NET ZERO SPECIAL

GAS INTERNATIONAL

SUMMER 2022

NEWS

- NORTH WEST HYDROGEN VILLAGE PAVES THE WAY TO A NET ZERO FUTURE
- GREENHOUSE GAS REMOVAL "NOT A SILVER BULLET TO ACHIEVE NET ZERO"
- BRITISH STEEL GETS GREEN LIGHT FOR HYDROGEN PROJECT

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WELCOME TO THE NET ZERO EDITION

WE ALL KNOW the clock is ticking on climate change. The deadline for reaching net zero emissions by 2050 is like an object viewed in the rear mirror – far closer than it appears, especially when one considers the depth and scale of the challenge across domestic heat and power, transport, aviation, shipping and industry.

Navigating the amount of information coming out of the climate change debate is difficult for even the most discerning reader, which is why *Gi* is proud to present this special edition bringing together all the latest news and analysis of the net zero challenge and the work taking place around the industry to tackle it.

Here, you will find in-depth features on the key pieces of government policy guiding the UK's response, plus reactions from leading industry players, the latest research into the capabilities of green gas and the issues at the heart of the boilers versus heat pumps debate.

You'll find a particular focus on the work of the gas networks to bring hydrogen to our homes and businesses, plus how the government intends to confront the energy security challenges posed by international turmoil.

And you'll discover the latest policy statements from IGEM as we attempt to support the industry through this time of transition, including our work with think tank Policy Connect to develop frameworks for the future.

We hope you enjoy the *Gi* Net Zero Special.

SHARON BAKER-HALLAM

EDITOR
BA (HONS) AIGEM
INSTITUTION OF GAS ENGINEERS AND MANAGERS (IGEM)

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NORTH WEST HYDROGEN VILLAGE PAVES THE WAY TO A NET ZERO FUTURE

WHITBY COULD BECOME THE COUNTRY'S FIRST HYDROGEN VILLAGE

AS PART OF an exciting new government-backed project, Whitby in Ellesmere Port could become the country's first hydrogen village, with 2,000 homes and businesses converted to run on 100 per cent hydrogen, according to *Politics Home.*

The scheme, put forward by Cadent and British Gas, supported by Cheshire West and Chester Council, is one of two areas shortlisted by the government for the conversion, which would take place from 2025 for around two years.

Dr Tony Ballance, Chief Strategy and Regulation Officer at Cadent, said: "Hydrogen offers the chance to create a reliable, low carbon method of heating homes, without having to make significant changes to infrastructure.

"We've already carried out extensive work to prove the case for using hydrogen for heating and cooking, and the Hydrogen Village is the next exciting milestone in taking this forward."

If Ellesmere Port is successful, every property in the selected area will see all their gas boilers swapped for new, hydrogen-ready versions. And Cadent has also guaranteed that, for the duration of the two-year programme, residents will pay the same to use hydrogen as they would for natural gas.

Jana Siber, Managing Director of British Gas Services, said: "Hydrogen offers a relatively easy and cost-effective method of transitioning UK homes to a low carbon alternative to natural gas. Over the next year we will engage with the local community to explain more about this exciting project and create a demonstration centre, where people will be able to see hydrogen in action for heating and cooking and learn more about the environmental benefits."

Currently, the average UK household emits over 2.7 tonnes of carbon dioxide each year, mainly by burning natural gas for heating, hot water, and cooking. Replacing natural gas with hydrogen as part of the energy mix is one option for tackling this challenge.

BRITISH STEEL GETS GREEN LIGHT FOR HYDROGEN PROJECT

BRITISH STEEL IS embarking on a major project that could see green hydrogen used to clean up its manufacturing operations, reports *Business Live.*

Government support for a feasibility study into the switching from natural gas to reheat furnaces has been secured.

If successful, an industrial scale demonstration will be rolled out, which could see the business roll out the developed technology across all sites.

The company is collaborating with EDF UK, University College London and the Materials Processing Institute, having pledged to deliver net zero steel by 2050 and significantly reduce its CO_2 intensity along the way.

British Steel's Environment and Sustainability Director Lee Adcock said: "As an energy intensive industry with hard to abate emissions, the steel industry offers the potential for large CO_2 emission savings through fuel switching from natural gas to hydrogen. This study is, therefore, a vital and hugely exciting step on our journey to developing the technology needed to transform the way we, and other steel manufacturers, operate.

"We're extremely grateful for the government's support and look forward to working with our partners to reduce the carbon intensity of our operations, enabling us to manufacture the clean, green steel society needs," Adcock added.

Research funding was secured from the Department for Business, Energy & Industrial Strategy's Net Zero Innovation Portfolio. With partners, a six-month study is to launch at the company's Teesside Beam Mill.

It links into the Tees Green Hydrogen project – a pioneering scheme that will use green electricity from the nearby Teesside Offshore Wind Farm along with a new solar

GREENHOUSE GAS REMOVAL "NOT A SILVER BULLET TO ACHIEVE NET ZERO"

THE PROGRAMME'S MOST POPULAR CARBON CAPTURE TECHNOLOGY IS DIRECT AIR CAPTURE

MANY OF THE UK's top scientists working on carbon capture technologies do not believe they will be developed and scaled up in time to reach net zero and limit global heating to 1.5°C.

Experts speaking at a Greenhouse Gas Removal Hub event in London warned that these techniques, including direct air capture, biofuels, biochar, afforestation and enhanced weathering, are not a silver bullet and should make up just a fraction of the efforts to decarbonise.

Event organisers polled attendees (mostly scientific researchers, plus a handful of government officials and journalists) on whether they believed the carbon removal targets would be met, reports *The Guardian*.

Of the 114 who voted, 57 per cent said they were "not confident" the UK would meet the 2030 goals in the net zero strategy of five million tonnes of engineered greenhouse gas removal, and 30,000 hectares a year of tree planting; 25 per cent said they were quite confident, and 11 per cent said there was no chance.

The scientists are taking part in a £70 million government-funded competition to find the best ways to remove greenhouse gases from the atmosphere. These technologies are due to begin removing vast amounts of carbon dioxide from the atmosphere by 2030, with the hope being that the winning methods could be scaled up and ready for market in two years' time.

The government appears, on the whole, to be confident that carbon capture methods will be developed fairly rapidly. The Department for Transport has stated, for example, that greenhouse gas removal (GGR) technologies will enable Britons to take "guilt-free flights" by the end of next year, but those involved in the programme were less optimistic.

When shown a press release from the government declaring that these technologies will enable net zero flights by 2023, Prof Mark Taylor, Deputy Director of Energy Innovation at the Department for Business, Energy and Industrial Strategy (BEIS), seemed sceptical. He told *The Guardian*: "No, that's not the case. We've got to get people to believe this can work, but maybe that claim is a little bit cheeky."

Gideon Henderson, Chief Scientist at the Department for Environment, Food and Rural Affairs (Defra), said: "GGR is hard and expensive. And we cannot afford to see it as a surrogate to compensate for continued emissions in sectors that can be decarbonised. It is not an excuse not to decarbonise, so we must drive down emissions anyway."

By far the most popular technology based on applications to the programme was direct air capture. This process involves removing carbon from the air, usually using giant fans, and heating it to a very high temperature. This carbon can then be stored in geological formations or combined with hydrogen to create synthetic fuels.

While ministers like this idea, those leading the programme believe it may not be the answer, due to the energy intensity required and how expensive it is.

Taylor said: "People see it as having the biggest market, there's been funding from American companies – it feels like a silver bullet, there are lots of people who like it. Ministers like it because they think: 'Oh, that sounds easy, you can take it out the air and that's it.' And that's the thing that gets investment.

"I'm very much on the fence as to whether it is the best solution. It's very, very expensive. So some of the other technologies may emerge as winners, but the good thing about our competition is we pick the best one."

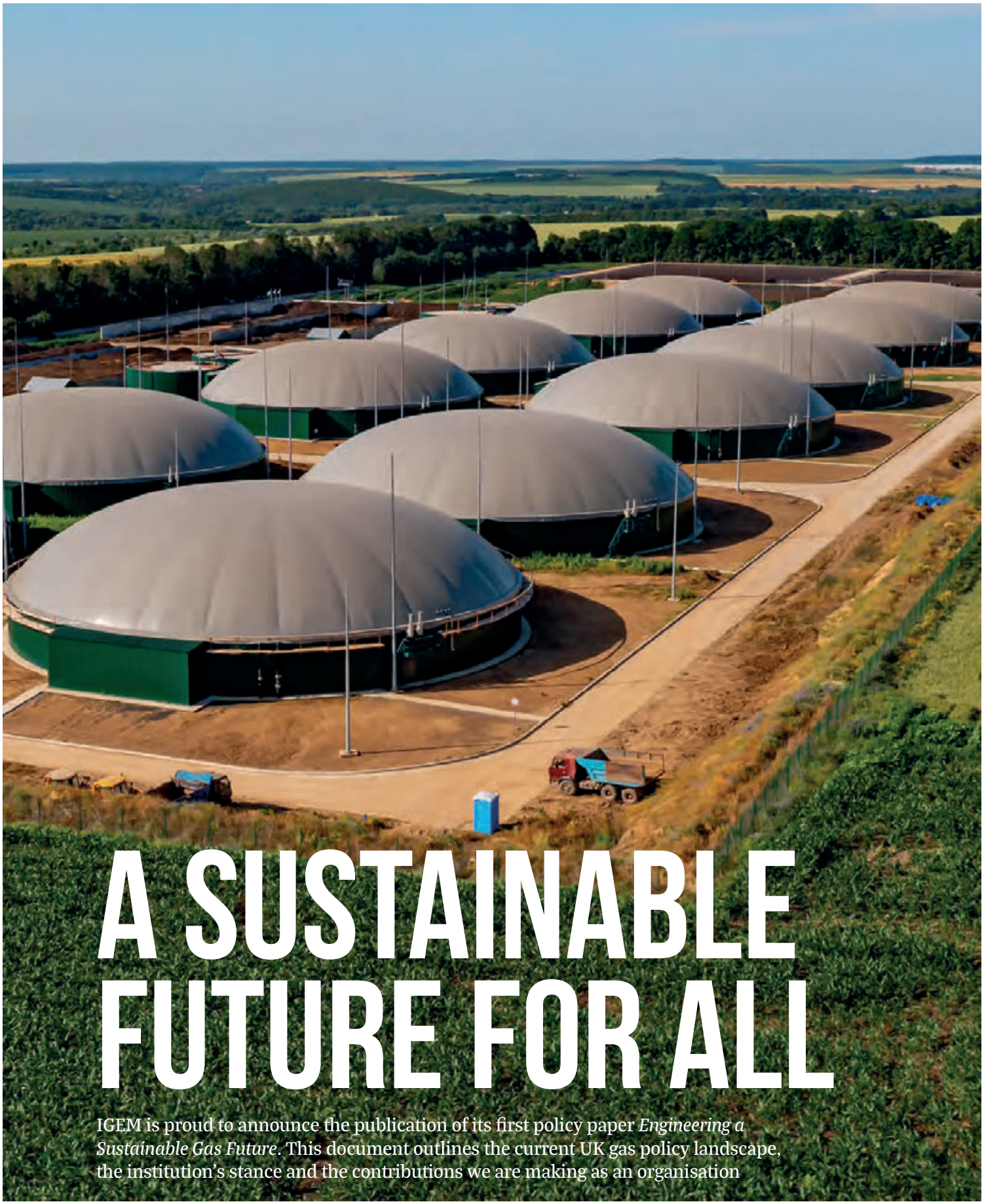
The Guardian approached BEIS for comment.

farm, which EDF Renewables UK intends to construct near Redcar, to power its hydrogen electrolyser.

Major plans for green hydrogen production are also in play on the Humber, where British Steel's main site sits, together with the grid connections of the world's two largest offshore wind farms.

Energy and Climate Change Minister Greg Hands said: "As we accelerate the UK's energy independence by boosting clean, home-grown, affordable energy, it's crucial that our industries reduce their reliance on fossil fuels. This investment will help them to not only cut emissions, but also save money on energy bills, on top of supporting jobs by encouraging green innovation across in the UK."

BRITISH STEEL WILL EXAMINE NEW HYDROGEN OPTIONS TO REHEAT FURNACES



A SUSTAINABLE FUTURE FOR ALL

IGEM is proud to announce the publication of its first policy paper *Engineering a Sustainable Gas Future*. This document outlines the current UK gas policy landscape, the institution's stance and the contributions we are making as an organisation

In its recently published progress report to Parliament, assessing the UK's progress in reducing emissions and adapting to climate change, the Climate Change Committee (CCC) acknowledged the historic climate promises made by the UK government over the past year, but states that it has been "too slow to follow these with delivery".

The UK government has recently published a suite of documents that set out its strategy to decarbonise the energy system and tackle climate change: the 10-Point Plan for a Green Industrial Revolution, the Energy White Paper, the UK Hydrogen Strategy, the Heat and Buildings Strategy and the Net Zero Strategy.

The measures set out in the Energy White Paper are estimated to reduce carbon emissions across power, industry and buildings by up to 230MtCO_2e in the period to 2032 (compared to 451MtCO_2e in 2018), and in delivering this, support up to 220,000 jobs per year by 2030.

Alongside investment in areas such as offshore wind, heat pump installation, carbon capture utilisation and storage (CCUS) and the development of industrial clusters, there are promising commitments made to hydrogen, with government analysis suggesting that a third of the UK's energy consumption could be hydrogen-based by 2050.

Key commitments include a target of 5GW of low carbon hydrogen production capacity by 2030, equivalent to the amount of gas consumed by over three million households in the UK each year, and aiming for 1GW by 2025 (embracing both electrolytic and carbon capture-enabled methods that can both achieve a net zero outcome).

In addition, the government has committed to a £240 million Net Zero Hydrogen Fund, an ongoing commitment to hydrogen heating trials and a scaling up of hydrogen infrastructure for the development of a Hydrogen Neighbourhood by 2023, a large Hydrogen Village by 2025 and a Hydrogen Town by 2030.

IGEM welcomes the UK government's acknowledgement that there is a need for further hydrogen research, changes to gas quality regulations and investment in the gas network to enable this to happen.

The UK aims to be a world leader in decarbonising industry with the development of industrial clusters across the UK. These regional concentrations of industries and economic activity will drive the decarbonisation of energy intensive sectors, including iron and steel, chemical and textile production, and transform them into low carbon manufacturing hubs.

This will drive global investment and create internal markets for low carbon technologies, including hydrogen. The hydrogen produced in these industrial clusters can be used for flexible power generation, transport and heat applications.

More recently, the UK government announced a new, more challenging target to reduce the UK's emissions by at least 68 per cent by 2030, compared to 1990 levels and builds on this goal to achieve a 78 per cent reduction by 2035.

IGEM welcomes this more ambitious target, which is aligned with the recommendations set out by the CCC and demonstrates the UK's leadership as part of the November 2021 UN COP26 climate summit hosted by the UK government.

'The UK aims to be a world leader in decarbonising industry with the development of industrial clusters across the UK

But to achieve these more challenging targets, government and industry must act with urgency. IGEM sees the potential for increased biomethane injection, hydrogen blending and hydrogen for transport all offering a meaningful contribution to the UK's 2030 target.

In terms of current low carbon gas supplies to the network, the UK government has reaffirmed its commitment to increase the proportion of biomethane injected into the gas grid and to accelerate the decarbonisation of gas supplies, with the expectation of trebling the amount of biomethane in the grid between 2018 and 2030 - supported by the Green Gas Support Scheme that replaces the Renewable Heat Incentive.

Quickly ramping up production will allow more biomethane to be injected into the gas grid for heating and use in trucks, while additional low carbon options are being developed and scaled up.

HyDeploy, funded by Ofgem and led by Cadent and Northern Gas Networks, is the UK's first pilot project to inject zero-carbon hydrogen into the gas network. The project is exploring the potential for safely blending up to 20 per cent hydrogen into the current gas supply.

