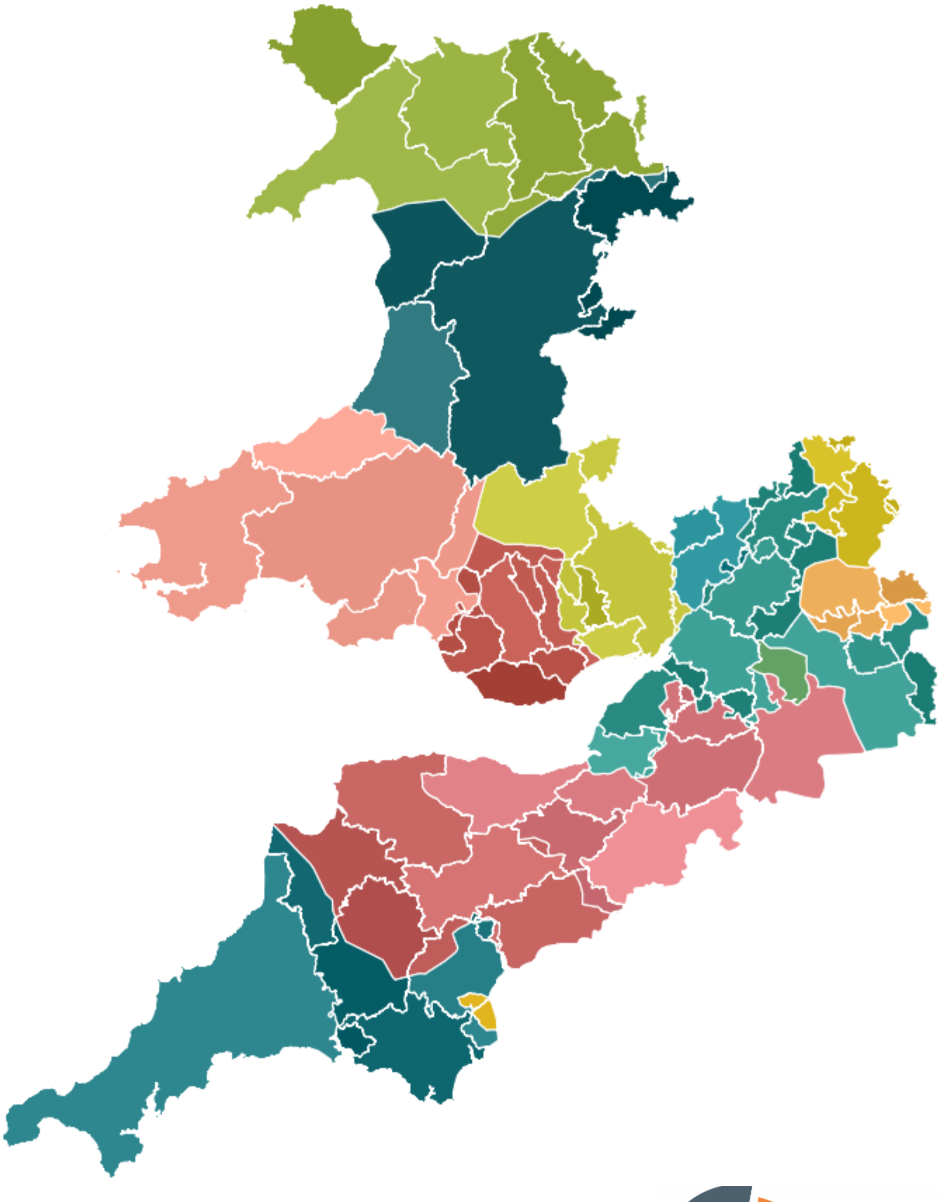
Network Innovation

Regional Growth Scenarios for Gas and Heat

Technical companion document: Method, approach and assumptions



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1 Regional Growth Scenarios for Gas and Heat – Report Series

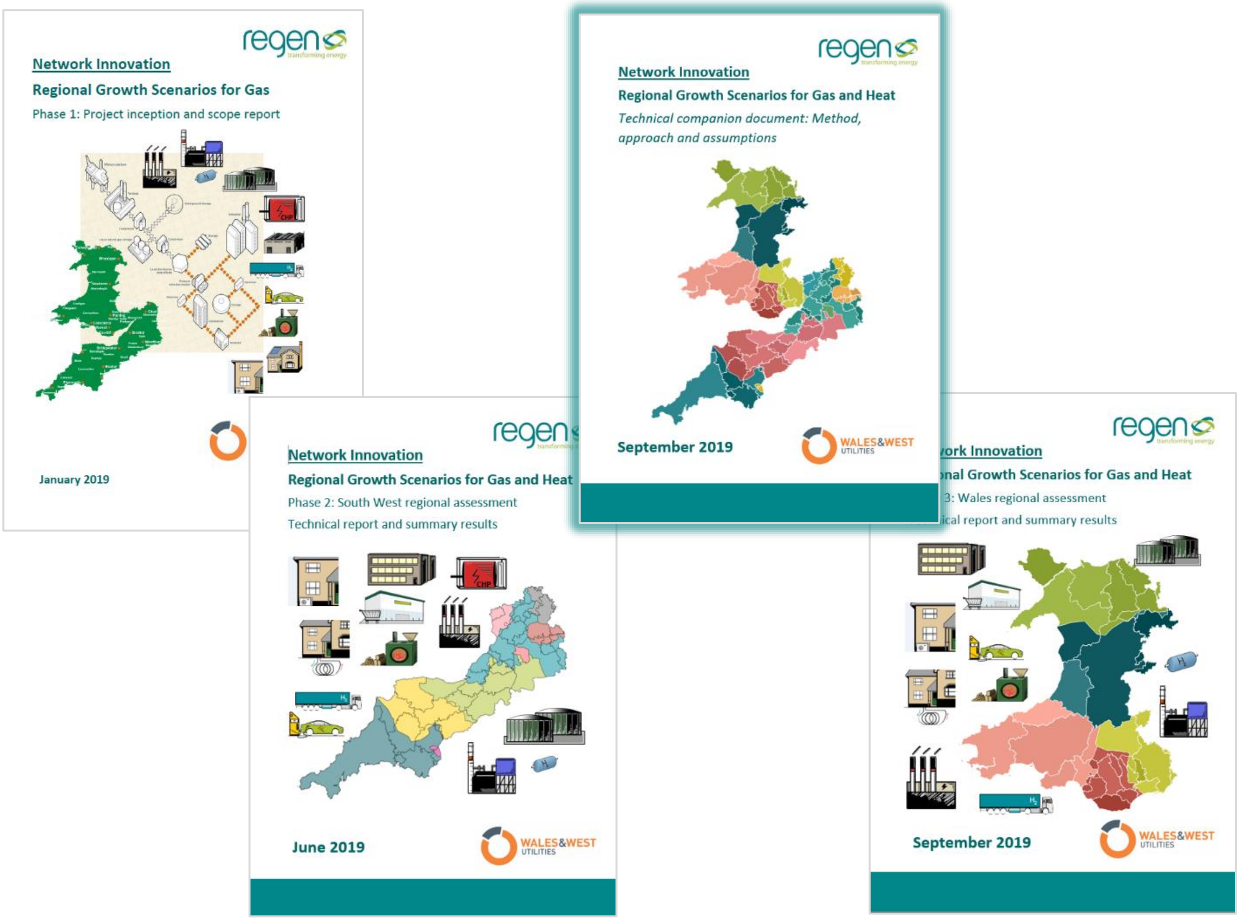
Regional Growth Scenarios for Gas and Heat is an NIA funded project, managed by Wales & West Utilities and delivered by Regen, to develop and demonstrate a methodology to create a set of regional future energy scenarios for the gas distribution network in Wales and the South West of England.

This **Technical Companion Document** is part of a suite of documents that Regen has produced for Wales & West Utilities (WWU) and provides an explanation of some of the more detailed aspects of the scenario modelling methods and approaches used for both the South West and Wales analyses.

A **Project Inception and Scope Report** was completed in February 2019 and developed the project scope, methodology and approach.

The overview of outputs and results for the South West gas Local Distribution Zone (LDZ), completed in June 2019, can be found in the **South West regional assessment: Technical Report & Results** document.

Similarly, the outputs and results for the Wales LDZs, completed in September 2019, can be found in the equivalent **Wales regional assessment: Technical Report & Results** document.



2 Glossary

Booked capacity – see 'Injection capacity'

Capacity factor – is the ratio of electrical power generated against the potential power generation if the plant ran at continuous peak output over the same period.

Category – the overall categorisation of factors as to whether they are a source of demand of supply.

Domestic hot water (DHW) - Domestic hot water (DHW) refers to the hot water used in sinks, showers and baths in any type of building (not just domestic dwellings).

Dwelling – is used as defined in the Building Regulations[1]: "*A self-contained building or part of a building used as a residential accommodation, and usually housing a single household.*" E.g. a bungalow, detached house, flat etc.

Element – a subset or component of a factor, to which scenario analysis has been applied (e.g. number of domestic properties, percentage of properties that are supplied by an air source heat pump or gas fired power generation capacity (MW_e) etc.).

Factor – a term to describe a high-level source of demand of supply (e.g. domestic heat or green gas).

Flexible generation – a business model for gas fired electricity generation that focuses around being dispatchable, flexible or in some cases 'peaking' generation, rather than traditional baseload generators.

Gas Distribution Network (GDN) – There are eight GDNs in Great Britain[2], each with a separate geographical coverage. Wales & West Utilities are one of the four companies that own and operate these gas distribution networks. GDNs are sub-divided into Local Distribution Zones.

Gas HHP – see 'Hybrid Heat Pump (HHP)'.

Generation – refers to the annual volume of electricity generated by a plant or group of plants under a particular technology grouping.

Green gas – For the purposes of this report, we are referring to the development of biomethane and bio synthetic natural gas (bio-SNG) for injection into the GDN as Green Gas.

Green gas volume – the annual volume, in energy terms, of green gas injected into the GDN, as GWh.

Heat networks – used as defined in SAP 10.0[3] "*systems where heat is generated and supplied by a network and heat generator(s) that is located outside of the dwellings it serves*". As such, heat pumps with shared ground loops are treated as individual appliances rather than being part of a heat network.

Household – used as defined by Office for National Statistics[4]: "*one person living alone, or a group of people (not necessarily related) living at the same address who share cooking facilities and share a living room or sitting room or dining area.*"

Hybrid Heat Pump (HHP) – A hybrid heat pump is a system that combines an electrically driven heat pump (usually air source) with a traditional combustion appliance (e.g. combi or heat-only boiler). The heat pump component is used to meet the majority of heat demand, with the system reverting to the

[1] https://www.planningportal.co.uk/directory_record/227/dwelling_and_dwelling_house
[2] https://www.ofgem.gov.uk/gas/distribution-networks/gb-gas-distribution-network
[3] https://www.bregroup.com/sap/sap10/
[4] https://www.ons.gov.uk/peoplepopulationandcommunity/populationandmigration/populationprojections/methodologies/methodologyusedtoproducehouseholdprojectionsforengland2016based#glossary

combustion appliance to meet peak demand (on cold days and possibly for provision of domestic hot water). An HHP allows a building that may not be immediately suitable for a heat pump to take advantage of the reduced energy and carbon burden associated with use of a heat pump, whilst retaining a relatively low cost and high-powered back-up to meet peak demand.

The HHP may be provided as a single dedicated product, or as a bespoke package of boiler, heat pump and control system. This analysis views an HHP as a single appliance in either instance, hence any reference to 'gas boilers', 'oil boilers' or 'heat pumps' excludes any that are a component of an HHP unless explicitly stated otherwise.

The combustion appliance component of an HHP will vary depending on the available fuel. Within this analysis we have referred to Gas HHP (using gas from the GDN) or Oil HHP.

Injection capacity – refers to the peak agreed rate (booked capacity) at which green gas can be injected into the GDN. The units of measure are Standard Cubic Meters per hour (scm/h)

Injection rate – is the ratio of actual green gas volume injected into the GDN against the potential injection if the plant ran at continuous booked capacity over the same period. Term used by BEIS around biomethane production when determining estimate budget commitments for RHI Tariff Guarantees.

Local Distribution Zone (LDZ) – Sub-division of a Gas Distribution Network, there are a total of 13 LDZs within Great Britain.[5] The WWU network is divided into South West (SW), Wales North (WN) and Wales South (WS) Local Distribution Zones. In this report the Wales North and Wales South LDZs have typically been shortened to the 'Wales LDZs'.

Main heating appliance – In instances where a hybrid heat hump is installed, reference is made to the main heating appliance (an ASHP) and the secondary heating appliance (a gas or oil boiler). The main heating appliance is defined as that which is meeting the majority of heat demand.

Non-domestic building – is used to refer to all buildings that are non-dwellings e.g. schools, offices, retail premises etc.

Oil HHP – see 'Hybrid Heat Pump (HHP)'.

Power capacity (gas fired power) – refers to the peak electrical output of a gas fired power plant.

WWU South West gas network area – the South West LDZ (see 'Local Distribution Zone' above).

WWU Wales gas network area – the Wales North and Wales South LDZs (see 'Local Distribution Zone' above).

[5] https://www.energybrokers.co.uk/gas/gas-network.htm#waleswest

3 Executive summary

Understanding how the enormous changes that are happening across the UK's energy system will impact on the need for future infrastructure and network management capabilities has become a critical requirement for both gas and electricity network operators.

As well as the need to evidence and justify future network planning and investment decisions, which has been given renewed priority by Ofgem in the RIIO-2 price control process, there is also an increasing need for network operators to demonstrate to stakeholders that they are delivering a network to meet a wide variety of economic and societal objectives. The need for investment to support decarbonisation and reduce the impact of climate change has grown in urgency. Network operators have other key priorities, which include:

- Supporting a clean growth industrial strategy
- The delivery of local and regional economic strategies
- Providing energy security
- Helping to deal with wider societal issues such as fuel poverty and supporting vulnerable customers

The **Regional Growth Scenarios for Gas and Heat project** is an NIA funded project, managed by Wales & West Utilities and delivered by Regen, to develop and demonstrate a methodology to create a set of regional future energy scenarios for the gas distribution network in Wales and the South West of England.

The project is being delivered in three phases. The first phase of the project, completed in Feb 2019, developed the project scope, methodology and approach. Phase 2, for which a report and accompanying dataset are the main deliverables, has created a set of regional future energy scenarios for gas and heat for the South West portion of the WWU gas distribution network, completed in May 2019. Phase 3 contains a similar set of deliverables for the Wales portion of the WWU network, completed in September 2019. This technical companion accompanies the second and third phases of the project.

The remit of the project has been to:

- Create strongly evidenced scenario projections for the all major sources of demand and supply for heat and gas for the period of 2018 to 2035
- Take a whole system approach to look across the energy uses for heat, power and transport
- Create projections (in the form of a dataset) with sufficient detail to be used to inform strategic network planning and investment decisions within the gas distribution network
- Provide a basis with which to engage, and share data, with key stakeholders including local authorities, industry, communities and other network operators.

The project approach and scope has been analogous to the approach taken by Regen to develop regional scenarios for the electricity distribution network and wherever possible, consistent assumptions and data has been used. This opens the potential that, in the future, each region could have an integrated and consistent whole energy scenario dataset for use by multiple stakeholders.

The project has used and adapted the four **National Grid FES 2018** energy scenarios with the addition of a fifth, **Hybrid Accelerator,** scenario which has been developed in conjunction with Wales & West Utilities and regional stakeholders. Use of these national scenarios has provided a common framework and an overarching set of assumptions, while the regional scenarios have themselves been developed through a "bottom up" process of data gathering, energy system analysis and stakeholder engagement. Of the five scenarios used, three are intended to be consistent with the UK's current commitment to reduce carbon emissions by 80% by 2050, while two would not deliver the required carbon reduction.

The scenarios would not necessarily meet a more ambitious net-zero carbon commitment by 2050, which has now been adopted, and would not meet a more accelerated net zero carbon target.

The requirement to create scenarios that can be used for strategic network planning within the distribution network, has led to the definition of **63 Gas Supply Areas within the WWU South West gas network area** and **37 Gas Supply Areas in the WWU Wales gas network area**. These geographic areas disaggregate the gas distribution network by both local authority area and linepack zone (gas network pressure management zone).

