Northern Gas Networks

A16 - NGN RIIO-2

Economic Outlook

together we are the network

Economic and Pricing Assumptions

A Report for Northern Gas Networks

31st January 2019

TPA Solutions Ltd
84 Whitemoor Drive
Solihull
B90 4UL
www.tpasolutions.co.uk

1. Introduction

This report provides the background to the development of the detailed assumptions that have been provided to Northern Gas Networks (NGN) as one part of their input to the NGN Business Plan.

These assumptions have been developed as a Base Case and one High and one Low Scenario. The NGN requirement for this work is given in Appendix 1. In addition to the economic assumptions NGN have requested content relating to energy efficiency which is also detailed in Appendix 1.

The report also provides

- All data sources
- Data issues and caveats
- All forecast sources
- Logic, justification, evidence and key uncertainties for forecasts

In addition the report provides commentary on

- State of the economy in the UK and the North of England region in particular
- The likely and possible evolution of the economy in the coming years and decades (up to 2050), with key uncertainties highlighted
- Recent and upcoming technological advances, political events, policy decisions, international deals and treaties and current affairs which are likely to influence UK and regional energy prices and therefore gas demand

2. Economic Assumptions

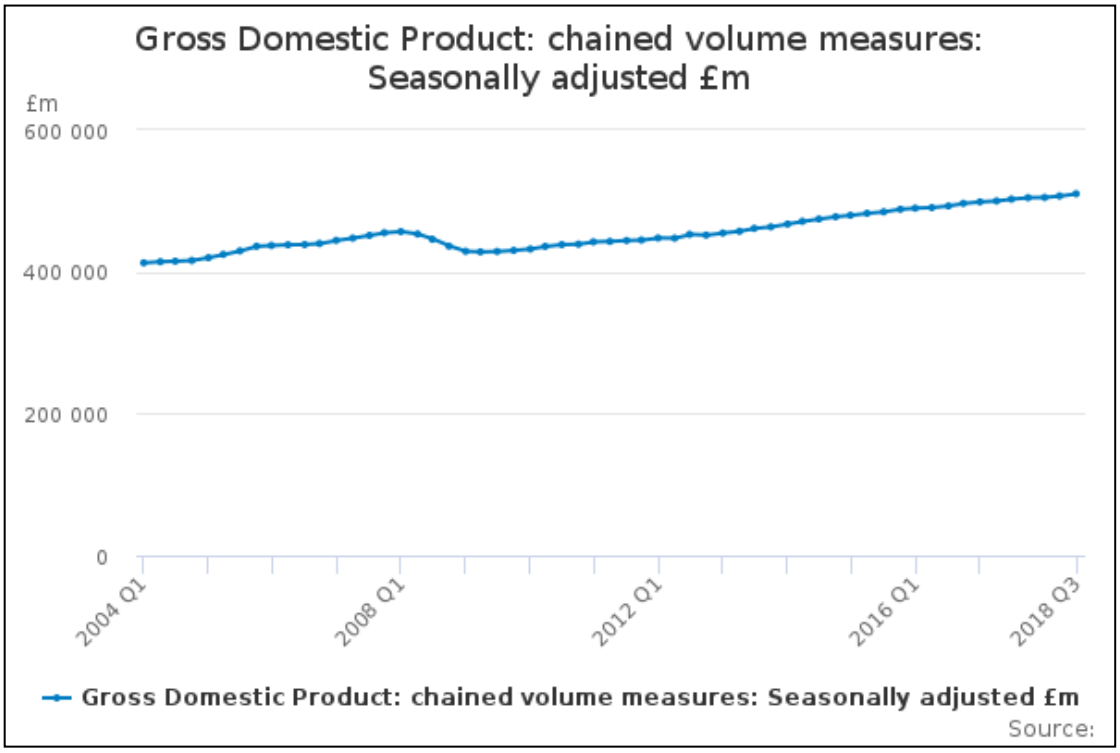
2.1. General Background

This section provides a general overview of the UK economy to give some context to the Regional data that will be provided in this report.

2.1.1. UK Gross Domestic Product (GDP) and Gross Value Added (GVA)

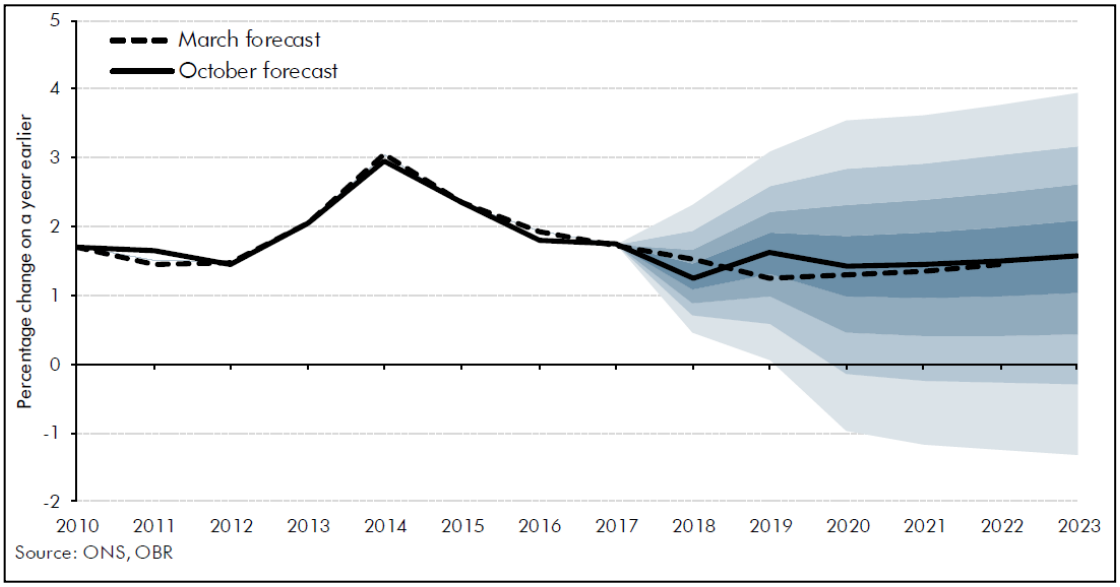
GDP is a key indicator of the state of the whole economy and equates to GVA plus taxes on products minus subsidies on products. Gross Value Added (GVA) measures the contribution to the economy of each individual producer, industry or sector in the United Kingdom. A significant decline in GDP occurred during 2008/9 set against a long period of growth from 1992. There has been a steady and sustained recovery in GDP since that time.

The latest economic figures produced by the Office of National Statistics (ONS) show a sustained growth in the economy during 2018 (see graph below). This is despite the EU referendum result to leave the EU and major ongoing uncertainty over future trading relationships with the EU and the rest of the world. The recent failure of the Government to gain approval of Parliament for the negotiated deal with the EU adds to the uncertainty. The preliminary figures from the ONS show that annual GDP growth for 2018 is around 1.4%. This is a significant decline from the outturn figure for 2017 of 1.7%.



ONS

This level of growth is expected to improve in 2019 at around 1.6% in the central case, but falling to 1.4% in 2020 and 2021 then up to 1.5% in 2022 and 1.6% in 2023. The Office for Budget Responsibility (OBR) published their central forecast in November 2017 which is shown below.



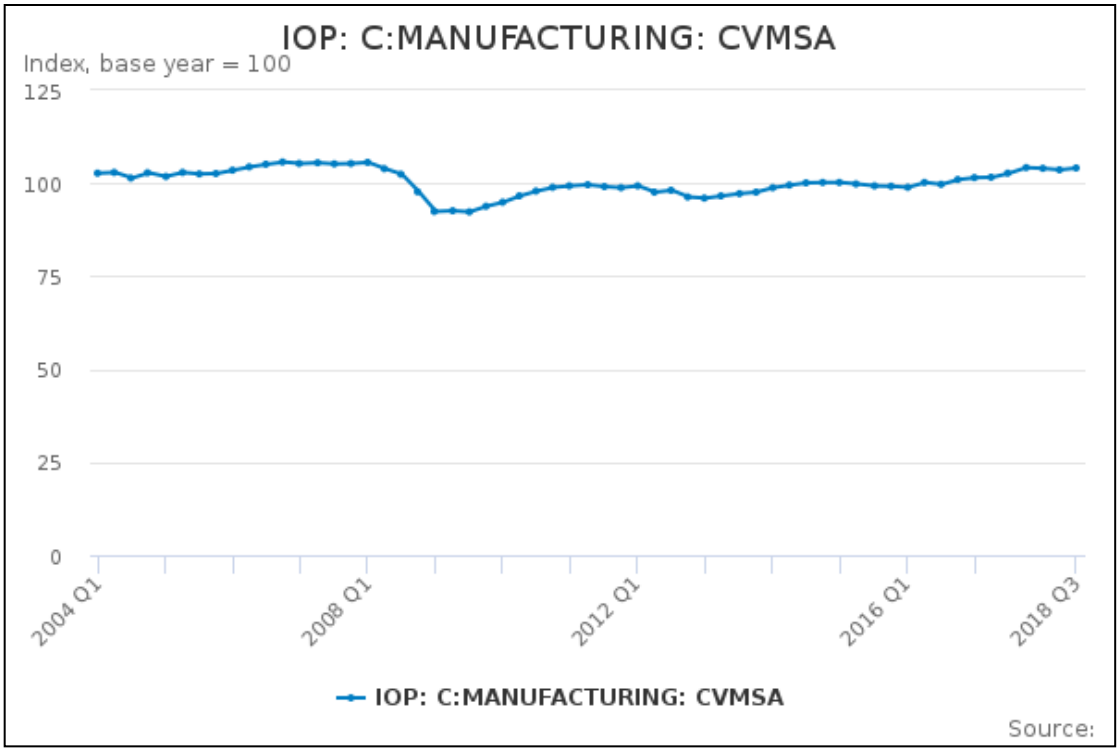
2.1.2. Gross Disposable Household Income (GDHI)

This can be used as an indicator of householders' ability to absorb rising energy prices and provides a reasonable indication of how affluent households are in a particular area. The latest published regional figures produced by the ONS are for 2016 and show that London has the highest GDHI per head of population followed by the South East. The North East is ranked lowest of all the UK regions with Yorkshire and the Humber ranked ninth. The source of this data is the ONS GDHI

table 1 level 1. Figures for the UK are available up to 2017. The figures for the North East have been taken as representative of the NO LDZ and Yorkshire and the Humber as representative of the NE LDZ. It is unfortunate that regional figures are not available for 2017 and 2018 at this stage so it has been necessary to estimate the figures using a forecast of regional growth based on the growth trend for each region. This is a change from last year as pro-rating the regional figures in line with each regions percentage contribution to the national figures gave rise to the same levels of growth in each region and the UK.

2.1.3. Manufacturing Output

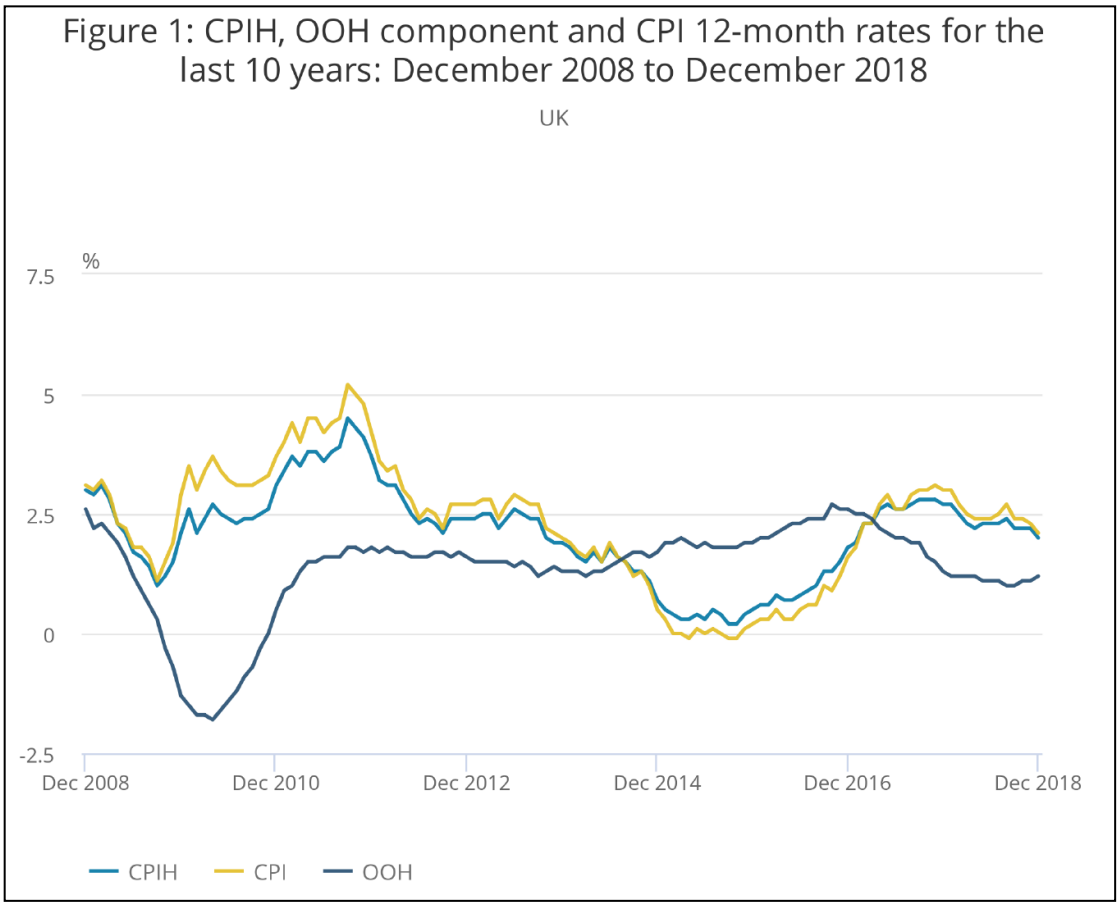
The index of Manufacturing Output provides one measure of how this type of industry is performing. Following the economic crisis in 2008 there was a significant downturn in manufacturing during 2009 but it has been showing some recovery since then, with periods of slight decline in 2012 and 2013, recovery in 2014, then decline again in 2015 another rise in 2016 and 2017 and finally a very minor drop over the first three quarters of 2018. This can be seen in the quarterly figures for the Manufacturing Index from the ONS (see below). There has also been further decline in October and November 2018 with the index at 103.1 in November 2018.



ONS

2.1.4. Inflation

During the years 2009 to 2012 the Consumer Price Index (CPI) was fluctuating significantly but had started to stabilise in the 2 to 3% range in 2013 and had fallen steadily to end up hovering around zero towards the end of 2015. Inflation had been rising steadily in 2016 but levelled off towards the end of 2017 finishing in December at 3.0%. During 2018 inflation fell ending in December at 2.1%. The graph contains two other indices the CPIH which is the Consumer Prices Index including owner occupiers' housing costs and the OOH component which is the owner occupiers housing costs only.



Source: ONS

2.1.5. North of England Economy (2019 update)

The current state of the economy in the North of England compared to the UK average can be assessed by taking a look at the GVA per head of population, which is a better comparison than pure GVA as it gives a better indication of the relative economic performance for the region.

In 2005 the figures for NE LDZ and NO LDZ were £17,217 and £15,817 respectively compared to the UK figure of £20,709 and £20,849 for England. The ranking was 8th for the NE and 11th for NO. The total number of all the regions in the UK for this ranking is 12.

In 2017 the figures for NE LDZ and NO LDZ were £21,748 and £20,121 respectively compared to the UK figure of £27,430 and £27,949 for England. The ranking was 9th for the NE and 11th for NO the same as in 2016.

These figures suggest that the gap between the North of England and the national average is growing. The national figure is however heavily influenced by London but not significantly by the South East as some commentators suggest, although there is a growing gap in the North/South divide. If the figures are rebased to 2016 prices however the gap is still significant but not quite as severe widening in the NE LDZ and NO LDZ by £1000.

A review of the north of England's economy in 2016 entitled "Powerhouse 2050: the North's Routemap for Productivity" found that the recent recession has

exacerbated the north-south divide, and calls for radical change to close the widening prosperity gap.

The northern powerhouse independent economic review found that the region was lagging behind the rest of the UK in terms of productivity and jobs. The north produces £4,800 less gross value added (GVA) per person each year than the south, and more than £22,000 less per person than London.

It is the first time such a comprehensive report has been commissioned for the north. Commissioned by Transport for the North (TfN), a body set up by George Osborne, it identifies a number of measures it says are needed to bring about improvements to the region's economy. It is part of the chancellor's plan to create a "northern powerhouse" to reinvigorate the region.

By focusing on four key industries, which account directly for 30% of the north's jobs and 35% of its GVA, the review says the region could bridge the economic gap with the south.

It claims that the four industries have the potential to transform the north's economy, adding £97bn and 850,000 jobs by 2050.

TfN, which has statutory authority for long-term transport investment strategy in the region, commissioned the review on behalf of councils and partner organisations.

The report says there needs to be increased collaboration between key partners, the government and national agencies for its ambitions to be realised. In particular, the north's economy will only be transformed if key road, infrastructure and rail routes are given the green light, promoting greater collaboration between northern towns and cities and propelling the region into a global player, according to the review.

Central to the report's predictions is the need to focus on education, logistics and financial and professional services to help shape the skills and prospects of the future workforce.

The review has recommended a number of improvements, including:

- Improved education outcomes and work-based and vocational training.
- Improved graduate retention and attraction, helped by better prospects for skilled, mobile workers to make their careers in the north through good access to opportunities in more than one town or city, and by a good supply of high-quality housing.
- Better commercialisation of university research to the benefit of the north's business base.

The report says the north of England could be world-leading in four fields – including energy and digital – with the right backing.

Among the four sectors, it calls for £2bn to replace the entire gas network of Leeds with hydrogen, which would be produced in the Tees Valley, and £1bn to creating a new northern economy of small nuclear reactors.

It also calls for £60m for the north to become the UK's first region to commit to industrial digitisation, and £100m to reinforce the UK as a leader in health data.

In November 2017 MPs from across all parties have launched a group to "drive business, skills and economic growth" in the north of England. The Northern Powerhouse parliamentary group aims to attract investment and highlight issues affecting the region. It was set up by the Northern Powerhouse Partnership.

The Government is showing their support by the following actions:

- Appointing a Northern Powerhouse minister, Jake Berry.
- New legal powers to give the North an unprecedented say on how money is spent on transport were announced on the 16 November 2017 by Transport Minister Jesse Norman. From April, TfN will get new powers to:
    - produce a statutory transport strategy for the North which the government must formally consider when taking funding decisions
    - fund organisations to deliver transport projects, for example, this could include transport operators delivering smart ticketing in the North
    - work with local authorities to fund, promote and deliver road schemes - and be consulted on rail franchises in the North
    - take forward smart ticketing to bring in faster, easier rail travel
- Investing a record £13 billion in transport in the North of England
- The Government has confirmed £150 million is available to TfN for smart ticketing, £60 million for Northern Powerhouse Rail and £50 million to run TfN, a total of up to £260 million.
- Allocated £3.4 billion in Growth Deals to the Northern Powerhouse – providing targeted financial support to locally determined projects in order to unlock growth and giving local people the powers and tools they need to drive forward growth for their areas.

One of these areas, Northern Powerhouse Rail, has stated that "A step change in rail connectivity between some of the North's largest cities is required to grow opportunities for the next generation of workers and investors. Northern Powerhouse Rail, together with HS2, would transform rail travel across the North, offering much faster, more frequent and reliable rail links and opening up new opportunities for Northern citizens and businesses. Northern Powerhouse Rail would link the North's six main cities and Manchester Airport, as well as other significant economic centres. It could be developed in stages, making best use of existing rail infrastructure and planned investments (such as HS2) alongside new railway lines and significant upgrades".

It should be noted that it is planned to deliver this over a 30 year period but the ultimate aim is to increase the number of people in the North that can access four or more of the North's largest economic centres within an hour, from 10,000 to 1.3 million.

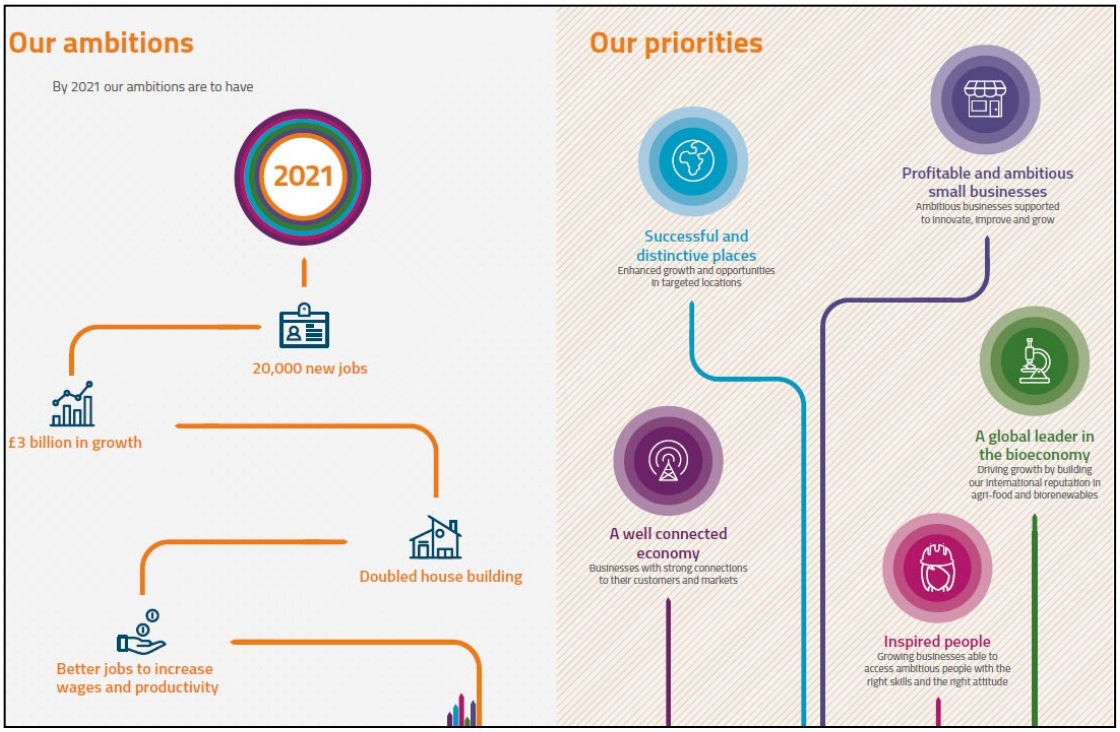
Reviewing the news items from the Northern Powerhouse parliamentary group doesn't show any major developments to date other than a number of new partners have joined.

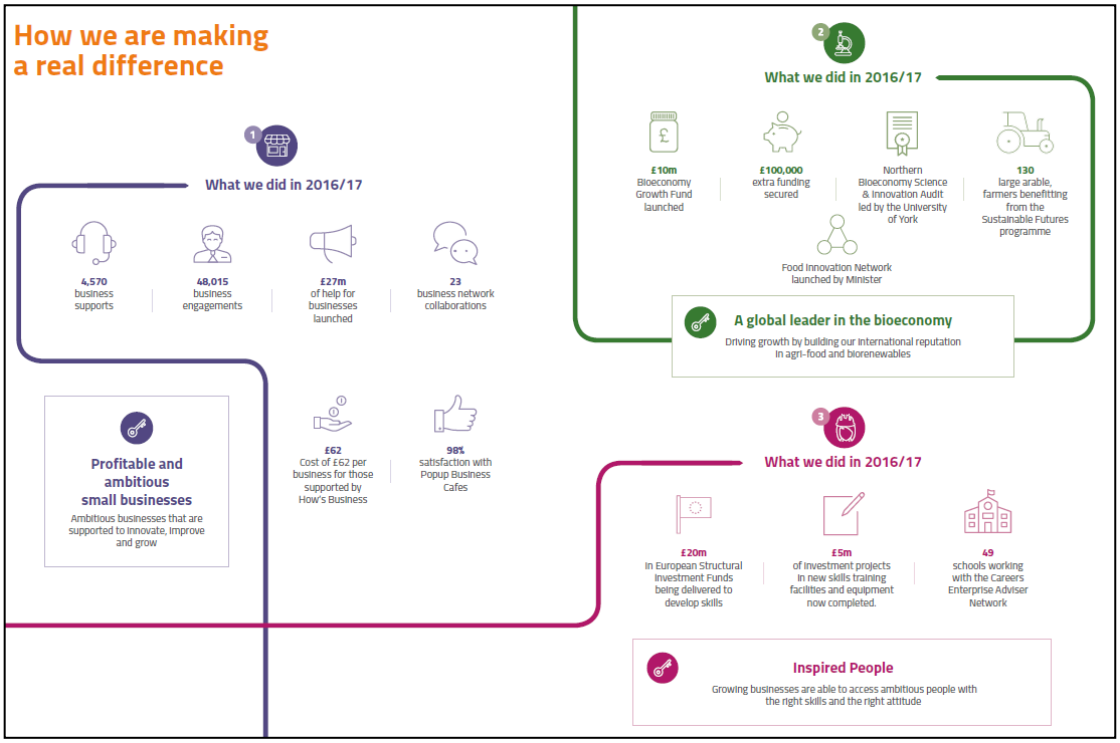
Yorkshire and Humber Economy (NE LDZ) – 2019 Update

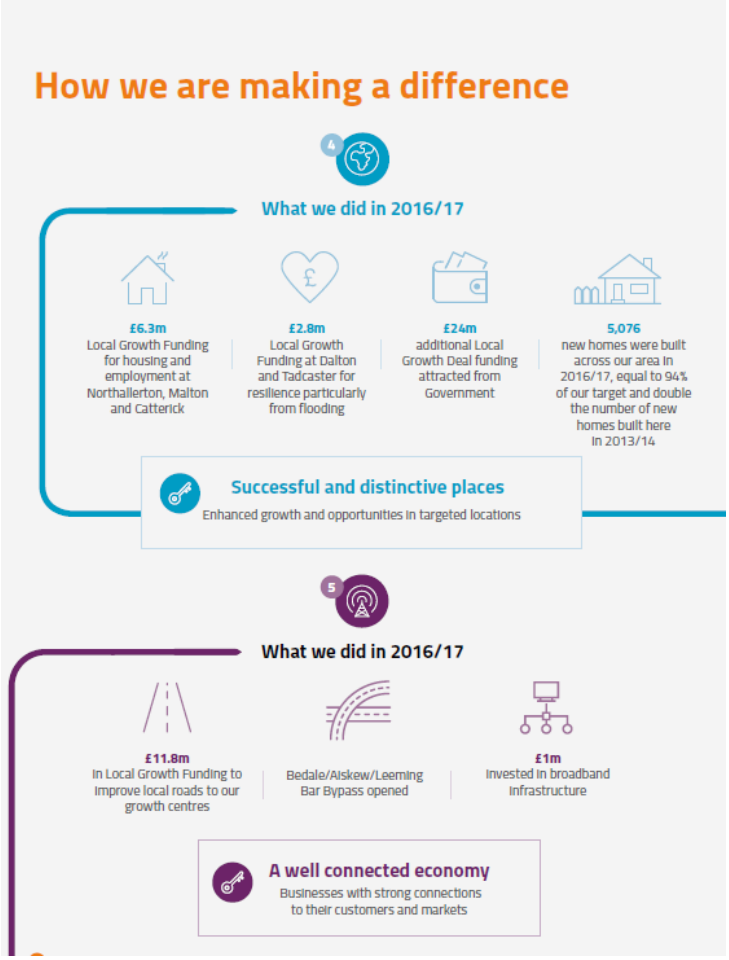
There are two main enterprise partnerships in this region the York North Yorkshire and East Riding (YNYEREP) and the Leeds City Region (LCREP). The following picks out material that highlights the way that the local economy may develop in future.

York North Yorkshire and East Riding Humber LEP

The priorities and targets and to some extent their current performance for this LEP are best illustrated by the following diagrams taken from their annual report.







Their updated plan has the following focus for 2016 to 2021 in their priority areas.

Profitable and Successful Business

- Help fledgling businesses get off the ground. Support activity to help pre-start and start-up businesses become established, working with the private sector and invest limited public funds for those that need it and are serious about starting up.
- Help established small and micro businesses be more successful. Leverage support from the private sector, help business owners get support from their peers, help develop new ideas that respond to customer needs and make it simpler to engage with the public sector. Public funds will be used where there are clear market failures, e.g. providing essential broadband infrastructure and helping with staff development. Small businesses that provide significant employment, such as tourism, care and retail will be helped to survive and thrive.
- Help growth minded businesses achieve their ambitions. Higher intensity public sector support will be used to support growth minded businesses where this has a clear link to high value employment growth. This will include the provision of access to finance, support for R&D and innovation, the development of leadership and management skills, access to opportunities in supply chains and help with staff recruitment and development.
- Establish 'How's Business' as the preferred access point to public and private business support. Ensure that the wealth of help and support

available locally is easy to access and business owners make the most of it. This means stimulating demand to get help with business improvement and establishing How's Business as the trusted source of that help.

Global Leader in Agri-food and the Bioeconomy

- Facilitate connections between agri-food / biorenewables businesses and support supply chains interventions. Connect businesses in the agri-food and biorenewables/bioscience supply chains and support interventions that add value locally or connect supply chains to develop a circular economy. Link complementary initiatives and commercial opportunities to maximise impact.
- Enable businesses to access new intellectual property, technology and processes which drive commercial value through:
    - Business-led development of the Knowledge Transfer Interface.
    - Innovation and resource efficiency support for businesses. Open access technology and business growth space.
    - Peer to peer learning.
    - Linking businesses to innovation assets.
- Attract investment to the area and businesses. Promote the local strengths in agri-food and biorenewables/ bioscience and seek to secure investment that:
    - Builds our reputation in the bioeconomy.
    - Supports small business growth through innovation.
    - Establishes or retains, high value jobs, including new businesses locating to key sites.
- Develop markets. Develop clear paths to export markets, as well as opportunities for bio-based materials in the new markets, such as the construction industry. Support activity that bridges the gap between concept and commercialisation, including fields such as the valorisation of food waste, bio-refining non-food biomass to high value chemicals and adopting technology in agriculture and horticulture.
- Develop the skills needed by businesses for the future. Develop, attract and retain an expert workforce by building a stronger academic and technical skills base through industry-led actions.

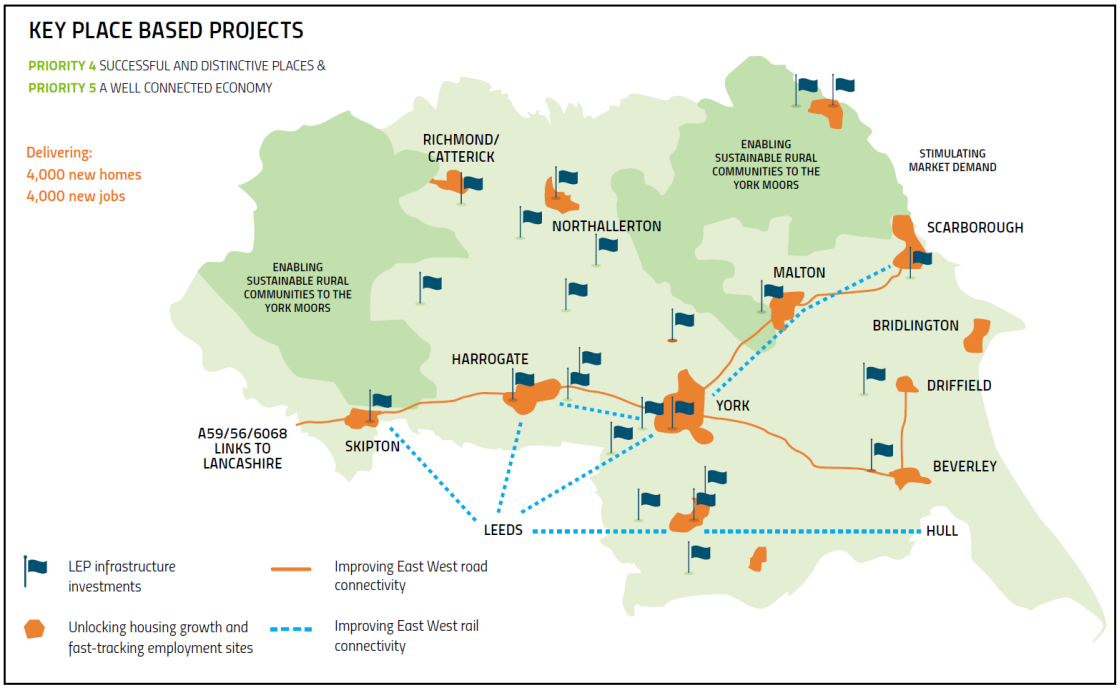
Inspired People

- Increase employability of young people and attract and keep young talented people in the area. Promote high quality apprenticeships and internships, improve links between businesses and education providers and ensure that young people are connected to careers guidance and job opportunities. Work to increase graduate retention and broker graduate opportunities to connect every student to business.
- Develop local workforce. Focus investment in priority sectors including the bio-economy, engineering, construction, health and social care, visitor economy and VCSE. Work with small and micro businesses to improve their staff's skills particularly linked to sector specific needs and leadership skills. Work to develop strong communities and build the skills, attitude and ambition to help people access jobs. Tackle rural and coastal unemployment and skills challenges through place based regeneration interventions, also tackling associated transport challenges. Develop the capacity of the community and social enterprise sectors to meet local needs. Build self-employment and enterprise skills.
- Ensure that the area has the right investment in skills infrastructure. Build on the earlier successes through the Growth Deal to bring all college

infrastructure to a high standard and create a pipeline of future skills investments.

Successful and Distinctive Places

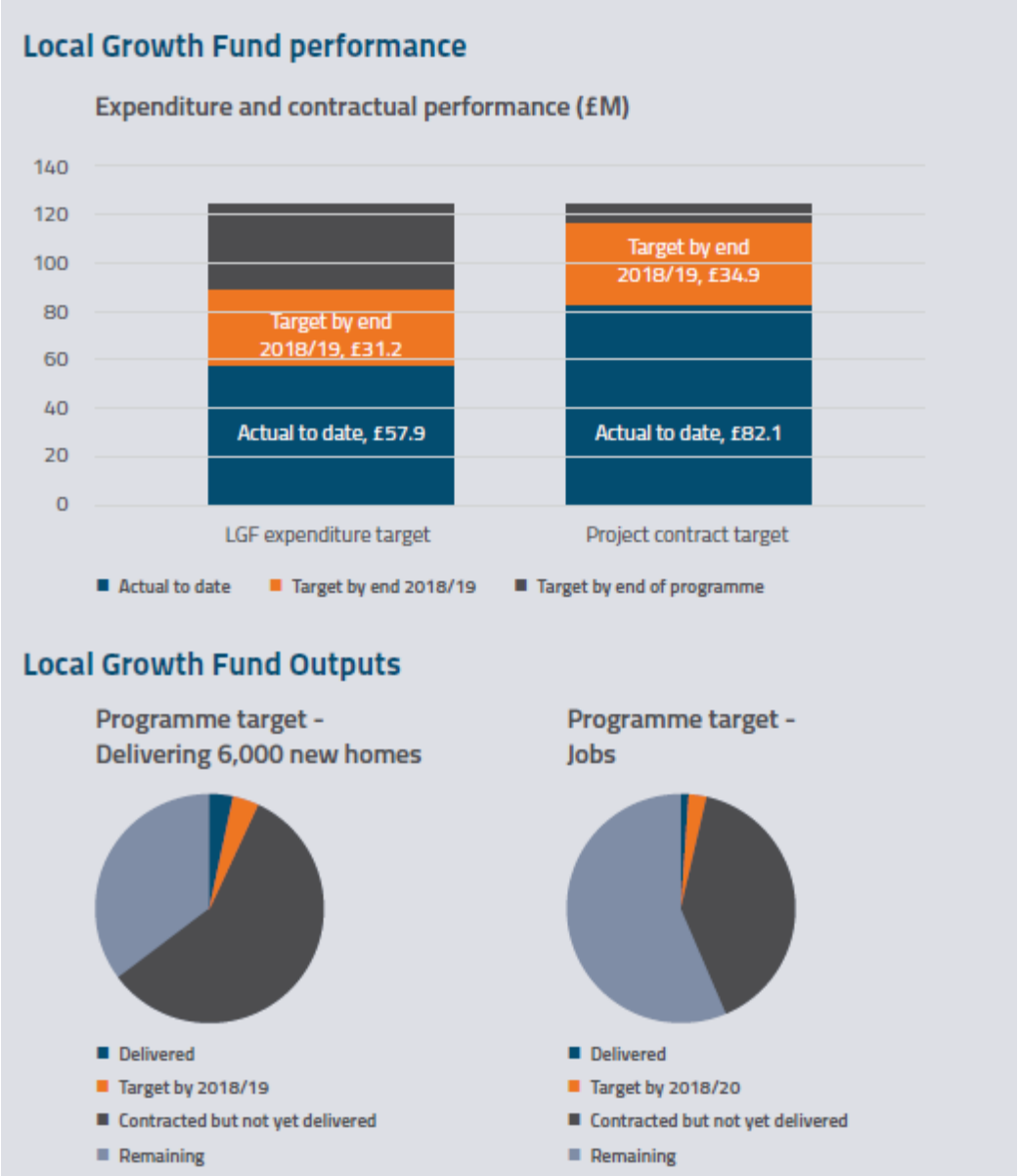
- Unlock the housing growth the area needs. Without action, the area could easily become an economy characterised by high living costs, low wages and an ageing population. Central to this is providing sufficient housing to enable a market which is within the means of current and future working age population. To do this:
    - Ensure all local authorities have up to date local plans.
    - Take a more collaborative approach to planning across local plan areas, including adoption of a regional Strategic Plan.
    - Work with the Homes and Communities Agency to address market failures on major sites.
    - Remove infrastructure barriers, and underlying issues e.g. skills shortage, preventing local plan housing allocations being fully delivered.
    - Support the viable delivery of affordable housing.
- Fast-track employment sites with market demand for high value sector growth. The second part of this high cost/low wage equation is driving high value sector growth through market led opportunities. As a largely rural geography, need to maximise and deliver the limited number of sites where there is strong market demand for new high value business space:
    - Address market failures for specific sites.
    - Fast-track take up of space through tailored incentives (e.g. through targeted use of business rates freedoms).
    - Drive inward investment on a site specific basis through relationships with property industry and key intermediaries.
- Stimulate market demand on the coast.
    - Explore supply chain opportunities from major investments (e.g. potash, renewables) to drive job creation.
    - Deliver place-based and business led interventions which complement community-led regeneration, enhancing the desirability of towns for businesses and workforce.
    - Explore use of business rate freedoms to stimulate demand.
- Enable sustainable rural economies. Continue to stimulate support for rural economies by:
    - Ensuring excellent digital/mobile connectivity as standard.
    - Creating excellent transport links to employment/urban hubs.
    - Using new housing to sustain balanced communities.
    - Enabling the area's natural beauty as a driver for rural jobs.



