TRANSITION TO NET ZERO: THE ROLE OF GAS

Understanding climate-related risks and opportunities of different climate scenarios to SSE's gas businesses

CONTENTS

ABOUT SSE

SSE is an energy company listed on the London Stock Exchange. Formed in 1998, it now has operations and investment across the UK and Ireland and is involved in the: generation, transmission, distribution and supply of electricity; the production, storage, distribution and supply of gas; and in the provision of energy-related services.

In March 2019, SSE announced four new 2030 Goals, aligned to the UN's Sustainable Development Goals (SDGs), which underpin SSE's strategic focus on long-term, low-carbon and sustainable assets; and they commit SSE to delivering its strategy in a way that creates value for shareholders and for society. Three of these goals have addressing climate change at their core, and to demonstrate its commitment to them, SSE has linked the pay of its senior directors to their progress in helping SSE achieve these goals.

Cut our carbon intensity by 50%

Reduce the carbon intensity of electricity generated by 50% by 2030, compared to 2018 levels, to around 150gCO_2/kWh.

Treble renewable energy output

Develop and build by 2030 enough renewable energy to treble renewable output to 30TWh a year.

Help accommodate 10m electric vehicles

Build electricity network flexibility and infrastructure that helps accommodate 10 million electric vehicles in GB by 2030.

Champion Fair Tax and a real Living Wage

Be the leading company in the UK and Ireland championing Fair Tax and a real Living Wage.

ABOUT THIS REPORT

SSE's stakeholders, particularly those in the investor community, are increasingly seeking information on how SSE is managing climate-related risks and opportunities. In light of SSE's low-carbon business model, they are especially keen to understand the role its gas businesses will play in the future. The purpose of this report is to provide detailed disclosure on the resilience of SSE's gas businesses to different climate-related scenarios, over the medium (2023 to 2030) and long term (2031 to 2050).

Scope of the report

This report focuses on SSE's material gas-related business activities in the UK and Ireland that are most impacted by market and policy changes associated with carbon reduction ambitions: generating electricity from gas and storing gas in underground cavities.

SSE has interests in other gas businesses which have been excluded from the analysis, largely due to their contribution to the Group and the impact they have in the energy system being less significant. More detail on reasons for inclusions and exclusions is outlined below.

Gas-related businesses/activities included in the assessment:

Gas-fired electricity generation

SSE owns and operates Combined Cycle Gas Turbine (CCGT) plant in GB and Ireland, and currently has a gas-fired generation capacity of 4,431MW.

SSE's high-efficiency thermal generation is a key part of the SSE Group, complimenting SSE's core regulated electricity networks and renewables businesses by providing flexible and reliable electricity.

Gas storage

SSE has an ownership interest in two major gas storage facilities in East Yorkshire: Hornsea (Atwick) and Aldbrough (SSE ownership 66.7%). SSE holds around 40% of the UK's conventional underground gas storage capacity

SSE's storage business supports its gas generation business in safeguarding UK's gas and electricity security of supply. SSE's ability to store gas is intrinsically linked with its gas-generation business.

Gas-related businesses/activities excluded from the assessment:

Scotia Gas Networks (SGN) Ltd

SSE has a 33% shareholding in SGN, which manages the networks that distribute natural and green gas to 5.9 million homes and businesses across Scotland and southern England.

SSE does not have a controlling stake in SGN. SGN has already been undertaking its own extensive research into the future of gas. Its publications can be found on SGN's 'Future of Gas' webpages: sgn.co.uk.

SSE E&P UK

SSE is involved in the extraction of natural gas and has a diverse equity share in over 15 producing fields in the North Sea and west of Shetland, on the outer margins of the Atlantic.

Gas Production is a non-core activity that is ultimately inconsistent with SSE's low-carbon ambitions. In May 2019, SSE announced its intention to sell its interests in gas production and is making progress with this planned disposal.

SSE's retail businesses

SSE's domestic retail business in GB, SSE Energy Services, provides energy and related services to around 6 million domestic customer accounts in GB and is currently held for sale.

SSE supplies energy and provides infrastructure services to business and public sector customers through its Business Energy and Enterprise divisions. SSE Business Energy supplies energy to around 500,000 commercial and industrial customers across GB and SSE Airtricity supplies energy to over 700,000 homes and businesses on the island of Ireland.

In September 2019, SSE announced its agreement to sell its domestic retail business in GB, SSE Energy Services, to OVO Energy Services Limited.

SSE's other retail businesses are less significant in their contribution to the Group. These businesses work closely with customers to meet their specific energy-related requirements.

Further information on SSE's business can be found in its Annual Report Sustainability Report 2019.

FOREWORD

This report is one part of SSE's increasing effort to provide transparency about the risks and opportunities it faces as the UK economy decarbonises and seeks to reach net zero carbon emissions by 2050. The UK has the clarity in its legislation for a net zero economy in 2050 and Ireland has its Climate Action Plan for 2030. However, what is not clear is the pathway that will be taken to get to net zero.

But when you start to break it down, there are some certainties. In the period to 2030 there is clarity about how much carbon we need to reduce to be on a path consistent with net zero and we can make some informed predictions about the sorts of trials, pilots and innovations we will need to make the necessary progress on decarbonisation in the 2030s and beyond. In the long term these technologies will be needed at scale to deliver this net zero ambition.

> For SSE, our vision, business purpose and strategy has never been so clear. We are here to be a leading energy provider in a low-carbon world, building a better world of energy for the future.

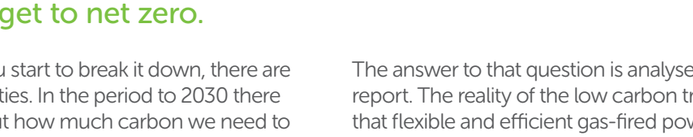
In all of this, it is no wonder that our investors, other finance providers and other stakeholders are asking companies like SSE for more information about business plans to decarbonise in addition to the impacts of climate-related risks and opportunities on the business.

And this is what this report is about: the pursuit of better quality engagement with our stakeholders, based on the best information and analysis we can give to enable us to participate in a better informed, mature debate about the careful judgements and trade-offs that need to be taken to deliver net zero.

In that context, there is a legitimate question to be answered: **What role does gas have in the, short, medium and long term, in a way that is wholly consistent with our net-zero carbon ambition?**

The answer to that question is analysed in this report. The reality of the low carbon transition is that flexible and efficient gas-fired power stations will be essential to fill the gap as the UK and Ireland transition to net zero by replacing older high carbon power stations that will come to the end of their life and providing an alternative to expensive nuclear. The way that gas operates will change too. It will run for fewer hours through the 2020's; but when it does run it will play a more important role than ever in keeping the electricity grid stable while the amount of electricity from renewable sources increases.

