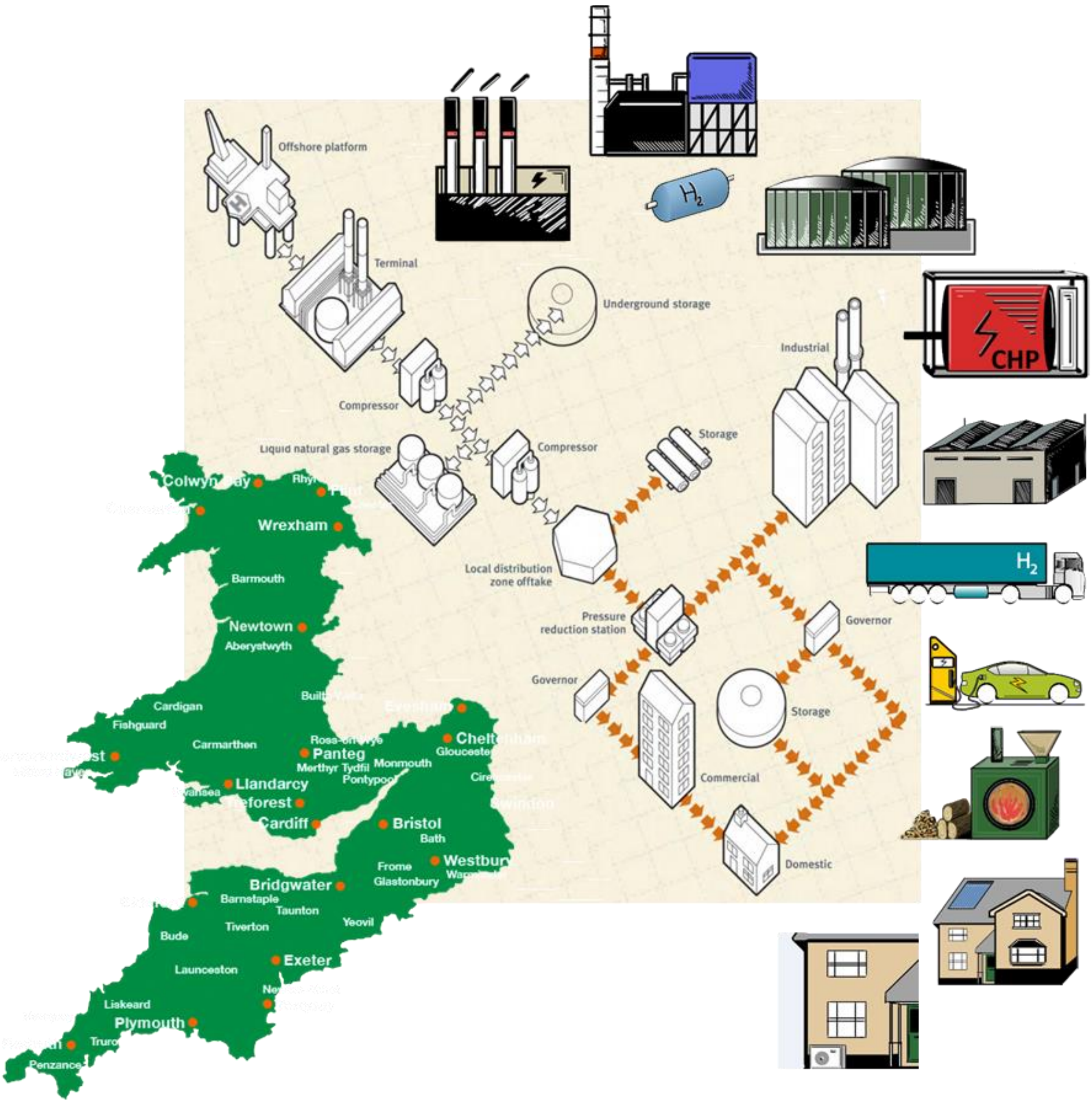
Network Innovation

Regional Growth Scenarios for Gas

Phase 1: Project inception and scope report



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1 Contents

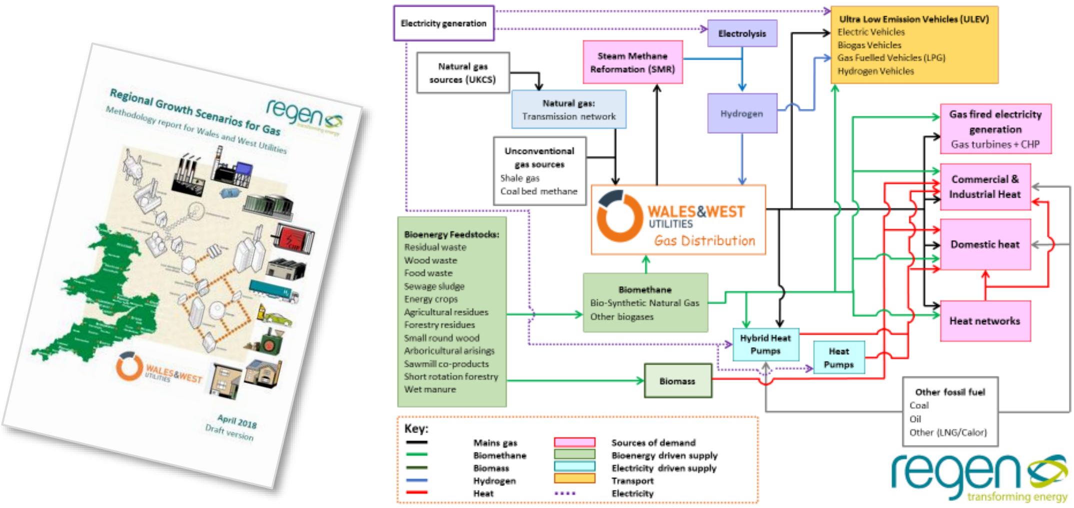
2 Introduction

To support Wales and West Utilities (WWU) future gas demand forecasting, network analysis and investment planning, Regen has been commissioned to undertake an innovation project to develop regional, and sub-regional, future energy scenarios for the key growth drivers impacting the gas distribution network.

2.1 Methodology development

In spring/summer of 2018, Regen worked with WWU to develop an overall methodology and approach to underpin the development of regional growth scenarios for gas. The methodology drew on the approach that has been adopted to develop regional growth scenarios for the electricity distribution networks[1], extending this approach to create an integrated methodology for heat demand and the gas network.

Figure 1: Regen Regional Growth Scenarios for Gas - Methodology Report (Spring 2018)



The methodology document sets out the key elements that are to be included in scenario forecasts, how the scenario forecasts are to be framed and projected, the timescales of the forecasts and the geographic distribution of the forecasts, as well as a consideration and verification of the forecasts through assessed modes of supply and profiles.

2.2 Innovation project launch

The Regional Energy Scenarios for Gas project has received Network Innovation Allowance (NIA) funding and was launched in November 2018. Some of the key features of the project were discussed and confirmed at the project launch between Regen and WWU.

Project phasing

The project has been divided into three phases.

- **Phase 1** – Project inception, clarification and data confirmation – Nov-18 to Jan-19
- **Phase 2** – South West Local Distribution Zone (LDZ) scenario analysis and projections – Q1/2 2019

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[1] See Regen's work around future development of distributed energy and demand up to 2030 for WPD: https://www.regensw.co.uk/the-future-of-network-infrastructure-studies

- **Phase 3** – Wales North and Wales South LDZ scenario analysis and projections – Q2/Q3 2019

2.3 Phase 1 Project inception, areas of clarification and scoping

This interim report marks the completion of the inception and scoping phase for the Regional Growth Scenarios for Gas (RGSG) project. It captures the key decisions, assumptions, definitions and scope.

This report and the slide set presented to the WWU team at the Phase 1 workshop outlined the following information:

- **Scope confirmation:** Confirmation of the overall innovation project scope, including geographic scope, scenarios, forecast timeframe and forecast elements
- **Scenario definition**: Including scenario interpretation and key growth assumptions and fifth Scenario
- **Definition of geographical distribution:** Define the geographical remit, the geographical boundary area(s), as well as smaller geographical 'zoning' to distribute the forecasts at a more local level
- **Confirmation of detailed growth factors:** Define the factors that will drive the scenario projections, such as 'growth factors' and 'geographical distribution' factors
- **Input data and evidence base:** List data sources that can act as the evidence for both the 'baseline' and 'pipeline' positions, for each of the identified sources of demand, supply, plus fuels and technologies
- **Stakeholder engagement plan:** Discuss the process to obtain key stakeholder and customer engagement, feedback and evidence to support, test and consult on the approach and results of the RGSG methodology
- **Updated Project delivery plan:** Such as the project timeline, milestones, resource and project team. (Including WWU role and resource)
- **Summary of the approach to ongoing issue and risk management:** Proposed risk register, issues log and method by which to flag risks and issues between the two organisations
- **Overview of the proposed dissemination and communications plan:** Summarise the communications 'pack' that is to be produced for each of the two phases, as well as the method by which the results are publicised.

3 Regional Growth Scenarios for Gas - Scope Confirmation

3.1 Purpose of assessment

The core aim of the project is to support WWU in their longer-term gas network planning, to understand the potential growth (or shrinkage) of potential new and existing sources of gas demand, potential sources and modes of supply and their related alternative heat delivery technologies and fuels. These future forecasts are to be projected for individual elements but are to culminate to provide an overarching gas demand forecast for WWU's wider gas distribution network.

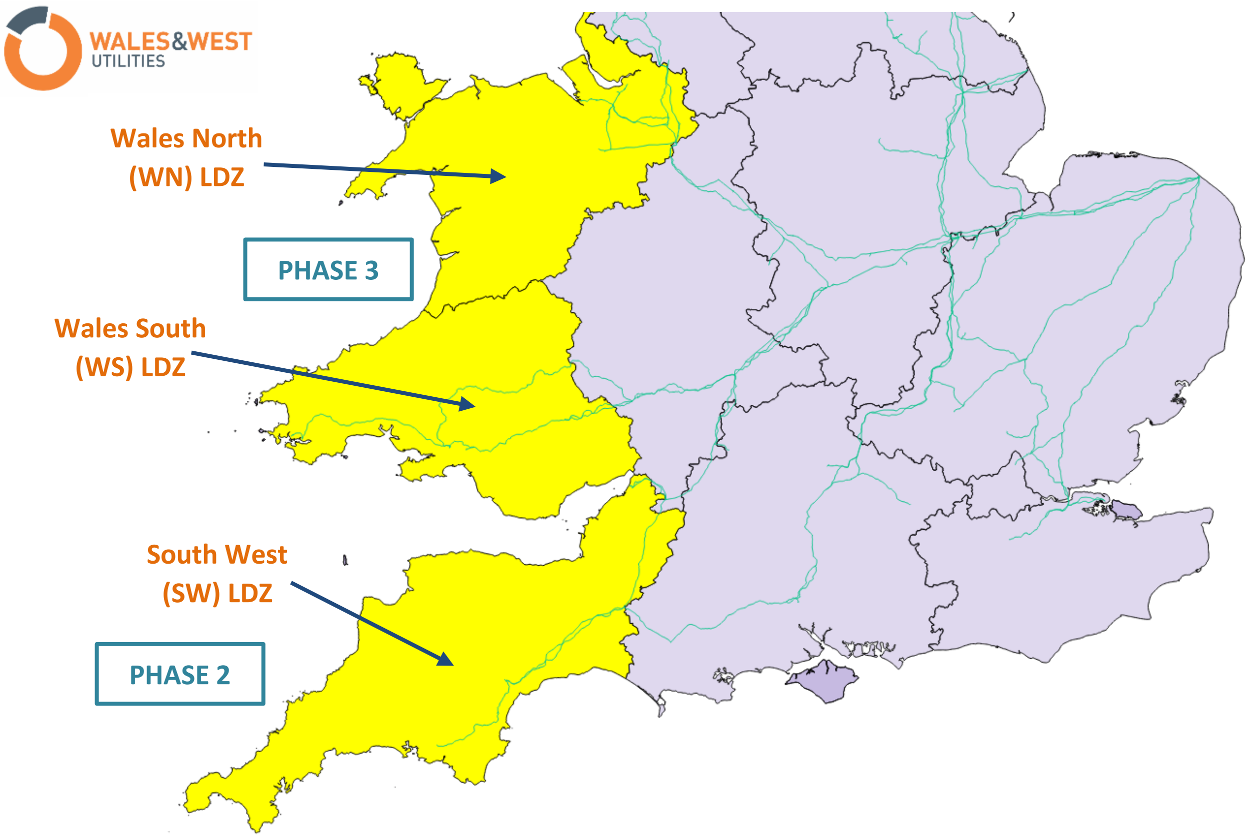
3.2 Sensitivity analysis

Sensitivity analysis of the projections will come via the use of a set of five energy scenarios (the National Grid FES 2018 + a fifth central WWU scenario). Using this five-scenario framework to frame the projections enables a useful level of variation in several areas concurrently, such as government policy and regulation, technological capability and costs, market factors and consumer behaviour. The use and interpretation of these five scenarios are discussed in more detail.