Enabling hydrogen blending to be widespread across the gas network will provide a valuable contribution to carbon emissions in the short term, with

the potential to deliver up to seven per cent emissions reduction from the grid.

The use of hydrogen in transportation is growing steadily. Currently there are over 140 hydrogen fuel cell vehicles in the UK, including cars, buses, trucks and trains, and the deployment of the UK hydrogen mobility programme could see this rise to 6,000 by 2025.

The UK government recognises the potential for hydrogen to deliver zero emissions technology for transport and has recently announced projects for zero emission road freight trials and hydrogen transport pilots.

DECARBONISING HEAT

There are various potential solutions for low carbon heating. Those with the potential to play a significant role in decarbonising heat include hydrogen, biomethane, heat networks, heat pumps and hybrid heating systems.

IGEM supports proposals to use the existing network of gas pipelines to carry low carbon gases, such as biomethane and hydrogen blends, working towards the eventual use of 100 per cent hydrogen.

Crucially, hydrogen produces zero carbon at the point of use and forms the basis of the gas industry's proposed pathway to a sustainable gas future. Evidence is also pointing to significantly reduced NO_x emissions from hydrogen boilers, compared to the most modern natural gas boilers on the market today.

Using electrified technologies such as heat pumps, powered using renewable electricity, is a strategy that the UK government has already embraced as a way of making near term reductions in carbon emissions. This approach will put significant additional strain on electricity capacity, and it is scarcely recognised that additional electricity demand is increasingly being accommodated by generation from reciprocating gas engines.

Electricity generation from gas today flexibly ranges from 7-70 per cent of the mix at any one time. The advantage of gas is its ability to balance daily and seasonal demand variations and provide flexibility in electricity supply.

In the future, low carbon gas could play an important role in reducing peak demand on the electricity system and increasing the deployment of renewable technologies through new methods, including power to gas and hybridisation of end use technologies involving a combination of electricity and low carbon gases.

The use of heat pumps will require significant additional energy efficiency measures and building retrofit to be effective across the UK. Recent research on decarbonising heat in buildings examines the challenge of retrofitting old housing stock with low carbon heating technologies, stating that heat pump-only systems could be unsuitable for up to 54 per cent of the existing UK housing stock.

Historically, the heat decarbonisation challenge was presented as a choice between large-scale electrification or the utilisation of low carbon gases – each with their own merits and challenges.

However more recently, we see growing support for an integrated, 'whole system' approach to meeting the energy transition challenge, with the UK government now supporting a portfolio of low carbon technologies and projects, looking across power, gas, heat and transport.

The policy approaches to date indicate that the UK government is keeping its options open; investing in low carbon technologies, R&D and developing the markets to support both electrification of heat and hydrogen for heating.

"Crucially, hydrogen produces zero carbon at the point of use and forms the basis of the gas industry's proposed pathway to a sustainable gas future"

The recently published Heat and Buildings Strategy reiterates its commitment to ramping up heat pump installations and phasing out fossil fuel heating in the near term. Strategic decisions on the implementation of hydrogen for heating are due in 2026, following the outcome of various strands of work, including 100 per cent hydrogen heating trials, hydrogen blending in the existing gas network, consultation on hydrogen-ready boilers, as well as extensive research and testing.

Regardless of the technologies used to achieve heat decarbonisation, it is imperative that consumers are put at the forefront of the energy transition if we are to reach net zero. The transition is likely to cause disruption to households and require consumer behaviour change, so offering consumer choice and ensuring they are closely consulted and supported throughout the journey will be key to its success.

Crucially, the energy transition must ensure that low income households and vulnerable consumers do not disproportionately bear the cost of low carbon energy policies, messaging echoed in the Heat and Buildings Strategy. The government must now deliver on its commitment to put consumer welfare and choice at the heart of the transition.

WHAT IS IGEM'S CONTRIBUTION?

Supporting the gas industry and our members

IGEM members and the engineering community as a whole are at the forefront of making a sustainable gas future a reality.

IGEM is dedicated to supporting them to achieve this. The intrinsic value of IGEM as a professional engineering institution lies embedded within its membership; to provide opportunities for UK-based and international members to come together, share knowledge, debate and learn from cutting edge developments around the world.

IGEM is supporting initiatives such as Gas Goes Green, which brings together all five of the UK's gas network companies to create the world's first zero-carbon gas grid. The initiative aims to speed up the switch from natural gas to a hydrogen and biomethane supply for the 85 per cent of UK households connected to the gas grid.

In turn, enabling people to use their heating, hot water and cooking appliances almost exactly as they are used today.

Safety and technical leadership

The UK has an excellent gas safety record and it is critical that we maintain this record throughout the transition to a low carbon gas network.

The resilience of the current gas system must also be maintained, where historically, customers experience an unplanned gas outage only once every 140 years.

IGEM will continue to provide technical leadership on gas safety and quality throughout the transition, underpinned by industry technical standards. At the core of IGEM's work lies a formal, robust process for the creation, review and further development of the technical standards and guidance documents upon which our gas industry safely runs its operations.

This process is strictly governed and supported by IGEM members and technical stakeholders, including industry regulators, and involves industry wide consultations to achieve consensus and ensure best practice.

Read the full policy paper Engineering a Sustainable Gas Future at www.igem.org.uk

STATS GROUP PRIMED TO SUPPORT INDUSTRY WITH NET ZERO GOALS

30IN REMOTE TECNO PLUG INLINE ISOLATION TOOL, SHETLAND GAS PLANT, UK

DUAL BISEPS WITH TEMPORARY BYPASS PROVIDES LEAK-TIGHT DOUBLE BLOCK AND BLEED ISOLATION ON 30IN LIQUID C02 PIPELINE, USA

PIPELINE TECHNOLOGY SPECIALIST

STATS Group is in a strong position to capitalise on new opportunities arising from the transition to more sustainable energy supplies and a carbon net zero future.

With decades of experience working on oil and gas pipeline projects, the Aberdeenshire-headquartered company has at its disposal the skills and proven technologies to isolate carbon capture and storage (CCS) related CO_2 pipelines and pipelines for natural gas blended with hydrogen.

STATS Group Business Development Manager Neil Mackay said: "STATS' double block and bleed isolation technologies have been helping our customers reduce emissions for 20 years. Our focus on innovation means we're ideally placed to continue this support, not only in the traditional hydrocarbon sector, but also as the industry transitions to more sustainable energy supplies."

With investment in both CCS and hydrogen projects accelerating, there is a growing focus on how existing pipeline infrastructure can be repurposed for both CO_2 and blended or pure hydrogen transportation. Therefore, the requirement for isolation, hot tapping and line stopping technology to safely and efficiently isolate these pipelines for repair, maintenance and modification is increasingly important. Over the past two decades, STATS Group has played a central role in the UK and internationally, in pipeline isolation, repair and maintenance projects, giving the company a deep knowledge base of the very infrastructure that, in the future, may be repurposed.

In that same period, and directly relevant to CCS, STATS has established itself as the go-to provider of hot tapping and line stopping services on high-pressure liquid CO_2 pipelines.

Neil Mackay said: "After safely completing multiple workscopes for Kinder Morgan on their high-pressure (up to 138bar) CO_2 pipelines in New Mexico in the United States, we're in an excellent position to support CCS infrastructure owners and operators with future pipeline maintenance and upgrade projects.

"Also with an eye to the future, STATS is partnering in a joint industry project with DNV and a number of pipeline owners and operators, looking at in-service welding for the purposes of providing isolation solutions on natural gas pipelines blended with hydrogen. The objective is to determine if welding onto an in-service pipeline that contains a mixture of methane and hydrogen results in an increased risk of hydrogen cracking and, if so, to develop guidance pertaining to measures that can be taken to mitigate the increased risk."

Notwithstanding the opportunities in relation to CCS and hydrogen, STATS continues to support its customers to reduce emissions, recognising the pivotal role that natural gas is playing as the world seeks to first reduce carbon emissions ahead of a longer term transition to more sustainable sources of energy.

Using the company's proprietary double block and bleed pipeline isolation technologies, localised repair and maintenance worksites can be safely isolated without the need to depressurise large sections of the pipeline, thereby avoiding the need to discharge significant quantities of greenhouse gases into the atmosphere. In the case of large diameter gas pipelines, this can prevent the potential discharge of thousands or tens of thousands of tons of methane emissions into the atmosphere.

Mr Mackay concluded: "We're excited about the future energy transition and the role STATS is playing in supporting our customers to achieve their net zero goals."

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STATS GROUP

CAPTURING A GREENER FUTURE

THE IMPORTANCE OF GREEN GASES IN DECARBONISING THE ENERGY SYSTEM

New DNV research has highlighted the ten energy systems technologies that must work together to meet global decarbonisation targets. **Sarah Kimpton**, Vice President, Energy Transition & Innovation Development, Energy Systems at DNV, speaks about the role of green gases in meeting this challenge

The world needs to transition faster to a deeply decarbonised energy system. Reducing emissions by around eight per cent each year could ensure an energy future in line with the 1.5°C ambition set under the Paris Agreement. This urgent and complex challenge

needs full energy system thinking and greater awareness of the tight timeline and interdependencies of technologies and policies. It critically requires the courage to make difficult decisions.

The recently released *Technology Progress Report*, a new supplement to DNV's annual *Energy Transition Outlook*, has highlighted how ten key energy transition technologies are expected to develop, compete, and interact over the next five years if global economies are to meet emissions reduction targets.

The technologies that have the potential to deeply decarbonise the world's energy system are well known. They are those that can help to scale renewable power generation and extend its reach through the electrification of new sectors, replacing natural gas with hydrogen and which can remove carbon from fossil fuel energy sources, before or at the point of combustion.

The real challenge lies in navigating how and when to implement these technologies – all of which are at different stages of maturity – and in managing how they interact and rely on one another. Understanding this will enable industry, governments and those financing the transition to effectively prioritise their efforts, to achieve the emissions reductions required every year through to 2050.

CARBON CAPTURE AND STORAGE

Governments are implementing more effective climate policies and shareholders are pressuring companies to reduce their emissions. There has been a significant increase in commercial carbon capture and storage (CCS) project announcements and investment, especially in industrial sectors that have limited near-future technology alternatives for abating large CO_2 emissions, such as oil and gas, steel, cement, and waste-to-energy. In 2020, there were 26 commercial scale CCS facilities in operation across the globe capturing just under 40 Mt CO_2[1].

Large-scale implementation of CCS technologies is a necessary part of reaching the Paris Agreement climate targets. Although CCS has long been considered an immature and risky distraction from other 'better' decarbonisation routes, today we see a renewed interest in this technology as it becomes an effective a tool for achieving net negative emissions and transitioning to a net zero emissions future.

CCS is expected to scale substantially over the next three decades thanks to the carbon price increase in Europe. However, because competitive carbon pricing in heavily industrialised countries such as China and India is not forecast to occur before 2035, we expect a more limited scale-up compared with the long-term International Energy Agency scenario[2].

Mature carbon capture technology exists for nearly all industries, but in recent years the focus has shifted away from the fossil fuel power generation sector to major industries like cement, steel, refining, hydrogen and ammonia.

Building CO_2 transport hubs in industrialised areas with access to storage sites under development – such as those in the Netherlands, Norway, UK and Italy, will speed large-scale uptake of CCS by allowing industrial clusters to share transport and storage infrastructure, thereby reducing costs and lead times

Costs vary greatly across industries from $15 to $125 per ton of CO_2, but these are expected to fall[3]. The largest savings will likely come from come from the replication of projects and economy of scale, process improvements, and increased competition between technology providers. Widespread deployment of the technology is paramount to significantly cut costs, where higher carbon prices will further strengthen uptake.

Connecting CO_2 sources to permanent geological storage sites is an essential part of the CCS chain. Today, CO_2 is primarily transported through pipelines, but transport by ship and truck is also an option. Studies have already identified many suitable and safe sites to store CO_2 across the world. However, sites must also be close to capture plants and identification, assessment and approval of storage sites can take up to ten years. Therefore, short-term development of CCS infrastructure will mainly occur in locations that already have tailored regulations, i.e., Northern Europe, North America and Australia.

Building CO_2 transport hubs in industrialised areas with access to storage sites under development – such as those in the Netherlands, Norway, UK and Italy, will speed large-scale uptake of CCS by allowing industrial clusters to share transport and storage infrastructure, thereby reducing costs and lead times.

TRANSPORTING GREEN GASES

DNV's 2020 *Energy Transition Outlook* forecasts that by mid-century around half of the energy mix will still be made up of hydrocarbons. Therefore, pipelines will remain critically important for transporting molecular energy from the point of production or storage to the point of consumption.

Increasing capacity by repurposing existing infrastructure for gases such as hydrogen and CO_2, rather than constructing new pipelines, can reduce both project risk and commercial burden. However, these projects are mainly at the pilot stage. Larger-scale deployment of hydrogen and CCS is likely to require linking production and carbon capture utilisation and storage (CCUS). This will be through hubs and purpose-built 'backbone' pipelines to connect facilities such as steelworks, chemical plants and power stations, that previously would not have had any reason for being partnered. In addition, many inland facilities will need to be coupled to coastal hubs for hydrogen supply or CO_2 export.

According to forecasts[4], CCUS demand in 2050 will be roughly 100 times larger than the collective capacity of the roughly 6,500km of CO_2 pipelines that exist today.

Research is underway to determine how new low carbon gas pipelines and existing pipeline materials will perform in hydrogen and CO_2 service and potentially at different operating temperatures and pressures.

Transporting CO_2 by pipeline links the process activities for capturing CO_2 at an emitter facility (e.g., power station, steel manufacturer, refinery) with the activities needed to inject it deep underground for permanent geological storage. Critical issues are as follows:

- Impurities in captured CO_2 affect the phase behavior and have a significant impact on pipeline design parameters. The current demand for rapid growth in CCS to support deep decarbonisation of industry will result in CO_2 being captured from a much wider range of emission sources, with a much broader range of contaminants than previously encountered.
- Pipeline capacity and size also needs careful consideration. It is tempting to design the pipeline for the maximum flow capacity that could be needed, but oversizing the pipeline carries significant risks

given that industry may pursue fuel switching or technologies that could significantly reduce the demand for CO_2 pipeline capacity. For example, if a major steel plant switched from blast furnaces to electric arc furnaces, or a blue hydrogen production facility were replaced by green hydrogen, CO_2 transport demand would drop dramatically.

- Transporting relatively pure CO_2 as either a liquid or a gas is preferable to managing a pipeline flowing a two-phase, less pure mixture. It is preferable to transport CO_2 either in the gas phase at about 35bar or as a dense liquid phase above 100bar. This must be carefully modelled to avoid CO_2 phase changes along the pipeline by ensuring the CO_2 is maintained at optimum pressure and temperature range.
- Contaminants and the need to avoid phase change in pipelines transporting CO_2 make metering and monitoring in CO_2 pipelines just as important as for traditional hydrocarbon pipelines.
- CO_2 flows are unlikely to be steady, so metering and pipeline monitoring will be essential for both single and multiphase flows. Further modelling and metering developments are needed to both forecast impacts and adequately monitor operating conditions.

HYDROGEN IN THE PIPELINE

As opposed to CO_2, which can be considered as a waste stream, hydrogen is a valuable energy carrier and feedstock with a variety of applications. The purity requirements of the end application can have a significant impact on pipeline design parameters. For pipelines that are to be repurposed for hydrogen, the original construction and maintenance records are required to avoid detailed and time-consuming additional inspections.

In its pure state, hydrogen has unique properties and when combined with some impurities the corrosion risks can increase dramatically; certain impurities, on the other hand, may be beneficial. Many metallic materials, including steels (especially high-strength steels), stainless steel, and nickel alloys, suffer embrittlement in hydrogen gas environments. As we move through the energy transition, and both industrial and domestic consumers convert from methane to hydrogen, both old and new systems will need to operate side by side. Though the role of pipelines in a decarbonised future is often not well understood, building these systems and vastly increasing CCS network capacity will significantly increase the demand for pipeline expertise.