Well Connected Economy

- Improve East West connectivity, particularly between towns and their neighbouring cities. It is paramount to improve East-West transport connections across the entirety of the LEP area, with the primary focus on routes between towns and cities: specifically the A64, A164, A1079, A1237 and A59 road corridors and the Leeds-Harrogate- York, York-Scarborough and Leeds-Selby-Hull rail corridors.
- Maximise high speed rail investment through station improvements and better access.
    - Get York Station high speed ready and as multi-modal sustainable transport hub for the area.
    - Station improvements at Harrogate, Thirsk, Selby and Seamer.
    - Improve access to rail stations across the area.
- Ease congestion in York and Harrogate
    - There are major improvements needed to add capacity to A1237 around York Ring Road and A59 / A61 Harrogate Relief Road.
    - Alongside this, deliver sustainable transport improvements supporting low emissions vehicle and Park & Ride infrastructures, and cycling networks.
- Enhance the resilience of the transport network, particularly to flooding.
    - Highlighted by the flooding in winter 2015/16, focus local highway improvements on improving resilience of known high risk areas.
    - This includes A59 Kex Gill realignment. Explore opportunities to enhance the resilience of East Coast Mainline.
- Ensure widespread reliable telecommunications and high speed broadband. To create a long term viable rural economies, high speed broadband and reliable mobile connectivity are non-negotiable, support the roll out of this, particularly where there is market failure.

The latest annual report for 2017/18 has the following highlights regarding their performance with respect to the Local Growth Fund (LGF).



It is unfortunate that the latest report does not contain much detail compared to the previous year's report.

Some other highlights are as follows:-

LGF - committed expenditure to date £88m (71%) of total of £124m - £49.5m Transport, £24.7m Housing and Employment, £4.7m Flood Alleviation and £9.1m Skills Capital.

European Structural and Investment Fund (Business) – committed expenditure to date £29.9m (73%) of total of £41.1m - £10.2m Innovation, £12.2 Business Support, £16.1m Sector Support (Agricultural) and £1m Technology.

European Structural and Investment Fund (Skills) – committed expenditure to date £22.5m (64%) of total of £32.9m - £6.75m Workforce, £15m Social Inclusion and £0.8m Young People.

LEP Achievements - £200m private sector investment leveraged, 5096 businesses supported and 5300 individuals supported.

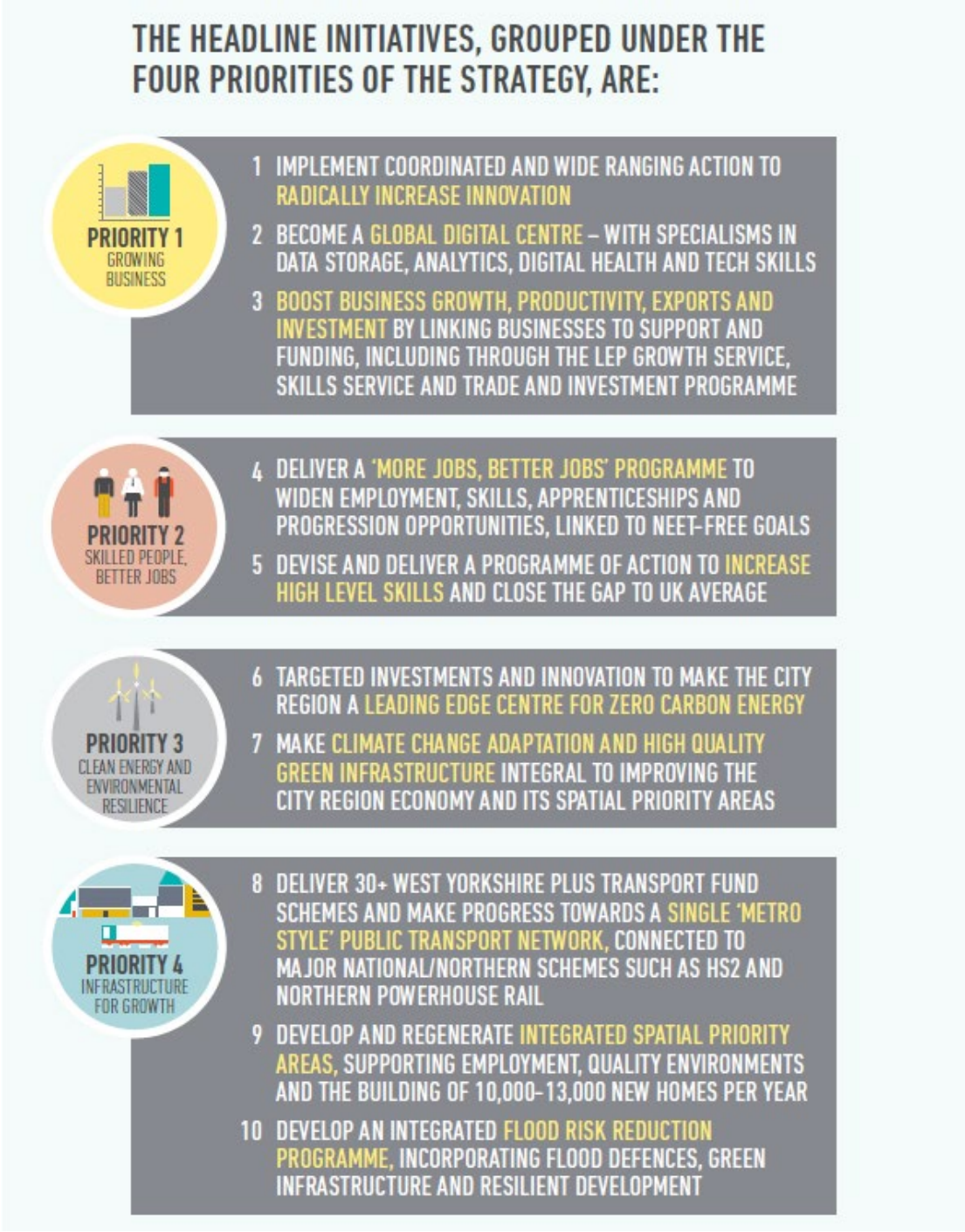
Leeds City Region

The stated function of the Leeds LEP is "Creating an even more skilled and prosperous Leeds City Region. We provide investment and support to help our workforce, businesses and the economy to thrive, working with organisations across the public and private sectors. With an overall aim of transforming the City Region economy, we focus on four key areas: supporting growing businesses, developing a skilled workforce, increasing energy efficiency and improving the region's infrastructure."

Their targets are stated as:

- 35,700 additional net jobs by 2036.
- £3.7 billion of additional annual economic output by 2036.
- £200 billion city region economy by 2036.
- Become a positive, above average contributor to the UK economy.
- Seek to exceed the national average on high level skills and to become a NEET(not in employment, education or training)-free City Region.
- Make good progress on Headline Indicators of growth and productivity, employment, earnings, skills and environmental sustainability.

Their priorities are illustrated in the following diagram.



Headline initiatives being taken are illustrated below.

HEADLINE INITIATIVE	IMPORTANCE	DELIVERY ROUTE
Implement coordinated and wide ranging action to radically increase innovation.	Innovation is critical to future growth and prosperity. This includes R&D, links to higher education institutions and a creative culture that drives better products and services.	Implement actions in Priority 1 and review and extend these in an updated Delivery Plan for Innovation, aligned with funding streams including Local Growth Fund, ESIF, Innovate UK and higher education institutions resources.
Become a global digital centre – with specialisms in data storage, analytics, digital health and tech skills.	Builds on existing assets in data and digitally driven solutions and will position the City Region as a globally significant place in a huge area of future economic opportunity. Building the skills to support this is crucial. Also responds to ageing population opportunities.	Integrates across all priorities and led by Priority 1, with a new Digital Delivery Plan taking it forward. Linked also to LEP Growth Service support and the Trade and Investment Business Plan.
Boost business growth, productivity, exports and investment by linking businesses to support and funding, including through the LEP Growth Service, Skills Service and Trade and Investment programme.	Essential to improving productivity and key factors which drive it, such as innovation, skills, enterprise and exports. Additionally, need to correct historic investment shortfalls, widen the business base and strengthen supply chains.	LEP Growth Service, grants and future ESIF projects and related activity covered in Priority 1 and the Trade and Investment Plan. Skills Service linked to Priority 2.
Deliver a 'more jobs, better jobs' programme to widen employment, skills, apprenticeships and progression opportunities, linked to NEET-free goals.	Integral to achieving inclusive, good growth, utilising untapped assets and making the City Region an above average contributor to national tax incomes. Builds on and extends progress on apprenticeships and youth employment.	Skills and access to work covered in Priority 2, to be progressed through the Skills Plan. All strategic priorities will help to create jobs.
Devise and deliver a programme of action to increase high level skills and close the gap to UK average.	High level skills underpin growth and productivity. Large scale, evidence led action is needed to transform performance.	Programme to be developed, led by Priority 2 and implemented as part of the updated Skills Plan.
Targeted investments and innovation to make the City Region a leading edge centre for zero carbon energy.	Integral to good growth and resilience, and to ensuring our economy can take advantage of changing energy markets and the low carbon economy.	Covered in Priority 3, taken forward by its priorities and action across the SEP.
Make climate change adaptation and high quality green infrastructure integral to improving the City Region economy and its spatial priority areas.	To ensure long term economic resilience and success, the City Region needs to plan for and manage future climate change impacts. Green Infrastructure can assist with this and help to attract and retain investment, skilled people and tourism.	Green infrastructure (GI) and climate adaptation span Priorities 3 and 4, with GI driven through a dedicated Delivery Plan and Spatial Priority Areas.
Deliver 30+ West Yorkshire plus Transport Fund schemes and make progress towards a single 'metro style' public transport network, connected to major national / northern schemes such as HS2 and Northern Powerhouse Rail.	Major economic boost from integrated and improved connectivity - through labour markets and agglomeration, business travel and profile benefits.	Covered in Priority 4 and to be progressed through the West Yorkshire Single Transport Plan and associated work.
Develop and regenerate integrated spatial priority areas, supporting employment, quality environments and the building of 10,000-13,000 new homes per year.	These will create many thousands of jobs and integration will ensure high quality and transport that connects people to jobs. More homes will support demand, economic needs and affordability.	Covered in Priority 4. Delivery detail to be included in the Housing and Regeneration Plan and Leeds City Region Infrastructure Investment Framework.
Develop an integrated flood risk reduction programme, incorporating flood defences, green infrastructure and resilient development.	Contributes to long term resilience in a changing climate, with benefits for business, homes and investment.	Led through action in Priority 4, and linked to Priority 3. Action/lead roles to be agreed.

The four priority areas have specific sub-sections for action.

Priority 1 - Growing Business

- Business Growth Hub (LEP Growth Service)
- Innovation
- Access to finance
- Digital
- Supply chain development
- Enterprise
- Trade and investment

Priority 2 - Skilled People, Better Jobs

- More and better apprenticeships
- Great education, connected to business
- Employability, access to jobs and realising potential
- Building workforce skills and attracting talent
- Addressing skills gaps and shortages

Priority 3 - Clean Energy and Environmental Resilience

- New energy generation
- Resource efficient businesses
- Energy efficiency and empowering consumers
- Green infrastructure

Priority 4 - Infrastructure for Growth

- Integrated spatial priority areas
- Urban Growth Centres
- Housing Growth Areas
- Employment Growth Areas
- Transport infrastructure and services
- Integrated flood risk reduction
- Digital infrastructure

Further details of these priorities are below.

PRIORITY 1: GROWING BUSINESSES

PRIORITY 1 SUMMARY	
AIM	**To drive up productivity, growth and employment through an environment that enables businesses to start-up, innovate, trade and invest**
KEY ACTION AREAS	**PRIORITIES**
(A) BUSINESS GROWTH HUB (LEP GROWTH SERVICE)	• Continue to deliver the LEP Growth Service as the route to simplified high quality business support in the City Region; to be financially sustainable from April 2018
(B) INNOVATION	• Deliver high quality innovation products and services • Maximise the role of universities in innovation, enterprise and international profile • Participate in government's Science and Innovation Audits, and related activity, with a focus on medical technology and bio-science • Work with Innovate UK so local firms secure a greater proportion of national funding
(C) ACCESS TO FINANCE	• Deliver a programme of capital expenditure grants and loan funding including at a pan-northern level • Use input and resources from the private sector to deliver a programme of support to enable SMEs to be more investor-ready
(D) DIGITAL	• Develop and deliver a Leeds City Region Digital Delivery Plan • Maximise business use of digital capacity, technology, skills and connectivity
(E) SUPPLY CHAIN DEVELOPMENT	• Establish a Supply Chain Group to help SMEs win large contracts; engage with infrastructure commissioners; and build capacity
(F) ENTERPRISE	• Respond to the gap in the City Region's business start-up architecture to ensure access to high quality support for pre-start, start and early stage businesses
(G) TRADE AND INVESTMENT	• Build capacity, develop and deliver an integrated City Region approach to trade and investment • Deliver targeted investment and investor development through unique propositions in financial and professional services, health, digital and manufacturing • Improve the City Region's export performance, including through simplified and joined up support accessible at all stages of the export journey • Explore opportunity for a UKTI Taskforce for the Northern Powerhouse
HEADLINE INITIATIVES	• Implement coordinated and wide ranging action to radically increase innovation • Become a global digital centre – with specialisms in data storage, analytics, digital health and tech skills • Boost business growth, productivity, exports and investment by linking businesses to support and funding, including through the LEP Growth Service, Skills Service and Trade and Investment programme
KEY PARTNERS	Businesses/employers, universities, Chambers of Commerce, business intermediaries and employer representative bodies, local authorities, UKTI, Innovate UK, finance providers. Also includes engagement with international institutions and businesses.
EVIDENCE LED OUTCOMES	This priority will support progress on headline indicators related to: • Increase in number of businesses innovating to bring new products/services to market • Increase in SME productivity, investment and jobs created • Increase in value of jobs created as measured through improvements in hourly / average wages and uptake of higher levels of skills • Increase business start-ups • Increase in business exports and inward investment

PRIORITY 2: SKILLED PEOPLE, BETTER JOBS

PRIORITY 2 SUMMARY	
AIM	**Increase skill levels and employability significantly to meet future job demands and enable people from all communities to secure more and better jobs – closing the gap to national average on higher level skills and progressing the City Region's NEET-free ambition**
KEY ACTION AREAS	**PRIORITIES**
(A) MORE AND BETTER APPRENTICESHIPS [cross cutting action area linked to b, c and d below]	• Support businesses to understand and make the most of apprenticeships • Support people to access traineeships and apprenticeships • Increase provision and uptake of apprenticeships (particularly at advanced, higher and degree level)
(B) GREAT EDUCATION, CONNECTED TO BUSINESSES	• Improve relevance of learning in schools, colleges and universities to increase attainment and employability skills, including a 'Great Code Campaign' • Produce accurate labour market information and forecasting and ensure it is well utilised in impartial careers information, advice and guidance • Increase student contact with, and understanding of, businesses (in schools, further education and higher education and through placements and internships) to develop employability and enterprise skills • Increase meaningful engagement between businesses and schools (including by influencing schools and Ofsted and governor engagement) and improve careers advice
(C) EMPLOYABILITY, ACCESS TO JOBS AND REALISING POTENTIAL	• Design programmes to help unemployed young people and adults move into work • Equip people with the skills needed to find and progress in work (including in low pay sectors), and connect them to the pipeline of new job opportunities • Work collaboratively to address barriers to work associated with transport and childcare and to help individuals to address issues that limit their economic potential (e.g. drugs, alcohol, criminality) • Maximise positive connections between health, jobs and prosperity
(D) BUILDING WORKFORCE SKILLS AND ATTRACTING TALENT	• Support employers in widening and enhancing workforce training (e.g. by highlighting its importance to growth and brokering solutions through the Skills Service) • Develop the leadership and innovation skills required for business growth • Close the gap to the UK average on high level skills, including promoting routes into higher level and technical skills, attracting and retaining talent, and higher graduate utilisation • Produce high quality forecasts of future employment trends and ensure that City Region partners can respond to them • Progressively influence, improve and take on leadership of the skills system through devolution
(E) ADDRESSING SKILLS GAPS AND SHORTAGES IN KEY AREAS: [A CROSS CUTTING FOCUS FOR AREAS A-D ABOVE]	• Infrastructure/construction skills (and associated employment opportunities) • Tech skills – become the graduate capital for tech skills by attracting and growing talent in coding/ software and data analysis • Manufacturing – e.g. engineering skills and addressing replacement demand
HEADLINE INITIATIVES	• Deliver a 'more jobs, better jobs' programme to widen employment, skills, apprenticeships and progression opportunities, linked to NEET-free goals • Devise and deliver a programme of action to increase high level skills and close the gap to UK average
KEY PARTNERS	Businesses/employers, LEP/Combined Authority, universities, colleges, schools, private training providers, local authorities, DWP/Jobcentre Plus, community organisations. The Skills Network will have a key role in engaging with partners including higher education, further education and private training providers.
EVIDENCE LED OUTCOMES	This priority will support progress on long term headline indicators related to: • % with skills at NVQ level 4 (close gap to national average on this measure) and NVQ2+ • % of schools engaging with businesses • Employment, unemployment, economic inactivity and NEET levels • Apprenticeship starts and completions (and % at advanced/higher/degree level) • Skills shortages in key areas (e.g. tech skills, coding, engineering, construction) • % of employers training their workforce • Earnings (median and 20th percentile)

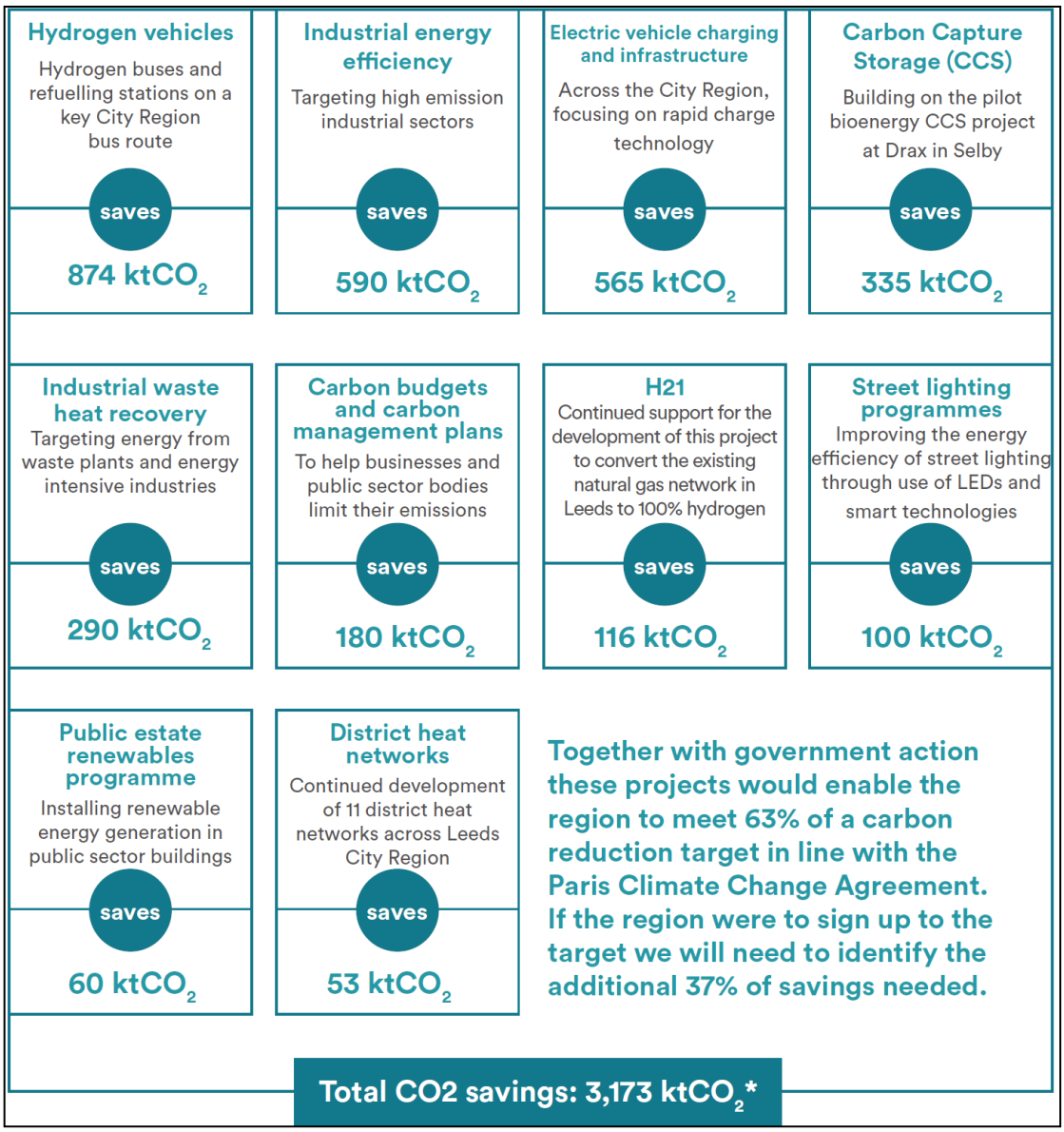
PRIORITY 3: CLEAN ENERGY AND ENVIRONMENTAL RESILIENCE

PRIORITY 3 SUMMARY	
AIM	**To become a resilient zero carbon energy economy underpinned by high quality green infrastructure**
KEY ACTION AREAS	**PRIORITIES**
(A) NEW ENERGY GENERATION	• Provide a test bed for game changing non-conventional fuel technologies, including the H-21 Hydrogen Conversion project • Drive investment in low carbon energy projects through access to high quality technical and commercial advice on how to move from concept through to investment • Deliver an ambitious programme of district heat networks providing access to locally generated, secure, sustainable and low cost heat
(B) RESOURCE EFFICIENT BUSINESS	• Deliver advice and financial support to businesses who want to reduce costs associated with environmental resources like waste, water and energy • Drive innovation and growth in energy intensive industries by promoting resource smart technologies that produce new revenue streams such as carbon capture and utilisation
(C) ENERGY EFFICIENCY AND EMPOWERING CONSUMERS	• Deliver improvements that make homes across the City Region warmer and reduce fuel poverty • Develop partnership and funding models with the health sector to deliver collaborative interventions that reduce extreme cold and damp and improve health • Establish a municipal energy company that provides benefits for local communities, improves choice and delivers smart meter rollout
(D) GREEN INFRASTRUCTURE	• Refresh and deliver the Leeds City Region Green Infrastructure Strategy • Plan and deliver whole catchment area investments that mitigate flood risk and improve the resilience of the City Region economy (linked to Priority 4, key action area c)
HEADLINE INITIATIVES	• Targeted investments and innovation to make the City Region a leading edge centre for zero carbon energy • Make climate change adaptation and high quality green infrastructure integral to improving the City Region economy and its spatial priority areas.
KEY PARTNERS	Investors, utility providers, industry and small businesses, LEP/Combined Authority, universities, local authorities, community groups, DECC, Innovate UK, Local Nature Partnership (and constituent organisations), scheme specific partners
EVIDENCE LED OUTCOMES	This priority will support progress on long term headline indicators related to: • Carbon emissions (linked to long term zero carbon energy economy goals) • Increased GVA, employment, innovation and productivity in the clean energy and energy intensive sectors • Reduced fuel poverty and associated improvements in health and spending power • Increase in the quality and extent of green infrastructure, including climate and carbon sequestration benefits related to tree cover

PRIORITY 4: INFRASTRUCTURE FOR GROWTH

PRIORITY 4 SUMMARY	
AIM	**To build a 21st century physical and digital infrastructure that supports the City Region to grow and compete globally; and to do this in a way that enhances places, transforms connectivity, maximises GVA benefits, minimises carbon impacts, and enables all businesses, people and places to have access to opportunities**
KEY ACTION AREAS	**PRIORITIES**
(A) INTEGRATED SPATIAL PRIORITY AREAS	• Establish a Leeds City Region Infrastructure Investment Framework that sets out the detail of spatial priority areas and their infrastructure requirements • Prioritise investment in spatial priority areas to maximise the City Region's economic, housing and regeneration potential • Enhance collaborative working on the evidence base that supports spatial planning
(Ai) URBAN GROWTH CENTRES	• Support mixed use growth in Urban Centres identified as spatial priority areas through the development of key infrastructure including employment, commercial and residential opportunities
(Aii) HOUSING GROWTH AREAS	• Accelerate delivery of new homes in spatial priority areas in balanced and sustainable communities • Deliver affordable home ownership options and sufficient supply of affordable rented homes • Enhance support for SMEs in construction, including promoting an increase in self build, custom build and modular homes delivery • Explore models and options to influence the direct delivery of housing • Improve the energy performance of housing to address fuel poverty and health impacts
(Aiii) EMPLOYMENT GROWTH AREAS (INCLUDING MIXED USE EMPLOYMENT SITES AND ENTERPRISE ZONES)	• Accelerate delivery of employment growth areas and supporting infrastructure to facilitate sustainable job growth • Identify and deliver upfront infrastructure to tackle development constraints • Deliver a comprehensive inward investment and marketing solution for all Leeds City Region Enterprise Zones
(B) TRANSPORT INFRASTRUCTURE AND SERVICES	• Deliver the package of 31 strategic projects prioritised within the £1 billion West Yorkshire plus Transport Fund • Identify, prioritise and deliver schemes within a second and further rounds of West Yorkshire plus Transport Fund • Maximise opportunities and improvements through investment across modes beyond the Transport Fund, e.g. HS2, Northern Powerhouse Rail, Transport for the North, smart motorways, smart ticketing, improved rail franchises and improved bus services • Deliver sustainable and affordable travel services and initiatives to promote access to employment, education and training
(C) INTEGRATED FLOOD RISK REDUCTION	• Develop an integrated whole catchment flood management and adaptation programme, including strategic green infrastructure (linked to Priority 3, Key Action Area D)
(D) DIGITAL INFRASTRUCTURE	• Deliver West Yorkshire and York Superfast Broadband programmes and related business take-up and support activities (linked to Priority 1, Key Action Area D) • Explore opportunities to use alternative technologies to improve the City Region's digital infrastructure
HEADLINE INITIATIVES	• Deliver 30+ West Yorkshire plus Transport Fund schemes and make progress towards a single 'metro style' public transport network, connected to major national/northern schemes such as HS2 and Northern Powerhouse Rail • Develop and regenerate integrated spatial priority areas, supporting employment, quality environments and the building of 10,000-13,000 new homes per year • Develop an integrated flood risk reduction programme, incorporating flood defences; green infrastructure and resilient development
KEY PARTNERS	Investors, utility providers, industry and small businesses, LEP/Combined Authority, universities, local authorities, community groups, DECC, Innovate UK, Local Nature Partnership (and constituent organisations), scheme specific partners
SUCCESS MEASURES	This priority will support progress on headline indicators related to: • Increased integration of up-to-date district Local Plans to ensure a coordinated approach to development delivery • Increases in GVA and job growth • Increases and acceleration in the number of new homes built, including affordable homes, and employment / commercial floorspace • Increases in the amount of brownfield land and buildings brought back into use and / or development ready • Increases in connectivity bringing people, places and jobs closer together • Reduced number of hospital admissions related to poor quality, cold and damp homes • Reduced delays, congestion and faster journey times across all transport modes and both within and beyond the City Region • Increase in super / ultrafast broadband network coverage and access / take-up by businesses and households • Reduced carbon emissions and vehicular air pollution, improved environmental quality • Sufficient supply of both minerals and waste treatment facilities to sustain and support the City Region's continued development and sustainable growth

Of particular interest is their strategy for priority 3. The Executive Summary for their Energy Strategy contains a list of their top 10 projects and initiatives which are shown below.



The latest minutes of the LEP board meeting provide their current performance against their targets for the Business Growth Programme.

Target Measure	6-Year Target (April 15 to March 21)	Achieved (as of July 18)
Expenditure	£38,96m	Committed - £29.57m Actual - £24.34m
New Jobs Created	4,100	Committed - 4,936 + 1,693 safeguarded Actual - 3,033 + 1,682 safeguarded
Businesses Supported	765	Committed – 538 Actual – 453
Number of Grants Awarded	N/A	Committed – 626 Actual – 520
Public/ Private Sector Leverage	£168.5m	Committed - £306.4m Actual - £231.6m
Total Cost Per Job	No contractual target	Committed - £5,991 Actual - £8,026

North East Economy (NO LDZ) – 2019 Update

The North East economy has been influenced by the activities of the North East Local Enterprise Partnership. This is a public, private and education sector partnership. They are responsible for promoting and developing economic growth in the local authority areas of County Durham, Gateshead, Newcastle, North Tyneside, Northumberland, South Tyneside and Sunderland.

They produce this area's Strategic Economic Plan, which acts as a blueprint for the activities that need to take place to improve the economy.

The North East Strategic Economic Plan (SEP) sets out six economic targets for the region. Progress against these targets are measured on a regular basis.

- Increase the number of jobs by 100,000 by 2024. The NELEP are working with partners to develop a more competitive economy for the North East, helping to create more and better jobs for everyone. By June 2017 the number of jobs in the North East had increased by 47,600 since 2014.
- 70% of all jobs created from 2014 will be better jobs. Better jobs are defined as managers, directors and senior officials; professional occupations (such as civil engineers and doctors); and associate professional and technical occupations (such as laboratory technicians and graphic designers). Of the 47,600 additional jobs since 2014, 76% – or 36,400 – are 'better jobs'.
- Reduce the gap in private sector employment density by 50% by 2024. There are fewer private sector jobs per head (16-64 population) in the North East than in England excluding London and the target is to reduce this gap by 50% by 2024. By 2015, the gap between the North East LEP area and England excluding London had reduced by 16%.
- Close the gap in the employment rate for people aged 16-64 by 50% by 2024. It is important that North East residents are benefiting from the additional jobs created. If this was happening, we would see the proportion of people in the North East LEP area with a job increasing. This is known as the employment rate is lower in the North East LEP area than in England excluding London. By June 2017, the gap between the North East LEP area and England excluding London had reduced by 21%.
- Reduce the gap in economic activity for people aged 16 – 64 by 50% by 2024. The economic activity rate measures the proportion of people aged

16-64 who are actively participating in the labour market, including both those employed and those out-of-work but actively seeking a job. It provides a wider measure of what is happening in the labour market. Again, the economic activity rate is lower in the North East LEP area than in England excluding London. By June 2017, the gap between the North East LEP area and England excluding London had reduced by 21%.

- Reduce the gap in GVA per full time equivalent by 50% by 2024. Gross Value Added (GVA) measures the contribution to the economy of each individual producer, industry or region in the United Kingdom. GVA per full-time equivalent (FTE) job is a way of measuring the productivity. Again, the GVA per FTE is lower in the North East LEP area than in England excluding London. By 2015, the gap between the North East LEP area and England excluding London had grown by 9%.

The NELEP have identified four business opportunity areas that provide huge potential to generate jobs within the North East economy. These are:

- Digital
- Advanced manufacturing
- Health and life sciences
- Subsea, offshore and energy technologies

The North East also has a strong service industry, enabling growing employment in a number of areas too.

- Financial and professional business services – the area is home to key segments of the UK's £180 billion including fintech, banking, insurance, and accounting services sectors
- Transport and logistics – the region's air and sea ports are crucial to enabling the North East and UK economy, as are the logistics, haulage and passenger transport businesses
- Education sector – includes over 700 schools, 9 colleges of further education and four universities with 82,000 students

The NELEP identify many areas of opportunity based around the following strengths the region has.

Digital

- The digital community is one of the most vibrant, productive and rapidly developing in the UK
- Newcastle is second in the UK for high-growth digital businesses at 22% (Tech Nation 2017 Report)
- The area has a software and technology industry valued at £2billion.
- The sector employs 29,000 people in IT and digital jobs
- Creative industries employ 15,250 people The GVA contribution from this sector is currently double the national average
- Emerging specialisms within this sector include data analytics, virtual reality, smart data, cybersecurity, software development, cloud computing, shared services, systems design and communications, building information modelling, games design and delivery

Projects and initiatives that will help this sector grow include:

- Digital alliance: Bringing together key networks, national agencies, universities and the public sector to support business and enterprise to grow the North East's tech sector
- Data for growth: Building on the North East's advantages in smart data delivery

Advanced manufacturing

Across the North East, advanced manufacturing and engineering are globally focused with strong clusters in automotive and medicines manufacturing.

- There are 62,500 people employed in advanced manufacturing (UK top five)
- The region has 120,000 employees in wider manufacturing There are 50,000 STEM students studying in universities every year
- Particular specialisms include automotive manufacturing and medicines manufacturing.

Projects and initiatives that will help this sector grow include:

- Automotive and Vehicles North East Enterprise Zone: A range of sites for investment into advanced manufacturing
- International Advanced Manufacturing Park: The project will generate around 10,000 new jobs
- Advanced Manufacture Science Park: A platform for testing and development of new technologies and education at all levels
- Centre for Sustainable Advanced Manufacturing: This will be a centre of excellence in advanced manufacturing sustainability
- Centre for Smart Packaging and Delivery of Medicines: this will focus on smart and intelligent packaging, sensing and drug delivery

Health and life sciences

This area is responding to trends in global markets towards more personalised medicines and treatments.

- The area has the highest ranked NHS Trust in clinical research studies in the UK
- The region has national centres of excellence in ageing and age related diseases, personalised medicine, formulation, and emerging centres in healthcare photonics and dementia
- The North East is home to the International Centre for Life, a world leader in STEM Cell technology

Projects and initiatives that will help this sector grow include:

- North East life sciences networking: this will strengthen co-ordination and communication and focus on interventions to enhance the business and innovation environment
- Health Quest North East: a challenge based project focused on accelerating innovation delivery, solving long standing health challenges and developing new approaches, products and technologies
- National Dementia Institute: This will build on Newcastle University's status as a European centre of excellence in dementia and healthy ageing.

Subsea, offshore and energy technologies

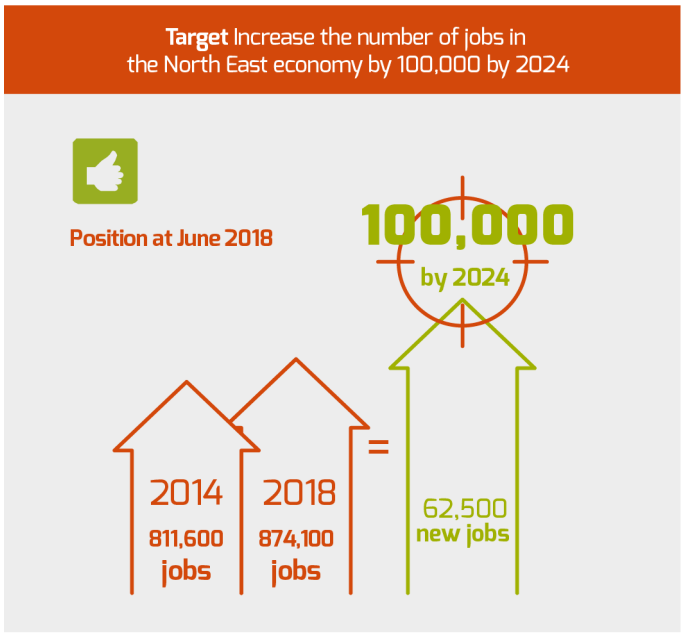
The region is world leading in offshore and subsea technology

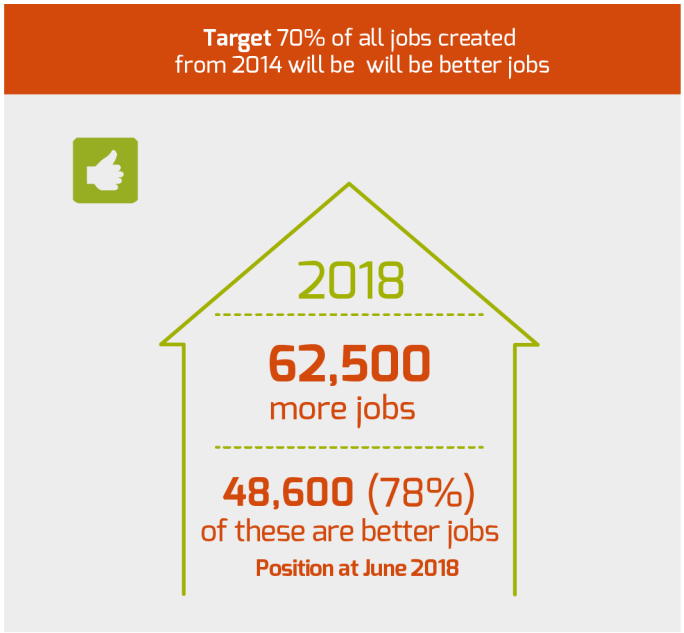
- Over 50 companies with a combined turnover of £1.5bn
- More than 15,000 working in the sector

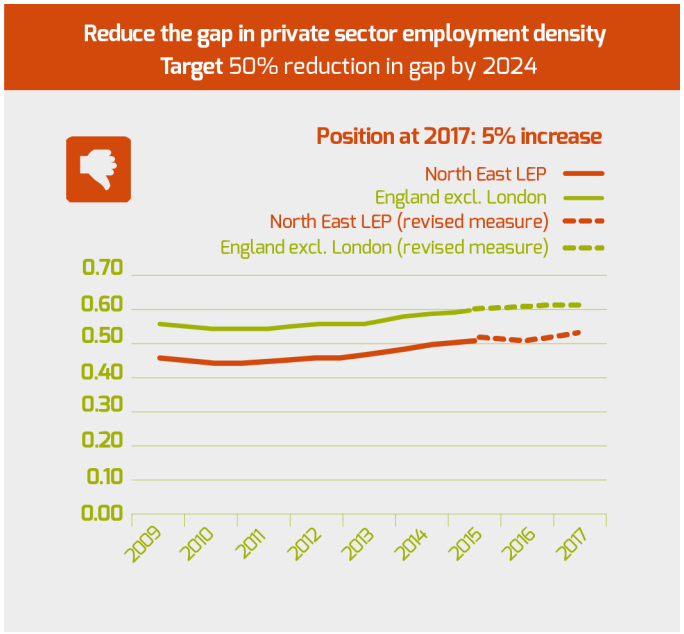
Projects and initiatives that will help this sector grow:

- North East Enterprise Zone: Offers a range of sites for investment into advanced manufacturing, around the Blyth Estuary and north bank of the Tyne
- Tyne Offshore Centre: A major research and hyperbaric testing facility located on the north bank of the Tyne
- Business support: New manufacturing support services will help diversification and growth.
- National Centre for Energy Systems Integration: £20m development at Newcastle Science Central to bring together energy expertise from across the world.

