Appendix 15C

Appendix 15C
Investment against Future Energy Scenarios (FES)

December 2019

WALES&WEST UTILITIES

Contents

1 Introduction

The future of energy in the UK is not certain. Legally binding obligations to eradicate the UK's contribution to climate change by 2050 require us to decarbonise heat and power. There are a number of pathways to achieve this, without common agreement across the industry or commitment from policy makers on the preferred route. It is hugely complex, as the solution will need to balance affordability, reliability and carbon impact. In reality, it is likely there will be a mix of bespoke solutions depending on location and consumer energy demand.

In this paper, we describe our approach to testing the robustness of our investment plan against future uncertainty, ensuring that it supports all credible pathways and avoids the risk of asset stranding.

We wanted to test our plan across a wide range of scenarios. The cross-sector common view of the future (single scenario) looks to a 2030 horizon, but we felt it appropriate to test our investment plan for our existing assets over a longer term.

To achieve this, we have utilised National Grid's Future Energy Scenarios (FES). These look out to 2050 and are widely regarded as a reputable source for examining the future UK energy mix based on the knowledge and intelligence available today.

2 Our approach

We've reviewed the 70 assumptions underpinning the FES 2018 and the 6 new assumptions introduced in FES 2019 for their impact on the future role of the gas network and our gas assets. This review has been done at a granular level by asset group; LTS pipelines (>7bar), Offtakes & PRIs, Governors, Distribution pipes (<7bar) and Services/Risers. We have considered this impact over the 2030, 2040 and 2050 horizons.

The outcome is a view, for each asset group, on the certainty of the requirements for the assets and their usage in the 2030s, 2040s and 2050s for each of the 4 scenarios. We compare the certainty of the requirement for the asset over time in the different scenarios. We then identify the shortest timeframe of certainty of any of the 4. This period is then used in our Cost Benefit Analysis (CBA) as a no regrets assessment period. We believe this is appropriate and robust as the 4 scenarios cover the extremes of the future realities.

As an example, if the LTS network was definitely required in its current form in 2050 for 2 of the scenarios but only in 2040 for the other 2, we would use 2040 as the no regrets assessment period. If an investment did not pay back in that timeframe, we would only put forward with additional justification such as specific stakeholder requirements, requirement in law or with additional supporting evidence for that particular pipeline.

The drivers that have the most material impacts on our assets are:

- Number of domestic gas users (as the current largest proportion of gas demand)
- Number of commercial gas users (as these typically represent larger loads per connection when compared with domestic)
- Number of industrial gas users (which currently represent around a third of total gas demand)
- Growth or proliferation of district heat networks (which can affect our existing assets depending on how these are fuelled)

- Changes to the generation mix (as decrease in coal combined with increasing amount of intermittent renewable generation means an increase in requirements for flexible gas generation)
- Extent of conversion to hydrogen networks (which would affect how we operate our network and our requirement for new assets to accommodate hydrogen such as strategic valves)

These factors are explored in sections 4-9 below

3 The scenarios

Figure 1 represents the four scenarios mapped against the level of decentralisation and green ambition and prosperity. The single scenario forms a hybrid of these.

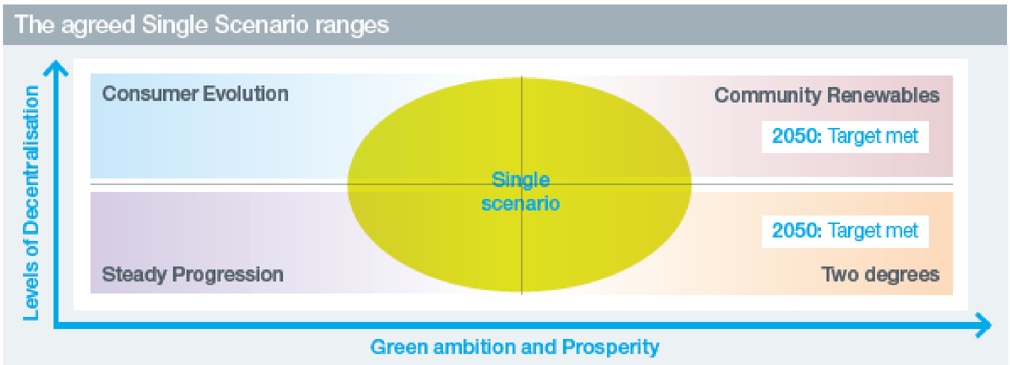

Figure 1 Future of energy scenarios

3.1 Community Renewables (CR)

The community renewables scenario is based on a high level of decentralisation and a high speed of decarbonisation. This scenario is summarised by

- a push for renewable gas by investment in improving the production technologies
- a high level of district heating
- many small-scale, renewable and decentralised decarbonisation projects
- the highest proportion of engaged customers to adopt electric vehicles