FIGURE 1 HYDROGEN DEMAND BY REGION

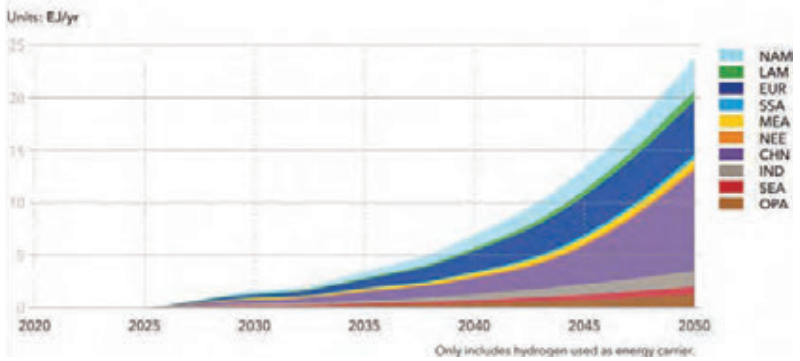


FIGURE 2 WORLD CCS CAPACITY BY REGION

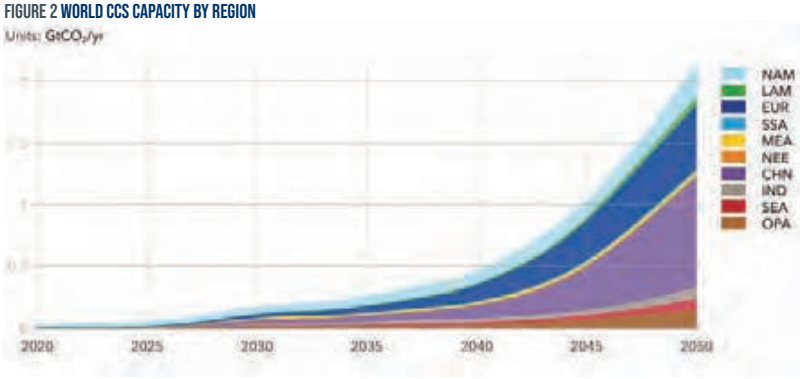
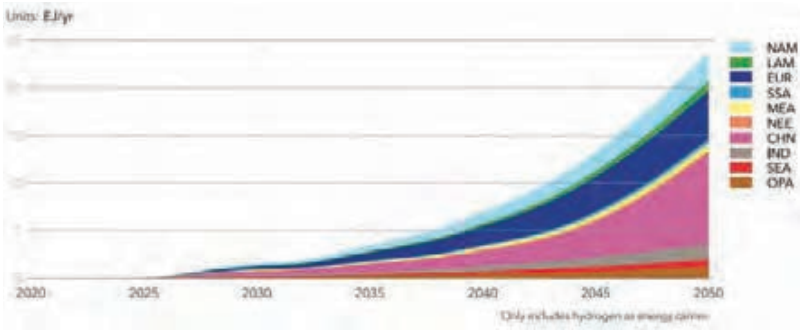


FIGURE 3 WORLD HYDROGEN PRODUCTION AS ENERGY CARRIER BY REGION



CONCLUSION

The world needs to act urgently on multiple fronts: increasing renewables, further improving energy efficiency, and developing CCS. Existing competitive technologies, such as solar and wind power, need to take full advantage of the virtuous circle where cost decline both causes and is caused by the growing number of unit installations. For less mature technologies, like green hydrogen, scaling from prototype to a commercially investable level is critical.

Crucially, these technologies are interconnected. For example, one cannot predict green hydrogen uptake without understanding developments in renewable sources of power, and an understanding of CCS is not complete without considering technical requirements for pipelines transporting enormous quantities of CO_2.

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THE STRUGGLE FOR ENERGY SECURITY

As economies around the world fight to protect themselves against rising fossil fuel prices as a direct consequence of the pandemic and the war in Ukraine, the UK government promises a major acceleration of homegrown power in Britain's plan for greater energy independence

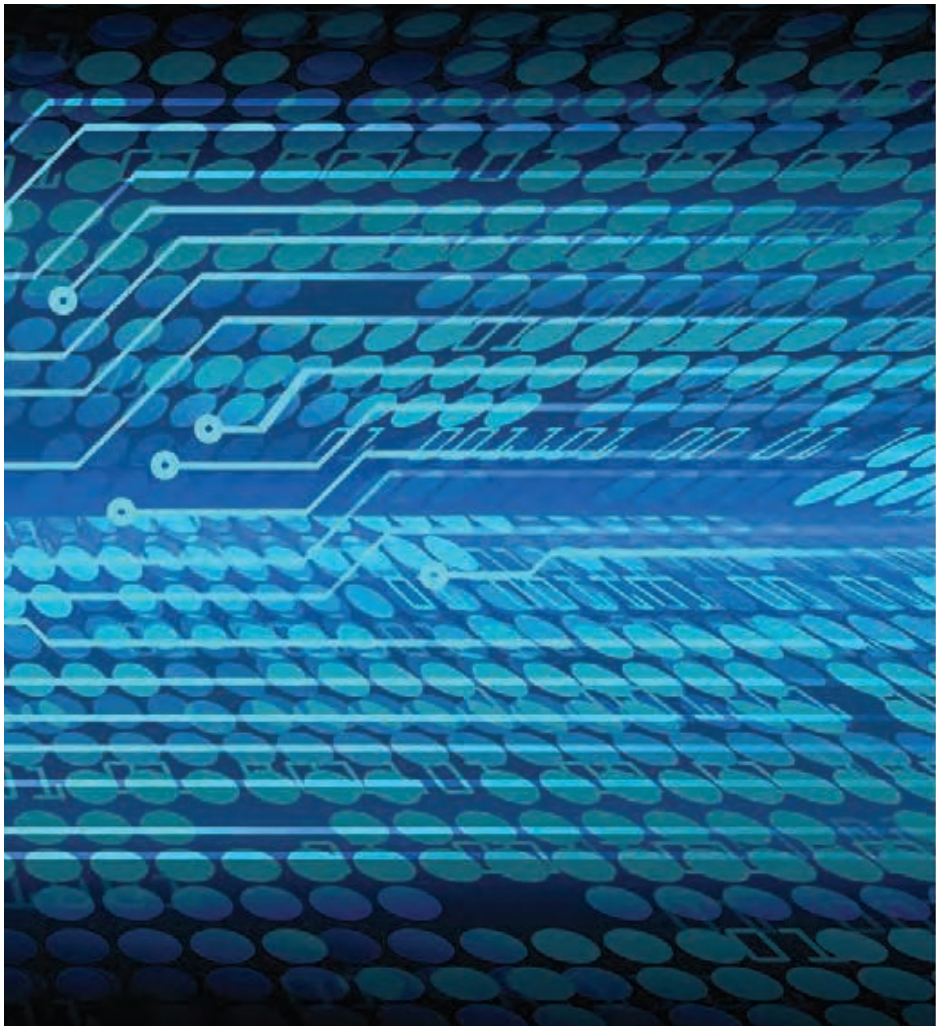
Cleaner and more affordable energy will be made available under plans to boost long-term energy independence, security and prosperity across Great Britain. This was the promise of the Department for Business, Energy & Industrial Strategy, on the release of its Energy Security Strategy last month.

The plan to boost Britain's energy security comes in the wake of rising global energy prices and volatility in international markets.

The strategy boasts bold new commitments to supercharge clean energy and accelerate deployment, which could see 95 per cent of Great Britain's electricity become low carbon by 2030.

The plans are ambitious and include faster expansion of nuclear, wind, solar, and oil and gas, plus a doubling of the previously published hydrogen production target. The government now is now aiming for 10GW of UK hydrogen by 2030, with half coming from green hydrogen and utilising excess offshore wind power to bring down costs.

In addition, the strategy lays out



plans to deliver the equivalent of one nuclear reactor a year instead of one a decade and the creation of over 40,000 more jobs in clean industries.

The Energy Security Strategy builds on the Prime Minister's 10-Point Plan for a Green Industrial Revolution, and, together with the Net Zero Strategy, promises to drive £100 billion of private sector investment into new British industries, including offshore wind and support for 480,000 new clean jobs by the end of the decade.

Prime Minister Boris Johnson said: "We're setting out bold plans to scale up and accelerate affordable, clean and secure energy made in Britain, for Britain – from new nuclear to offshore wind – in the decade ahead.

"This will reduce our dependence on power sources exposed to volatile international prices we cannot control, so we can enjoy greater energy self-sufficiency with cheaper bills.

"This plan comes in light of rising global energy prices, provoked by surging demand after the pandemic as well as Russia's invasion of Ukraine. This will be central to weaning Britain off expensive fossil fuels, which are subject to volatile gas prices set by international markets we are unable to control, and boosting our diverse sources of homegrown energy for greater energy security in the long-term.

"Consumer bills will be lower this decade than they otherwise would be as a result of the measures this government has taken."

Business and Energy Secretary, Kwasi Kwarteng, added: "We have seen record high gas prices around the world. We need to protect ourselves from price spikes in the future by accelerating our move towards cleaner, cheaper, home-grown energy.

"The simple truth is that the more cheap, clean power we generate within our borders, the less exposed we will be to eye-watering fossil fuel prices set by global markets we can't control.

"Scaling up cheap renewables and new nuclear, while maximising North Sea production, is the best and only way to ensure our energy independence over the coming years."

THE ENERGY SECURITY STRATEGY AT A GLANCE

THE AMBITIOUS PLANS INCLUDE:

HYDROGEN: Up to 10GW of low carbon hydrogen production capacity by 2030, with at least half coming from green hydrogen and utilising excess offshore wind power to bring down costs. This will not only provide cleaner energy for vital British industries to move away from expensive fossil fuels, but could also be used for cleaner power, transport and potentially heat.

OIL AND GAS: A licensing round for new North Sea oil and gas projects planned to launch in autumn, with a new taskforce providing bespoke support.

HEAT PUMP MANUFACTURING: A Heat Pump Investment Accelerator Competition in 2022 worth up to £30 million to make British heat pumps.

OFFSHORE WIND: A new ambition of up to 50GW by 2030 – more than enough to power every home in the UK – of which 5GW would come from floating offshore wind in deeper seas.

ONSHORE WIND: A planned consultation on developing partnerships with a limited number of supportive communities who wish to host new onshore wind infrastructure in return for guaranteed lower energy bills.

SOLAR: he government will look to increase the UK's current 14GW of solar capacity, which could grow up to five times by 2035.

THE INDUSTRY RESPONDS

Following the release of the strategy, IGEM's CEO Ollie Lancaster said: *"With the gas system currently underpinning energy demand and delivering a significant flexibility service today, I'm really pleased that the government is doubling the ambition for low carbon hydrogen and making clear its intention for hydrogen's use in homes, industry and transport.*

"IGEM supports the adoption of a secure and diverse multi-vector system for net zero, with major roles for hydrogen, wind, nuclear, energy efficiency and demand response that are optimised for lowest total system cost and balanced across local, regional and national levels.

"Like natural gas today, hydrogen offers a multi-sector role, reaching customers everywhere through our climate-resilient gas grid. Our thousands of individual members, and hundreds of supply chain company members, stand ready to engineer this sustainable gas future to keep cumulative emissions as low as possible."

David Smith, Chief Executive of Energy Networks Association, which represents the UK and Ireland's energy network companies, said: *"Faced with a number of challenges, the government's plans to strengthen energy security by boosting clean power and doubling the UK's hydrogen production targets are welcome.*

"Having shown our ability to mobilise over £300 million of early investment in energy networks for a green recovery from Covid-19, the UK's networks are ready to move with the same urgency to deliver these new ambitions and continue to ensure security of supply.

"However, we are concerned that planning reforms underway don't fully reflect the needs of the network infrastructure necessary to connect new generation and support new demand. If unresolved, this is a significant barrier to achieving the government's aims."

The Energy and Climate Intelligent Unit (ECIU) highlighted that the government's Energy Security Strategy took *"very limited steps on energy efficiency". It noted that the home energy efficiency scheme ECO could have been expanded to allow an estimated 22,500 homes to benefit from insulation upgrades.*

Sepi Golzari-Munro, Deputy Director at ECIU, said: *"Soaring gas prices are responsible for adding at least £500 to energy bills, forcing another 2.5 million households into fuel poverty.*

"Without help to insulate their homes to bring down gas bills there may be little prospect they can afford to keep their homes warm."

Likewise, Carl Ennis, CEO of Siemens GB & Ireland and Chair of Net Zero North West, said there was still scope for improvement in terms of energy efficiency. He said:

"The UK needs a mixed and dynamic energy policy to ensure secure and affordable energy and manage the transition to net zero. While the strategy provides greater certainty about the UK's major generating priorities, which will help to unlock investment and innovation, there remains much to do to drive up energy efficiency and leverage the benefits of local energy systems."

RenewableUK's CEO Dan McGrail said: *"The renewables industry is ready and able to work with government to deliver the ambitions set out in the new Energy Security Strategy. Renewables can deliver new, low-cost power quicker than any other option and wind will be at the heart of a secure, affordable net zero energy system.*

"Scaling up our ambitions for renewables, and increasing speed of delivery, will help us cut bills and be more energy independent. The sector is investing tens of billions of pounds in cheap wind power, as well as cutting-edge green hydrogen and floating wind technology, so that the UK can reduce our dependence on gas. Green investment is creating tens of thousands of jobs across the UK to support levelling up and reaching net zero faster."

Deirdre Michie OBE, Chief Executive of Offshore Energies UK, said: *"We are pleased that the government's strategy recognises the vital role of the UK's offshore energies sector in supporting energy security and the transition to net zero. It will be crucial to ensuring our 2050 Paris Agreement climate commitment stays on course.*

"Through the North Sea Transition Deal, the first of its kind by any G7 nation, we have a blueprint for delivering security of energy supply through oil and gas, while accelerating crucial cleaner energies like offshore wind, hydrogen and carbon capture. We recognise that this is an important moment in the energy transition and this challenge requires everyone and every level of government across the UK to be involved if this plan is to succeed."

Clare Jackson, CEO of Hydrogen UK, said: *"We are thrilled that the government has doubled down on hydrogen by increasing the production target to 10GW, recognising that hydrogen is a key part of the net zero transition. This new goal will allow industry to unleash investment, bring down costs and widen the use-case for hydrogen, exploring its potential in transport, heavy industry and to heat homes."*

Chris O'Shea, CEO of Centrica, said: *"We welcome the government's boost for renewables and nuclear and the focus on kick-starting the hydrogen economy.*

"This will help us reduce our dependency on foreign gas and, done properly, could help make us a net exporter of energy, boosting our economy and creating well paid, highly skilled jobs. We look forward to working closely with the government to do everything we can to bring this strategy to life."

Shell CEO Ben van Beurden, said: *"This is a once-in-a-generation opportunity to ensure an orderly transition to net zero while bolstering the UK's energy security and Shell is ready to play our part. We plan to invest up to £25 billion in the UK energy system over the next decade subject to board approval, and more than 75 per cent of this is for low and zero-carbon technology. Offshore wind, hydrogen and CCS will all be critical, but we need the right policy frameworks in place. We look forward to working with government on the important detail in order to make this a reality.*

John Pettigrew, CEO of National Grid, said: *"There's no doubt that this is a crucial moment for the energy sector. A strategy with clean energy at its heart is critical. Net zero is achievable and affordable and is a clear route to long-term resilience. We must now collectively focus on delivery - we are ready to collaborate with government, the regulator and industry to ensure this strategy delivers a clean, fair and affordable energy transition."*

David Parkin, Project Director for HyNet, said: *"From the mid-2020s, HyNet will begin to produce low carbon hydrogen in the heart of the North West. This will rapidly enable vital industry to switch away from fossil fuels to produce low carbon products – from food to chemicals and from cars to glass.*

"By 2030, industry in the region will have reduced their carbon dioxide emissions by a total of 10 million tonnes every year – a quarter of the region's entire emissions - the equivalent of taking four million cars off the road."