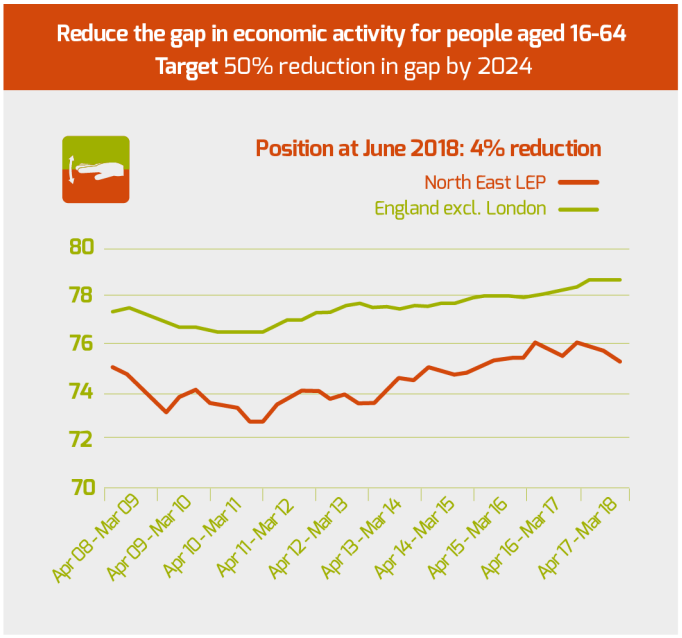
The latest reported performance against targets as provided by the LEP is shown below.



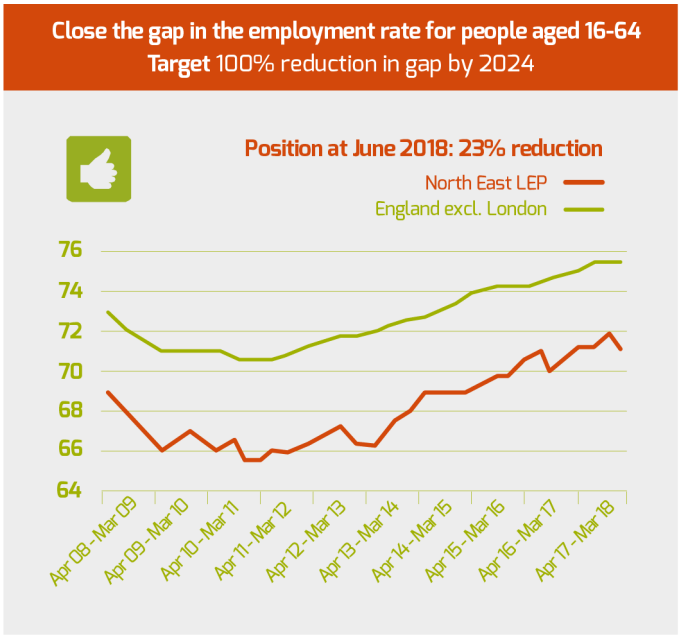




Between 2015 and 2017, the gap had widened on this measure by 5%. This reflects a larger increase in private sector employment per head across England excluding London, than in the North East LEP area.



By June 2018, the gap between the North East LEP area and England excluding London had reduced by 4%.



By June 2018, the gap between the North East LEP area and England excluding London had reduced by 23%.

With regard to the final target of "Reduce the gap in GVA per full time equivalent by 50% by 2024"

Progress: Between 2014 and 2015, the gap between the North East LEP area and England excluding London had increased by 9%.

However, there has been a discontinuity in the data that underpins the FTE element of this measure. Changes have also been made to regional GVA data (with a new balanced GVA figure published for the first time in December 2017)

and there is a case that it would be more appropriate to use a GVA per worker or GVA per hour figure as an alternative. As a result, this target is being reviewed by the North East LEP, in consultation with partners. Once the revised target is agreed, this will be provided on the LEP website.

There is in this region two further enterprise partnerships for Cumbria and Tees Valley.

Cumbria LEP

The Cumbria LEP has the following strategic plan

"With £12billion of major scheme investment in the pipeline for Cumbria, the LEP are well placed to not only maximise the economic potential of Cumbria, but also to make a significant contribution to UK plc."

The priorities for Cumbria LEP are set out in their Strategic Economic Plan, between now and 2024 they will:

- Create 15,000 additional full-time equivalent jobs
- Boost Cumbria's economy by £600m more than current predictions through targeted investment in key projects
- Increase the county's GVA growth by 0.6 percentage points above current forecasts, yielding a GVA growth rate of 2.2% during the plan period
- Support the local planning authorities to deliver 30,000 new homes through their Local Plans
- Raise skill levels through working with local education and training providers, reducing the proportion of Cumbria's firms facing a skills gap by 3%
- Increase visitor expenditure by over £500m
- Increase the number of businesses reporting growth by 5% through the Cumbria Growth Hub support
- Achieve 100% coverage of superfast broadband.

There are no indicators in the plan of the performance to date against these targets. However a recent presentation to the AGM provided the following reported figures.

- 4,000 new jobs
- 3,000 new homes
- 60,000 sq. metres of business space
- 5,000 additional premises with superfast broadband by 2021
- 1,700 learning opportunities

A whole host of future priorities were also identified for the remainder of 2018/19 and beyond from a number of different speakers.

- Place marketing – selling Cumbria as a great place to live and work
- Productivity Challenge – working with our sectors to address this
- Stimulating Innovation - creating an eco-system to stimulate this
- Testbed – the ideal location for proof of concept
- Addressing skills supply – meeting the demand from the economy and business
- Extending the skills offer – collaborative working to develop an offer that provides genuine choice
- Higher Level skills – management and leadership development

- Infrastructure – improving road, rail and digital connectivity
- Promoting Entrepreneurs – creating an enterprise culture
- Accelerating Growth – more fast growing businesses
- Internationalisation – inward investment and exports
- Commercialisation – creating new markets
- Diversification – entering new markets
- Infrastructure – more on road, rails and digital connectivity
- Housing – supporting all areas to deliver housing priorities

The Cumbria LEP has identified from the economic assessment four key economic assets that provide the rationale for the development of their four strategic priorities.

- Advanced manufacturing growth: Manufacturing, and advanced manufacturing in particular, accounts for approximately 20,000 jobs in Cumbria and offers very significant potential for growth through the LEP's plans to further unlock private sector investment.
- Nuclear and energy excellence: West Cumbria continues to be home to one of the most diverse and experienced centres of nuclear expertise in the world. This priority builds on existing expertise for the benefit of both the UK taxpayer and the economy. The target is to deliver over 3,000 new jobs in West Cumbria and around 7,000 construction jobs, as well as consistently growing GVA contribution to the UK economy over the next 10 years.
- Vibrant rural and visitor economy: Cumbria is a large rural county, renowned for its world class landscape and environment. The county contains the Lake District National Park, part of the Yorkshire Dales National Park, the Hadrian's Wall World Heritage Site and several designated Areas of Outstanding Natural Beauty
- Strategic connectivity of the M6 Corridor: Providing the gateway into Cumbria, the M6 corridor and West Coast mainline provides East Cumbria with excellent inter-regional links. This connectivity makes the key settlements of Carlisle, Penrith and Kendal easily accessible and attractive locations for investment, while supporting and servicing the wider rural county.

Tees Valley LEP

The Tees Valley LEP has the following strategic economic plan.

"Industrial Strategy for the Tees Valley coincides with the establishment of the Tees Valley Combined Authority and its associated new powers and funding. The plan sets out the growth ambitions and priorities for the Tees Valley over the next ten years to 2026 and provides a framework for economic development activities. It has been refreshed to ensure that it includes all of the latest priorities to diversify and accelerate growth in the local economy to benefit businesses and residents and to contribute to the overarching objectives of enhancing productivity and improving lifetime opportunities through the provision of more and better jobs."

Some highlights from their plan are:

With a £12.3 billion economy and world class expertise and critical mass in chemicals, energy, health innovation and advanced manufacturing, Tees Valley already makes a major contribution to the UK economy. Previous investment has ensured that Tees Valley is a:

- Highly productive region: Overall GVA is low but GVA per employee in the production sector (£86,000 in 2014), is well above the Local Enterprise Partnership (LEP) average (£76,800) and other major LEP geographies such as Leeds, Manchester and Birmingham.
- Highly innovative region: The fourth highest proportion of businesses undertaking product or service innovation in the UK.
- Export intensive region: Part of the only continuous net exporting region of goods in the UK with additional opportunities to pursue.
- Region with growth potential to be unlocked: 3rd place in the UK for business expansion of existing companies and business start-up rates continue to outperform the UK average. However, there is a need to develop more indigenous SMEs with high growth ambition and to attract more Foreign Direct Investment in priority sectors.

The area needs to create more and better jobs as levels of unemployment are relatively high. To unlock future growth the following is also needed:

- To be better connected;
- A workforce that is fit for purpose; and
- A supportive business environment.

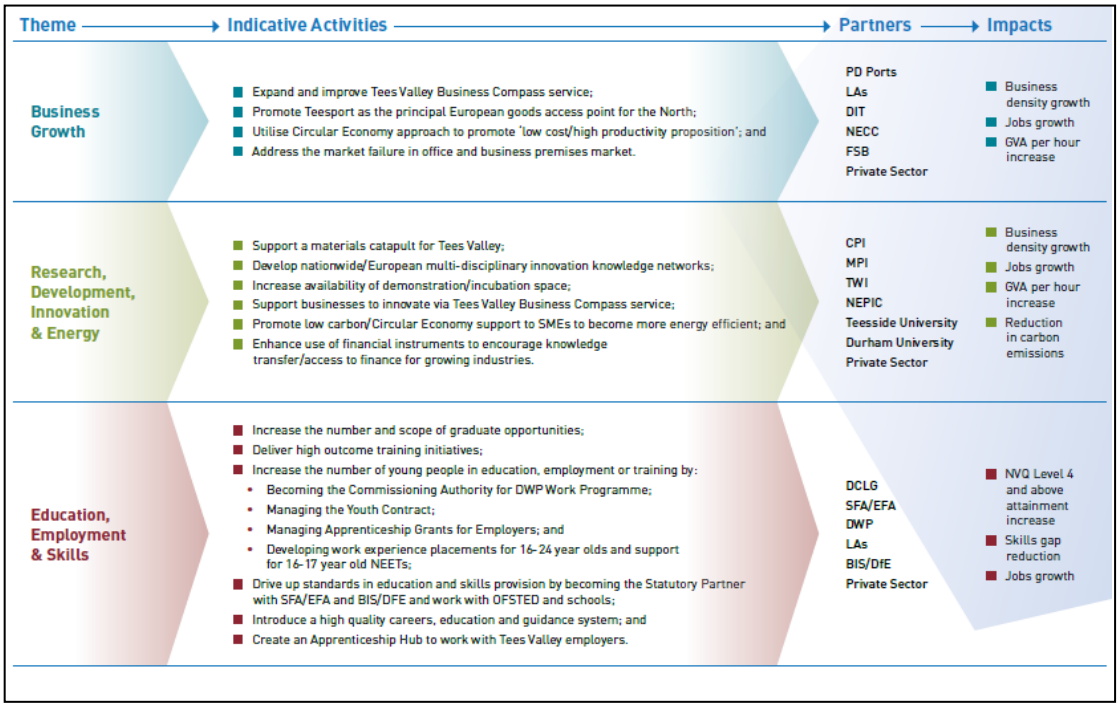
The refreshed SEP will further develop the Tees Valley growth narrative:

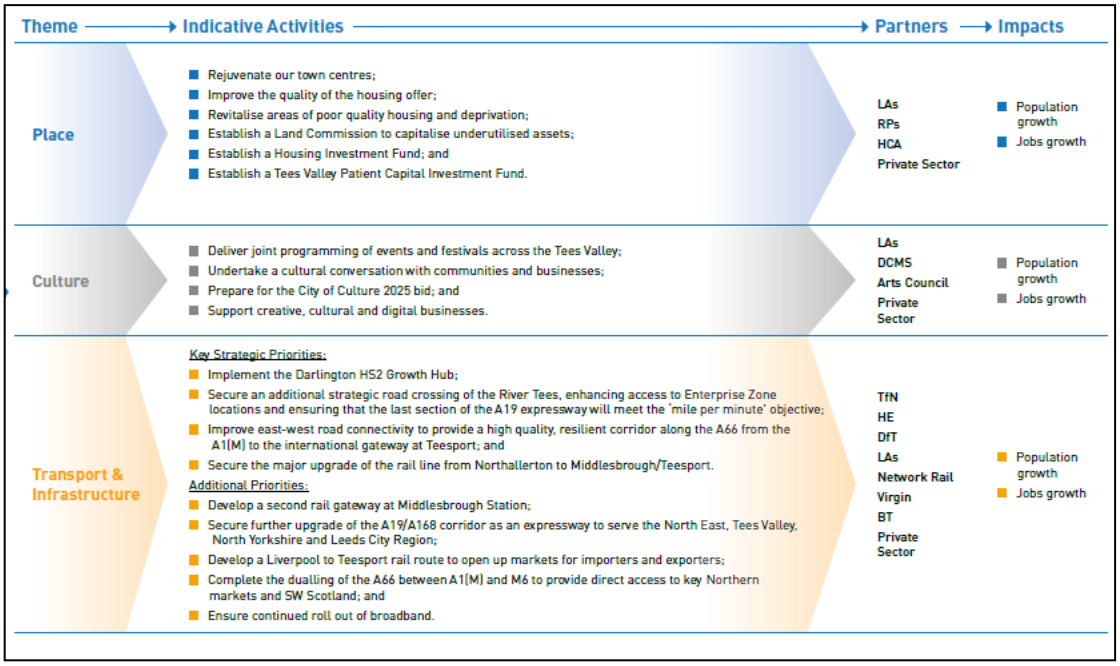
- By targeting support on Foreign Direct Investment and indigenous SMEs with high growth potential in internationally competitive key sectors such as process, chemicals and energy, health innovation and advanced manufacturing, whilst encouraging further diversification into new sectors and technologies (including logistics, digital and creative, culture and leisure and professional and business services); and
- By ensuring a fit for purpose labour force which also recognises the lifetime opportunities of all residents.

This can be translated into two transformational ambitions:

- Through a culture of enhancing productivity, increase the number of high growth firms which have the greatest potential to create jobs; and
- Improve lifetime opportunities, particularly in relation to post primary education and links to business.

The following diagrams illustrate the LEP's six thematic building blocks which reflect the main priorities and areas of activities over the next ten years to unlock transformational growth.





With regard to SEP targets and current performance the Tees Valley Combined Authority have produced a report entitled "Tees Valley Investment Plan 2019/29" that has been discussed at their cabinet meeting on the 24th January 2019. Highlights are as follows.

The Strategic Economic Plan set a target for the creation of 25,000 net additional jobs (after any job losses) in the economy by 2026.

- Between June 2017 and June 2018 there was a net loss of 1,000 jobs with 279,400 jobs in June 2018.
- There has been a change in the occupational profile of people working in Tees Valley:

    - with losses in highly skilled occupations (managers, professionals and associate professionals) across a range of sectors including, science, research, engineering and technology, and teaching and education, with some gains in health professionals, business, media and public service professionals and culture, media and sports occupations. However, the gains have been overshadowed by significant losses.
    - Increases have taken place across the intermediate skilled occupations (administrative & secretarial, skilled trades and caring, leisure and other service occupations) and to a lesser extent in low skilled occupations (sales and customer service, process, plant & machinery).
- Against the Strategic Economic Plan baseline of 275,900, the number of jobs in Tees Valley has risen by 3,500 in two years. Whilst the rate of job increase is below national rates (1.3% compared to the UK's 2.4%), this is against a backdrop of a declining working age population in contrast to the increasing population nationally.
- Since the Strategic Economic Plan in 2016 there are an additional 130 businesses in Tees Valley with 17,230 business enterprises in 2018, including 17,150 SMEs. However, the number of businesses has decreased since 2017 when there were 17,500. Tees Valley's business density (number of businesses per 1,000 of population) is now the lowest of all Local Enterprise Partnership areas. Most Tees Valley businesses are micro (employing fewer than ten people). However, more than one third of private sector workers are in firms employing more than 250 staff and 29% work in very large companies employing more than 500.

During 2017/18 a total of £51m was invested in programmes, projects, grant schemes and development funding which will support the creation of 4,000 new jobs through making or attracting investment into the region. By the end of 2018/19 the Combined Authority expects to have invested at least a further £25m.

With regard to transport the Authority has secured funding since 2016 for a wide range of transport projects which are listed in the report. They have currently £257m to fund further projects across the whole spectrum of transport projects that are also identified in the report.

The progress to date in the Education, Employment and Skills area is also covered.

- Launched the Inspiring Our Futures Plan
- Supported more than 1,200 (since August 2016) apprenticeships through the Apprenticeship Grant for Employers
- Secured £6m of Government funding, matched with £1.5m Combined Authority funds, for the innovative Routes to Work pilot. The initiative has already engaged with 719 residents with 61 having gained employment
- Held events for schools including the annual schools summit in September 2018 attended by more than 2,000 year 9 -13 pupils and hosted the annual Big Bang Science, Technology, Engineering and Mathematics event at Teesside University attended by 3,000 children
- Had Government confirmation that they have met the requirement for the devolution of the Adult Education Budget (in the order of £30.5m per annum for the area)
- Secured a Careers Hub Pilot
- Developed a Careers Framework and Young Persons Careers Pledge

On Business Growth they have achieved the following.

Since the first Combined Authority Investment Plan significant European funds have been invested in Business Growth. Tees Valley has allocated £19.5m ERDF to the Northern Powerhouse Investment Fund and £12.9m to the Tees Valley Business Compass Growth service commissioned by the Combined Authority. Additionally European funds are supporting the delivery of start-up advice and SSI funds are now being used to provide start-up grants across Tees Valley, building on the success of the scheme for former SSI and supply chain workers which has already supported the creation of 341 new businesses.

- Since the 2017 Investment Plan the Combined Authority has worked with companies to create and safeguard a total of 1,400 jobs through more than £209m private sector investment. This includes new inward investment and the growth of existing businesses in the Tees Valley. There are almost 10,000 further jobs identified within the 2019-21 pipeline of projects.
- The Tees Valley Grant scheme, provided by the SSI Task Force, has supported businesses to expand and create and safeguard a total of 1,167 jobs of the overall total of 1,400. The Tees Valley Business Compass Growth activity has undertaken more than 1,000 detailed company diagnostics and supported 417 SMEs to the value of £4.2m against projects totalling almost £13m private capital investment. However, the project is significantly behind profile spend of the £12.9m ERDF for the programme through to the end of December 2019. There are several reasons for this, including the economic uncertainties over the past few years. It is critical that moving forwards the UK Shared Prosperity Fund, as the replacement for EU funding, is as business friendly as possible and can address the business needs and opportunities to unlock growth.
- The Northern Powerhouse has invested £5.98m (as at September 2018) into Tees Valley companies. This represents 8.7% of the total invested across the entire Northern Powerhouse, whilst Tees Valley is home to only 4% of SMEs eligible for funding.

The South Tees Development Corporation (STDC) was established in shadow form in February 2016 and formally launched by the Prime Minister in August 2017. The vision will create 20,000 new jobs in Tees Valley; realise a world-class industrial business park that will ensure sustained economic growth for Tees Valley; contribute an additional £1bn per annum into the Tees Valley economy; and utilising the powers transferred from Whitehall, will transform the area into a global industrial hotspot. Infrastructure development has already started with the development of the roundabout to access the South Bank Wharf site and land acquisition of the SSI land from the Thai banks and other strategic sites within the STDC area that are closer to development are a critical part of the masterplan. Government funding is already in place for elements of this work. The intention is that the acquisition of land will be locally funded and this Investment Plan makes provision for it. Funding for the site redevelopment will be sought from Government.

The Research Development and Innovation area has the objectives to be the lead in the development of hydrogen production and carbon capture and storage. They don't specify any performance against targets but identify that since the 2017 Investment Plan, the Combined Authority has led the development of a Middlesbrough District Energy Network. This £40m scheme will deliver energy savings to businesses and public-sector buildings in Middlesbrough (including

James Cook Hospital, Teesside University, and some council buildings), and, when developed, could reduce residents' energy costs. Seen as a flagship scheme by Government, it will provide financial benefits including energy cost savings, returns to investors and also significant carbon savings by potentially utilising waste industrial heat generated in the region.

Place – Investing in our Towns and Communities doesn't have any information about performance against targets but does contain some useful information about potential developments in the Tees Valleys five boroughs.

2.2. NGN Economic Assumptions

2.2.1. National GDP

GDP is a key indicator of the state of the whole economy and equates to GVA plus taxes on products minus subsidies on products. The reference year used for the data series is 2016 to be consistent historically with the data provided by the Office of National Statistics (ONS). The data is presented on a gas year basis as requested by NGN.

UK GDP growth is assumed to be in line with the average GDP growth for the historical data set. The average forecast from independent bodies for 2019 produced in October 2018 is 1.48% which is very close to the value used in this forecast at 1.49%. The OBR forecast is 1.6% for 2019 but then drops to 1.4% for 2020 and 2021 then up to 1.5% for 2022. The independent forecasts average at 1.7% for 2020 and 1.8% for 2021 and 2022. There is however a wide range of forecasts in those years and the forecasts shown by the OBR are only a sample of three forecasters.

2.2.2. National GVA[1]

It has been necessary to change the reference year for the historical data from the previous assumptions of 2015 to 2016 to be consistent with the data provided by the Office of National Statistics (ONS). A revised set of historical data has therefore been produced which has a reference year of 2016 and continues to be adjusted to represent gas years instead of calendar years as requested by NGN.

As UK sectoral GVA growth is required by NGN total UK GVA growth is calculated by summing the sectoral growth. This approach was introduced five years ago for the LDZ GVA growth to avoid complications that arise when trying to create the high and low scenarios. The Commercial and Services sector has seen substantial growth over many years only being halted by the recession. It has recovered significantly since that time but has shown a slowdown in recent years. The UK sector is forecast to grow at a rate equivalent to the average rate of growth over the historical data set.

The UK Industrial and Manufacturing sectors both show significant variability with periods of decline and growth, with 2017 showing significant growth. The Construction sector was a major contributor to the Industrial growth in 2017.

2.2.3. Regional GVA[2]

As with National GVA it has been necessary to change the reference year to 2016 from 2015 for this year's set of Regional GVA data. From the data produced by the ONS the GVA for North East has been taken as representative of the NO LDZ, and Yorkshire and the Humber as representative of the NE LDZ. The figures provided for 2017 are estimates, as official regional figures were not available at the time the forecasts were produced. These estimates use a forecast of regional growth based on the growth trend for each region. This is a change from last year as pro-rating the regional figures in line with each regions percentage contribution to the national figures gave rise to the same levels of growth in each region and the UK.

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[1] UK GVA is at 2016 prices

[2] All Regional GVA categories are at 2016 prices

GVA growth in both LDZs has generally been below the growth for the whole of the UK in the period 2004 to 2016 with the impact of the recession being present at the same time in both LDZs as the UK but of lower impact in 2008 particularly in NE LDZ. With regard to the NO LDZ there was in fact minimal growth in 2012 but recovering after that date.

Total GVA growth for the two LDZ's continues to be calculated by summing the sectoral growth. This approach was introduced five years ago to avoid complications that arise when trying to create the high and low scenarios.

The Commercial and Services sector has seen substantial growth in both LDZs over many years only being halted by the recession. It has recovered to some degree in real terms in both LDZs each showing sustained recovery. There was strong growth in NO LDZ in 2014 and 2015 and in NE LDZ in 2015 and 2016. Both LDZ's are forecast to grow at a rate equivalent to the average rate of real growth over the period of the historical data set. The change in methodology was introduced last year to reflect the fact that taking the last five year average could be overly optimistic given the uncertainty resulting from the UK's decision to leave the EU.

The Manufacturing sector in both LDZs has seen a cycle of rise and fall over the last 20 years but the general trend has been downwards, although there is evidence of some reasonable recovery in this sector in both LDZ's. It is assumed that there will be some continued recovery but this could be influenced by the impact of the ongoing negotiations with the EU over future trading arrangements with EU countries. This will have an impact on certain industries that export goods to the EU or import goods from the EU although the value of the pound will also have a significant impact.

The Industrial sector (which includes Construction) has seen a similar cycle of rise and fall as Manufacturing but the general trend is towards a flattening of output in recent years. It is not expected to show any growth although the Construction sector is generally on an upward trend as new housing recovers and there is new development around the ports associated with the growth in offshore wind developments, although there are some signs that there may be some decline in new developments. Both LDZs are expected to show a very slow rate of decline. There is currently a stuttering recovery in the construction industry in the two LDZs which may be sustained leading to pockets of growth in this area. Previous announcements by the Government regarding the direct commissioning of 13,000 new homes on publicly-owned land combined with a desire to build 200,000 new starter homes should support sustained growth in the Construction sector. This has been supported by announcement of the plans for garden towns and villages, but local opposition to some of the town sites has resulted in a change of policy to focus on garden villages. Of the sites identified only one lies within the two NGN LDZs, in Cumbria near Carlisle. It was announced in November 2017 that new housing growth was 15% higher than the previous year.

The forecast approach for the Manufacturing and Industrial sectors is the same as for the Commercial and Services sector.

2.2.4. Household disposable income (GDHI)[3]

[3] GDHI is at 2016 prices

As with historical GVA data it has been necessary to change the reference year to 2016 from 2015 for this year's set of National and Regional GDHI data to allow the latest published figures from the ONS to be utilised. The figures used for 2017 and 2018 are estimates for Regional GDHI as official figures were not available at the time the forecasts were produced. The 2018 figures for National GDHI are reported values. The OBR have not produced any forecasts of Regional GDHI to date for these years.

The growth assumed for 2017 and 2018 for regional GDHI is calculated using a an assumed regional growth rate for these years based on the growth trend for each region. The forecast for both National and Regional GDHI is assumed to be at a rate equivalent to the average growth rate for the historical data set.

2.2.5. Inflation

It has been assumed for the purposes of making adjustments to account for inflation and to bring prices back to 2016 levels that the rate of inflation used in these calculations is based on the level of inflation used by Government departments to develop the factor know as the GDP deflator. The largest downward contributions to change in the 12-month rate came from falls in petrol prices and from air fares, where ticket prices rose between November and December 2018, but by less than a year ago. These downward effects were partly offset by upward contributions from a variety of categories including accommodation services and, to a lesser extent, mobile phone charges, games, toys and hobbies, and food. Within the accommodation services group, the largest contributions were from domestic fuels, principally electricity and gas and from owner occupiers' housing costs. Future inflation levels are in line with Government forecasts which go to 2022. After that date it is assumed it will continue to remain at 2022 forecast levels. This may be slightly optimistic given the remaining uncertainty surrounding the impact of the UK leaving the EU in both the short and medium term.

2.2.6. Household Numbers

The historical data used as the basis for our analysis is based on the Department for Communities and Local Government (DCLG) website reported data (mid-year) adjusted to year end and then gas year.

Regional data has been derived from the figures for UCA's and have been assigned to each LDZ based on a geographical match. There may be some boundary issues with other DN's (SC/NW/EM) but the figures are as accurate as the level of detail provided allows. It should be noted that the historical data has been adjusted slightly by DCLG.

Forecasts are based on the forecasts provided on the DCLG website. As they continue to provide annual figures it is not necessary to pro-rate missing years.

2.2.7. Employment

Total UK employment levels have been rising steadily for nearly 20 years with only small reductions in 2009 and 2011. In 2017 a total of 268,000 jobs were created the majority of which were employee jobs as opposed to self-employed. The steady growth in total jobs is driven by the Commercial/Services sector where 305,000 jobs were created in 2017. In addition 22,000 jobs were created in Construction (12,000), Agriculture (1,000) and Mining (9,000), and 27,000

jobs that were unclassified. This was countered by a loss in Manufacturing of 86,000 jobs. By the end of Q3 2018 an additional 335,000 were created driven by the Commercial/Services sector but with a decline in Manufacturing. Manufacturing has seen a steady decline since 1998, with some fluctuation over the period to Q3 2018. Prior to 1998 there was a period of small growth from 1992 to 1998 in Manufacturing. There was a small recovery in jobs between 2011 and 2014, numbers rising by around 160,000 over the three years. Since 2014 numbers have declined with the latest figures for 2017 showing a fall in that year of 90,000 and a fall of 74,000 in the first three quarters of 2018.

Future employment levels are quite unpredictable at the moment as a result of uncertainty over the EU exit negotiations but we are assuming that future employment levels in UK and the LDZ's for the Central Case it is assumed will grow at a level equivalent to the average rate of growth over the period of the historical data set.

2.2.8. Average Wages

Historical data on average UK and Regional wages is sourced from the ONS at current prices and adjusted to be based at 2016 prices and for a gas year. The growth rate is assumed to be equivalent to the average growth in wages over the historical data period.

2.2.9. Debt per household

Historical data on average UK Debt per Household is sourced from the reports produced by the Money Charity as no other suitable sources are available. This is at current prices and is adjusted to be based at 2016 prices and for a gas year. The growth rate is assumed to be equivalent to the average growth in debt over the historical data period.

There is unfortunately no reliable data on regional variations on total household debt although there is some current data on regional variations for unsecured debt which shows that on average the NE LDZ is £550 per person and NO LDZ is £582 per person compared to the national average of £603 per person.

As a result it was necessary to use a proxy for the relative levels of debt in each LDZ. As the highest item in total household debt is by far the mortgage a proxy for regional household debt is the relative value of regional property prices to the national average.

3. Gas Prices

3.1. General Background

All prices in all markets have shown, until very recently, significant rises from 2002 for households and effectively from 1999 in the non-domestic market. This is a direct result of the pass through of the wholesale gas price rises, which has in turn been driven by rising oil prices. However this had turned around significantly in 2015 and 2016 with the recent sharp decline in oil price, driven by the entry into the market of the shale oil in North America, decline in worldwide consumption and the initial refusal of OPEC to cut back production. New oil exports from Iran did have an impact on the market and potentially increased the surplus. OPEC producers did however cut back production in 2017 and self imposed output limits have been encouraged lead by Saudi Arabia and Russia.

This lead to a steady recovery in oil prices to a significant degree during 2017 and into 2018. It was also forecast that US shale oil will continue to be developed along with new conventional US oil production despite the low oil price. The reasoning behind this is that shale costs are expected to fall with further innovation and the shale technology is being utilised on conventional reservoirs.

Between early October 2018 and the end of December 2018 there has been a dramatic fall in oil prices recovering partially during January 2019. There are multiple reasons for this drop. Promised cutbacks in production from OPEC and Russia have not materialised yet and US shale production has risen again in 2018. Stocks of oil are high and world economic growth is slowing reducing energy demand.

There is extreme uncertainty regarding the future sustainability of any long term recovery in oil price. Additional factors that can be expected to impact oil prices are the ongoing instability in Eastern Ukraine and any knock on effects in the neighbouring countries like Azerbaijan and Turkmenistan, and the ongoing tensions in the Middle East and Africa.

On balance it can be expected that oil prices may fluctuate a little before rising again, but slowly, unless there is a major supply disruption, which would almost certainly see a significant rise in oil prices, and hence wholesale gas prices. US shale oil production is however forecast to increase again in 2019 so this may counter some of the efforts by OPEC and bring oil prices down again. It should be noted that US oil production is now greater than both Saudi Arabia and Russia.

Any assertions made by commentators regarding the delinking of gas prices from oil, continue to appear to have been unfounded given the fact that wholesale gas prices have fallen broadly in line with oil prices in recent years although not as dramatically, but are starting to rise again in 2018 as oil prices have for the greater part of 2018.

All historical fuel prices used in the development of the retail price indices forecasts are obtained from the Department for Business, Energy and Industrial Strategy (DBEIS) quarterly statistics.

3.1.1. Wholesale Price

There has been some significant fluctuation in the wholesale gas price (as represented by the UK NBP price at 2016 prices) over time but the general trend has been upwards. Following the steep decline in oil prices between 2014 and 2015 the wholesale price fell in 2016, but as stated above has started to rise again in 2017 and 2018. The forecast provided is based on an assessment of the forecasts used by National Grid and DBEIS for their energy demand forecasts.

3.1.2. Retail Price – Domestic

Following the dip in the real price of domestic gas prices in 2017 there was a rise in 2018 as a result of the impact of the sustained wholesale price rise which has an impact on a proportion of the costs incurred by domestic suppliers. To counter this competition from smaller suppliers is increasing, although there have been a number of small company closures resulting in Ofgem having to designate a replacement supplier. There are ongoing developments to make switching supplier easier and quicker and the Government have introduced a price cap mechanism. Beyond 2018 with forecast wholesale prices due to rise steadily, we have assumed that the major suppliers will as a minimum control prices using the

full wholesale price plus a 2% premium for the ongoing costs associated with smart metering and the development of smart grids.

The index provided in the assumptions is a real price index with 1987 having an index of 100 and based on 2016 prices. The current retail gas price as calculated using the above assumptions is adjusted for inflation to create the real price index.

3.1.3. Retail Price – Industrial

There has until 2014/15 been a steady rise in the real price of industrial gas prices for many years but with significant fluctuations in line with the fluctuation in wholesale prices. This fluctuation is particularly felt by those customers with large annual consumption as the wholesale price is a much greater proportion of their charges from their supplier. In 2017 and 2018 there was a steady rise in the industrial gas price following falls in 2014 and 2015 as a result of the large rise in wholesale gas prices, driven by the rise in oil price, which has however in the last 3 months dropped significantly.

Ongoing current price rises are expected to reflect the changes in wholesale gas prices with a premium of 1% added to the current price to accommodate the development of smart grids, smart metering and other green initiatives. The lower premium level is anticipated as non-domestic customers will see greater benefits from this technology compared to domestic customers and hence be early adopters or already have some form of smart metering already.

The index provided is a real price index using 2016 prices.

4. Efficiency Improvements and Renewables

4.1. Efficiency

Gas demand, when corrected to seasonal normal weather conditions, has been declining in recent years, although there are some instances of growth in some sectors in some parts of the country, possibly driven by historical falling gas prices and the improving economy. There is also evidence that average consumption per customer is falling steadily. It is difficult to separate the impact of efficiency improvements from the impact of variations in gas prices and the effects of variations in the number of supply points. This is further complicated by the impact of the penetration of renewables into households that were using gas as their primary source of heating and now have renewable alternatives when they are available and then use gas heating as a top-up. Therefore there remains the possibility that gas demand at peak could be the same as previously seen at those properties before the installation of renewable heat sources.

It is a fact that there has been a steady and substantial programme of gas fired domestic boiler replacement for a very long period now and the high levels of efficiency achieved with these new boilers is a significant contributory factor in the decline in gas demand. However the increases in efficiency may in some circumstances have been used to provide higher comfort levels, especially in winter. There has also been a sustained effort by gas suppliers and other parties to encourage the use of loft and cavity wall insulation. This has been extensively used to reduce household consumption. The major suppliers are however in many instances refusing to offer top-up loft insulation as the benefits are not sufficient to cover the cost.

The DECC pathways analysis has much commentary on different types of insulation and anticipates high levels of take up of previously underutilised insulation categories e.g. solid wall insulation. It is expected that cavity wall and loft insulation (being relatively cheap) will be increased to the point of saturation in a relatively short space of time but solid wall insulation requires substantial investment and disruption to install and doesn't currently provide an economic solution (without large subsidies) to those households that pay their own energy bills and could benefit from savings made. There are examples however of local authorities funding this investment either wholly or in part to meet their own green agendas, although there are some where it does seem that the payback periods are very long. With ever increasing pressure on local authority budgets it is possible that this may not be sustainable, especially as the council tenant sees the benefit in reduced energy costs and not the councils. A major influencing factor in this area could be the tragic events of the fire in Grenfell Tower. Many local authorities are already planning to remove cladding and it has to be assumed that they would not replace it until the results of the public enquiry are known.

The DBEIS statistics as at the end of 2017 show that there are only 749,000 homes with solid wall insulation which equates to 8.6% of the total properties that do not have a cavity wall. This figure is ten times the number at the end of 2008.

As part of this year's analysis NGN have requested a set of efficiency data relating to the following items.

- Energy efficient gas boilers installed
- Lofts insulated
- Cavity walls insulated
- Ownership of double-glazing
- Total heat pumps installed and hybrid/gas absorption heat pumps
- Electric/ hybrid/ ultra-low emission vehicle uptake – gas/hydrogen vehicles
- Heat networks set up
- Combined Heat and Power generation
- Bio-methane & green gas
- Power generation (base load and peaking)

NGN requested that TPA provide a set of historic annual data for the period 2005-2017 and annual forecasts for 2018-2030. The assumptions relating to the forecasts are provided below.

4.1.1. Energy Efficient Gas Boilers

There has been a substantial increase in the number of condensing boilers that have been installed since the change in building regulations in 2005 that required all new and replacement boilers to be condensing boilers, wherever possible.

The historical data that has been obtained was taken primarily from statistics produced by DBEIS relating to energy efficiency. This provided annual data for the period 2005 to 2016 with the figures for 2017 and 2018 being estimates by TPA based on an average of the rate of installation over the historical data period.

Forecasts assume that the reduction continues at a level of 100,000 less new units per annum until 2025, then stays at around 300,000 new units per annum.

The high scenario is produced by taking the average growth in new installations over the historical data period. The low scenario assumes that 80% of all new houses have a gas boiler.