Whilst providing that critical role of security and stability, gas generation itself has the potential to decarbonise through carbon capture, usage and storage (CCUS) technology and through the substitution of hydrogen for natural gas. We will be guided by financial discipline and won't develop further combined cycle gas turbine assets without a pathway to decarbonisation, which these technologies could provide. Through demonstration of these technologies, and development of policy support, we can create the conditions to abate gas generation. Creating those conditions is a challenge, not just for energy companies like SSE, but for consumers, politicians, regulators and investors too.



From Martin Pibworth
Energy Director, SSE Plc

EXECUTIVE SUMMARY

The purpose of this report is to provide detailed disclosure on the resilience of SSE's gas businesses to different climate-related scenarios.

SSE's stakeholders, especially those in the investor community, are keen to understand the role its gas businesses will play in the future. To provide enhanced disclosure, SSE has undertaken an analysis of the resilience of its gas-related businesses against three climate-related scenarios in the medium (2023 to 2030) and long term (2031 to 2050).

Climate scenarios

SSE has taken a combination of climate-related scenarios from the Climate Change Committee (CCC) and National Grid's Future Energy Scenarios (FES) to develop the following three scenarios:

- 4 degree – assumes a pathway to 2050 that results in 4 degrees of temperature rise and 56% emissions reduction since 1990;
- Net zero – assumes a pathway to 2050 that results in 1.5 degree temperature rise and close to zero emissions; and
- Net zero (low nuclear) – assumes a pathway to 2050 that results in 1.5 degree temperature rise and close to zero emissions, however, there is no further build out of nuclear power.

A continued role for gas

For all climate scenarios and time horizons, it is identified that there is a crucial role for gas to play in providing a flexible and reliable means to meet electricity demand, stability to the grid along with increased diversity and system security of supply.

Risks and opportunities

Net zero and net zero (low nuclear) scenarios:

In these scenarios, in addition to the provision of flexible and reliable system services, a number of other opportunities were identified. The need in the medium term to develop the next generation of low-carbon technologies (such as CCUS and hydrogen) and for these technologies to be rolled out at scale in the long term to deliver the net zero targets. For the net zero (low nuclear) scenario the role gas plays is even greater as low-carbon gas generation replaces nuclear as an electricity source.

There are a number of risks to SSE from these scenarios in the medium term, including: that gas runs less as low-carbon generation replaces high carbon emitting sources; and additional emission limits could be imposed to drive the transition towards decarbonisation. In the long term there is a risk that stretching climate policy results in the closure of unabated gas assets and the growth and scalability of low-carbon thermal technologies is unviable as alternatives emerge.

4 degree scenario:

There will be some decarbonisation of gas and SSE will be in a good position to take part in that technology change as and when it takes place. The risk of this scenario to SSE's gas assets is that demand for electricity will not grow at the pace of the other scenarios and renewables will continue to displace gas generation which creates less opportunity for SSE to grow its gas businesses.

Resilience of SSE's gas business

Overall, SSE has skills, assets and expertise to realise the opportunities that have been identified across the scenarios. In addition, SSE's gas businesses have risks mitigation plans in place which means they are well equipped to deal with the identified risks in each scenario as well. SSE therefore believes its gas businesses are resilient to the different climate scenarios and is well prepared to respond depending on which pathway plays out.

INTRODUCTION

This report aims to assess the impact of three different climate change scenarios on SSE's gas businesses. This section outlines why SSE is conducting this assessment. The second section describes the methods used and the final sections show the results.

The imperative to decarbonise

There is a rapidly growing public momentum behind the urgent need to tackle climate change. This has in part been triggered by significant developments in climate science studies, such as the Intergovernmental Panel on Climate Change's (IPCC) landmark report in October 2018[1], which estimates unprecedented levels of change are needed in a much shorter timeframe if society is to avoid the dangerous impacts of climate change.

A framework for net zero

In June 2019, following a recommendation from the UK Committee on Climate Change (CCC), the independent statutory body established as a result of the UK Climate Change Act 2008, the UK became the first major economy in the world to pass a net zero emissions target into law. This target will require the UK to bring all greenhouse gas (GHG) emissions to net zero by 2050, compared with the previous target of at least 80% reduction from 1990 levels.

In the same month, The Irish Government launched its new Climate Action Plan which aims to dramatically improve Ireland's efforts in reducing GHG emissions, which are currently estimated to rise 6% by 2030 under existing measures[2]. The new Plan sets out more ambitious targets for 2030 and commits to evaluating in detail the changes which would be necessary in Ireland to achieve net zero by 2050.

Stakeholder scrutiny around climate action

This growing sense of urgency around the need to tackle climate change has resulted in further focus from stakeholders, in particular from the investment community.

An increasing number of investors are actively choosing to invest in companies that manage ESG (environmental, social and governance) issues well, and as a result are requesting more meaningful climate-related corporate disclosures.

Groups such as the Institutional Investors Group on Climate Change (IIGCC) are actively engaging with companies in high emitting sectors and encouraging them to undertake scenario analysis to understand the resilience of their business models to different warming scenarios.

As a result of this engagement, SSE has been working over the past few years to better disclosure around its management of climate-related risks and opportunities.

[1]Intergovernmental Panel on Climate Change (2018) https://www.ipcc.ch/sr15/
[2]Environmental Protection Agency (2019) Ireland's Greenhouse Gas Emissions Projections: 2018-2040. https://www.epa.ie/pubs/reports/air/airemissions/ghgprojections2018-2040/Greenhouse_Gas_Projections.pdf

Driving climate-related disclosure

Financial markets are increasingly trying to understand the impact of climate-related risks and opportunities on their investments. In response to this need, the Financial Services Board (FSB) established the Task Force on Climate-Related Financial Disclosures (TCFD) to support companies to provide consistent, quality climate-related financial risk disclosures for investors.

The TCFD has set out recommendations for companies, which include a focus on financial disclosures and the use of scenario analysis. SSE has committed to meeting these recommendations in full by March 2021 and, as part of its progress, has quantified and disclosed the potential financial impact of climate-related risks and opportunities on its business (see pages 22 to 25 of its Sustainability Report 2019). This analysis is another step in the progress towards full TCFD disclosure.

TCFD | TASK FORCE ON CLIMATE-RELATED FINANCIAL DISCLOSURES

Role of gas in a net zero world

Given this context, SSE's stakeholders are seeking clarity around the role of SSE's existing and prospective gas assets in this low-carbon future.

Natural gas is used by domestic customers, primarily for heating; by industry; and by power stations, with the latter typically making up around 30% of total annual gas demand in the UK[3].

Overall gas demand is expected to reduce in a net zero world primarily as electrification displaces gas as a heat source along with other low-carbon alternatives in industry (such as hydrogen).