3.3 Geographic scope

The overall scope of the assessment is to cover all WWU's gas distribution network area. These can be readily ring-fenced to WWU's three Local Distribution Zones (LDZs): **South West (SW), Wales South (WS) and Wales North (WN)**, see Figure 2. The method by which the assessment will break down LDZs into smaller areas, namely Gas Supply Areas (or GSAs), is discussed in more detail later in this document.

Figure 2: Geographical scope of the project (with WWU LDZ boundaries and gas transmission network)

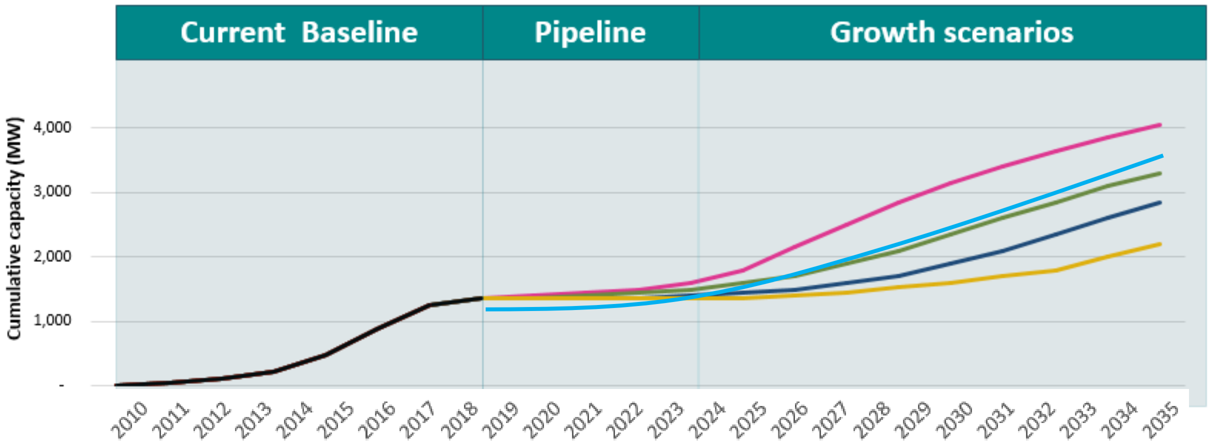


3.4 Timeframe

In order to produce annual projections for each of the identified gas system elements, factors and drivers, the timeframe for the assessment determines **2018** as the baseline year and **2035** as the end projection year. Depending on the element/factor in question, the projection analysis may also fall into three timeframe stages, see Figure 3:

- The current baseline (historical connected position → 2018 baseline year)
- The near-term pipeline (2018 baseline → mid-2020s, but this may differ by element)
- The future scenario-driven projections (end of pipeline → 2035 projection year)

Figure 3: Scenario projection time frame and stages



3.5 Approach to identifying the elements for future forecasting

The project has an overall intention to develop regional growth scenarios for key elements and factors that will have a material effect on the demand for gas from WWU's gas network. The methodology developed an approach to categorising many of the key elements of a gas network and a wider gas demand/supply system, breaking elements down into four key areas as described in Table 1.

Table 1: Description of gas system element categories

System Element Category	Description	Example Factors for Growth
Sources of demand	Identified classes of heat demand and energy demand	Domestic Heat Demand Commercial Heat Demand Industrial Gas Demand Gas Fired Power Generation
Modes of supply	The class of supply of heat or energy for each source of demand identified	Direct boiler, electric or heat pumps District heat networks Power generation or CHP plant
Delivery technologies	The variants of primary heat or power delivery technologies likely to be used – referring to conversion efficiency and gas volumes	Gas fired boiler, LPG boiler, oil boiler Biomass boiler Air source, Ground Source or Hybrid Heat Pumps (ASHP, GSHP, HybridHP) Electric heater, night storage heater, Gas Turbines, CHP
Supply fuels	The types and volume of fuel that is required to fire the delivery technologies	Mains gas, LPG, oil Biomethane injection or portable Biomass Electricity

In the methodology the overarching gas network and supply system was summarised in a high-level gas distribution system diagram, see Figure 4.

Figure 4: WWU gas distribution system diagram

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An assessment of the high-level elements that would need to be lifted from the above diagram to feed into and inform WWU's Network Investment Model was completed. The key elements that were identified are as follows:

- **Non Daily Metered (NDM) gas supply customers (including sub classes, new & existing)**
- **Daily Metered (DM) gas supply customers (including standard industrial users, new & existing)**
- **Gross and peak gas consumption adjustment factors (EPC efficiency, new build standards etc.)**
- **Alternative heat delivery technology adoption (heat pumps, hybrid heat, biomass boilers etc.)**
- **Gas fired power generation customers (new and existing)**
- **Biomethane injection sites (new and existing)**
- **Hydrogen – potential for gas blending and/or discrete hydrogen networks**
- **Transport demand (Gas fired vehicles and Electric Vehicles)**

In identifying these areas, it was identified that the reduction of one type of connected customer may affect the growth of another type of gas customer. Similarly, a connected customer switching the type of heat delivery technology or mode of supply (i.e. heat network) would have a similar shift-change effect on network gas demand and the volume and types of customers that are connected to WWU's network.

The next section of this report therefore identifies the actual elements and factors the project will look to undertake scenario projections on and details the relationship between the key factors.

4 Use of FES 2018, scenario definition and key scenario assumptions

4.1 Use of the FES 2018 within regional growth scenarios

The RGSG project will develop region specific growth scenarios to reflect regional growth drivers and demographics within the analysis framework of the National Grid ESO Future Energy Scenarios 2018 (FES 2018)[2].

The FES 2018 scenario framework will therefore be used to provide:

a) The national context for the scenario analysis framework and their underpinning assumptions
b) A point of reference and weighting for overall scenario growth and decarbonisation projections
c) A set of national benchmarks against which to analyse and explain regional projections and regional differences

Where regional scenario projections differ to the national projections, the project will identify and explain why this is the case. This is likely to be due to regional demographic, geographic or societal factors.

4.2 National Grid ESO - Future Energy Scenarios 2018 Overview

The 2018 edition of the Future Energy Scenarios (FES) introduces a number of new scenarios, based on a new axes framework reflecting the **Speed of Decarbonisation** and **Level of Decentralisation** in the GB energy system. Two of the four scenarios, '**Two Degrees**' and '**Community Renewables**, broadly meet the UK's decarbonisation commitments as set out in the Climate Change Act 2008, and commitment to decarbonise by 80% (compared to 1990 levels) by 2050. The two other scenarios, '**Steady Progression**' and '**Consumer Evolution**', do not meet the UK's decarbonisation commitments. See Figure 5.

Figure 5: National Grid ESO FES 2018 scenarios

[2] See National Grid ESO FES website launch of the 2018 document: http://fes.nationalgrid.com/fes-document/

These four scenarios are described by National Grid ESO to represent:

> *"…transparent, holistic paths through the uncertain energy landscape to help Government, our customers and other stakeholders make informed decisions. These scenarios are not forecasts, instead they show a range of plausible and credible pathways for the future of energy, from today out to 2050."*
>
> **Source: National Grid ESO, http://fes.nationalgrid.com/**

All the FES 2018 scenarios envisage a future GB energy system and economy that:

- Is more decarbonised, with an increasing influence of renewable energy sources and technologies
- Is more decentralised, with a greater proportion of energy demand and supply connected to a distributed energy system
- Relies on greater use of flexibility within the energy system enabled by smart technology
- Has a greater penetration of renewable electricity generation, including offshore wind, onshore wind and solar PV, and a falling carbon intensity of electricity
- Is more energy efficient, achieved through more efficient appliances and boilers, smarter energy use and improved building fabric of both new and existing properties
- Decarbonises transport through the use of electric vehicles and other fuels
- Features a reduction in gas demand from today's figure of over 800 TWh per annum

Where the scenarios differ, alongside the speed with which decarbonisation is achieved, is the mix of technology solutions adopted. This is particularly true of heat decarbonisation which, as the scenarios acknowledge, is still considered to be the most difficult area to decarbonise and for which a number of potential solutions are still in development. The consensus for heat decarbonisation is that no technology solution is likely to provide a single or universal solution. It is assumed, therefore, that different solutions may need to be deployed, and that these may well be specific to regional and local factors, including the nature of the heat demand, building or housing stock, urban-rural factors, energy resources and local infrastructure.

The key scenario questions, or areas of uncertainty, for gas and heat are therefore:

- The extent to which electrification of heat (via heat pumps or other electrification solutions) penetrates the market
- The options and opportunity to deploy new energy sources such as hydrogen and biomethane
- Delivery technologies such as the use or adaption of existing gas networks, new (hydrogen) networks and/or local heat networks
- The degree and depth of energy efficiency and building stock improvements

A further factor is the cost efficiency of the various options and the multi-vector (substitution) factors, such as the competing uses for hydrogen and biomethane in heat, transport and potentially power generation, that can only be considered by looking holistically at the whole energy system.

Consideration must also be given to energy security, and the need to ensure that future energy systems are able to meet peak demand as well as total demand and decarbonisation.

4.2.1 Two Degrees – scenario summary and implications for gas and heat

The **Two Degrees** scenario envisages a highly decarbonised economy, meeting the UK's decarbonisation objectives, but within an energy system that is more centralised, using larger-scale technologies such as nuclear and CCGT gas-fired generation with carbon capture and storage (CCS). **Two Degrees** also envisages a policy and governance environment that is more centrally directed through government intervention, investment and regulatory measures.

The **Two Degrees** scenario therefore features:

- High penetration of renewable generation, including larger-scale offshore wind, onshore wind and solar PV projects
- The highest deployment of nuclear power generation, including new nuclear investment. This has the effect of squeezing out baseload gas generation into a peaking function
- Larger-scale gas generation (CCGT), enabled with carbon capture and storage, performs the main peaking electricity generation function
- Other, centralised sources of generation flexibility, including interconnectors and large-scale battery and other storage technologies
- Very significant improvements in energy and appliance efficiency with the adoption of widespread and radical measures to improve building efficiency and performance of the GB housing stock
- Decarbonisation of heat achieved using a number of solutions, including high growth in heat pump installation, alongside district heat networks and the use of hydrogen
- 14% of homes have heat pumps by 2035. 19% percent of heat pumps installed are hybrid
- Over two million GB homes on a district heat network, and over one million homes are supplied with energy via a hydrogen network, by 2035
- Electric vehicles dominating the transport sector and providing the main means of decarbonisation. Other vehicle types, including hydrogen vehicles, biomethane and natural gas vehicles, also play a key role
- Hydrogen providing an important new energy medium for use in both heating and transport. Hydrogen is manufactured using large-scale steam-methane reformation (SMR) plus CCS, creating a new demand source for methane gas which to some extent offsets the fall in demand for methane for direct heat and power generation
- Delivery of hydrogen for heating via discrete hydrogen networks, such as the proposed Leeds H2 project. None of the FES 2018 scenarios envisage hydrogen gas blending into the existing gas networks
- Overall demand for natural gas dropping significantly for both power generation and heating, falling to 506 TWh by 2035, before demand for methane for hydrogen production increases demand through to 2050

4.2.2 Community Renewables – scenario summary and implications for gas and heat

Community Renewables also achieves a high level of decarbonisation consistent with the UK's climate change goals. In this scenario, however, more emphasis is placed on local and regional solutions, including the greater use of decentralised technologies and resources. This includes the greater deployment of small-scale renewables, in particular community and roof-mounted solar PV. Flexibility is also provided at smaller scale through decentralised peaking plant, battery storage and demand side flexibility.

While there is less reliance on nuclear energy, offshore wind provides an important source of low carbon energy.

Community Renewables envisages a policy and governance environment that is less centrally directed, with more local regional and city level investment and interventions with fewer top-down regulatory measures.