4.1.2. Loft Insulation

Loft insulation has been installed at a steady rate for many years with some fluctuation in levels due to various funding schemes.

The historical data that has been obtained was taken primarily from regular DBEIS reports which provide quarterly installed levels. This has been supplemented where required by annual data from the DECC report "Great Britain's Housing Energy Fact File" and the DECC Energy Consumption in the UK tables. These various sources provided annual data for the period 2005 to 2017. The figure for 2018 is estimated by TPA by assuming that the growth in 2018 is the same as 2017.

Forecasts assume that the level of growth as seen last year is sustained for the plan period.

The high scenario is produced by taking the growth that occurred in 2012/3 gas year the first year that extreme levels of growth (seen in earlier years) was reduced. The low scenario assumes that an additional 100,000 homes are insulated each year.

4.1.3. Cavity Wall Insulation

Cavity wall insulation has been installed at a steady rate for many years with some quite significant fluctuation in levels.

The historical data that has been obtained was taken primarily from regular DBEIS reports which provide quarterly installed levels. This has been supplemented by annual data from the DECC report "Great Britain's Housing Energy Fact File" and the DECC Energy Consumption in the UK tables. These various sources provided annual data for the period 2005 to 2017. The figure for 2018 is estimated by TPA by assuming that the growth in 2018 is the same as 2017.

Forecasts assume that the level of growth as seen in the last year is sustained for the plan period.

The high scenario is produced by taking the average growth in new installations over the historical data period, capped each year at the maximum number of suitable homes. The low scenario assumes that an additional 100,000 homes are insulated each year.

4.1.4. Double Glazing

As with other forms of insulation there has been a steady growth in full double glazing and there is some triple glazing being installed. The only data that has been analysed here is the installation of full house double glazing. There appears to be a steady reduction in the rate of installation over recent years.

The historical data that has been obtained was taken primarily from the DECC Energy Consumption in the UK tables which contains data on installed double

glazing on an annual basis. This provided annual data for the period 2005 to 2016. The figures for 2017 and 2018 are estimated by TPA by assuming that the growth in 2017 and 2018 is the same as 2016. Forecasts assume that the installed levels rise at this rate for the plan period.

The high scenario is produced by taking the average growth in new installations over the historical data period, capped each year at the maximum number of suitable homes. The low scenario assumes that an additional number of homes are fitted with double glazing at the lowest positive rate seen over the historical data period.

4.1.5. Heat Pumps

Heat pump installations are in their early days still but levels are rising steadily and are expected to grow significantly due to both RHI schemes (domestic and non-domestic).

The historical data that has been obtained was taken from a combination of information published by Building Service Research and Information Association (BSRIA) and reports produced by other parties to support industry bodies. This provided annual data for the period 2005 to 2014. The figures for 2015 to 2018 assume an annual installation rate based on DBEIS assumptions. Forecasts assume that the installed levels rise at an exponential growth rate over the plan period, escalating in line with an assessment of the level of growth forecast by NG in their four scenarios. The figures for hybrid and gas absorption heat pumps are calculated historically based on spot figures quoted by DBEIS as percentages of total installations. Forecast figures are derived from NG FES assumptions.

Regional data has been produced pro-rata using a relationship between regional and national levels for approvals for heat pumps given under the Renewable Heat Incentive scheme. This data is obtained from Ofgem.

High and low scenarios are based on specific high and low NG forecasts from their Future Energy Scenarios. The regional scenarios are pro-rata to the national figures.

4.1.6. Electric Vehicles and Alternatively Fuelled Vehicles (AFVs)

The historical data for electric vehicles, hybrids and ultra-low emission vehicles was obtained by analysing the Society for Motor Manufacturers and Traders (SMMT) monthly records of vehicles registered. This provided data from 2011 to 2018. The data for previous years was estimated by TPA based on the assumption that electric vehicles of modern design started around 2004 and grew exponentially from that date.

Forecast levels are based on an assumption that demand grows exponentially at a level equivalent to the average year on year increase in new annual registrations over the period 2012 to 2018.

The high scenario is produced by assuming that demand grows exponentially at a level equivalent to the highest year on year increase in new annual registrations over the period 2012 to 2018. The low scenario uses the same methodology but applied to the lowest year on year increase.

There is some limited but slightly misleading data on the registration of gas and hydrogen vehicles for the UK that has been analysed in an attempt to estimate

the historical figures for this category. The early data relates to registrations of AFVs. It should be noted however that the number of reported registrations of these vehicles has essentially fallen to very low numbers by February 2013 and there are no regular further reports on these vehicles from the SMMT. The current use of the term AFVs by the SMMT incorporates diesel hybrids which were originally reported separately to AFVs and now only diesel hybrids are reported under the overall EV category. The SMMT have produced some statistics on CNG buses which show that in 2013, 2014 and 2017 around 40 CNG buses were registered in each of those years.

By the end of 2017, 11 hydrogen-refuelling stations (HRS) were publicly accessible in the UK. They were developed with the help of government's Hydrogen for Transport advancement Programme (HyTAP), which provided £5 million. In March 2017, a further £23 million funding from government was announced, which will support hydrogen vehicle and infrastructure development.

The existing stations are geographically located to support vehicle manufacturers' initial fuel cell electric vehicle (FCEV) launch plans and are a significant first step towards building the national network of 65 stations proposed by UK H2 Mobility.

With regard to historical data for gas powered vehicles, given the similar premium for these vehicles compared to an EV, but more restricted fuelling infrastructure, we have assumed that they will maintain the same proportion of EV registrations as the limited data history suggests. The figure is 3.9%. For forecasts and scenarios the same percentage has been applied.

4.1.7. Heat Networks

There is extremely limited historical data available on heat networks and the sources appear to provide conflicting numbers. The primary source that was used however was a document produced by the former government department DECC entitled "Summary Evidence on District Heating Networks in the UK". This provides information on both national and regional sites in one year 2012. This was supplemented by a graph obtained from another DECC document entitled "The Future of Heating: Meeting the Challenge."

TPA have taken the limited data and produced a history by prorating between any published figures, so caution should be taken in using this data until there is any published new data to validate the assumptions.[4]

We have however generated some forecasts for both national and regional heat networks which have been produced by using the average growth rate from the historical data set.

The national and regional high scenarios assume that the highest growth seen in the historical data set occurs each year going forward. The low scenarios assume the lowest level of growth.

4.1.8. CHP

CHP plant has seen a steady growth over many years and its continued growth may depend on future strategies and options for providing heat. The latest figures from DBEIS (2017), show that natural gas is the predominant fuel (68.7%), with

[4] Experimental data was produced by DBEIS in March 2018 giving the figure for 2017 which has been included in the historical record.

renewables (16.5%), other fuels (7.9%), refinery gases (5%), blast furnace gas (1.3%) and coal (0.5%). Compared with 2016 natural gas has fallen from 72% and renewables has risen from 12%. The big rise in renewables is mainly due to the inclusion of a number of CHP schemes fuelled by biogas generated by anaerobic digestion fed with food waste.

There is a reasonably comprehensive set of historical data for CHP plant installed from a national perspective and regional data from 2010 onwards. The missing data up to that date was filled in by taking the average percentage of the national figure for each region and applying that to the historical national data back to 2005.

Growth in both national and regional base cases is produced by applying the average level of growth over the period where there was real historical data.

The national and regional high scenarios assume that the average of all positive growth seen in the historical data set occurs each year going forward. The low scenarios assume the lowest level of growth.

4.1.9. Biogas Networks

There has been considerable growth in this source of energy for many years now more recently driven by the RHI incentive scheme, however there has been some temporary reductions in the tariff for biogas schemes which may result in some reduction in growth in the short term, but the subsequent reversal of the reduction should result in more growth in the medium to long term.

There is only one main source of data for biogas schemes presently which is the Official Information Portal on Biogas Digestion, which lists all biogas plant in the UK by location. This data forms the basis for the historical national and regional data supplemented by occasional data snapshots from the European Biogas Association. Some data back fill was required for earlier years.

Forecasts for both national and regional base cases are produced by applying the average level of growth over the period where there was real historical data.

The national and regional high scenarios assume that the highest growth seen in the historical data set occurs each year going forward, excluding any extreme growth that was the result of data backfill. The low scenarios assume the lowest level of growth.

4.1.10. Power Generation (Baseload and Peaking)

Baseload power plant is broadly defined as consisting of:-

- Nuclear power plant
- Coal power plant
- Hydroelectric plant
- Geothermal plant
- Biogas plant
- Biomass plant
- Solar thermal with storage

Peak load or peaking plant is broadly defined as consisting of:-

- Gas plant

- Solar power plants
- Wind turbines
- Diesel generators

There has however been a significant decline in the traditional baseload plant for many years (apart from very small rises in 2014/15 and 2017/18) and growth in peaking plant over a similar period, primarily driven by solar and wind generation.

Because of the way that the UK electricity market operates there is really not a clear definition between baseload and peaking plant that can be assigned to a specific type of generation. It is further complicated by the various incentives that are available for renewable generation and the growth in smaller diesel and gas generation plant to provide back up for wind.

In order to meet the NGN requirement for a split between baseload and peaking plant it has been necessary to use the above definitions to collate the data. Our source is the very comprehensive data base on power plant produced by DBEIS. This has plant details by region so it was possible to create a full historic data base for both national and regional baseload and peaking plant under the strict definitions we have used.

The forecast uses the following rules.

As there has been a slowdown in the decline in baseload plant in very recent years it is assumed that the number of sites will stay at current levels.

For peaking plant the growth in the number of sites is assumed to rise at a rate equivalent to the average rate of growth over the historic data period.

The national and regional baseload high scenarios assume that the highest growth seen in the historical data set occurs each year going forward. The low scenarios assume the lowest level of growth.

The national and regional peaking high scenarios assume that the highest growth seen in the historical data set occurs each year going forward. The national low scenario assumes the lowest level of growth, whereas the regional low scenarios assume no growth to avoid these sites declining too rapidly during the forecast plan period.

4.1.11. Energy Bill 2011 (Updated 2019)

There are a range of provisions in the Bill to encourage energy efficiency and to remove barriers to investment in energy efficiency.

Green Deal
This creates a new financing framework to enable the provision of fixed improvements to the energy efficiency of households and non-domestic properties, funded by a charge on energy bills that avoids the need for consumers to pay upfront costs. This framework includes:

- powers to set parameters around the use of this facility to ensure consumer protection for both the originator of the work and subsequent occupiers;
- powers to limit access to the financial mechanism in the framework to the installation of measures that are expected to deliver savings exceeding the level of the charge; and

- obligations on energy companies to administer the charges and pass monies to the appropriate party.

Energy suppliers are exempt from the Consumer Credit Act requirement to gain a credit licence when they collect Green Deal payments. Green Deal Providers will also be exempt from the requirement to hold a consumer credit licence in respect of Green Deal Finance offered to smaller businesses, to avoid segmenting the non-domestic market.

The latest monthly report from DBEIS (June 2018) provides the latest position on the Green Deal. The number of Green Deal assessments that have been completed in total by May 2018 is 699,000. 13,000 were completed in 2017 compared to 57,000 in 2016. For the first five months of 2018 the number was only 2,300[5]. The total number of efficiency measures installed under the Green Deal in 2017 was 59 compared to 140 in 2016 across the full range of type which is a further slowdown. To the end of September 2018 the number was only 25.

It should be noted that the Government has stopped funding the Green Deal Finance Company, which was set up to lend money to Green Deal providers. New schemes will therefore not be funded through this route but there may be Green Deal funds available from providers that are funding the scheme themselves. The declining numbers of Green Deal assessments and efficiency measures installed under the Green Deal suggests that there are limited providers of Green Deal finance.

Private Rented Sector
Powers established for the Secretary of State, which will, in the event of continued poor energy efficiency performance in the Private Rented Sector, prevent private residential landlords from refusing a tenants' reasonable request for energy efficiency improvements to be undertaken in their properties, where a finance package is available. It will also require private landlords in the domestic and non-domestic sector to improve some of the least energy efficient properties where finance is available. With effect from 1st April 2016 tenants will be able to request consent from their landlords to carry out energy efficiency improvements to privately rented properties. The landlord will not be able to unreasonably refuse consent. It will, however, be the responsibility of the tenants to ensure that the works are funded and the intention is that no upfront costs should fall on the landlord, unless the landlord agrees to contribute. There are separate regulations requiring properties to be brought up to an E rating on an Energy Performance Certificate (EPC) which are effective from the 1st April 2018.

Energy Company Obligation (ECO)
This is the Government's new domestic energy efficiency programme which has replaced the existing CERT and CESP programmes, both of which came to a close at the end of 2012. ECO works alongside the Green Deal to provide additional support for packages of energy efficiency measures. ECO also provides insulation and heating packages to low income and vulnerable households and insulation measures to low income communities.

ECO creates a legal obligation on energy suppliers to improve the energy efficiency of households through the establishment of three distinct targets:

- The Carbon Emissions Reduction Obligation (20.9 million lifetime tonnes of carbon dioxide). Focusing on hard to treat homes and, in particular, measures

[5] There is no further planned update to these figures.

that cannot be fully funded through the Green Deal. Solid wall insulation and hard-to-treat cavity wall insulation are the primary measures that the Government intends to be promoted under this target. Other insulation measures and connections to district heating systems are also eligible if they are promoted as part of a package that includes solid wall insulation or hard-to-treat cavity wall insulation.

- The Carbon Saving Community Obligation (6.8 million lifetime tonnes of carbon dioxide). Focusing on the provision of insulation measures and connections to district heating systems to domestic energy users that live within an area of low income. This target has a sub-target, which states that at least 15% of each supplier's Carbon Saving Community Obligation must be achieved by promoting measures to low income and vulnerable households living in rural areas

- The Home Heating Cost Reduction Obligation (£4.2bn of lifetime cost savings). Requiring energy suppliers to provide measures which improve the ability of low income and vulnerable households (the 'Affordable Warmth Group') to affordably heat their homes. A heating qualifying action is the installation of a measure that will result in a heating saving; including the replacement or repair of a qualifying boiler

The scheme is administered by Ofgem.

In 2017 there has been a total of 202,000 efficiency related installations under the ECO, compared to 360,000 for 2016. The figure for 2018 to the end of September is 197,000, suggesting a potential upturn in this area. To date a large proportion of these installations were for loft and cavity wall insulation (24% and 35% respectively). Boiler replacement accounted for 23% and solid wall insulation 7%[6].

Further measures to improve energy efficiency
Some additional provisions include:

- Amendment of the smart meters powers in the Energy Act 2008 to allow Government to direct the approach to the roll-out of Smart Meters until 2018 and to enable the Secretary of State to make changes to transmission licences to ensure the effective introduction of the new central communications arrangements to support all Smart Meters
- Amendment of the Energy Performance of Buildings (Certificates and Inspections) (England and Wales) Regulations 2007, to enable the removal of unnecessary restrictions on access to data
- Establish powers for the Secretary of State to require energy companies to provide information on the cheapest tariff on energy bills

As high level principles the provisions cannot be seen as providing the only solution to cut carbon emissions to the target levels. Relatively low cost measures to improve efficiency like boiler replacement and cavity wall and loft insulation benefitted from the Green Deal, but higher cost solutions like renewable heat or solid wall insulation would need to allow protracted payback periods (approaching 50 years or more) to be viable, unless a significant subsidy is obtained.

In summary it would appear that there are still some barriers to major investment in efficiency savings, although recent incentive developments have

[6] It should be noted that these figures have not been updated by DBEIS since March 2017.

reduced these, but the key driver, at least in the short term, will be the price of gas when compared to the cost of installing new energy efficient appliances or means of reducing heat loss from premises.

If it is considered necessary to incorporate an assessment of efficiency savings from different options and there is a clear econometric relationship between gas price and energy demand, it could create added complexity. Although it is possible to forecast the uptake of certain efficiency measures by type, modelling the impact that this could have on demand may require significant scenario development, given the range of efficiency measures available, with varying impacts on consumption. In addition there could very likely be the need to predict changing consumer behaviour, reflecting the comfort levels that people are prepared to accept. The DECC Pathways has much in it about how energy savings can be made by having lower comfort levels, but would this behaviour be different in severe weather conditions, which are the conditions that are of greatest interest to NGN when designing the network.

With the recent rise in energy prices it will be important to understand the possible impact of this on consumer behaviour, especially if the oil price doesn't recover significantly and lower prices return for any length of time, possibly sustained by the recent imposition of a price cap.

4.1.12. Smart Meters

Ofgem in their report for the energy Demand Research Project (EDRP) from December 2010 that there is evidence to suggest that smart meters can be a vehicle for effective action to reduce domestic energy demand. However there was no distinction between gas and electricity meters.

In the final reports produced in June 2011 the following conclusion was reached with respect to the impact of smart meters on gas consumption. "The smart meter itself (e.g. the information provided on consumption and cost) or some aspect of the experience of getting a smart meter appears to be a positive mechanism, resulting in savings of around 3%. E.ON found that these effects were persistent into the first quarter of the second in-trial year (i.e. for 15 months) and for one or two further quarters in some groups. The literature and other EDRP findings indicate that this effect may require support over time from other interventions (e.g. advice or billing information) to be sustained for longer periods."

A supplementary comment was also made. "The effect of smart meters in isolation from other measures on gas consumption has not been investigated before but is in keeping with theoretical considerations, that real-time feedback is more relevant to electricity consumption than to gas. Applications of gas (e.g. heating and hot water) tend to be subject to more occasional adjustments having long-term effects (e.g. changing a thermostat setting in response to getting a smart meter or Real Time Device)."

This report was expected to provide information on seasonal variations. This was somewhat inconclusive as the following comment on seasonal smoothing reflects. "The E.ON findings also demonstrated an important issue with comparing data between smart and non-smart meters. The smart meter groups show greater seasonal extremes than the non-smart control groups for both electricity and gas, with significantly lower consumption than the control group in almost every spring/summer quarter in every group, sometimes outweighing higher consumption in autumn/winter quarters. This may be entirely due to "smoothing"

of the non-smart data because of the need to interpolate infrequent readings over each quarter. If so, then analysis at sub-annual level would be valid only when comparing smart meter trials with smart-meter-only groups treated as control groups. In the current assessment, it is assumed that smoothing is a sufficient account of this seasonal variation but this needs to be better understood for any future trials."

We expect that any realistic assessment of the impact of smart meters should involve the comparison of weather corrected demand for periods throughout the year of a large sample of smart meter data. Ofgem have suggested that this data will be made available but this has not been to date.

The most recent formal update on the full roll-out programme was from the DBEIS Smart Meters Implementation Programme 2018 progress update. This stated that good progress continues to be made on the rollout of smart meters, with 12.8 million smart and advanced meters operating across homes and small businesses in Great Britain up to 30 September 2018. The latest statistics release for the end of Q3 2018 shows that the total installed as opposed to operating is 14.8 million.

Other highlights from the progress report are:-

- In May 2018 the Smart Meters Act 2018 received Royal Assent, extending the Government's right to exercise powers over the roll-out to November 2023.
- The transition to second generation smart meters began this year with over 176,000 of these meters connected to the national smart metering communications infrastructure at the end of November 2018. These second generation meters are fully interoperable between all energy suppliers, so consumers will be able to retain their smart services when they switch energy supplier.
- To ensure all consumers with first generation smart meters are able to retain smart services upon switching, the Data and Communications Company (DCC) has been developing a solution to move them into the national smart metering communications infrastructure. The Government confirmed in 2018 that the DCC will be required toprovide a service for enrolling two thirds of first generation meters, so they can be operated by all suppliers. The provision for enrolling the remaining third of meters will be considered in 2019. The Government also asked the DCC to prioritise meters that have lost smart services, so that those consumers can benefit first, and set a backstop to ensure that all meters are made interoperable, and so retaining smart functions when customers switch energy suppliers, by the end of 2020.
- In February 2018, the Smart Meter Installation Code of Practice was amended to require that energy efficiency guidance delivered at install is tailored to each consumer's circumstances. This will further help consumers become aware of the changes they can make to improve the efficiency of their energy use, helping them to save money.
- The review of the Smart Meter Data Access and Privacy Framework found that consumer privacy is being safeguarded while simultaneously allowing energy consumption data to be used to develop new services that benefit consumers and the energy system more widely.
- In November 2018, the second phase of the Smart Meter Customer Experience Study was published. The research from this study showed that more than 80% of people with smart meters say they have taken steps to reduce their energy use.

The Governments outlook for 2019:-

- In 2019, they expect energy suppliers to serve more of the country with second generation smart meters, supported by software and hardware developments that unlock the capability to install in more premises.
- The enrolment of first generation smart meters into the national smart metering communications infrastructure will be underway in 2019, with priority given to return smart functionality to those meters that lost it when consumers switched suppliers.
- The Government expects to decide in 2019 on the activation of the New and Replacement Obligation which requires energy suppliers to take all reasonable steps to install a compliant smart meter where a meter is installed for the first time (for example in new build properties) or where a meter is replaced.
- The Programme will continue to develop and deliver sector-specific engagement to raise awareness of smart metering amongst microbusinesses and Small and Medium-sized Enterprises.
- The Government has committed to update the cost-benefit analysis for the Programme and complete a stocktake of consumer benefits in 2019.
- Following the recent review of the Programme by the National Audit Office the (NAO) Government is taking action in each of the recommendation areas which were
    - as part of its upcoming work to update its cost–benefit analysis, assess the value for money of leaving the 2020 deadline in place compared with adopting a new deadline;
    - over the course of 2019, clarify for the industry what the smart metering policy landscape will look like beyond 2020;
    - draw up contingency plans for maximising value for money in scenarios where the DCC and SMETS2 system encounters further delays or cost increases and SMETS1 meters are unable to enrol within the DCC;
    - commission an expert independent review of testing, focused on determining whether energy suppliers are testing a sufficient cross-section of smart metering set-ups and scenarios (including change of energy supplier and swapping smart metering equipment) to provide reasonable assurance that the SMETS2 system will work as intended for all consumers;
    - by early 2019, launch research to assess the potential impact of additional forms of energy efficiency advice and feedback to consumers, and consider whether new requirements should be introduced to support benefits realisation;
    - systematically monitor the actual energy savings that smart meters achieve and continue to assess the delivery of key consumer engagement activities, intervening if necessary.

The NAO also recommended that Ofgem should:

- work with the Competition and Markets Authority as part of its review of the prepayment price cap to understand the impact of SMETS1 meters on competition, and set out how issues will be addressed;
- work with the Department to improve the transparency of DCC costs, both for price control and for public and parliamentary scrutiny;
- and ensure, by March 2019, that no energy suppliers are falling materially short of their obligation to provide advice on energy efficiency.

As at the end of September 2018 there were 5.9 million smart gas meters installed at domestic premises (compared to 7.7 m for electricity) and 3700 smart gas meters at non-domestic sites. The small non-domestic numbers have been growing steadily but the numbers are relatively low compared to electricity at 73,000. The number of domestic and non-domestic smart gas meters actually operating is however around 5m and 3000 respectively.

4.2. Renewables (updated 2019)

In March 2011 the government announced the introduction of the Renewable Heat Incentive Scheme (RHI).

The original RHI documentation is still considered to be a primary source of information for any study on renewables until analysis has been carried out on the effectiveness of RHI and the level of adoption of renewable energy. The RHI was aimed at helping to accelerate deployment of renewable heat sources by providing a financial incentive to install renewable heating in place of fossil fuels. Initially, in the first phase, long-term tariff support was targeted at the big emitters in the non-domestic sector. This sector, which covers everything from large-scale industrial heating to small business and community heating projects, was anticipated to provide the vast majority of the renewable heat needed to meet the targets and represents the most cost-effective way of increasing the level of renewable heat.

In March 2012 the Government announced further plans for the delivery of the RHI including a time table setting out what they intend to do and when for both the domestic and non-domestic sectors. They consulted on how support for renewable heating for households can be provided in the longer term in September 2012 and confirmed that the scheme opened for applications in Spring 2014.

In advance of the introduction of RHI for domestic customers, the Government introduced phase 1 of the Renewable Heat Premium Payments (RHPP) for the domestic sector. They ring-fenced funding of around £15 million which was used to make premium payments to households who installed renewable heating. The original intention was to focus support for primary heating systems, such as heat pumps and biomass boilers, on households off the gas grid, where fossil fuels like heating oil are both more expensive and have higher carbon content. However Phase 1, which ran until 31st March 2012, allowed any eligible customer to apply for a voucher. As part of the scheme, DECC and EST ran a competition for social housing providers to part-fund projects to install renewable heating.

The Renewable Heat Premium Payment (RHPP) has provided support to the domestic sector since August 2011 due to the later than anticipated household scheme under RHI. A second phase of this scheme, worth £25m (£10m more than the first phase), to provide support for the installation of renewable heat technologies in the household sector was also announced. The support consisted of a new voucher scheme for domestic households and a new social landlords' competition building on the experiences of Phase 1 of the RHPP. The second phase also included a new £8m Communities Competition which was intended to help to bring renewable heat to a wider pool of householders.

It was only in the second phase that opened on the 1st May 2012 that homes not heated by mains gas are the only households that can apply for grants for air-to-

water-source and ground and water source heat pumps and biomass boilers. All householders can apply for grants for solar thermal.

DECC withdrew the RHPP scheme as it was effectively replaced by the domestic RHI scheme and any guidance documents were withdrawn on the 20th May 2015.

Under the new domestic RHI scheme introduced in April 2014 there is financial support for renewable heat, targeted at, but not limited to, off gas grid households. The support is paid at a set rate per unit of renewable heat produced (kWh), for seven years, to the owner of the heating system. The scheme supports air source heat pumps (ASHP), biomass systems, ground source heat pumps (GSHP) and solar thermal technologies. The support rates vary depending on the technology installed. The first set of tariffs when the scheme was introduced is shown below.

	ASHP	Biomass	GSHP	Solar Thermal
Tariff (p/kWh renewable heat)	7.3	12.2	18.8	19.2[1]

All installations must be certified under the Microgeneration Certification Scheme and meet relevant required standards for each technology, including limits on harmful emissions for biomass systems.

The scheme covers single domestic dwellings and is open to owner-occupiers, private landlords, Registered Providers of Social Housing, third party owners of heating systems and self-builders. It is not open to new build properties other than self-build. In addition, the scheme is open to anyone in these groups who installed an eligible technology since 15th July 2009, provided they meet the latest criteria.

All applicants, with the exception of Registered Social Landlords were initially required to complete a Green Deal Assessment (GDA) before applying and to ensure that they have met minimum energy efficiency requirements of loft and cavity insulation where required by the Assessment. From the 24th March 2016 the requirement for a GDA was removed as Government funding for the Green Deal has been stopped.

The renewable heat generated is estimated in most cases for payment purposes. For biomass and heat pumps, it is based on an estimated figure of heat demand from an Energy Performance Certificate. For heat pumps, this is combined with an estimate of the heat pump's efficiency to determine the renewable proportion of the heat. For solar thermal systems, the payments are based on the estimate of system performance completed as part of an MCS installation. Those applying for a space heating system who have a back up heating system, such as an oil boiler, or people applying for a second home, need to install metering equipment on which the RHI payments can be based.

To help improve performance of renewable heating systems, there is an extra incentive for applicants who install metering and monitoring service packages, of £230 per year for heat pumps and £200 per year for biomass boilers.

The scheme is administered by Ofgem and in order to control the costs of the policy a system of degression was introduced, which is reductions in tariffs over time as threshold spend figures (known as triggers) are reached.

The tariffs are reassessed regularly and three monthly tariff periods are published by Ofgem. The current published tariff for the period 1st July 2018 to 30th September 2018 is as shown below. This shows that the support for biomass has been retained and there are minor increases for the rest. There were no degressions this quarter. Heat demand limits came into force in September 2017 for all but solar thermal.

ASHP	Biomass	GSHP	Solar Thermal
10.49p	6.74p	20.46p	20.66p

- The Renewable Heat Incentive Scheme Regulations 2018 came into effect on the 22nd May 2018. The impact on the domestic scheme relates to mainly metering requirements for heat pumps and associated payments to encourage consumers to monitor the performance on their systems. In addition the DBEIS is introducing an option to help householders access finance to overcome the barrier of the upfront cost of a renewable heating system. This is called assignment of rights, where households can assign their rights to RHI payments to investors.

To ensure the success of the non-domestic scheme (that launched in November 2011), they have prioritised the delivery of a cost control regime. A package of policy options was developed that included modified pre-accreditation, degression and reviews. Consultation on proposals took place during 2012 and 2013, with a response from Government issued in December 2013.

The key points of the response were as follows.

- An increase in support for renewable CHP, large biomass boilers (over 1MW), deep geothermal, ground source heat pumps, solar-thermal and biogas combustion
- New support introduced for air-water heat pumps and commercial and industrial energy from waste
- An evolved approach to budget management, using improved market intelligence to allow credible growth rates across the range of renewable heating technologies supported, whilst ensuring that the scheme remains affordable and achieves value for money

Government estimate the policy changes set out could incentivise around 5,000 non-domestic installations and an additional 6.4TWh of renewable heat by the end of 2015/16. These proposed changes were intended to come into force in spring 2014. Ofgem have released two large documents in October 2015 which set out administrative procedures for managing the RHI programme[7]. One deals with eligibility and the other ongoing requirements for RHI participants and information on how periodic support payments are calculated and paid.

From October 2015 the fuel used has to meet new RHI sustainability requirements, consisting of a greenhouse gas (GHG) emissions limit and specific land criteria[8]. Participants burning fuels or using feedstocks which meet the

[7] A recent survey carried out by DECC published in January 2016 cites the complexity of the guidance as a factor that could deter applicants for non-domestic RHI, particularly relating to GSHP and solar heat, which incidentally offer the highest tariff.

[8]Land criteria consider factors associated with the land from which the biomass was sourced.

definition of waste are considered to be using sustainable material and so do not need to report against the GHG and land criteria.

The changes introduced by the Renewable Heat Incentive Scheme Regulations 2018 relate to tariff guarantees, registration requirements for shared ground loops and removal of support for some heat uses. In addition some changes have been made to the rules for biomethane plant.

- Biomethane applicants to specify the biogas production plant to be used for the purposes of RHI registration and to confirm that the equipment used to produce biomethane has been commissioned. The aim of this particular change is to remove the process of staggered commissioning for biomethane plants.
- Allow participants of the RHI scheme to replace their accredited installation under certain circumstances. The aim of this change is to enable participants whose plant may break down to replace their plant and stay on the same tariff for the remainder of their participation on the scheme.

A summary of the current tariffs as applied to new installations accredited after the 1st July 2016 is given below.

Tariff name	**Eligible technology**	**Eligible sizes**	**Tariffs**
Small commercial biomass	Solid biomass including solid biomass contained in waste	Less than 200 kWth Tier 1	3.05
		Less than 200 kWth Tier 2	2.14
Medium commercial biomass		200 kWth and above & less than 1MWth Tier 1	3.05
		200 kWth and above & less than 1MWth Tier 2	2.14
Large commercial biomass		1MWth and above – Tier 1	3.05
		Tier 2	2.14
Solid biomass CHP systems (commissioned on or after 4 December 2013)	Solid biomass CHP systems	all capacities	4.42
Water/Ground-source heat pumps	Ground-source heat pumps & Water-source heat pumps	all capacities Tier 1	9.36
		Tier 2	2.79
Air-source heat pumps (commissioned on or after 4 December 2013)	Air-source heat pumps	all capacities	2.69
Deep geothermal (commissioned on or after 4 December 2013)	Deep geothermal	all capacities	5.38
All solar collectors	Solar collectors	Less than 200 kWth	10.75

Biomethane injection	Biomethane	On the first 40,000 MWh of eligible biomethane Tier 1 Next 40,000 MWh of eligible biomethane Tier 2 Remaining MWh of eligible biomethane Tier 3	4.76 2.80 2.16
Small biogas combustion	Biogas combustion	Less than 200 kWth	4.64
Medium biogas combustion (commissioned on or after 4 December 2013)		200 kWth and above & less than 600 kWth	3.64
Large biogas combustion (commissioned on or after 4 December 2013)		600 kWth and above	1.16

There will be a 15% degression on 1 January 2019 for biomethane and large biogas.

HMG is committed to providing 12% of heat from all renewable sources. The total figure quoted by them is 73 TWh, a reduction of 15 TWh from the original target of 88 TWh.

For further information on Renewables please see section 6.2.

5. Economic Scenarios

The high and low scenarios that have been developed for this study are based on the following assumptions.

5.1. UK GDP

High – GDP for GB to be equivalent to the average of all positive rates of growth in the historical data set.

Low – GDP for UK to be equivalent to the lowest positive growth rate in the historical data set.

5.2. GVA for UK, NE & NO

High –GVA for Commercial, Manufacturing and Industrial will all grow at a rate equivalent to the average of all positive growth in the historical data set.

The total GVA for UK and each LDZ is the sum of the different sectors.

Low –GVA for Commercial, Manufacturing and Industrial will all grow at a rate equivalent to the average of all negative growth in the historical data set[9].

[9] In the case of the UK and the NE LDZ the extreme drop in GVA Industrial during the recession has been removed from the average. With regard to the

The total GVA for UK and each LDZ is the sum of the different sectors.

5.3. Wholesale Gas Price

High – This scenario reflects the high case forecast used by NG/DBEIS.

Low – This scenario reflects the low case forecast used by NG/DBEIS.

5.4. Retail Gas Price

The scenarios presented reflect the impact of the wholesale price scenarios directly on the retail price as a cost pass through.

5.5. National and Regional GDHI

High – GDHI will grow at a rate equivalent to the average of all positive growth in the historical data set.

Low – GDHI will grow at a rate equivalent to the average of all negative growth in the historical data[10].

5.6. Household Numbers

High – UK and LDZ household numbers reflect the highest growth in household numbers from the historical data set.

Low – For UK this reflects the lowest growth in household numbers from the historical data set. As the DCLG projections for the LDZs are lower than the lowest growth in household numbers in the historical data set we have reduced the DCLG annual growth by 1000 households to create the low case.

5.7. Employment

High – The National and Regional growth rates are equivalent to the highest rates of growth over the period of the historical data set.

Low – The National and Regional growth rates are equivalent to the lowest rates of growth over the period of the historical data set.

5.8. Average wages

High – The National and Regional growth rates are equivalent to the average of all positive growth over the period of the historical data set.

Low – The National and Regional growth rates are equivalent to the average of all negative growth over the period of the historical data set.

Commercial sector there was only decline in this sector around the deep recession so the lowest rate of growth over the historical period was used.

[10] Negative growth rates that have been a result of estimates of GDHI are not included.

5.9. Debt per household

High – The National and Regional growth rates are equivalent to the average of all positive growth over the period of the historical data set.

Low – The National and Regional growth rates are equivalent to the average of all negative growth over the period of the historical data set.

6. Impact of renewables

TPA Solutions have thoroughly analysed the impact of renewable energy sources on both annual and peak demand and can provide a range of possible outcomes depending on the level and phasing of take up by consumers and the energy source that the renewable source is replacing. The focus has been on renewable heat sources for this analysis. Specific adjustments can be made to the annual and peak forecasts to take account of renewable energy and could result in changes to the annual/peak relationship over time.

Factors that have been considered in developing the potential impact of renewable energy include:

- The payback period for different types and the likelihood that subsidies or renewable heat incentives will be available and continue to be available or that the Green Deal will provide sufficient support to justify installation
- Restrictions in using biomass in many locations due to the Clear Air Act
- Any circumstances where gas will still be needed as a back up to support renewable sources that cannot guarantee supply in winter, or are too expensive to run in winter (e.g. solar, wind, and air and ground source heat pumps)
- Assumed that oil and coal users will be the target for early adoption on the basis that these are the most polluting, followed by either gas or current electricity users depending on what the objective becomes. If it's purely environmental then gas should be first, but the economics without subsidy favour gas over electricity

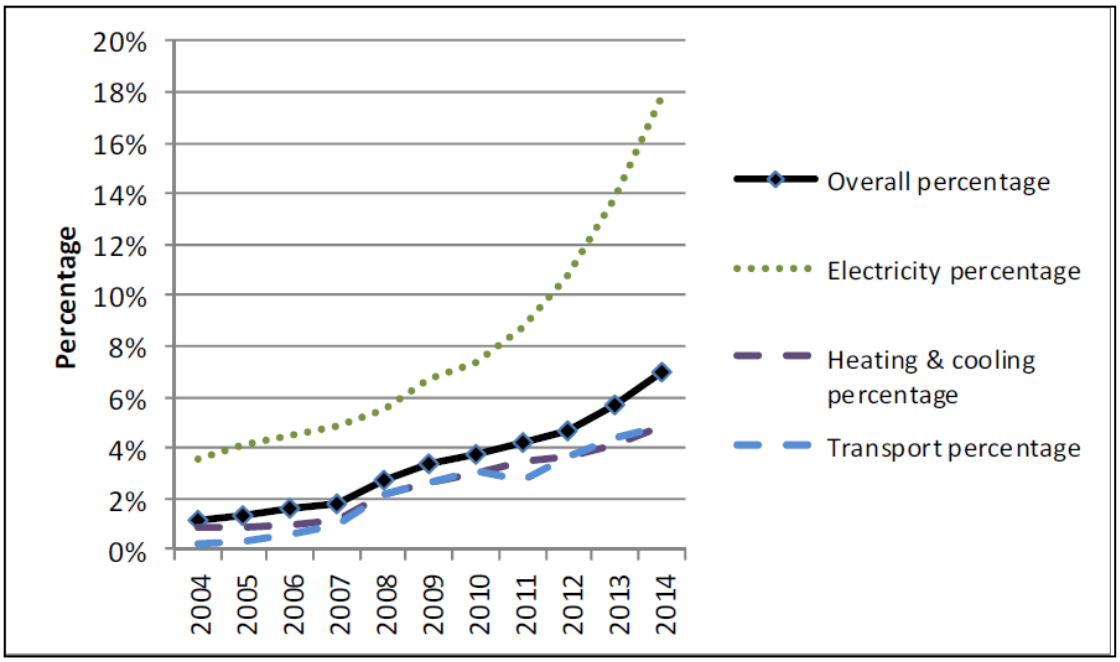
Biogas is excluded from any impact analysis on the grounds that if it is to be distributed locally to maximise its use, then the current network is the most efficient way to do this. So there will be the same level of demand, but a different source. This may require local reinforcement to allow transportation of the biogas.