The holistic treatment of the energy system has entailed the project creating individual forecast projections for over **60 forecast elements** (sources of energy demand or alternative sources of supply) and an even greater number of component elements therein. The supporting dataset, comprising element forecasts by scenario, by GSA and by year, comprises well over half-a-million individual data. With the accompanying results reports for the South West and Wales, the forecast elements have been grouped together into a number of energy system areas:

1. **Domestic heat demand (including existing properties and new housing)**
2. **Commercial and industrial heat and gas demand (including existing and new developments)**
3. **Gas fired electricity generation**
4. **Gas fuelled transport**
5. **Alternative supplies of gas energy such as biomethane, hydrogen and unconventional natural gas**

A key part of the project methodology has been to engage with local stakeholders. As well as four workshops held in Exeter, Bristol, Cardiff and Llandudno with over 150 delegates representing industry, consumers, academia, Welsh Government, local authorities and community organisations attending. The project has also engaged directly with other key organisations and WWU's connected customers and has collated data and information from a number of regional sources including, for example, local development plans. The support and insight from these organisations have been invaluable to the project.

The results of the two regional future energy scenario assessments are outlined in two results reports, that accompany this Technical Companion Document.

Phase 2: South West Regional Assessment – Technical Report and Summary Results (Feb - May 2019)

Phase 3: Wales Regional Assessment – Technical Report and Summary Results (Jun - Sep 2019)

These reports summarise:

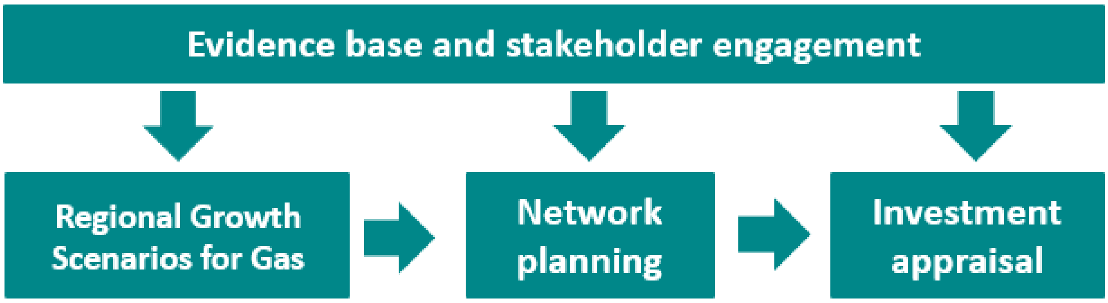
- The overall regional outcomes for each of the five scenarios, showing total forecast annual gas demand between 2018 and 2035 for the South West and for Wales.
- The overall carbon impact of each of the scenario outcomes for the South West and for Wales, related to the sources of demand and supply that are within the scope of the assessment.
- The headline outcomes, detailed results, overview of methods and geographical distribution for each of the five energy system areas listed above, with a section dedicated to each area.

Many of the assumptions, data sources and references used when developing the scenarios for each of these areas, are summarised in a series of Appendices in this document.

4 Introduction and background

To support Wales & West Utilities' (WWU) future gas demand forecasting, network analysis and investment planning, Regen has been commissioned to undertake a Network Innovation Allowance (NIA) funded project[6]. The scope of the project is to develop and trial a new methodology to create a set of regional and sub-regional growth scenarios for gas and heat from a 2018 baseline out to 2035. The intention is that these growth scenarios, backed by extensive analysis and stakeholder engagement, will create a dataset and evidence case to help WWU, and other stakeholders, to understand the future requirements and usage of the gas network.

Figure 1: High level asset and investment planning process



The first phase of the project, completed in Feb 2019, developed the project scope, overarching methodology and approach.

The second phase of the project, which developed a set of regional scenario projections for the South West gas network area, was completed between February and May 2019.

The third and final phase of the project developed equivalent regional scenario projections for Wales, covering both the North Wales and South Wales gas Local Distribution Zones (LDZs), was completed between June and September 2019.

The assessment has endeavoured to take a 'whole energy system' approach to understand the demand for energy delivered by the gas network within the context of an integrated system, covering the use of energy for heat, power, transport and industrial processes. This integrated approach led to a very complex energy model with over 60 individual projection elements with multiple interdependencies between them. For each element an assessment of the baseline (historic and current), near term pipeline and future scenario projections has been made.

A system view of the relevant demand and supply flows for this project can be seen in Figure 2.

[6] See *Regional Future Energy Scenarios* project summary on the ENA Smarter Networks Portal: http://www.smarternetworks.org/project/nia_wwu_054

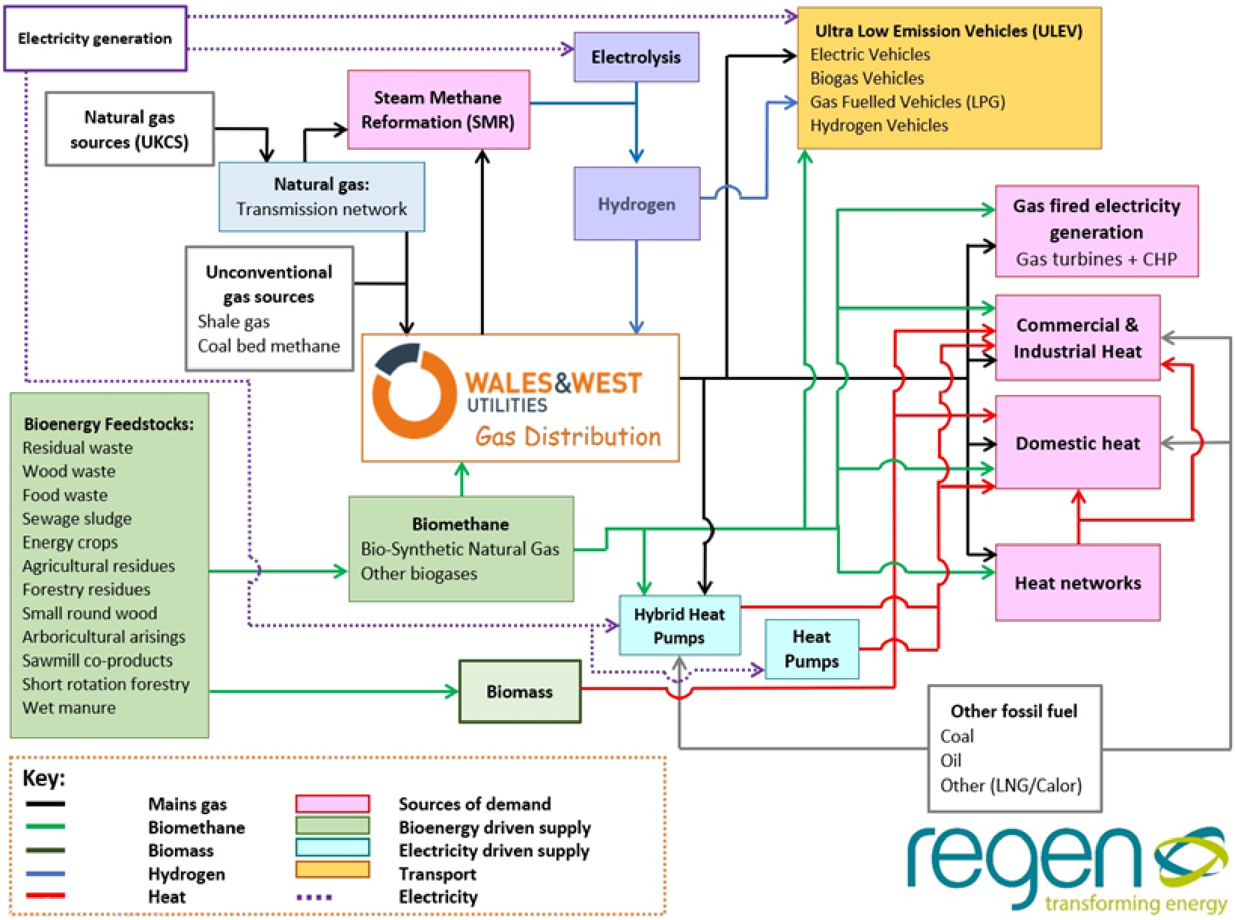


Figure 2: Overview of the gas/heat energy system

A further source of complexity has been the need to develop projections at a sub-regional level, and therefore the requirement to map or distribute energy demand and supply to smaller geographical areas within the gas distribution network. To do this, the project has taken the combination of local authority areas and gas distribution linepack zones, to create a set of Gas Supply Areas (GSAs).

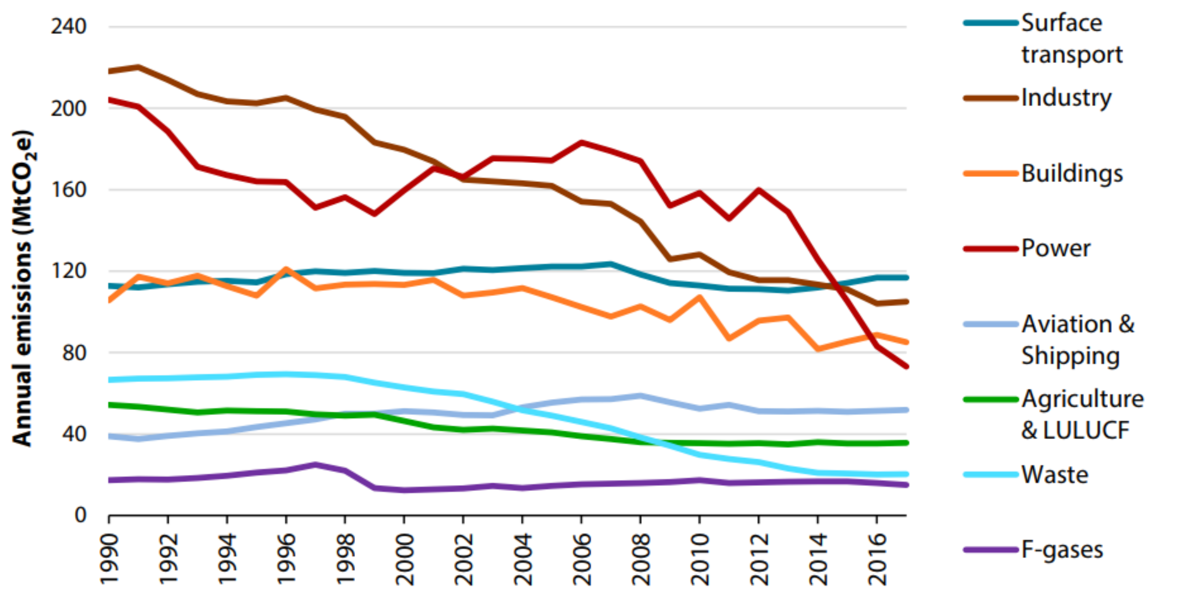
This geographic breakdown, which is discussed in more detail in section 5.7, has resulted in the definition of a total of 100 GSAs for the South West and Wales WWU network areas. The resulting GSA breakdown is intended to allow the locational analysis of energy scenarios to understand impacts on the physical gas network, for network planning and investment purposes, and to allow local authorities and other potential stakeholders to conduct social, economic and other impact analysis.

4.1 Decarbonisation and the changing energy system

Any analysis of the future demand for gas, and the utilisation of the gas distribution network, must consider the requirement to decarbonise the UK's economy and its energy system to meet the challenges of climate change.

As the UK Government's Clean Growth Plan[7], and recent studies by the Committee on Climate Change[8], have identified, the UK energy system is already undergoing significant change. Over the last decade transformation has been especially rapid in the power sector, which has seen the replacement of coal by gas as the main fuel source of dispatchable power generation and the growth in generation from renewable energy, mainly from wind and solar, to now provide almost 30% of the UK's electricity. Together these measures have helped to reduce the carbon intensity of electricity from over 400 gCO_2e/kWh to circa 200 gCO_2e/kWh. The decarbonisation of electricity has been accompanied by a rapid increase in the amount of decentralised power generation, both of renewables and smaller scale turbine and reciprocating engine gas plants. Many of these new forms of generation are connected to both the gas and electricity distribution networks.

Figure 1.4. Progress reducing emissions in the UK has been imbalanced



Source: BEIS (2019) *Final UK greenhouse gas emissions national statistics 1990-2017*; CCC analysis. LULUCF = land use, land use change and forestry.

Figure 3: Progress to reduce carbon emissions 1990 to 2018
Source and Credit: Committee on Climate Change, Net Zero report, May 2019

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[7] UK Government Clean Growth Plan 2018

[8] See Committee on Climate Change report *Net Zero: The UK's contribution to stopping global warming,* May 2019: https://www.theccc.org.uk/publication/net-zero-the-uks-contribution-to-stopping-global-warming/

Decarbonisation progress in other energy sectors has been much slower and, although there has been marked reduction in energy demand from domestic, commercial and industrial sources, it is largely accepted that during the next period of decarbonisation much more needs to be done to reduce emissions from energy use for heat and transport. The recent CCC report[8] to government has especially identified the need to reduce carbon emissions in domestic and commercial buildings.

It is therefore very likely that the demand for energy on, and use of, the gas network will change significantly over the period covered by this assessment (to 2035) and in subsequent decades. The role of gas itself is anticipated to change as well. At present, by replacing coal-fired power generation and by replacing coal, oil and LPG for heat, the growth in demand for gas and expansion of the gas network has been allied with carbon reduction. Looking ahead however, as the UK faces ever tougher decarbonisation goals[9] by 2035, achieving a near net zero carbon position by 2050, the use of all types of fossil fuels must be dramatically reduced.

Studies, including National Grid's Future of Gas[10] series, have identified a number of potential decarbonisation pathways. These range from the near-complete electrification of heat to the near-complete decarbonisation of the gas used for energy using carbon capture and storage (CCS), hydrogen and 'green' gases such as biomethane.

As this assessment highlights, decarbonisation is set to change the way we think about gas and even the use of the terminology "gas", by which we have historically referred to the fossil fuel natural gas or methane. To accommodate this change in definition we have therefore adopted an approach to separately consider:

- Energy demand (generally measured in MWh),
- Energy supplied by the gas network or by other technologies and infrastructure
- Underlying fuels of natural gas, green gas and/or hydrogen or the blend of fuels that might be delivered by the future gas network.

4.2 Use of energy scenarios and consistency with climate change goals

In order to provide a consistent basis[11] for comparison and investment planning at both a national level and with other gas and electricity network operators, the **National Grid Future Energy Scenarios (FES) 2018** have been used to provide the overall scenario framework. The FES, at a summary level, provides four scenarios; two of which (**Two Degrees** and **Community Renewables**) are broadly compliant with the decarbonisation targets set out in the Climate Change Act 2008 and two of which (**Consumer Evolution** and **Steady Progression**) are not.

This project has added a fifth scenario, which has been called the **Hybrid Accelerator**. The **Hybrid Accelerator** scenario is also broadly compliant with the UK decarbonisation targets, but allows for an increased adoption of hybrid heat pump technology, as well as the accelerated decarbonisation of the gas network through the injection and blending of green gas biomethane (and potentially hydrogen). The **Hybrid Accelerator** therefore draws heavily on the Freedom Project[12] analysis of hybrid heat pumps as well as studies looking at the potential for green gas injection.