3.2 Two Degrees (TD)

The Two Degrees scenario is based on centralised generation and a high speed of decarbonisation. This scenario is summarised by

- a medium level of district heating
- large scale renewable generation
- hydrogen networks with centralised hydrogen production from steam methane reformation and some from electrolysis
- a high proportion of engaged customers to adopt electric vehicles

3.3 Steady Progression (SP)

The Steady Progression scenario is based on more centralisation and a low speed of decarbonisation which means 58% emissions reduction is achieved. As such, decarbonisation happens but at a slower rate than needed due to:

- low priority on decarbonisation
- limited support for decarbonisation technology
- a low level of large-scale district heating
- some hydrogen blending with natural gas
- customers being the least engaged to adopt electric vehicles

3.4 Consumer Evolution (CE)

The consumer evolution scenario is based on a high level of decentralisation and low speed of decarbonisation. Decarbonisation happens but only 58% emissions reduction is achieved because of:

- low priority on decarbonisation
- limited support for decarbonisation technology including Carbon Capture and Storage (CCS)
- low level district heating and at a small community scale
- a low proportion of engaged customers to adopt electric vehicles

4 Annual Gas demand

All scenarios observe a decrease in annual gas demand. For domestic consumers, this shows a marked change, particularly in Community Renewables and can be explained by factors such as increased home efficiency, improved efficiencies of appliances and the shift from natural gas boilers to other low carbon alternatives. For industrial and commercial consumers, a steady initial decrease can be explained by increased efficiency off-setting economic growth and then moving to low carbon alternatives such as heat pumps and biomass combined heat and power (CHP), the extent of which differs by scenario. The figures show that gas assets are still required in 2050 for all scenarios although less so for Community Renewables.

Figure 2 to 5 below have been produced from FES 2019 data and show annual gas demand split into the different available sectors including residential, industrial and commercial, demand from power and transport.

In Community Renewables the total annual gas demand is expected to significantly decline by 75% by 2050 base on 2018 usage.

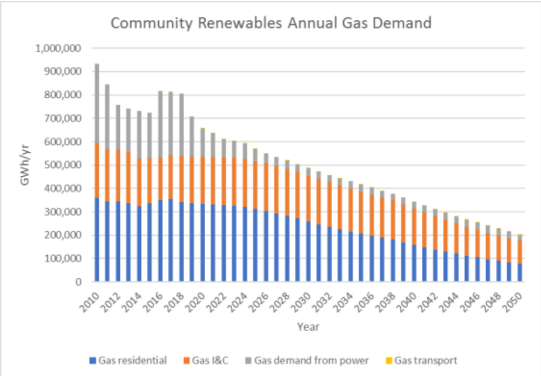

Figure 2 Community Renewables Annual Gas Demand

The Two Degrees scenario shown in Figure 3, includes a shift to the use of hydrogen from 2030 which displaces the natural gas demand so that overall annual gas demand starts to increase. By 2050, annual gas demand is expected to have decreased overall by 27% from 2018.

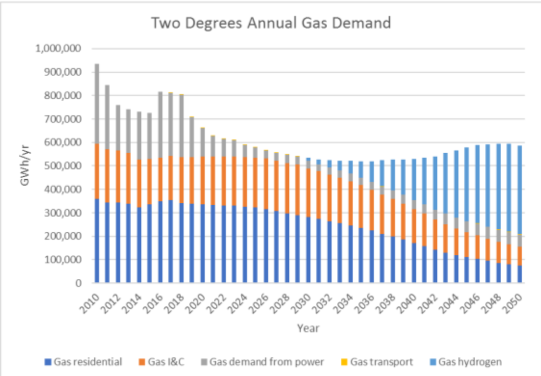

Figure 3 Two Degrees Annual Gas Demand

In contrast, Steady Progression and Consumer Evolution in Figure 4 and Figure 5 indicate a slow but steady decline in total annual demand with some hydrogen blending in Steady Progression. By 2050, annual gas demand is expected to have decreased overall by 11% and 19% respectively from 2018.