The **Community Renewables** scenario therefore features:

- The highest deployment of renewable electricity generation (reaching 125 GW capacity by 2035) with very high levels of solar PV generation
- A significant decline in nuclear generating capacity
- A higher capacity of gas-powered electricity generation, with a growth in smaller-scale peaking plant including OCGT and gas reciprocating engines
- Other sources of generation flexibility, including interconnectors, the highest deployment of large-scale and small-scale electricity storage, and use of vehicle-to-grid technology
- Very significant improvements in energy and appliance efficiency, in a similar fashion to the **Two Degrees** scenario, with the adoption of widespread and radical measures to improve building efficiency and the GB housing stock
- Heat pumps and electrification as the dominant technology used to decarbonise heat, alongside district heating solutions and biomethane. In addition, 23% of homes have heat pumps by 2035; 15% percent of heat pumps installed are hybrid
- Over one million GB homes on a district heat network by 2035
- Electric vehicles dominating the transport sector and providing the main means of decarbonisation. Other vehicle types, including hydrogen vehicles, biomethane and natural gas vehicles, also play a key role
- Hydrogen is used for transport, growing post-2040, but not for heating. Hydrogen is manufactured using electrolysis, taking advantage of low carbon electricity from renewables and storage
- Overall demand for natural gas significantly reduced for both heating and power generation fuel. Demand falls to 406 TWh by 2035 and continues to fall through to 2050, without the added demand for methane for hydrogen production that features in the **Two Degrees** scenario.

4.2.3 Consumer Evolution and Steady Progression – scenario summaries and implications for gas and heat

While both scenarios include a greater uptake of low carbon energy sources, neither the **Consumer Evolution** or **Steady Progression** scenarios achieve the level of decarbonisation needed to meet the UK's climate change commitments.

Both scenarios envisage a continued reliance on fossil fuel technologies, with a lower deployment of renewables for power generation, heating and transport. Gas generation capacity grows under both scenarios to over 36 GW (**Steady Progression**) and 40 GW (**Consumer Evolution**) by 2035, although both volume of gas consumed and generation capacity factors fall. Although there are some efficiency improvements, when combined with population and economic growth, the overall level of energy demand remains high.

Given lower renewable deployment, the requirements for flexibility from storage and interconnectors are reduced relative to **Two Degrees** and **Community Renewables** scenarios.

Steady Progression presents a more centralised energy future, in a similar fashion to **Two Degrees**, but features:

- A slower build-out of renewable electricity generation, reaching only 80 GW by 2035, mainly in the form of larger-scale offshore wind with some additional growth in onshore wind and solar PV deployment
- A high growth in nuclear capacity, replacing existing capacity and increasing to 10 GW by 2035
- An overall increase in gas-fired power generation capacity with a replacement of over 28 GW of large-scale CCGT capacity. Gas usage for power and generating capacity factors continue to fall, however, as renewables and nuclear capacity grow
- High growth in deployment of interconnectors, but a much lower growth in energy storage and other sources of flexibility
- Much lower and slower levels of improvement in energy and appliance efficiency
- Heat pump uptake remaining very slow, reaching only 3% of households by 2035
- Over 800,000 GB homes are on a district heat network by 2035, compared to c.490,000 today
- Delayed electric vehicle growth, although by the late 2030s electric car sales begin to accelerate rapidly. There is little demand for hydrogen vehicles but some slower growth in gas vehicles in the 2040s
- Overall the demand for natural gas is reduced both as a heating and power generation fuel, falling to 596 TWh by 2035, but rising again to over 600 TWh by 2050 as further economic growth kicks in

Consumer Evolution is similar to **Community Renewables** in the sense of presenting a more centralised energy future, albeit with a much slower uptake of renewable energy. Within the **Consumer Evolution** scenario the adoption of new, cleaner technology is driven by consumer choice, rather than policy intervention, and is therefore predicated on cost reduction and value for money considerations. The **Consumer Evolution** scenario features:

- A slower build-out of renewable electricity generation, reaching 83 GW by 2035 with more solar PV and onshore wind but less offshore wind relative to Steady Progression
- A reduction in nuclear power to 6 GW by 2035
- An overall increase in gas-fired power generation capacity, reaching 40 GW by 2035, with a big increase in distribution connected gas CHP, reciprocating engines as well as growth in larger scale CCGT capacity
- Falling demand of gas for power leads to falling capacity factors, however generators still achieve an average capacity factor of around 17% in 2035, indicating retention of some base power generation as well as peaking loads
- Lower growth in interconnector capacity, but a higher growth in energy storage and other sources of flexibility compared to Steady Progression
- Much lower and slower levels of improvement in energy and appliance efficiency
- Heat pump growth reaching 7% of households by 2035
- Only 650 thousand GB homes are on a district heat network by 2035, compared to 450 thousand today
- Delayed electric vehicle growth, although by the late 2030s electric car sales begin to accelerate rapidly. There is little demand for hydrogen vehicles but some slower growth in gas vehicles in the 2040s
- The smallest reduction in natural gas demand of the four scenarios, falling to 615 TWh by 2035, as fossil fuels remain an important fuel source for both heating and power generation. Demand continues to fall, however, reaching as low as 548 TWh in 2050 as the adoption of low carbon technologies eventually gathers pace

4.3 Regional factors and a potential fifth Scenario or sensitivity analysis

A key part of the RGSG will be to interpret and translate the national scenarios summarised above into a regional context by understanding and applying regional growth drivers and demographic factors.

In developing a set of regional scenarios, the RGSG project will consider whether there is a potential fifth Scenario which also achieves the UK's decarbonisation objectives in the period to 2035, but which would make better use of the existing gas network and infrastructure.

The working title of the fifth Scenario is **'Hybrid Accelerator'**, featuring:

- **Hybrid Heat Pumps** - A high uptake of heat pumps (less than **Community Renewables** but slightly higher than **Two Degrees**) of which a high proportion are in the form of hybrid heat pumps with a gas backup. This approach draws on the research and conclusions of the Freedom[3] project, which suggests that hybrid heat pumps could be both carbon and energy efficient
- **Decarbonisation of Gas** – A strategy to blend biomethane and hydrogen into the existing gas network at low concentrations, which would not require network or appliance upgrade

The **Hybrid Accelerator** scenario is based on the use of hybrid heat pump (HHP) technologies that combine the use of gas and electric heating systems, with a smart controller that determines when it is most cost and carbon efficient to use each technology. The gas in a hybrid heating system could be natural gas, a carbon-neutral gas such as biogas, or in the future, hydrogen.

An advantage of such an approach would be to make better use of the existing gas infrastructure, whilst still achieving a high degree of decarbonisation in the near term. This approach would also keep options open for future strategies to electrify heat (rolling out heat pumps) or new hydrogen-based energy solutions. A further key advantage would be to provide an additional source of flexibility within the energy system; in particular, the ability to switch heating load away from electricity at times when the network may be constrained, or generation is reduced.

This "hybrid pathway" is one of the heat decarbonisation pathways identified by the Committee on Climate Change and Imperial College[4] as a potential least-regret option to decarbonise heat. A hybrid pathway would enable decarbonisation to proceed over the next decade while innovation and demonstration projects address the uncertainty about the cost and carbon efficiency of hydrogen production via steam methane reformations with CCS, or electrolysis.

[3] Freedom Project - https://www.wwutilities.co.uk/media/2829/freedom-project-final-report-october-2018.pdf

[4] Imperial College - Analysis of Alternative UK Heat Decarbonisation Pathways For the Committee on Climate Change August 2018 https://www.theccc.org.uk/wp-content/uploads/2018/06/Imperial-College-2018-Analysis-of-Alternative-UK-Heat-Decarbonisation-Pathways.pdf

4.3.1 Additional regional factors within WWU's gas network licence areas

Table 2 highlights some of the key regional factors and assumption which will be applied to develop regional scenarios within the WWU distribution areas.

Table 2 Highlights of regional factors with the WWU distribution areas

Initial regional factors for the South West, South Wales and North Wales	
Heat pump deployment	The historic rate of heat pump deployment has been low throughout the WWU network areas, and although there has been some recent uplift, heat pump adoption remains challenging. The South West has seen a higher adoption rate than Wales. It is anticipated that heat pump adoption will continue to lag behind the national average under all scenarios, and would require significant policy intervention under a **Two Degrees** or **Community Renewables** scenario.
District heat networks	There are a number of regional district heat projects in the pipeline, either in planning or proposal stage, such as the projects proposed in Cardiff, Bridgend and Bristol. Under a **Two Degrees** scenario it is assumed that these will be built and that there will be a continued growth of heat networks through the next decade. In other scenarios it is assumed that a proportion of the heat networks will be built, with very little delivered under **Steady Progression** and **Consumer Evolution**.
Biomethane injection	There are several biomethane-to-grid injection projects already in operation in the South West, and a smaller number in the pipeline for South Wales. Biomethane injection to the grid could help to decarbonise the gas network, but is competing with other potential uses of biomethane for transport and power generation.
CHPs and gas-powered generation	A key growth driver for the gas network will be the deployment of distributed, gas-powered generation. Already WWU has seen a significant increase in gas reciprocating engines and CHP assets and there is a strong pipeline of projects with connection agreements. The business case for 'peaking' gas plant could however be impacted by changes to the methodology for network charging[5], as well as

[5]https://www.ofgem.gov.uk/system/files/docs/2018/11/decision_to_launch_a_balancing_services_charges_taskforce.pdf

	competition from other sources of flexibility, including new generation CCGT plants with reduced response times. In a **Community Renewables** and fifth **Hybrid Accelerator** scenario, it will be assumed that the current pipeline of distribution network connected CHP and peaking plant will largely be deployed. Under a **Two Degrees** scenario a lower deployment rate will be modelled.
Hydrogen	Hydrogen could become a significant fuel in a future decarbonised energy system. There are uncertainties however over the role that hydrogen can play and the mode of energy delivery: • Hydrogen for transport • Hydrogen networks • Hydrogen injection into the existing gas network There are also uncertainties over the method of manufacture, and the cost/carbon efficiency of hydrogen conversion and carbon capture processes: • Steam Methane Reformation (SMR) with CCS – the most likely manufacturing process if conversion efficiency and carbon capture technology is proven to be viable • Electrolysis – if there is access to low cost and low carbon renewable electricity Within the WWU network areas there are already a number of small-scale SMR sites producing hydrogen for industrial uses. It is unlikely that large-scale hydrogen manufacturing and hydrogen networks, on the scale of the Leeds H2 project[6], will be developed in the WWU distribution areas within the period to 2035. In a **Two Degrees** scenario it is anticipated that some smaller hydrogen networks may be established in the South West and Wales by 2035, with manufacture via SMR plus CCS. In a fifth **Hybrid Accelerator** scenario, it is projected that some hydrogen blending into the gas distribution network will be achieved.

https://www.ofgem.gov.uk/system/files/docs/2018/11/targeted_charging_review_minded_to_decision_and_draft_impact_assessment.pdf

[6] Leeds H21 project https://www.northerngasnetworks.co.uk/wp-content/uploads/2017/04/H21-Report-Interactive-PDF-July-2016.compressed.pdf