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[9] See 4th and 5th Carbon budgets – Climate Change Act 2008
[10] National Grid – The Future of Gas paper and website series. https://futureofgas.uk/
[11] Use of the FES has been widely adopted by gas and electricity networks for the purpose of RIIO 2 investment planning
[12] See Freedom Project - https://www.wwutilities.co.uk/media/2829/freedom-project-final-report-october-2018.pdf

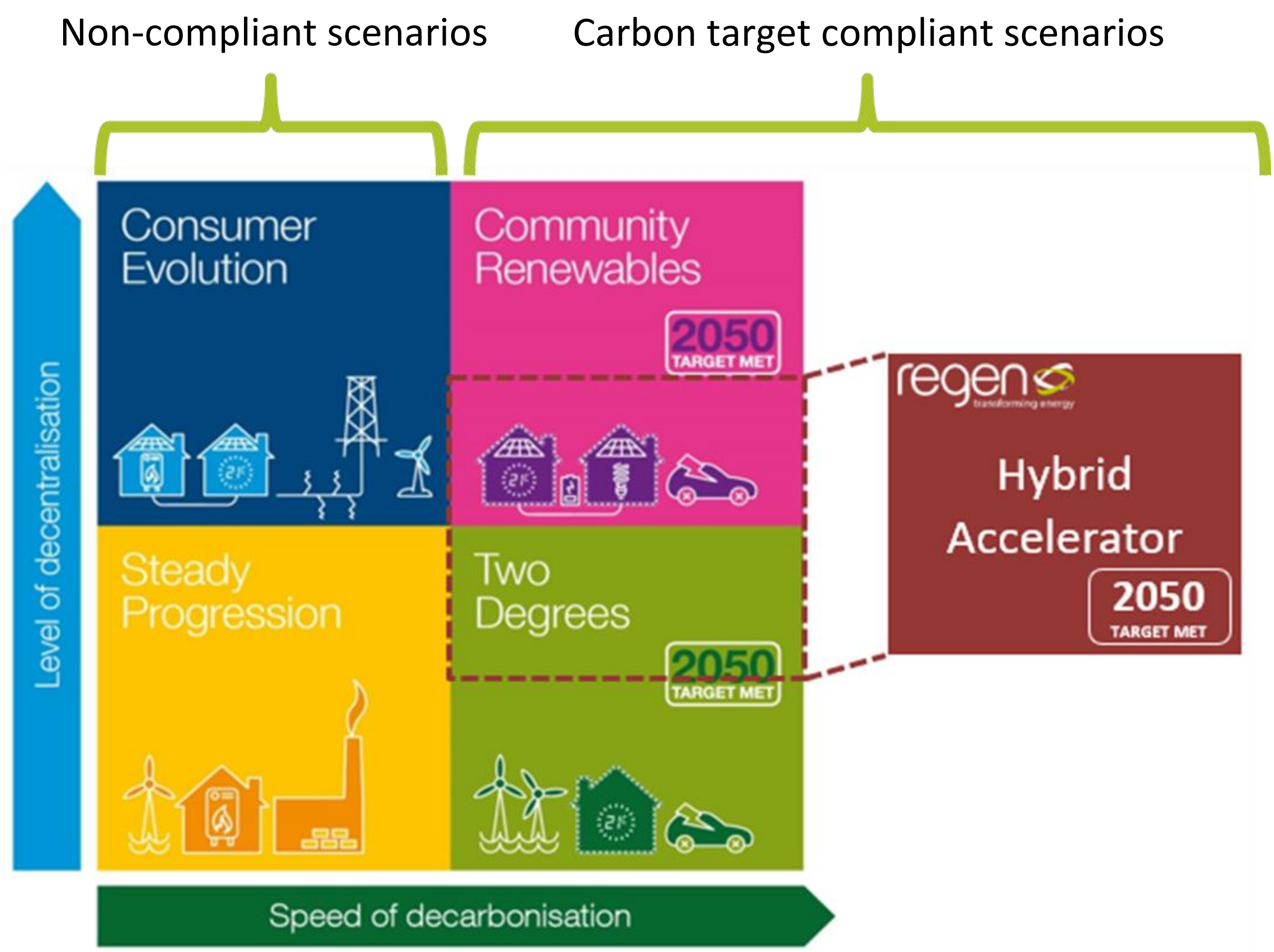

Figure 4: Scenarios framework for regional growth scenarios for gas and heat (Credit: National Grid and Regen)

An important point to note is that while the compliant scenarios deliver a high degree of decarbonisation by 2035 to be consistent with achieving the UK's current target of 80% carbon emission reduction by 2050, they are not necessarily consistent with the more ambitious 'net zero' target by 2050 that has now been proposed by the Committee on Climate Change and adopted by UK Government.[8]

The scenarios are not consistent with a much more accelerated 'net zero by 2030' decarbonisation goal that has been proposed and/or adopted by a number of local authorities in the South West or the equivalent decarbonisation goals for Wales, set by Welsh Government.

As regional and national decarbonisation policies change it will be necessary to revisit the scenario analysis to understand the impacts of a more ambitious and accelerated decarbonisation pathways.

4.3 The challenge of decarbonising heat

Heat is widely recognised as the most difficult energy vector to decarbonise, so it is unsurprising that the decarbonisation of heat is a key area where there is significant divergence within the energy scenarios. Heat was also the key area for which the project obtained both input and challenge during the stakeholder engagement workshops.

In part, the problem with heat is that there is no single technology solution that meets the three key outcomes of being **low cost, low carbon** and **feasible to universally deploy at scale.** Perhaps more fundamentally heat, unlike power, is much more than a commodity fuel. Households and businesses have a more hands-on relationship with their heating systems which are very often part of the fabric of the building. Replacing heat technologies therefore may often require significant consumer agreement and behavioural change, as well as financial investment.

With around 85% of domestic heat currently delivered by the gas network, the decarbonisation of heat using alternative technologies such as heat pumps is also coming from a much lower basis. The RHI scheme has been in place for over five years with some moderate success[13]. However, with very low public awareness of the carbon impact of heating, and even less awareness of the potential alternative options, shifting people and businesses away from fossil fuels has proved to be both much harder than anticipated and much harder than electricity.

The principle 'no silver bullet' conclusion was reinforced during the stakeholder engagement events. Indeed, the consensus across all four events, and with current research[14] is that for the medium term at least, a multi-faceted approach that combines several actions and technology solutions is needed to drive the decarbonisation of heat forward.

This multi-solution approach is reflected in the scenarios in the sense that all potential solutions are deployed with differences in terms of timing, numbers and degrees, rather than more binary choices or absolutes. All the scenarios therefore feature, to some extent, the key decarbonisation measures of:

- **Energy efficiency measures**: retrofitted to older houses and regulated into new build
- **Electrification of heat**: potentially in different guises for both on-gas and off-gas properties
- **Decarbonisation of gas:** through the increased development of green gas such as biomethane
- **Heat networks:** being deployed using low carbon technologies and operated effectively
- **Alternative fuels:** such as biomethane or hydrogen blending or 100% hydrogen networks in cities or industrial clusters

In the context of the need to deploy multiple solutions and given that heat is currently mainly delivered by gas fired boilers, it is expected that gas boilers will continue to deliver heat to a very significant portion of the UK's businesses and households in the period to 2035.

The carbon reduction outcomes of the analysis, which are described in more detail in relevant regional results reports, are achieved by greater energy efficiency, deployment of heat pumps, hybrid heat pumps and other low carbon technologies and through the partial decarbonisation of energy delivered by the gas network through biomethane injection and hydrogen blending.

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[13] See Ofgem RHI accredited installation data: https://www.ofgem.gov.uk/environmental-programmes/non-domestic-rhi/contacts-guidance-and-resources/public-reports-and-data

[14] For example: Regen Swansea Bay City Region : A Renewable Future analysis

4.4 Using regional analysis to understand the role of energy networks

As this section has highlighted, the main objective of the assessment has been to create a dataset and evidence base to better inform future network and investment planning. As a secondary benefit it is hoped that the detailed analysis and baseline assessment will also provide useful data and a point of reference to help inform current network operations.

As the UK's energy sector prepares its investment and business plans for the Ofgem RIIO-2 price control period, the need for network operators to provide greater data and evidence to inform investment decisions has increased. In particular, Ofgem[15] has asked network operators to demonstrate plans that:

- Put stakeholders at the heart of their decision-making process.
- Invest efficiently to ensure continued safe and reliable services.
- Innovate to reduce network costs for current and future consumers.
- Play a full role in delivering a low carbon economy and wider environmental objectives.

It is hoped that by providing bottom-up, regional analysis to inform longer-term network planning, this NIA backed project will enable the roll-out of a more integrated and evidenced-based asset management and network planning processes for WWU and potentially for other network operators.

There are already numerous cross-over areas with WWU and their equivalent electricity network operators in the South West and Wales. These include the increase in the interest to connect distributed gas fired power generation, the adoption of electrified heating technologies, the future registrations of both electric and gas vehicles and use of alternative gases, such as biomethane and hydrogen.

This new approach to undertake regional, scenario-based assessments intends to provide WWU with more localised, granular projections for specific areas of their network. The use of GSAs will also enable WWU to identify potentially disruptive future gas demand or biomethane injection 'hot spots', as well as areas of their network where they are may potentially see notable demand reduction, due to an uptake of the electrification of heat or heat networks.

The South West and Wales regional assessments are therefore intended to provide WWU with a scenarios-based projection database, which the can interrogate, acting as a new, more detailed and localised first stage of their investment planning process and RIIO2 business plan (Figure 1).

[15] OFGEM – RIIO website https://www.ofgem.gov.uk/network-regulation-riio-model/network-price-controls-2021-riio-2/what-riio-2-price-control

4.5 Considering peak demand

This assessment has produced projections of the annual demand for gas across the South West LDZ and Wales LDZs, through modelling the evolution of annual network gas fuel consumed between 2018 and 2035. Annual gas demand has been modelled out to 2035 by producing geographically distributed scenario projections for all of the key sources of demand. These annual demand projections, and the ability to geographically disaggregate them to local level using the GSA methodology, are intended to inform the medium/long term operability and investment strategy for WWU, as discussed in the Inception Report.

In addition to meeting annual demands, it is essential that the network can also meet the peak demand placed upon it. Gas network operators have historically based a proportion of both their near-term operational forecasting and longer-term network investment planning on **peak day demand (GWh/day)**, which centres around demand behaviour on a "1-in-20 year" extreme cold day.

A significant proportion of demand within each LDZ is driven by Temperature Sensitive Loads (TSLs), much of the peak day demand forecasting to date completed by GDNs, has been based on historic demand and weather data. This allows the creation of an LDZ demand curve that can be combined with weather forecasts to produce demand forecasts. These peak demand forecasts are then diversified, naturally accounting for the fact that not all loads will be at their peak demand on the network at exactly the same time. However, with the increasing numbers of gas fired electricity generators connecting to the distribution network, peak demand forecasting is becoming more complex and less directly correlated to space heating demand in homes and businesses.

This assessment has produced scenario projections for TSLs in the form of domestic, commercial and industrial connections (accounting for properties switching their heat to alternative technologies) and annual demand. Modelling and projecting future peak demand for these TSLs is not within the scope of this assessment. In addition to these, the study has produced projections for the following non-TSLs:

Demand Factor	Specific Element	Unit
Gas fired power generation	Electricity generation capacity	MW_e
	Annual gas demand (based on an average capacity factors)	MWh
Industrial processes	Number of daily metered sites	Number of (#)
	Annual gas demand (based on an average value)	MWh
Gas fuelled vehicles	Number of vehicles (HGV, buses)	Number of (#)
	Annual gas demand (based on an average value)	MWh

Previous innovation projects[16] have identified the following key drivers of change in peak on the LDZ:

- New connections, from newbuild homes and new connections of existing homes
- Replacement of older (non-condensing) gas boilers

As some of the scenario projections in this study bring with them significant changes to the annual demand on the network, it can be considered that there may be a similar impact on diversified peak demand on the network. Some changes in annual demand could be expected to bring about similar changes in peak, whilst others will likely have more complex interactions, where they also impact the diversification of that source of demand (some examples are shown in Table 1).

[16] https://www.smarternetworks.org/project/nia_wwu_011/documents

Table 1: Examples of some drivers of change to annual and peak demand

Driver of change	Likely impact on peak demand in relation to annual demand, at the individual site level	Likely impact on the diversification of peak demand across an LDZ
Increased insulation levels in existing buildings	**Similar level of reduction in peak vs annual demand →→**	**Increase in diversification ↑↑** Due to more stable temperature within buildings
No new build dwellings on gas network post 2025	**This will result in a reduction in the growth of peak and annual demand.**	**Similar level of diversification of peak →→**
Increase in efficiency of gas heating appliances	**Similar level of reduction in peak vs annual →→**	**Possible reduction in diversification ↓↓** As condensing boilers have poorer performance during very low temperatures[17]
Increased deployment of gas Hybrid Heat Pumps (HHPs)	**Potentially significant reduction in annual demand[18], but much less impact on peak demand →→**	**Diversity factor for HHPs depends on implementation** Mode of operation is dependent on control logic, efficiency of house and potentially location. So there could be some diversification of operation, which could lead to some widening of the peak during very cold periods.
High proportion of flexible gas fired power generation	**Unknown impact on peak demand vs annual** Peak demand for power depends on a number of factors, including: • Size and type of plant • Changing capacity factors • Operating modes • Geographic location • Electricity market activity • Gas and electricity pricing There are also future considerations such as the extent to which heat and transport sectors are electrified, that may affect the role that gas fired power will need to play. It is however likely that flexible gas fired generation will be very	**Diversity factor for power generation could vary, but unlikely to be diversified on 1-in-20 peak days** Across a given year the various factors highlighted in the left column can result in some uncertainty around forecasting when gas fired generation sites may be at their peak output across the network. However, for the purposes of determining a 1-in-20 peak day demand for gas, it can be considered that connected flexible gas generators will most likely be operating at peak output, to support the electricity network or exploit

[17] https://www.cibsejournal.com/cpd/modules/2019-07-gas/?utm_content=buffer027dd&utm_medium=social&utm_source=linkedin.com&utm_campaign=buffer
[18] The results from the Freedom Project, showed around an 80% reduction in annual gas demand using hybrids: https://www.wwutilities.co.uk/media/2829/freedom-project-final-report-october-2018.pdf

	peaky/sporadic in nature, at times potentially operating at full capacity, whilst overall annual demand could be low.	strong market prices in the near/medium-term. The diversification of peak 1-in-20 gas demand from power generation sites is therefore likely to be minimal, for forecasting and network planning purposes.

These drivers of change in demand are notably different and potentially even disruptive, to the historical way by which forecasting has been determined. Building a bottom-up model of peak demand and projecting this out to 2035 is out of the scope of this future energy scenarios assessment, but as a key facet of future network planning it is important to recognise and understand the different factors that influence total annual demand and peak demand periods on the network.

In four of the five sets of projections, reduction in annual demand is seen by 2035 to a varying degree. Whilst it is reasonable to assume that peak demand will evolve over this timeframe, the future trajectory for peak day demand is uncertain, as there will be trade-offs between greater energy efficiency and use of low carbon heating versus potentially greater levels of flexible generation plant that will be operating more sporadically.

In the two more decarbonised scenarios, the 2019 National Grid FES[19] suggests that nationally, peak demand is likely to notably decrease in gas peak day demand from 2020 onwards, see Figure 5. However, the two less-decarbonised scenarios show a stark increase in peak day over the next year, flattening off in the 2020s and a moderate decrease between 2030 and 2035.

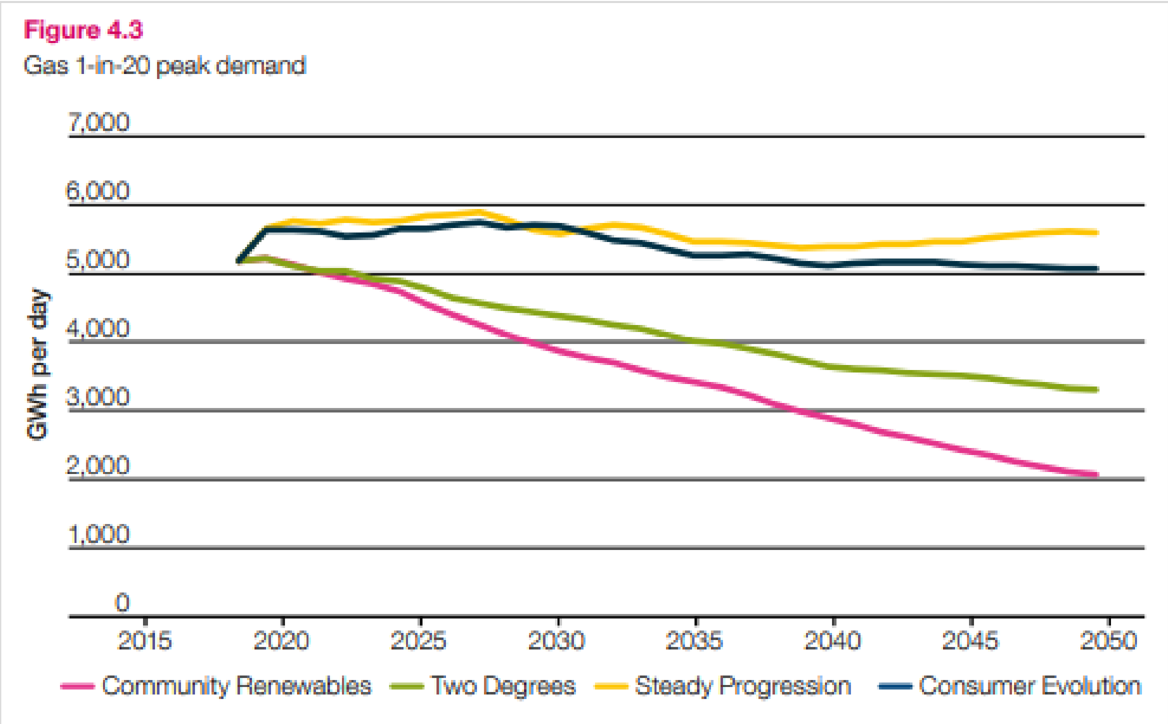

Figure 5: GB national peak demand for gas in a 1-in-20 year (Source: National Grid ESO Future Energy Scenarios 2019)

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[19] http://fes.nationalgrid.com/fes-document/

Evidence across these scenarios therefore points to the possibility of either an increase or a decrease in peak day demand over the next decade and beyond. There is therefore clear scope for more work understanding peak at a distribution level, specifically to analyse the impact of the changes to heating, industrial gas demand and the future role of gas fired electricity generation out to 2035.