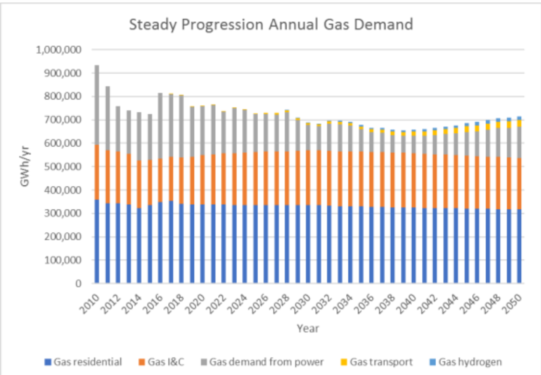

Figure 4 Steady Progression Annual Gas Demand

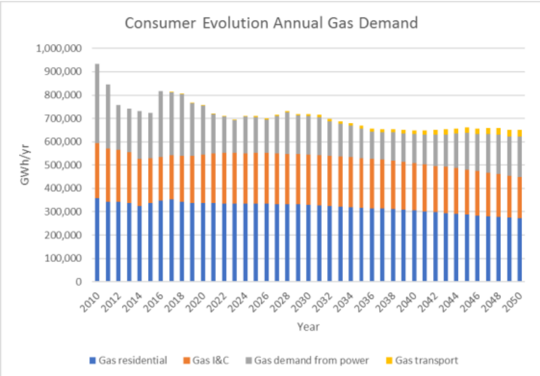

Figure 5 Consumer Evolution Annual Gas Demand

A reduction in annual demand will result in decreasing carbon emissions through use of fossil gas. There would also be further reductions from anticipated increases in supplies of carbon neutral green gas such as biomethane and in the longer term, hydrogen produced with carbon capture technology or electrolysis. If we are to be prepared for full hydrogen conversion, we will need to ensure that we accelerate our programme of works to convert metallic mains pipes to polyethylene (PE) pipes from GD3, to create hydrogen ready networks.

5 Peak gas demand

Peak demand drives capacity related investment in our network and is a key consideration in the design of condition and risk driven asset replacements. Changes in peak demand do not necessarily correlate to changes in annual demand because of the low load factors associated with lower carbon technologies. For example, with hybrid heating systems, the production of heat via an air source heat pump when used away from peak periods is likely to significantly reduce gas use at those times. However, during colder weather and when renewable generation is not available, the use of the gas boiler would mean that peak gas demand is likely to remain unchanged. A model of gas use with hybrid heat pumps compared with gas boilers is depicted in Figure 6 to demonstrate this. This indicates that a large adoption of hybrid heat pump gas boilers is unlikely to impact peak gas demand if it is preferable to complete conversion to air source heat pumps only from gas boilers.

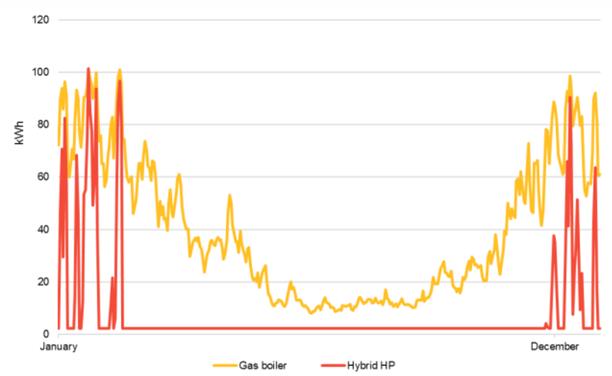

Figure 6 Modelled gas use with hybrid heat pumps from FES 2019

Our predictions of peak data for our Local Distribution Zones have been compared with the FES in Figure 7 to 9. Our current forecasts are most similar in trend to Steady Progression and Consumer Evolution. As such, we will ensure our assets are suitable for maintaining security of supply during the worst peak demand periods at these levels whilst also ensuring that we do not increase the risk of stranded assets if the trend deviates in the coming decades to be more aligned with Two Degrees or Community Renewables.