However, the CCC and National Grid's Future Energy Scenarios (FES) reports acknowledge that gas has the potential to play a crucial role in electricity generation as the system evolves and transitions towards net zero. Its role is to provide:

- a flexible and reliable means to meet electricity demand, including when renewable output is low;
- stability to the grid through provision of flexible system services;
- increased diversity and system security of supply; and
- the basis to develop a low-carbon gas generation source, equipped with carbon capture usage and storage technology (CCUS) and critical to a net zero carbon electricity system.

Gas will also have a role in meeting the need for residual heating; in industry with CCUS; and, through the process of methane reformation, in hydrogen production for use across all sectors.

In addition to its production from natural gas, hydrogen can also be produced through electrolysis, which creates hydrogen using electricity and water. Where the electricity comes from renewable sources, it is known as 'Green Hydrogen' and could play a role in displacing natural gas use up to and beyond 2050. SSE's generation and storage assets are well placed to support wider use of this Green Hydrogen, as outlined further in this report.

[3]UK Government (2019) Digest of UK Energy Statistics (DUKES) 2019: https://www.gov.uk/government/statistics/digest-of-uk-energy-statistics-dukes-2019

Crucial role of gas in a world transitioning to net zero

The role of gas will evolve and transition as the energy system decarbonises. Its role will still be crucial as it would be used:

1. In gas-fired electricity generation equipped with post-combustion CCUS technology;
2. As a feedstock for the production of hydrogen, via methane reforming equipped with CCUS technology;
3. In industrial processes, again equipped with post-combustion CCUS technology; and
4. As 'Green Hydrogen' develops, SSE's gas assets can play a role in storing and generating electricity from this new energy carrier.

Importance of carbon price in the net zero world

Carbon Pricing is a 'polluter pays' mechanism to incentivise emitters to choose lower carbon solutions. Electricity generation across the EU is subject to the EU's Emissions Trading Scheme (EU ETS) and in addition GB generation is subject to the Carbon Price Support (CPS).

SSE believes that carbon pricing is a powerful tool to reduce carbon emissions, and that it has been particularly effective in decarbonising electricity supply in GB.

In the transition to net zero, there must be a strong carbon price signal to drive low-carbon investment. Carbon pricing regimes across interconnected markets must be designed to ensure that decarbonisation efforts are not undermined by imports of higher carbon electricity.

METHODS TO ASSESS CLIMATE RESILIENCE

BUILDING THE SCENARIOS

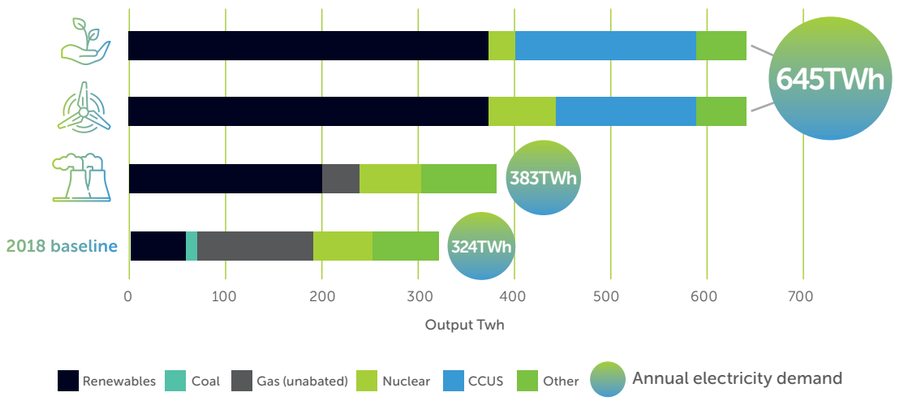
To assess the resilience of its gas businesses, SSE has used three different climate scenarios based on scenarios from the Committee on Climate Change's (CCC) report on net zero[4] and the recent National Grid's Future Energy Scenarios (FES)[5]. These three scenarios are:

4 DEGREE
Assumes a pathway to 2050 that results in 4°C of temperature rise.

NET ZERO
Assumes a pathway to 2050 that results in 1.5°C of temperature rise.

NET ZERO (LOW NUCLEAR)
Assumes a pathway to 2050 that results in 1.5°C of temperature rise, but there is no further build out of nuclear power.

2050 generation mix and electricity demand for different scenarios*



Net zero explained

The definition of net zero carbon emissions is that by 2050 there will be close to zero emissions of all greenhouse gases, expressed as carbon dioxide equivalent for each greenhouse gas. To reach net zero there is an assumption that greenhouse gas emissions will reduce by around 96% compared to 1990 levels using known technologies in the UK. For the remaining emissions it is assumed that other, as yet commercially unproven, technologies will enable the reduction or removal of the residual emissions.

[4]The Committee on Climate Change (2019) Net Zero – The UK's contribution to stopping global warming. https://www.theccc.org.uk/publication/net-zero-the-uks-contribution-to-stopping-global-warming/
[5]National Grid (2010) Future Energy Scenarios: July 2019. http://fes.nationalgrid.com/media/1409/fes-2019.pdf
* Information based on scenarios from the Committee on Climate Change's (CCC) report on net zero and the National Grid Future Energy Scenarios. See Appendix 1 for more detail.

SCENARIO DEVELOPMENT

This report uses a combination of the CCC and National Grid FES scenarios to stress test SSE's gas business against future different climate change scenarios:

4 degree:
This scenario assumes that the Climate Change Act 2008 targets are not met, instead carbon emissions fall by around 58% from 503 $MTeCO_2$ to 345 $MTeCO_2$. In this scenario, the pace of the low-carbon transition is initially maintained with continued build-out of renewables but slows towards 2050. Consumers are slower to adopt electric vehicles and take up of low-carbon alternatives for heat is limited by costs and lack of information and access to suitable alternatives. New technologies such as carbon capture, usage and storage (CCUS) develop slowly and hydrogen blending into existing networks begins to take place. This scenario assumes a generation mix of mainly renewables, unabated gas and nuclear.

Net zero:
This scenario assumes that the UK will reduce emission by 96% from 1990 baseline. The measures that will deliver this target include: energy efficiency, low-carbon power, deep decarbonisation of the heating and transport sectors, use of CCUS and electrification in industry, tree planting and on-farm measures, diversion of waste from landfill and phasing out of fluorinated gases.

In terms of the electricity generation mix, it is assumed that almost all carbon dioxide emissions from power generation will be eliminated by 2050. To achieve this the CCC report predicts that, in addition to significant growth in renewables, gas generation is largely decarbonised using CCUS technology.

In a net zero world, SSE assumes that abated gas for power generation provides 23% of electricity output (around 148TWh).

Net zero (low nuclear):
In the 4 degree and net zero scenario, nuclear is assumed to be a key part of the generation mix with just under 70TWh of output in 2050 both scenarios. This low nuclear scenario reflects a reduction in nuclear generation due to delays or cancellation of new nuclear development following the completion of Hinkley Point C, the earlier closure of existing nuclear stations, or both of these events combined.