In the context of a Net Zero outcome and trajectory, the longer term actions to further reduce carbon to meet adopted legally binding targets will very likely need to result in a nationwide reduction in both annual and peak day gas demand. There are a number of options being assessed to heavily decarbonise our heating through the production and delivery of hydrogen as a low carbon alternative to natural gas[20], increased levels and use of biomethane or significant numbers of homes and businesses being using heat pumps. The most prevalent solutions and the regional variability of how and when they are adopted are further unknowns, causing the near-term, 2035 and longer term (i.e. to 2050) projections for peak day demand on the gas distribution network to be difficult to predict.

[20] Considering both 'green' hydrogen produced by surplus electricity or 'blue' hydrogen manufactured through methane reformation and mitigated via carbon capture and storage

5 Regional Growth Scenarios for Gas and Heat - project and methodology overview

5.1 Project inception and scoping

The methodology underpinning the development of regional scenarios for gas and heat was initially developed over the summer of 2018, and was finalised, with significantly more detail added, during the Phase 1 project inception and scoping of this project.

The methodology and scoping report completed in January 2019[21] and provided the following information:

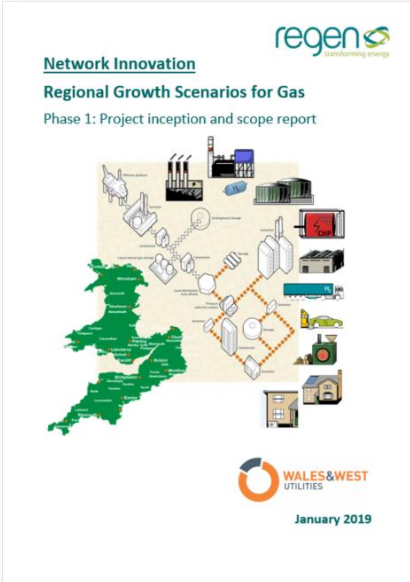

Figure 6: Phase 1 Inception & Scope Report (Jan 2019)

- **Scope confirmation:** Confirmation of the overall innovation project scope, including geography, scenarios, timeframe and the elements of the gas and heat system to be assessed
- **Scenario definition**: Interpretation and the key growth assumptions for the future energy scenarios used for the assessment, including the fifth '**Hybrid Accelerator**' scenario
- **Definition of geographical distribution:** Defining the geographical remit, the geographical boundary area(s), and Regen's bespoke Gas Supply Areas; used to distribute the scenario projections at a sub-regional level
- **Confirmation of detailed drivers:** Defining the factors that will drive the scenario projections, such 'growth drivers' and 'geographical distribution' drivers
- **Input data and evidence base:** A register of some of the data sources that can act as the evidence for the historic baseline, near-term pipeline (where applicable) and future scenario projections
- **Stakeholder engagement plan:** Outlining the approach to obtain stakeholder and customer engagement, feedback and evidence to consult on the approach and results of the project
- **Updated project delivery plan:** Including project timeline, milestones, resource and project team
- **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 proposed dissemination and communications plan:** Summary of the communications pack and publication plan that is to be produced for each of the two regional analyses.

As an innovation project it was expected that some aspects of the methodology would evolve as the project was delivered. Some of these evolutions include:

- The various bespoke spreadsheet models that have been developed to work through the baselining, pipeline processing and future scenario analysis was created, tested and used
- The definition and development of GSAs was revised and finalised
- The fifth scenario **Hybrid Accelerator** was further developed
- The definition of factors and elements and their units of measure were further enhanced
- The approach, agenda and method of delivering stakeholder engagement evolved

[21] More detailed information about the clarifications around scope, methodology and approach can be found in the Phase 1 Inception and Scope Report, issued to WWU in January 2019.

5.2 Geographical scope

The core analysis of the project, following on from the project inception and scope confirmation, has been divided into two regional phases, echoing WWU's local distribution zones (LDZ).

- Phase 2 analysis for the South West LDZ
- Phase 3 scenario analysis is for the North Wales and South Wales LDZs combined together

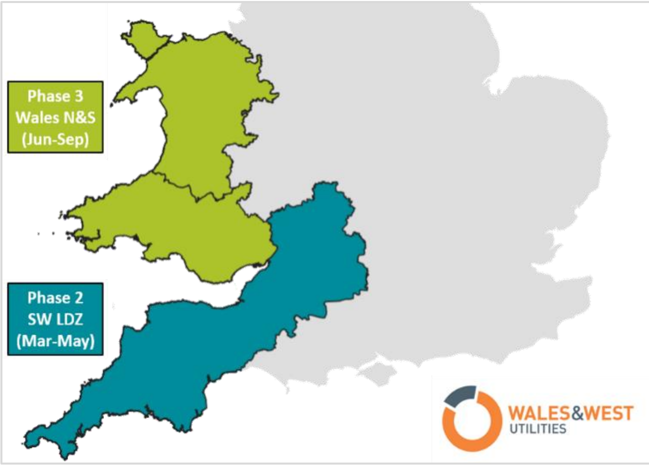

Figure 7 WWU Local Distribution Zones and Project Phases

5.3 Scenario framework

The project utilises the 2018 edition of the **National Grid Future Energy Scenarios (FES)**[22] as the overarching framework for the analysis and projections, demonstrating high or low levels of decentralisation and decarbonisation. In the context of this regional scenario assessment, this framework is used to provide:

- The national context for the scenario analysis and underpinning assumptions (e.g. societal, economic, technological and political positioning in time)
- A point of reference for overall growth for key elements and wider decarbonisation
- A set of national benchmarks against which to analyse, interpret and underpin the regional projections and differences

As part of Phase 1 of this project a fifth scenario, **Hybrid Accelerator**, was developed to sit alongside the existing four FES scenarios (Figure 8).This scenario achieves the UK's decarbonisation objectives in the period to 2035 but would make more direct use of the existing gas network and infrastructure. The **Hybrid Accelerator** scenario also assumes a high uptake of heat pumps, of which a high proportion are in the form of gas hybrid heat pumps. In addition to this, this fifth scenario also assumes a strong decarbonisation of the gas in the networks, as a mid-point between the two carbon-target-compliant scenarios. More information about the high-level interpretation and context of the five scenarios is outlined in the Phase 1 inception and scoping report.

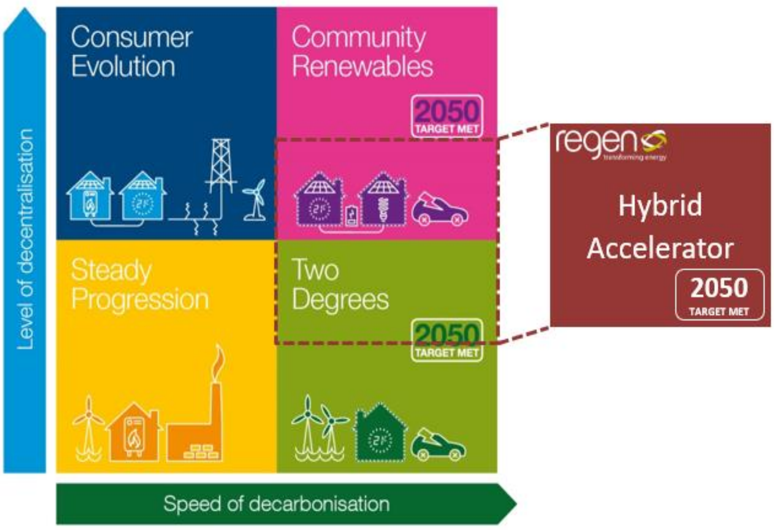

Figure 8: Scenarios framework for regional growth scenarios for gas and heat (Credit: National Grid and Regen)

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[22] See National Grid FES website - http://fes.nationalgrid.com/media/1363/fes-interactive-version-final.pdf

5.4 Factors and elements for scenario projection

For each of the key factors, the project has analysed a number of elements and used them to drive future scenario projections to 2035. A summary of these factors and elements is in Table 2.

Table 2: List of factors of gas and heat system being analysed and projected for regional future energy scenarios

Category	Factor	Element of Projection	Projection Units
Sources of demand	**Domestic heat demand**	Properties	Number (#)
		Annual heat demand	Energy (MWh)
		Heat delivery technology	Proportion (%)
			Efficiency (%)
		Annual fuel demand	Energy (MWh)
	Commercial & industrial heat	Properties	Number (#)
		Annual heat demand	Energy (MWh)
		Heat delivery technology	Proportion (%)
			Efficiency (%)
		Annual fuel demand	Energy (MWh)
	Gas fired power generation	Sites	Number (#)
		Power capacity	Power (MW_e)
		Annual energy generation	Energy (MWh)
		Conversion efficiency	Efficiency (%)
		Annual gas demand	Energy (MWh)
	Industrial processes	Properties	Number (#)
		Annual gas demand	Energy (MWh)
		Annual hydrogen demand	Energy (MWh)
	Gas fuelled vehicles	Vehicles	Number (#)
		Annual fuel demand	Energy (MWh)
	Electric Vehicles (EVs)	Vehicles	Number (#)
		EV charging stations	Number (#)
		Power capacity	Power (MW_e)
		Annual electricity demand	Energy (MWh)
Alternative supply	**Green gas injection**	Gas injection sites	Number (#)
		Gas injection capacity	Capacity (scm/h)
		Annual green gas entry	Energy (MWh)
		Proportion of gas	Proportion (%)
	Hydrogen blending	Annual hydrogen energy	Energy (MWh)
		Proportion of gas demand	Proportion (%)
	Unconventional natural gas (coal bed methane, shale gas)	Sites	Number (#)
		Capacity	Capacity (scm/h)
		Annual gas entry	Energy (MWh)
		Proportion of gas	Proportion (%)

For these elements, the year-on-year growth, reduction or proportional change will vary across the five scenarios. The results of many of these elements can also be combined/aggregated together to provide a resultant demand for gas, heat electricity demand and carbon footprint by 2035.

5.5 Scenario projection process and timeframe

From a baseline year of **2018** to a projection year of **2035**, the analysis provides annual projections of energy demand and supply. This is a smaller timeframe to the National Grid FES assessment, which culminates in 2050, but 2035 was chosen to align with existing assessments Regen has completed with electricity DNOs and also provide more direct input into the timeframe of RIIO-2, which ends in 2026. Milestone years (2020, 2025, 2030 and 2035) have also been used in some aspects of the modelling for incremental growth analysis, where assessing annual variances may not necessarily be required.

The approach to scenario projections can be broken down into two or three key stages, the exact years for which can depend on the individual element in question, see below and Figure 9.

- **Baseline position (up to 2018):** using historical regional data, deployments and registers.
  Baseline position is constant for all scenarios.
- **Near-term pipeline (from 2018 to mid-2020s):** using known developments, enquiries or accepted connection contracts for projects in the near term.
  Pipeline position may slightly vary for some elements in some scenarios.
- **Scenario projections (from mid-2020s to 2035):** applying element-specific growth drivers and assumptions to lesser or greater degree for each scenario.
  Scenario projections will likely vary notably for all elements across all five scenarios.

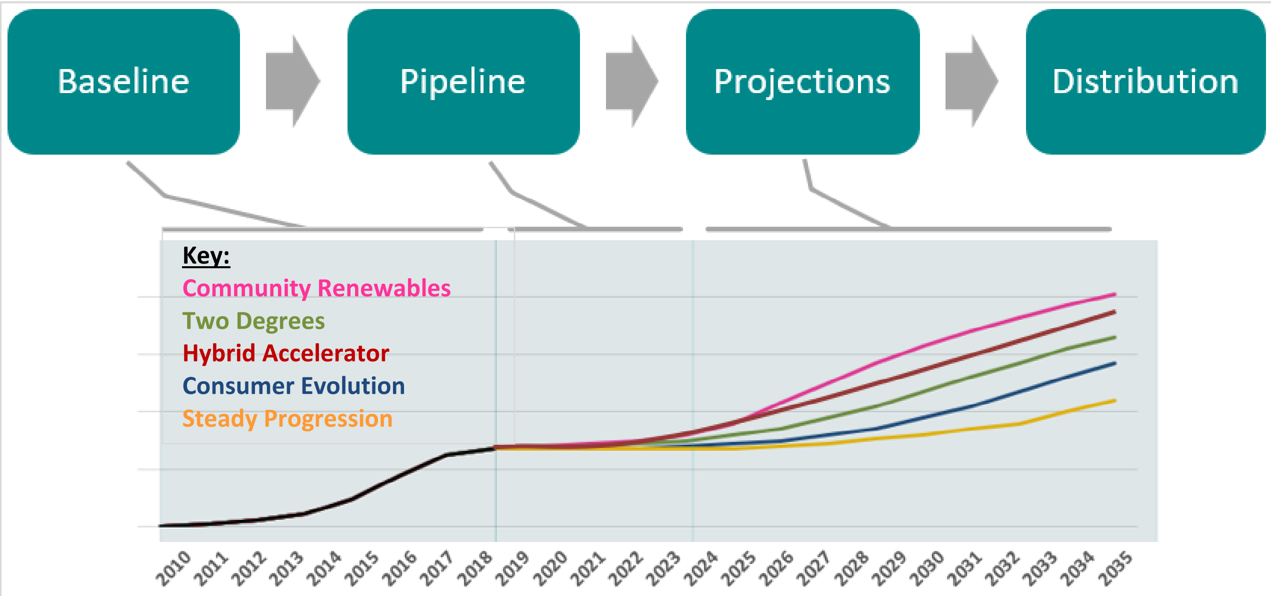


Figure 9: Example of the scenario stages / process used for projections in this project

5.6 Key Data Sources

In order to establish a baseline and near-term pipeline position for each of the key elements in Table 2, the assessment utilises a number of key data sources, evidence bases and publications. Some of these are outlined in Table 3:

Table 3: Key sources of data and evidence used to define the baseline and near-term pipeline of key elements of the regional future energy scenario assessment

Data / Evidence Base	Source
Connection and spatial gas network data Gas fired generation register Biomethane entry register New developments tracker	WALES&WEST UTILITIES
Sub-national consumption data Renewable Heat Incentive data Heat Networks Delivery Unit data Microgeneration Certification Scheme data Feed in Tariff (ROOFIT) data	Department for Business, Energy & Industrial Strategy
New housing developments forecasts	Office for National Statistics
Gas fired power generation connection data South West and South Wales regional FES assessment data	WESTERN POWER DISTRIBUTION Serving the Midlands, South West and Wales
UK Capacity Market data and registers	Electricity Market Reform DELIVERY BODY
National Grid ESO balancing services market data	nationalgridESO
Housing heating technology historic data	2011 Census
Biomethane injection spatial data	ADBA Anaerobic Digestion & Biogas Association
Planning activity locational information Local planning authority information	PLANNING PORTAL
Electric vehicle and gas vehicle uptake data	Department for Transport
Existing South West and Wales regional modelling Gas fired power generation projections and Electric Vehicle uptake modelling for WPD South West and South Wales licence areas	regen transforming energy

It should be noted that the majority of baseline and pipeline data will be applicable from when the analysis phase of this report was completed, which was mostly applicable within Q1 2018.