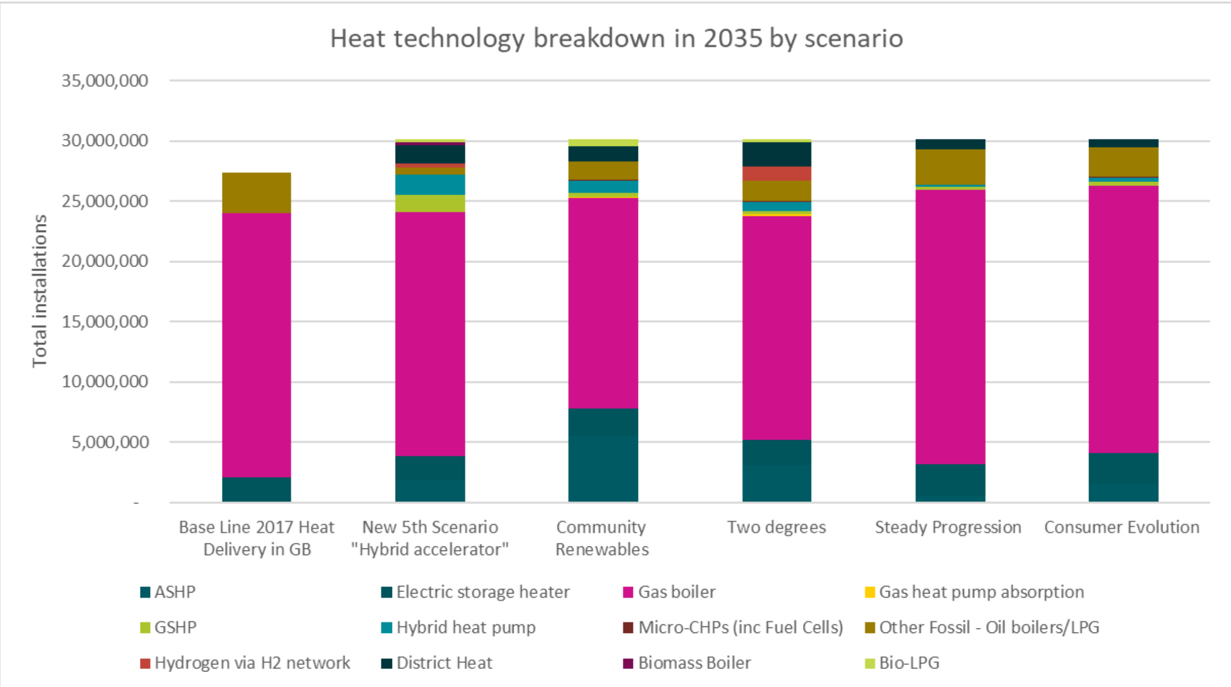
4.3.2 FES 2018 key charts and analysis relating to gas and heat

Technologies for domestic heating 2035

Figure 6 GB Domestic heating technologies 2935 snapshot - Source FES 2018 and New fifth scenario

FES 2018 Domestic Heat Technology Installations in 2035	Base Line 2017 Heat Delivery in GB	New 5th Scenario "Hybrid accelerator"	Community Renewables	Two degrees	Steady Progression	Consumer Evolution
ASHP	29,339	1,796,085	5,511,260	3,107,759	593,897	1,559,505
Electric storage heater	2,077,074	2,077,074	2,250,000	2,100,000	2,530,000	2,500,000
Gas boiler	21,933,029	20,245,923	17,500,000	18,550,000	22,800,000	22,200,000
Gas heat pump absorption	-	-	108,983	165,901	40,153	54,064
GSHP	8,658	1,384,040	301,670	222,910	219,056	270,751
Hybrid heat pump	-	1,742,427	1,038,087	758,938	159,992	356,061
Micro-CHPs (inc Fuel Cells)	1,003	-	92,579	91,308	44,080	59,763
Other Fossil - Oil boilers/LPG	3,328,873	563,949	1,500,000	1,700,000	2,950,000	2,500,000
Hydrogen via H2 network	-	286,591	-	1,146,364	-	-
District Heat	-	1,508,423	1,236,033	2,022,066	843,016	646,508
Biomass Boiler	-	281,974	-	-	-	-
Bio-LPG	-	281,974	629,848	314,924	-	-
Total	**27,377,976**	**30,168,460**	**30,168,460**	**30,180,170**	**30,180,193**	**30,146,653**

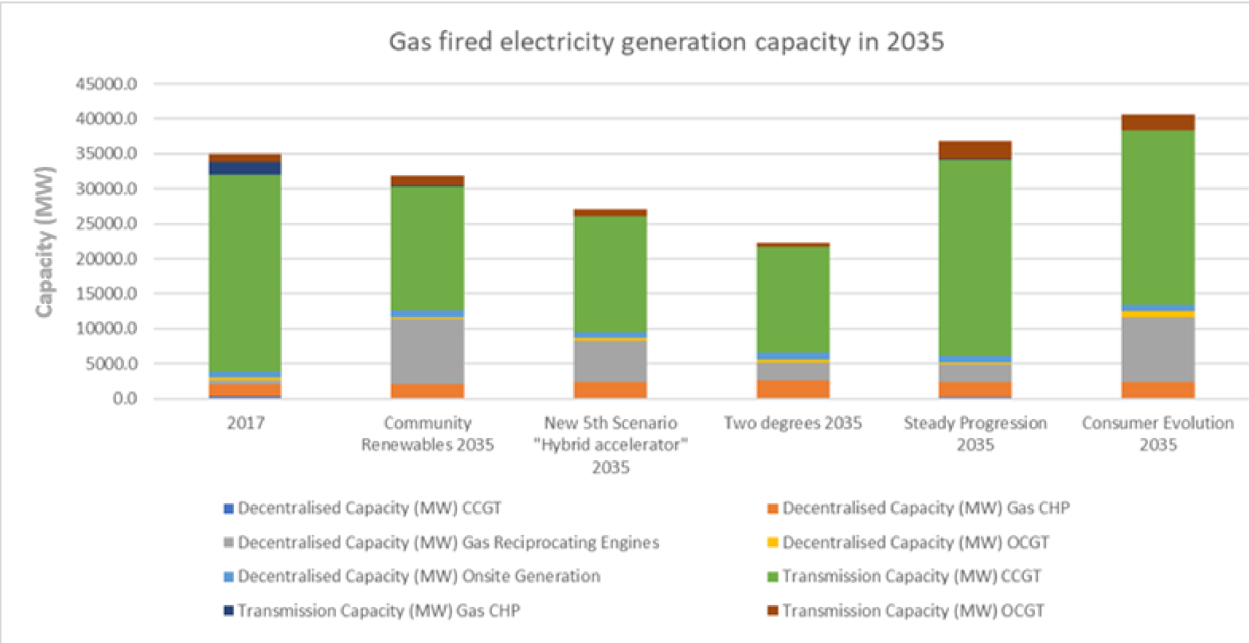
Figure 7 Heat technologies for GB domestic heating in 2035 - Source FES 2018



Gas-powered electricity generation in 2035

Gas fired electricity generation Scenario Comparison 2035 - FES 2018			2017	Community Renewables 2035	New 5th Scenario "Hybrid accelerator" 2035	Two degrees 2035	Steady Progression 2035	Consumer Evolution 2035
Decentralised	Capacity (MW)	CCGT	422.0	0.0	0.0	0.0	268.0	0.0
Decentralised	Capacity (MW)	Gas CHP	1691.0	2028.7	2360.7	2692.8	2147.6	2366.0
Decentralised	Capacity (MW)	Gas Reciprocating Engines	487.1	9354.5	5908.5	2462.4	2462.4	9354.5
Decentralised	Capacity (MW)	OCGT	477.2	318.1	397.6	477.2	318.1	742.4
Decentralised	Capacity (MW)	Onsite Generation	881.1	926.1	926.1	926.1	926.1	926.1
Transmission	Capacity (MW)	CCGT	28073.0	17737.0	16414.5	15092.0	28015.0	24997.0
Transmission	Capacity (MW)	Gas CHP	1808.0	30.0	30.0	30.0	187.0	46.0
Transmission	Capacity (MW)	OCGT	1108.0	1541.0	1091.5	642.0	2464.0	2164.0
Decentralised	Generation (TWh)	CCGT	0.0	0.0	0.0	0.0	0.0	0.0
Decentralised	Generation (TWh)	Gas CHP	6.4	7.3	8.5	9.7	7.8	8.7
Decentralised	Generation (TWh)	Gas Reciprocating Engines	0.1	0.1	0.0	0.0	0.1	0.6
Decentralised	Generation (TWh)	OCGT	0.0	0.0	0.0	0.0	0.0	0.0
Decentralised	Generation (TWh)	Onsite Generation	5.0	4.0	3.9	3.7	4.5	4.8
Transmission	Generation (TWh)	CCGT	106.4	8.7	5.0	1.3	26.3	45.4
Transmission	Generation (TWh)	Gas CHP	9.2	0.1	0.1	0.1	0.2	0.2
Transmission	Generation (TWh)	OCGT	2.5	0.0	0.0	0.0	0.0	0.0
		All Gas Capacity MW	34,947	31,935	27,129	22,323	36,788	40,596
		Decentralised Capacity MW	3,958	12,627	9,593	6,559	6,122	13,389
		Transmission Capacity MW	30,989	19,308	17,536	15,764	30,666	27,207
		All Gas Generation TWh	129.7	20.2	17.6	14.9	39.0	59.7
		Decentralised Generation TWh	11.5	11.4	12.4	13.5	12.4	14.0
		Transmission Generation TWh	118.1	8.8	5.1	1.4	26.6	45.6
		All Gas Capacity Factor	42%	7%	7%	8%	12%	17%
		Decentralised Capacity Factor	33%	10%	15%	23%	23%	12%
		Transmission Capacity Factor	44%	5%	3%	1%	10%	19%

Figure 8: Gas-powered electricity generation in 2035 – Source FES 2018



Demand for Natural Gas

Figure 9 Demand for natural gas - Source FES 2018

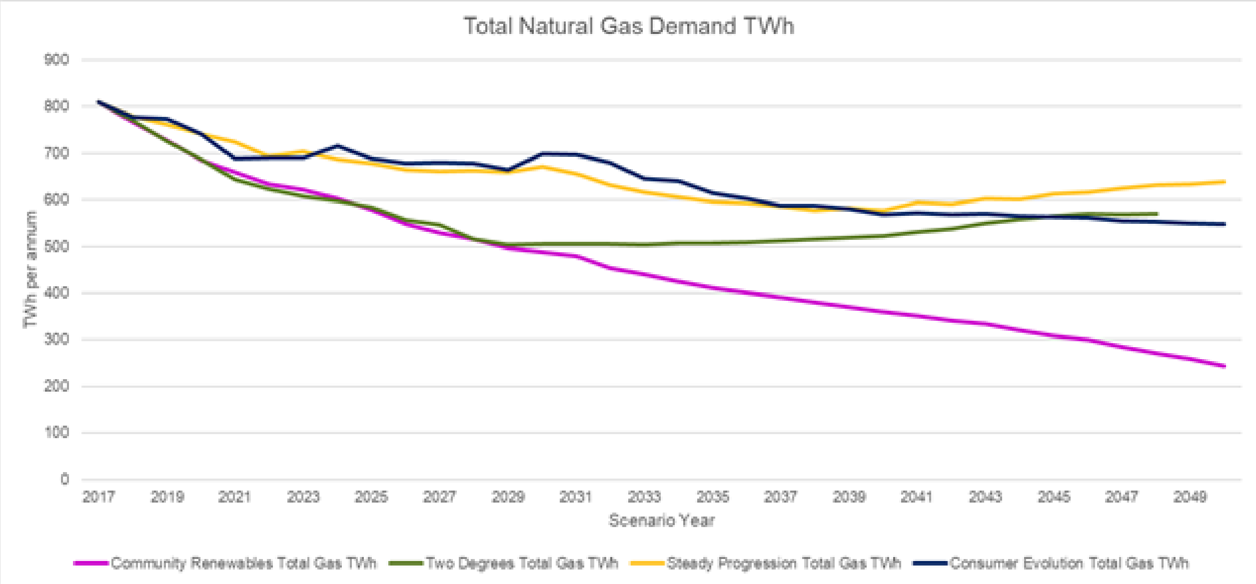


Table 3 Changes in demand for natural gas: Source FES 2018

Natural Gas demand TWh (FES 2018)					
	2017	**2025**	**2030**	**2035**	**2050**
Community Renewables					
Gas: Industrial	195	172	165	161	125
Gas: Commercial	50	41	35	31	18
Gas: Residential	332	278	239	198	77
Gas: Power Gen	233	88	46	17	17
Gas: Transport	0	1	3	5	7
Total Gas	**810**	**579**	**487**	**412**	**244**
Two degrees					
Gas: Industrial	195	184	184	171	80
Gas: Commercial	50	48	45	40	14
Gas: Residential	332	281	244	206	68
Gas: Power Gen	233	70	31	85	396
Gas: Transport	0	1	2	4	7
Total Gas	**810**	**585**	**506**	**506**	**565**
Steady Progression					
Gas: Industrial	195	187	185	182	171
Gas: Commercial	50	56	56	55	55
Gas: Residential	332	319	310	305	281
Gas: Power Gen	233	116	119	51	127
Gas: Transport	0	1	1	2	4
Total Gas	**810**	**678**	**671**	**596**	**638**
Consumer Evolution					
Gas: Industrial	195	186	184	180	167
Gas: Commercial	50	55	54	53	51
Gas: Residential	332	316	302	292	255
Gas: Power Gen	233	132	159	88	70
Gas: Transport	0	1	1	2	4
Total Gas	**810**	**689**	**700**	**615**	**548**

5 System elements, growth factors, drivers and assumptions

Key system elements were identified in the methodology and mapped into the energy system diagram, shown in Figure 4. The work in phase 1 has built on this, taking into account the key data outputs required, which will contribute as inputs required by WWU for their internal investment model.