This is a plausible scenario given the high cost of nuclear, the long and complex development period, and nuclear power stations' relative inflexibility, in a system with increasing electricity from renewable sources. In all respects renewable sources of energy complemented by gas-fired power stations with CCUS provide a very competitive alternative to nuclear. High efficiency combined cycle gas turbines (CCGTs) can be built at a lower cost, can be deployed quickly and provide greater flexibility to the electricity system, with their ability to operate as a baseload, mid-merit and peaking plant. In comparison to nuclear, CCGTs can be built as smaller units reducing the risks associated with a large single infeed loss (SIL) on the electricity transmission system.

For this low nuclear net zero scenario, the nuclear contribution reduces to 26TWh of output in 2050 and is replaced by additional abated gas generation. Abated gas generation provides around 30% or 191TWh of electricity as it plays a greater role to provide low-carbon clean power providing the flexible operation required in the energy system to support high renewables output. This is believed by SSE to be the most efficient and credible alternative to nuclear generation.

HORIZONS

To assess the resilience of its gas businesses, SSE looked at the three climate change scenarios over two time horizons:

- **Medium term (2023 to 2030)**
- **Long term (2031 to 2050)**

This allowed SSE to identify the different risks and opportunities that may arise from the scenarios in the different time periods, and meant that it could assess the potential role that its gas businesses can play depending on which scenario may unfold.

The medium and long term time horizons are where there is less certainty in the potential makeup of the energy system, however the role of SSE's gas businesses in these periods is of most interest to SSE's stakeholders.

DEFINING CLIMATE-RELATED RISKS AND OPPORTUNITIES

SSE recognises that climate change presents serious risks to the environment, the economy, business and society. It also recognises that the need to decarbonise presents significant opportunities in supporting the UK and Ireland transition to low-carbon electricity systems. SSE must articulate both these risks and opportunities to its stakeholders so they can make informed judgements on SSE's resilience to climate change.

Climate-related risks and opportunities can arise from either physical impacts or transitional impacts:

- **Physical impacts:** such as increased severity of extreme weather events (acute) such as cyclones, droughts, floods, fires or a longer-term shift in weather patterns (chronic) such as changes in precipitation and temperature patterns.

- **Transitional impacts:** associated with the transition to a low-carbon economy, for instance from changes to policy and legal actions, technology, market and reputational concerns.

The SSE Group's main climate-related risks arise from both physical and transitional impacts, however its key climate-related opportunities arise from the transition to a low-carbon economy, which requires the development of renewable generation and electricity networks to support the transition – core elements of the Group's business.

These core businesses are complemented by flexible thermal electricity generation, which has a key role to play in supporting the low-carbon transition. This report focuses on transitional risks and opportunities facing SSE's gas businesses.

SSE discloses information on the physical impacts of climate change to its business in various reports. More detail can be found in SSE's Sustainability Report 2019 and CDP Climate Change Programme response, both of which are available on its website at sse.com/sustainability.

SSE'S LOW-CARBON STRATEGY

SSE's core purpose, vision and strategy are wholly centred around supporting the low-carbon transition and addressing the challenge of climate change. At the core of its business is regulated electricity networks and renewable sources of energy, which have a central role in enabling progress towards net zero emissions. These core businesses are complemented by flexible thermal electricity generation and a series of energy services businesses, all with a strategic focus to provide energy-related services in a low-carbon world.

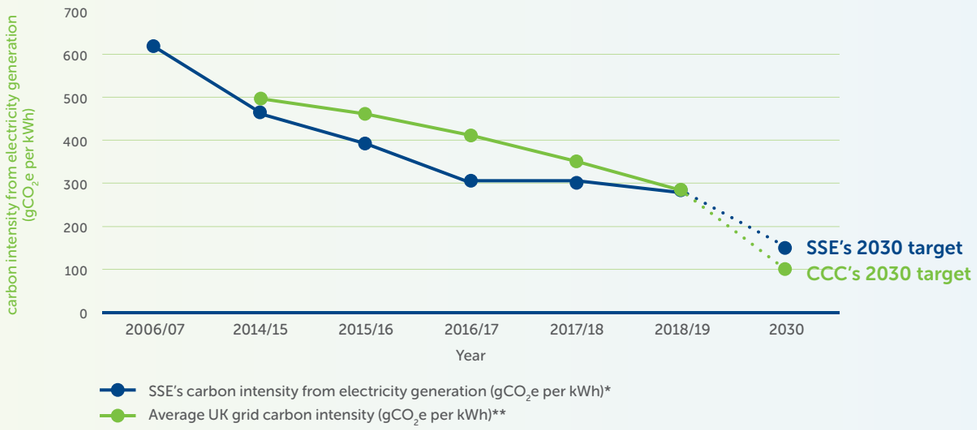
REDUCING SSE'S CARBON INTENSITY

Cut carbon intensity by 50%

One of SSE's core 2030 business goals is to reduce the carbon intensity of electricity generated by 50% by 2030, compared to 2018 levels, to around 150gCO2e/kWh. This target supersedes SSE's previous target to halve the carbon intensity of its electricity generation between 2006 and 2020, which was first achieved in 2017. The actions taken by SSE to deliver this target involved undertaking a strategic shift from a generation portfolio weighted towards coal and gas to one weighted towards gas and renewable. This was supported by a public policy and market framework which had the Renewables Obligation at its heart. This framework has evolved, with Carbon Price Support and Contracts for Difference for offshore wind farms now central to it.

With SSE's carbon intensity anticipated to be around 150gCO2e/kWh in 2030, this is above the CCC's recommendation that the average grid intensity of electricity generated in the UK in 2030 should be between 50gCO2e/kWh and 100gCO2e/kWh if the UK is to meet its carbon targets (see Graph 1). However, SSE believes that the UK will be able to meet the CCC recommendation on average as the result of the UK's overall generation mix.

Graph 1: SSE's carbon intensity from electricity generation in comparison to the UK grid with the 2030 forecasts



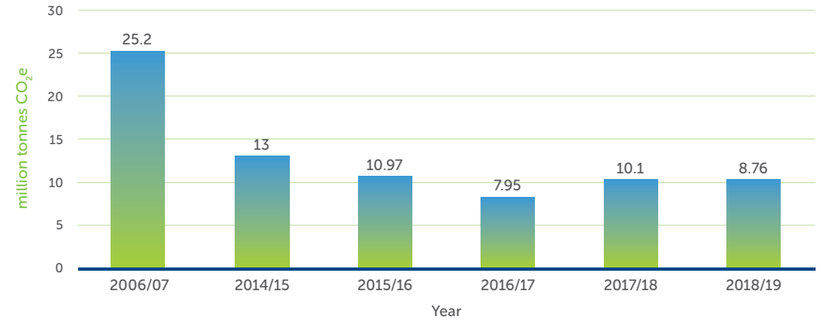
*2006/07, 2014/15, 2015/16, 2016/17, 2017/18 and 2018/19 is actual data and is based on SSE's 100% share of wholly owned sites, 100% share of Seabank & Marchwood PPAs due to contractual arrangement.
**Average UK grid intensity taken from 'UK Government GHG Conversion factors for company reporting' document for relevant year from BEIS website.