Some updated information for the Wales regional analysis was used, due to Phase 3 commencing 3 months after the South West (Phase 2).

For each element there are specific growth (or reduction) drivers that have been applied, to determine the year-on-year projections, under each scenario. These growth drivers can be categorised into:

- **Policy drivers -** 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 drivers -** 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 drivers -** 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.
- **Resource drivers -** 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.

In addition to these drivers, the national FES projections have been referred to for some specific technologies and fuels, specifically for the proportional changes, annual differences and trends.

In some cases, milestone year positions in 2020, 2025, 2030 and 2035 have been used, through interpolation, as a method of shaping interim years for some of the specific elements of the analysis.

5.7 Geographical distribution and Gas Supply Areas

To provide a more granular view of the scenario projections, the annual projections for each of the five scenarios, have been disaggregated or distributed geographically the 100 **Gas Supply Areas** or **GSAs** in the South West LDZ (63 GSAs) and Wales LDZs (37 GSAs) - see Figure 10 and Figure 11.

Figure 10: Gas Supply Areas for the WWU South West Local Distribution Zone

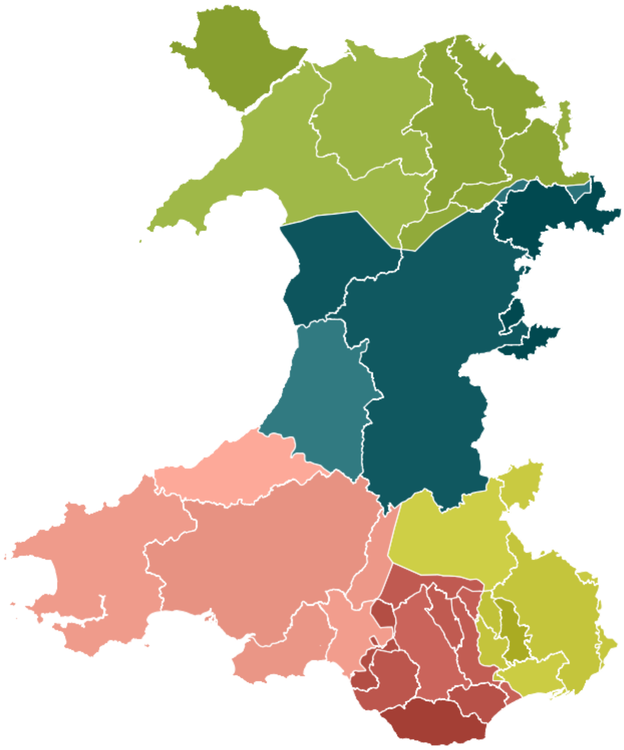
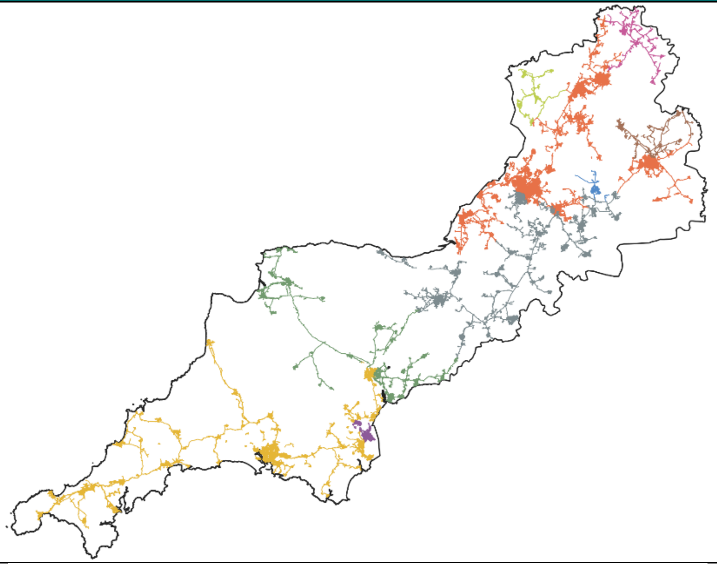
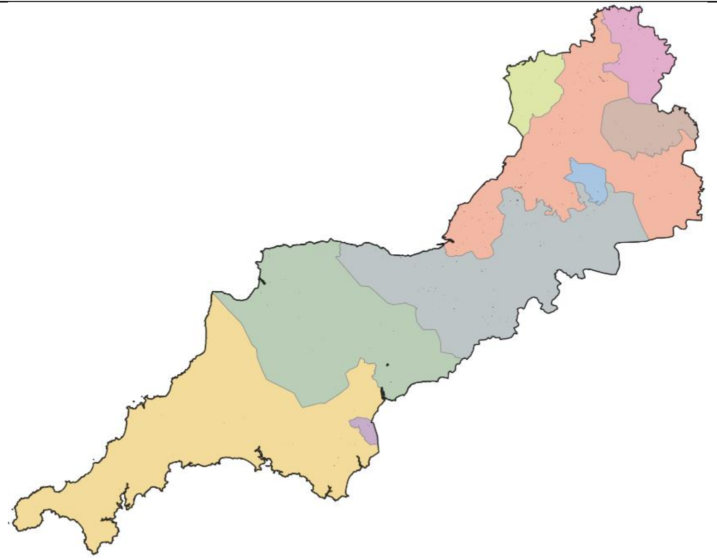
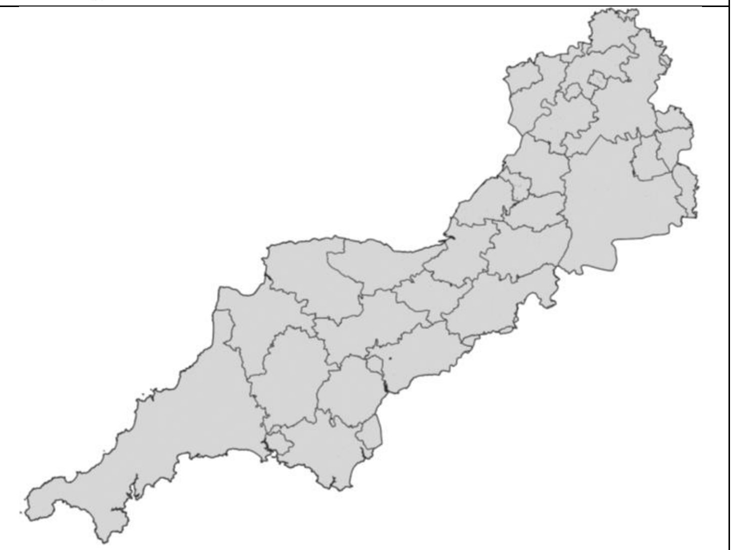
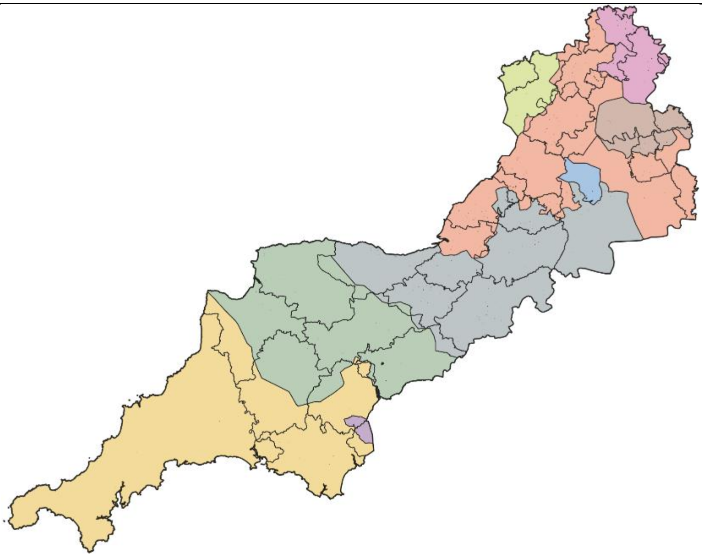


Figure 11: Gas Supply Areas for the WWU Wales North & South Local Distribution Zones

The GSAs have been developed in GIS mapping, through the process outlined below:

Step	GSA Creation Description	GSA Creation Stage Map
1	**Analyse the WWU South West gas distribution pipe network locations in GIS**	
2	**Assign sections of the network to the nine operational linepack zones in the WWU South West LDZ**	
3	**Overlay the 33 local authority boundaries applicable to the WWU South West LDZ**	

4	**Combine the nine linepack zones with the 33 local authority areas to create 63 bespoke GSAs**	

The GSAs have been used to distribute the baseline, pipeline and scenario projections for each element, to a finer resolution. The GSAs being a combination of WWU's linepack zones and local authority boundaries enables data to be aggregated up either to a linepack zone for WWU operational modelling, or to a local authority area for external communication and customer engagement.

5.8 Relationship between mapping and scenario projection data

The mapping used throughout this report is a visual representation of the geographical distribution of the scenario specific projections for individual gas and heat elements. For example, as can be seen in Figure 12, the value held in the projection dataset against a specific year and scenario is distributed spatially across the GSAs, based on element-specific distribution factors.

Category	Factor	Element	Units	Fuel	Scenario	GSA	Baseline	2019	2020	2021	2022	2023	2024	2025	2026
Demand	Gas fired	Power ca	MWe	Mains ga	Community Renewables	Aylesbeare - East Devon	0	0	0	0	0	0	0	0	0
Demand	Gas fired	Power ca	MWe	Mains ga	Community Renewables	Aylesbeare - Exeter	0	0	0	0	0	0	0	0	0
Demand	Gas fired	Power ca	MWe	Mains ga	Community Renewables	Aylesbeare - Mid Devon	0	0	0	0	0	0	0	0	0
Demand	Gas fired	Power ca	MWe	Mains ga	Community Renewables	Aylesbeare - North Devon	0	0	0	0	0	0	0	0	0
Demand	Gas fired	Power ca	MWe	Mains ga	Community Renewables	Aylesbeare - Taunton Deane	0	0	0	0	0	0	0	0	0
Demand	Gas fired	Power ca	MWe	Mains ga	Community Renewables	Aylesbeare - Teignbridge	0	0	0	0	0	0	0	0	0
Demand	Gas fired	Power ca	MWe	Mains ga	Community Renewables	Aylesbeare - Torridge	0	0	0	0	0	0	0	0	0
Demand	Gas fired	Power ca	MWe	Mains ga	Community Renewables	Aylesbeare - West Devon	0	0	0	0	0	0	0	0	0
Demand	Gas fired	Power ca	MWe	Mains ga	Community Renewables	Central - Bath and North East Somerset	0	0	0	0	0	2	2	2	2
Demand	Gas fired	Power ca	MWe	Mains ga	Community Renewables	Central - Bristol, City of	0	0	0	0	0	0	0	0	0
Demand	Gas fired	Power ca	MWe	Mains ga	Community Renewables	Central - East Devon	0	0	0	0	0	0	0	0	0
Demand	Gas fired	Power ca	MWe	Mains ga	Community Renewables	Central - Mendip	0	0	0	0	0	0	0	0	0
Demand	Gas fired	Power ca	MWe	Mains ga	Community Renewables	Central - North Somerset	0	0	0	0	0	0	0	0	0
Demand	Gas fired	Power ca	MWe	Mains ga	Community Renewables	Central - Sedgemoor	10	10	10	10	10	10	10	10	10
Demand	Gas fired	Power ca	MWe	Mains ga	Community Renewables	Central - South Somerset	0	0	6.4	6.4	6.4	26.4	26.4	26.4	26.4
Demand	Gas fired	Power ca	MWe	Mains ga	Community Renewables	Central - Taunton Deane	0	0	0	20	20	20	20	20	20
Demand	Gas fired	Power ca	MWe	Mains ga	Community Renewables	Central - West Somerset	0	0	0	0	0	0	0	0	0
Demand	Gas fired	Power ca	MWe	Mains ga	Community Renewables	Central - Wiltshire	0	14	14	14	21.5	48.5	48.5	48.5	48.5
Demand	Gas fired	Power ca	MWe	Mains ga	Community Renewables	Cirencester - Cotswold	0	0	0	0	0	0	0	0	0
Demand	Gas fired	Power ca	MWe	Mains ga	Community Renewables	Cirencester - Swindon	0	0	0	0	0	0	0	0	0
Demand	Gas fired	Power ca	MWe	Mains ga	Community Renewables	Cirencester - Vale of White Horse	0	0	0	0	0	0	0	0	0
Demand	Gas fired	Power ca	MWe	Mains ga	Community Renewables	Cirencester - West Oxfordshire	0	0	0	0	0	0	0	0	0
Demand	Gas fired	Power ca	MWe	Mains ga	Community Renewables	Cirencester - Wiltshire	0	0	0	0	0	0	0	0	0
Demand	Gas fired	Power ca	MWe	Mains ga	Community Renewables	Coffinswell - Teignbridge	0	0	0	0	0	0	0	0	0
Demand	Gas fired	Power ca	MWe	Mains ga	Community Renewables	Coffinswell - Torbay	20	20	20	20	20	20	20	20	20
Demand	Gas fired	Power ca	MWe	Mains ga	Community Renewables	Evesham - Cotswold	0	0	0	0	0	0	0	0	0
Demand	Gas fired	Power ca	MWe	Mains ga	Community Renewables	Evesham - Stratford-on-Avon	0	0	0	0	0	0	0	0	0
Demand	Gas fired	Power ca	MWe	Mains ga	Community Renewables	Evesham - Tewkesbury	0	0	0	0	0	0	0	0	0
Demand	Gas fired	Power ca	MWe	Mains ga	Community Renewables	Evesham - West Oxfordshire	0	0	0	0	0	0	0	0	0
Demand	Gas fired	Power ca	MWe	Mains ga	Community Renewables	Evesham - Wychavon	0	0	0	0	0	0	0	0	0
Demand	Gas fired	Power ca	MWe	Mains ga	Community Renewables	Littleton - Wiltshire	16	16	16	16	16	16	16	16	16
Demand	Gas fired	Power ca	MWe	Mains ga	Community Renewables	Northern - Bath and North East Somerset	0	0	0	0	0	0	0	0	0
Demand	Gas fired	Power ca	MWe	Mains ga	Community Renewables	Northern - Bristol, City of	30	30	40	40	40	40	40	60	60
Demand	Gas fired	Power ca	MWe	Mains ga	Community Renewables	Northern - Cheltenham	0	0	0	0	0	0	0	0	0
Demand	Gas fired	Power ca	MWe	Mains ga	Community Renewables	Northern - Cotswold	0	0	0	0	0	0	0	0	0
Demand	Gas fired	Power ca	MWe	Mains ga	Community Renewables	Northern - Forest of Dean	0	0	0	0	0	0	0	0	0
Demand	Gas fired	Power ca	MWe	Mains ga	Community Renewables	Northern - Gloucester	60	79.3	79.3	79.3	79.3	99.3	99.3	99.3	99.3

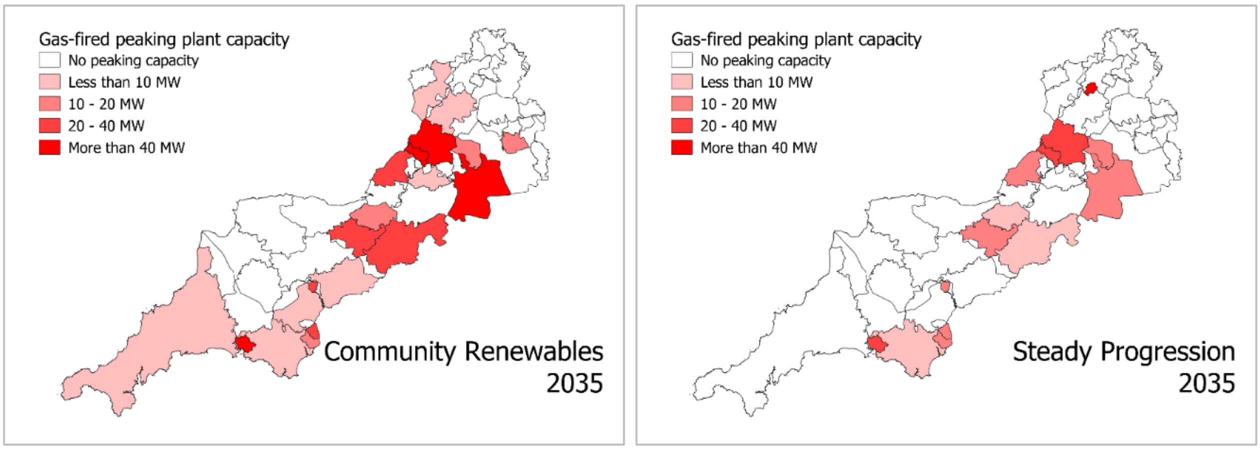


Figure 12: Extract from Regen scenarios projection database showing annual gas fired power generation capacity (MWe) distributed to WWU South West LDZ GSAs

5.9 Engagement workshops and stakeholder insights

5.9.1 Stakeholder engagement events - overview

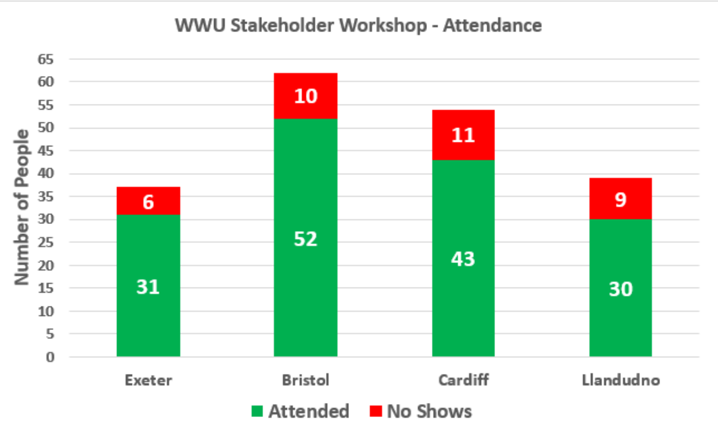
A key part of the project has been to engage with WWU's stakeholder community. Stakeholder engagement workshops were held in Exeter, Bristol, Cardiff and Llandudno and was attended by over 150 people, from a wide variety of organisations including industry representatives, project developers, academic and research organisations, local authorities and community groups.