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ADDRESSING THE MATERIALS CHALLENGES OF THE TRANSITION TO HYDROGEN INFRASTRUCTURES

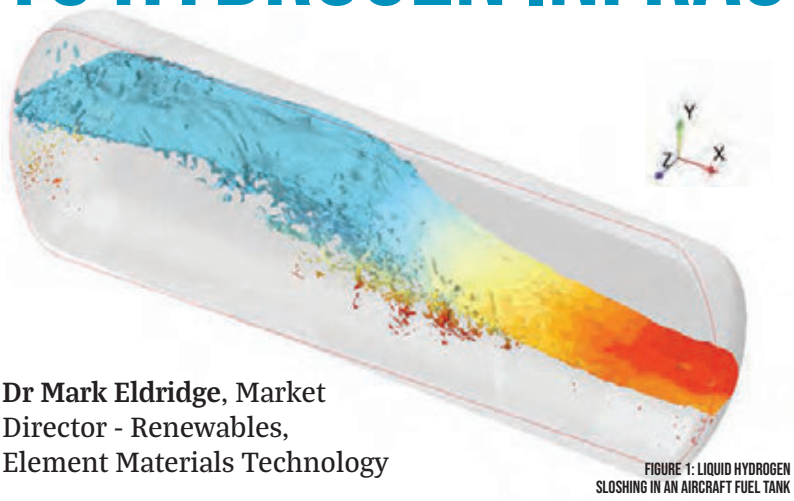

FIGURE 1: LIQUID HYDROGEN SLOSHING IN AN AIRCRAFT FUEL TANK

Dr Mark Eldridge, Market Director - Renewables, Element Materials Technology

Pipelines transferring fossil fuels have been developed over the last 50-100 years. The material science has been refined over this period, enabling these systems to be reliable, safe and efficient. Yet the negative impact of CO_2 emissions originating from fossil fuels is forcing change to sustainable fuels, in a matter of years, not decades.

Hydrogen is an energy vector which offers an elegant alternative to fossil fuels. Yet the transition poses several materials challenges. From fundamental materials used, to datasets required to validate safe operation under a range of hydrogen service conditions.

Element Materials Technology have extensive material science expertise, tests and services, which have been used to ensure optimum operation for many infrastructure developers. It is now focused on supporting the exponential demand for the re-validation, replacement and evolution of the material science for the energy transition to ensure the same reliability, safety and efficiency exists for new gases such as hydrogen.

Focus is at several levels, from what is possible in a virtual world, to the physical infrastructure and materials that exist throughout the supply chain, to the end use – both for the H_2 gas and the containment and manipulation systems throughout the process, such as compressors, valves, and seals.

VIRTUAL INFRASTRUCTURES

Element Digital Engineering provides simulation and data analysis consultancy to high-hazard and capital-intensive industries. Providing three main areas of expertise for hydrogen projects: process analysis and thermodynamics for performance optimisation in cryogenic and high-pressure hydrogen systems; integrity analysis and material behaviour analysis ranging from high-temperature creep to low temperature embrittlement and fracture mechanics; and safety support such as gas dispersion, explosion, and fire risk assessment analysis. At the end use stage, Element has simulated liquid hydrogen sloshing in aircraft tanks, the combustion performance of hydrogen as a replacement industrial fuel, explosion consequences in hydrogen fuel cells, and low-temperature embrittlement caused by rapid expansion of cryogenic gases in large-scale transport systems. Based on the early-stage development of many hydrogen-based systems, this ability to simulate both material behaviour, and the control and monitoring of the whole system is invaluable to current and future projects across the supply chain.

NON-METALLIC SYSTEMS

Non-metallics are used throughout the gas transportation industry from pipe linings to seals in valves, compressors and flanges, to complete composite pipe solutions. Hydrogen poses a unique set of challenges compared to natural gas.

There are three main areas of concern. Firstly, the rate and the amount of hydrogen that permeates through non-metallic components is higher mainly due to its small molecular size compared to methane. Element has decades of experience with methane and carbon dioxide permeation and is now focusing on hydrogen with tests to 200bar and from sub-zero to 200°C.

Figure 2 shows hydrogen versus methane permeation through a thermoplastic at 40°C and 40bar with hydrogen permeating approximately 40 times faster than methane (green vs red curves).

Rapid gas decompression damage, which occurs when high pressure gas is quickly de-pressurised, causes significant damage to elastomers (Figure 3), thermoplastics and even composites. Testing has already been undertaken at Element at initial pressures of 220bar and 150°C and decompression rates associated with several standards such as ISO 23936 and API 17J.

The final concern is the longer-term effects of material degradation over years. Element is exposing materials in high pressure (300bar) hydrogen at temperatures up to 200°C from weeks to months to accelerate chemical degradation and subsequently assess the impact on mechanical and physical performance.

METALLIC SYSTEMS

When considering the design or ongoing integrity of metallic pipelines and infrastructure, which may contain

weld flaws, dents or gouges, then the material properties need to be characterised, taking into account the operational environment.

When the environment degrades the performance of the material, testing needs to be performed 'in-situ' to replicate service conditions. In-situ refers to testing in an environment which can degrade the material properties, such as in seawater and CP, brine, spend completion fluid, oil, H_2S, sodium peroxide, acetic acid and hydrogen gas. The material properties measured are fundamentally the same, just tested in an environment to see the comparable effect to the baseline test in air.

The laboratory test types are chosen to provide quantitative data which is representative of the material in operation to provide data input into computational analysis. Some examples are as follows:

- An example of 'static' in-situ test would be a fixed displacement elastic fracture toughness threshold stress intensity test (KIH), performed in accordance to ASTM E1681
- A more informative elastic/plastic fracture toughness test, for a tougher material, would be a 'pseudo static', i.e., slow rising displacement test, performed in accordance with ISO 12135, BS 8571, BS EN ISO 15653, ASTM E1820
- Fatigue endurance (SN), fatigue crack growth rate (FCGR) and frequency scanning tests are 'dynamic', although test frequency is normally limited to approximately 0.3Hz, performed in accordance with ASTM E466, ASTM E647 and BS 12108.

There are some guidelines with respect to testing in an environment, however not all have a specific governing standard for testing in a hydrogen environment and this is the subject of ongoing research.

The data generated is then used in analysis tools such Finite Element Analysis (FEA) and Engineering Critical Assessment (ECA), which are used as part of a Fitness for Service philosophy, enabling the significance of flaws to be assessed in terms of structural integrity.

ADDRESSING THE VOLUME CHALLENGE WITH TEMPERATURE

Hydrogen can be stored as either a gas or a liquid. Storage of hydrogen as a gas typically requires high pressure tanks (350-700bar [5,000-10,000psi] tank pressure – 5kg of hydrogen can be stored in a 125-litre tank). Storage of hydrogen as a liquid requires cryogenic temperatures because the boiling point of hydrogen at one atmosphere pressure is -252.8°C, therefore benefiting from a significant volume reduction (5kg of hydrogen can be stored in a 75-litre tank). Materials across the supply chain, both behave differently and also need to be characterised at these temperatures for safe use. In advance of using liquid hydrogen as a test medium, Element offers liquid helium testing facilities, at similar cryogenic temperatures (-269°C) as a precursor to liquid hydrogen setup. Liquid hydrogen services will form part of subsequent development along the pathway to 2025. Currently, Element Materials Technology is exploring opportunities for collaboration and partnerships for developing liquid hydrogen facilities in the UK and across Europe to meet the needs of refuelling infrastructures, principally in support of aerospace.

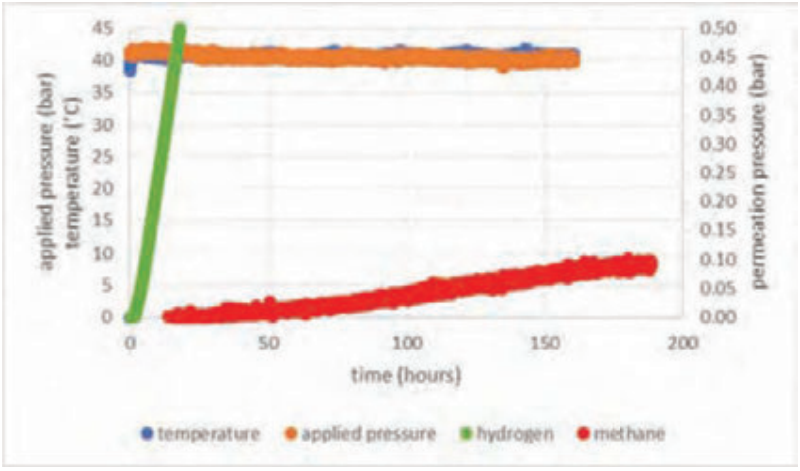

FIGURE 2: HYDROGEN VS METHANE PERMEATION THROUGH A THERMOPLASTIC

FIGURE 3: GAS DECOMPRESSION DAMAGE SEEN IN A SECTION OF ELASTOMER SEAL

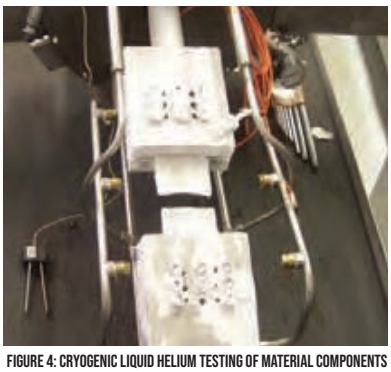

FIGURE 4: CRYOGENIC LIQUID HELIUM TESTING OF MATERIAL COMPONENTS

SUMMARY

To ensure we continue to take our energy system for granted in a safe, efficient, reliable and, most importantly, sustainable way for generations to come, Element Materials Technology is striving to provide the knowledge and services to support a wide range of hydrogen infrastructures, in order to make tomorrow safer than today. Please contact us if we can help you in your energy transition to hydrogen.

element

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SPECIAL DELIVERY

BRITAIN'S HYDROGEN BLENDING DELIVERY PLAN

Britain's gas grid will be ready to start blending hydrogen around the country from next year, helping to provide families with more secure, homegrown energy supplies, according to new plans published by the UK's energy networks. Energy Networks Association (ENA) has published its Hydrogen Blending Delivery Plan, setting out how all five of Britain's gas grid companies will be ready to deliver 20 per cent hydrogen to homes and businesses around the country from 2023

The UK government has set out ambitious, legally binding obligations to reach net zero by 2050. If this target is to be met, it will require wide-ranging industry collaboration and a mosaic of innovative solutions to deliver the carbon reduction required. Low carbon gases such as biomethane and hydrogen are expected to play a vital

role in transitioning to a low carbon future. Recent policy documents have begun to define the role of hydrogen and how blending hydrogen with natural gas in the existing gas infrastructure can support the transition to a net zero future.

The process of mixing natural gas with up to 20 per cent hydrogen could lead to significant carbon savings. If 20 per cent hydrogen is blended into the gas grid together with existing natural gas, this could save up to six million tonnes of carbon dioxide equivalent every year, the equivalent of taking 2.5 million cars off the road.

As hydrogen blending would be an intermediate step towards a 100 per cent decarbonised gas future, it is vital that blending delivers the maximum benefit for the minimum outlay. It needs to be delivered quickly, simply, and efficiently to give momentum to the transition towards 100 per cent decarbonised gas. Ongoing trials and projects are examining the physical, operational, safety and cost-benefit cases for blending hydrogen into the gas networks.

In addition to this evidence, the market frameworks governing the duties, rights, and incentives of gas market participants across the value chain must also be compatible with blending. The existing market frameworks assume the conveyance and trading of a relatively homogeneous natural gas. Therefore, existing market frameworks must be reviewed, with any necessary changes made as a matter of urgency in order to ensure that blending can commence once operational trials have demonstrated that it is technically safe and economically efficient to do so.

The project has created two timelines to map out how the existing gas market frameworks could be changed to enable blending. For the purposes of this project, the gas market frameworks have been broken down into five market pillars. The market pillars are primary legislation, regulation, licence, code, and safety change.

As hydrogen blending would be an intermediate step towards a 100 per cent decarbonised gas future, it is vital that blending delivers the maximum benefit for the minimum outlay. It needs to be delivered quickly, simply, and efficiently to give momentum to the transition towards 100 per cent decarbonised gas

ROLL-OUT MODELS

First, the project explored a number of potential physical roll-out models for blending. In order to support the market and regulatory changes required to facilitate hydrogen blending, it was deemed important to understand at a high-level what regime the market rules would be creating. The project investigated a range of potential options for the roll-out of hydrogen blending onto the network, two indicative routes were chosen to be explored further based on their differing underlying principles. These were called the Strategic Approach and the Free Market Approach.

The project undertook a high-level assessment of the roll-out models and found benefits and challenges for each approach. Further work is required in this area to define the most suitable approach, to deliver the highest potential carbon reduction savings, whilst taking into consideration the key principles of efficiency, speed, and simplicity.

Engagement and collaboration are needed from the wider gas industry to develop a detailed roll-out model that can deliver the benefits of blending. The project has highlighted the potential development of a methodology to set out the practicalities and incentives required to deliver an appropriate roll-out model.

Strategic Approach

The Strategic Approach would designate connection locations based

on the most suitable parts of the network, considering a number of potential factors, including where would maximise hydrogen blending volumes and where on the network would allow efficient control and operation of blends.

Free Market Approach

The Free Market Approach mimics the existing arrangements for connections to the gas networks and would let the market decide where to inject hydrogen into the network, with the hydrogen capacity being made available on a "first come, first served" basis.

TIMELINES

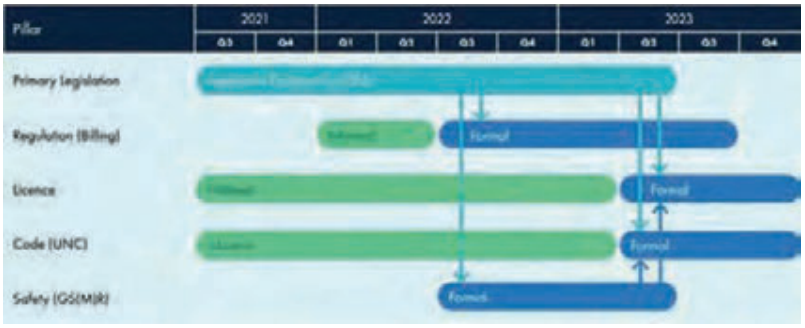
The first timeline the project created was a target-driven timeline related to the date set out in the 2020 BEIS Energy White Paper to enable hydrogen blending by 2023. The Target 2023 timeline showcases that whilst there are uncertainties and unknowns, with the right level of collaboration, engagement, and coordination it would be possible to enact gas market change at an accelerated pace to meet the 2023 target.

It is important to highlight that this timeline is driven by the government target and there is uncertainty regarding the volume of physical hydrogen production that will be available to be connected to the networks in 2023. A key reason why the 2023 target could be met was the concept of undertaking informal pre-work before a final policy decision is taken on whether to go forward with network blending.

This final policy decision is expected from BEIS in 2023. The Market Pillar timeline shows how the interaction between the informal and formal processes could deliver accelerated change to meet the government target. The pre-work would need to be undertaken in a collaborative way to build industry consensus to expedite formal process timescales. It should also be noted that the pre-work shown would have to be completed 'at risk' (i.e., before the formal policy decision is taken). This risk could reduce the willingness of industry parties to engage.

In contrast to the target driven nature of the Target 2023 timeline, the project also created a second timeline called Sustained Progress. This timeline shows steady progress with pre-work still being undertaken, but highlights how the uncertainties related to certain change activities could extend timelines. The Sustained Progress timeline still results in all the market frameworks being updated by the end of 2024 to enable blending, with residual system change being completed in 2025. This timeline still showcases industry engagement and collaboration taking place throughout 2022 and 2023 to deliver the change required. Both timelines and the details related to each change activity can be found within the full report.