LOWERING CARBON EMISSIONS

One of the key influencing factors in SSE's carbon intensity is the total carbon emissions emitted from its thermal generation activities. Overall carbon emissions from SSE's thermal power stations (coal-, gas- and oil-fired) have fallen dramatically since 2006 (see Graph 2) as SSE has moved away from the most carbon-intensive sources of electricity generation. This has supported the significant decline in the carbon intensity of SSE's generated electricity.

Over the next decade, SSE's gas generation business will continue to play a key role in supporting SSE to achieve its 2030 carbon intensity reduction target.

Graph 2: SSE's carbon emissions for thermal (coal, gas and oil-fired) generation between 2014/15 and 2018/19 against the baseline year 2006/07*



*All data based on SSE's 100% share of wholly owned sites, 100% share of Seabank & Marchwood PPAs due to contractual arrangement.

SSE'S GAS-RELATED BUSINESSES

SSE's gas assets were primarily developed in the late 1990s early 2000s. Its existing assets are explained in this section. By describing these assets it allows an understanding of the key features of SSE's gas portfolio. In the short term SSE believes that the technology, policy and market conditions can be understood with a high degree of confidence. Therefore, it is not the intention of this section to assess the climate-related risks and opportunities rather to provide the context of the gas assets in order to assess SSE's resilience in the medium and long term in the next sections of the report.

Gas-fired generation output and capacity in GB and Ireland

The current capacity of SSE's gas-fired generation portfolio and plant in construction is outlined in Table 1. The output of SSE's gas-fired generation for the last five years is outlined in Graph 3. For the last five years gas-fired generation output has continued to play an important role in providing electricity, with CCGTs providing around 40% of the UK's electricity needs[6], as well as supporting security of supply.

Table 1: SSE's portfolio of gas-fired generation in GB and Ireland (current and in construction)

Asset	Commissioning year	Location	Capacity (MW)[1]
Medway	1995	England	735
Keadby 1	1996	England	755
Peterhead	2000	Scotland	1,180
Seabank 1 and 2	2000	England	617
Marchwood	2010	England	460
Great Island	2014	Ireland	464
Embedded gas generation[2]	Various	England	100
Keadby 2[3]	Expected 2022	England	840

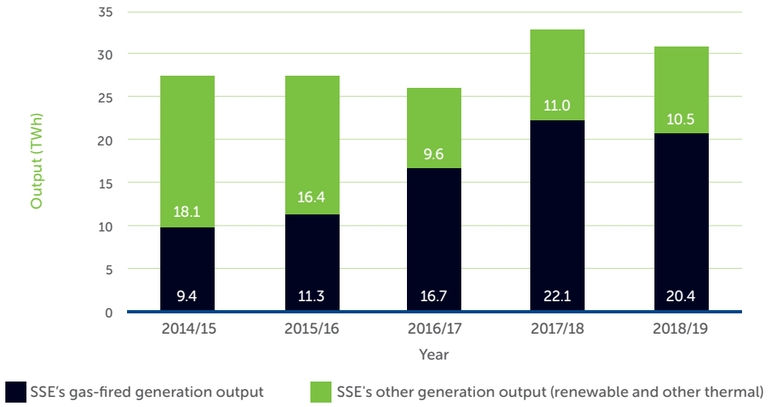
[1]Based on SSE's share
[2]SSE has three embedded gas-fired power stations: Burghfield, Chickerell and Chippenham.
[3]Keadby 2 CCGT is currently in construction and is to be delivered early 2022.

SSE began construction of its £350m, 840MW CCGT at Keadby 2 in Lincolnshire and it is expected to be delivered by early 2022. On completion, it is expected to be the most efficient CCGT in Europe. Its efficiency means it is expected to displace older, more carbon-intensive plant in the electricity system. This high efficiency gas-fired generation technology will be put into future Capacity Market auctions and is included in the Table 1.

In Ireland, SSE operates the 464MW Great Island CCGT, which entered commercial operation in the all-island Single Electricity Market in 2015 and is one of the most efficient gas generators on the island.

[6]UK Government (2019) Digest of UK Energy Statistics (DUKES) 2019: https://www.gov.uk/government/statistics/digest-of-uk-energy-statistics-dukes-2019

Graph 3: SSE's GB and Ireland gas-fired generation output between 2014/15 and 2018/19*



*All data is actual data and is based on SSE 100% share of wholly owned sites and 100% share of Seabank & Marchwood PPAs due to contractual arrangement.

Gas Storage

As the UK continues its shift away from coal-fired generation, taking with it the energy storage inherent in coal stocks, the security of supply provided by remaining gas storage facilities is expected to play an increasingly important role in safeguarding the UK's gas and electricity security of supply. SSE currently holds around 40% of the UK's conventional underground gas storage capacity. SSE's gas storage assets are well placed to provide this service to energy users. In addition, these assets may also prove useful in the longer term decarbonisation of the energy system, potentially able to be repurposed for other lower carbon gases, such as hydrogen, in the future.

RESILIENCE TO SCENARIOS OVER THE MEDIUM TERM (2023 TO 2030)

The level of policy, market and technology certainty in relation to the medium term is less than is the case for the short term: and SSE itself is advocating policies to enable the UK and Ireland to go further and faster towards decarbonisation. Nevertheless, in the medium term, it is expected that the market for gas-fired generation will evolve as policy, market and technology drivers become increasingly focused on attaining net zero emissions. These decisions will depend on the climate change scenario that plays out. The key differentiator between each scenario is the level at which decarbonisation takes place. This section describes the role that gas will potentially play in each of the three climate scenarios and describes the impact of this role to SSE's gas assets.

NET ZERO SCENARIO

Role of gas

A net zero world involves the elimination of most carbon dioxide emissions in the power sector by 2050, as described by the CCC 2019 net zero report.

There are several power generation technologies which could support a net zero economy in 2050. The CCC report highlights continued growth in the share of renewables but states this needs to be combined with significant volumes of thermal generation (in the form of gas, nuclear or hydrogen).

In their 'Core' and 'Further Ambition' scenarios gas plant, equipped with CCUS plays an increasing role and by 2050 provides almost 25% of electricity demand.

CCC has publicly stated that "carbon capture and storage (CCS) is a necessity, not an option, for reaching net zero emissions".

