pdf [Accessed May 2021]
- Wales & West. 2021. *Freedom*. [Online] Available at: <https://www.wutilities.co.uk/news-and-events/wales-west-utilities-and-uk-power-networks-launch-green-home-heat-trial/> [Accessed May 2021]



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