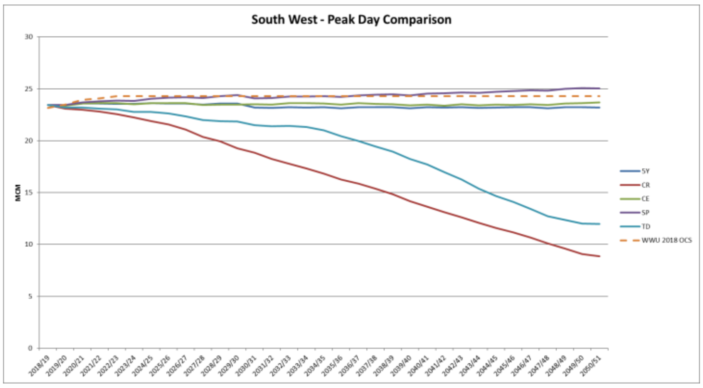

Figure 7 South West Peak Day Comparison

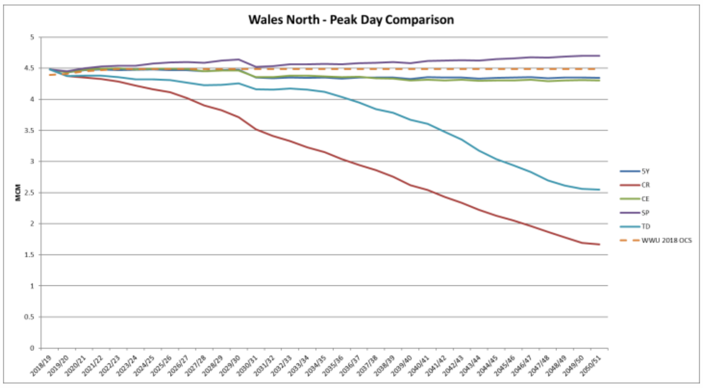

Figure 8 North Wales Peak Day Comparison

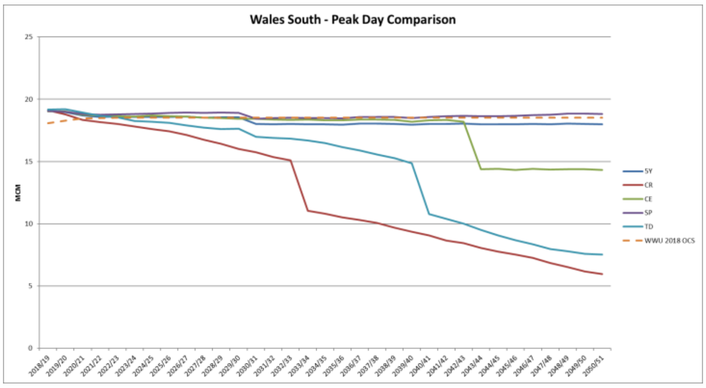

Figure 9 South Wales Peak Day Comparison

6 Intermittent renewables

Electricity demand increases in each of the FES. This is because of:

- adoption of electric vehicles
- switching to electricity as a heating source
- an increase in the use of electrical appliances
- electrification of railways
- an increase in population

The increase in intermittent renewable technologies requires more flexible generation and storage to ensure security of supply. If there are insufficient small modular reactors (SMRs) or other flexible sources of generation and storage available, gas-fired peaking power plants may be required to meet peak electricity demands as shown in Figure 10, potentially calling for reinforcement of the gas network.

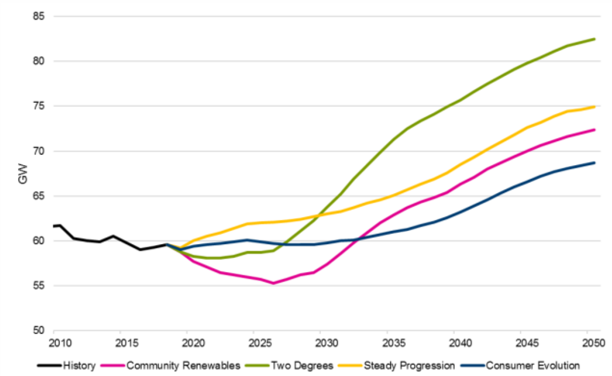

Figure 10 Electricity peak demand (including losses) from FES 2019

Figure 11 was produced using data from GridWatch Database (1) which shows the demand profile for 1st March 2018 during the 'Beast from the East' when we observed peak demand day. Solar generation was minimal although wind was consistently high. The chart shows that flexible generation is required to support wind and solar especially during peak times to meet demand.

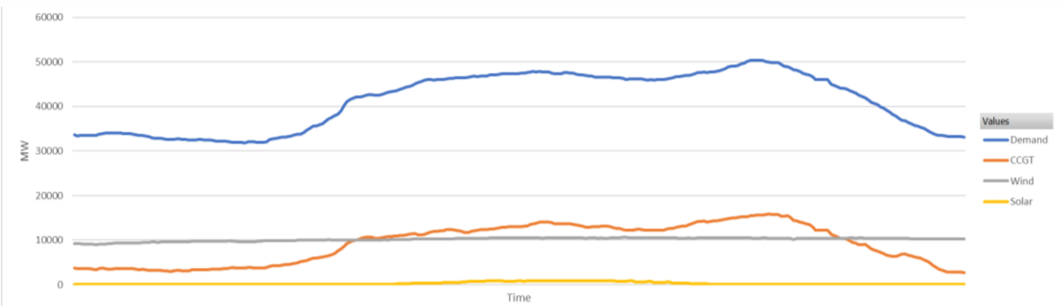

Figure 11 Demand profile with intermittent renewable and gas generation on 1st March 2018

Figure 12 and 13 show a winter month in 2018 (January) and a summer month in 2018 (July) respectively, which highlights the seasonality of solar and wind generation.