TARGET 2023 MARKET PILLAR TIMELINE



It is important to highlight that this timeline is driven by the government target and there is uncertainty regarding the volume of physical hydrogen production that will be available to be connected to the networks in 2023

CONCLUSIONS

The key project conclusions are summed up below and the complete suite of recommendations can be found within the full report.

1 2023 is an ambitious yet achievable target. The Target 2023 timeline showcases how the 2023 date for market framework change can be met, through a route of minimum viable change to deliver blending.

2 Early policy clarity can accelerate change. With minimal infrastructure changes required to enable blending the earlier policy clarity can be provided, the more it de-risks industry parties, the more it will drive up engagement and collaboration and the quicker formal change processes can commence.

3 Delivery of the timeline requires centralised coordination of change plans. Robust coordination from a centralised body of change plans from across the blending value stream would remove the risk of piecemeal change and ensure the change is delivered in a coherent and structured way. It is vital that change is undertaken in parallel and there is clear communication across the different work streams.

4 Need for industry collaboration and engagement before final policy decision is made. If the industry waits until a formal policy decision is made before starting to try and answer some of the outstanding questions related to blending, it will delay the implementation of network blending. It is vital that those parties who are responsible for leading market change activities undertake collaborative pre-work to ensure the relevant market changes are completed in a clear and ordered way.

5 Implement quick-win system solutions first. Central IT systems cannot be a barrier to innovation and change. Engaging with service providers at the earliest opportunity and implementing the quick wins in the first instance would reduce the potential risk of IT system change delaying the rollout of hydrogen network blending. The impacts on third party systems also need to be considered when developing quick-win system solutions to ensure the industry has time to complete their necessary changes.

Stakeholders' views are very important to the Gas Goes Green programme as they can help shape and enhance future deliverables. If you would like to discuss any aspect of this project or find out how you can get involved in the wider Gas Goes Green programme, please contact ENA at gasgoesgreen@energynetworks.org. Read the full report at www.energynetworks.org.

HY HOPES

The BEIS Hy4Heat programme has been a critical first step in establishing that it is technically possible, safe and convenient to replace natural gas with hydrogen in the gas network for a large number of residential and commercial buildings and a range of gas appliances. As the programme comes to a close, a final progress report assesses its impact on the industry

Over the past few years, the BEIS Hy4Heat programme has played a significant role in the transformation of the mindset of industry towards a hydrogen future, and has helped to put the UK at the forefront of international efforts

to develop safe, high-performance hydrogen technology for heating.

The UK is setting out its vision for transitioning to a net zero economy and, with around a third of UK emissions coming from households and some 80 per cent of homes heated by natural gas, finding alternatives to natural gas as a domestic fuel is a high priority.

In 2017, BEIS committed £25 million of its £505 million Energy Innovation Fund to Hy4Heat. The programme has proved to be a critical foundation piece for the government's 2021 Hydrogen Strategy and its Ten Point Plan for a Green Industrial Revolution, which includes hydrogen neighbourhood and village trials by the middle of the decade.

These community trials will be possible as a result of the Hy4Heat programme. Hy4Heat has achieved the technical, performance, usability, and safety evidence to demonstrate that hydrogen can be used for heat in some buildings.

However, the outcomes and benefits of the study are broader and more significant than expected at the start of the programme. With a relatively small budget, the programme has unlocked hydrogen innovation across the gas industry.

Consortia were encouraged to develop fully working prototypes within a constrained timeframe and lay the foundations of an entirely new customer-focused hydrogen appliance market. In a short time, the programme has moved UK hydrogen heating technology from a Technology Readiness Level (TRL) of 1-2 up to 8-9 on the scale; from a position of academic knowledge and understanding, to one of commercial market readiness.

The programme encouraged the development of products that are like-for-like 'hydrogen-ready' replacements of existing appliances, maximising their convenience and acceptability for customers.

Innovation developments in this area include cooker hobs with burners that allow the pale blue, generally barely visible hydrogen flame to be easily seen by the naked eye. Something that it is thought will be important in shaping the public perception of hydrogen if it becomes part of the mix of technologies and options to decarbonise heat.

By adopting an evidence-based, stakeholder-led approach, Hy4Heat has mobilised manufacturers, supply chains and academic partners to collaborate on developing the boilers, meters, cookers, heaters and other appliances that will be central to a community-level trial – which will be essential for evaluating the practicalities of a potential conversion to hydrogen.

Unforeseen positive outcomes have arisen, too, in that emissions of NO_x (nitrogen oxides – greenhouse gases) from burning hydrogen can be significantly lower than from methane with well optimised burner designs. This has helped stimulate new scientific research to investigate and explain these findings.

Another significant element of the programme was the completion of a first holistic safety assessment that shows the use of 100 per cent hydrogen for heating and cooking can be made as safe as the use of natural gas in the most common domestic buildings (detached, semi-detached and terraced houses). This safety assessment is informing continuing work.

In addition, the programme has supported the development of technical standards, certification guidance and a hydrogen competency framework for training, and has conducted market research studies on industrial and commercial appliances. Many of the programme's domestic appliances are showcased at the Hydrogen Home, developed in partnership with NGN and Cadent, and are also being used in other testing and display locations.

GETTING THE RIGHT TEAM

In 2017, BEIS appointed Arup+, a team that brought together:

- Arup's programme management expertise and thought leadership in energy
- Leaders in the field of hydrogen Kiwa Gastec
- Energy specialists Progressive Energy and Yo Energy
- Appliance experts Embers

The Arup+ team's responsibility was to manage the programme on BEIS's behalf and together with BEIS oversee the procurement and delivery of all the work packages.

A CLEAR MISSION

At the start, a short mission statement was created to both guide the programme and to enable its large endeavours to be explained in a concise and precise way. Hy4Heat's mission was: "To establish if it is technically possible, safe and convenient to replace natural gas (methane) with hydrogen in residential and commercial buildings and gas appliances. This will enable the government to determine whether to proceed to a community trial."

The primary goal was to provide the technical, performance, usability, and safety evidence to de-risk the use of hydrogen and lay the groundwork for potential community trials. Central to achieving this would be the critical safety assessment work and the development of a range of affordable hydrogen appliances, ready for use in homes and businesses.

A CHALLENGING START

Industry engagement research conducted at beginning of the programme identified that overcoming scepticism in the gas industry about the technical and commercial viability of hydrogen technology would be a challenge.

Equally, the manufacturing industry emphasised the timescales of the programme were unreasonably short in order to develop appliances.

There was a high level of uncertainty regarding the final outcomes of the research and development programme, particularly about the timescales of appliance development.

The overlapping nature of the work packages was complex and there would be a large number of different stakeholder organisations involved. The success of the programme lay in the ability of the Hy4Heat team to navigate these complexities and achieve results that lasted beyond the programme's lifetime.

The evidence-based, stakeholder-led approach saw leading manufacturers and their consortia team-up with academic partners to defy the odds and develop the appliances that would be central to a community trial within just three years. By creating a competitive environment for this surge of innovation, Hy4Heat laid the foundations for a consumer market of affordable, like-for-like, 'hydrogen-ready' appliances.

BUILDING BLOCKS FOR COMMUNITY TRIALS

The appliances developed, alongside the safety assessment work and hydrogen standards created by IGEM, have all provided reassurance that progressing to the next stage of community trial is both feasible and plausible. This next stage is to be a hydrogen neighbourhood in 2023, a hydrogen village by 2025 and plans for a potential hydrogen town pilot before the end of the decade.

STAKEHOLDER ENGAGEMENT

At COP26 in Glasgow in November 2021, speakers from Hy4Heat organisations presented at the Hydrogen Transition Summit held in the Climate Action Innovation Zone and webcast globally.

A display stand in the Innovation Zone enabled hundreds of senior business people and opinion-formers from across the world to see the hydrogen-burning stove, oven, boiler and meters up close.

The exhibition stand was also displayed at the DIT Global Investment Summit in October, opened by the Prime Minister.

Throughout the programme, Hy4Heat undertook extensive engagement with stakeholders. In part, this was conducted through links and relationships built with relevant trade bodies to drive programme awareness amongst its members, but Hy4Heat also ran its own supplier events.

These interactive sessions showcased the programme and also gathered insight and information from feedback in order to draft robust and relevant tenders for work package procurement purposes.

HYRROGEN BOILER AND HYDROGEN HOMES

The number of attendees at the stakeholder event held in early March 2020 was double that at the first event in March 2018. More than 200 people attended from organisations including appliance manufacturers and retailers, academics, energy industry consultants, trade bodies and associations, gas distribution network operators, exhibition agencies and the media.

WORK PACKAGE OVERVIEW

The programme consisted of ten distinct but inter-linked work packages each of which operated to different procurement and delivery timescales. The Hy4Heat team oversaw the programme and technical management of the entire programme, coordinating the delivery of each work package.

The team was able to respond to the changing needs of the programme as gaps were identified and new work packages added (for e.g., meter development and ancillary components) were added once the programme was underway.

LAYING THE FOUNDATION STONES

Mark Taylor, Deputy Director for Energy Innovation Science and Innovation for Climate and Energy at BEIS, said: "As the Hy4Heat programme ends, its legacy continues. The Hydrogen Home in Gateshead with hydrogen-powered heating and cooking appliances is open to the public and has already welcomed many energy professionals, journalists and local citizens.

"It's likely that the general public's understanding of hydrogen's potential to help overcome some of the trickiest decarbonisation challenges facing us will also increase as boiler manufacturers begin to market hydrogen-ready products in the coming years.

"Hy4Heat has been a critical first step in establishing if it's technically possible, safe and convenient to replace natural gas with hydrogen in the gas network for residential and commercial buildings and gas appliances."

Mark Neller, Hy4Heat Programme Director and UKIMEA Energy Leader at Arup, said: "I'm very proud of what the Hy4Heat programme has achieved through the programme team and wider supplier teams collaborating to deliver all of its work packages.

"I'm also proud of the solid legacy and inheritance that Hy4Heat passes on to the next set of hydrogen innovation projects in the UK, and also in other nations with a significant gas distribution network.

"The Hy4Heat programme made a great deal of progress in just a few years: from establishing hydrogen standards and a training framework for installers, through to the significant milestones of the safety assessment and the development of prototype hydrogen appliances, meters and components. The studies into commercial and industrial appliances and the market research into consumers' likely response to community trials are all foundation stones for the planned hydrogen community trials and potential future town pilot."

He added: "The Hy4Heat programme is just one small, but important, piece of the jigsaw. There's still a very long way to go and there must be an even greater sense of urgency to accelerate the pace of change, in order to meet our net zero targets and reduce our impact on the environment."

A final report has been published covering the Hy4Heat programme's activity in 2021 and early 2022. For more information, visit www.hy4heat.info

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GAS PUMP SET TO REVOLUTIONISE MAINS ABANDONMENT ACTIVITIES

2022: The year of COP26, declaration of emergency mode for the environment by the UNEP, and pledges from the US and EU to limit methane emissions by 30 per cent compared to 2020

2023: Will be the year of the GECO MK II

HOW IT STARTED

Originally developed in 2013, Pipeline Technology, commonly known as Pipetech, worked in conjunction with SGN and the NIA, to create an intrinsically safe gas-eco pump, to prevent the gas from mains abandonment activities from being vented into the atmosphere. Pipetech and SGN have collaborated on multiple occasions under the NIA scheme, due to their shared desire to improve operator safety, create innovative tooling, improve efficiencies and develop equipment to improve the environmental impact of various operations in the gas industry.

WHY IT'S IMPORTANT

The gas inside mains is natural, comprised of 70-90 per cent methane (Climate Change Communication), which is between 84-86 times more harmful to the environment than CO_2 over 20 years (United Nations Economic Commission for Europe). Gas shrinkage has been a long-standing problem with delivery networks. There is the well-known environmental impact of dissipating natural gas, but there are also additional health and safety risks for operators when venting gas, such as inhalation and fire hazards.

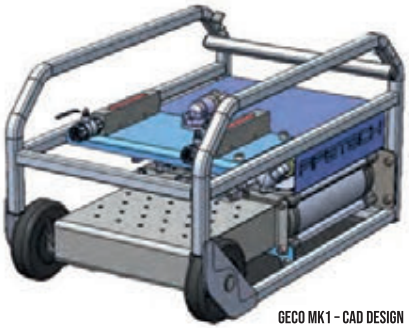
As of spring 2022, there is another issue: natural gas is under a supply constraint, with trade sanctions being placed on Russia, one of the largest suppliers of oil and gas in the world. The net effect is that gas shrinkage results in significant unrecoverable costs when the gas is not contained within the delivery network.

It has never been clearer: "cutting methane emissions is the fastest opportunity we have to immediately slow the rate of global warming"

– EDF Energy

HOW IT WORKS

With no electrical components, the gas-eco pump, which was named the GECO, is an intrinsically safe pump, predominantly used for mains abandonment and dead/live insertion. The GECO runs via one pneumatically driven actuator and two slave cylinders.



GECO MK1 - CAD DESIGN

PIPETECH
PIPELINE TECHNOLOGY LTD

Gas is drawn from the abandoned main and is then reinjected into a 2bar pressurised replacement main. The entire operation is performed with minimal escape or venting, drastically reducing delivery networks' carbon footprint, and improving health and safety.

GECO MK I – THE DESIGN

Developed by Pipetech from concept through to production, the original design featured a steel chassis for heavy-duty use, and two wheels to aid in transport. The project received huge accolades from the NIA and SGN for its innovation and environmental benefits. Whilst the GECO met all the requirements from the project scope, the size and weight meant that transportation required a two-person lift and was difficult to manoeuvre in the soft and loose terrain of trenches. It was clear that the benefits of the GECO would be revolutionary if the ergonomics could be improved.

GECO MK II – THE EVOLUTION

Pipetech is pleased to introduce its redesign: the patented GECO MK II. Three times lighter and 2.5 times smaller than the original, the MK II is housed in a briefcase-sized plastic case, ready to fulfil the updated design brief:

"To create a product which becomes an essential part of gas maintenance and repair operations, helping delivery networks on their journey to net-zero 2050"

– James Hodgson, Managing Director, Pipeline Technology

GECO BODY OUT OF CASE

Simply put, this is a device that should be on every gas engineer's van in the country. With the product undergoing final approval, it is expected that the GECO MK II will be essential in day-to-day activities on the network. With the additional design benefits of a speed controller, stroke counter and moisture trap on the air inlet, the MK II is a product evolution which enhances form without compromising on functionality.

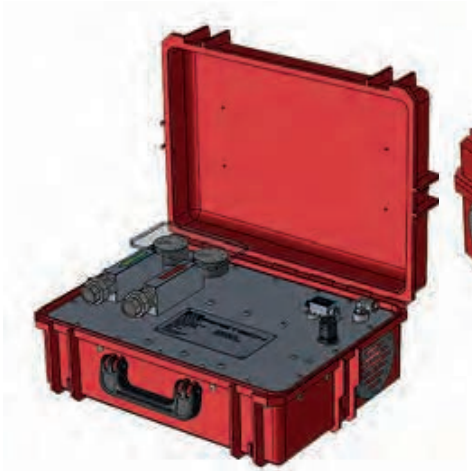
Pipetech is also developing and testing ancillary products, which when used in conjunction with the GECO, further extend the gas-saving potential on other operations where venting of gas has become routine.

SO, WHO IS PIPETECH AND WHAT DO WE DO?

Pipetech is the leading manufacturer and supplier of under-pressure drilling, flowstop equipment and associated pipeline tooling, supplied to the international water and gas industries.

Our experience enables us to offer associated engineering consultancy services, often leading to the design of innovative and efficient products, specifically for your needs. We have a reputation for problem-solving and supplying product packages for piping projects throughout the world.

We look at your problem in a way that no other business can. We then create solutions which will save time and money and help businesses reduce their carbon footprint. Our latest focus has been on the development and implementation of products which allow the supply to remain 'always on' with no disruption of service to the consumer.