Recent developments in the RHI and RHPP schemes with the withdrawal of the RHPP scheme and the latest subsidy levels for the RHI scheme has caused us to review and update the analysis of renewables. It is also unclear that all the 2020 targets are going to be met.

DECC published in January 2016 a document entitled "Third Progress Report on the Promotion and Use of Energy from Renewable Sources for the United Kingdom", which is a requirement under the EC Renewable Energy Directive. In heating and cooling the UK continues to exceed the deployment trajectory set out in the National Renewable Energy Action Plan, reaching 4.5% in 2014, against a target level of 2.0% for the two year period 2012 to 2014. Uptake of renewable heat has been supported by the RHI schemes and this is being extended with additional support available under the RHI, with the budget for that scheme rising to £1.15bn in 2020/21. In 2014, around 27.6 TWh of renewable heat was generated from renewable sources, an increase of 4.6% on the previous year's

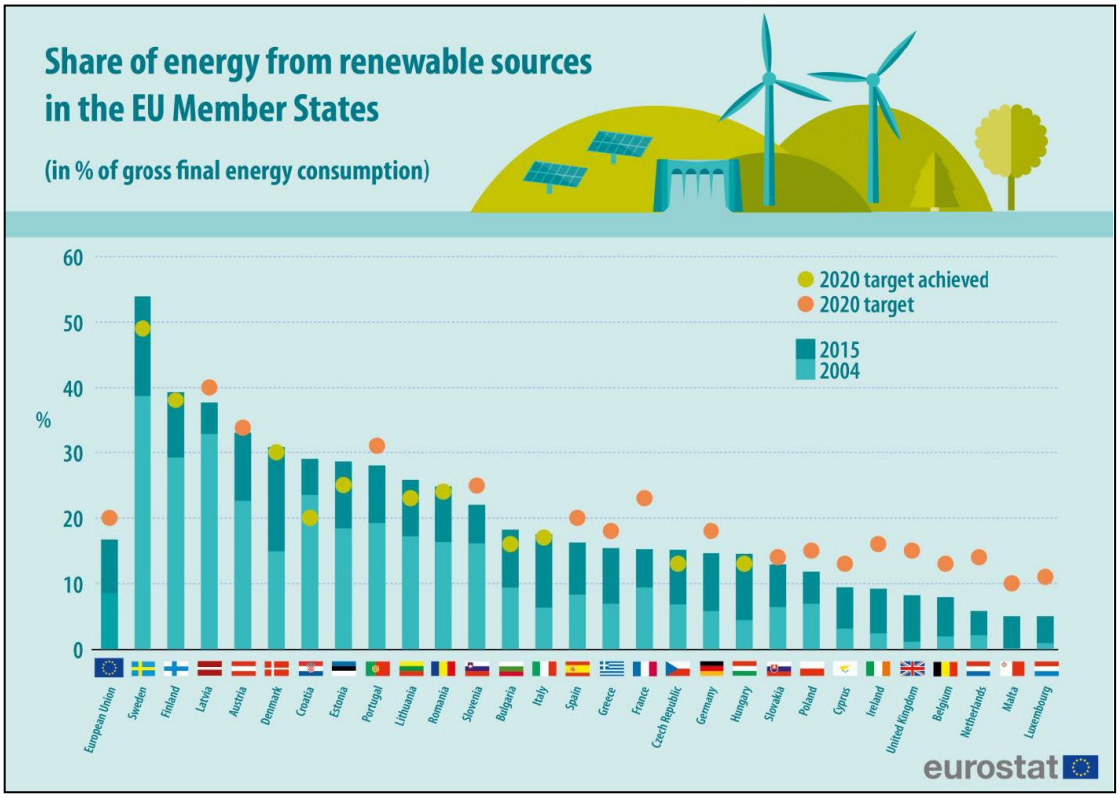
26.4 TWh. It should be noted that DECC have reassessed their analysis of renewable heat due to an improvement in methodologies for calculating various sources of renewable heat, the most substantial revision being to domestic wood combustion which contributes 57% of total renewable heat. As a result of this progress towards the 73 TWh target has jumped from 20% to 38% (although another DECC source suggested that the level in 2014 was 31.7 TWh, 43% of target).

The graph below shows the growth of all the elements of the renewable targets with the overall target only reaching just over 7% by 2014 against a target for 2020 of 15%.



The previous slow progress with renewable heat was the key driver for expanding the RHI to domestic premises and further developments to the RHI for non-domestic sites. However the revisions to the renewable heat figures could possibly mask the real progress against the target and the impact of the RHI schemes. The additional sustainability requirements for biomass schemes could affect those wishing to move to wood burning. Slightly higher tariffs for GSHP and solar heat may help counter the impact of reduced biomass. The most up to date published figures from DBEIS show the position for the end of 2017. The level of renewable heat produced was 7.7% of total heat (up from 6.3% in 2015) compared to a target of 12%, assuming that target remains appropriate. Equivalent electricity and transport figures are 27.9% and 4.6% respectively (2015 figures were 22.1% and 4.4%). The overall performance against the target of 15% for all energy consumption is 10.2%. It would seem that there is very little time left to meet the 2020 targets and therefore it may be prudent to assume that will be the case. The first three quarters of 2018 show that electricity generation from renewables has risen by 10% compared to the same period in 2017, but the main reason for this was that it was sunnier and windier in 2018.

The EU produced via Eurostat in March 2017 the following chart which shows how all the EUMS have performed up to 2015. The graph is left in for information but has not been updated by the EU.



EU countries have now agreed on a new 2030 Framework for climate and energy, including EU-wide targets and policy objectives for the period between 2020 and 2030. These targets aim to help the EU achieve a more competitive, secure and sustainable energy system and to meet its long-term 2050 greenhouse gas reductions target.

The new targets for 2030 are:-

- A 40% cut in greenhouse gas emissions compared to 1990 levels
- At least a 27% share of renewable energy consumption (subsequently updated in mid 2018 to 32%
- At least 27% energy savings compared with the business-as-usual scenario.

To meet the targets, the European Commission proposed:

- A reformed EU emissions trading scheme (ETS)
- New indicators for the competitiveness and security of the energy system, such as price differences with major trading partners, diversification of supply, and interconnection capacity between EU countries
- First ideas for a new governance system based on national plans for competitive, secure, and sustainable energy. These plans will follow a common EU approach. They will ensure stronger investor certainty, greater transparency, enhanced policy coherence and improved coordination across the EU.

There were further amendments made mid 2018:-

- A minimum share of at least 14% of fuel for transport purposes must come from renewable sources by 2030. In particular: first generation biofuel, based on food crops, must be capped at 2020 levels (with an extra

1%) and in no case exceed 7% of final consumption of road and rail transport; the share of advanced biofuels and biogas must be at least 1% in 2025 and at least 3.5% in 2030.

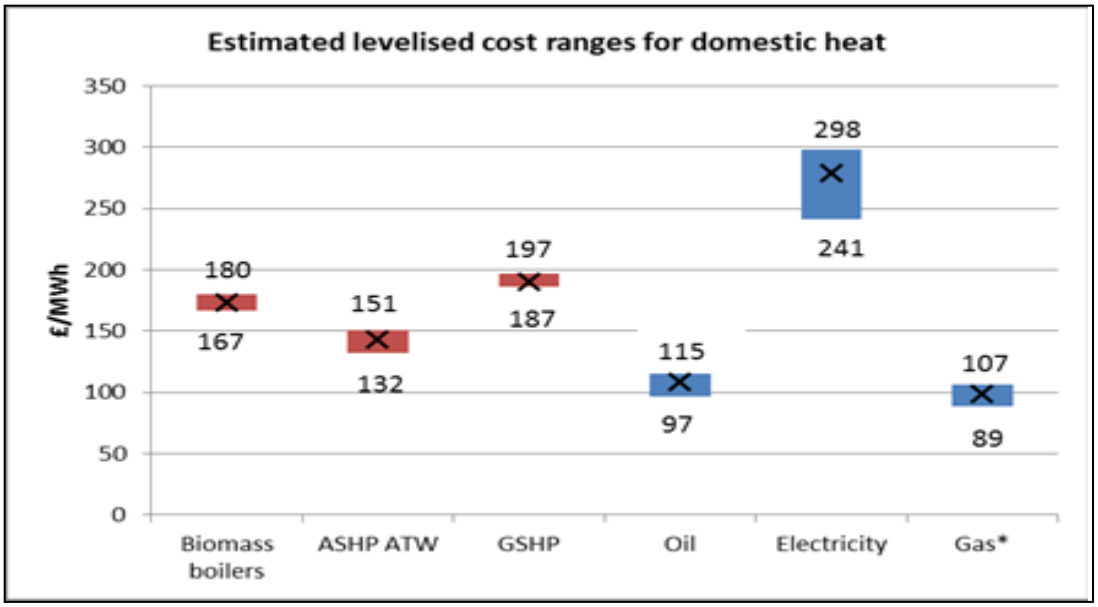
- Food-crop biofuels like palm oil, which have a high "indirect land use change" (ILUC, i.e. changing how land from non-crop cultivation, such as grasslands and forests, with a negative impact on CO2 emissions, is used), will be phased out through a certification process for low ILUC biofuels, which is to be set up.
- Member states must ensure that an EU consumer is entitled to become a renewable self-consumer, who may:
    - generate renewable energy for their own consumption, store and sell excess production;
    - install and operate electricity storage systems combined with installations generating renewable electricity for self-consumption, without liability for any double charge;
    - not to be subject to any charge or fee on self-consumed energy until 2026, with some limited exceptions foreseen thereafter;
    - receive remuneration for the self-generated renewable electricity they feed into the grid;
    - join renewable energy communities to integrate self-consumption into the transition to cleaner energy.
- The deal provides a sub-target of an indicative 1.3% yearly increase of renewables in heating and cooling installations, calculated on a period of 5 years starting from 2021.
- Member states must ensure that information on energy performance and the share of renewables in their district heating and cooling systems is provided to final consumers in an accessible manner. Customers of district heating or cooling systems that are not efficient are allowed to terminate their contracts in order to produce heating or cooling from renewable energy sources themselves.

A key factor that could influence the government in this area is the fact that the UK will be leaving the EU following the outcome of the referendum that took place in June 2016. But the UK still has legally binding targets relating to their decarbonisation targets for 2050 under the Climate Change Act 2008. A recent House of Commons Energy and Climate Change Committee report entitled "2020 renewable heat and transport targets - Second Report of Session 2016–17" states that:

> *If the UK misses, or reneges on its commitment to, the 2020 renewables targets, this will undermine confidence in its commitment to future targets, including the 2050 decarbonisation objectives of the Climate Change Act 2008—both rely on the Government driving policy to change patterns of electricity, heat, and transport consumption and supply; both are Government promises in which stakeholders must be able to trust. Leaving the EU renders the status of the 2020 targets uncertain. The Government must reassess its capacity to meet them and, if able, recommit to them notwithstanding its exit from the EU. If it is not, it must set and commit to replacement targets and explain how these will support the longer-term decarbonisation objectives of the 2008 Act as effectively as the 2020 targets.*

Any incentives would need to be strong though to move consumers away from natural gas, although the recent rise in gas price may encourage more consumers to consider an alternative, but the price cap may reduce the incentive to change to a degree. For further commentary on the relative costs of each renewable

source please see the following sections. Early stage analysis of the levelised costs of different heat sources showed no financial advantage to all of the alternatives to gas (see below). This analysis did not assume any incentives at the time.



This price advantage for gas was why non-gas areas had significant advantage to change to renewable technologies under the RHI, although the historical reduction in the incentives associated with biomass may have reduced the level of biomass schemes in these areas in the short term. The reduced biomass and increased heat pump incentives attracted criticism from the House of Commons Energy and Climate Change Committee, where they claimed that heat pumps have proven unsatisfactory in actual use, yet are being prioritised over biomass, which has been successful. As a result of this the small biomass scheme incentives have been increased significantly for both domestic and non-domestic which could see a revival of these schemes.

There is also concern expressed that consumer awareness of the availability of RHI for heat pumps is low, as is the fact that heat pumps are a viable alternative to gas boilers for households.

The following sections describe the different sources of renewable energy and how they could influence the demand for gas and affect the relationship between annual and peak gas demand.

6.1. Biomass Heat

This is defined as burning any form of biological matter that can be used in a boiler to generate heat. The target published by the previous government was set at 42.9 TWh on an input basis and 38 TWh on an output basis.

The UK Renewable Energy Strategy under the previous government stipulated that if small scale biomass heat plant is used to meet the renewable target, to minimise the impact on air quality they should replace existing solid fuel (primarily oil and coal) fired plant, and be located off the gas grid, or away from populated areas.

The RHI has within its Impact Assessment (IA) a figure of 28 TWh as an assumed impact of the RHI tariff on new biomass schemes, but this is primarily rural (70%).

Large scale plant is likely to be associated with district heating schemes or Industrial & Commercial consumers and only then in areas where air quality will not be affected, although the RHI Impact Assessment (RA) includes some costs for dealing with air quality issues. There is some discussion about this in the RHI report and there will be emissions limits imposed on biomass plant. An additional sustainability requirement may impact the cost of using biomass.

It should be assumed that some gas demand will be lost to biomass heat, affecting both throughput and peak. However it should also be assumed that there should be limited impact on domestic demand because of the constraints and marginal incentive for current gas customers. Recent changes to RHI that allow domestic customers to apply for RHI from Spring 2014 have improved the economics but the benefits of adopting biomass by domestic customers is marginal and only if the customer has a low efficiency gas boiler. As mentioned in the section above the House of Commons Energy and Climate Change Committee were concerned about the reduced incentives to certain biomass schemes. This has resulted in an increase in the incentive which could improve the economics[11].

Replacing a new natural gas condensing boiler with a wood burning boiler currently results in a potential loss of £350 to £535 per year but there would be reduced CO_2 emissions.[12] The savings for an inefficient non-condensing gas boiler are between £150 to £170 per annum. Savings against coal or electricity amount to between £130 and £855 per annum. There would be substantial losses against an high efficiency oil installation. An automatic feed domestic installation costs £8,000 to £15,000. However, it may be possible to get an annual RHI incentive of between £1,280 and £1,635. This does improve the economics of biomass significantly, but there does remain the need for storage and handling of the wood pellets and the air quality constraints.

It is conceivable that some biomass operators may seek a gas supply as back-up in winter due to the fact that under severe conditions, stocks of biomass fuel will not be available, either because of excessive demand, insufficient storage space to stock up for severe conditions, or weather conditions that prevent supplies getting through. There may also be opportunities for dual-fuel applications mixing natural gas with biomass. The availability of suitable feedstock is mentioned in the RHI report and installations over 1 MWth are required to report on availability of feedstock on a quarterly basis.

6.2. Biogas Heat

This is essentially gas produced from biological matter and used to produce heat. The intention is that this gas will be delivered into the current gas network as biomethane, or used locally to the source. The Government were committed to ensuring that all new homes are low carbon by 2016, which could have constrained the use of biogas primarily to existing homes. With the abandonment of the low carbon requirement this constraint may be removed. The RHI previously only supported the direct production of heat for installations up to 200kWth and biomethane injection of all capacities through a single biomethane

[11] Chatham House report of the 23rd February 2017 challenges the assertion that woody biomass is less polluting than fossil fuels.
[12] Energy Savings Trust (EST) website figures.

injection tariff. A recent change to the RHI has introduced a tariff for all biogas heat schemes that were commissioned after 4th December 2013. There has also been a significant rise in the tariffs.

The quality issues are such that the gas has to be treated before entry to the network and it is stated in the UKRES that there will be studies to establish what elements of the entry specification can be changed to avoid barriers to entry, providing safety is not compromised.

A workgroup was created under the auspices of the Joint Office of Gas Transporters to deal with a range of issues associated with biomethane. This group was entitled Energy Market Issues for Biomethane and DECC have emphasised the potential contribution that could be made by biomethane to renewable targets. This group is now closed but a number of recommendations were made to ensure that barriers to entry are minimised.

Although some of the local usage may lead to loss of some customers connected to the NGN network, it should be assumed that Biogas Heat has no impact on throughput or peak.

6.3. Air Source Heat Pumps

Air Source Heat Pumps absorb heat from the outside air, which can then be used to warm water for radiators or underfloor heating or to warm air that is circulated within the property. This can still be done at temperatures as low as -15°C. They consume electricity to operate. Current economics are such that to replace a lower efficiency domestic gas boiler with an air source heat pump annual savings are £400 to £465 per annum[13] compared to other fuel savings of between -£45 and £990 per annum. Installation costs are estimated at £6,000 to £8,000[14]. It may be possible to get an annual RHI incentive of between £875 and £1,035. This does improve the economics of self funding of ASHP significantly.

For this reason it could be assumed that domestic use of this technology will be to replace non-natural gas heating in the first instance. For gas customers with less efficient boilers the payback period is now much shorter at around 5 years with the RHI, which could lead some customers to switch to ASHP. Recent increases in gas prices could increase the numbers that switch however, but with rising electricity prices at the same time this could discourage those thinking of switching over the ASHP's. The energy price cap may have some impact. Consumer awareness of ASHP's may be improved by recent television adverts for this type of heat pump. The recent entry into the market of gas absorption heat pumps and the availability of hybrid heat pumps could increase the number of heat pumps installed.

The economics of larger scale plant used in I&C applications would depend on the installation costs and retail energy prices to this sector. In the worst case it would result in a decline in throughput and some decline in peak depending on the heat output on a very cold day. It is stated by the BSIRA that as temperature falls the level of heat output declines so in cold or severe weather supplementary heating will be required. Again this may result in gas back-up for cold weather. There will be a base load of heat from the heat pump but this will fall as weather gets colder, unless the installation is designed with the extreme condition in mind. This

[13] EST website figures
[14] EST website figures

could however mean that the efficiency is so low in cold weather that it would be cheaper to use gas than the electricity used for the heat pump.

There are some planning restrictions that may limit their use in certain locations. One rather unusual stipulation is that it is not a Permitted Development if there is already a wind turbine present.

6.4. Ground Source Heat Pumps

Ground Source Heat Pumps absorb heat from the ground, which can then be used to warm water for radiators or underfloor heating. It can also be used to pre-heat water going to conventional boilers. As the ground temperature is relatively constant the heat flow should be constant throughout the year. They consume electricity to operate.

Current economics are such that to replace a lower efficiency domestic gas boiler with this technology would result in lower running costs and for a good performing system the saving is £505 to £580 per year. Installation costs are estimated at £10,000 to £18,000. There were opportunities under the Green Deal to obtain loans for this investment with the payback of the loan coming from the energy savings, but the Green Investment Bank (GIB) has been sold to Macquarie which may affect potential customers, although Macquarie have committed to the GIB's target of leading £3 billion of investment over three years. It may be possible to get an annual RHI incentive of between £2,335 and £2,750. This does improve the economics of self funding of GSHP significantly. Due to the need for significant open ground for installation, use in many domestic premises may be limited by space constraints.

Large scale plant will have similar issues to the air source heat pump but the constant heat input of ground source heat pumps leads to lower back-up requirements in winter compared to air source heat pumps.

There are no planning limitations normally for this type of installation.

6.5. Solar Heat

The principle here is that solar panels are used to heat water and this water is used to support the current heating system.

Current economics are such that the energy savings made for domestic customers are very small (£50 per annum for gas customers[15]) which would typically make the £4,000 to £5,000 investment cost uneconomic. This technology is eligible for Green Deal funding. It may be possible to get an annual RHI incentive of between £200 and £485 depending on household size. This does improve the economics significantly but with a payback of anywhere between 7 to 20 years this is a marginal decision for many domestic customers.

It would be unwise to assume that gas demand peaks will also decline due to the reduction in heat output on days of low sunlight hours, which occur in winter when the heat will be needed the most.

[15] EST website figures

It is therefore most likely that there should be an adjustment to annual demand to reflect the reduction in gas demand but no adjustment to peak as there is no guarantee that solar heat would be available on a peak day.

There are no planning limitations normally for this type of installation.

6.6. Hydrogen Networks

There are possible opportunities in the long term for natural gas to be replaced by hydrogen as a heating fuel. The production of hydrogen is an indirect renewable energy source if the hydrogen is produced using renewable electricity. This renewable source will have no impact with regard to the 2020 target, but could be relevant with regard to the 2050 targets. Further commentary on this source is provided under section 7.

6.7. Thermal Stores

Thermal stores are becoming increasingly common in domestic renewables heating technologies as a means of storing excess heat generated. They can be used with an individual renewable heating technology or to combine different renewable heating technologies. Thermal stores can also be used as a renewables technology with a conventional boiler or immersion heater.

Thermal stores have proved to work particularly well with wood-fuelled biomass boilers, heat pumps, wind energy and solar water heating systems. Space limitations in some properties may restrict the ability to install a thermal store.

Please note when a solar water heating system is combined with a thermal store the system will not be eligible for domestic Renewable Heat Incentive (RHI) payments. This is because solar panels that are part of a system that also provides heat for a purpose other than domestic hot water are not eligible for the scheme.

6.8. Scenario options

The following is a list of possible scenarios that can be developed to test a range of assumptions with regard to the take up of various renewable heat sources in competition with carbon based fuels. These scenarios also include different assessments of the impact on annual and peak demand which can be incorporated into the different forecasts, reflecting an assessment of the changing relationship between annual and peak demand.

1. The full renewable heat target set by the government of 73TWh is met and energy produced by all the renewable heat sources to meet that target results in a full loss of gas consumption equivalent to the amount of heat energy produced by the replacement renewable sources, converted to the gas consumption that would be required to produce that heat.[16] NGN's share of the total loss of gas consumption can be calculated pro-rata to NGN's proportion of total national LDZ demand. The reduction in peak day demand can be calculated by applying the average load factor for the whole market to the annual reduction in demand under this scenario

[16] This is becoming less likely the closer we get to 2020 so it may be necessary to assume that the 2020 target values are not achieved until 2023.

2. The full renewable target set by the government is met and energy produced by all the renewable heat sources results in a loss of gas consumption equivalent to 68.8% of the total renewable heat produced, as opposed to 100% in scenario 1. The figure of 68.8% is selected as it is the level of penetration of gas into the heating market. Peak reduction can be calculated as in scenario 1.

3. The full renewable target set by the government is met and energy produced by all the renewable heat sources results in a loss of gas consumption equivalent to 53% of the total renewable heat produced

   This scenario is based on scenario 2 but includes the following revised assumptions

   - Gas will contribute its fair share to the renewable target, but the reduction in demand from biogas in scenario 2, equivalent to 10.8% of the full target, is not included because the gas will be transported by the gas networks
   - Biomass will not be used in households currently using gas as a result of air quality issues, equivalent to a reduction of 5% of the full target. Up to 70% of the non-domestic reduction is expected to be rural and therefore this could be assumed to replace solid fuel or oil. However the maximum available alternative fuel reduction from non-gas sources in this category of renewables is insufficient to meet this objective, so it has to be assumed simply that biomass will not be used in domestic applications but could be used in non-domestic applications.
   - It is assumed that there will be no impact on peak demand based on the assumption that any of the alternative energy sources cannot deliver sufficient energy to meet a 1 in 20 peak day requirement

4. A variation to scenario 3 is to assume that the full potential for biomass in domestic properties is realised resulting in a reduction in gas demand equivalent to the amount of heat energy produced by the replacement biomass sources, converted to the gas consumption that would be required to produce that heat. The reversal of the tariff reductions for biomass could make this option marginally more likely. There is no reduction in the peak demand in this scenario

5. Additional scenarios could be developed which assume that the reduction in peak demand will be 50% of the maximum that would occur by applying the average load factor to the annual reduction in demand under any of the scenarios 1 to 4. The only one that has been selected here is to apply the 50% peak demand reduction to scenario 4. For the purposes of this report this is designated as scenario 5.

6. Multiple sensitivities could be developed making different assumptions regarding the amount of renewable heat that has been achieved by 2020 compared to the target. It was decided to opt for a level of 50% of the full renewable target and apply this to all scenarios that assume that the target is met. Scenario 6 is therefore a variation of scenario 1 but it assumes that only 50% of the full renewable target is met and results in a loss of gas consumption equivalent to the amount of heat energy produced by the replacement renewable sources, converted to the gas consumption that would be required to produce that heat. The peak reduction can be calculated by applying the average load factor to the annual reduction in demand under this scenario

7. This scenario is scenario 2 adjusted to reflect the assumption that 50% of the full renewable target is met and energy produced by all the renewable heat sources results in a loss of gas consumption equivalent to 34% of the total renewable heat that would be produced to meet the full target. The peak reduction can be calculated by applying the average load factor to the annual reduction in demand under this scenario

8. This scenario is scenario 3 adjusted to reflect the assumption that 50% of the full renewable target is met and energy produced by all the renewable heat sources results in a loss of gas consumption equivalent to 26% of the total renewable heat that would be produced to meet the full target. It is assumed that there will be no impact on peak demand based on the assumption that any of the alternative energy sources cannot deliver sufficient energy to meet a 1 in 20 peak day requirement

9. This scenario is scenario 4 adjusted to reflect the assumption that 50% of the full renewable target is met and energy produced by all the renewable heat sources results in a loss of gas consumption equivalent to 29% of the total renewable heat that would be produced to meet the full target. It is assumed that there will be no reduction in peak demand

10. This scenario is scenario 5 adjusted to reflect the assumption that 50% of the full renewable target is met and energy produced by all the renewable heat sources results in a loss of gas consumption equivalent to 29% of the total renewable heat that would be produced to meet the full target. The peak reduction can be calculated by applying the average load factor to the annual reduction in demand under this scenario

There are additional sensitivities that could be developed that assume that priority will be given to reducing oil & coal before gas

6.9. Qualitative comments on scenarios

As a general observation, prior to the introduction of strong new incentives under the RHI, it was assumed that it would be more probable that the targets will not be met than will be met, but as to what the percentage would be it was difficult to say. The new RHI schemes have been introduced to increase the amount of renewable heat and it could be assumed that it is more likely that the renewable heat targets will be met. The level of ramping up required to achieve the 2020 target is still significant, even after DECC's upwards revised figures. The restated figures mask the true causes of growth in renewable heat and it may not be clear, until another year of actual growth has been observed, that the 2020 target is going to be met. It will still require a fundamental change in consumer behaviour and significant investment by the consumer or by government through the incentive mechanisms. The reversal of the reductions in the tariff for biomass (which make up a large part of renewable heat) will help.

One study carried out for DECC (Enviros Consulting – September 2008 – Barriers to Renewable Heat Part 2: Demand Side) identifying the barriers to renewable technology show that there are many barriers classified as high (over 50% of all the barriers across all the renewable technologies). This same study acknowledged that "lack of interest" was an important factor but did not address it because it was mainly a domestic issue and there was sufficient untapped interest in the non-domestic sector and with some domestic customers. They therefore considered it was not a high priority to address this as the major barrier

was cost. However modelling carried out by another consultant referred to in the Enviros Report (Element Energy - TNS UK, 2007, The Growth Potential of Micro-generation - Report on Qualitative Research) suggests that opportunities for renewable heat are greater in the domestic sector.

Scenarios 1 and 6 are the least likely to occur given that it is certain that all current alternative energy sources for heat are more polluting or more costly than gas, hence they should be the sources that are going to be replaced first.

Scenarios 2 and 7 are probable scenarios but marginally less likely than scenarios 3 and 8 as it is clear from government documents that the adoption of biomass in household situations may not occur in most circumstances because of clean air restrictions. The upwards revised renewable heat figures are a result of much higher figures for wood burning. But it is difficult to establish if these increases are in non-gas areas or not. Also biogas is very likely to be delivered using existing gas networks and therefore will have no impact on the demand for gas from the networks and may as a worse case require investment to accommodate the flows from biogas plant.

Scenarios 4 and 9 are also probable scenarios should the increases in biomass incentives result in greater take up of this form of renewable.

Scenarios 4 and 9 from the point of view of annual gas are equal to 5 and 10. However from a peak perspective it is very difficult to say at the moment, without any detailed evidence of the impact that current renewable sources have on consumer behaviour at peak. What is known currently is that there will be a need to supplement renewable energy sources on a peak day with a very flexible source of instantaneous energy, unless

- The renewable sources are oversized significantly to cope
- More than one renewable source is installed that is unaffected by the particular conditions that impact the primary source
- Consumers are prepared to be colder than they would normally be
- Widespread district heating is adopted which can accommodate fuel storage/alternative heating options

With regard to scenarios 5 and 10 the probability of these occurring will be dependent on the various mechanisms that the government are developing to encourage renewables. The actual level of reduction in gas demand will be determined by consumer take-up from those that want to use the new technology because of personal preference. There are uncertainties going forward particularly with regard to biomass versus natural gas as it is clear that the government wants to get some quick early impacts on reducing emissions and therefore should be encouraging the biggest polluters to adopt renewable technology first. This could mean in the short to medium term that coal and oil users should be early adopters of biomass.

Consumers may also feel that there is uncertainty over the future of biomass given the conflicting views over its credentials as a carbon neutral source. The public perception of the ability of central government to manage the UK's environmental issues may be affected by the u-turn by Government on diesel cars, whereby it is now stated that they are more polluting than petrol cars. Previously Government had actively encouraged consumers to switch to diesel to reduce pollution.

One final point on this subject is that if gas becomes the peak heat provider the cost of supplying gas could become prohibitive as fixed costs for delivering gas

are spread over much lower throughput. In addition the price paid for wholesale gas could be higher as the demand will only be in the peak winter period. There will be a ceiling on this though of summer prices plus storage costs.

7. Application of Analysis to 2050 (Updated 2019)

7.1. Introduction

The application of the economic variables included in this report and the translation of the assessments of energy efficiency to a period long into the future is extremely speculative. A starting point for this could be the Redpoint study or alternatively we could equally use the DECC Pathways analysis which has multiple scenarios any of which could be feasible, given a certain behavioural change by consumers and depending on the amount of money that the consumer or other parties are prepared to spend on changing behaviour.

In addition to the above there have been some other reports on the outlook to 2050. These are the WWF report entitled "100% Renewable Energy by 2050" and the Government "Carbon Plan – Delivering our low carbon future." Summaries of these documents are provided in Appendix 2.

The last document to contain any reference to the roadmap to 2050 is the DECC publication "UK Renewable Energy Roadmap Update 2013" published in November 2013. This contains reference to a document published in March 2013 by DECC entitled "The Future of Heating: Meeting the Challenge", which sets out specific actions to support the long term transition to low carbon heating, including but not limited to renewable heating systems.

Relating these back to the 2050 DECC Pathways analysis is not possible, but it is clear that the trend in carbon emissions should continue to be downwards, but it is very early days to say if the 80% reduction in emissions envisioned by the Pathways analysis can be achieved.

The former DECC produced a plan for the period 2015 to 2020, published on the 19th February 2016, which had some interesting items that could have an impact on the progress of renewable schemes:

- Reduce the projected cost of green policies on the average annual household energy bill by £30 from 2017. This will primarily be achieved by reforms to the current ECO scheme, under which energy suppliers deliver energy efficiency measures to households. This will be replaced from April 2017 with a new cheaper domestic energy efficiency supplier obligation which will run for 5 years. The new scheme will upgrade the energy efficiency of over 200,000 homes per year, saving those homes up to £300 off their annual energy bill.
- Continued support for consumers both domestic and non-domestic with efficiency measures
- With regard to decarbonising heat provision will be made for over £300m of funding for local heat infrastructure over the next 5 years, generating enough heat to support the equivalent of over 400,000 homes. There will also be increased funding for the RHI to £1.15bn by 2020 to 2021, reforming the scheme with a focus on improving value for money and reducing costs, improving cost control and budget management, and exploring the best way to support households that are less able to pay. By

the end of 2020 to 2021 DECC expect to have supported sufficient additional renewable heat installations to over 500,000 homes.
- DECC also intended to bring together heat with energy efficiency in buildings, to reduce carbon through a combination of demand reduction and efficient generation. In the short term they are looking at the performance of boilers and conventional heating systems.
- They state that they will continue to develop a long-term strategy to drive low carbon and renewable heat through a stable, coherent and affordable framework.

Another document relating to Government strategy in this area was published in October 2017 updated in April 2018. The DBEIS policy paper entitled "Clean Growth Strategy" contains the following key policies and proposals.

Accelerating clean growth

Develop world leading Green Finance capabilities.

Improving business and industry efficiency – 25% of UK emissions

Develop a package of measures to support businesses to improve their energy productivity, by at least 20% by 2030.

Establish an Industrial energy efficiency scheme to help large companies install measures to cut their energy use and bills.

Publish joint industrial decarbonisation and energy efficiency action plans with 7 of the most energy intensive industrial sectors.

Demonstrate international leadership in carbon capture usage and storage (CCUS), by collaborating with our global partners and investing up to £100 million in leading edge CCUS and industrial innovation to drive down costs.

Work in partnership with industry, through a new CCUS Council, to put us on a path to meet our ambition of having the option of deploying CCUS at scale in the UK, and to maximise its industrial opportunity.

Develop our strategic approach to greenhouse gas removal technologies, building on the government's programme of research and development and addressing the barriers to their long term deployment.

Phase out the installation of high carbon forms of fossil fuel heating in new and existing businesses off the gas grid during the 2020s, starting with new build.

Support the recycling of heat produced in industrial processes, to reduce business energy bills and benefit local communities.

Invest around £162 million of public funds in research and innovation in Energy, Resource and Process efficiency, including up to £20 million to encourage switching to lower carbon fuels

Support innovative energy technologies and processes with £14 million of further investment through the Energy Entrepreneurs Fund.

Improving our homes – 13% of UK emissions

Support around £3.6 billion of investment to upgrade around a million homes through the Energy Company Obligation (ECO), and extend support for home energy efficiency improvements until 2028 at the current level of ECO funding.

Objective to have all fuel poor homes upgraded to Energy Performance Certificate (EPC) Band C by 2030 and our aspiration is for as many homes as possible to be EPC Band C by 2035 where practical, cost-effective and affordable.

Develop a long term trajectory to improve the energy performance standards of privately rented homes, with the aim of upgrading as many as possible to EPC Band C by 2030 where practical, cost-effective and affordable.

Consult on how social housing can meet similar standards over this period.

Following the outcome of the independent review of building regulations and fire safety, and subject to its conclusions, consult on strengthening energy performance standards for new and existing homes under building regulations, including futureproofing new homes for low carbon heating systems.

Offer all households the opportunity to have a smart meter to help them save energy by the end of 2020.

Rolling out low carbon heating

Build and extend heat networks across the country, underpinned with public funding (allocated in the Spending Review 2015) out to 2021.

Phase out the installation of high carbon fossil fuel heating in new and existing homes currently off the gas grid during the 2020s, starting with new homes.

Improve standards on the 1.2 million new boilers installed every year in England and require installations of control devices to help people save energy.

Invest in low carbon heating by reforming the Renewable Heat Incentive, spending £4.5 billion to support innovative low carbon heat technologies in homes and businesses between 2016 and 2021.

Invest around £184 million of public funds, including two new £10 million innovation programmes to develop new energy efficiency and heating technologies to enable lower cost low carbon homes.

Accelerating the shift to low carbon transport – 24% of UK emissions

End the sale of new conventional petrol and diesel cars and vans by 2040

Spend £1 billion supporting the take-up of ultra low emission vehicles (ULEV), including helping consumers to overcome the upfront cost of an electric car

Develop one of the best electric vehicle charging networks in the world.

Accelerate the uptake of low emission taxis and buses.

Work with industry as they develop an Automotive Sector Deal to accelerate the transition to zero emission vehicles.

Announce plans for the public sector to lead the way in transitioning to zero emissions vehicles.

Invest £1.2 billion to make cycling and walking the natural choice for shorter journeys.

Work to enable cost-effective options for shifting more freight from road to rail, including using low emission rail freight for deliveries into urban areas, with zero emission last mile deliveries.

Position the UK at the forefront of research, development and demonstration of Connected and Autonomous Vehicle technologies, including through the establishment of the Centre for Connected and Autonomous Vehicles and investment of over £250 million, matched by industry.

Invest around £841 million of public funds in innovation in low carbon transport technology and fuels including ensuring the UK builds on its strengths and leads the world in the design, development and manufacture of electric batteries through investment of up to £246 million in the Faraday Challenge. Delivering trials of Heavy Goods Vehicle (HGV) platoons, which could deliver significant fuel and emissions savings.

Delivering Clean, Smart, Flexible Power – 21% of UK Emissions

Reduce power costs for households and businesses by implementing the smart systems plan, which will help consumers to use energy more flexibly and could unlock savings of up to £40 billion to 2050.

Working with Ofgem and National Grid to create a more independent system operator to keep bills low through greater competition, coordination and innovation across the system

Publish a draft bill to require Ofgem to impose a cap on standard variable and default tariffs across the whole market.

Phase out the use of unabated coal to produce electricity by 2025.

Deliver new nuclear power through Hinkley Point C and progress discussions with developers to secure a competitive price for future projects in the pipeline.

Improve the route to market for renewable technologies such as offshore wind.

Target a total carbon price in the power sector which will give businesses greater clarity on the total price they will pay for each tonne of emissions.

Invest around £900 million of public funds, including around:

- £265 million in smart systems to reduce the cost of electricity storage, advance innovative demand response technologies and develop new ways of balancing the grid
- £460 million in nuclear to support work in areas including future nuclear fuels, new nuclear manufacturing techniques, recycling and reprocessing, and advanced reactor design
- £177 million to further reduce the cost of renewables, including innovation in offshore wind turbine blade technology and foundations

Enhancing the benefits and value of our natural resources – 15% of UK emissions

As we leave the EU, design a new system of future agricultural support to focus on delivering better environmental outcomes, including addressing climate change more directly.

The very latest publication from DBEIS document entitled "Clean Growth – Transforming Heating" out in December 2018 states that a full roadmap for policy on heat decarbonisation is promised in the next 18 months taking into account the outcomes of the next spending review.

The following diagram summarises their current policy approach.

Highlights of the next steps being taken by Government until the full roadmap is developed are as follows.

- In association with the HSE and other interested parties, and subject to the satisfactory demonstration of safety, the inclusion of a percentage of low carbon hydrogen into gas networks, within the context of strategic decisions for the long term decarbonisation of heat, and the potential for an emerging hydrogen economy.
- Consider how low carbon heat can be supported in the Government's Spending Review (RHI for biomethane, heat pumps etc.).
- Consult on a specific package of measures for off gas grid homes (focus on increasing efficiency standards for new homes and discouraging new high carbon installations e.g. oil).
- Continue support for improved energy efficiency measures and work on heat networks
- Step up innovation work on low carbon heating in partnership with industry, academia and other partners.
- Consult on Industrial Energy in 2019, and continue CCUS Task Force work.
- Undertake further work to explore the longer term potential for electric heating, hydrogen and bioenergy.