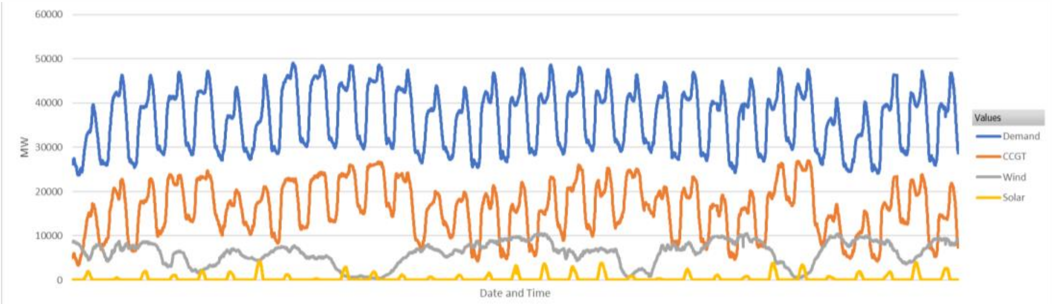

Figure 12 Demand profile with intermittent and gas generation in January 2018

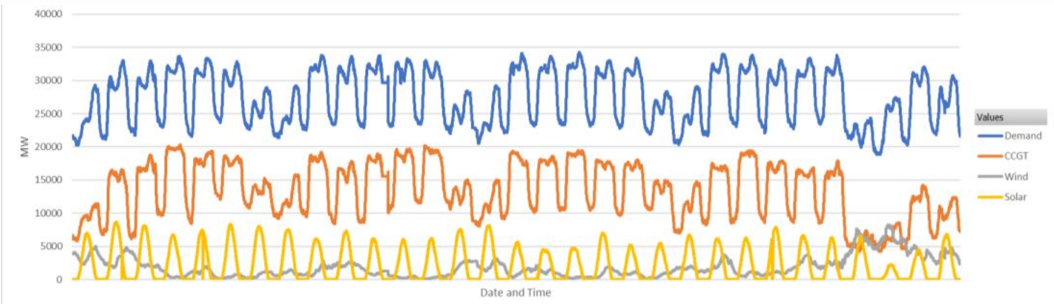

Figure 13 Demand profile with intermittent and gas generation in July 2018

The chart below shows generation capacity by technology type for 2030 and 2050 in each scenario from FES 2019. As expected, the Community Renewables and Two Degrees have the highest amount of capacity that is renewable but there is also a distinct growth in solar and wind capacity for all scenarios.

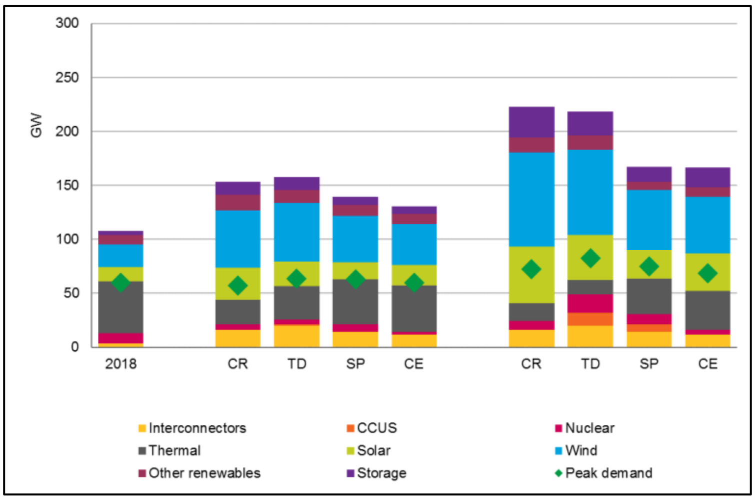

Figure 14 Installed electricity generation capacity by technology type

Using the data from FES 2019, the percentage of installed electricity generation capacity that is wind or solar was calculated as shown in Table 1 (although the source for interconnectors and storage is unknown). This shows an increase in the proportion of 31% in 2018 up to 62% by 2050 for Community Renewables.

Gas can fulfil some of the need for flexible generation and the existing infrastructure offers a safe and secure storage for energy. We are currently observing a growth of flexible generation plants connected to our network and anticipate more in the future. This will change the way we operate our network, and in some cases, may need reinforcement to ensure gas supply is maintained at the extremities of the network.

	2018	2030	2050
CR	31%	54%	62%
TD	31%	49%	55%
SP	31%	42%	49%
CE	31%	43%	53%

Table 1 Proportion of electricity generation capacity that is wind or solar

7 Heating installations

Figure 14 shows the change in numbers of residential heating installations in each of the FES compared to 2018. This does not include district heat or micro CHP which may or may not use gas and so the changes assume 'the worst case' for gas i.e. the lowest requirement for gas. The FES team expects for all scenarios that there would be a transition from carbon intensive to lower carbon fuels for district heat as time develops.