GECO MK2 - CAD DESIGN - OPEN

GECO MK2 - CAD DESIGN - CLOSED

A NOTE FROM US

CHANGING OUR DAILY activities is no longer a choice, it's a moral obligation and a requirement by law. As a society, both in our personal and professional lives, we must look at the activities we perform to see if there is a smarter, more eco-friendly way to achieve the same result. Ignorance is not an excuse. There is enough data and forecasting to show we are the generation that will seal the fate of all living organisms on our planet. We will either adopt innovation and prevent global warming, or, we will continue to do what has always been done, the consequences of which are already known and can no longer be ignored.

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DUNKELFLAUTE DAYS

As our energy system becomes increasingly reliant on renewables, the question remains: how can we guarantee supply on those days when the sun doesn't shine and the wind doesn't blow? IGEM CEO **Ollie Lancaster** examines this phenomenon and looks at how the gas industry can support the energy system during the dark doldrums

A couple of years ago, if anyone had mentioned the word 'dunkel' to me I'd have thought it was in reference to German beer – the darker, puncher stuff, such as Erdinger Dunkel that we can get off the supermarket shelves. Not even my fluent German-speaking best buddy Tom had introduced me to the word 'flaute' – but the word 'dunkelflaute' has become a staple in energy systems language of late.

Dunkelflaute is a term used to describe a period of weather characterised by low wind and not so much sunshine, which directly translates to 'dark lull' or 'dark doldrums'. As more and more renewable generation has come on board, this matter has become more prominent as energy system modellers try to grasp with how we may affordably enjoy a secure supply of electricity, as we increasingly reduce emissions for the energy system as a whole.

Modelling has, in the vast majority of cases, been drastically over-optimistic about how short these periods could be. I think it's fair to say that the full-electrification lobby have typically under-accounted for windless periods, but now seem to be grappling with more realistic lengths of time. Just to put this into context, modelling had often included only five days of low renewables, when historical data suggests it could be over 60 days.

The longer the period without wind and solar, the greater the challenge and the more energy storage needed to cover for that time. It's also important to have an energy system that's ready for consecutive dunkelflaute periods that are broken only by limited days of renewables performing well. And this isn't just when we have low renewables in GB, but when weather systems across the whole European continent are unfavourable for wind. Don't get me wrong – we need wind power, and lots of it – we need it for decarbonising electricity supply and to make use of it in times of over-supply to produce hydrogen via water-splitting electrolysis, to complement flexible hydrogen production from reformation of natural gas with CCS.

Before the Russian invasion of Ukraine impacted energy system security and prices, there was already a price crisis due to a range of reasons – one of which was 2021 being a low wind year. In April last year we had 19 consecutive days of low wind at the same time as all our boilers were being used – outlining a supply issue for electrification of heat on top of other electricity demands. In the late summer to early autumn, we had 35 consecutive days of low wind – energy nerds far and wide were observing the generation statistics to see how long it would last.

So, what's the answer to a dunkelflaute? Well – not batteries, that's for sure. Batteries are great for short-term storage over a few hours, and certainly sub-day. The answer to long duration storage is through molecular energy – that being hydrogen, and indeed natural gas used to make some of the hydrogen. Some say we should make the hydrogen to support us in a dunkelflaute by using it to generate electricity in a fully-electrified world. However, hydrogen availability through the gas grid provides storage and flexibility benefits beyond just being used for back-up power generation in gas turbines or local gas engines found within cities, towns and villages – it provides a way to distribute to industry, heat homes and supply for transport needs.

Of course, there's the opposite of a dunkelflaute, or at least the opposite of flaute, that offers another challenge. That's when we get the storms that cut off electricity supplies to thousands of customers and highlight the importance of diversity in our energy system – with the climate change resilient gas system helping to limit the impact of power cuts for homes and businesses. Those who had a gas hob, gas oven, gas fire and/or a wood burner during those recent outages were able to cope much better than those who didn't have an alternative.

Dunkelflaute or otherwise, the case is there for a hydrogen grid system balanced and integrated with electricity to securely deliver the energy we want, when we want it, where we want it and for whatever use we want it for – in a way that can deliver lowest total system cost, including storage for the dark doldrums, and therefore lower energy bills that we have to stump up for.

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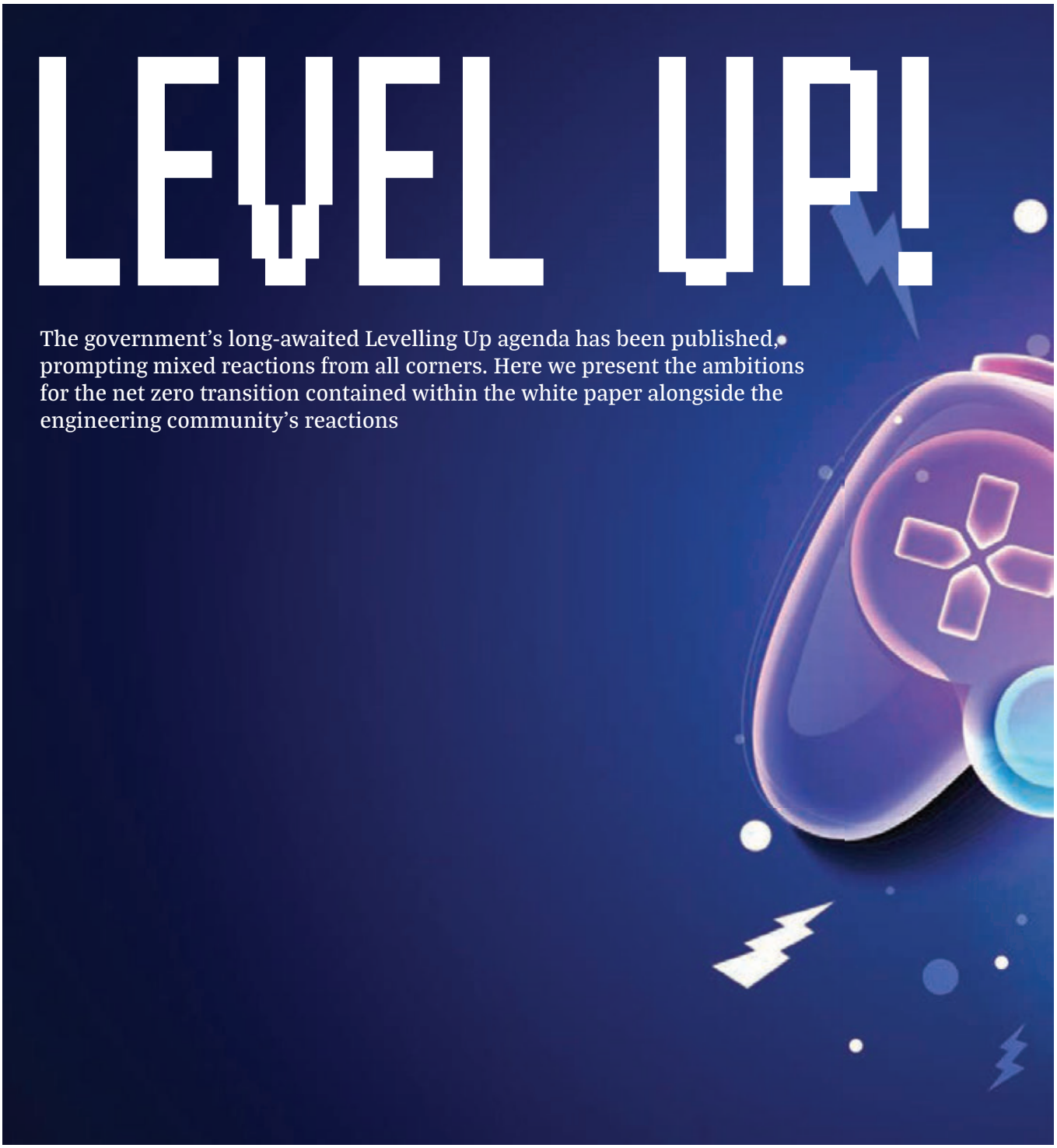
LEVEL UP!

The government's long-awaited Levelling Up agenda has been published, prompting mixed reactions from all corners. Here we present the ambitions for the net zero transition contained within the white paper alongside the engineering community's reactions



In February, the government published its 332-page *Levelling Up the United Kingdom* white paper, more than two years after announcing the flagship policy in its 2019 election manifesto.

The white paper set out 12 missions to reduce the gap between the richer and poorer parts of the UK by 2030. They include improving employment opportunities and productivity in all parts of the country, growing research and development investment by more than 40 per cent outside the Greater Southeast, improving public transport connectivity outside London and increasing the number of people completing high quality skills training to 200,000 every year in England.

Michael Gove, Secretary of State at the Department for Levelling Up, Housing and Communities, said: "For too many decades, too many communities have been overlooked and undervalued." He said the levelling-up agenda was about ending "historic injustice" and "calling time on the postcode lottery".

But the reaction has been mixed, with praise for the document's ambition and criticism for the lack of funding, originality and focus, according to *Civil Service World*.

There was no mention of the UK economy's ongoing transition towards net zero emissions in the official

press release unveiling these 12 new missions. Yet, accelerating this transition and rapidly implementing the government's recently published Net Zero Strategy is going to be key to achieving these ambitions.

First, with close to half a million people working in low-carbon businesses and their supply chains, the green economy is already sizeable and is a key potential source of future economic prosperity.

Writing for sustainability website *edie*, a spokesperson for business alliance the Aldersgate Group said: "The Covid-19 crisis has led to a significant body of economic evidence from the likes of the World Bank, the International Energy Agency, the London School of Economics and Oxford University's Smith School for Enterprise and the Environment, all showing that ambitious climate and environmental policies and investments are one of the most effective ways of putting world economies – including the UK's – on a rapid and durable path towards long-term economic recovery."

WHAT DOES THE LEVELLING UP PAPER SAY ABOUT THE UK'S TRANSITION TO NET ZERO?

The UK government has put into law a net zero emissions target by 2050.

This structural shift could have large and long-lasting effects on virtually every aspect of the economy, including jobs and skills, infrastructure and technology, and investment and innovation.

The net zero transition could create huge opportunities for many of the UK's left-behind places, but also poses risks for them which, if unmanaged, could be damaging.

Parts of the UK that need to undergo the largest transition lie outside the South East, often in some of the least well-performing areas of the UK.

As home to the largest emitting industrial sectors (manufacturing, aviation and shipping), emissions per capita are higher in the Midlands and North of England, as well as Scotland, Wales and Northern Ireland. More than one in every two jobs in carbon-intensive industries are in the Midlands, the North and Scotland.

The net zero transition could create huge opportunities for many of the UK's left-behind places, but also poses risks for them which, if unmanaged, could be damaging

While the transition to net zero will be disruptive for these places, it could also be transformative. The white paper states that the 'Green Industrial Revolution' will require significant investment in new infrastructure and production processes using new technologies.

This could average £50 to £60 billion of capital investment per year by the late 2020s and into the 2030s.

This investment has the potential to benefit disproportionately less well-performing parts of the UK, particularly those with a rich heritage of manufacturing and engineering.

Analysis commissioned by the Department for Business, Energy and Industrial Strategy (BEIS) shows that the North East stands to gain an extra 27,000 direct jobs by 2050.

Many other places, outside London

and the South East, have the potential to build on existing areas of strength, such as renewable energy, electric vehicle manufacture, carbon capture, utilisation and storage (CCUS) and hydrogen.

Some industries will require significant upskilling. Those currently employed in carbon-intensive sectors tend to be most vulnerable to long-term unemployment.

To avoid this risk, the government suggests those places will need to re-skill their workforce so that the new jobs created are located there.

As set out in the UK government's 10-Point Plan and Net Zero Strategy, successful re-skilling of this type could boost living standards and support jobs in poor places undergoing the sharpest transition.

HOW HAS THE ENGINEERING SECTOR RESPONDED?

Howard Forster, Chief Operations Officer at Cadent, responded to the white paper by saying: "Our industry, along with some others, already delivers opportunities to some of the poorest and most deprived parts of the United Kingdom. Cadent employs about 6,000 staff, the vast majority of which are highly skilled engineers.

"For example, in South Yorkshire, one area identified by many as a levelling up priority, we provide work to over 250 skilled engineers and support staff – each one of which has the opportunity to progress and grow their careers.

"I, and many colleagues, have benefited from the opportunities for growth and success that we all already enjoy. I think levelling up will be a success if, as Michael Gove suggests, it becomes about creating more of these opportunities across more parts of our country.

"That is where private enterprises like Cadent can lead. We are working, as part of our ambition to support the move towards net zero, to bring new skills, and with them, new opportunities, to every corner of our networks."

He added: "As part of that plan, we will by 2024 to open a hydrogen skills academy, preparing the engineers of the future. And we have committed to, by the same year, developing a hydrogen education programme."

Looking to the future of the gas industry, Mr Forster said: "We will be getting out there and creating opportunities for many thousands of young people and those who want to re-train, opportunities in every part of the UK in which Cadent operates to become an engineer in a new and exciting field.

"The gas industry is already playing a significant role in bringing opportunities to every corner of the United Kingdom – yet if the industry was supported to facilitate a wholesale conversion of the gas networks to hydrogen, we could do so much more."

DRAX POWER STATION, NORTH YORKSHIRE

Similarly, Professor Joe Howe, Chair of the North West Hydrogen Alliance and Executive Director, Energy Research Institute at the University of Chester, stressed the importance of hydrogen in bringing economic opportunities to the UK's industrial heartlands. He said: "Hydrogen will be essential to delivering net zero and driving the green industrial revolution.

"In regions like the North West, the burgeoning hydrogen economy will not only deliver the decarbonisation of our homes, industries and transport systems, it will drive new skills, thousands of jobs and millions of pounds of investment.

"We welcome the Levelling Up white paper and urge government to continue to support hydrogen as making a significant contribution to levelling up the UK."

"In regions like the North West, the burgeoning hydrogen economy will not only deliver the decarbonisation of our homes, industries and transport systems, it will drive new skills, thousands of jobs and millions of pounds of investment"

Ged Barlow, Chief Executive of Net Zero North West, echoed this sentiment, saying: "We welcome the publication of the Levelling Up white paper, which is clear that the transformation of our industrial heartlands into clean growth and green tech innovation hubs is pivotal to delivering the key levelling up mission of boosting productivity, pay, jobs and living standards.

"The North West is uniquely positioned to deliver the UK's first low carbon industrial cluster by 2030. We hope that the white paper's plan to empower our regions with deeper devolution and the autonomy to create tailored skills programmes that meet the needs of local industry can drive our work to achieve this."

EngineeringUK's Head of Public Affairs Beatrice Barleon said: "We welcome the long-term vision of the Levelling Up white paper and its recognition of the importance of education and skills in ensuring opportunity is spread more equally across the country.

"As the paper rightly recognises, 'human capital' is vital to the long-term success of this country. Ensuring that all young people regardless of where they live, and their background, have the opportunity to succeed must always be central to that ambition.

"We also welcome the future skills unit and the engineering voice on the levelling up advisory council. Together with the wider engineering sector, we have long argued for government to have a better central understanding of the skills gaps in this country, enabling more targeted policies to fill those gaps. The engineering sector has for a long-time struggled with skills shortages and this provides a real opportunity to address those challenges.

"The white paper rightly identifies many of the challenges the country faces and brings together in a more coherent format the policies that already exist to address those, as well as announces some new ones. We now look forward to working with the different departments and the levelling up advisory council to develop some of the detail that will ensure that we as a country provide young people with STEM skills that they need in order to access the sectors that will create the jobs of tomorrow wherever they are."

Read the full white paper Levelling Up the United Kingdom at www.gov.uk/government/publications/levelling-up-the-united-kingdom

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Application sheet
Methanization / Anaerobic Digestion

Biogas challenges

In the context of environmental policies and the development of renewable energy, states pay particular attention to biogas, which has many advantages.