Engagement Workshops	Overview of attendees
Event 1 – Exeter Castle, Exeter, 21 March 2019 **Event 2 – Mercure Holland House Hotel, Bristol, 18 April 2019** **Event 3 – Principality Stadium, Cardiff, 25 June 2019** **Event 4 – Venue Cymru, Llandudno, 7 August 2019**	83 individuals representing: • Welsh Government + WG Energy Service • Local authorities • Energy suppliers and service companies • Other gas network operators • Electricity distribution network operators • National Grid ESO + FES Heat Analysis Team • Power generation developers • Green gas project developers • Water and sewage utility companies • Sustainability, campaign and advice organisations • Gas engineering companies • Business council representatives • Energy consultancy organisations • Academic and research organisations • Energy solicitors and law firms • Community energy groups and cooperatives

The attendance was strong across all events, with most people attending the second South West event in Bristol in mid-April. See overview of event attendance in Table 4, Figure 13 and Figure 14.

Table 4: Summary of attendance to engagement workshops

Event	Booked	Attended	No Shows	Rate
Exeter	37	31	6	84%
Bristol	62	52	10	84%
Cardiff	54	43	11	80%
Llandudno	39	30	9	77%
Total	**192**	**156**	**36**	**81%**



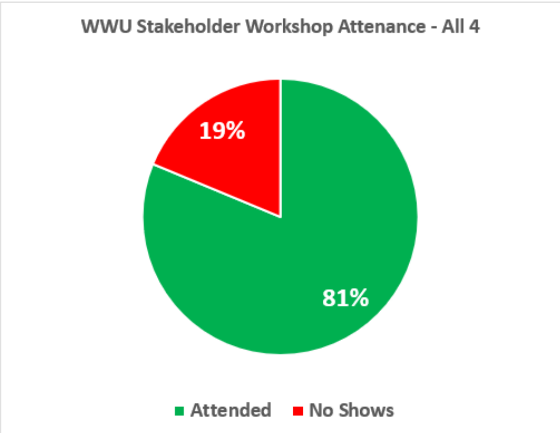


Figure 13: Stakeholder engagement workshop - attendance overview statistics

Figure 14: Images from Regen and WWU's Exeter (March), Bristol (April), Cardiff (June) and Llandudno (August) engagement events

5.9.2 Engagement workshop structure and content

The four workshops, which were jointly hosted by Regen and WWU, proved an effective means to enable WWU to update stakeholders on their business planning process and future network planning, as well as to gather insight and input to develop the regional scenarios.

In particular delegates were asked to:

- Clarify the impacts of key market, policy and technology drivers
- Provide insight on the changing commercial landscape for the use of gas in domestic, commercial and industrial sectors
- Understand the future growth/reduction of some of the key elements of the scenario analysis
- 'Road test' the approach, data, evidence base, assumptions and results with a wider audience

The content of these events covered the following areas, from the perspective of the region:

1. **An overview of WWU's future network forecasting, investment planning and approach to understanding the future of energy, including how the network responds to new peak events**
2. **High level methodology and approach for the regional scenarios for heat and gas**
3. **A summary of the draft scenario outputs and geographical distribution results, for each of the key sources of demand and supply**
4. **Two repetitions of four roundtable sessions, focussing on core topics within the project:**
    a. **Evolving domestic heating demand and supply**
    b. **Commercial and industrial gas usage**
    c. **Gas fired power capacity growth and generation**
    d. **Green gas injection development potential (including hydrogen)**

5.9.3 Stakeholder insights incorporated into scenario modelling

Table 5 provides some examples of feedback and insight received from the events, specifically from the roundtable discussions, was incorporated into the analysis.

Table 5: Summary of how the feedback received from engagement events was used to adjust Regen's analysis/modelling

Aspect of analysis	Feedback received	Action on analysis
Domestic heat – New build rates	The assessment takes a view of future housing developments that combines information gathered from local authority development plans and Office of National Statistics (ONS) new housing projections. The assessment initially put more weighting on the ONS data, which resulted in a much lower build out rate than local plans in the near term. The feedback received was that whilst a combination of the local plan and ONS projections was a sensible approach, the weighting towards the ONS figures may not be fully considering Government targets for new housing on local authorities.	The modelling resultantly reduced some of the dampening of new developments in the 2020s and redressed the weighting more towards what local plans were projecting and less towards the ONS conservative figures.
Domestic heat – Application of the proposed ban on fossil fuel fired	In the scenarios that incorporated a ban on gas and oil boilers in new-build homes, stakeholders expected to see a 'cliff edge' whereby developers continue to install gas/oil right up until the 2025 deadline, rather than seeing industry steadily	The scenarios for new build heat delivery technology split has been adjusted up to and after 2025, to reflect

boilers in new builds post-2025	transition to i.e. heat pumps over a seven year period.	the installation practices in reality.
Domestic heat – Energy efficiency deployment data	Our modelling focussed predominantly on deployment data under the Government ECO programme. Feedback from attendees in Wales, was that Welsh-specific energy efficiency schemes are deploying measures in homes in Wales at a significant scale and thus should also factor into our heat demand modelling for the Wales Phase analysis.	Sourced information from: • ARBED • NEST • SPECIFIC Project • Active Buildings • Active Homes Neath • SOLCER House And included in the energy demand calculation for Wales domestic heat.
Domestic heat – Use of non-compliant scenarios	Stakeholders flagged that the non-compliant scenarios (Steady Progression and Consumer Evolution) could be more conservative than we had currently applied them, in Wales. This was specifically focussed on a potential slow-down of energy efficiency measures, reflecting many 'easy win' efficiency deployments had been done.	Lessened the reduction of energy demand reduction in SP and CE scenarios, to not be a continuation of the last 5-year trend.
Domestic heat – Efficiency of heat networks	Stakeholders validated the analysis (which we based on SAP 10.0) that heat networks currently had relatively high losses. There was suggestion that these could be reduced, but possibly not significantly within the horizon of this analysis.	Justification for the heat distribution losses used within the analysis.
Domestic heat – Nature of heat networks now and in the future	Stakeholders validated the analysis that heat networks are currently high temperature and being installed largely as fuelled by biomass and gas CHP, but that designs are in place to transition towards low temperature heat sources.	On this basis heat networks developed in both new and existing analyses have been assumed to mainly be on gas and biomass until 2025, mainly GSHP thereafter (and now includes Water Source Heat Pumps).
Commercial & industrial users – District heat also supplying C&I sites	Feedback was received around a gas fuelled energy centre in Blaenau Gwent that is supplying heat to five commercial buildings (schools and public offices), with ambitions to extend to a nearby industrial estate and potentially domestic customers in the future.	This featured as baseline evidence for commercial heat in Wales and future projections in the Blaenau Gwent related GSAs. Feedback also clarified our assumptions around commercial properties being good anchor loads for district heat
Commercial & industrial users –	Feedback was received that reducing gas consumption is not high-priority while gas cheap, especially when reducing gas consumption is	Modelling considerations around breakdown of commercial property types

Gas consumption reduction & tenure	capital intensive – the discounted value of any consumption reduction is low. Reducing consumption is also very strongly tied to tenure. Feedback that heat demand reduction could be spurred by regulation, such as a minimum EPC to lease out a commercial property.	and their ownership/ tenure as a distribution factor for heat demand/ reduction.
Commercial & industrial users – Large industrial users - bespoke	There was agreement that industrial gas users are significant factors, specifically for Wales. This warranted a bespoke approach for very large sites (i.e. steel works). There was agreement that options to tackle industrial emissions included efficiency improvements and heat recovery.	Justified Regen's approach to refocus modelling on small group of large Daily Metered users, whilst ensuring anonymity.
Commercial & industrial users – Future use of gas could increase	Whilst there was broad agreement with the FES trajectories that showed some limited decrease in large industrial gas demand to 2035, there was the potential for demand to actually **increase**, due to some organisations switching away from coal to gas as part of decarbonisation strategies.	Follow up engagement with key stakeholders on this topic has led to a bespoke approach for scenario-specific industrial demand modelling in the mid-2020s and beyond.
Commercial & industrial users – South Wales Industrial Hydrogen Cluster	Notable amount of discussion and feedback around the South Wales Industrial Cluster and the notable proportion of WWU's gas demand it accounts for. There is the potential for this cluster of sites switching to hydrogen as a group.	Wales scenarios now has specific modelling reflecting staged switching of hydrogen for key industrial cluster GSAs in the Two Degrees scenario.
Green gas – overall growth potential	The draft scenario projections saw the capacity and thus volume of green gas notably increase across all five scenarios by 2035. Increase in green gas in all scenarios was challenged by stakeholders, as growth is only likely with continued subsidy support post-RHI.	As a result of this consideration, the Steady Progression scenario now has a significantly lessened growth out to 2035 compared to the other 4
Green gas – Feedstock availability	Green gas feedstock availability was not seen as a limiting factor on development. If anything, the potential mandate on local authorities to increase food waste collection may push for more green gas production in the 2020s. Energy crops were also accepted as not being an overly sustainable feedstock and that food, farm, animal and sewage waste feedstocks are currently massively underutilised.	Some growth was brought forward in the analysis.
Green gas – location factors	Feedback was given around the nature of smaller and more distributed resources. One approach to this is a hub and spoke model, where a central feedstock and green gas production 'hub' would	GSA distribution factors for green gas capacity was weighted even more

	draw in multiple sources of feedstock in an area. The business model for green gas relies partially on proximity between both the digestion and gas injection infrastructure.	towards proximity to the gas network than before. Distribution into urban areas was also increased, reflecting food waste feedstock availability.
Green gas – Low Wales baseline	Discussed why the uptake of biomethane injection is so much lower in Wales than in the SW. Core reasons were summarised as: • Nature and scale of farming, with there being more remote Hill Farms in Wales • Potentially less food processing currently • Food waste collection is more centrally coordinated in Wales, with more centralised contracts with AD/CHP plants, thus not using as much food waste for injection • Nature of gas grid - no coverage in some rural areas where some waste feedstocks are located, so feedstocks used for standalone AD • Low/no energy crops – Wales Agriculture Policy considerations • Opportunity for sewage gas is very locational, i.e. larger strategic sludge centres for Welsh Water is where biomethane injection may occur. Trade off with need to use biomethane for power generation and use onsite, especially with non-domestic RHI disappearing in the near term • The gas network is not always where farms are, population centres are not where farms are to get rid of digestate. Very expensive to transport digestate and not popular with planners in urban areas – mismatch. • There is food waste in urban areas but difficult to transport digestate • There is farm waste in more rural areas, but a lot are far from the gas network to inject Also, an interesting side issue of the lack of broadband internet in some areas of Wales, preventing remote control of AD plants(!)	Some of these factors could be temporary, but overall biomethane injection growth will inevitably be lower overall by 2035 in Wales than the SW. Analysis has reflected this in all scenarios, whilst still modelling some growth in injection capacity in the more compliant scenarios. Potential for biomethane to feature as an alternative fuel for other elements of the analysis, i.e. AD plants for onsite heat and power usage etc. was factored in.
Gas fired power – Asset classification	Originally, the analysis for gas fired electricity generation was sub-divided into three business models or asset classes, baseload generation, flexible generation and behind the meter generation. Feedback received around the	As a result of this feedback the analysis was changed to be divided into: • CCGT • OCGT

	potential for development is more aligned to the generation technology, than the business/operating model. Similarly, in terms of identifying disruptive new capacity and gas demand for WWU, it was considered that behind the meter generation was more suited to be a subset of industrial processes and/or new commercial & industrial connections.	• Reciprocating engines Behind the meter engines were also removed from the standalone modelling.
Gas fired power – Market for growth	Stakeholder feedback was that uncertainty around the Capacity Market, the saturation of commercial flexibility markets, local flex markets being low value and the Balancing Mechanism likely to be dominated by batteries, causing growth to be less clear than even a year ago. Welsh Government fed back that there is a policy ambition to reduce the emissions from power generation in Wales, regardless of whether the energy is consumed in Wales or not. This is primarily targeting large coal fired generation. Welsh Government also recognised the role that small distributed reciprocating engine gas generation sites have to play in the near term.	A dampening factor was applied to growth projections for gas generation. Stakeholder feedback has confirmed that this was a fair reflection of the market. Justification for the decommissioning of large CCGT sites in all scenarios (i.e. Barry Power Station) and other CCGT capacity coming offline in most scenarios. Reciprocating engine capacity modelling was similar in South West and Wales.
Gas fired power – Capacity factors	Stakeholder feedback around capacity factors for CCGT, OCGT and reciprocating engines was varied but lower values (e.g. for OCGT by 2035 in Two Degrees) were surprising to many. However, discussion around the likely principle of more hybrid sites, where gas fired generation is co-located (potentially even behind the same meter point) with other technologies, such as solid state or liquid state batteries.	The likelihood of hybrid sites coupled with sporadic need for gas generation in the decentralised and high intermittent generation scenarios, acts as a firm justification that there will be reduced annual generation from gas.
Gas fired power – GSA distribution	When discussing the development of new gas fired generation projects, stakeholders fed back that constraints on the electricity distribution networks were barriers to the feasibility of some projects going ahead. Stakeholders specifically referenced Active Network Management (ANM) Zones, restricting the potential to export to the network at certain times of the year, due to capacity, voltage or thermal constraints in certain network areas. See Figure 15 a map of live ANM zones in the WPD South West licence area.	Feedback on ANM zones as a geographical constraint on project development, the location of existing or pending ANM zones was assessed as an additional (low weighted) GSA distribution factor, putting a moderate weighting to GSAs that are outside of ANM zones in the SW.