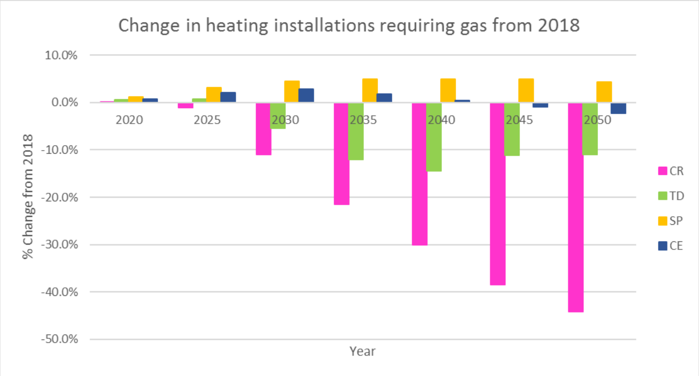

Figure 15 Change in residential gas heating installations from 2018

Community Renewables observe the greatest decrease of 44% by 2050 (relative to 2018) in heating installations using gas boilers. This is due to an increase in adoption of air source heat pumps (ASHPs) and district heat networks. Unless there are strategic schemes to convert whole areas and networks to non-gas fuelled heating installations, gas assets remain relevant and in use to supply those requiring gas. If whole areas and networks are converted, however, pressure reduction stations and governor sites would likely require downsizing in 2050 to reflect the reduced capacity needed as well as decommissioning of mains pipes.

In the case of Two Degrees, depending on the extent of hydrogen network conversion, we would be making use of the existing mains and services as well as potentially investing in new assets for bulk transmission of hydrogen by the 2030s.

Table 2 shows the percentage of total residential heating installations which are connected to gas for Community Renewables (CR), Two Degrees (TD) and Net Zero (NZ) scenarios based on FES 2019. This excludes district heating and micro CHP but includes hydrogen, giving assurance that net zero targets are achievable whilst keeping existing gas assets relevant.

2018	2050		
	CR	TD	NZ
78%	40%	63%	57%

Table 2 Percentage of total residential heating installations which use gas in 2018 and 2050

There is no FES data to show a breakdown of the number of heating installations by type for industrial and commercial users to determine an estimate of change in the proportion of total installations connected to gas relative to today. As with residential connections, strategic conversion to non-gas fuelled installations would be needed before decommissioning of pipelines is necessary. If large users (or clusters of users in a network area) disconnect from gas, our stations would likely operate at lower capacities in accordance with this and hence, require no additional investment. We will maintain our strong relationships with industries to enable us to anticipate their effect on our assets.

8 District heat

The extent of the impact of district heat networks on our assets will depend on their location and how those heat networks are fuelled. Where heat networks are installed on existing developments, our mains, services and risers directly supplying consumers would no longer be needed. However, where those heat networks are fuelled by grid-connected gas, investment in other parts of our network may be required to accommodate them. Figure 16 shows the growth of residential district heat installations compared with 2018. As mentioned, it is not clear how these heat networks are fuelled and their contribution to reducing carbon emissions is dependent on them using a low carbon source of heat.

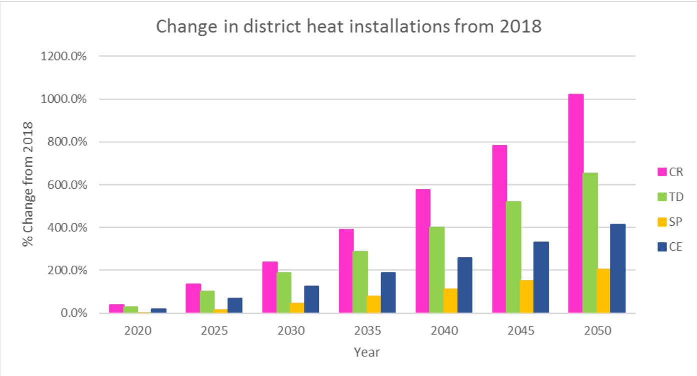

Figure 16 Change in district heat installations from 2018

9 Hydrogen networks

In Community Renewables, hydrogen produced from electrolysis is predominantly used for commercial vehicles. The only scenario that features hydrogen heat networks is Two Degrees where hydrogen is predominantly derived from steam methane reformation and begins in the 2030s.

PE pipes can be used to transport hydrogen to homes. Part of our strategy to support the UK net zero target is to replace all < 7 bar metallic pipes with PE by 2035 (currently, over 70% of WWU’s distribution network is PE). This is a huge contributor to reducing methane emissions to atmosphere due to leakage. Another benefit is that PE provides a hydrogen ready network, negating the need for additional investment in mains and services for those already connected to the PE natural gas network. However, new assets, such as strategic valves may be required to support a part natural gas, part hydrogen gas network or to segment a network to aid the conversion process. Depending on the scale of conversion in our network, we may require new hydrogen offtakes where hydrogen enters from the national hydrogen transmission system and/or hydrogen connections for local production.