The European Renewable Energy Directive 2009/28/EC of April 23, 2009 sets country-by-country targets for the share and use of energy produced from renewable sources.
The economic activity related to biogas is therefore in full development: if it is not upgraded it must be burned by flaring process. Its toxicity, explosiveness and large volume are the main reasons for its upgrading or destruction.

Biogas is produced directly from organic substrates. Biogas is therefore a fully renewable energy and an energy for the future.

The principle of Methanization / Anaerobic Digestion

Methanation is a natural phenomenon that has been reproduced under industrial conditions.
Due to the action of a variety of microorganisms, this is a natural biological process which breaks down animal or plant organic matter in the absence of oxygen (anaerobic). The principle of Anaerobic Digestion is based on the fermentation of organic waste.

The Methanization stages

1. "Food": The management of incoming substrates

To operate, a methanization unit must be fed by different types of waste throughout the year. This waste can come from different sectors such as:

- Agricultural activities: manure, crop residue, livestock effluent...
- Communities: canteen waste, green waste, sewage treatment sludge...
- Some industries: waste from food processing plants, waste from various organic materials...
- Household waste.

2. Methanization

Once sorted and collected, the waste is sent to the methanation unit, and the organic materials are introduced into the digester. This enclosed, oxygen-deprived space heats up (37°C - promoting the growth of bacteria) and ferments waste for several days, transforming it into two products:

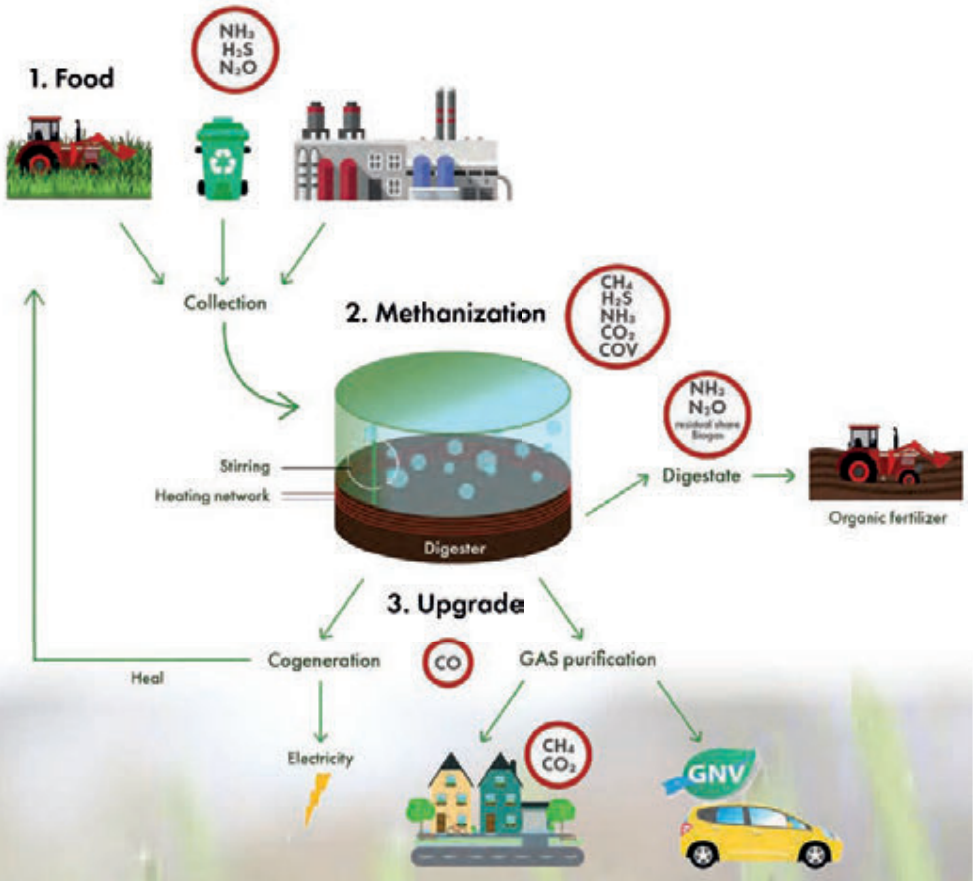
- **Biogas:** renewable energy consisting mainly of methane (CH_4), carbon dioxide (CO_2), water and traces of other gases. Biogas can be compressed after removal of Carbon dioxide, the same way as natural gas is compressed to CNG, and used to power motor vehicles. In the United Kingdom, for example, biogas is estimated to have the potential to replace around 17% of vehicle fuel.

- **The digestate or residue:** one of the substances from the methanization process is called digestate. It is used as an organic fertilizer of recognized agronomic quality, which can halve the consumption of chemical fertilizers on a farm.

3. Biogas upgrading

- Heating unit: Cogeneration (combined generation) of electricity or heat
- Purification

Biogas must be purified before injection into the natural gas distribution network. It must meet technical specifications and specific regulatory requirements. At the end of this cycle, biogas becomes biomethane, a renewable gas also called green gas that can be injected into the natural gas distribution network or used as fuel for NGV (natural gas vehicle).



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MAKE NET ZERO HAPPEN

Recent power outages across the north of England and in Scotland from Storm Arwen show the current energy system is failing people across the UK. Following a nine-month inquiry sponsored by IGEM, cross-party think tank **Policy Connect** says the country must use the transition to net zero to put this right

In June 2019, the UK government announced a world-leading net zero target to cease domestic carbon emissions by the year 2050.

Two years on, the UK finds itself at a landmark moment on the road to this target, as President for COP26 and releasing key strategies that will determine the decarbonisation of our society.

In these two years however, the UK has also experienced the serious challenges presented by the coronavirus pandemic and its widespread impacts.

In light of these circumstances, the path to net zero not only presents an opportunity to urgently cease domestic contributions to climate change, but also to build a green future and embed low carbon measures in daily life as part of recovery from Covid-19.

Important pieces of the puzzle of net zero have come in the form of the government's Energy White Paper, Transport Decarbonisation Plan, Industrial Decarbonisation Strategy, Hydrogen Strategy, and Heat and Buildings Strategy, as well as its overarching Net Zero Strategy.

Almost every government department has a role to play in making net zero a reality. Despite these commitments, there is currently a lack of follow-through and coordination between these policies and stakeholders, which limits the successful implementation of decarbonisation plans.

Unless coordination is prioritised, the UK is in danger of missing its 2050 net zero target. Policy Connect's latest inquiry proposes a public delivery authority for net zero, to support this and future governments in connecting its net zero action into an unprecedented cohesive delivery effort, of the scale and pace of change never seen in peacetime before.

This nine-month cross-party inquiry has shown that to move quickly enough to deliver on our net zero ambition, the government needs to take, in a very visible and high-profile way, three important steps.

First, every government department needs to publicly sign up to apply a Net Zero Test to its individual strategies and policies and be held to account.

Second, local government and its partners – who have the reach into local communities and businesses – need to be empowered to plan the transition and resourced to make it happen.

Third, the government needs to establish a net zero delivery authority with the responsibility for bridging the gaps across government and its agencies as well as between central and local government, and to provide the drive and leadership to enact it. Whilst being accountable to government and Parliament for delivering on net zero strategies and working within the framework set by government, this authority should have the autonomy to make the necessary implementation decisions. It would need to work across the UK's nations and regions. To provide assurance to business and people about its longevity and clout, it should be established by statute and sponsored jointly by the Department for Business, Energy and Industrial Strategy (BEIS) and Her Majesty's Treasury (HMT), to demonstrate it has cross-departmental backing and fits with the UK's financial and budgetary policies.

Report co-chair Darren Jones MP, Chair of the BEIS Select Committee, said: "I would like to thank Policy Connect for their report detailing a roadmap to net zero.

"Now Parliament must consider which pathways will help us to reach our legally binding net zero targets and achieve a just transition. The government must not waste the momentum that we've gained from COP26. Now is the time for delivery, so I welcome the publication of this action-orientated report."

Report co-chair Wera Hobhouse MP said: "A coordinated response involving local people is vital for the UK to reach net zero.

"My constituents have many questions about reaching net zero and how this might impact their lives and this report sets out an impressive approach that connects local people to policymakers as the UK works towards a zero-carbon future. A just transition must be central to any net zero programme."

Connecting the Watts: The case for a net zero delivery authority was sponsored by Baxi Heating, E.On, Energy & Utilities Alliance, IGEM and Worcester Bosch Group. Read the full report at www.policyconnect.org.uk

KEY MESSAGES FOR POLICY-MAKERS

POLICY CONNECT'S action-focused report, *Connecting the Watts*, calls for a net zero delivery authority to provide delivery leadership in England and make net zero happen

CONNECTING DEPARTMENTS AND STRATEGIES

Strategies and targets across government must work together to meet the net zero target. Applying a Net Zero Test to all spending decisions and policy announcements would help ensure these are compatible with, and actively contribute to, net zero by 2050. Government should agree and publish whole-of-government metrics on the delivery of its net zero targets.

CONNECTING CENTRAL TO LOCAL

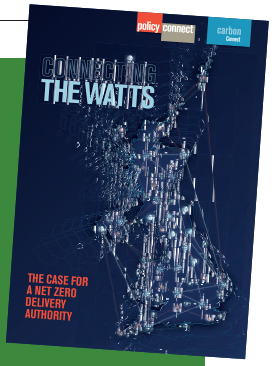
Local government and communities have a crucial role to play in reaching net zero. The low carbon transition must centre multi-directional communication and leadership between local authorities and central government departments. Local authorities must be given long-term resources that allow them to plan, autonomy to make transition decisions in their areas and the requisite staff and funding to carry out these functions.

A net zero delivery authority would provide the forum to coordinate these relationships and help oversee local decarbonisation plans.

A CONNECTED APPROACH

A joined-up approach to the energy system is needed, which requires the breaking down of silos between electricity, heat, transport and industry and the joining up of physical requirements of the energy system with policy, markets and digital arrangements. Infrastructure development and upgrades must also precede the roll-out of low carbon technology and products. This would optimise consumer cost and experience, and maximise energy efficiency savings. Whilst this will be the responsibility of the Office of Gas and Electricity Markets (Ofgem) and a potential Independent Systems Operator, a net zero delivery authority will have a brokering role to play in this process to ensure it feeds into strategy delivery with local government, businesses and consumers.

KEY FINDINGS AND RECOMMENDATIONS



GOVERNANCE

Key findings

- Government must move towards a connected, cross-departmental approach to policymaking to deliver its net zero targets effectively and consistently across the UK.
- Net zero delivery must become an integral part of government policy across all departments, coordinated through long-term strategies and the carbon budgets.
- Local government must play a key part in the delivery of net zero.
- Local government, enterprise agencies and partnerships must be enabled to feed into national net zero policy, acting as a gateway between local actors and national strategies.

Recommendations

- Recommendation 1: Government should adopt a Net Zero Test across all departments, as well as agree and publish whole-of-government metrics on the delivery of its net zero targets.
- Recommendation 2: Government should establish a net zero delivery authority to facilitate the delivery of net zero strategies in order to meet the UK's 2050 net zero target.
- Recommendation 3: Central government should provide local government with the appropriate mandate and resources to deliver net zero in their area.

SKILLS AND STANDARDS

Key findings

- More attention to net zero skills must be paid at primary and secondary education, in order to raise awareness of new possibilities and prepare pupils for the future world of work.
- Training courses currently available at post-16 education level must in future equip individuals with the skills to enter net zero industries, and be co-designed with local business leaders.
- Government must provide clarity on its roadmap to net zero for businesses, public sector organisations and skills providers to be able to invest in training programmes, apprenticeships and conversion courses, in order to fill skills gaps and provide the jobs needed for the net zero transition.

Recommendations

- Recommendation 4: As part of its approach to delivering net zero, the net zero delivery authority should work with local partners to inform comprehensive net zero skills plans based on targets set by government.
- Recommendation 5: Government must provide stronger regulation of new and improved skills standards in addition to incentives to expand and equip the workforce needed to deliver net zero.

PUBLIC ENGAGEMENT

Key findings

- Businesses and government must make links with the organisations that consumers trust to give them impartial, well-informed advice.
- Decarbonisation of heating and power will require local authorities, social housing providers and others to deliver on a street-by-street basis where appropriate – the delivery authority can coordinate this work with local partners.
- Government must embed fairness and justice into the decarbonisation transition.

Recommendations

- Recommendation 6: Government should establish a network of independent consumer information hubs, which would provide information about net zero, consumer protections and offer tailored advice.
- Recommendation 7: The net zero delivery authority should work with local authorities and relevant businesses, such as energy suppliers, to deliver a public information campaign about the path to net zero.
- Recommendation 8: Government should introduce measures to incentivise homeowners to adopt low carbon heating, energy and transport early, at key points such as home renovation or sale.

BUSINESS MODELS

Key findings

- Government strategies need to be long term (beyond election cycles) with sustainable, multi-year funding settlements.
- A net zero delivery authority will help drive an enabling business environment for net zero delivery.
- The transition to net zero must be fair and just, ensuring that no one is left behind, fuel poverty is properly addressed, and new net zero technologies are accessible to all.

Recommendations

- Recommendation 9: Government must give the net zero delivery authority the mandate to be involved in long-term strategic energy systems planning, including working closely with Ofgem.
- Recommendation 10: A government-backed pilot study should be carried out before 2025 to establish how local and combined authorities can be given the resource and mandate to build and deploy their skills and capacity to deliver net zero, in coordination with the net zero delivery authority.
- Recommendation 11: Government must cease incentives which lock in reliance upon fossil fuels, instead shifting focus to making the unit price of zero-carbon forms of energy more affordable.

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ARE WE READY?

The latest whitepaper from the Heating and Hotwater Industry Council (HHIC) has raised concerns over the suitability of current UK domestic heating systems on the journey to net zero

The Heating and Hotwater Industry Council's (HHIC) latest whitepaper urges the government to consider the suitability of current UK domestic heating systems to facilitate the transition to net zero.

Retrofitting homes with low carbon technologies, like heat pumps and hydrogen boilers, will be key to meeting the UK's net zero targets, says HHIC.

However, many of the different heating systems that circulate heat and hot water in properties are not currently appropriate for these emerging technologies, nor are they adequately covered by strategy and policy work.

Outlining where improvements need to be made and how different domestic systems can be aligned with the country's long-term goals, the whitepaper entitled *Heating up to Net Zero* has been researched and written by members of HHIC, the Hot Water Association (HWA), and the Manufacturers Association of Radiators and Convectors (MARC). It seeks to clarify what the challenges are, as well as what is required for them to be overcome.

Stewart Clements, Director of the HHIC, said: "A mix of low carbon technology along with low temperature heating systems will be required to meet the government's target of net zero by 2050. As most replacement heating appliances are due to a distressed purchase, there is a tendency for the rest of the system to be forgotten.

"Homeowners need support to ensure they can plan and upgrade their heating and hot water systems. This will ultimately come down to government initiatives, which is where the whitepaper aims to provide a framework for formulating new policy."

This challenge is only made more difficult by the UK's disparate housing stock, dominated by older properties using mains gas as the main heat generation source

KEY FINDINGS

Transitioning homes to low carbon heating and hot water systems is a complex process and will require a range of different solutions, according to the whitepaper.

This challenge is only made more difficult by the UK's disparate housing stock, dominated by older properties using mains gas as the main heat generation source. These homes are also more likely to have insufficient levels of insulation when compared to new-build homes and there is a high chance the original installed heating system was designed around high temperature primary circulation with a lower degree of control.

Switching to low temperature heating will raise efficiency and reduce carbon emissions, but also support the use of key future technologies like heat pumps and hydrogen boilers. Designing for such systems from new is relatively straightforward, but considerable work is needed to prepare legacy building stock for a net zero economy.