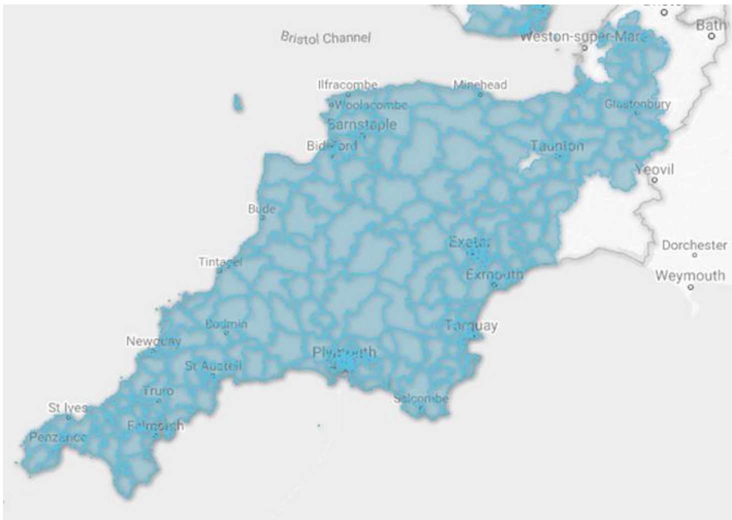


Figure 15: Map of WPD ANM Zones in the South West (Source: WPD[23], May 2019)

[23] See WPD *ANM Further Information* web page and *Network Capacity Map*:
https://www.westernpower.co.uk/anm-further-info
https://www.westernpower.co.uk/our-network/network-capacity-map

6 Appendix 1 - Domestic Heat: Method, Assumptions and References

6.1 Detailed approach

Step	Step Description	References / Data sources
Step 1	Number of existing dwellings	Census 2011 ONS household projections
Step 2	Number of new build completions 2019 - 2035	WWU Developments Tracker (Local Plan data) ONS household projections
Step 3	Derive mean efficiency of existing domestic gas boiler stock, project out to 2035	English Housing Survey 2017-2018[24] Building regulations
Step 4	Convert mean gas demand per dwelling to energy demand per dwelling, deduct fixed amount assumed for cooking to obtain heat and hot water demand per dwelling	BEIS sub-national statistics & data from 'Step 3'
Step 5	Derive mean heat demand per new dwelling for baseline period (2011 – 2018)	EPC statistics for South West and Wales LDZs Regen SAP modelling
Step 6	Model scenarios for change in heat demand within existing dwellings	Regen analysis
Step 7	Model scenarios for change in heat demand within new dwellings	Regen analysis
Step 8	Establish baseline set of heating appliance types and proportion of each serving existing dwellings	Census 2011 English Housing Survey 2017-2018 Welsh Housing Conditions Survey 2017-2018 BEIS ECUK 2018[25] Ofgem[26] BEIS FiT statistics[27] RHI statistics[28] Regen analysis
Step 9	Establish baseline trend for proportion of new dwellings served by each heating appliance type	EPC statistics for South West and Wales LDZs
Step 10	Establish natural replacement rate for domestic gas boilers	English Housing Survey 2017-2018[29]
Step 11	Derive ceiling for rate of change between appliance types in existing dwellings, based on Step 10	Regen analysis

[24] https://www.gov.uk/government/statistics/english-housing-survey-2017-to-2018-headline-report
[25] https://www.gov.uk/government/statistics/energy-consumption-in-the-uk
[26] https://www.ofgem.gov.uk/ofgem-publications/98027/insightspaperonhouseholdswithelectricandothernon-gasheatingpdf
[27] https://www.gov.uk/government/statistics/monthly-small-scale-renewable-deployment
[28] https://www.gov.uk/government/collections/renewable-heat-incentive-statistics
[29] https://www.gov.uk/government/statistics/english-housing-survey-2017-to-2018-headline-report

Step 12	Project scenario-aligned trends for shifts in appliance types serving existing dwellings	Regen analysis National Grid FES
Step 13	Project scenario-aligned trends for shifts in appliance types serving new dwellings	Regen analysis National Grid FES
Step 14	Project scenario-aligned trends for shifts in appliance efficiencies serving new and existing dwellings	Regen analysis
Step 15	Convert projections to number of appliances in existing and annual new build, sum new build to produce cumulative data, sum with existing to produce complete set of appliance numbers by scenario by year, derive proportional split for all dwellings by scenario by year	Regen analysis
Step 16	Resolve data from step 6,7,14 and 15 to produce complete set data for domestic heating energy demand and resulting carbon emissions by scenario by year, derive annual proportional split for all dwellings by scenario by year out to 2035	Regen analysis

6.2 Assumptions

The following assumptions have been made when determining the modelling:

Baseline and pipeline analysis:

Based on analysis, the following heat source categories were identified for domestic dwellings:

Gas - mains boiler
Air Source Heat Pump
Ground Source Heat Pump
Gas Hybrid Heat Pump
Heat network - gas boiler
Heat network - gas CHP
Heat network - biomass
Heat network - GSHP
Oil boiler
LPG boiler
Solid fuel
Electric heating
Other
Gas room heaters
No central heating
Bio-LPG boiler
Biomass boiler
Oil Hybrid Heat Pump
Gas - micro CHP

Instances of ‘Other’ and ‘No central heating’ were assumed to make use of plug-in electrical heaters.

Future scenario projection analysis:

- Growth of the market for deep retrofit has been based on the potential growth out to 2025 shown in "Reinventing Retrofit"[30], thereafter assumed to continue to deliver an additional 20,000 retrofits over the previous year per annum.
- Deep retrofit is assumed to reduce demand for space heating and hot water by 60% from the baseline average.
- A minimum threshold for reducing demand in new build was based on an average hot water requirement for three people and the Passivhaus design standard[31] of 15 kWh/m^2/annum for space heat.
- For existing dwellings, it has been assumed that each year a proportion of conventional heating appliances that need replacement (approximately 7.5%) shift to an alternative heat source, rather than replacing like for like. This proportion is then distributed amongst the available alternative technologies.

For new dwellings it has been assumed that the recently proposed ban on gas boilers[32] in new build dwellings is enacted in 2025 in compliant scenarios, but not in non-compliant scenarios. Based on stakeholder feedback this has been modelled as a 'cliff-edge' rather than a smooth transition where industry moves to alternative appliances over several years (Figure 16).

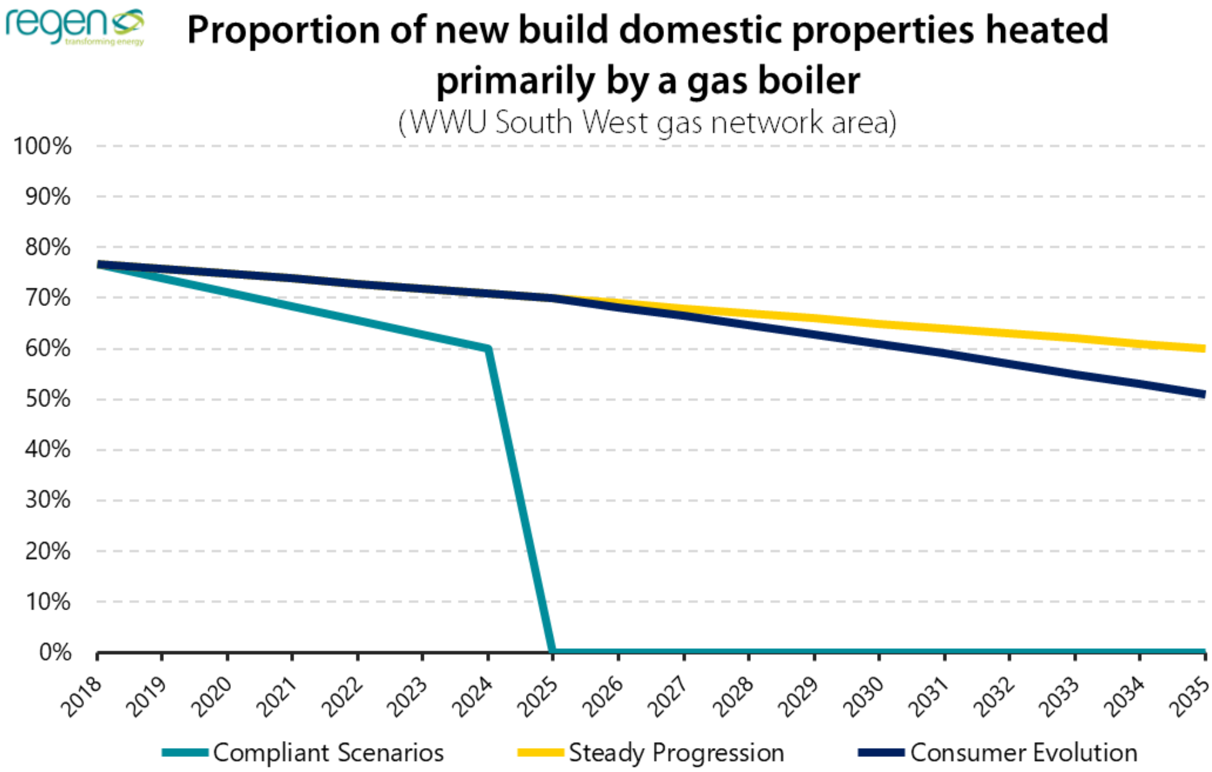


Figure 16: Proportion of annual new build completions served by a gas boiler in the WWU South West LDZ

[30] https://www.green-alliance.org.uk/resources/reinventing_retrofit.pdf
[31] http://passivhaustrust.org.uk/what_is_passivhaus.php
[32] https://www.gov.uk/government/speeches/spring-statement-2019-philip-hammonds-speech

Geographical distribution:

- The strategic sites allocated by local authorities, as collated in the WWU new developments tracker, are assumed to represent the most likely areas for new builds to be constructed.
- The 'heat demand per property' metric is assumed to encompass the various aspects of the heat demand for a property by GSA, such as typical dwelling size, average temperature, existing efficiency of housing stock, fuel poverty etc.
- Characterisation of GSAs has been produced using 2011 Census data. It is assumed that the overall characteristics of entire GSAs have not substantially changed since this period. Where more up to date data are available, these have been prioritised and correlated with Census data. Similarly, it must be assumed that these GSA characteristics are applicable throughout the timeframe of the analysis.
- The **Regen Distributor Model** uses probabilistic logic to determine the distribution of heating technology changes per year, disaggregated from overall projections for the two gas network areas.
- In the **Steady Progression** scenario, network extension is assumed as connected gas boilers increase over the plan period. New connections to the gas network are expected to predominantly occur in GSAs with high existing proportion of on-gas properties.

7 Appendix 2 - Commercial & Industrial Heat & Processes: Method, Assumptions and References

7.1 Detailed approach

Step	Step Description	References / Data sources
Step 1	Number of existing properties requiring heating	Non-domestic rating: properties stock WWU connections data
Step 2	Number of new build completions 2019 - 2035	WWU baseline and developments tracker (local authority local plans)
Step 3	Convert mean gas demand per property to energy demand per property, less amount attributable to catering & other uses, to obtain heat and hot water demand per property, and refine to account for mean floorspace by fuel type.	BEIS sub-national statistics BEIS ECUK 2018[33] Regen analysis EPC and DEC data
Step 4	Derive mean heat demand per new property for baseline period (2011 – 2018)	EPC and DEC data for South West and Wales Regen SAP modelling
Step 5	Model scenarios for change in heat demand in existing properties	Regen analysis
Step 6	Model scenarios for change in heat demand in new properties	Regen analysis
Step 7	Establish baseline set of heating appliance types and proportion of each serving existing properties	EPC and DEC data for South West and Wales RHI statistics[34] Regen analysis
Step 8	Establish baseline trend for proportion of new properties served by each heating appliance type	EPC and DEC data for South West and Wales
Step 9	Project scenario-aligned trends for shifts in appliance types serving existing properties	Regen analysis National Grid FES
Step 10	Project scenario-aligned trends for shifts in appliance types serving new properties	Regen analysis National Grid FES
Step 11	Project scenario-aligned trends for shifts in appliance efficiencies serving new and existing properties	Regen analysis National Grid FES
Step 14	Convert projections to number of appliances in existing and annual new build, sum new build to produce cumulative data, sum with existing to produce complete set of appliance numbers by scenario by year, derive proportional split for all commercial & industrial properties by scenario, year	Regen analysis
Step 15	Resolve data from produce complete set data for commercial and industrial heating energy demand and resulting carbon emissions by scenario by year, derive proportional split for all dwellings by scenario by year	Regen analysis

[33] https://www.gov.uk/government/statistics/energy-consumption-in-the-uk
[34] https://www.gov.uk/government/collections/renewable-heat-incentive-statistics

7.2 Assumptions

The following assumptions have been made when determining the modelling:

Baseline and pipeline analysis:

Based on analysis carried out, the following heat source categories were identified for commercial and industrial properties:

Gas - mains boiler
ASHP
GSHP
Air conditioning
Gas HHP
Heat network - gas (boiler or CHP)
Heat network - Energy from Waste (EfW)
Heat network - biomass
Heat network - GSHP
Oil boiler
LPG boiler
Solid fuel
Electric heating
Other
Bio-LPG boiler
Biomass boiler
Oil HHP

Instances of 'Other' were assumed to make use of plug-in electrical heaters.

Where an EPC or DEC identified the main heating fuel as 'electricity', and the building environment as 'air conditioning' it was assumed that air conditioning was used to provide both heating and cooling.

It is assumed that each industrial connection on the WWU connections register represents a single industrial unit.

Where sub-national data is unavailable – for example, the proportion of commercial gas demand used for catering purposes – values for the South West/Wales, England/GB, or the UK (in order of preference) are used as proxies. This has been avoided in the modelling unless absolutely necessary.

In the South West - 8% of industrial properties use gas for process, space and water heating.

In Wales – 9% of industrial properties use gas for process, space and water heating.

The 'whole-system' analysis used for domestic and commercial space heating has not been repeated for industrial heat, given that process heating is fundamentally different to space and hot water heating, and heating technology switching is much less likely.

Distribution

- Distribution of heating technologies is assumed to be based mainly on what is available in the area (gas, heat network etc.) alongside the baseline, rather than the more nuanced domestic heating technology distribution factors such as social renting and affluence, as these data are irrelevant or unavailable for commercial and industrial properties. Stakeholder feedback confirmed that commercial and industrial heating technologies are less likely to vary throughout the gas network areas, beyond availability of networks.
- The baseline breakdown of commercial heating technologies for each GSA have been collated from analysis of non-domestic EPCs and DECs, and compared against BEIS and WWU data for gas connections.
- Industrial gas demand distribution is assumed to continue existing baseline trends.