We recognise that different decarbonisation strategies are likely to be implemented in different regions based on for example, whether they are rural or urban and levels of industry. In our network we anticipate the use of pure hydrogen to support industry in South Wales which will then be adopted in cities along the M4 corridor. We anticipate an element of blended hydrogen in North Wales which will be available from hydrogen clusters in the North West of England. In other regions we anticipate the use of biomethane, synthesis gas and a small amount of blended hydrogen along with increased numbers of hybrid heating systems. By assessing our plans against all four scenarios, we will have a robust assessment against all these different regional approaches.

10 FES impact on existing assets

The following tables summarise the most impactful changes on gas assets in each scenario and the conclusions for payback periods drawn from them, based on the decade they occur. Our Engineering Justification Documents (Appendices 15A&B) show the use of this in our asset investment assessment process.

Community Renewables	**2030**	**2040**	**2050**	**Conclusion**
Highlights	11% decrease in residential heating installations connected to gas network from 2018 due to replacement by air source and hybrid heat pumps plus district heat. 238% increase in residential district heat installations from 2018. 54% of installed electricity generation capacity from wind and solar.	30.1% decrease in residential heating installations connected to the gas network from 2018. 575% increase in residential district heat installations from 2018.	44.2% decrease in residential heating installations connected to the gas network from 2018. 1023% increase in residential district heat installations from 2018. 40% of heating installations connected to gas network. 62% of installed electricity generation capacity from wind and solar.	
LTS Pipelines	No impact as still required.	No impact as still required.	No impact as still required.	A 30 year payback period is no regrets and will avoid asset stranding

Offtakes and PRIs	No impact as still required.	May decrease if district heat networks are fuelled by low carbon alternatives.	May decrease if district heat networks are fuelled by low carbon alternatives.	A 20 year payback period is no regrets and will avoid asset stranding
District Governors	No impact as still required.	May decrease if district heat networks are fuelled by low carbon alternatives.	May decrease if district heat networks are fuelled by low carbon alternatives.	A 20 year payback period is no regrets and will avoid asset stranding
Mains, services and risers	No impact as still required. May need reinforcement to support flexible generation.	No impact as still required.	Length may decrease if strategic conversion to non-gas heating installations. May need reinforcement to support flexible generation.	A 30 year payback period is no regrets and will avoid asset stranding

Two Degrees	**2030**	**2040**	**2050**	**Conclusion**
Highlights	5.4% decrease in residential heating installations connected to gas network from 2018 due to installations of air source and hybrid heat pumps plus district heat schemes. 188% increase in residential district heat installations from 2018. 49% of installed electricity generation capacity from wind and solar.	14.4% decrease in residential heating installations connected to gas network from 2018. 401% increase in residential district heat installations from 2018.	11% decrease in residential heating installations connected to gas network from 2018 due to growth of hydrogen boilers. 655% increase in residential district heat installations from 2018. 63% of heating installations connected to natural gas or hydrogen network. 55% of installed electricity generation capacity from wind and solar.	
LTS Pipelines	No impact as still required.	No impact as still required.	No impact as still required.	A 30 year payback period is no regrets and will avoid asset stranding

Offtakes and PRIs	No impact as still required.	No impact as still required.	May decrease if district heat networks are fuelled by low carbon alternatives.	A 20 year payback period is no regrets and will avoid asset stranding
District Governors	No impact as still required.	No impact as still required.	May decrease if district heat networks are fuelled by low carbon alternatives.	A 20 year payback period is no regrets and will avoid asset stranding
Mains, services and risers	No impact as still required. May need reinforcement to support flexible generation.	No impact as still required.	No impact as still required. May need reinforcement to support flexible generation.	A 30 year payback period is no regrets and will avoid asset stranding

Steady Progression	**2030**	**2040**	**2050**	**Conclusion**
Highlights	4.5% increase in heating installations connected to the gas network from 2018 due to virtually no reduction with small roll out of air source and hybrid heat pumps plus some district heat. 46% increase in residential district heat installations from 2018. 42% of installed electricity generation capacity from wind and solar.	5% increase in heating installations connected to the gas network from 2018. 112% increase in residential district heat installations from 2018.	4.4% increase in heating installations connected to the gas network from 2018. 204% increase in residential district heat installations from 2018. 40% of heating installations connected to gas network. 74% of heating installations connected to gas network. 49% of installed electricity generation capacity from wind and solar.	