Future strategically important issues identified by DBEIS are:

- Whole system implications need to be understood
- There is no consensus, but electricity, hydrogen and bioenergy all have potential to make important contributions. A mix of technologies will be needed, but the balance is not clear, including in terms of the relative costs.
- Electrification has the potential to deliver very deep CO2 reductions, but depends on new/reinforced infrastructure, innovation in demand/storage/system management, and some buildings/processes not being suitable.
- Hydrogen can also deliver deep reductions subject to establishing the feasibility, developing new infrastructure including CCUS, and sourcing a secure supply of natural gas to meet a significant increase in demand, but the level of reductions possible are less clear.
- Biomethane has a role but is limited by feedstock availability.#
- All scenarios require extensive change and capital investment. Public awareness of these changes is low. Hybrid heat pumps may play a role in reducing the level of disruption for transition to heat pumps.
- A comprehensive policy framework is needed, along with improved evidence on solutions and continuing innovation to drive down costs.

It should also be noted that there are other piecemeal initiatives and incentives that the government were planning to roll out that in aggregate could lead to some further reductions in overall carbon emissions.

Some examples are as follows:-

- The Energy Entrepreneurs Fund. The last phase of this closed in January 2015. No indication of further funding at present.
- Creation of a delivery unit in 2013 to support local authorities exploring heat network opportunities. This unit, the Heat Networks Delivery Unit (HNDU), combines grant funding with guidance from a team of commercial and technical specialists with experience in developing heat networks.
- DBEIS produced a document in October 2017 entitled "Industrial Decarbonisation and Energy Efficiency Action Plans" which is an initiative that forms part of the Clean Growth Strategy that sets out how Government will work with industry to achieve the most cost effective path to the decarbonisation required to meet carbon budgets, while realising opportunities for growth, job creation and exports and improving energy security. It is also aligned to the Industrial Strategy, particularly its pillar on delivering affordable energy and clean growth to secure the economic benefits of the transition to a low-carbon economy.
- There is also in place since March 2015 the Industrial Decarbonisation and Energy Efficiency Roadmaps to 2050 which have been produced for each large industry sector, including: Iron and Steel, Chemicals, Oil Refining, Food and Drink, Pulp and Paper, Cement, Glass and Ceramics. It should be noted that where there are large possible reductions in CO2 emissions these nearly all have Carbon Capture and Storage (CCS) as part of the requirement. Another major element is Electrification of Heat.

7.1.1. The Future of Heating: Meeting the Challenge

In summary this document has specific actions identified that will be taken in four main areas to support maximum decarbonisation of heat by 2050.

Carbon Heat in Industry

- Develop a decarbonisation 'roadmap' for each industrial sector for the long term, focusing on the sectors that use the greatest amount of heat and represent the greatest CO2 emissions
- Identify how to further support development of CCS technologies for industrial emitters as part of the Government's wider efforts on CCS
- Assess the technical and economic potential for re-use of recovered heat as a low carbon energy source. DECC will then use this evidence to explore the scope for extra incentives for use of recovered 'waste' heat from industry, in particular alongside the non-domestic RHI review in 2014
- Develop a bespoke policy to support new natural gas-fired CHP capacity, subject to confirmation that this will not displace low carbon generation. This policy will aim to reflect the range of different scales, technologies and commercial motivations in the CHP market.
- Explore the use of European Regional Development funding to support CHP and waste heat recovery by Local Enterprise Partnerships

Heat Networks

- Support to local authorities in developing heat networks by establishing a Heat Networks Delivery Unit (HNDU) within DECC that will work closely with project teams in individual authorities
- Provide funding over two years to contribute to local authorities' costs in carrying out early stage heat network development. This will enable local authorities to bring forward projects to the stage where they are suitable for investment by the Green Investment Bank and commercial lenders
- Endorse an industry-led consumer protection scheme for heat network users later this year, and encourage the heat networks industry to work with consumer groups in developing this practice
- Develop heat metering
- Identify the key technological solutions that require innovation support
- Consider further how heat networks can be better supported as part of the next Renewable Heat Incentive policy review in 2014

Heat and Cooling for Buildings

- Introduce a voucher scheme for installer training to build up the installer base
- Pilot a green apprenticeship scheme, with the aim of offering 100 places in the renewable heat sector
- Support development of a new consumer guide produced by industry and consumer organisations, improving the way low carbon heating is communicated to consumers and providing advice to installers and intermediaries such as local authorities
- Explore what role tighter standards on building emissions and heating systems could play in achieving the goal of decarbonising heat in all buildings between 2020 and 2050

Grids and Infrastructure

- Examine the strategic interaction between lower carbon electricity generation and heat production
    - Commission further research to improve understanding of the role hydrogen could play across our energy system
- Explore with the industry how best to address the strategic questions facing the gas network

- Trial prototypes of novel compact heat stores which can be integrated with low carbon technologies (such as heat pumps) to help balance peak loads on the electricity grid

The bullet above that refers to the strategic questions facing the gas network is summarised below.

The high-level conclusions of the modelling commissioned by the former DECC for this document are broadly consistent with the conclusions of the Strategic Framework. However, the modelling suggests there could still be a limited role for natural gas in 2050 to help meet peaks in heat demand on the coldest days of the year. The modelling suggests this could be more cost effective than the alternative of full electrification of the peak seasonal heat demand, with the consequent need for large amounts of additional generation capacity to meet only occasional use. The modelling suggests a more cost-effective solution could be to maintain some gas in buildings for use by gas absorption heat pumps, or in hybrid systems where gas appliances operate alongside an electric heat pump, for example. This was confirmed by the results from the modelling run which removed the option of using gas in domestic buildings. This run showed higher overall system costs, in part because the increase in domestic electricity use required additional reinforcement of the distribution grid as well as additional generation.

However, the model currently only includes a simplified representation of the gas and electricity grids and their costs. Therefore, the model does not necessarily factor in all the implications of keeping a system of gas boilers and associated infrastructure that are used only occasionally. Further work is required to understand the practical implications of a partially-used gas grid, including the technical feasibility and the implications for network costs. It follows that whether gas or electricity is used to meet occasional peaks in heat demand, some expensive redundancy in the systems is involved. For this reason, new approaches to storage and balancing could be crucial to the overall system.

A consistent conclusion from the model is the greater role for heat networks in part because of their storage potential. The modelling also suggests a potential role for hydrogen both to provide heat for buildings and, more significantly, heat for industry. However, this finding needs to be treated with some caution as further work will be required to fully understand hydrogen’s potential across the energy system and more accurate infrastructure costs.

A major barrier to implementation of a hydrogen network could be the acceptance of conversion by the customer. Ofgem in its “Future Insights Series - The Decarbonisation of Heat” report produced in November 2016 suggest that the adoption of hydrogen as a fuel in the home may require mandatory arrangements to be put in place (see summary of report below).

There has been some recent activity with respect to the use of hydrogen in networks, either on its own or mixed with natural gas.

- NGGD have received funding from the Ofgem Gas Network Innovation Competition in 2016 for a project entitled HyDeploy. It is intended to demonstrate on Keele University's private network that natural gas containing levels of hydrogen (10% to 20%) beyond those permitted by the current safety standards (0.1%) can be distributed and utilised safely. The project will provide evidence to contribute towards the case for allowing increased use of hydrogen on the network.

- Cadent (formerly NGGD) are hoping to undertake a pioneering trial in the 2020s using hydrogen as a cleaner alternative to methane in pipelines across parts of the NW region. It is intended that certain industries will receive pure hydrogen as part of an initial trial and that hydrogen will be mixed with natural gas for domestic customers.
- H21 Leeds city gate project. NGN commissioned a report into the feasibility of supplying central Leeds with hydrogen instead of natural gas. The conclusion of this report is that it is feasible to do this. In April 2017 a project office was opened in Leeds with the help of Leeds City Council to further examine, and build the foundations to deliver, the conversion strategy outlined in its H21 Leeds City Gate study. The office has been tasked with delivering innovative projects which prove the case for conversion to hydrogen, not just for Leeds but for the whole of the UK.
- The Green Gas book was published by the Labour Party and the Climate Change Committee in Summer 2016 which contains a section that examines the feasibility of using hydrogen mixed with natural gas in the current network.
- Tees Valley LEP has the objectives to be the lead in the development of hydrogen production and carbon capture and storage.

The core scenario of the modelling shows overall gas demand falling by 40% by 2050 (compared with 2011). There is a reduction of around 90% in the use of gas for buildings heat. This reduction in demand may enable parts of the National Transmission System to be converted for other uses such as the transport of carbon dioxide for CCS, but the modelling does not currently include this option.

Although natural gas use for heat will have to reduce significantly over time if the UK's carbon targets are to be reached, it will play an essential part in the transition to a low carbon future. There are a range of potential outcomes for the gas distribution networks. For example, there may be opportunities to decarbonise parts of the networks with renewable gas or to transport carbon dioxide for CCS where branches or parts of the distribution network are maintained to meet specific circumstances as part of an integrated local solution.

Other uses for the network are explored that include transport of biogas generated from biomass and transport of hydrogen, produced from hydrocarbons or electrolysis of water, either as pure hydrogen or mixed with natural gas.

7.1.2. National Grid's Future Energy Scenarios 2018

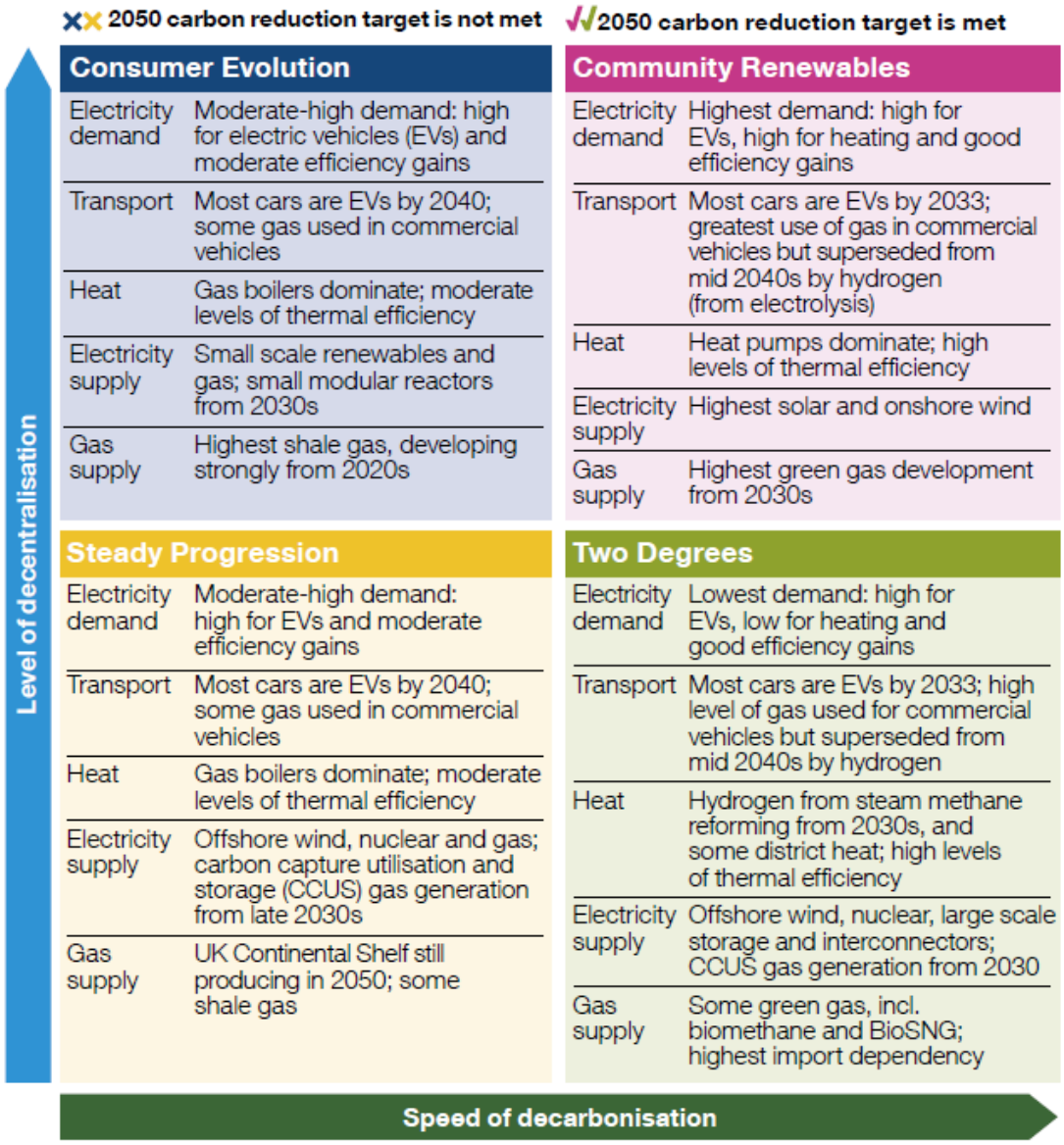
In July 2018, National Grid launched its annual update of its Future Energy Scenarios publication. It produces this analysis to help inform its network planning, but also as a driver for industry debate, and energy companies use the document as a reference in developing their own scenarios. It produces the analysis based on data gathered through meetings and workshops with industry and webinars.

The document outlines a range of credible pathways for the future of energy out to 2050. They outline the possible sources of and demands for gas and electricity in the future, and the implications for the energy industry. National Grid emphasises that it is impossible to produce a single energy forecast for the long term, as well as highlighting the increasing interlinking of the components of the 'energy world' and the opportunities which flexible thinking can bring for innovation across the industry.

A brief summary is given below.

Scenarios

National Grid describes four new scenarios assuming different levels of 'speed of decarbonisation' and 'level of decentralisation', using the same descriptive headings for only one of them as it has used in previous years, introducing new headings for the other three. Two Degrees remains the same combined with Consumer Evolution, Community Renewables and Steady Progression.



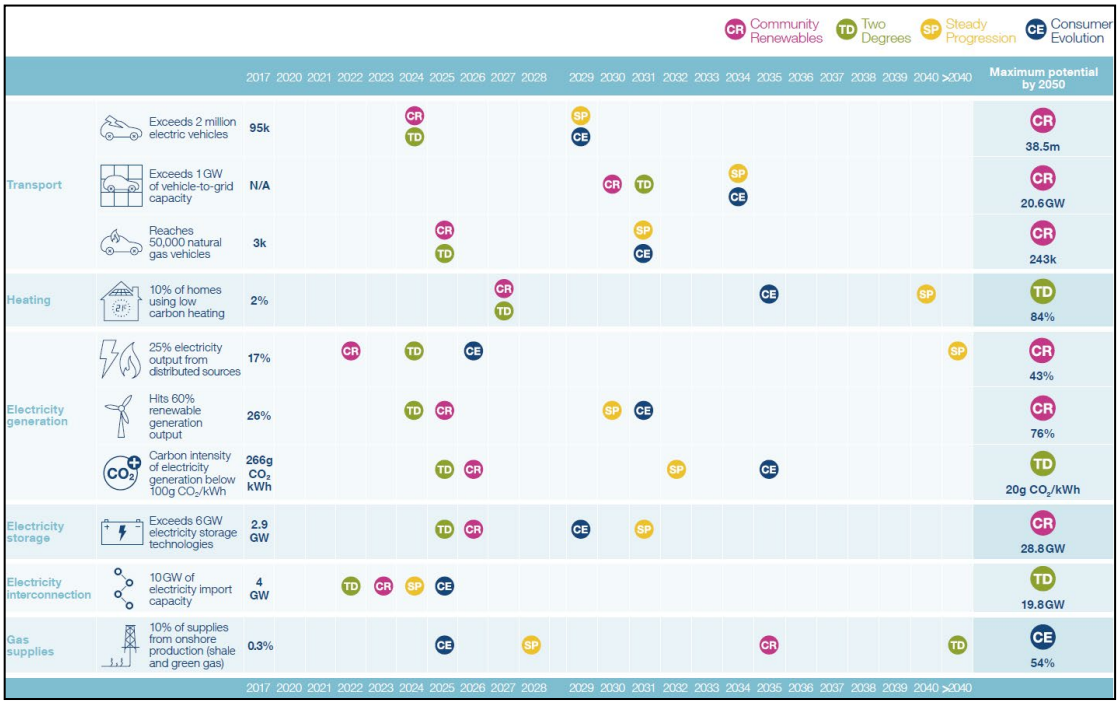
Consumer Evolution	
Electricity demand	Moderate-high demand: high for electric vehicles (EVs) and moderate efficiency gains
Transport	Most cars are EVs by 2040; some gas used in commercial vehicles
Heat	Gas boilers dominate; moderate levels of thermal efficiency
Electricity supply	Small scale renewables and gas; small modular reactors from 2030s
Gas supply	Highest shale gas, developing strongly from 2020s

Community Renewables	
Electricity demand	Highest demand: high for EVs, high for heating and good efficiency gains
Transport	Most cars are EVs by 2033; greatest use of gas in commercial vehicles but superseded from mid 2040s by hydrogen (from electrolysis)
Heat	Heat pumps dominate; high levels of thermal efficiency
Electricity supply	Highest solar and onshore wind
Gas supply	Highest green gas development from 2030s

Steady Progression	
Electricity demand	Moderate-high demand: high for EVs and moderate efficiency gains
Transport	Most cars are EVs by 2040; some gas used in commercial vehicles
Heat	Gas boilers dominate; moderate levels of thermal efficiency
Electricity supply	Offshore wind, nuclear and gas; carbon capture utilisation and storage (CCUS) gas generation from late 2030s
Gas supply	UK Continental Shelf still producing in 2050; some shale gas

Two Degrees	
Electricity demand	Lowest demand: high for EVs, low for heating and good efficiency gains
Transport	Most cars are EVs by 2033; high level of gas used for commercial vehicles but superseded from mid 2040s by hydrogen
Heat	Hydrogen from steam methane reforming from 2030s, and some district heat; high levels of thermal efficiency
Electricity supply	Offshore wind, nuclear, large scale storage and interconnectors; CCUS gas generation from 2030
Gas supply	Some green gas, incl. biomethane and BioSNG; highest import dependency

A comparison chart for all the different scenarios is provided by NG.



The key messages from the document are as follows:

The expected growth of low carbon and decentralised generation means the electricity system will need to change.

- The market will need to adapt to the changing plant mix. Key industry processes are likely to need reviewing, bringing with them opportunities for new services.
- Balancing security of supply, affordability and efficiency in a decarbonised world presents new challenges.
- We will work with industry, Ofgem and the Government to meet these challenges to deliver a reliable, efficient and operable low carbon system.
- Increase in capacity from 103GW today to between 189GW and 268GW by 2050.

Electric vehicle growth goes hand in hand with electricity decarbonisation. Smart charging and vehicle-to-grid can actively support the decarbonisation of electricity.

- Balancing demand and supply and power flows will become increasingly complex and need a coordinated approach across the whole industry. This presents opportunities for developers and suppliers, but data and information flows will become increasingly critical.
- Electricity demand is expected to grow significantly by 2050.
- 36m potential number of electric vehicles (EVs) by 2040.

Action on heat is essential and needs to gather pace in the 2020s to meet carbon reduction targets. A mix of low carbon heating solutions and better thermal efficiency of buildings is needed.

- Decarbonising heat is crucial but needs to address significant technical and commercial challenges.

- A balance of technologies is needed to meet the heat challenge. Development of hydrogen and the rollout of heat pumps need to be driven by clear policy and supportive market arrangements.
- There are different ways to decarbonise heating. Up to 60% of homes could be using heat pumps by 2050. Or hydrogen could heat one third of homes by 2050.

Gas will play a role in providing reliable, flexible energy supplies for the foreseeable future. New technologies and sources of low carbon gas can decarbonise the whole energy sector.

- Gas networks and markets will need to adapt to accommodate changing gas flows and reduced annual demand with more pronounced winter peaks.
- The development of hydrogen and carbon capture utilisation and storage (CCUS) needs innovation and demonstration projects to help overcome the technical, commercial and implementation challenges and to enable commercial rollout of CCUS and hydrogen in the 2030s.
- Gas continues to provide more energy than electricity by 2050 in three of the four scenarios. Gas usage patterns are changing, providing flexibility for heat and generation.

Two of the four scenarios meet the 2050 decarbonisation target, but in different ways.

Community Renewables shows a more decentralised approach. In this world, factors like the large growth of renewables, supported by storage and smart appliances, enable a large reduction in the carbon intensity of electricity. Transport is almost completely decarbonised, thanks to a very high number of EVs and some vehicles that use hydrogen created by electrolysis using excess renewable power. Significant progress is made in the decarbonisation of heat due to factors such as the improved thermal efficiency of homes and the rollout of electric and hybrid (gas and electric) heat pumps.

Two Degrees meets the 2050 carbon reduction target through a more centralised approach. In this world, factors like large growth of renewables, nuclear and gas-fired generation using carbon capture utilisation and storage (CCUS) bring about a very large reduction in the carbon intensity of electricity. Transport is almost completely decarbonised, thanks to a very high number of EVs, and some vehicles that use hydrogen created by steam methane reforming paired with CCUS. Significant progress is made in the decarbonisation of heat due to factors such as the improved thermal efficiency of homes and the rollout of low carbon district heating and hydrogen networks for heating in a number of city regions.

In all the scenarios, the level of decentralised energy increases. In terms of electricity supply, there is a significant increase in smaller scale generators, such as solar and wind turbines, which are not connected directly to the transmission network. Decentralised gas supplies will increase from a low base in all the scenarios. On the demand side, data exchange technologies and business models are developing and these allow consumers to move away from traditional models of energy trading.

The current annual demand for gas in GB is 810 TWh and for electricity 297 TWh. In all the scenarios, the total energy demand reduces by 2050. A major component is the decline in the use of gas for electricity generation, although gas continues to provide the majority of energy in all but one of the scenarios by

2050. In the more centralised scenarios, the use of CCUS leads to an increase in gas use from the 2030s.

The key statistics from the report for 2030 and 2050 are shown below.

Electricity	2017	2030			
		CR	TD	SP	CE
Annual demand (TWh)*	297	302	293	304	308
Peak demand (GW)	59	62	64	62	64
Total installed capacity (GW)	103	158	161	134	131
Low carbon and renewable capacity (GW)	47	99	100	70	70
Interconnector capacity (GW)	4	17	20	15	10
Total storage capacity (GW)**	3	10	10	6	7
Vehicle-to-grid total capacity (GW)	0	1.1	1.0	0.2	0.2

Gas	2017	2030			
		CR	TD	SP	CE
Annual demand (TWh)	810	487	506	671	700
1-in-20 peak demand (GWh/day)	5,522	3,925	4,013	5,083	5,068
Residential demand (TWh)	332	239	244	310	302
Gas imports (%)	51%	81%	69%	57%	51%
Shale production (bcm/yr)	0	0	0	10	22
Hydrogen production (TWh)	0	1	3	0	0
Green gas production (bcm/yr)	0.3	2	1.3	0.3	0.8

*Excludes losses
**Includes vehicle-to-grid

2050				
CR	TD	SP	CE	Electricity
441	373	386	392	Annual demand (TWh)*
83	79	87	87	Peak demand (GW)
268	224	189	199	Total installed capacity (GW)
178	160	110	116	Low carbon and renewable capacity (GW)
17	20	15	10	Interconnector capacity (GW)
50	35	27	34	Total storage capacity (GW)**
20.6	17.9	15.5	17.7	Vehicle-to-grid total capacity (GW)

2050				
CR	TD	SP	CE	Gas
244	565	638	548	Annual demand (TWh)
2,047	2,992	4,817	4,147	1-in-20 peak demand (GWh/day)
77	68	281	255	Residential demand (TWh)
61%	89%	75%	46%	Gas imports (%)
0	0	16	32	Shale production (bcm/yr)
33	265	2	2	Hydrogen production (TWh)
11.9	6.7	0.3	3.6	Green gas production (bcm/yr)

7.1.3. Ofgem Future Insights Series - The Decarbonisation of Heat

Ofgem published (November 2016) the second in their series of "Future Insights" documents outlining the key challenges involved with the decarbonisation of heat.

Ofgem claim that the decarbonisation of heat is the biggest challenge facing UK energy policy over the next few decades. Although it should strictly be seen as a joint challenge with security of energy supply.

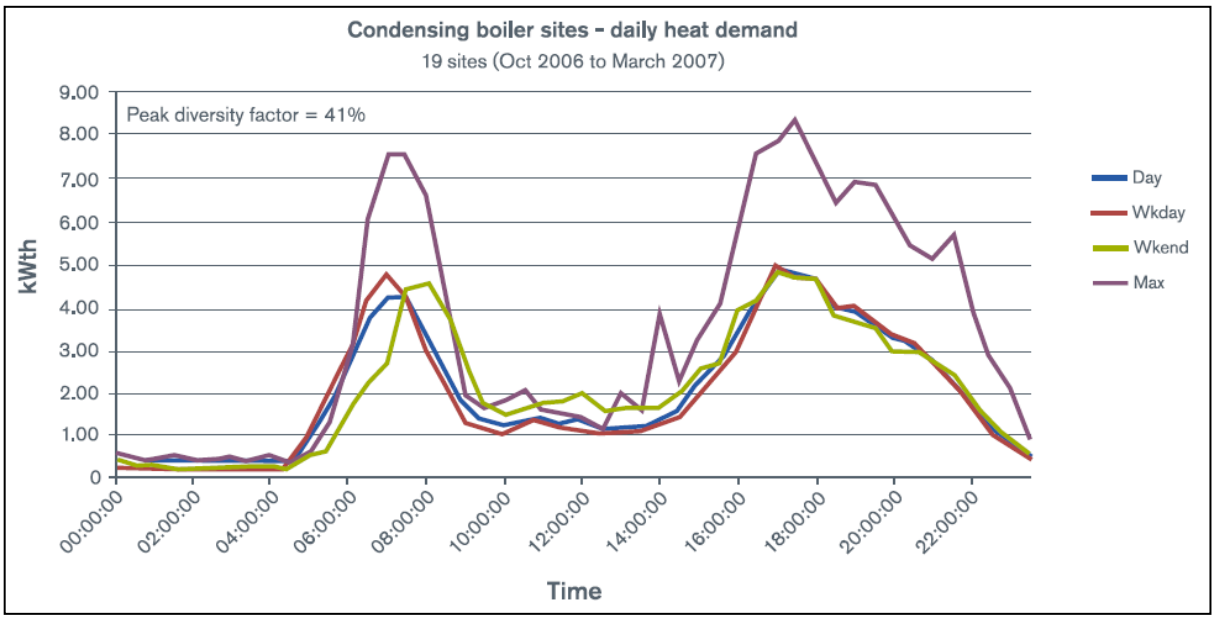
In the paper they consider the nature of heat demand and supply today and some of the decarbonisation options that are presently being discussed by policy makers. They also discuss how decisions might be made and potential consumer and regulatory implications.

Some of the potential options are already known and deployed to some extent, but their role in the future will partly depend on cost-effectiveness. Others, such as use of hydrogen, are at an earlier stage. The challenge for policy, compared to decarbonisation of electricity for example, is not limited to technological developments, new business models and system integration, but also extends to consumer acceptance of changes within their property, often on a mandatory basis. Coordinating decisions on a regional basis may require new governance arrangements and longer-term decisions to reduce the extent to which individual choices are superseded.

Demand

Almost half of the final energy consumed in the UK is to provide heat (760 TWh) – more than that used to produce electricity or for transport. Around 57% of this heat (434 TWh) goes towards meeting the space and water heating requirements of our homes. This means that decarbonising domestic buildings, many of which are connected to the gas grid, forms a key part of the challenge of reducing greenhouse gas emissions.

At approximately 300GW, aggregate peak demand for heat is roughly 5 times greater than that for electricity. This is driven by the technology we currently use – predominantly gas condensing boilers providing heat on demand (see graph below) and our gas infrastructure having the capability to meet this demand. But our underlying need for comfortable temperatures is less peaky. If we switched to provide heat from electricity, the costs of providing a peak of 300GW would be excessive, but the same level of comfort could be provided with somewhat less peaky energy use. Nonetheless, it would still represent a dramatic increase in capacity requirements.



Supply

Most of our heat energy currently comes from burning natural gas – over 70% across the domestic, industrial and service sectors. The remainder is made up of a combination of electric heating (direct and heat pumps) and non-gas fuels (oil, solid fuel, bioenergy and waste). It is estimated that heat delivered by heat networks meets around 2% of building heat demand.

The Renewable Heat Incentive (RHI) is the key policy driver currently incentivising uptake of heat from renewable sources. The RHI has led to the installation of biomass boilers in off-grid locations, to the introduction of biomethane into the gas grid and to some electrification of heating through heat pumps.

However, whilst increasing year-on-year, the overall contribution of renewable heat under the RHI in 2015 was less than 5 TWh. This shows the scale of the challenge in decarbonising a heating supply centred on natural gas. Latest estimates put 5.64% of heating energy coming from renewable sources, compared to the UK's indicative target for 2020 of 12%.

The Nature of Heat

Ofgem outline in this section the fundamental difference in the way heat is supplied when using gas compared to either electricity or district heating schemes. Basically gas heating takes place at the point of use, whereas the process of producing electricity or heat from a district heating scheme is remote from the point of use, although the process of converting electricity to heat actually takes place at the point of use.

Ofgem's key point in this section is that in order to decarbonise heat it is necessary to change the way that heat is delivered. This would require major changes to equipment at point of use and/or centrally managed heating schemes. The changes will be very intrusive and consumer resistance to this change is expected. Mandatory changes are a possibility, but will require even more effort to manage consumer resistance than the non-mandatory smart meter roll out.

A clear framework for delivering change at local, regional and national levels will be critical to the different decarbonisation options, but the growing public resistance to big government could create significant challenges to any fundamental changes to the way heat is provided.

Ofgem use the conversion to natural gas in the 1970's as the last example of major disruption in this area. This was accepted as the basic heat source was unchanged and many people received new appliances as a result. Asking people to relinquish on demand control of their own heating levels in their own home is a totally different proposition.

Decarbonisation Options

The options described based on current technology are:

- Improved energy efficiency
- Adaptation of natural gas networks through blending in lower carbon gas
- Electrification of heating through heat pumps
- Further development of heat networks
- Hydrogen networks

<u>Energy Efficiency</u>

There are still areas that require tackling here, for example older houses with solid walls. The major obstacle here is the cost and the disruption involved. Ofgem suggest that these measures should be coordinated with any changes to the heat supply. The inference here is that if you are causing major disruption to someone, then making a fundamental change to heating service could be done with minimal objection.

Gas Networks

This section looks at the introduction of biomethane into gas grids and the possibility of raising the acceptable limit for hydrogen in natural gas to allow injection. This would have limited impact with regard to decarbonisation. Biomethane could be considered a renewable source of energy, but is still carbon based. Hydrogen injection would have the effect of reducing the calorific value of the gas meaning more gas volume will be burnt for the same heat.

Ofgem acknowledge that gas heating is generally the cheapest and this was the reason they support the Fuel Poverty Network Extension Scheme. But they are considering changing their approach to support heat pumps for off-grid customers.

Electrification

This covers the areas of direct electric heating and heat pumps. However Ofgem do not discuss direct heating on grounds of efficiency and ongoing costs and focus on heat pumps.

They are dismissive of ground source heat pumps because of cost so believe air source heat pumps are better suited to domestic applications. But ground source heat pumps currently receive a much larger Renewable Heat Incentive (RHI) payment (nearly 3 times that of air source).

They touch on hybrid gas/electric heat pumps, suggesting that this gives the opportunity to use gas either as a back up or to mitigate high electricity costs. Wider interactions across gas and electricity that can drive more efficient system outcomes in meeting demand for heating, cooling and power are likely to be increasingly important to our future energy system.

Heat Networks

Current networks use primarily gas but could be converted to any suitable source as the pipes to supply the heat are already in place.

Some new schemes have been developed recently but the high capital costs of projects and need to secure a baseload of customers have led to difficulties in securing the required investment for widespread take-up. The spatial requirements of distributing hot water through large insulated pipes overlay further complexity for potential retrofit of heat networks to existing buildings,

Hydrogen

The use of hydrogen through the current gas network instead of natural gas clearly has the potential to decarbonise heat as the combustion of hydrogen only produces water vapour. The production of hydrogen however can produce carbon dioxide in one of the two bulk production processes, which utilises natural gas as a feedstock. The other, electrolysis, uses electricity. This would have to be cheap sourced, surplus electricity. Ofgem suggest that centralised bulk production of hydrogen would better facilitate carbon capture storage should it be needed.

The H21 Leeds City Gate project has assessed the potential to use the same network we use today for natural gas to pipe hydrogen into our homes and businesses. Ofgem report that this study found that the polyethylene pipes increasingly used in gas distribution networks can safely transport hydrogen. That is not true for the entire gas transportation network and new hydrogen transmission pipelines would be required to connect to medium pressure

distribution networks and inter-seasonal storage facilities. Changes would also be required to appliances at the points of end use. Once converted to hydrogen however there would be no going back to natural gas. A recent report produced by the Sustainable Gas Institute provides some further analysis of issues surrounding the decarbonisation of the gas grid. A summary is provided in Appendix 3.

Ofgem have toned down what was originally reported however. Some key points are:

- There might be some leakage from PE pipes, but only small amounts (compared to zero from the pipe itself for natural gas).
- Until all the iron mains are replaced parts of the network could be unusable for hydrogen.
- Meters need to be replaced but there aren't any reliable ones available at the moment and leak detectors need installing as there is no suitable odorant at present.
- Limited knowledge of the risks associated with domestic use.
- There is a 20-30% loss of capacity and linepack is reduced to a quarter.
- Would probably require subsidy from government and possibly also from network operators.
- Probably not feasible until after 2030.

One key area that is briefly touched on is the safety aspects, but this is an area that will require substantial education of consumers and strict training and regulation for installers. Natural gas explosions are infrequent but can cause severe harm to people and property. Hydrogen explosions are on another level in terms of the devastation that they can cause.

Decision points and pathways

The current consensus is that decarbonisation of heat in the 2030s and 2040s will involve a mix of the above options. It is clear from the content that Ofgem don't have sufficient information at present to evaluate options. They do seem to suggest that there should be different treatment of on and off grid consumers and new build versus existing properties.

They also want to avoid situations where consumers make short to medium term decisions that could be seriously affected by future changes in policy. They talk about the possibility of mandated hydrogen networks, which could render previously installed new natural gas installations redundant.

An understanding of the likely direction of travel for policy will be crucial in mitigating situations such as these. In the short term Ofgem think that this may mean that it is better to focus changes to lower carbon sources on individual households where community or regional scale solutions seem less likely.

The question of who decides about policy is touched upon, but it is obvious that should it be necessary to implement a regional or national policy elected politicians will set it.

Regulatory implications

With regard to consumer protection Ofgem feel that there would not need to be any further protection for heat pump customers as this would be covered by current electricity regulation.

Hydrogen networks are envisaged to require the same regulation as natural gas.

Heat networks however may require some form of regulation as there are currently a lot of complaints about the service, which is provided by a single supplier in an area.

Funding arrangements for heat networks require a suitable regulatory regime. Ofgem are suggesting that they would look at similar regulated entities that best fit the circumstances of heat networks. They would also need to take account of the fact that some operators will be local authorities.

Implications for current gas and electricity networks

Ofgem make the following statement regarding existing networks.

Some of the above options clearly raise the possibility of declining use of current gas networks or of switching to alternative use, and of increased use of electricity networks. This implies that the economic asset life of gas networks is lower than their technical life and suggests that potential decommissioning may need to be considered. Ofgem do not see particular barriers to considering such issues. There is sufficient flexibility in how they consider price controls and within the RIIO framework.

Where consideration is given to alternative future pathways, it is important to consider economic choices based on future costs rather than past, and to ensure charging arrangements do not distort choices. In particular, the scale of past investment should not drive future decisions. Decisions about the best approach to a decarbonised heating future should be based on future not past costs.

In terms of charging, it is important not to load the costs of previous investments on one option but allow them to be evaded through choice of an alternative – when such a choice cannot change costs that have been incurred already. For example, if there is a choice between re-use of current natural gas networks for hydrogen or switching to electric heating, that choice could be distorted if future (hydrogen) gas customers were asked to bear all the sunk costs of the natural gas network but electric customers had no such requirement.

In the nearer term, there is clearly uncertainty around future gas demand scenarios given the potential impact of improved energy efficiency and the adoption of electric and district heating. Network companies will need to work with their stakeholders to justify assumptions in their business plans, and to develop contingency plans to prepare for the situation that assumptions which are adopted may turn out not to occur.

Ofgem have produced three further documents in the Future Insights series which are entitled "Local Energy in a Transforming Energy System" (January 2017), "The Futures of Domestic Energy Consumption" (March 2017) and "Implications of the Transition to Electric Vehicles" (July 2018).

The local energy document focuses on various forms of local energy matters related to electricity, covering consumer services, generation and supply. The domestic energy document is of more interest but is more focused on electricity than gas. A summary of the content of this report is provided in Appendix 4. The paper on EVs is aimed to inform the debate on how the EV transition will affect the energy system, consumers and regulation in three key areas:

- The evolving transport sector - Much of the current public debate overlooks or underestimates the role of wider societal change, and how changes in how we access and use transport will manifest in the energy

system. Ofgem explore the motivations behind current trends, and what they might mean for the energy and transport sectors.
- Implications for consumers and the energy system - They explore where and when EV owners are charging, and what that means, given current market arrangements. They also explore the benefits of flexible charging, extracting value out of the existing system as an alternative to network reinforcements. Examine how broader societal change could influence charging behaviour.
- Considerations for regulation - Ofgem explore key regulatory considerations such as efficient investment in infrastructure, improving access to charging, how costs and benefits are distributed, and technological interoperability.

7.2. 2050 Viewpoint (Updated 2019)

It would be appropriate to examine the different elements included in the earlier sections of this report to establish if it would be relevant to extend the model to 2050 or not and if so how this could be achieved.