CCUS could also support the production of hydrogen through reformation of natural gas. This provides an alternative means of low-carbon thermal generation – using hydrogen to fuel CCGTs producing no carbon dioxide emissions at the point of use. Although turbines burning very high levels of hydrogen are not possible with today's technology, all the main Original Equipment Manufacturers (OEMs), have developed a pathway towards a heavy-duty hydrogen turbine for the long term (see Box 6.0 on page 26). Hydrogen could also play a role in the transport, heating and industrial sectors.

In addition to renewables and nuclear, gas generation assets whether equipped with post-combustion CCUS or able to burn hydrogen will continue to play a unique and important role in the system towards and beyond net zero, providing:

- a flexible and efficient energy source, including when renewable energy output is relatively low;
- system stability services to support grid with high penetration of renewables; and
- improved system diversity and security of supply.

These benefits are explored more in Box 1.0.

Box 1.0: Unique features of large scale gas power generation

Large scale highly efficient power generation CCGTs provide electricity systems with several benefits more difficult to deliver by other means. CCGTs are highly controllable, able to run baseload to satisfy the country's power needs as well as over shorter timescales to provide the necessary balance to intermittent renewables. The benefit of this technology is that it delivers high levels of energy security and supports the maintenance of a diverse energy system.

Critical services provided by large scale gas power plant include:
- inertia – reducing the sensitivity of the grid to imbalance;
- frequency response – helping the grid to recover from instability; and
- recovery from blackout – bringing the system back safely from failure.

These services support increased penetration of renewable power sources as well as ensuring the system can continue to operate reliably.

SSE's opportunities and strengths in a net zero scenario

There are two key opportunities for SSE's gas generation business in the medium term in a net zero world:

- **Flexible running of existing and new CCGT gas generation assets:** To provide flexible and secure electricity generation to support increased renewable penetration and system reliability (as described in Box 2.0 in relation to the Ireland grid system). For this opportunity SSE has two very clear roles to play:

  – One that involves the running of existing gas assets up to the end of their expected lives. This has been identified as a priority area by government and regulators in order to deliver ongoing security of supply throughout Great Britain during the 2020s. As coal closes and is replaced by gas the overall carbon intensity of the system will reduce.

  – And two, to build and operate new super-efficient CCGT gas generation assets. SSE is developing a new super-efficient CCGT, Keadby 2, due to be completed by 2022. This new CCGT will have a lower carbon intensity and will be able to respond to a more flexible and changeable energy system. This site is also capable of being upgraded to reduce carbon emissions further through the deployment of CCUS or use of hydrogen, as routes to market develop. SSE has further options for additional super-efficient CCGTs at existing sites and these are well placed for further development if required to support increased electrification and the transition to a low-carbon energy system. SSE will ensure that any new projects will design and build in options for low-carbon technologies (such as CCUS and hydrogen) to support a net zero scenario.

- **Development of low-carbon technology for 2030s and beyond:** At the same time as gas is providing these vital energy and system services, there is a need to develop and roll-out the next generation of low-carbon thermal assets which are a necessity to deliver net zero. The UK Government is encouraging the development of low-carbon industrial clusters with carbon capture, transport and storage infrastructure and/or production of hydrogen. Several of SSE's assets (generation and gas storage) are in or close to these proposed clusters. SSE is monitoring closely the development of CCUS and hydrogen technologies and believes that they present a viable low-carbon pathway for the long term. SSE is engaging constructively in this ongoing development to be well placed to exploit these technologies, whether through low-carbon thermal generating plant or repurposing its gas storage facilities to store hydrogen, when routes to market emerge.

Box 2.0: The role of existing and new CCGTs as intermittent renewables increase in Ireland

For instance, Ireland has set a 2030 target of 70% renewables, meaning that the remainder will need to be delivered from thermal sources. There is a limit to the proportion of non-synchronous plant, such as wind-farms and interconnectors, can provide. This means that synchronous thermal plant will play an important role in both system stability and energy security.

SSE has a number of strengths to enable it to take advantage of the opportunities presented in this scenario, described in the table below.

Strengths

- Fleet of gas plants that provide security of supply and flexibility for the grid supporting increased renewable penetration (see Box 3.0).
- Experienced at constructing and operating new CCGT gas plants.
- SSE's thermal business has a new leadership team with a mandate to explore new low carbon technologies.
- Current portfolio of gas assets that are in areas identified by BEIS as the largest industrial clusters by emissions as part of its 'Industrial Clusters Mission[7]' and sites that are technically suitable for CCUS and/or hydrogen development.
- SSE has strong stakeholder relationships at its existing thermal generation and storage sites.
- SSE has experience of CCUS projects for gas power generation (see Box 4.0).
- SSE has excellent relationships with its suppliers to explore low-carbon technologies like CCUS and hydrogen.
- Optionality of future conversion of new CCGT plants to low-carbon technologies.
- SSE's renewable assets could be used to support production of green hydrogen.

These strengths complement and relate to SSE's wider portfolio of renewable energy capacity, pipeline of renewable energy projects and its transmission and distribution infrastructure assets.

Box 3.0: Revenue Streams for flexible gas-powered generation

There are a number of revenue streams through which power generation stations are remunerated in order for them to provide flexible and reliable electricity to the grid, these involve:

• Energy Market – power stations are paid for the electricity they generate. This is organised through a market structure which allows stations to sell their electricity at various timeframes, right up to a few minutes before real time. The market decides which generators should run based on the prices they bid into the market. Gas stations are relatively flexible so can change their running profile at shorter notice than many others; this equips them to support intermittent renewables by responding quickly to changes in wind generation, and this flexibility allows them to bid into the market accordingly, realising value for the flexibility of their output.

• Capacity Market (CM) – this is designed to ensure security of supply, by providing a payment for reliable sources of capacity to ensure that they deliver energy when needed. Capacity agreements are awarded to generators in an auction process under which generators take on obligations to be available to generate at times of system stress, or else face penalties.

• Ancillary Services – aside from energy, many power stations provide other services to the grid, for example inertia, quicker ramp times, frequency response and black start capability. These services are necessary to ensure grid stability and are paid for by the system operator under a system overseen by the regulator.

Box 4.0: SSE's CCUS experience

SSE has had a long history of development of carbon capture usage and storage (CCUS) technology development. In 2007 SSE partnered with BP to explore the feasibility of an integrated hydrogen station at its Peterhead site in the north of Scotland. More recently in 2014 SSE, together with Shell, reached the final stages of a UK Government competition in which the existing CCGT at Peterhead was to be equipped with post-combustion CCUS. The captured carbon emissions were to be transported to the depleted Goldeneye oil field in the North Sea.