For the purposes of modelling, the system has been broken down into demand and supply elements, with a bottom up approach taken to demand calculation. For the baseline year, this will be cross checked with actual gas demand data to calibrate outputs.

To improve the relevance of the output dataset for WWU, the WWU customer classification codes shown in Table 4 have been incorporated into the model such that projections can be reported by number of customer types within a given geography, by year, by scenario. We are envisaging 'collapsing' the Commercial classifications (C1-C4) down to be a general non-domestic commercial customer class.

Table 4: WWU customer classifications

WWU Classification	Customer type
Non-Daily Metered D1	Domestic
Non-Daily Metered C1	Shops/offices
Non-Daily Metered C2	Schools/hospitals
Non-Daily Metered C3	Hotels
Non-Daily Metered C4	Pubs/restaurants
Non-Daily Metered I2	Typical industrial
Daily Metered	Daily metered sites

Key to the development of the modelling is the relationships between factors as, for example, a growth in deployment of heat pumps necessarily results in a reduction in deployment of other heating technologies. A relationship mapping exercise identified the key factors and the interplay between them. Following creation of test baseline databases, a number of iterations have resulted in the relationship maps shown in the sections that follow.

5.1 Table of factors

A full list of factors would run to >1,500 individual lines, a simplified list is shown in Table 5 and Table 6. These are divided into inputs and outputs, where the inputs are the levers used to drive each scenario.

Table 5: Simplified list of input factors

	Factor	Category	Input / output	Units
	Carbon conversion factor	Universal factor	Input	kgCO2e/kWh
Applied to domestic, commercial and industrial heat demands	Total new properties	New domestic/commercial/industrial	Input	N/A
	Properties demolished	Existing domestic/commercial/industrial	Input	N/A
	Fuel poor network extension scheme	Existing domestic/commercial/industrial	Input	N/A
	Existing properties, % served by mode, tech., fuel	Existing domestic/commercial/industrial	Input	% of total existing domestic properties
	Efficiency reduction, existing peak	Existing domestic/commercial/industrial	Input	peak day kWh/property
	Efficiency reduction, existing gross	Existing domestic/commercial/industrial	Input	kWh/property/year
	Efficiency reduction, new peak	Existing domestic/commercial/industrial	Input	%
	Efficiency reduction, new gross	Existing domestic/commercial/industrial	Input	%
	Conversion efficiency, by mode, tech., fuel	Existing domestic/commercial/industrial	Input	%
	Vehicles, % served by tech., fuel	DM/other	Input	% of total existing domestic properties
	Power generation capacity MWe	DM/other	Input	MWe
	Power generation conversion efficiency	DM/other	Input	Input MWth/Mwe
	Daily metered loads	DM/other	Input	GWh/year
	Biomethane injection sites	Supply	Input	#
	Biomethane injection per site	Supply	Input	GWh/site/year
	BioSNG injection sites	Supply	Input	#
	BioSNG injection per site	Supply	Input	GWh/site/year

Table 6: Simplified list of output factors

	Factor	Category	Input / output	Units
Applied to domestic, commercial and industrial heat demands	Total existing properties	Existing domestic/commercial/industrial	Output	#
	Total properties	All domestic/commercial/industrial	Output	#
	Net change in total properties on gas	All domestic/commercial/industrial	Output	#
	Net change in existing properties on gas (lost existing connections)	All domestic/commercial/industrial	Output	#
	Existing properties, # served by mode, tech., fuel	Existing domestic/commercial/industrial	Output	#
	Energy demand per existing property - peak	Existing domestic/commercial/industrial	Output	peak day kWh/property
	Energy demand per existing property - gross	Existing domestic/commercial/industrial	Output	kWh/property/year
	Energy demand per new property - peak (peak day kWh/property)	Existing domestic/commercial/industrial	Output	peak day kWh/property
	Energy demand per new property - gross (kWh/property/year)	Existing domestic/commercial/industrial	Output	kWh/property/year
	Peak energy demand, by mode, tech., fuel	Existing domestic/commercial/industrial	Output	peak day GWh
	Gross energy demand, by mode, tech., fuel	Existing domestic/commercial/industrial	Output	GWh/year
	% gross demand split for hybrid heat pumps	Existing domestic/commercial/industrial	Output	%
	Peak fuel demand, by mode, tech., fuel	Existing domestic/commercial/industrial	Output	peak day kWh
	Gross fuel demand, by mode, tech., fuel	Existing domestic/commercial/industrial	Output	kWh/year
	Resulting heat networks, by mode, tech., fuel	Existing domestic/commercial/industrial	Output	#
	Vehicles, # served by tech., fuel	DM/other	Output	#
	Fuel demand per vehicle - gross	DM/other	Output	kWh/vehicle/year
	Gross fuel demand, by vehicle tech., fuel	DM/other	Output	GWh/year
	Power generation demand by tech., fuel	DM/other	Output	GWh/year
	Total biomethane injection	Supply	Output	GWh/year
	Total BioSNG injection	Supply	Output	GWh/year

5.2 Supply factors - technologies and fuel sources

Fuel supply is calculated as an output of the bottom up demand model which will provide the calorific value (Wh) of a given fuel required to fulfil demand, within a given geography by scenario by year.

The fuels considered are shown in Table 7.

Table 7: Fuel sources

Bio LPG
Biomass
Biomethane (standalone)
Electricity
LPG
Mains gas
Hydrogen network (100%)
Oil

Bio LPG is assumed to be 0% fossil derived and delivered into fixed tanks connected to properties to provide heat, as LPG is typically used at present.

Biomass refers to solid woody biomass (largely log, chip or pellet).

Biomethane (standalone) is included as there is a consideration that there may be heat networks driven by CHP plants co-located with biomethane production

Electricity demand does not account for transmission and distribution losses, these would need to be included if modelling required generation capacity, depending on the location of the generator.

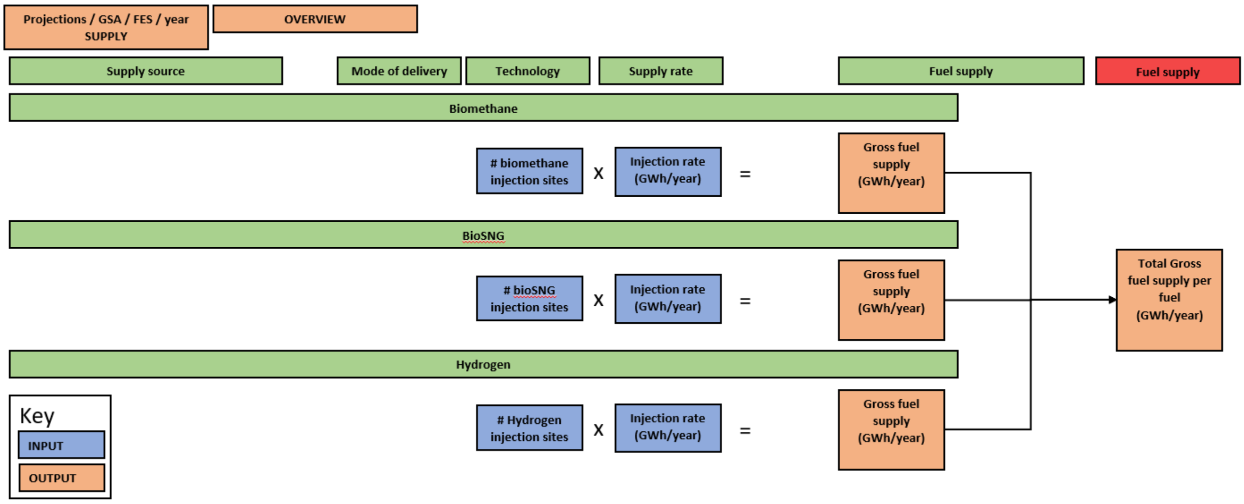
Mains gas demand would be demand met via the existing gas network, this could consist of 100% natural gas or could include a blend of biomethane (e.g. through injection), bioSNG and/or hydrogen. The relationship diagram that follows shows how the natural gas proportion would be calculated as a remainder of demand less injection of alternative gasses.

Mains hydrogen (100%) demand would be created where an area of the existing gas network is disconnected from the mains gas system and supplied by a new supply (local or national) of 100% hydrogen, as proposed in the H21 Leeds City Gate project.

Oil refers to 28 second heating oil, commonly used to heat properties that are off the gas grid.

Supply factors considered relate to the production of alternative gas fuels that would be injected into the mains gas grid, the relationship map for these is shown in Figure 10.

Figure 10: Relationship map for alternative gas injection



5.3 Demand factors and their treatment

Demand is subdivided into: Domestic Heat, Commercial Heat, Industrial Heat and Processes and Daily Metered connections/customers.

5.3.1 Demand gross and peak attributes

WWU hold extensive data relating to the location and magnitude of demand and as such is able to provide typical attributes for each of the customer classifications, shown in the Table 8.

Table 8: WWU classifications and attributes

WWU Classification	Customer type	Gross annual demand (kWh/year)	Peak demand 1 in 20 6 min (kWh)
Non-Daily Metered D1	Domestic	TBC by WWU	TBC by WWU
Non-Daily Metered C1	Shops/offices	TBC by WWU	TBC by WWU
Non-Daily Metered C2	Schools/hospitals	TBC by WWU	TBC by WWU
Non-Daily Metered C3	Hotels	TBC by WWU	TBC by WWU
Non-Daily Metered C4	Pubs/restaurants	TBC by WWU	TBC by WWU
Non-Daily Metered I2	Typical industrial	TBC by WWU	TBC by WWU
Daily Metered	Daily metered sites	May be bespoke to DM customer	May be bespoke to DM customer

For modelling purposes, it is assumed that gross annual heat demand is equivalent whether a property is connected to the gas grid or not, as such these attributes will be applied universally. The peak demand attribute is specific to the gas industry and used for network capacity planning, as such it will only be applied to demands that are connected to the gas grid.

5.3.2 Heating technologies

Heat demands have been characterised by mode of delivery, technology/fuel to produce 18 distinct heating technologies which can be distributed across each source of heat demand, shown in Table 9.

Table 9: Modes and technologies meeting demand

Mode	Technology	Fuel
Boiler	Boiler	Oil
Boiler	Boiler	LPG
Boiler	Boiler	Mains gas
Boiler	Boiler	Bio LPG

Boiler	Boiler	Hydrogen network (100%)
Boiler	Boiler	Biomass
Boiler	Boiler	Electricity
Boiler	Micro CHP	Mains gas
Heat network	Biomass Heat Network Customer	Biomass
Heat network	Mains gas Heat Network Customer	Mains gas
Heat network	GSHP Heat Network Customer	Electricity
Heat network	Biomethane Heat Network Customer	Biomethane
Direct electric	Night storage or Radiant	Electricity
Heat pump	ASHP	Electricity
Heat pump	GSHP	Electricity
Heat pump	Oil HHP	Oil/Electricity
Heat pump	LPG HHP	LPG/Electricity
Heat pump	Mains gas HHP	Mains gas/Electricity
Heat pump	Gas absorption (GAHP)	Mains gas

5.3.3 CHP

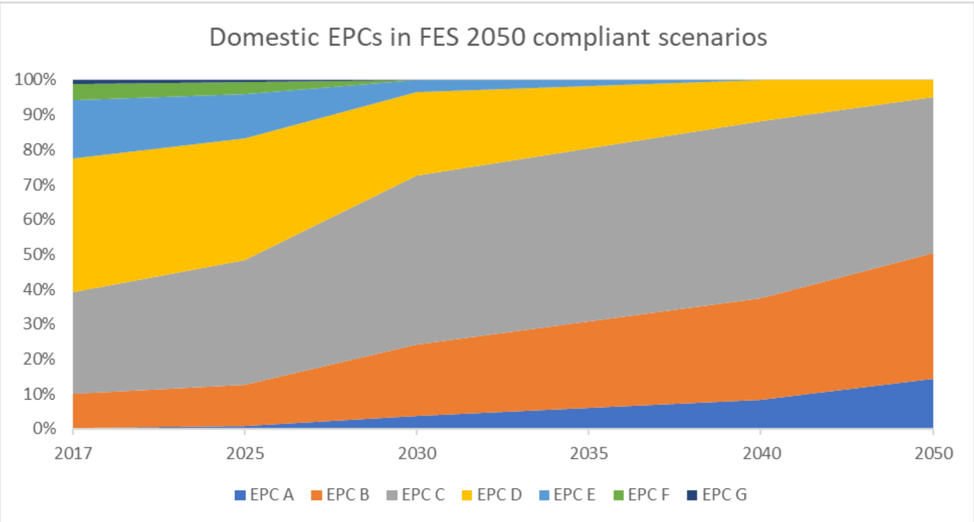
The number of heat network customers (on a mains gas or biomethane heat network) is used as a driver for growth in CHP. As an example, each 800 'mains gas heat network customers' could represent a loss of 800 'D1' connections, but the creation of a new 'I2' connection on the WWU network, equivalent to approximately 3 MWth CHP and increasing gas demand (the extent of which depending on efficiency assumptions). The specific figures presented here are an example, data gathered to form the baseline will inform the typical conversions that will be used in the modelling.