7.2.1. Economic Assumptions

Any model that attempts to forecast the state of the economy beyond the very near future, however good the model, can't anticipate everything that could happen in the next 30 plus years. The EU referendum result was something that some commentators have said was a once in a generation event. There is even speculation that the transition period could be many years or even decades. There are economic cycles that can be replicated but the further out that the forecast goes, the more scenarios that are needed to encompass the range of possibilities. Furthermore, the relationship that is developed between gas demand and for example the economy, could become less reliable as a predictor of gas demand as greater influences take over, for example the extent of renewable heat that replaces gas, or the improvements in insulation and energy efficiency.

Taking that uncertainty down to a regional level has the potential to create even greater uncertainty as the interpretation of the impact of specific national assumptions on each region could introduce another possibility for error in the forecast. Regional economics will be influenced by any devolving of power to local government from central government, which is happening to some degree at present and is expected to increase. The traditional way to address this is to use more scenarios.

7.2.2. Energy Prices

The same can be said about energy prices as can be said about economic assumptions, but for quite different reasons. Creation of a forecast of gas prices way into the future will require the impact of more possible variables than currently used. In addition to oil price and the linking or decoupling of gas from oil price, there will be the effect that the penetration of renewable heat has on the dynamics of gas pricing. There could be a shift to link gas prices to renewable heat prices in some sectors of the market where they are directly competing with each other. The ability of gas to compete with renewable heat sources will be dependent on how long the government is prepared to support the development of renewable sources when they become established. A further consideration when looking at gas prices is the relationship in the longer term between the natural gas price and the hydrogen price. This may be a mute point as hydrogen

should in the future be generated using hydrolysis rather than from methane and if it is mandated that hydrogen replaces methane then the two gases will not be in competition.

Recent cost analysis[17] suggests that production costs of hydrogen from natural gas with CCS are around double that of natural gas so in a purely competitive market it is likely that natural gas could prevail depending on the costs of distributing hydrogen and the cost of switching for the consumer.

A recent analysis by Dieter Helm for the Government raises some quite important issues about future energy prices, particularly electricity prices, although it is unclear from the Government response that they will take any action on his recommendations. A summary of his report is provided below.

- The cost of energy is too high, and higher than necessary to meet the Climate Change Act (CCA) target and the carbon budgets. Households and businesses have not fully benefited from the falling costs of gas and coal, the rapidly falling costs of renewables, or from the efficiency gains to network and supply costs which come from smart technologies. Prices should be falling, and they should go on falling into the medium and longer terms.
- Households and businesses have not benefited as much as they should because of legacy costs, policies and regulation, and the continued exercise of market power.
- The scale of the multiple interventions in the electricity market is now so great that few if any could even list them all, and their interactions are poorly understood. Complexity is itself a major cause of rising costs, and tinkering with policies and regulations is unlikely to reduce costs. Indeed, each successive intervention layers on new costs and unintended consequences. It should be a central aim of government to radically simplify the interventions, and to get government back out of many of its current detailed roles. This review explains how to do this.
- The legacy costs from the Renewables Obligation Certificates (ROCs), the feed-in tariffs (FiTs) and low-carbon contracts for difference (CfDs) are a major contributor to rising final prices, and should be separated out, ring-fenced, and placed in a 'legacy bank'. They should be charged separately and explicitly on customer bills. Industrial customers should be exempt. Once taken out of the market, the underlying prices should then be falling.
- The most efficient way to meet the CCA target and the carbon budget is to set a universal carbon price on a common basis across the whole economy, harmonising the multiple carbon taxes and prices currently in place. This price should vary so as to meet the carbon targets. It would be significantly lower than the cost of the current multiple interventions.
- There should be a border carbon price to address the consequences of the UK adopting a unilateral carbon production target.
- The FiTs and other low-carbon CfDs should be gradually phased out, and merged into a unified equivalent firm power (EFP) capacity auction. The costs of intermittency will then rest with those who cause them, and there will be a major incentive for the intermittent generators to contract with and invest in the demand side, storage and back-up plants. The balancing and flexibility of markets should be significantly encouraged.
- After all existing commitments in respect of FiTs and low-carbon CfDs have been fully honoured, and in the transition to a proper, uniform carbon

[17] Producing Low Carbon Gas – Carbon Connects Future Gas Series: Part 2 – July 2018

price and an EFP auction, they should be split into three parts: the construction and project-development phase; the operation of the plant; and decommissioning. The first should have a higher cost of capital, reflecting the equity risks; the second should be more akin to a regulatory asset base (RAB) in the utilities and closer to the cost of debt; and the third should be a charge to operating costs. The customers should benefit from the refinancing when the project comes into operation.

- The current RIIO (Revenue = Incentives + Innovation + Outputs) periodic review price caps for the transmission and distribution companies are already being significantly outperformed – in part because of mistakes in the assumptions – and have resulted in higher prices than need to be charged for the efficient delivery of their functions. Ofgem should consider what actions should be taken now.
- For the networks, going forward, there should be no more periodic reviews in the current RIIO framework. Technical change is so fast that predicting costs eight–ten years hence is impractical.
- The government should establish an independent national system operator (NSO) and regional system operators (RSOs) in the public sector, with relevant duties to supply, and take on some of the obligations in the relevant licences from the regulated transmission and distribution companies. The NSO and the RSOs should, where practical, open up the various functions and enhancements to the networks to competitive auctions and, at the local level, invite bids for network enhancements, generation and storage, and demand-side response (DSR) from energy service companies.
- The separate generation, supply and distribution licences, at least at the local level, should be replaced by a simpler, single licence.
- As a result of the above changes, the role of Ofgem in network regulation should be significantly diminished.
- There should be a default tariff to replace the Standard Variable Tariff (SVT), based on the index of wholesale costs, the fixed cost pass-throughs, levies and taxes, and a published supply margin.

It is anticipated currently that renewable heat that relies on the weather to deliver will be somewhat variable and unless there is a reliable and cost effective means of storing heat (or electricity) there could be an enduring role for gas (natural gas, biogas or hydrogen) as a peak shaving fuel[18]. So the overall decline in gas consumption predicted by some as a result of renewable heat, could lead to a declining average price for gas as surplus capacity builds up for a period, especially if it is decoupled from oil, but there could be very high value attributed to gas on high heating demand days. Many new gas developments and LNG import facilities require a long period of return to justify the investment. It would be difficult to justify this investment in gas supply for a few days' sales, when weather is very cold.

One important aspect of gas prices that could develop is the comparison with retail electricity prices, particularly in the domestic sector. Renewable heat sources like air and ground source heat pumps use electricity to operate and currently the electricity prices are sufficiently high to make this type of renewable heat uneconomic when compared to high efficiency gas boilers. This has changed significantly with the introduction of the RHI for domestic customers, but the incentive is limited to seven years for domestic compared to twenty years for non-domestic. The recent introduction of gas absorption heat pumps into the market and the significant level of hybrid heat pump sales could lead to greater

[18] See DECC report "The Future of Heating: Meeting the Challenge"

growth in the amount of renewable heat. The impact on emissions of these two types of heat pumps would depend on the efficiency levels compared to electric heat pumps and the proportion of renewable electricity generation. Introduction of low carbon gases would also have an impact.

If it is to be believed that we will become heavily reliant on electricity in the future for our heating purposes, what will happen to the price spread between gas and electricity by 2050. Will it be so big as to turn around the decline in demand for gas despite the best efforts of government to encourage renewables, unless mandatory arrangements are put in place? Does the development of new unconventional gas, particularly shale gas, combined with increasing demand for electricity make matters worse?

Many of the DECC Pathways scenarios have high proportions of air and ground source heat pumps, which would push up demand for electricity substantially, unless other localised renewable sources of electricity are implemented to match the growth in heat pumps. Could the very growth in these types of renewables create a barrier to their use? The RHI will improve the position of these types of renewable but the level of incentive is currently limited and likely to decline over time.

The current low margins for electricity generation availability at peak and uncertainty over the timing for new generating plant, particularly large scale new nuclear, could put upward pressure on wholesale and retail electricity prices, retaining gas as a more economical choice for heat. Some recent large scale renewable projects based on wave power have been seeking high guaranteed payments over tens of years, greater than nuclear in some instances. This has currently been turned down, but it gives an indication that to increase renewable generation with these projects could lead to upward pressure on prices. The recent demise of Carbon Capture as a viable solution to deal with carbon dioxide from fossil fuel generation increases the pressure on finding new generation capacity that has low or zero emissions. It should be noted that CCS features significantly in future strategies for industrial emissions reduction and hydrogen production. Its resurrection as a viable cost effective means of emissions reduction will be crucial to the adoption of some technological options.

Another possible driver of gas price could be the cost of heat being supplied in competing heat networks should these become widespread.

It is conceivable in the medium to long term, with the possible introduction of hydrogen as a diluting component in natural gas, that gas prices could rise significantly if hydrogen production costs remain higher than prevailing natural gas prices.

7.2.3. Energy Efficiency and Renewables

The DECC Pathways study is a major source of information about the potential for future development of both efficiency measures and renewable technologies. We examine what can be used from this study to inform the debate into the impact on gas demand out to 2050.

7.2.3.1. Energy Efficiency

The DECC Pathways analysis contains a lot of information about potential developments in insulation that could be important to the long term assessment of energy and gas demand out to 2050.

They set out four levels of change that could happen with wide ranging results for the different types of insulation measures.

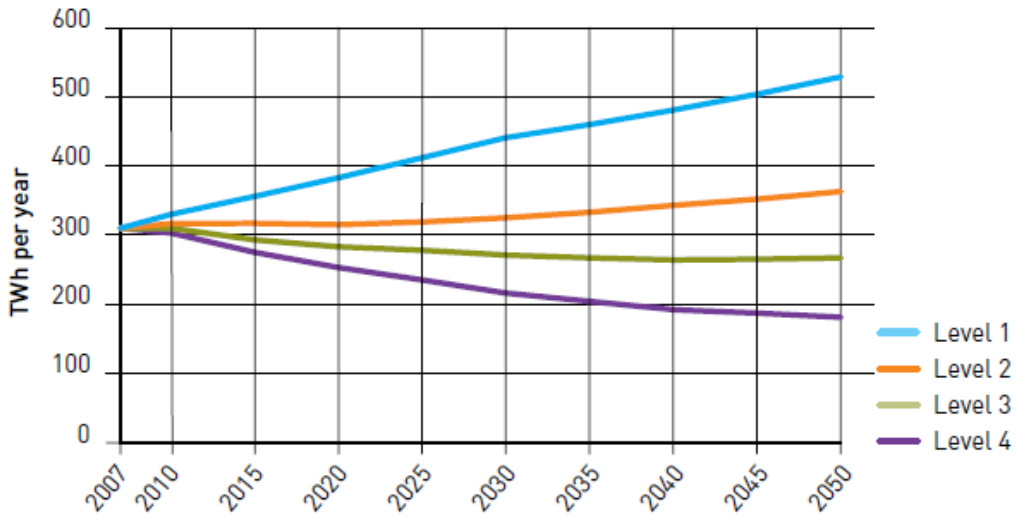
These four levels are then translated into a graph of annual consumption for the household sector. Two of the four levels lead to an increase in demand. Level 1 rises steeply and level 2 rises steadily.

If you look at the data closely you can see that they assume that in 2007 8m premises are suitable for solid wall insulation, 9m for cavity wall insulation, 12m floor insulation, 24m triple glazing, 22m loft insulation and 25m improved air-tightness.

To illustrate how wide the range of assumptions are, solid wall insulation is assumed to be carried out in 400,000 homes by 2011 in level 1 (a 5% success rate) compared to 7.7m homes by 2040 (a 96% success rate) in level 4. It can only be assumed that what they are saying in level 1 is that 400,000 homes will have had solid wall insulation completed in four years. But then nothing happens after that. The number of solid wall insulation installations that were carried out in 2007 is estimated at 34,000 of which 16,000 were new builds. So the rate of installation would have to increase significantly to meet the 400,000 target (up from 34,000 per year to 100,000 per year). In fact the actual level by the end of 2016 was in fact 715,000, but the rate of installation is currently only 50,000 per annum and has been for the four previous years. The rate of installation for the level 4 target would need to be 230,000 per annum. But there is a slight problem with solid wall insulation. The Energy Savings Trust states that it costs somewhere in the range £7,400 to £13,000 with a saving of £115 to £415per annum which gives an average payback period of around 40 years. There is also the added problem that it can increase the amount of condensation produced and this can lead to a range of problems from mould to structural damage. There are various hidden costs of this type of insulation of between £5,000 to £9,000 for external and £10,000 to £19,000 for internal. As mentioned earlier in this report the tragedy of the Grenfell fire will undoubtedly have an impact on the use of solid wall insulation.

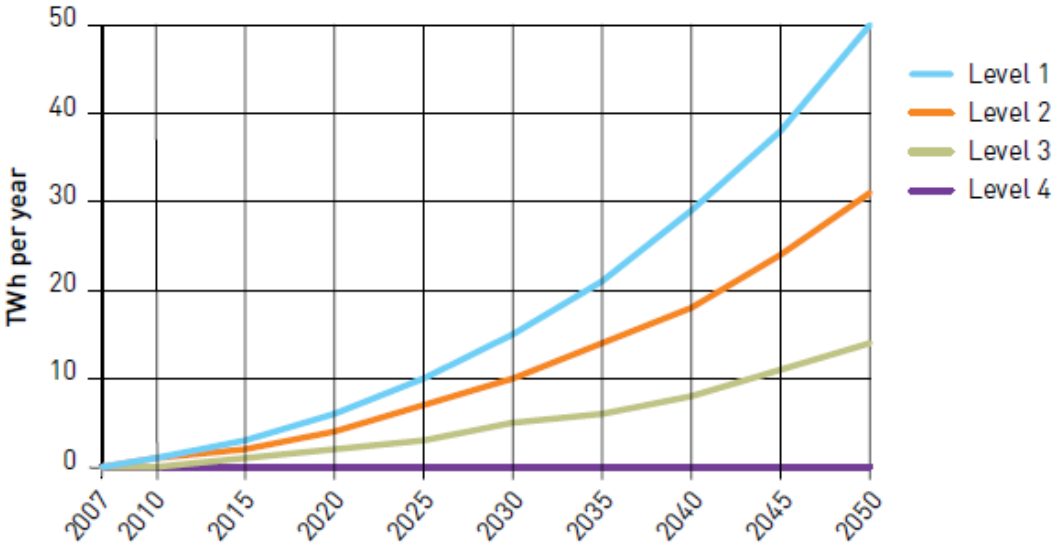
The four trajectories that DECC have used are illustrated in the graph below.

Figure D3: Trajectories for total domestic heat demand under four levels of change



On top of heat demand there is growth in energy consumption for cooling demand in all cases except level 4.

Figure D4: Trajectories for total domestic cooling demand under four levels of change



The same figures for the non-domestic sector are shown below which have a similar outcome.

Figure D5: Trajectories for total non-domestic heat demand under four levels of change

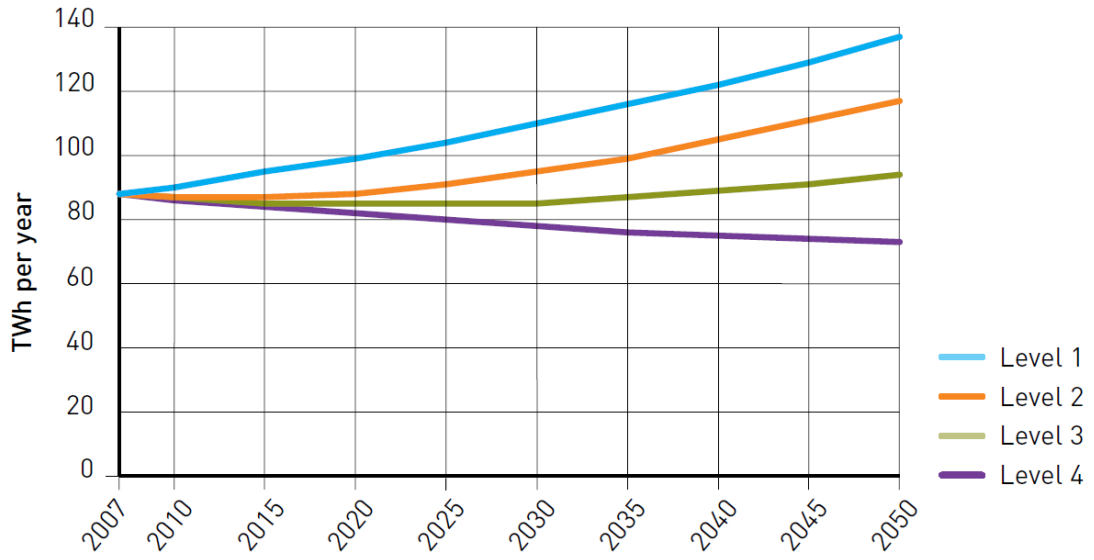
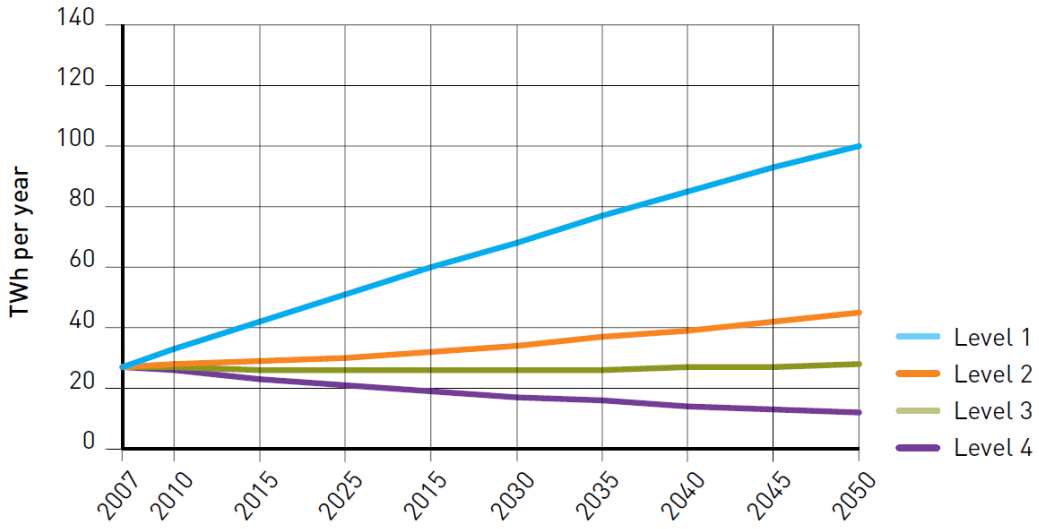


Figure D6: Trajectories for total non-domestic cooling demand under four levels of change



However the greatest impact on NGN demands of the DECC Pathways report is not whether various types of insulation will be installed, but whether there will be any gas demand (other than biogas) in the long term. If we exclude the impact of any growth in renewable heat then the impact of all insulation measures on domestic heating demand between 2007 and 2050 can be assumed to be broadly in the range from zero (as any increase in consumption in the DECC figures is assumed not to be attributed to reducing levels of insulation) and the difference between the level 1 consumption and the level 4 consumption. This equates to 350 TWh. If we assume that 70% of domestic heat is from gas that relates to a range for gas of zero to 245 TWh. The figures for non-domestic heat are zero to

63 TWh (which is zero to around 44 TWh for gas). This would give a total reduction in gas demand due to insulation measures of 290 TWh by 2050.

If we take the mid-point from the DECC data we get a total reduction in demand of 145 TWh by 2050. It would appear that the growth in energy efficiency from insulation is close to a linear relationship (at least in the major domestic market) and therefore it would be appropriate to pro-rate any reductions to obtain the figures for any year up to 2050.

DECC have acknowledged that there may still be a role for gas as a peak heat provider in 2050. The question is at what price would this gas be sold at given the need to recover the cost of maintaining the ability to supply at peak rates would be spread over a much smaller throughput? This throughput could be increased should there be a large amount of biogas produced. It should be noted however that high levels of biogas from waste are not likely given that there is a finite amount of waste produced. There is also pressure to reduce the amount of waste, particularly food waste, which will tend to reduce the potential for biogas generation. In any event biogas is still a fossil fuel and there would be sustained pressure to keep its production to a minimum, unless it was combusted to reduce methane leakage from waste sites into the atmosphere, methane having a global warming potential of between 7 and 60 times that of carbon dioxide.

7.2.3.2. Renewable Heat

DECC Pathways has a lot of commentary about the potential for renewable heat sources and in all its sixteen scenarios as stated above natural gas does not feature and only biogas has a role. This could in most cases be transported by the current networks.

The uptake of renewable heat is heavily dependent on consumers seeing more than just environmental benefits. There has to be a significant financial incentive to adopt new technology and to change their reliance on an extremely reliable and on demand service. Recent changes to the RHI could provide sufficient incentive in the short to medium term and would go some way to meet the scenarios presented by DECC. But the longer term situation is more uncertain if incentives tail off.

It would seem on balance that the outcome of the Green Gas scenario from Redpoint to be a much more pragmatic approach, rather than an idealistic one that places almost total reliance for the large proportion of heat supply on a combination of a single network (electricity) and the weather.

Should there become plentiful supplies of shale gas in the medium to long term there is potential to extend the lifespan of gas as a fuel, in combination with renewable energy sources, and even use gas as a source for high efficiency domestic CHP to provide back-up for renewable heat and localised electricity production. The current government is actively supporting the development of shale gas and in fact the technology used for shale extraction is being used to improve the economics and viability of conventional gas fields. There have however been instances of significant objection by green activists to the development of shale gas and some local authorities have refused planning permission for some sites, only to be overruled by central government. The extremely tight rules regarding the level of localised earth tremors that trigger production shutdown will hamper shale gas production.

By 2050 it is conceivable that hydrogen becomes a major energy source, generated from renewable electricity which could be transported in the existing gas networks. This may require some refurbishment to ensure that there is no leakage from the network as hydrogen molecules can pass through polyethylene pipe walls. Hydrogen leakage must be avoided at all cost as hydrogen explosions are considerably more destructive than those with natural gas. A better option may be to combine hydrogen with natural gas in some way in the existing network, although the amount of hydrogen that could be used would be limited by the impact that hydrogen has on appliance combustion characteristics when combined with methane. It would also reduce the capacity of a network as its calorific value is much lower than natural gas. Studies also show that hydrogen leakage rates through PE pipes are the same for pure hydrogen and a mixture with natural gas.

Hydrogen as a heat source is an area that is receiving some attention from NGN, Cadent, Ofgem, the Labour Party and the Energy and Climate Change Committee. There could therefore be developments in the medium to long term, if hydrogen production costs were sufficiently low compared to natural gas prices to make the mix, or even pure hydrogen a viable alternative energy source for heat. There is a possibility that Government may consider a mandatory switch to hydrogen, but this will meet with strong public resistance unless the safety and cost aspects are dealt with satisfactorily. A detailed study by Imperial College London on behalf of the Climate Change Committee does make it clear that the least cost solution for decarbonisation is the hybrid heat pump, using natural gas initially, then low carbon gas. Pure hydrogen and all electricity as a heat source are more expensive, pure hydrogen being the most expensive.

7.3. Conclusions

It would appear from the wide ranging information presented in all the relevant reports that there is an unprecedented level of uncertainty in the future of gas demand in Great Britain if you are looking to forecast gas demand out to 2050. There does seem to be currently an unprecedented focus on certain options, for example hydrogen as a replacement for natural gas.

Any forecast of drivers of gas demand will become either increasingly difficult to predict reasonably reliably requiring more scenarios or the drivers themselves change significantly over time. The current forecasts provided to NGN are appropriate for the relatively short period of 10 years but to forecast assumptions to be used out to 2050 would require a quite radical rethink of the methodologies used or include more drivers and more scenarios. With regard to gas prices there will need to be greater attention paid to the interaction with electricity prices, as opposed to oil prices, should the "electrification" of heating requirements develop. Other potential interactions are with heat prices for heat networks if they are developed extensively or hydrogen or biogas prices if these options become competitive or mandated.

It does appear that there are clear indications from government that they do not see a future for gas by 2050, but since the publication of the DECC Pathways document there does appear to be some slight softening of that stance, at least in the medium term, and many commentators are saying that we should not dismiss the role of gas in reducing carbon emissions, many of which have no clear vested interest in the future of the gas industry, like Dieter Helm. DECC themselves acknowledged that there may still be a role for gas as a peak heat provider in 2050. The government department that is the successor to DECC, DEBIS does not appear to have any strong policy at present with regard to the future use of

natural gas for heat. The government's encouragement of shale gas developments also suggests that support for gas is there, at least in the short to medium term.

How much power will the consumer actually have in deciding how to heat their homes? In an era where consumer choice has been strongly encouraged by Ofgem and the government, to take away a fundamental right to choose your energy source would be seen as a significant backward step. There are hints that in order to meet the 2050 targets some form of mandatory switch away from fossil fuels may be considered.

The key areas that will take on a much more significant role in the future are energy efficiency, renewable heat and sophisticated energy management systems. There were some clear indications from the former DECC of the level of insulation improvements that could be achieved, but in the absence of the highest levels of improvement, greater reductions in carbon based consumption will be required to achieve the 2050 emissions target. The renewable heat target for 2020 is almost certainly at risk of not being met.

The fundamental issue that affects the UK's ability to achieve its target is the upfront cost of installing high quality insulation and renewable technology. This is particularly important to households being the single largest major users of gas for heating currently. The Green Deal and RHI were intended to partly address the cost issues. The Green Deal was not as effective as expected by Government, until it was rebranded as a home improvement fund. RHI for both domestic and non-domestic premises has significant potential in the short to medium term.

To develop a realistic set of scenarios out to 2050 with regard to the impact of energy efficiency and renewable heat requires very careful scrutiny of the range of possibilities. It is recommended that changes that require the most extreme payback periods (say 40+ years) are not included in any analysis and low probability applied to those with long paybacks (say 20+ years). Where subsidies are available to bring down the payback periods, the most successful renewable projects will be those where the subsidy is likely to be more sustainable. There have been concerns from the Climate Change Committee that the RHI is most beneficial to those types of renewable heat equipment that are least likely to be installed, to the detriment of others that are more likely. The role of hybrid heat pumps may become increasingly significant and some commentators see the level of penetration of this form of renewable increasing over time, up to 40% of all heat pumps by 2050. Although the assumption is that natural gas would not be used by 2050.

Certain commentators have raised concerns that the market will not deliver the 2050 targets and some government intervention will be needed. This will clearly be a very sensitive political issue for some parties more than others and the Conservative win at the 2015 election did result in a softening of the environmental agenda. However the subsequent failure of the Conservatives to win an overall majority in the 2017 election and needing to rely on the DUP to retain power shows how volatile the political situation is at present. A shift away from the Conservatives to Labour with a strong left agenda could result in a strengthening of the environmental strategy in favour of tighter targets and even mandatory changes to UK heating policy.

Any prescriptive approach to energy policy will have a major impact on gas demand. This prescriptive approach could take the form of permitting wide scale fracking on the one side, using gas as the only permitted carbon based fuel, to

full support for all forms of renewable technology on the other with prohibition of all forms of carbon based energy and mandatory use of hydrogen for domestic heating. The DBEIS policy paper entitled "Clean Growth Strategy" sets out some key objectives aimed at greater efficiency and reduced carbon based fuel use.

The recent tightening to the 2030 EU targets and objectives will have an impact on the UK if these are retained as part of UK targets.

The legislative processes relating to the UK leaving the EU could produce a completely different approach to the handling of our environmental obligations. We may decide to remove the 2030 EU targets from our legislation and simply stick with the 2050 target set under the Climate Change Act 2008. The UK may choose to replace the 2030 EU targets with some other interim target to increase confidence in the UK's ability to meet the 2050 targets. Although there does not appear to be any indications that the UK would relax its targets compared to the EU. In fact it may well be a condition of trade with the EU that environmental targets are the same as the EU. If any of this happens then the actual pathways to 2050 will need to be revisited.

Appendix 1 – NGN Requirement

	Key Economic Indicators Historic & Forecast for UK economy & NGN Regions (North & North East) inc Scenarios	Data type	Historical Data Range	Forecast Data Range
Economic Factors	Gross Value Added	Annual	2005-2017	2018-2030
	Gross Value Added (Industrial Sector)	Annual	2005-2017	2018-2030
	Gross Value Added (Commercial Sector)	Annual	2005-2017	2018-2030
	Gross Value Added (Manufacturing Sector)	Annual	2005-2017	2018-2030
	Wholesale Gas Price	Annual	2005-2017	2018-2030
	Retail and Industrial Gas Price	Annual	2005-2017	2018-2030
	Gross Domestic Household Income	Annual	2005-2017	2018-2030
	Household Numbers	Annual	2005-2017	2018-2030
	Employment	Annual	2005-2017	2018-2030
	Average Wages	Annual	2005-2017	2018-2030
	Average Debt per household	Annual	2005-2017	2018-2030
Efficiency Measures	Energy efficient Gas boilers installed	Annual	2005-2017	2018-2030
	Lofts insulated	Annual	2005-2017	2018-2030
	Cavity walls insulated	Annual	2005-2017	2018-2030
	Ownership of Double glazing	Annual	2005-2017	2018-2030
	Total heat pumps installed and hybrid and gas absorption heat pumps	Annual	2005-2017	2018-2030
	Electric/ hybrid/ ultra-low emission vehicle uptake and gas/hydrogen vehicles	Annual	2005-2017	2018-2030
	Heat networks set up	Annual	2005-2017	2018-2030
	Combined Heat and Power generation	Annual	2005-2017	2018-2030
	Bio-methane & green gas	Annual	2005-2017	2018-2030
	Power generation (base load and peaking)	Annual	2005-2017	2018-2030

Appendix 2 – Historical Reports on Pathways to 2050

Redpoint Analysis

The Redpoint analysis commissioned by the Energy Networks Association draws heavily on the DECC Pathways analysis. Its conclusions are that gas does have a major role to play to 2050 but this is quite heavily caveated by the need for some major developments. These include:

- Successful roll-out of Carbon Capture Storage technology
- Biomethane injection into the distribution networks
- Roll-out of district heating systems
- Development of dual fuel domestic systems that can use gas and/or electricity

The study does highlight the fact that there are significant cost advantages of using gas compared to more electrification (£20,000 per household on an NPV basis). A high gas future also has advantages as other options rely heavily on new technology which will pose a range of risks to the delivery of a low carbon future compared to established technology associated with gas.

Gas networks are also stated as being cheaper to maintain than other options associated with a transition to a low-carbon future.

Four scenarios were developed by Redpoint which are summarised below.

- Green Gas – low prices (due to development of unconventional gas), CCS development, biomethane injection and use in CHP for district heating (some with CCS), duel fuel in domestic with gas providing the peak, some CNG
- Storage Solution – mainly gas at transmission level, low prices (due to development of unconventional gas), CCS development, gas key source of low carbon power generation, electricity and heat storage development resulting in steep decline in gas via distribution system (2/3rds decommissioned)
- Gas Versatility – No CCS so transmission gas for generation very low by 2050, heat/electricity storage not developed so gas retains balancing role and major source for heat, some CNG, maximise biomethane injection to reduce overall emissions from gas used in heating
- Electrical Revolution – gas eliminated over 30 to 40 year period, 2050 all gas networks decommissioned

The most important aspect of this study is that the Green Gas solution is on the surface a lower cost solution, but one which relies on the commercial development of CCS, district heating and large amounts of biogas. Given the recent developments of shale gas in the NW UK and other parts of the world, particularly the US, lower gas prices could be achieved (at least in the short to medium term) which could keep gas at the forefront when comparing with other energy sources, especially renewables that rely on incentives that can be removed at any time, or those that need electricity to operate. There are recent examples of renewable projects being shelved because of the changes to feed-in tariffs.

DECC Pathways

This document contains a detailed analysis of the possible future of different energy sources in different market sectors going out to 2050. For each sector of the economy, four trajectories have been developed, ranging from little or no effort to reduce emissions or save energy (level 1)to extremely ambitious changes that push towards the physical or technical limits of what can be achieved (level 4). The overall target is to reduce greenhouse gas emissions by 80% in 2050.

In the specific area of heating and cooling the technology pathways are detailed under sixteen different scenarios. For natural gas the implications are quite severe to say the least. Of the sixteen scenarios developed there are none with natural gas as a source and ten that contain biogas as a source, where it is acknowledged that this could be transported by the existing network. An essential element of the analysis is the assumptions regarding insulation and hence efficiency improvements.

From the material provided by DECC in the study there are some comments about factors that will affect take up rates of different types of efficiency measures. For example:-

- 28% of owner-occupiers do not take up any measures irrespective of how cost effective they are
- There is no incentive for landlords to spend money on insulation to save on their tenants energy bills – other than a £1500 tax allowance for them on each property where they install "solid wall insulation" for example – the latest Energy Bill does try to address this issue
- People are put off by floor and internal solid wall insulation because of the disruption and loss of floor space from the wall insulation
- Greater efficiency encourages "comfort taking" such that energy efficiency supports higher internal temperatures

There has been a theme running through many of the studies on renewable and efficiency improvements that will not go away, that is customer inertia.

Since the first publication of this document there have been updates to the underlying analysis. DECC have provided a substantial amount of detailed information and a model to allow anyone to vary the assumptions and see the impact that those changes make to UK consumption. This is available at https://www.gov.uk/2050-pathways-analysis#the-analysis

The major concern that this model raises is the large amount of variables that it introduces to what is obviously an extremely complex problem. The key issue for gas throughout is that the final result has to be a large reduction in the demand, either by much better efficiency in the short term and replacement by alternative less polluting energy sources in the long term.

It has been eight years since its original publication so it would be prudent for DECC, now DBEIS, to revisit their analysis to reflect on any developments in the interim period and update the analysis. The EU referendum should not affect this area given that this is a global issue and the 2050 targets are legally binding figures that were originally set by the UK as part of their commitment to the Kyoto protocol.

Carbon Plan

This document essentially restates the Governments objectives over the next 40 years or so.

In summary the following points are made.

- By 2020, we will complete the 'easy wins' that have helped emissions to fall by a quarter since 1990. By insulating all remaining cavity walls and lofts, while continuing to roll out more efficient condensing boilers, we will cut the amount consumers spend on heating by around £2 billion a year. Having fallen by a quarter in the last decade, average new car emissions will fall by a further third in the next, as internal combustion engines continue to become more efficient. Emissions from power stations, already down a quarter since 1990, will fall a further 40%, with most existing coal-fired power stations closing.

- The 2020s will require a change of gear. Technologies that are being demonstrated or deployed on a small scale now will need to move towards mass deployment. By 2030, up to around a half of the heat used in our buildings may come from low carbon technologies such as air- or ground-source heat pumps. Electric or hydrogen fuel cell cars will help to reduce vehicle emissions to less than half today's levels. New low carbon power stations – a mix of carbon capture and storage, renewables and nuclear power – will be built. In the 2020s, we will run a technology race, with the least-cost technologies winning the largest market share. Before then, our aim is to help a range of technologies bring down their costs so they are ready to compete when the starting gun is fired.

- The transition to a low carbon economy will require investment. But by insulating our homes better, and driving more fuel efficient cars, we will use less energy, offsetting the funding needed for low carbon energy. By investing in more diverse energy sources, we will be less vulnerable to fossil fuel price spikes. And by investing in industries that suit our geography and skills, such as offshore wind and carbon capture and storage, we will gain a long-term comparative advantage in industries with a big future.

- This plan shows that moving to a low carbon economy is practical, achievable and desirable. It will require investment in new ways of generating energy, not a sacrifice in living standards. But turning it into reality will require business, government and the public pulling in the same direction. We face big choices on infrastructure and investment.

100% Renewable by 2050

The conclusion of this report is that all heat can be produced from some form of renewable source in combination with hot water storage and the electricity grid. There is not acknowledgement of the difficulties that can be experienced in meeting heat demand in severe weather, which is a major omission from this study.

There are many good messages in the report however regarding recycling, reducing food waste and energy conservation.

Appendix 3 – A Greener Gas Grid

The Sustainable Gas Institute (SGI) published a white paper in July 2017 which examines the options available to decarbonise the gas network.
The SGI is an academic-industry partnership[19], with collaboration between the United Kingdom and Brazil. The Institute is multidisciplinary and operates on a global open innovation model, based at Imperial College London, and collaborating with leading universities in Brazil.

The stated aims of the Institute are to:

- Examine the environmental, economic and technological role of natural gas in the global energy landscape;
- Define the technologies and develop energy systems models that could explore the role of gas and other energy sources;
- Help to advance technology roadmaps to support future industry R&D investment decisions; and
- Address the global challenge of how to mitigate climate change

There follows a summary of the content of this white paper.

Existing gas networks are extensive, with an estimated 2.8 million kilometres of gas transport pipelines globally. Low pressure gas networks deliver a significant amount of energy annually to commercial and domestic consumers (8,158 terawatt-hours globally) with a large proportion of this used for heating in buildings. However, unabated natural gas use in the domestic and commercial sectors is unlikely to be compatible with climate change goals. The carbon emissions created by burning natural gas in modern gas boilers is in the range of 230 to 318 gCO2eq/kWh heat, including supply chain methane emissions.[20]

The carbon dioxide and methane emitted by natural gas systems and the difficulty in capturing emissions at domestic, commercial, and many industrial end-uses, is a problem for global carbon reduction ambitions. Country-level scenarios show a reduced role for gas networks in the future, often preferring electricity and heat pumps to decarbonise domestic and commercial energy services. However, there are significant technical, economic and consumer barriers to electrifying heat, which have made widespread uptake of electric heat challenging. Given these concerns there is a growing argument that decarbonised gas networks could play a significant role in the future energy system and contribute significantly to decarbonisation. The aim of the white paper is to review the evidence on options for the future use of gas networks, including the use of biomethane and hydrogen, focusing on their technical potential, carbon intensity and costs.

While much of the evidence is from a small number of countries, implications for other countries are explored. The study examines how these options compare to each other and to the electrification of heat via heat pumps.

The key findings of the study are outlined below.

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[19] The Sustainable Gas Institute was founded by Imperial College London in partnership with BG Group (now Royal Dutch Shell).
[20] This assumes 90% boiler efficiency for a modern domestic condensing boiler, UK 2015 natural gas combustion emissions of 184 gCO2 eq/kWh and supply chain emissions of 47 to 134 gCO2 eq/kWh.

1. Gas networks have the potential to play an important role in decarbonising the future energy system and therefore should not be discounted in energy scenarios.