SSE has invested millions over the past 20 years in developing CCUS and this gives us a good platform of experience and skills to support these projects in the future. To become a reality, CCUS will need a sound commercial structure and financial incentives in the UK and SSE is advocating with the UK government to bring forward these measures. Today, as SSE designs new projects it is building in optionality (such as CCUS and hydrogen) for the future.

Risks of a net zero scenario

The principal risks to SSE's gas businesses from a net zero world would involve:

• **Limited running hours for gas and CCGTs to lower carbon emissions:** Increasing renewable penetration will displace the running hours for CCGTs as carbon emitting generation sources are replaced with renewable generation over the medium term. However, it is believed that this risk will be partly offset by growing electricity demand combined with the fact that gas assets will provide flexibility services and that these services will have a greater value in the market.

• **Additional emissions limits are imposed to drive the transition towards decarbonisation:** Emissions limits are being introduced for the Capacity Mechanism; although at this stage SSE's efficient CCGTs are comfortably within these limits. However, there is the risk that emission limits will be tightened over time, and that this would impact value from the CM. SSE's investment in the highest efficiency CCGTs combined with developing options for reducing the carbon intensity even further is a key factor in mitigating this risk.

[7]https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/803086/industrial-clusters-mission-infographic-2019.pdf

NET ZERO (LOW NUCLEAR)

In this scenario, earlier closure of existing nuclear and/or the delay or cancellation of new nuclear generation development results in a lower capacity than that required by FES and CCC in their low-carbon scenarios (ie Two Degrees and net zero). As a result, SSE has assessed the sensitivity of a net zero low nuclear world where the baseload generation expected to be provided by nuclear is replaced with increased gas generation – initially unabated in the medium term, with the longer term moving towards low-carbon gas.

The opportunities therefore are similar for SSE to those detailed above, with the requirement to run flexible gas and super efficiency CCGTs assets to replace the baseload nuclear generation as well as support the increasing volumes of electricity from renewable sources which are variable. The development of new low-carbon technologies (ie hydrogen or CCUS) that will support the move towards net zero up to 2050 are even more important in this scenario.

Therefore, the low nuclear sensitivity plays to SSE's strength in gas generation and renewables.

4 DEGREE SCENARIO

Role of gas

In a 4 degree world, the availability and affordability of gas generation combined with its efficiency mean that it will play a significant role in providing bulk power for longer. Whilst renewables continue to develop at the same pace as today it is projected that this development will slow as progress on decarbonisation slows towards 2050. The role of gas in this scenario is similar to the other scenarios, however, it is unlikely that any abated gas will feature in this scenario.

SSE's opportunities and strengths in a 4 degree scenario

Current gas generation plant and CCGTs have a role to play in a 4 degree world, this includes providing:

- **Flexible lower carbon support to renewables:** Flexible existing assets will support increasing renewables on the grid. Run times will reduce as renewables increase, but flexibility services will have a greater value in the market.

- **New super-efficient CCGTs will displace older assets:** New gas will be required to replace lower efficiency existing CCGTs as they come to the end of their lives. New assets will be super-efficient and have lower carbon intensities. These will be rewarded as outlined above.

This scenario again plays to SSE's strengths in gas generation enabling it to play a role using its diverse portfolio and experience to support the GB and Ireland electricity systems. This, along with other strengths SSE has to enable it to take advantage of the opportunities presented in this scenario are described in the table below.

Strengths
• Fleet of gas plants that provide security of supply and flexibility for the grid. • Experienced at constructing and operating new CCGT gas plants (see Box 5.0). • Strong supply chain relationships to build new CCGT gas plants. • SSE's thermal business has a new leadership team with a mandate to explore new low-carbon technologies. • SSE has strong stakeholder relationships at its existing thermal generation and storage sites. These strengths complement and relate to SSE's wider portfolio of renewable energy capacity, pipeline of renewable energy projects and its transmission and distribution infrastructure assets.

Box 5.0: Super efficient CCGTs

SSE is currently investing £350m in state-of-the-art technology for its new power station at Keadby.

The project, known as Keadby 2, follows the formation of a unique partnership with industry-leading technology provider, Siemens. The CCGT power station will use first of its kind, high efficiency gas-fired generation technology, making the new power station the most efficient on the UK power system.

The station will be hydrogen and carbon capture ready and able to deploy these technologies once a route to market becomes available. The decision to invest in Keadby 2, with its high thermal efficiency, is compatible with SSE's new ambition to achieve a further 50% reduction in the carbon intensity of electricity it generates, to around 150gCO_2/kWh. Keadby 2 is also expected to reduce carbon emissions for the overall GB electricity system by reducing the need for older, lower efficiency CCGTs as well as single cycle thermal generators, all of which produce higher carbon emissions when running.

RESILIENCE TO SCENARIOS OVER THE LONG TERM (2031 TO 2050)

The period from 2031 to 2050, is clearly the period where there is far less clarity or certainty. There is the understanding by both the CCC and FES that gas assets will be critical to the future energy system – whether this is decarbonised or not. However, it is less clear on the speed and trajectory of technologies that will be present in this timeframe.

Nevertheless, it is possible for SSE to understand and consider a number of permutations of both opportunities and threats it may face in that period.

SSE has gas assets that are geographically spread and that are situated in areas that are suited to low-carbon development or the support of high renewable power generation. It is expected that these businesses will be able to respond to the opportunities that the decarbonisation agenda brings at the same time as making an important contribution to reducing carbon emissions.

NET ZERO SCENARIO

SSE's opportunities and strengths in a net zero scenario

In a high ambition world it is well understood that the high penetration of renewables will require flexible and firm generation to support the grid. As detailed in the previous section this can be provided by a variety of technologies including abated gas, hydrogen and nuclear. In addition to this, the demand for electricity will have changed as the population and income grows and the heat and transport sectors electrify or switch to low-carbon fuels. It is likely that electricity demand will rise in the long term. As a result, there are a number of opportunities for SSE in this high ambition world including:

- **Development and operation of low-carbon technologies at scale throughout the 2030s and beyond:** new low-carbon technologies will need to be built at scale. SSE is in a good position to support this. SSE has the gas generation and storage asset infrastructure in the right places to be developed at scale once supporting policy is implemented and is committed to supporting and developing options in the future. Furthermore, the potential of electrolysis and green hydrogen gives a clear opportunity for SSE's renewable fleet to produce this zero carbon fuel during times of excess wind.

- **Decarbonisation of existing super-efficient CCGTs:** SSE's current CCGT technology is well placed to take advantage of any potential policy or market changes that encourage decarbonisation of CCGTs. The potential for SSE's new CCGT at Keadby to be fitted with CCUS or to be hydrogen-powered is discussed above, and this is a capability SSE will design in to any of its new developments. SSE has strong relationships with the Original Equipment Manufacturers (OEMs) to develop and build future CCGTs that are future proofed for a low-carbon economy (see Box 6.0).