5.3.4 Energy efficiency

The gross and peak attributes provided by WWU will be used to generate the baseline of energy demand for existing buildings. Where new build properties are modelled, these attributes will be scaled to reflect the reduced demand expected, based on typical EPC data for new properties against the existing baseline. For each modelling year, it has been considered that in order to track year on year connection gains and losses, the previous years 'new' may become subsumed into the 'existing' category, thus the typical attributes will naturally shift as the proportion of more efficient new buildings increases. In all scenarios a degree of retrofit fabric improvement is required to reduce overall demand for heat, this will be factored in as an annual shift in addition to the new build driven trajectory.

For domestic energy demand the FES uses a shift in the proportion of EPC bands (as shown in Figure 11, this represents a reduction in average domestic annual demand of ~25% by 2035.

Figure 11: EPC shift used in FES (interpolated for 2035)



5.3.5 Relationship maps for heat demand

The relationship maps for heat demand are as follows, input factors are shown in blue and output factors in salmon. As described in the previous section, new properties could be considered as separate from existing, so that changes in WWU customer classifications can be accurately tracked, without increases in one area masking a decrease in another (or vice versa).

Figure 12: Relationship map for domestic heat demand

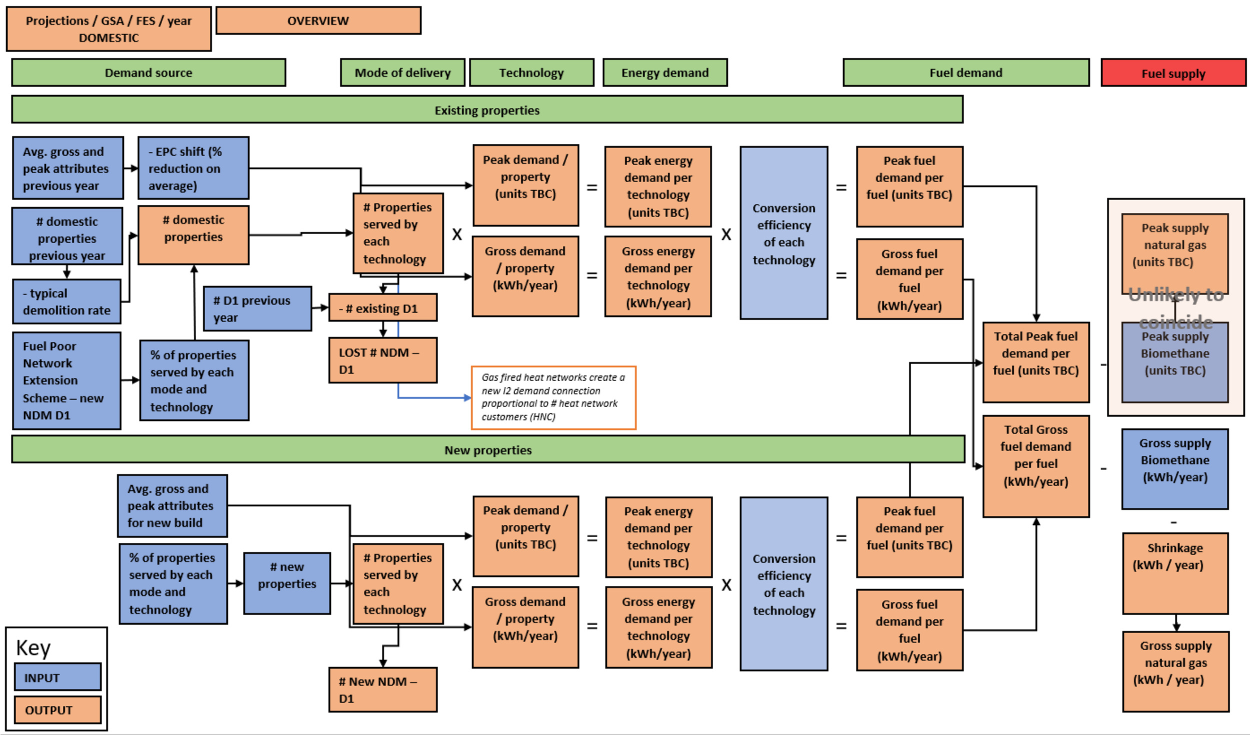


Figure 13: Relationship map for commercial heat demand

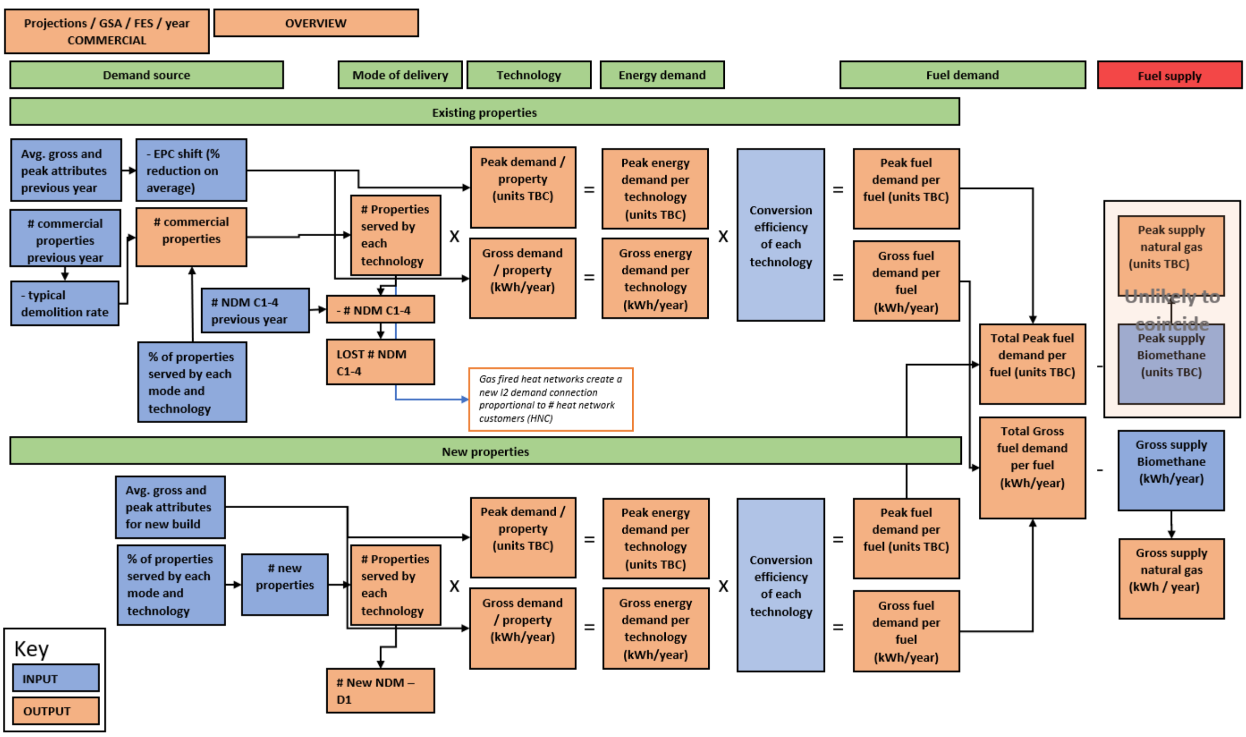
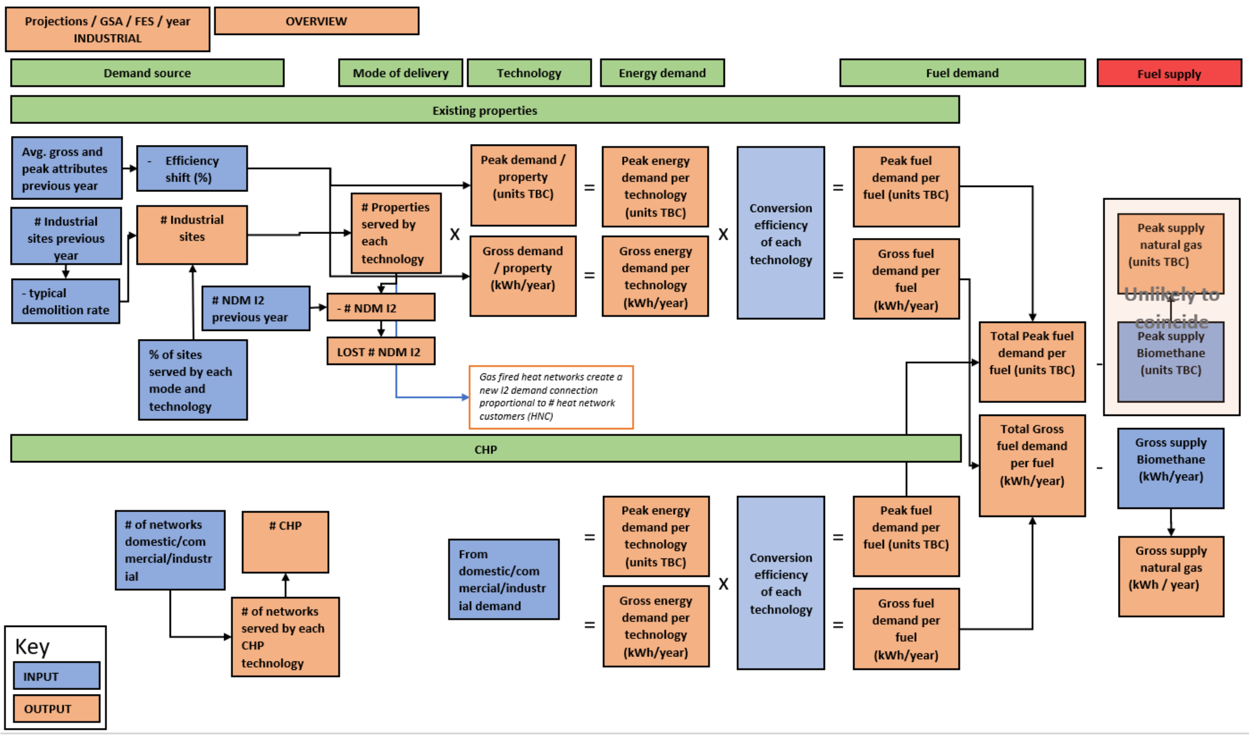
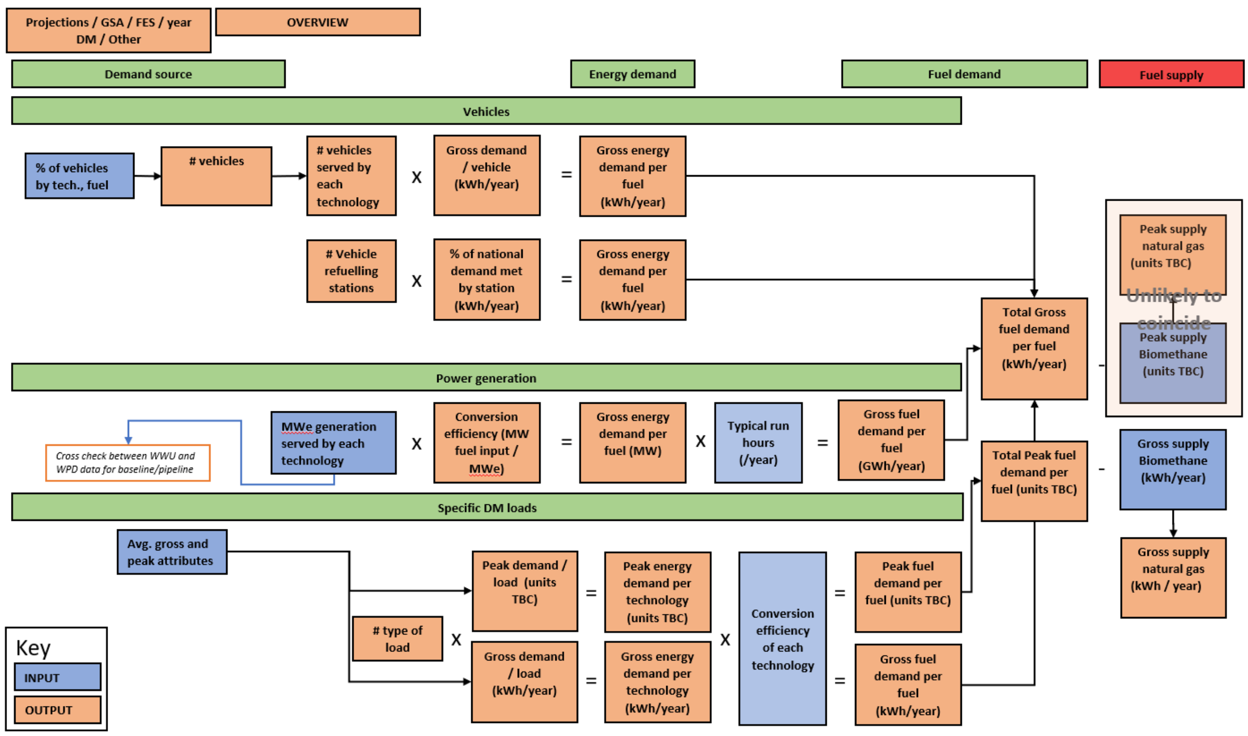