8 Appendix 3 - Gas Fired Power Generation: Method, References and Assumptions

8.1 Detailed approach to scenario projection analysis

Step	Step Description	References / Data sources
Step 1	Analysed existing connected gas fired generation assets to establish regional baseline	WWU connection register
Step 2	Correlated WWU connection data with electricity network connection data	DNO connection data[35] National Grid TEC register[36]
Step 3	Analysed gas flow data for connected sites to determine capacity factors for existing CCGT, OCGT and gas reciprocating engine sites	WWU metered hourly gas flow data
Step 4	Analysed not-yet-connected sites on WWU connection register to establish regional pipeline	WWU connection register
Step 5	Assessed pipeline sites for local planning activity and national Capacity Market activity.	Local planning portals NSIP register[37] Capacity Market registers[38]
Step 6	Assigned pipeline projects to go through to connection and operation (or not) for each of the scenarios and the year in which they come online. See Table 6 for the logic chain that was applied to each pipeline project.	Referencing Regen's approach to undertaking electricity DNO licence area scenario assessments
Step 7	Separated the proportion of National Grid FES gas fired technology projections, that are associated to WWU gas distribution network in the SW, including all electricity distribution network and a proportion of the transmission network connected assets. These national figures were then categorised by CCGT, OCGT and Reciprocating Engine technologies.	National Grid FES 2018 data workbook[39]
Step 8	Used separated FES values from Step 7 to establish the percentage changes between 2026 (post near-term pipeline) and 2035 for each scenario and technology. Applied these scenario-specific increases/decreases to the pipeline position to create initial annual capacity projections from 2026 to 2035.	National Grid FES 2018 data workbook Regen analysis
Step 9	Applied site specific CCGT/OCGT decommissioning years in applicable scenarios, where these technology classes reduce in capacity on distribution networks in the 2030s	National Grid FES 2018 data workbook Regen analysis

[35] Sourced through consultation with Western Power Distribution (WPD) and reviewing WPD generation capacity register data: https://www.westernpower.co.uk/our-network/generation-capacity-register
[36] Available on the National Grid ESO registers, reports and guidance portal: https://www.nationalgrideso.com/connections/registers-reports-and-guidance
[37] See National Infrastructure Planning register for the South West: https://infrastructure.planninginspectorate.gov.uk/projects/south-west/
[38] See EMR Delivery Body Capacity Market register document library: https://www.emrdeliverybody.com/CM/Registers.aspx
[39] See National Grid FES 2018 data workbook, ES1 'Electricity Supply data table' worksheet: http://fes.nationalgrid.com/media/1366/2018-fes-charts-v2_as-published.xlsx

Step 10	Applied a reduction factor to reciprocating engine capacity growth, reflecting educed UK government outlook for new gas generation capacity since 2018[40], feedback gained from the Exeter and Bristol stakeholder engagement events (see 5.9) and harmonisation to existing South West and South Wales 2032 projections as produced for WPD[41].	WPD's 2017 South West and South Wales Distribution Future Energy Scenario assessment
Step 11	Derived 2018 baseline capacity factors for all operational OCGT, CCGT and reciprocating engines using actual flow data and installed capacities. Derived scenario-specific annual capacity factor values for each technology type from 2025 to 2035 using National Grid FES annual gas fired generation and installed gas fired power capacity figures. Interpolated the remaining scenario specific 2019 – 2024 annual capacity factor values, referencing the 2018 baseline and 2025 figures.	National Grid FES 2018 data workbook Regen analysis
Step 12	Calculated annual electricity generation in the LDZ using the annual scenario projections for installed capacity (MW_e) and calculated capacity factors (%).	Regen analysis
Step 13	Estimated annual CCGT, OCGT and reciprocating engine gas-to-electricity conversion efficiencies (for all scenarios) out to 2035, setting milestone values.	Online research around manufacturer expectations
Step 14	Calculated annual gas demand from power for each scenario using generation and conversion efficiencies.	Regen analysis

Table 6: Gas fired power generation - assessment logic for not-yet-connected pipeline sites

Site Activity Assessment	Connects in which scenario	Connects in which year
Granted planning approval	All scenarios	CE, TD, HA, CE – CM delivery year SP – CM delivery year + 2 years
CM auction winner	All scenarios	CE, TD, HA, CE – CM delivery year SP – CM delivery year + 2 years
Conditionally prequalified CM	All scenarios	CE, TD, HA, CE – CM delivery year SP – CM delivery year + 2 years
No CM info or planning info	CE, CE and HA only	+ 2 years after application date
Did not prequalify for CM	CE and CE only	All scenarios - delivery year of CM auction entered + 2 years
Rejected CM	CE and CE only	+ 5 years of CM auction entered
Refused or withdrawn planning	No scenario	No year

[40] See BEIS April 2019 Energy and Emissions Projections, showing a 50% reduction in the expectation of new gas fired generation capacity required by 2035, compared to 2018 equivalent projections: https://www.gov.uk/government/publications/updated-energy-and-emissions-projections-2018

[41] Sourced through consultation with WPD and reviewing the 2032 scenario outcomes from Regen's previous assessments for the WPD licence area. See WPD D-FES portal: https://www.westernpower.co.uk/our-network/network-strategy/distribution-future-energy-scenarios

8.2 Assumptions

The following assumptions have been made when modelling gas fired power generation:

Baseline and pipeline analysis:

- Some of the existing baseline connected OCGT and CCGT sites were modelled to come offline through the 2030s in some scenarios, reflecting the FES' reduction of installed capacity for these technologies in these scenarios.
- The pipeline was not assumed to all go ahead in all scenarios within the next couple of years. From researching the individual proposed project in planning and in the Capacity Market and using the logical tests outlined in Table 6, differing amounts of new pipeline capacity is modelled to come online in different years across the five scenarios.

Future scenario projection analysis:

- The post-pipeline projections were driven by applying scenario-specific percentage increase or decrease derived from analysing the FES, decommissioning of existing OCGT/CCGT sites where applicable and applying a dampening factor to flexible generation growth, as described in Steps 8, 9 and 10 of section 8.1.
- Baseline capacity factors for OCGT and reciprocating engines were derived using a c.6-month snapshot of gas flow data sourced from WWU, (extrapolated to be annual volumes) and installed power capacities.
- Future scenario and technology specific capacity factors were derived using National Grid FES projections for gas generation, interpolating back to the actual 2018 capacity factor of gas fired generation on the WWU gas distribution network.
- Annual gas demand was determined by:
    - Increasing OCGT gas-to-power conversion efficiency from 45% in 2018 (based on average actual generation vs gas usage data for connected OCGT sites) to 60% in 2035
    - Increasing reciprocating engine efficiency from 40% in 2018 (based on average actual generation vs gas usage data for reciprocating engine sites) to 50% by 2035
    - Using resultant scenario specific annual electricity generation values and conversion efficiencies to derive annual gas demand, by scenario

Geographical distribution:

- Baseline and pipeline distribution is given a strong distribution weighting, given the clear trend of distribution towards urban areas in both historic and near-term data. This reflects the approach taken for gas fired power distribution for electricity DNOs.
- In the medium term in the South West LDZ, distribution is focussed towards urban areas outside of WPD Active Network Management (ANM) zones, alongside baseline and pipeline sites. This is a result of discussion at stakeholder engagement events.
- In Wales, and beyond the late 2020s in the South West, ANM zones are no longer used as a distribution factor under the assumption that by this point in time, most if not all the electricity distribution network will be under some form of active management.
- Proximity to gas and electricity networks are considered by proxy, as the urban areas to which the projections are distributed are ubiquitously on-network areas.

9 Appendix 4 - Gas Vehicles and Electric Vehicles: Method, Assumptions and References

9.1 Detailed approach

Step	Step Description	References / Data sources
Step 1	Established 2018 baseline for the number of registered vehicles in the WWU LDZs, split by fuel types, compared to existing fuelling stations connected to the WWU gas distribution network	Regen Transport Model Department for Transport Registration Data[42] National Grid FES Data[43] WWU CNG connections register
Step 2	Determined scale and uptake factors for natural gas and hydrogen fuelled vehicles in the WWU LDZs	Regen analysis
Step 3	Determined scale and uptake factors for Electric Vehicles in the WWU LDZs	Regen analysis
Step 4	Converted scenario projection values into mileage and resultant annual fuel demand	Regen Transport Model

9.2 Assumptions

The following assumptions have been made when determining the modelling:

- The alternative fuelled vehicles that were chosen to be elements in this assessment were natural gas vehicles (in the form of CNG), hydrogen vehicles and electric vehicles. LPG fuelled vehicles and standalone biogas vehicles were not separated as individual vehicle categories.
- Standalone biogas fuelled vehicles was determined to have a very small uptake potential, thus was incorporated into the natural gas/CNG fuelled vehicles, as a general gas fuelled class.
- Distribution is assumed to follow existing distribution of the relevant vehicle type, inferred through registration, mileage data and major roads, combined with gas distribution network proximity.

[42] See Department for Transport 2018 report and data tables: https://www.gov.uk/government/statistics/vehicle-licensing-statistics-2018
[43] See National Grid FES 2018 data workbook, RT1, RT2 and RT3 data tables: http://fes.nationalgrid.com/media/1366/2018-fes-charts-v2_as-published.xlsx

10 Appendix 5 - Green Gas Supply: Method, Assumptions and References

10.1 Detailed approach

Step	Step Description	References / Data sources
Step 1	Analysed existing connected green gas injection sites to establish regional baseline.	WWU green gas entry register
Step 2	Correlated WWU register with national biogas map data and non-domestic RHI registration database.	Anaerobic Digestion and Bioresources Association (ADBA) AD Map[44] BEIS non-domestic RHI data[45]
Step 3	Analysed green gas site flow data for operational sites (2015-2018) to determine average annual injection rates and overall volume of green gas as a percentage of each WWU LDZ's total annual demand.	WWU green gas logger data
Step 4	Analysed not-yet-connected sites on WWU connection register to establish regional pipeline.	WWU green gas entry register
Step 5	Assessed pipeline sites for local planning activity, RHI noted tariff guarantee activity and correspondence notes, determining in which year each of the not-yet-connected projects come online, for each scenario. See Table 7.	Local planning portals RHI registration information WWU green gas entry register
Step 6	For connected sites that are currently not flowing, the modelling assigned a year in which they will begin to inject green gas into the network, based on consultation with WWU and correspondence noted.	Regen analysis WWU green gas entry register WWU expertise
Step 7	Included additional green gas projects (using the typical 750 scm/h capacity) connecting in the early 2020s, reflecting recent policy around food waste collection[46]. The number of additional pipeline projects, all connecting between 2020 and 2025 were varied across the five scenarios and phases	DEFRA Resources and Waste Strategy policy statement Regen analysis

[44] See ADBA AD Map, http://adbioresources.org/map

[45] BEIS non-domestic RHI registration data, sourced through a freedom of information request by Regen: https://www.ofgem.gov.uk/environmental-programmes/non-domestic-rhi/contacts-guidance-and-resources/public-reports-and-data

[46] See DEFRA announcement around *Resources and Waste Strategy*, December 2018: https://www.gov.uk/government/news/gove-launches-landmark-blueprint-for-resources-and-waste

Step 8	Reviewed GB average proportion of gas that is green gas up to 2018 and compared this to the regional baseline defined in steps 1-3.	FES 2018 data workbook[47] WWU green gas logger data
Step 9	Analysed the GB annual proportion of green gas in each FES scenario out to 2035 and the incremental increase at each milestone year. Derived an equivalent number of projects and capacity, using a typical 750 scm/h project capacity, to meet the expected capacity at each milestone year, to 2035, for each scenario.	FES 2018 data workbook Regen analysis WWU expertise
Step 10	Determined an 'in-year' injection rate matrix table, ramping up over two years from 40% to 80%, for all new green gas injection projects connecting in each year, under each scenario.	BEIS RHI Budget Caps report[48] Regen analysis
Step 11	Equated new green gas capacity and derived in-year injection rates, to provide annual green gas volumes by scenario, between 2018 and 2035, in scm.	Regen analysis
Step 12	Utilised the following formula to convert derived annual cubic meters of green gas to kWh: ***(Green gas volume (scm) x Volume correction factor x Calorific Value) / scm to kWh conversion factor*** Where: Green gas volume = annual derived green gas in scm Volume correction factor = **1.02264** CV of GDN gas = **37.4 (SW), 37.6 (Wales)** Cubic meters to kWh conversion factor = **3.6**	Online gas conversion tool[49] Regen analysis WWU CV factors
Step 13	Interpolated 2035 total GB biomethane availability from AD value, from milestone values (2030 and 2040) in Cadent Gas' renewable gas availability assessment data workbook. Compared the scenarios with highest, middle and lowest green gas volumes in 2035 to the 2035 GB biomethane from AD total, as a benchmark feasibility check on the scenario analysis	Cadent Gas Renewable gas potential in the GB – data Regen analysis

Table 7: Green gas injection - assessment logic for not-yet-connected pipeline sites

Green Gas Site Assessment	Connects in which year	Connects in which year
Positive planning information RHI tariff guarantee information Positive correspondence noted	All scenarios	**All scenarios** – 2019 or 2020, depending on acceptance year
No planning, RHI or positive developer correspondence	All scenarios	**CE, TD, HA** – delayed to 2022 **CE, SP** – delayed to 2025/2026

[47] See National Grid FES 2018 data workbook, worksheets 5.10, 5.11, 5.14 and 5.15 'Annual gas supply patterns': http://fes.nationalgrid.com/media/1366/2018-fes-charts-v2_as-published.xlsx
[48] See BEIS RHI Budget Caps report, Table 5: https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/795517/RHI_budget_cap_publication_data_to_end_of_February_2019.pdf
[49] See Utilities Savings Gas kWh conversion tool: http://utilitiessavings.co.uk/gas-kwh-conversion-tool/

10.2 Assumptions

The following assumptions have been made when determining the modelling for green gas entry:

Baseline and pipeline analysis:

- Some of the existing connected green gas injection sites are not currently flowing/injecting any gas into the WWU network. These sites were resultantly treated as ‘pseudo pipeline’ sites, whereby the capacity and volume was not counted until later years. The year that these sites were effectively brought online, was the same for all five scenarios and assumed to be 4 years after the year that they were connected, through consultation with relevant WWU experts. One of the sites (Trowbridge Sewage Treatment Works), was manually set to come online to commence injecting gas in 2019, reflecting direct feedback received from WWU.
- Not all the not-yet-connected sites were assumed to commence injecting in the same year. From assessing planning information, RHI tariff guarantee information and notes showing positive correspondence from developers, some of the projects were modelled to connect in different years, under different scenarios. The logic that was used is shown in Table 7.

Future scenario projection analysis:

- For the South West LDZ, the post-pipeline projections were driven by firstly determining the variance between the regional baseline percentage of green gas capacity and volume and the GB national average. For example, the WWU South West regional ‘headroom’ above the GB national average[50] was maintained in the future projections out to 2035, reflecting the WWU South West LDZ’s enhanced potential for AD and waste feedstock resources.
- Both the operational green gas injection capacity and number of operational projects between 2019 and 2025, for each scenario, was based on a combination of:
    - The pseudo pipeline sites starting to flow as described above
    - The not-yet-connected site capacity assigned to each scenario (see Table 7)
    - The additional pipeline capacity described in Step 7 of section 10.1.
- The operational green gas injection capacity between 2026 and 2030 was determined by taking the proportional changes seen for each scenario in the National Grid FES and applying this to the number of operational projects. The **Hybrid Accelerator** scenario was taken as an average of the **Community Renewables** and **Two Degrees** scenarios. The installed capacity between 2026 and 2030 was then derived using the resultant number of sites in each year and a typical green gas injection capacity of 750 scm/h.
- The operational green gas capacity between 2030 and 2035 was determined by Regen modelling an indicative number of green gas projects in 2035 that would maintain a similar trend of projects and capacity, in each scenario. These capacity and project count values referenced the following as benchmark checks:
    - The percentage of LDZ/LDZs demand that would be green gas (based on WWU proportional estimates of the National Grid FES total gas demand in 2035)
    - The proportion of the total GB biomethane from AD that would be used for green gas injection on the WWU gas distribution network

[50] WWU South West gas distribution network 2018 baseline proportion of gas volume that was green gas, was shown to be c.1.8%, compared to the national average of 0.4% (derived using National Grid FES 2018 figures).

- Due to the very limited biomethane injection projects in Wales LDZ, a revised approach was taken, focussing on the pipeline site and a forecast peak number of sites by 2035, by scenario and modelled backwards, based on the proportional *differences* in green gas seen in the FES.

The annual green gas volume used for all scenarios between 2019 and 2035, was determined using in-year injection rates for new capacity coming online. These rates, referencing BEIS biomethane production factors used to estimate budget commitments to RHI tariff guarantees, were variable depending on whether the project (and its capacity) was in its first year, second year or third+ year of its operation:

  - First year of its injection operation = injection rate set at **40%**
  - Second year of its injection operation = injection rate set at **70%**
  - Third year of its operation and moving forward = injection rate set at **80%**

Geographical distribution:

- Agricultural land of every grade has been used to represent farmland for modelling purposes; it is likely that plant feedstocks would be derived from higher grade agricultural land, and animal wastes from lower grade land. However, on the back of stakeholder feedback regarding the greater feasibility of utilising more 'collectable' arable waste compared to more dispersed livestock waste, higher grade agricultural land was given a greater weighting in the distribution modelling.
- Urban areas are a factor for population-based waste feedstocks, under the assumption that critical mass of sewage or food waste for feasible green gas production would be limited to urban areas. In the Wales LDZs, actual locations of sewage processing sites have been incorporated into the distribution.
- The importance of gas network proximity decreases over time but remains a significant factor throughout. This assumes that in later years, especially in the scenarios that meet our carbon reduction targets, enhanced incentives for green gas production would enable a wider area around the existing network to become feasible to operate a green gas injection site. This also reflects potential extensions to the existing network.
- The existing baseline and pipeline is used to identify the significance of gas network proximity, farmland and urban land as distribution factors, but is not directly used as a distribution factor in itself. This reflects possible network constraints and feedstock competition. As a result, a GSA with an existing green gas site is no more likely to receive distributed capacity than a similar GSA without any sites; however, existing sites are likely to be sited in optimal areas in terms of feedstock availability and gas network pervasiveness, which is accordingly reflected in the distribution.