Box 6.0: Working with Siemens to develop low-carbon technologies

SSE is currently working with leading OEM Siemens to build one of the most efficient CCGT power stations in the world at our site in Keadby, Lincolnshire, with technology optimised for future hydrogen and CCUS capability. In January 2019, Siemens, along with industry body EU Turbines, committed to gradually increasing the hydrogen-burning capability of gas turbines to at least 20% by 2020, and 100% by 2030. SSE and Siemens share a commitment to a net zero future. Through this industry-leading partnership, SSE is exploring opportunities to decarbonise its existing CCGTs and develop new power stations capable of operating with hydrogen, or fitted with emerging CCUS technology.

This scenario again plays to SSE's strengths in gas generation enabling it to play a role using its diverse portfolio and experience to support the GB and Ireland electricity systems. This, along with other strengths SSE has to enable it to take advantage of the opportunities presented in this scenario are described in the table below.

Strengths

In addition to its renewable (wind and hydro), CCGT, transmission and distribution assets and project experience, SSE's:

- Current portfolio of assets that are in areas identified by BEIS as the largest industrial clusters by emissions as part of its 'Industrial Clusters Mission[8]' and sites that are technically suitable for CCUS and hydrogen development.
- Has strong stakeholder relationships at its existing thermal generation and storage sites.
- Has experience of CCUS projects for gas power generation.
- Gas storage assets that could be used to store hydrogen
- Has excellent relationships with OEMs to develop low-carbon technology at scale from 2030 onwards.
- Is well placed to take advantage of the emergence of green hydrogen through electrolysis.

Risks of a net zero scenario

The net zero scenario represents an ongoing and significant transformation of the electricity industry in GB. This scale of change poses challenges to SSE and the industry as a whole with potential longer term risks to SSE's business identified below:

- **Stretching climate change policy results in the closure of unabated gas assets in the approach to 2050:** In the approach to 2050, retro-fit of existing assets may prove to be prohibitively expensive in the context of their remaining life expectancy. There could therefore be curtailment of generation and a shortening of asset lives as an increasing proportion of demand is met by abated thermal plant. Ensuring SSE's assets are as efficient and flexible as possible will mitigate this risk, and that any new assets have a clear route to decarbonise, protecting profitability for as long as possible.

- **Growth and scalability of low-carbon thermal technologies is unviable:** Current expectations are that the achievement of net zero requires the build out of large volumes of gas with CCUS or hydrogen power generation. There is an underlying threat of new and emerging technologies providing an alternative pathway to net zero. The risk to SSE is that it will not be able to realise the opportunities detailed in this report in relation to the role of gas in the transition to a low-carbon economy and its future growth and scalability, though this is mitigated by the Group's investment opportunities across the value chain.

NET ZERO (LOW NUCLEAR) SCENARIO

The low nuclear sensitivity plays to SSE's strength in gas generation and renewables. Increased renewables output should be needed to compensate for the lack of nuclear output. Gas generation should be needed in some form to provide security of supply. The level to which type of fuel in the generation mix plays out would depend on the technology available and SSE has the flexibility to respond to each of variety of options available.

4 DEGREE SCENARIO

This scenario plays to SSE's strengths in gas generation and renewables development. SSE's portfolio of super-efficient gas assets would continue to play a role providing a flexible option to support renewables.

The key risks to the business of ending in the four degree scenario are:

- **Reduced growth in overall demand for electricity:** The lack of impetus behind electrification in the heating and transport sectors sees demand for electricity grow more modestly. This creates less opportunity for SSE to grow its gas asset base, though its super efficient assets will be well placed to compete in this market.

- **Displacement of gas generation by continued renewable growth:** The continuation of renewable build out in this scenario displaces gas generation further exacerbating the problem described above. In this scenario, the continued growth of renewables does present opportunities for the SSE Group.

[8]https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/803086/industrial-clusters-mission-infographic-2019.pdf

CONCLUSION

The National Grid's FES and CCC reports both show a clear role for gas in all the scenarios that they describe. Each scenario shows that gas generation whether it is unabated, equipped with CCUS or burns hydrogen will continue to provide a unique and important role in the UK and Ireland systems in the short, medium and long term. Fundamentally, this role is to provide:

- a flexible and efficient energy source when renewable energy output is low;
- system stability services to support grid with high penetration of renewables; and,
- improved system diversity and security of supply.

It is assumed that in all scenarios that the role of gas will be rewarded for these services and that these services will be increasingly valuable as the energy system has a higher proportion of intermittent generation.

The question is which scenario will play out, and whether new low-carbon gas generation technologies will be developed in the medium term if the market and policy conditions are correct. The long term is uncertain, however, SSE has options available dependent on which technology develops to support the decarbonisation trajectory of that scenario.

Overall, SSE is in a good position to adapt its portfolio to these different scenarios, with its assets able to respond to opportunities to be part of innovative new low-carbon technology developments as they develop.

APPENDIX 1

CORE ASSUMPTIONS FOR EACH SCENARIO

The scenarios outlined on pages 10 and 11 assume the following levels of electricity demand, generation output and decarbonisation for GB outlined in Table 2.

For Ireland, there is the assumption that the renewable target for 2030 of 70% is achieved and that beyond this Ireland moves towards a net-zero carbon emissions position. This assumes that gas (with or without CCUS depending on the scenario) will be a key feature of the electricity system up to and beyond 2050.

Table 2: Assumptions underpinning each scenario in GB

			2050		
	Units	2018 (baseline year)	4 degree	Net zero	Net zero (low nuclear)
Electricity					
Annual demand	TWh	317.5	375.0	632	632
Annual output	TWh	323.9	382.9	645	645
Gas generation	TWh	122.9	37.5	0.0	0.0
Coal generation	TWh	10.1	0.0	0.0	0.0
CCUS	TWh	0.0	0.0	148	191
Hydro	TWh	5.6	6.6	7.0	7.0
Wind (onshore and offshore)	TWh	55.6	193.6	369	369
Nuclear	TWh	58.0	66.3	69	26.4
other	TWh	71.7	78.9	51	51
Peak Demand	GW	59.6	74.9	Up to 150GW	Up to 150GW
Total installed capacity	GW	100.7	138.7	> 200GW	> 200GW
Low-carbon capacity	GW	52.2	99.0	> 200GW	> 200GW
Low-carbon capacity	%	52%	71%	100%	100%
Carbon emissions	%		56%	Close to 0%	Close to 0%

This data is derived from National Grid's Future Energy Scenarios July 2019 report and the Committee on Climate Change's Net Zero Technical Report. The 4 degree scenario is based on the FES scenario 'Steady Progress'. For the 1.5 degree scenario SSE has taken the CCC net zero scenario as a basis and estimated implications for capacity. For the nuclear sensitivity SSE assumes new nuclear is replaced by further gas CCUS capacity.

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