Figure 14: Relationship map for industrial heat demand and CHP



5.3.6 Daily metered, power generation and vehicle demand

Figure 15: Relationship map for daily metered, power generation and vehicle related mains gas demand



5.4 Sources of data and evidence – baseline, pipeline and growth projections

From clarifying these factors for forecasting, (categorised as the key sources of demand, modes of supply, delivery technologies and fuels), the first step in the growth scenario analysis is to establish an existing baseline and to understand and assess the potential near-term pipeline.

The method by which to establish these will vary depending on the factor in question and in some cases establishing the positions for one factor may need to happen, before other factors can be analysed.

5.4.1 Setting the baseline

Setting the baseline position will require an assessment of existing connection data sourced from WWU. Regen has been working with WWU to define the approach and data requirements, to set the baseline for the key factors outlined in section 5. Some of the WWU data requirements include:

- Number of domestic connections, associated with Gas Supply Areas (see section 0)
- Count of other non-domestic connection classes (as described in Table 4)
- Typical peak and annual consumption for each of the connection classes (see Table 8)
- Housing stock energy efficiency
- Register of existing Daily Metered connections, with capacity and location
- Register of existing gas fired power generation sites, with capacity and location
- Register of existing biomethane injection sites, with capacity and location

This data can also be supplemented and/or correlated by utilising additional or alternative external data sources. Some examples include:

- Renewable Heat Incentive (RHI) and Microgeneration Certification Scheme (MCS) deployment data for e.g. heat pumps or biomass systems
- Heat Network Deployment Unit (HNDU) deployment data, by local authority
- Relevant electricity DNO connection data for gas fired power generation developments
- Commercial mapping data services to assist with connection classes (if required)

5.4.2 Assessing the near-term pipeline

Once a baseline position is established and before growth scenario projections can be undertaken, for some system factors/technologies, an interim stage of analysis for near-term developments or 'pipeline' can be completed, as described in Figure 3. Some examples of pipeline data sources include:

- WWU local authority developments tracker for future domestic and non-domestic connection
- Regen analysis on housing developments completed for WPD and SSEN for the South West, South Wales and Southern licence areas
- WWU Daily Metered register of applications
- WWU gas fired power generation register of accepted network entry/exit agreements (NEXA)
- DNO 'Accepted-Not-Yet-Connected' connection data for gas fired power generation sites
- WWU register of biomethane entry applications and accepted NEXAs

The identified pipeline projects/instances for some of the factors may not all be taken forward to feature in the forecasts. The number of sites/capacity etc. that are/is taken forward may vary depending on several things, including information gleaned from online research and customer updates to WWU. In addition to this, the pipeline site/capacity allocations may vary by each of the 5 FES scenarios.

5.4.3 Establishing growth factors

As described in Regen's methodology, produced for WWU in Spring 2018, analysis and regional/local assumptions are then to be identified, that will outline the scenario forecasts themselves for each of the system factors described in 5.1, defined as 'growth factors'. These will affect long term growth, reduction or evolution of the system factors/elements in question, to the projection year of 2035.

It was proposed that the growth factors could be grouped under four categories:

- **Policy driven growth factors** – e.g. known air pollution policy decisions such as the amendments to Environmental Permitting Regulations relating to the Medium Combustion Plant Directive (MCPD) or new or evolving government policy objectives around heat energy decarbonisation.
- **Market driven growth factors** – e.g. changes to existing incentive programmes and pricing such as the RHI and Capacity Market. Other factors such as the demand for green gas electricity network constraints and rising energy costs, driving demand for alternative energy vectors.
- **Technology driven growth factors** – e.g. efficiency improvements and reduction in cost of heat delivery technologies, the development of hydrogen conversion technologies, CCS technologies or increased sophistication around controlling hybrid heat pumps
- **Resource driven growth factors** – e.g. the availability of waste feedstocks in specific for biomethane + bio SNG production, sewage sludge market separation for biomethane production or growth of 'surplus' electricity that could be converted to hydrogen using electrolysis.

For more detail around the potential growth factors that are to be used in the analysis, please refer to Regen's methodology document[7].

[7] See *Regional Growth Scenarios for Gas – Methodology Report for Wales and West Utilities,* April 2018.

6 Creating Gas Supply Areas (GSAs) and Geographical Distribution

6.1 Short recap of options considered for GSAs

A range of options for creating geographical areas, onto which the future scenario projections will be distributed, have been considered. The critical considerations were whether to produce the forecasts for geographical areas that aligned with administrative geography such as local authorities, or geographical areas that aligned with WWU's gas network infrastructure. These options are briefly summarised below. Each geographical area should be considered the base unit in the projections, since the projections can be aggregated up as required, though they cannot be analysed at a smaller scale. The areas will receive a projection for each of the identified sources, elements and technologies by scenario and by year.

Administrative divisions

UK administrative divisions establish a hierarchy of geographical areas that relate to local and national government. While administrative divisions are non-uniform, examples include the four countries of the UK, regions, counties, local authorities and parishes.

Postcodes

Postcodes establish a reference point throughout the UK for postal delivery that on average contain 15 delivery points. However, they are also used for some statistical purposes in the UK and due to their typically small size, are considered an option for geographic modelling that requires very high resolution.

Census geography

A UK census is undertaken every 10 years, most recently in 2011. The census collects information on UK population and other key statistics that is primarily used to aid planning and resource allocation. This information provides valuable insights into spatial data such as social, economic, housing and work characteristics of different areas. The base geographic area for the Census are Output Areas (OA) which typically comprise of 125 households. OAs can be aggregated into the more commonly used Lower Layer Super Output Area (LSOA), Middle Layer Super Output Area (MSOA) and local authority areas.

Linepack Zone

In principle, a Linepack Zone is the method by which Gas GDNs store intra-day gas volume by pressurising the gas into the actual distribution pipes (or linepacking). In a gas network, the Linepack Zones may not be distributed evenly and, for example, regions of the network with greater pipe volumes may have greater potential in offering flexibility/storage. Therefore, to model and manage this, the network is partitioned into a set of Linepack Zones.

Governor stations

The management and regulation of gas pressure through WWU's pipe network is handled by pressure reduction stations (PRSs) and district governor stations (DGSs). These assets, the pipe network and connected properties that are associated to them, could be used to define GSAs.

Electricity Supply Area

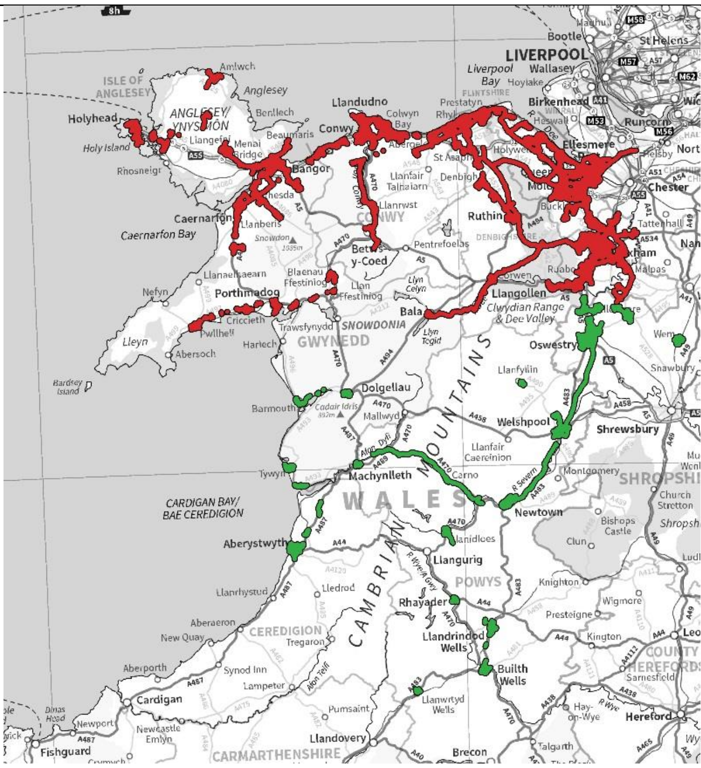
Electricity Supply Areas (ESAs) can be considered similar to the Gas Supply Areas (GSA) that are being created for this study. A concept developed by Regen as part of the work with electricity DNOs to create a future scenarios forecast area, an ESA is a geographical area that is supplied by a defined portion of electricity network infrastructure. Each ESA sits within an established electricity network hierarchy and refers to geographic areas supplied by the same (or portion of) 132-33 kV, 132-11 kV or 33-11 kV substations. Each of these substations and related geographic areas have connected generation, storage and demand loads. The geographic boundaries of these areas do not follow local authority or other administrative boundaries, they are determined by the location of electricity network infrastructure.

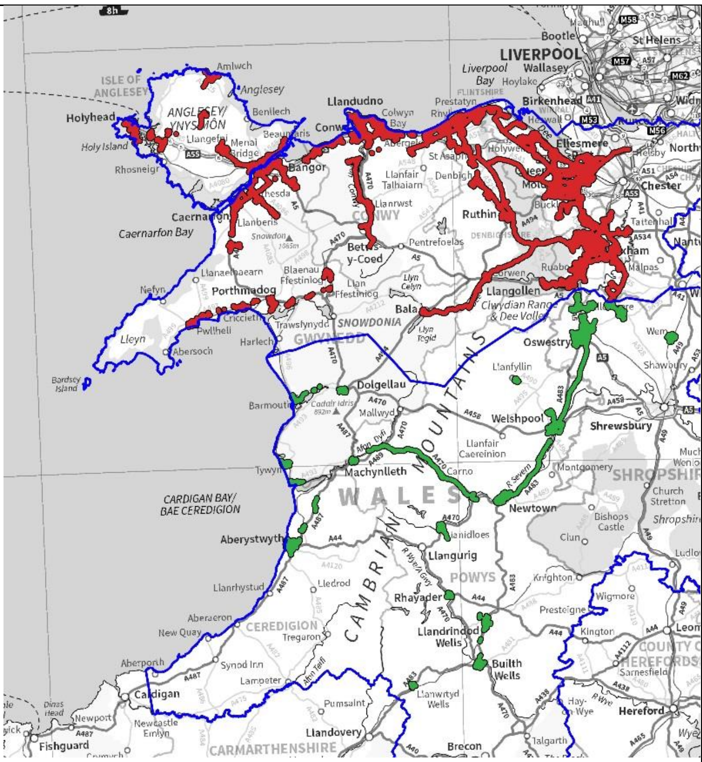
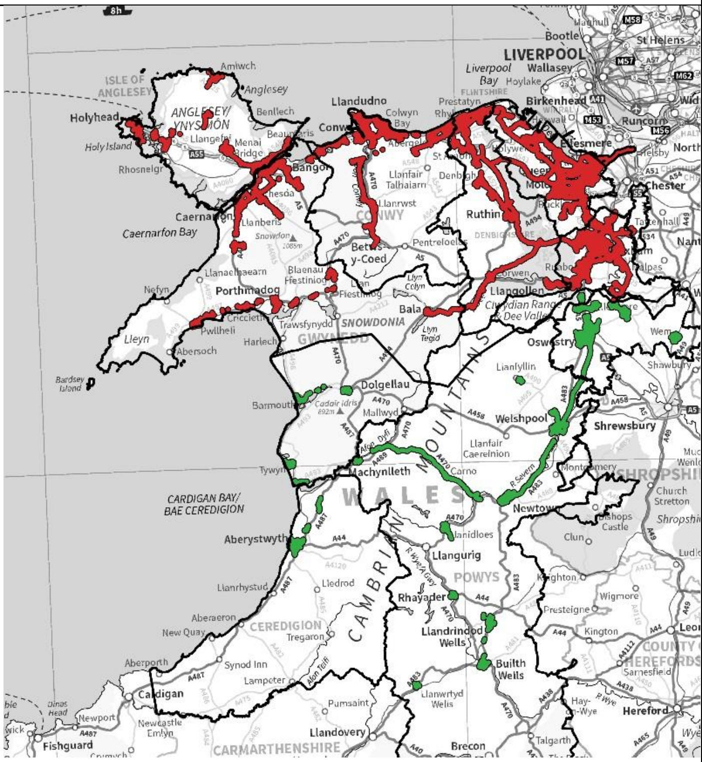
6.2 Definition of GSAs