LTS Pipelines	No impact as still required.	No impact as still required.	No impact as still required.	A 30 year payback period is no regrets and will avoid asset stranding
Offtakes and PRIs	No impact as still required.	No impact as still required.	May decrease if district heat networks are fuelled by low carbon alternatives.	A 20 year payback period is no regrets and will avoid asset stranding
District Governors	No impact as still required.	No impact as still required.	May decrease if district heat networks are fuelled by low carbon alternatives.	A 20 year payback period is no regrets and will avoid asset stranding
Mains, services and risers	No impact as still required. May need reinforcement to support flexible generation.	No impact as still required.	No impact as still required. May need reinforcement to support flexible generation.	A 30 year payback period is no regrets and will avoid asset stranding

Consumer Evolution	**2030**	**2040**	**2050**	**Conclusion**
Highlights	2.8% increase in heating installations connected to the gas network from 2018 due to limited roll out of hybrid and air source heat pumps plus district heat. 126% increase in residential district heat installations from 2018. 43% of installed electricity generation capacity from wind and solar.	0.4% increase in heating installations connected to the gas network from 2018. 258% increase in residential district heat installations from 2018.	2.2% decrease in heating installations connected to the gas network from 2018. 414% increase in residential district heat installations from 2018. 69% of heating installations connected to gas network. 53% of installed electricity generation capacity from wind and solar.	
LTS Pipelines	No impact as still required.	No impact as still required.	No impact as still required.	A 30 year payback period is no regrets and will avoid asset stranding

Offtakes and PRIs	No impact as still required.	No impact as still required.	May decrease if district heat networks are fuelled by low carbon alternatives.	A 20 year payback period is no regrets and will avoid asset stranding
District Governors	No impact as still required.	No impact as still required.	May decrease if district heat networks are fuelled by low carbon alternatives.	A 20 year payback period is no regrets and will avoid asset stranding
Mains, services and risers	No impact as still required. May need reinforcement to support flexible generation.	No impact as still required.	No impact as still required. May need reinforcement to support flexible generation.	A 30 year payback period is no regrets and will avoid asset stranding

11 The common scenario

The common scenario, derived in collaboration across sectors under the instruction of Ofgem, was based on National Grid's FES assumptions and establishes that there would be greater change between 2030 and 2050 than in the period up to 2030. The key drivers identified for GDNs in this scenario are:

- shale reserves and supply
- low carbon gases
- gas '1 in 20' peak demands
- gas vehicles
- hydrogen
- heat
- gas generation

Table 3 shows the common scenario view of WWU on the expected ranges for each driver in 2030 compared to today.

Driver	Today	2030	Units
Shale	0	0	bcm
Low carbon gases (biomethane and bioSNG)	0.06	0.09-0.21	bcm
Gas 1 in 20 peak demand	504	>419	GWh
Gas/hydrogen vehicles	0	5-12	thousand
Decentralised gas generation	537*	571-993	MW

Table 3 Common scenario view for WWU compared with today

*flexible generation connected since 2012.

This scenario's post 2030 highlights include:

- continued growth of gas generation capacity to support peak electricity demand
- growth in the use of Compressed Natural Gas (CNG) and/or hydrogen for vehicles
- growth of green gas injection including hydrogen

- further sources of generation such as gas generation with CCS technology
- increased use of ASHPs
- gas usage declining - driven largely by offices, retail and health sectors due to the increased efficiency, shrinking commercial sectors and some uptake of new heating technologies
- by 2050 in the industrial sector, demand will decrease due to declining output, energy efficiency improvements and a shift away from gas boilers
- continued integration of the gas and power sectors, with reduction in use of gas as a fuel in some sectors. This will result in an equivalent increase in gas generation to deliver heat via electrical appliances.

12 Conclusion

The FES and common scenario views are in relative agreement in terms of the direction of changes from 2030 to 2050 but the extent and speed of change is uncertain. FES' Community Renewables and Two Degrees observe the greatest changes by 2050 which can affect our portfolio of existing and future assets. As the UK strives towards achieving its decarbonisation targets, the real scenario of the future is likely to be a hybrid of elements from the scenarios mentioned. In FES and the single scenario, not a lot of change is expected to occur before 2030 and we do not expect major impacts on our existing assets by 2040. Therefore, our analyses for future investments are typically based on payback periods of between 20 and 30 years from 2021. The details of the use of these payback periods and the results can be found in our Engineering Justification Papers and associated CBAs – appendices 15A and 15B of our GD2 Business Plan.

13 References

1. U.K. National Grid status download data [Internet]. [cited 2019 Sep 30]. Available from: http://gridwatch.templar.co.uk/download.php
2. Future Energy Scenarios 2019 [Internet]. [cited 2019 Sep 30]. Available from: http://fes.nationalgrid.com/media/1363/fes-interactive-version-final.pdf