THE CHALLENGE OF NEWER HOMES

Even more recent builds pose problems. Since the late 1980s there has been a move towards the use of combination

boilers in small- to medium-sized properties, where domestic hot water is produced instantaneously. This eliminated the need for a hot water storage cylinder, leaving many newer property designs without space for one. Heat pump output powers do not support instantaneous heating of hot water, meaning upgraded systems will once again require the use of a hot water store (or means to store the thermal energy produced for hot water).

This presents a major challenge for transitioning homes with combination boilers over to low temperature systems. Similarly, microbore circulating pipework has been widely used since the 1970s. In high temperature systems the primary circulation flowrates are relatively low, so the higher flow resistance generated by microbore pipes does not cause issues.

However, low temperature systems, such as those using heat pumps, require much higher circulation rates. It is likely that many existing systems will require replacement of at least some pipework where new heating appliances are set to be installed.

It is likely that radiators were also sized based on higher flow temperatures, meaning some will need to be replaced to achieve a sufficient heat output. These kinds of major retrofit exercises will be expensive and disruptive for many people. Yet there is now an urgent need to transition existing building stock over to newer low carbon heating and hot water systems.

As such, homeowners will likely need incentivising so that proactive work can be carried out. This will mean appropriate consideration of heat pumps, hybrids and preparing for hydrogen boilers.

PREPARING FOR THE FUTURE

Ensuring systems are suitable for heat pumps or other low temperature heating systems will mean retaining the hot water store. In new builds, it should be mandated that space be retained for future installation of a cylinder, while older properties should be encouraged to replace.

As with many heating appliances, old cylinders are relatively inefficient, having a much higher heat loss, poor thermal transfer characteristics and a very simple interface with the heating system. The introduction of a cylinder scrappage scheme, or discounted purchase scheme for DHW cylinders or thermal stores, would not only make hot provision more efficient but equip homes with appliances necessary for future low carbon technologies.

This paper highlights that hybrid approaches could be an effective way to accelerate the move to low carbon heating. Use of a control system ensures that the most suitable technology is used, with a heat pump satisfying the majority of a home's demand.

The remaining gas boiler would only be used for support during the coldest days of the year when demand is highest. Again, homeowners will need incentives to take this step, not least sight of lower running costs.

The paper also shows there remains a significant number of households using a mains gas combination boiler. In many cases, major changes to pipework, controls and heat emitters will be necessary in these properties, notwithstanding the lack of a hot water store.

These systems are best suited to replacement with a hydrogen boiler, but the infrastructure necessary to deliver this system is still in development. Clear commitment from the government in support of a hydrogen grid will be necessary to incentivise boiler manufacturers to develop H_2-ready models.

Projects like HyDeploy, the UK's first demonstration of hydrogen in homes, will be essential for proving the fuel's viability and more should be rolled out across the country.

OPPORTUNITIES

There are many challenges ahead but also a number of opportunities. Existing boilers are more efficient if operated at lower primary flow temperatures, though this may require upgrades to system piping and controls.

However, mandating low temperature system retrofit measures would reduce the cost of adding a heat pump at a later date.

Low temperature heating systems with existing gas boilers can also deliver six to eight per cent efficiency improvements and should not be overlooked as part of a wider programme of change.

This is especially relevant where properties have already received insulation upgrades. Perhaps most important of all, this paper has shown that extensive retraining of the installer base will be necessary for any successful transition.

This will ensure correct assessment of existing systems, as well as the identification of appropriate technologies and system improvements, including design, installation and commissioning.

All low carbon technologies require this to ensure the theoretical energy savings are realised in practice. Consumer awareness campaigns will also be needed to help homeowners understand why transition is vital. This should include information about differences in performance and why behavioural changes are necessary to extract the best energy savings and carbon reductions. The campaign can be backed by installers but would benefit from targeted advice from trusted third-party consumer advice bodies.

Clements added: "There are many challenges ahead, but also a number of opportunities, not least in providing extensive retraining for the UK installer base. *The Heating up to Net Zero* paper looks at these in detail, highlighting the different ageing systems that circulate heat and hot water in our homes, and aims to ensure they are adequately covered by future government policy."

The Heating and Hotwater Industry Council (HHIC) is a member organisation committed to using its knowledge and expertise to define practical solutions for decarbonising heat and hot water in UK homes and businesses. Read the full whitepaper Heating up to Net Zero at www.hhic.org.uk

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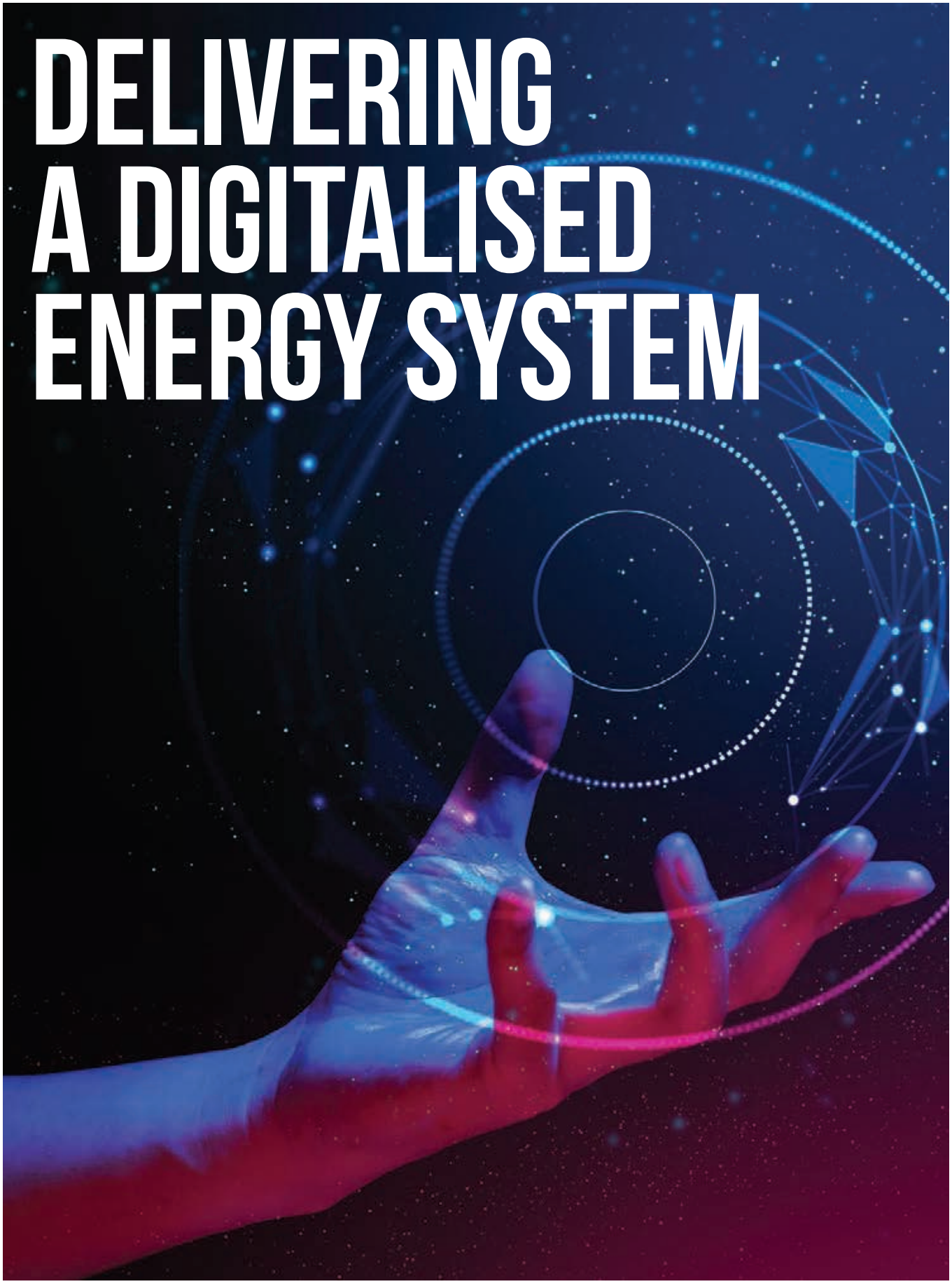
DELIVERING A DIGITALISED ENERGY SYSTEM



A new report from the Energy Digitalisation Taskforce, chaired by **Laura Sandys**, lays out a set of actionable recommendations that challenge the status quo and could help the UK to deliver the digitalised energy system needed to reach net zero

The future energy system will be profoundly different to the one that exists today; it will have to manage hundreds of millions of actions and assets every year, each interacting, engaging, and delivering value to customers and stakeholders.

Customers will have the opportunity to access more complex, blended products through digital platforms and services, with algorithms and smart technology managing energy needs on their behalf.

Generators and storage vectors of all sizes will need to respond to demand profiles, optimising their assets in a more dynamic manner to unlock value in their respective business models.

Stability will need to be managed throughout the system at all levels, with varied and multiple roles interacting with new actors and actions. This is a significantly more complex operational environment and will require a different approach to the design, management, and governance of the system.

Furthermore, these outcomes will need to be flexible enough to adapt to changes in the system as the energy transition evolves.

The Energy Digitalisation Taskforce aims to empower consumers and drive decarbonisation by outlining the digital journey that must be undertaken. Importantly, these benefits must be realised without compromising the high standards of system stability, security, and resilience.

Finally, two key principles have been used to test and guide the recommendations throughout the taskforce: customer satisfaction and decarbonisation. These are the ultimate outcomes the UK must deliver to declare the energy transition a success.

ENERGY IS NO LONGER AN ISLAND

The energy sector will support countless other sectors in their drive to decarbonise, achieving net zero through electrification and new low carbon energy vectors.

In addition, energy is becoming more reliant on other sectors to ensure the smooth operation of the system, utilising new flexible energy assets across sectors such as water, waste, and manufacturing, as well as increasingly and crucially relying on digital systems and telecommunications networks to operate a highly distributed energy system.

Energy is closely intertwined with other sectors and this presents a range of challenges and opportunities.

WHAT SHOULD A DIGITALISED DECARBONISED ENERGY SYSTEM FEEL LIKE?

The energy system we will create is an energy system that is designed for customers, shaped and controlled by their actions and needs, anticipating and adapting to their changing preferences, served by frictionless retailers all rewarded for outcomes, not inputs.

Customers have a whole system carbon account revealing their carbon consumption. New business entrants can tailor and shape new propositions to a wide and varied range of options designed around customer products as well as commodity needs. New propositions can access markets at scale and deploy many more plug and play options rather than expensive, clunky navigation around an overly complex marketplace.

Networks can manage their network dynamically, responding to changing needs and opportunities, creating integrated market options for their capacity management while also being able to offer options to a wide and varied number of participants to deliver their growing system operation functions.

Network interventions are reduced, physical interventions are predicted and mitigated before any outage, and the networks can actively plan investments to get more from less.

The national system operator can predict, visualise, and oversee the key drivers of imbalance, anticipate responses utilising the most cost-effective response to deliver system stability, providing an open and accessible market portal that triages options autonomously, driving down

costs and utilising all existing assets and capabilities.

There are small, medium, and large generation and storage assets, in a more dynamic, renewables-led environment they access much more information about the demand profile, maximising their asset utilisation and their rewards through greater responsiveness to changing demand dynamics.

Regulation can manage risk with the data and analysis to anticipate, strategically plan and adapt with agility to the changing market, the new level of interactions, and customer enablement and protection.

Regulated investments are informed by excellent data and quality anticipatory analytics, with all actions and interventions producing a whole system carbon read-out.

PRINCIPLES GUIDING THE TASKFORCE

The energy system must change substantially to support the delivery of a net zero economy.

However, there are many possible choices, and it is unclear what the ultimate architecture of a future net zero energy system will be.

The Energy Digitalisation Taskforce has considered a wide range of possible technical, operational, and commercial options and made recommendations which will help to guide the sector to progress towards a digitalised energy system.

These recommendations aim to provide policy leaders and regulators with a clear outline of the key requirements, enabling them to implement new policies without predetermining any specific architecture.

The taskforce has strived to propose the thinnest policy and regulatory recommendations, supporting innovation and commercial development while retaining the ability to be flexible and agile as the digital environment evolves.

The recommendations aim to enable others to develop the innovative propositions and solutions to deliver a truly modern, decarbonised energy system.

To guide this work, the taskforce has focused on four key drivers:

1 **Exciting tailored customer propositions** Enabling net zero-compatible products and services that provide customers with compelling, personalised offers to deliver outcomes the customer values.
2 **Accelerating decarbonisation** Creating a digitalised energy system that supports and encourages rapid decarbonisation across energy vectors and user needs.
3 **A stable and resilient system** Developing a system that continues to deliver high levels of stability for end customers, while using digitalisation to create additional resilience through more accurate forecasting and dynamic responses.
4 **Whole system optimisation** Making the best use of all energy assets across vectors and locations. Using digital tools to guide strategic investment in new infrastructure to deliver an ideal overall solution.

KEY RECOMMENDATIONS

The Energy Digitalisation Taskforce recommendations are based around a single strategic aim of developing a modern, decarbonised digital energy system.

The six high-level recommendations from the taskforce are as follows:

RECOMMENDATION 1: **Unlock value of customer actions and assets** – Crucially building trust and delivering control through a Consumer Consent portal, delivering a seamless ability for assets to connect and benefit from system value by mandating all large customer energy assets to be energy-enabled. Consumer protection will need to be enhanced to reflect different risks and smart meter data needs to be released for the public good.

RECOMMENDATION 2: **Deliver interoperability** – The sector needs to deliver interoperability through the development and deployment of four Public Interest Digital Assets with particular focus on a 'Digital Spine'. To ensure interoperability, we can build on some existing assets but require data sharing fabric, data catalogue and development of some limited but crucial standards.

RECOMMENDATION 3: **Implement new digital governance approach and entities** – Governance of new digital assets and actions will be important and will need to be developed soon. Governance around public interest assets, interacting algorithms and opening up regulated assets to digital competition will be important. There also needs to be a digital delivery body established by government to deliver the public interest assets quickly to be subsequently handed over to the sector.

RECOMMENDATION 4: **Adopt digital security measures** – Digital security principles and interventions are crucial but need to be fit for digital purposes with particular focus on cascade impacts, zero trust principles and a sharing culture.

RECOMMENDATION 5: **Enable carbon monitoring and accounting** – Carbon visibility sits at the heart of all the taskforce proposes, but much greater carbon visibility and standardisation is required. The taskforce recommends that dynamic carbon monitoring is put in place, and an open carbon standard needs to be deployed economy-wide.

RECOMMENDATION 6: **Embed a digitalisation culture** – Digitalisation is not valued or understood in all parts of the energy sector, with not enough skills or value given to digital assets and activities. The Department for Business Energy and Industrial Strategy (BEIS) should employ a Chief Data Officer and, importantly, investors and the rating agencies need to value digital assets as well as their traditional value assessment for infrastructure.

THE DIGITAL TRANSFORMATION

It is agreed that digitalisation of the energy system is not just a 'nice to have' but a core requirement in ensuring the UK can accelerate the journey to net zero, that a new decarbonised system works effectively, and, importantly, rewards customers for their actions.

Stability and resilience of the future system cannot be achieved without deep digitalisation built on the availability of more accurate and timely data.

Generators, storage operators and supporting services will require much more textured information flows to ensure that they can respond to the dynamics of a more integrated system.

While digitalisation is deeply embedded in many sectors, the energy sector is behind the development and deployment curve.

However, this presents an opportunity to build on and benefit from the experiences and lessons from other sector's digitalisation journeys.

By drawing on best practice from these sectors, risk and uncertainty are significantly reduced in implementation.

We also recognise that digitalisation poses new risks and we have considered consumer detriment, system stability and, importantly, security, and have addressed the challenges posed by greater interoperability of a much more complex system.

The Energy Digitalisation Taskforce was established by the Department for Business Energy and Industrial Strategy (BEIS), Ofgem and Innovate UK. Read the full report, Delivering a Digitalised Energy System, at www.es.catapult.org.uk

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