   A number of options exist to decarbonise gas networks. A significant proportion of consumers could be converted to low-carbon gas where suitable networks exist. There are also significant benefits to decarbonising and maintaining these networks. These include:
   - utilising the value of existing assets;
   - the inherent flexibility of gas vectors;
   - consumer preference for gas based appliances; and
   - the relative low cost and ease of installing gas-fired heating systems in existing dwellings.

2. The storage potential of low carbon gas offers a significant advantage over electricity networks, providing relatively low cost flexibility, particularly for seasonal fluctuations in energy demand.

   - The fluctuations in gas demand are significant, though natural gas currently handles this challenge well. Future decarbonised gas options will have similarly flexible properties whereas for an electricity system, flexibility is more technically challenging and expensive.
   - For example, per kilowatt-hour the cheapest forms of electricity storage are approximately four times more expensive the highest cost estimates for hydrogen storage in salt caverns.
   - However, the value of this flexibility is unclear and dependent on a number of factors including the future balance of decarbonised gas and electricity demand, and the future costs and potential of all technologies that can provide system flexibility. Improving our understanding of the value of low carbon gas flexibility is therefore important.

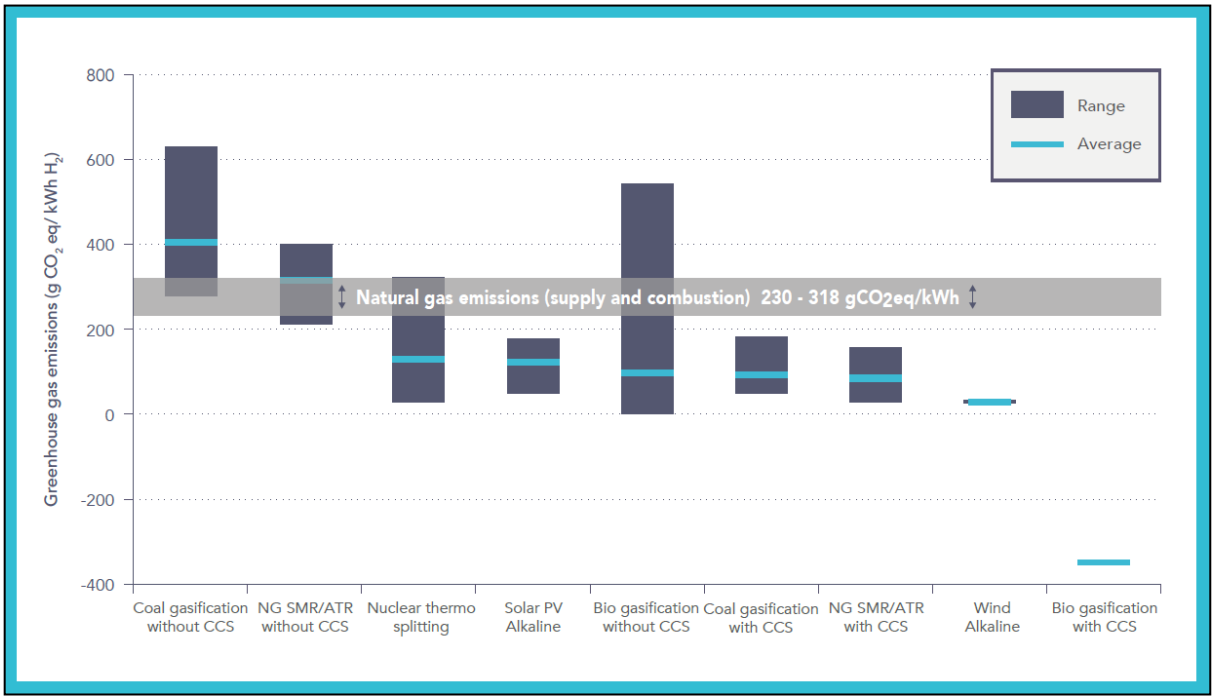
3. The options for producing decarbonised gas have a range of different positive characteristics, but there is no 'best option'.
   - Biomethane is most compatible with existing gas networks and may deliver negative emissions. Electrolysis has the potential to deliver very low carbon hydrogen from renewable energy without the need for carbon capture, and steam methane reformers (SMR) are scalable at relatively low cost.
   - However, these options also have limitations. For example, there are limitations on the future availability of biomass, and there will be competition for these resources. Electrolysis is currently expensive relative to other methods to produce hydrogen, although cost reductions are anticipated. Using natural gas to generate hydrogen in steam methane reformers could increase gas demand by 15% to 66% per unit of energy delivered to consumers relative to direct use of natural gas.
4. The range of CO2 emissions estimates for the different methods to produce low carbon gas is extremely large; -371 to 642 gCO2eq/kWh for hydrogen, and -50 to 450 gCO2eq/kWh for biomethane (see graph below).

   - The highest and most variable emissions come from fossil fuel routes to produce hydrogen that do not include carbon capture and storage (CCS). These technologies are likely to produce carbon intensities greater than current gas networks. Any fossil fuel routes to hydrogen

production must therefore include carbon capture and storage to avoid higher carbon intensity than the natural gas system it replaces.

- Emissions estimates for steam methane reformers with carbon capture and storage typically lie in the range of 23 to 150 gCO2eq/kWh, while CO2 emissions from electrolysis range from 25 to 178 gCO2eq/kWh[21] for renewable electricity sources. The carbon intensity of heat might be between 26 and 167 gCO2eq/kWh for methane based hydrogen and 27 to 198 gCO2eq/kWh for hydrogen from electrolysis, assuming a 90% efficient hydrogen boiler. Heat pumps with 250% efficiency using the same electricity might deliver heat with CO2 intensity of 10 to 71 gCO2eq/kWh.
- Supply chain emissions are an important aspect of decarbonised gas life cycles, particularly as emissions from decarbonised gas production decrease.
- Supply chain emissions include the methane and carbon dioxide emissions in the natural gas supply chain, the embodied carbon dioxide emissions in electricity generation, and the negative emissions associated with biomass cultivation.
- The supply chain emissions for hydrogen production from both steam methane reforming and electrolysis are the most important source of total emissions due to the relatively low emissions in the hydrogen production process. In both cases supply chain emissions are expected to decrease as emissions in gas production and transportation are reduced, and as decreasing electricity carbon intensity feeds back into the manufacturing of electricity generating technologies.
- Biomass gasification emissions are characterised by large negative supply chain emissions and large positive hydrogen production emissions. Small percentage improvements in biomass gasification emissions could therefore have relatively large impact on total emissions.

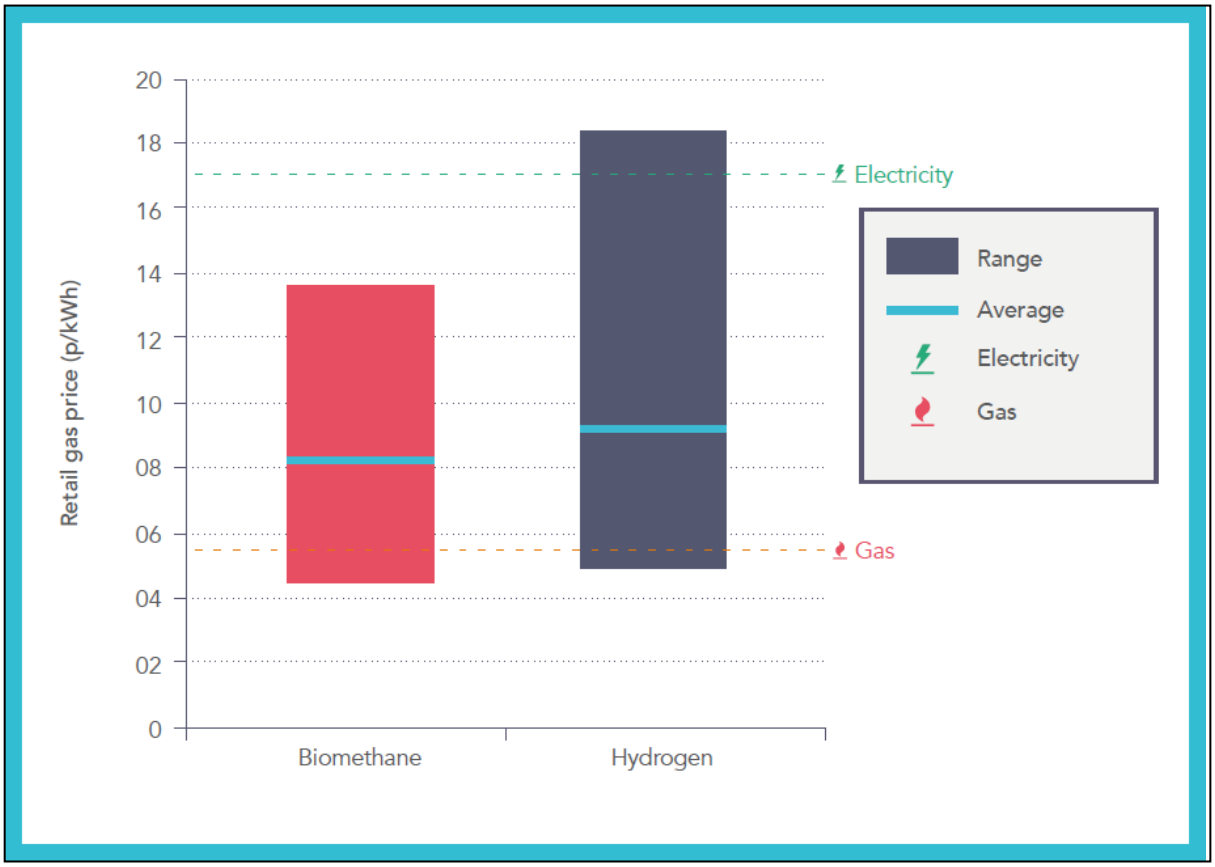
[21] This includes embodied emissions of renewable generation manufacturing.



5. The cost estimates for different decarbonised gas options vary significantly. The retail price achievable based on these costs might be 4.4 to 13.6 p/kWh (average 8.1 p/kWh) for biomethane compared to a hydrogen price estimate of 4.9 to 18.4 p/kWh (average 9.3 p/kWh)[22]
    - These prices exclude the costs of converting gas users to hydrogen compatible systems. Estimates can be compared to the EU average retail price of natural gas, 5.4 p/kWh, and the EU average retail price of electricity, 17p/kWh (both in 2015).
    - If the future efficiency of methane or hydrogen fired boilers is 90%, the costs of delivered heat ranges from 4.9 to 15.1 p/kWh heat for biomethane and 5.4 to 20.4 p/kWh heat for hydrogen. For comparison, at heat pump efficiencies of 250%, a retail electricity price of 17 p/kWh, heat pumps could produce heat for 6.8 p/kWh.
    - The additional cost of converting consumers to hydrogen gas networks may be over £3,000 per household including appliances and supporting equipment such as meters and domestic service pipes. This can be compared to the cost of installing air source heat pumps at between £4,000 to £11,000 or ground source heat pumps at £13,000 to £20,000.[23]

The graph below shows the estimate of retail price of decarbonised hydrogen and biomethane compared to the EU average retail prices of natural gas and electricity in 2015.

[22]These prices include costs for gas generation, transportation, storage, and assumptions regarding tax, profit and other additional costs.
[23] Note: SGI do not refer to the current Renewable Heat Incentives available for various renewable technologies.



6. Countries with mature gas networks such as the Netherlands, the UK and the USA may find gas network decarbonisation options attractive given the value of their existing assets.
    - Existing low pressure gas networks are compatible with biomethane, and the cost of converting existing low pressure gas networks to carry hydrogen is expected to be small relative to total system costs.
    - Countries with gas networks connected to less than 50% of gas consumers may continue to develop low pressure networks and may have opportunities to design those assets to be compatible with potential hydrogen conversion in the future.
    - Where low pressure gas distribution networks are very small or nonexistent the cost of building them may be significant, but not necessarily prohibitive. For example, to build a new hydrogen low pressure distribution network similar in length to the networks existing in the UK or Japan might cost £145 billion. Spread over 20 million domestic gas consumers (approximate number of UK gas consumers) this is £7,250 per household, which is within the order of costs associated with other types of domestic heat decarbonisation such as installing air source or ground source heat pumps. This can be compared to an estimated cost for repurposing an existing natural gas network of the same length to transport hydrogen of £2 billion or £10,000 per km.

7. There is limited real-world evidence on the capability of low pressure gas networks to transport 100% hydrogen gas streams effectively. Improving our understanding in this area will be key to making future investment decisions.

A number of studies exploring the decarbonisation of gas networks are designed around the transportation of hydrogen through existing low pressure gas infrastructure.

- However, there are a number of potential issues associated with this, including the increased potential for gas leaks.
- Several studies have considered, and tested, the durability, integrity and safety of existing low pressure gas distribution infrastructure in a small number of countries. They found increased but manageable gas leakage rates and safety concerns. However, this evidence often focusses on hydrogen/methane blends and not on 100% hydrogen gas streams. The diversity of materials and variable quality and age of existing low pressure gas networks is an issue for extrapolating these findings to realworld gas systems.

8. Key considerations for policy include:

- *Setting gas decarbonisation standards.* The carbon intensity of decarbonised gases differs due to a range of factors. If decarbonised gas networks are pursued then policy should ensure these systems are sufficiently low carbon. A number of policy approaches are possible, including a standard for low carbon gas or a market based mechanism. It is important that any policy measures used should ensure decarbonisation at the network level, and encourage the lowest possible carbon intensities.
- *Developing consumer awareness approaches for network conversion.* Choosing areas of the existing gas network to convert to hydrogen will be a significant policy consideration. Consumers in these areas will not have the option to continue using natural gas. This will raise related questions including what rights do these consumers have, how do you ensure equity between all gas network consumers and what does this mean for competitive energy markets.
- *Advancing the evidence base and standards around hydrogen safety.* Establishing the safety of hydrogen networks is an important first step before more significant gas network investment decisions are made. There is evidence that the safety of hydrogen networks is not a barrier. However, there is, currently, little demonstration evidence. An extensive and robust evidence base on safety issues should be developed before significant commitments are made on hydrogen networks. In 2017 the Department of Business Energy and Industrial Strategy announced a £25 million programme investigating hydrogen standards and the development and testing of hydrogen appliances in domestic buildings. Efforts should be made to coordinate these projects with existing activities.

9. There are a number of opportunities for future research. These include the development of practical demonstration projects, and new wholesystem modelling research that incorporates evidence from practical experience and quantifies the system-wide impacts.

- Future projects should be coordinated to ensure findings from practical demonstrations inform modelling efforts, and vice versa.

Priorities for practical demonstration of gas network decarbonisation options include:

- Examining the main gas network options to understand real world efficiencies, carbon intensities and costs achievable;
- Testing of hydrogen safety, in households, commercial consumer premises and in the existing low pressure gas network; and
- Analysis of the consumer and system-level impacts associated with new technologies such as hybrid gas/electric heat pumps, fuel cells or gas heat pumps.

Better whole-systems modelling analysis is needed, grounded in the practical reality of gas network decarbonisation options, to provide a stronger evidence base for decision makers. This includes:

- Spatially resolved and fine timescale whole-system modelling examining the conditions and locations under which gas networks may be competitive options;
- Modelling the interactions between gas, electricity and other energy infrastructures to better quantify the system value of gas flexibility and the optimal balance of energy system options to maximise this value while taking advantage of the positive characteristics of other energy system options; and
- Quantifying the economic costs and benefits of different gas network decarbonisation options to establish the conditions needed for a positive business case for investment in these options.

In conclusion the SGI are basically suggesting that we don’t make snap decisions based on a drive to decarbonise gas networks but that we evaluate the various options thoroughly from all perspectives and develop a coherent, rational and cost effective solution that is inherently as safe as the current system.

Appendix 4 – Ofgem's Future Insights Series - The Futures of Domestic Energy Consumption

This paper is the fourth in a series of "Future Insights" publications produced by Ofgem. It has developed from their Insights for Future Regulation project, launched in Spring 2016.

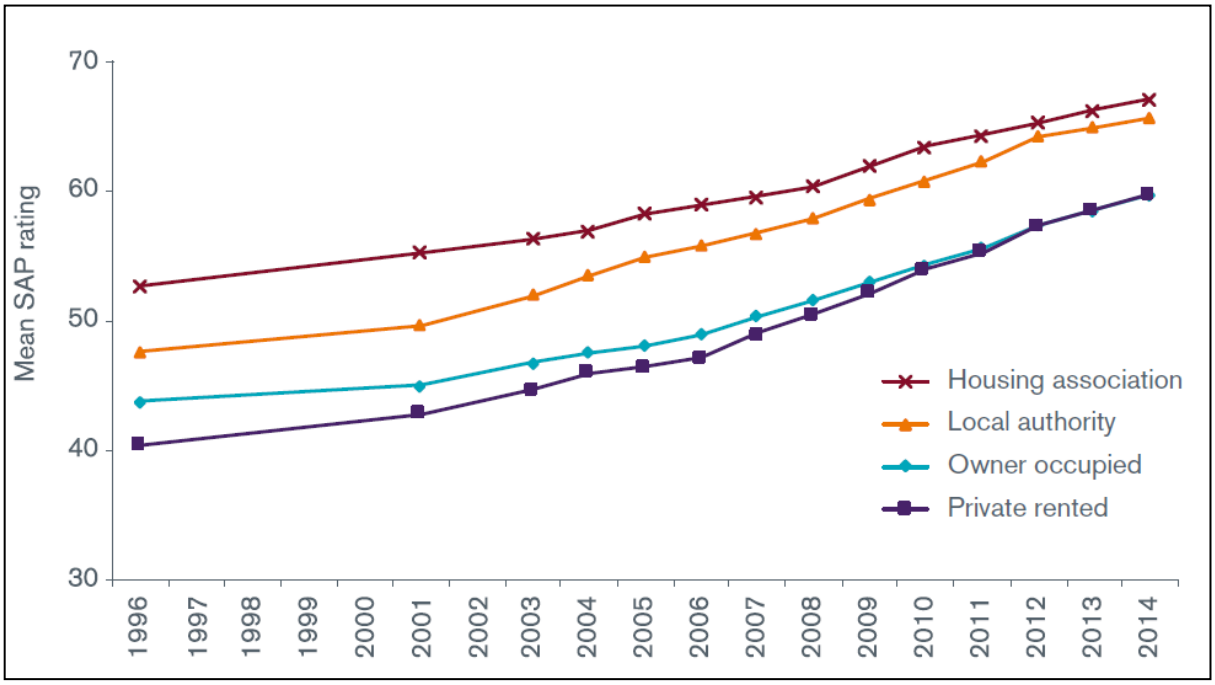
Ofgem acknowledge that many of the dynamics they discuss in this paper are more closely linked to electricity than to gas, while some go beyond specific fuels to consider experiences and energy services. They outlined their thinking on possible changes to the ways in which consumers heat their homes in their November 2016 paper, The Decarbonisation of Heat, which was outlined in a special topic in our November 2016 report. They do not look specifically at non-domestic consumers, but Ofgem claim that the experiences of smaller businesses may be similar to those of domestic consumers.
The report first puts things into context and then examines the potential changes to the demand profiles of consumers and in future how they will interact with the energy industry. They then look at what impact this will have on consumers and finish with an analysis of the regulatory implications.

Context

Technological Change

People do not consume energy for its own sake – rather, it is an essential intermediate good, used to heat homes, transport us from A to B and power appliances. The changing nature of goods and services that consume energy is therefore central to overall energy consumption. Positively, the energy efficiency of homes, means of transport and appliances continues to increase. Domestic energy demand has fallen by 19% since 2000, despite a 12% increase in the number of households and a 10% increase in population. The UK government estimates that, in 2014, the average SAP[24] rating of English dwellings was 61 – up from 45 in 1996, implying a 25% fall in modelled energy usage (see graph below). However, we will need to make significant further progress to achieve the goal of reducing carbon emissions by 80% by 2050 – particularly in decarbonising heating and transport.

[24] The government's Standard Assessment Procedure (SAP) is used to monitor the energy efficiency of homes. It is an index based on calculating annual space and water heating costs for a standard heating regime and is expressed on a scale of 1 (highly inefficient) to 100 (zero net energy cost).



While energy efficiency is increasing, the range of goods that consume energy is also growing. Twenty years ago, less than a third of households owned a computer. Now, many households own several, often operating day and night. In this context, the way in which energy consumption is managed could be crucial. The government's commitment to roll out 53 million smart meters by the end of 2020 is hoped will form the basis for enabling consumers to play an active role in managing their energy needs, but other technologies like Hive, Nest and others are probably going to be more effective. Along with other system changes, such as half-hourly settlement in electricity, it will also allow domestic consumers themselves to become providers of system services in new ways, if they see any financial benefit.

Ofgem list the various services that smart metering allows.

- Real time information on energy usage
- Automated use of smart appliances at cheapest times
- Billed for actual usage not estimates
- Growth of data
- Easier switching
- Personalised tariffs
- Consumer as provider of system services?

Many consumers have already become energy producers and service providers in their own right by installing micro generation equipment such as solar panels. There are around 900,000 photovoltaic installations across the UK, with a cumulative capacity of over 11GW. Over 90% of these installations are of a small-scale, domestic size (0 to 4kW). Although this is clearly a substantial amount there is no acknowledgement of the unreliability of this source and the potential issues associated with large summer generation surpluses should there be greater numbers of these installations.

The next phase of the ongoing technological revolution could take place within homes – through the appliances and platforms that control energy services. In the short term, smart tariffs, appliances and battery storage could allow

consumers to manage their demand more flexibly, providing battery storage technology is developed suitable for this application. Longer term, big data, accompanied by machine learning, could enable both more personalisation of services and more automation of the relationship between consumers and firms. Developments such as blockchain[25] could redefine domestic consumption practices, for instance by enabling consumers to trade with each other on a peer-to-peer basis, without the need for third parties. Achieving the benefits from such technological developments will require a regulatory and policy framework that supports innovation while recognising the need to protect consumer interests. This includes a more flexible and consumer focussed system for changing the energy industry rulebook where necessary.

Demographic and economic developments

These technological changes must be considered against the backdrop of potential large-scale changes in the nature of energy consumers. Some of these are fairly certain – we can be reasonably hopeful that average longevity will continue to increase, meaning that there will be more elderly consumers, and potentially more demand for tailored living arrangements for them. The Office for National Statistics expects more than one in 12 people to be aged over 80 by 2039; regulators and policymakers will need to ensure that elderly consumers, including those with health problems or restricted mobility, are able to engage fully with energy market developments.

The UK population is also likely to continue to increase – though the scale of the increase is dependent upon developments in net migration. The Office for National Statistics expects the total UK population to increase by 9.7 million by 2039, to 74.3 million people. The impact of these changes is more speculative.

We may see continued growth in the numbers of people living in rented accommodation, and in those living in high-density accommodation. While high-density living tends to be more energy-efficient, people living in rented accommodation currently often have limited choice over their energy supply and their methods of consumption, reducing their engagement with energy usage. The growth of smart metering could help to enhance consumer choice across payment and tenancy types.

Wider economic developments will also affect the energy sector. Real wages have stagnated in recent years, due to disappointing productivity growth and workers receiving a declining share of total economic output. The Institute for Fiscal Studies expects average real wages to be no higher in 2021 than they were in 2008. Unless energy bills fall in real terms, continued slow wage growth could lead to increasing numbers of people being at risk of fuel poverty.

An evolving retail market

Ofgem comment on the growth in the number of suppliers, tariffs and pricing models resulting in more switching by consumers. But then state that for many consumers, it could be that simplicity and a personalised service are more important considerations than financial savings alone; their 2016 consumer survey found that on average, consumers said that a financial saving of around £300 would be needed to encourage a change of supplier or tariff.

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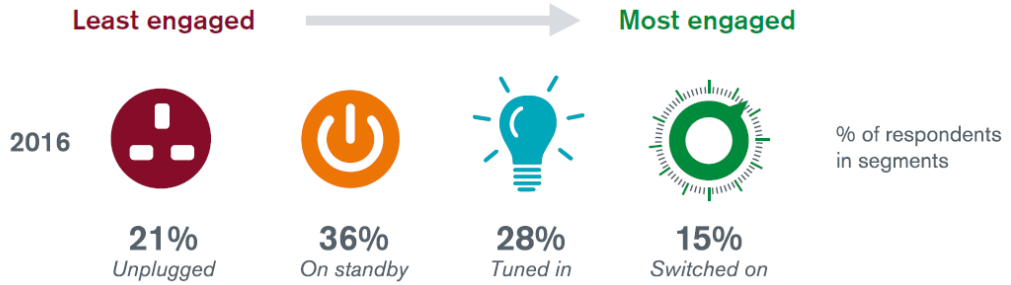
[25] Blockchain is a distributed digital database that automatically tracks transactions across a network. It is the basis of the Bitcoin digital payment system.

Continued evolution of the retail market, combined with technological developments, could result in new consumer offers such as the ability to purchase bundles of energy by the day rather than pay for metered usage (Scottish Power recently introduced a pay as you go package along these lines).

We may see consumers choose to pay for different service levels rather than primary fuels, blurring the traditional boundaries between energy and other services. Some energy service contracts already include insulation or appliance upgrades over time, as with mobile phone contracts. Increasingly, payments for such services are likely to happen in real time, via mobile apps or other platforms.

Evolving consumer profiles and interactions

The changes we are seeing in the energy system have implications for what it means to be an energy consumer, and how Ofgem should approach issues of consumer protection, engagement and vulnerability. Consumer surveys show that there are already many different ways of engaging with the energy industry. For instance, Ofgem's retail market surveys identify four categories of engagement – Unplugged, On standby, Tuned in and Switched on – based on factors such as rates of switching between suppliers and changing tariffs. The summary results of this survey are shown below.



Social Grade	Unplugged	On standby	Tuned in	Switched on
AB	14%	22%	27%	39%
C1	27%	32%	34%	33%
C2	23%	21%	20%	17%
DE	35%	25%	19%	12%

Source: Ofgem (2016) 'Consumer engagement in the energy market since the Retail Market Review - 2016 survey findings.'

Switched on consumers are more likely to be from higher socio-economic groups - a pattern that has strengthened since 2014. This means that it may be difficult to ensure that the benefits of innovation and decarbonisation are shared by all. Wealthier consumers may find it easier to invest upfront capital costs in battery storage, smart appliances and micro generation.

High-level categorisation of consumers can play a useful role in understanding consumer behaviour and developing responses to remedy a lack of engagement and to mitigate the effects of vulnerability.

However, the dynamics discussed in this paper hint at new developments within a number of these segments. For example, consumers that we presently consider Unplugged may choose to disengage by handing control of their energy supply or usage to a third party. Switched on households may no longer be involved in active switching, but could instead be selling their energy directly to local consumers.

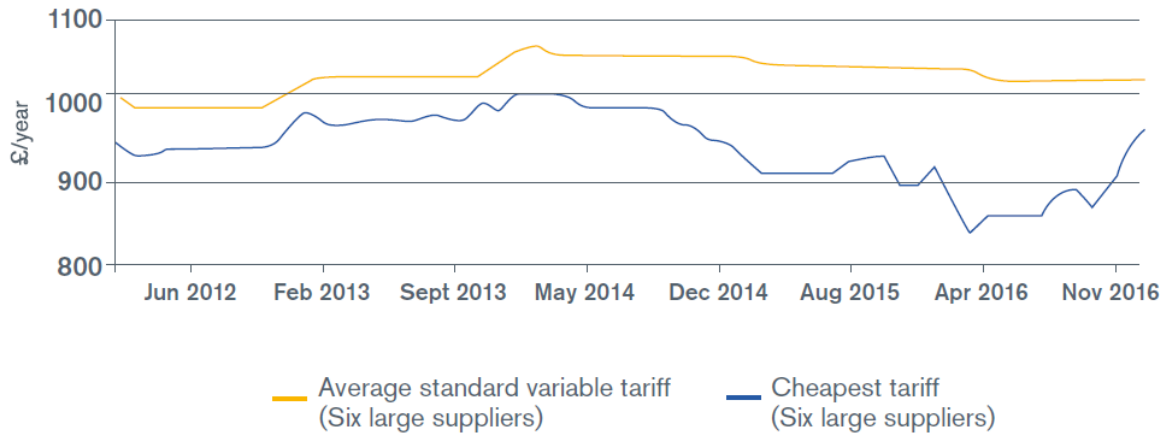
Consumer segmentation

The transition to a smarter energy system will lead to energy suppliers receiving vast amounts of data regarding consumer behaviours and preferences. This should permit greater diversity in tariff offerings.

Some of these may be more complex – with charges more closely reflecting real-time prices of energy and providing incentives to reduce energy demand at peak times. Tariff structures could incentivise charging of batteries or electric vehicles at times that are most beneficial to the wider system.

Alternatively, particularly if the marginal cost of energy falls, suppliers may choose to offer unlimited usage packages to consumers, as we see in telecoms markets. Consumption would then be limited by capacity rather than through pricing incentives.

Such developments could have very different implications for different types of consumers. There is already substantial dispersion of prices among customers (see below), with less engaged consumers tending to pay more on average. As suppliers gather more data on consumer behaviours and preferences, the scope for customer segmentation increases. This could lead to more perceived unfairness or to vulnerable consumers paying higher prices on average.



Source: Ofgem (2017) Data portal

As well as greater diversity in pricing schemes, big data may enable offers to be targeted to specific customers or customer groups on the basis of factors such as age, geography, wealth, behaviour or other factors. The theoretical economic concept of first-degree price discrimination – whereby each consumer is charged

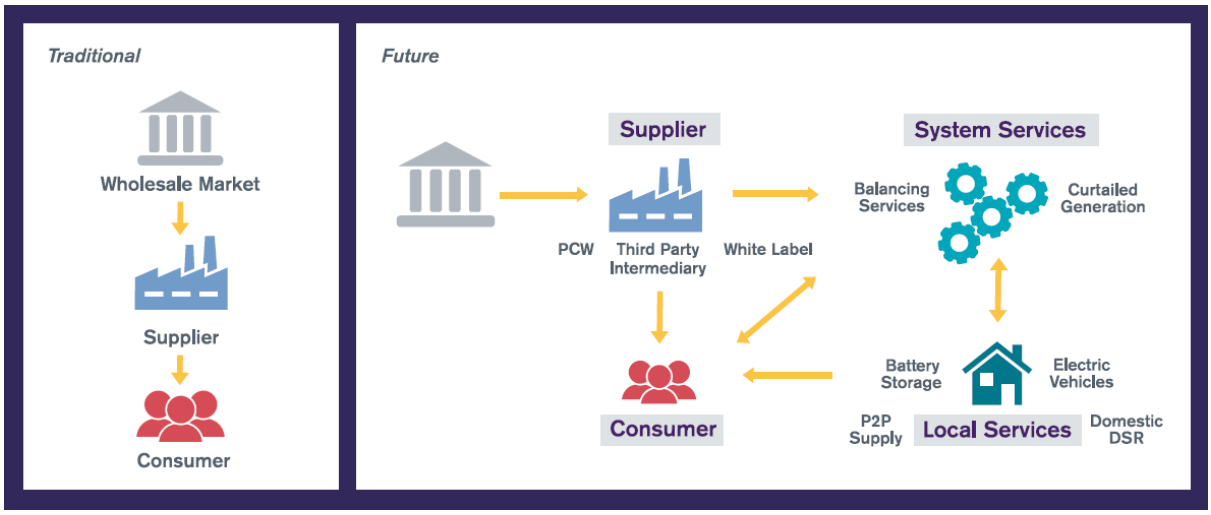
an individual price – becomes more practical in a data-rich world. While this could help to open new markets and respond to customer needs, competition could be harmed because of the information advantage of existing suppliers, leading consumers to lose out overall.

The role of consumers in the energy system

The shift away from a centralised, carbon-intensive energy system to one that is increasingly decentralised could see consumers play new roles and engage with the market in different ways. Some consumers may install more micro-generation and battery equipment, and participate fully in demand-side response activities. Others may prefer to hand over responsibility for decision-making to third parties, with energy services automated through smart equipment.

New business models are likely to emerge to provide balancing services or curtailment of generation, allowing better management of demand and supply changes at a system level. This will help the system to respond to trends such as the uptake of electric vehicles and increasing amounts of renewable energy, should the take up continue.

Consumers may also choose to engage more as members of groups, for instance through collective buying arrangements or local distributed generation projects. The diagram below shows one possible future role for consumers in a transformed energy system.



However, there remains a possibility that consumers will not adapt their behaviour or offer flexibility, for instance if they are unaware of the benefits of doing so or are concerned about the perceived loss of control over their energy usage or data. Moreover, there will inevitably remain consumers who lack the time or motivation to engage actively with the energy system. Ofgem and government need to ensure that their interests are still protected, and that decarbonisation and other objectives can be achieved.

<u>What does this mean for consumers?</u>

Ofgem's view of the future sustains their belief that there will be much new technology developed, new services and alternative ways of buying and selling energy that will transform the relationship between the energy market and consumers. Core to this is realising the potential of smart technology.

They state that in order to achieve the full potential of smart technology, the infrastructure around it will need to satisfy three key conditions:

- Ease of use and simplicity. These principles have been at the heart of the success of items such as tablets and mobile phones. We have already witnessed a digital transformation in other retail markets such as payments, travel and food, which has set expectations for the choice, standards of service and regulation that energy customers will want to see.
- Interoperability between different devices, where feasible. This should support effective competition between technologies and suppliers.
- Robust data handling procedures and cyber security will be important to ensuring consumers are confident in allowing firms to use their personal data. Some demand-side response activities may enable third parties to control appliances remotely. Secure systems will be needed to mitigate harm to individual consumers and potential adverse impacts on the wider energy system. This is a very serious issue, there have already been multiple examples of hackers getting into a whole range of remotely managed equipment.

Even with these conditions in place, some early trials suggest that consumer demand patterns will only shift substantially through automated responses, rather than through behaviour change alone. If the behaviour change necessary for a flexible energy system is not realised, restrictions on choice and activity could in some cases be justified – for example with regards to charging times for electric vehicles. This restrictive approach does go against Ofgem's traditional stance of letting the market control usage times.

Ofgem believe that the future could be not about buying energy per se but taking a service that meets a range of requirements, for example keeping heating within a range of temperature. Many of the potential services could sit outside current regulation for energy supply under the licences.

They also float the idea that billing might need to be linked to an individual rather than a premise with respect to rented accommodation.

<u>Possible regulatory implications</u>

Ofgem see there is a potential need for widening their current role to encompass enforcement of standards of behaviour of third party intermediaries when consumers may in practice see them as identical to licensed energy suppliers. Alternatively, should sector specific regulation become more limited in scope, with a greater role for generic consumer protection arrangements across sectors?

Protecting less-engaged and vulnerable consumers

At the heart of the issues discussed in this paper is the notion that energy services in the future will be increasingly personalised to consumers. It is likely that a data-rich environment will permit segmentation of consumers in different ways. If greater segmentation is possible, then is it desirable? This is a fundamental question that cuts to the heart of the current requirement for licensed suppliers to offer terms to all domestic consumers. Allowing energy suppliers to choose 'desirable' customers is unlikely to be in the interest of consumers as a whole if it restricts competition to particular market sub-groups. However, in certain circumstances, characteristics such as location or demand

profile could be used to offer a tariff that benefits both the consumer and the energy system.

Many of the changes taking place with regards to new business models and products are potentially positive. But it is important that the less engaged and those in vulnerable situations are also able to benefit.

With a greater diversity of service offerings and levels of engagement, Ofgem's regulatory role could become more focussed on those who are less engaged or more vulnerable. Questions of fairness could become more prominent, with an expectation that they ensure that the benefits of innovation are shared across consumers.

As the environment becomes more diverse and complex, providing an appropriate level of service for those not able to navigate the market could become more challenging. Ofgem and government will need to be able to use large real-time datasets to allow them to respond quickly and effectively to issues such as vulnerability and fuel poverty – or they will need to ensure that companies are doing so. For example, data on heating profiles for a home could be used to determine the more cost-effective approach to cutting costs – switching fuels or improving energy efficiency.

Vulnerability could also manifest itself in different ways. Ofgem define vulnerability as occurring when consumers' personal circumstances and characteristics combine with aspects of the market to mean that they are significantly less able than typical consumers to protect their interests in the energy market, or significantly more likely to suffer detriment. As the energy system develops, we might find that, for instance, middle-income families with limited time or assets find it harder to get a reasonable deal. Not all consumers may want to or be able to participate in an energy system based on real-time transactions and active management of energy usage and generation. Some may choose to hand over control to third parties but others could be at risk of being left behind. Social enterprises and local authorities could play a crucial role in spreading the benefits of energy system innovation more widely across society.

Enabling change

In a rapidly-changing energy system, Ofgem's believe that one of their key regulatory roles will be helping to enable firms to make changes that benefit consumers, through their rule-making, guidance and thought leadership. This will require greater understanding of the nature and extent of possible technological developments. They cannot predict the future with certainty, but they must be able to react quickly as possibilities begin to become more concrete. They will also need to continue to adapt to a changing landscape of energy suppliers, which is likely to include engagement with a wider range of firms and business models.

Sometimes, the best thing they can do will be to get out of the way and leave firms to innovate in ways that benefit both them and consumers. Through their Future of Retail Regulation project, they aim to establish broad principles that they expect energy companies to follow – without setting detailed rules as to how they should do so. But the extent of possible market or coordination failures in the energy sector means that they will sometimes have to intervene more actively, for instance to remove barriers to innovation (as in their recently-launched Innovation Link) or to achieve system-wide changes such as those needed to support domestic customer halfhourly settlement in electricity markets.

Many of the changes they hope to see will require consumers to change how they engage with the energy sector to achieve their full potential. Developments such as smart meter rollout and potential future changes to the appliances that heat our homes are examples of physical change that will enable, and in some instances require, consumers to behave in different ways. Communicating this message to energy consumers and active experimentation with business models and technologies that work with preferences will be key to the successful transition to a low-carbon economy.

If they do need to intervene to help consumers to engage more effectively, they must take heed of the lessons from previous interventions, summarised in Amelia Fletcher's recent report on behalf of Which?, "The Role of Demand-Side Remedies in Driving Effective Competition." These include looking to work with the grain of commercial approaches, and considering how firms' pricing strategies are likely to respond to regulatory interventions. In terms of process, the pace of change means that they will need to be able to test the effectiveness of proposed changes quickly, and adapt to the lessons learned.