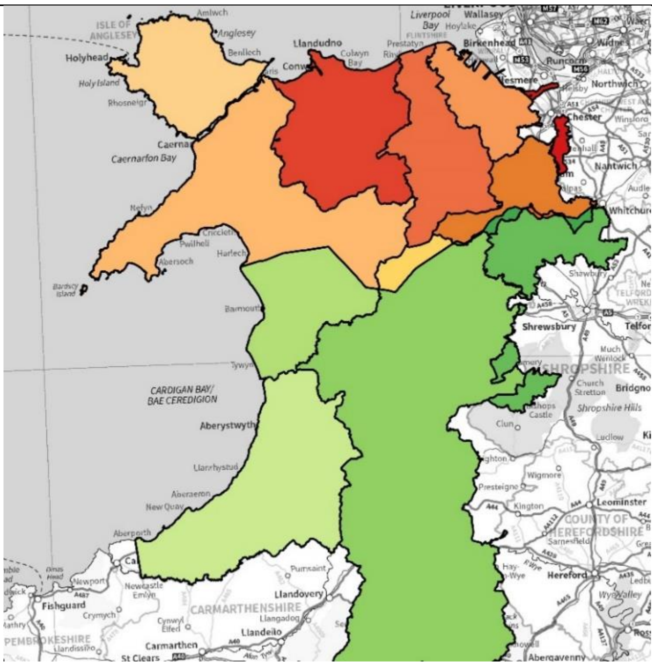
For the purpose of the RGSG project a GSA is defined as a unique geographical area whose gas is supplied from a defined portion of the gas network (Linepack zone) and is within a defined local authority. GSAs will therefore be created for WWU's gas network using a combination of Linepack Zones and local authority boundaries.

This method means that the future scenario projections can be aggregated up to local authority totals, Linepack Zone totals or LDZ totals.

6.3 GSA creation method – example North Wales LDZ

Gas Supply Area creation stages		Description
North Wales GSA creation legend Maelor Mid Linepack Zone Maelor Coastal Linepack Zone Linepack Zone regions in North Wales (not cut to local authority borders or the edge of WWU's licence area) GSAs in North Wales (cut to local authority borders or the edge of WWU's licence area)		-
1		The first stage in creating the GSAs involved identifying the location of the low and medium/ intermediate gas network. The map here identifies the areas that that the networks of Maelor Mid and Coastal Linepack Zones serve. There is a clear split between the two geographic areas that these two Linepack Zones serve, which can be isolated in the next stage.

2		In this stage, two areas are created around the two Linepack Zones in order to identify the geographic area served by each Linepack Zone. The method used to complete this was a mathematical function called Voronoi Partitioning, also known as Voronoi Polygons. This function partitions a plane into regions, the borders of which are equidistant from the target objects. Therefore, every point within a region is closest to the host target object, which in this case are the network pipes. This function is straightforward to apply on clearly defined areas, such as those here, but can also be applied on very complex, though not overlapping target objects.
3		In this stage, the two geographic regions in stage 2 have been split along local authority borders, in addition to being trimmed to WWU's licence area border. These areas that are unique to both local authorities and Linepack Zones are, therefore, the GSAs for the North of Wales. N.b. the GSAs extend to the outside of WWU's licence area to the east due to WWU's network extending there. This can be seen in the top right of the graphic.

4		This map illustrates the GSAs more clearly, coloured as shades of red or green based upon the Linepack Zone they are within. These areas can be aggregated together up to Linepack Zone, or local authority as is required.

6.4 Use of GSAs and geographic distribution of projections

The GSAs are the geographical base unit onto which the future projections will be made. The human, environmental and technical spatial factors of each GSA will be assessed to inform a geographical distribution of each forecast. These factors are used to create a weighting or 'attractiveness' score for each GSA, which could vary by scenario. The distribution factors and the weighting of them may therefore vary, depending on the system element(s) being distributed.

For example, to inform the distribution of heat pumps variants, we will investigate the geographical factors for each GSA such as the availability of the gas network to inform the type of heat pump, numbers of domestic and non-domestic properties, suitability of housing for heat pumps, affluence and numbers of social housing. Whereas for gas fired power stations for example, we will assess the location of existing operational plants (baseline) and near-term project developments (pipeline), as well as other factors such as the correlation of availability of both gas and electricity network capacity and/or connection proximity. Regen will be distributing the forecasts for each system element/factor, using an in-house developed geographic distributor model, see Figure 16. This model enables the number of distribution factors used and weighting of them to be bespoke to each system element/factor.

Figure 16: Extract of Regen Geographic Distributor Model

B	C	D	E	F	G	H	I	J	K	L	M	N	O
Sub-projection	Sum c	Scenario	Timeframe	home ownership	D and Semi-D homes	Number of houses	Number of off-grid houses	2/3 cars	Flats by ESA	On-gas houses	Number of c	Factor 9	Factor 10
Retrofit-on-gas G-backup	100%	TD	Short	25%	25%			10%		40%			
	100%	TD	Medium	25%	25%			5%		45%			
	100%	TD	Long	25%	25%			0%		50%			
	100%	CR	Short	25%	25%			10%		40%			
	100%	CR	Medium	25%	25%			5%		45%			
	100%	CR	Long	25%	25%			0%		50%			
	100%	CE	Short	25%	35%			10%		30%			
	100%	CE	Medium	25%	35%			5%		35%			
	100%	CE	Long	25%	40%			0%		35%			
	100%	SP	Short	25%	35%			10%		30%			
	100%	SP	Medium	25%	35%			5%		35%			
	100%	SP	Long	25%	40%			0%		35%			
	Sum c	Scenario	Timeframe	home ownership	D and Semi-D homes	Number of houses	Number of off-grid houses	2/3 cars	Flats by ESA	On-gas houses	Number of c	Factor 9	Factor 10
Retrofit-on-gas E-backup	100%	TD	Short	30%	10%			10%	10%	40%			
	100%	TD	Medium	30%	10%			5%	10%	45%			
	100%	TD	Long	30%	10%			0%	10%	50%			
	100%	CR	Short	30%	10%			10%	10%	40%			
	100%	CR	Medium	30%	10%			5%	10%	45%			
	100%	CR	Long	30%	10%			0%	10%	50%			
	100%	CE	Short	30%	10%			10%	10%	40%			
	100%	CE	Medium	30%	10%			5%	10%	45%			
	100%	CE	Long	30%	10%			0%	10%	50%			
	100%	SP	Short	30%	10%			10%	10%	40%			
	100%	SP	Medium	30%	10%			5%	10%	45%			
	100%	SP	Long	30%	10%			0%	10%	50%			

Q	R	S	T
		Up to...	
Sub-technology		Baseline	Short M
Retrofit-on-gas G-	Two Degrees	2017	###
Retrofit-on-gas G-	Community Renewables	2017	###
Retrofit-on-gas G-	Consumer Evolution	2017	###
Retrofit-on-gas G-	Steady Progression	2017	###
Retrofit-on-gas E-l	Two Degrees	2017	###
Retrofit-on-gas E-l	Community Renewables	2017	###
Retrofit-on-gas E-l	Consumer Evolution	2017	###
Retrofit-on-gas E-l	Steady Progression	2017	###
Retrofit off-gas E-b	Two Degrees	2017	###
Retrofit off-gas E-b	Community Renewables	2017	###
Retrofit off-gas E-b	Consumer Evolution	2017	###
Retrofit off-gas E-b	Steady Progression	2017	###
New homes E-back	Two Degrees	2017	###
New homes E-back	Community Renewables	2017	###
New homes E-back	Consumer Evolution	2017	###
New homes E-back	Steady Progression	2017	###
New homes G-bac	Two Degrees	2017	###
New homes G-bac	Community Renewables	2017	###
New homes G-bac	Consumer Evolution	2017	###
New homes G-bac	Steady Progression	2017	###
4	Two Degrees	2017	###
4	Community Renewables	2017	###
4	Consumer Evolution	2017	###
4	Steady Progression	2017	###
5	Two Degrees	2017	###
5	Community Renewables	2017	###
5	Consumer Evolution	2017	###

7 Stakeholder engagement events

In developing scenario projections to inform WWU's longer term forecasting and business planning process, it is important to engage WWU's wider stakeholders and key customer base. Insight from these stakeholders, whilst analysis is underway, could be critical to:

- Clarifying some of the key market, policy and technology drivers
- Understanding future growth/shrinkage of certain elements of the gas system
- Gaining a more detailed understanding of strategic developments and projects connecting to WWU's network.

Regen's methodology to undertake this innovation project identified an opportunity for stakeholders to review the approach, data, evidence base and assumptions that are driving these regional growth scenarios. This engagement will enable WWU to continue dialogue with stakeholders they already have good engagement with, as well as approaching and connecting with new parties and stakeholders that WWU may have not yet engaged with.

7.1 Proposed approach

7.1.1 Timing and location

Regen is proposing to hold two stakeholder engagement events per Phase in Phases 2 and 3, targeting two events in the South West, one in South Wales and one in North Wales.

As stakeholder engagement events, these would naturally fall at a time when growth scenario analysis was underway – i.e. engaging and seeking feedback, not just presenting results. Aligning with the current project timeline, the event timings could therefore be as outlined below:

Event Type	When	Potential Location
South West - stakeholder awareness and engagement event	Mid-March	Exeter
South West - biomethane development specialist event	Mid-April	Bristol
South Wales - stakeholder awareness and engagement event	Mid-June	Cardiff / Newport
North Wales - stakeholder awareness and engagement event	Mid July	Llandudno

7.1.2 High level content / aims for events

Regen has delivered a number of stakeholder engagement events for electricity DNOs. The approach and core themes for these events have varied, some examples of event content being:

- Presentation of the methodology and approach to developing scenario projections
- Inclusion of a series of exhibition type stands to showcase specific elements of the analysis (e.g. future housing development, solar developments etc.)
- A focus on geographical 'hot spots' for future network demand/generation growth
- Roundtable discussions on specific city regions or local authority areas

Regen will work closely with the WWU team to tailor appropriate content for the four events.

7.1.3 Target audience / attendees

Some key stakeholders to target for attending these events are as follows (including examples):

- **Large gas demand customers**: Gas fired generation operators and industrial users
- **Welsh Government representatives**
- **Strategic Local Authorities:** Cornwall County Councils, Devon CC, Welsh Borough Councils
- **Key city region authorities:** Plymouth, Exeter, Bristol, Cardiff, Swansea City Councils
- **Key Local Enterprise Partnerships:** Heart of the South West, Cornwall and Scilly Isles, West of England and Welsh LEPs
- **Key and strategic housing associations:** Sanctuary Housing, Curo Housing and key council housing departments such as BANES Council, North Somerset and South Glous Councils
- **Relevant Electricity DNOs:** Western Power Distribution, SP Energy Networks, Scottish and Southern Electricity Networks and potentially UK Power Networks (Swindon City Vision)
- **Major water and waste utility companies:** South West Water, Welsh Water, Wessex Water and Bristol Water