POST-PARIS

Understanding SSE's long term resilience against different carbon reduction scenarios following the Paris Agreement

About SSE

SSE is a UK-listed energy company focused on the energy markets in the UK and Ireland. Its core purpose is to provide the energy people need in a reliable and sustainable way. To deliver this, SSE is involved in the generation, transmission, distribution and supply of electricity; in the production, storage, distribution and supply of gas; and in other energy related services.

About this report

This report represents a first attempt by SSE to assess and disclose its resilience to different pathways to decarbonising the energy industry in Great Britain. It analyses the impact of three scenarios of increased global temperatures on SSE's business, based on the outcome of the Paris Agreement. The first is a 2°C increase above pre-industrial levels ('Gone Green'), the second is a 1.5°C increase ('Super Green') and the third is a 3-4°C increase ('No Progress').

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Executive summary

This report has been prepared by SSE in response to requests from institutional investors for additional disclosure relating to climate change risks and opportunities – how they are identified and how they are managed. SSE welcomes this focus from investors and seeks to work closely with them and other stakeholders to ensure its business is resilient to policy and market changes that may result from national and international carbon reduction ambitions.

SSE recognises that there are business risks associated with a failure, both nationally and internationally, to meet stated carbon reduction ambitions. If failure becomes apparent in the medium term, the likelihood of a less orderly policy and market response may in itself pose further business risks.

Against this background, the objective of this report is to set out SSE's existing business model and its resilience to three core scenarios, and provide a basis for ongoing stakeholder feedback and comment:

- Gone Green: a scenario where Great Britain (GB) contributes its share of carbon reduction to limiting global temperature rises to 2°C;
- Super Green: a scenario where it contributes to a 1.5°C scenario; and
- No Progress: a business as usual scenario where emissions would be in line with a 3-4°C warming scenario.

It was also considered to be prudent to undertake a sensitivity analysis of low nuclear versions of each of these three scenarios.

The report shows the possible events that may take place if each scenario plays out and how SSE may respond to each of them. It finds that SSE's current mix of economically regulated and market based businesses make, and will continue to make, an important contribution to the transition to a low carbon electricity system across GB.

SSE is also in a strong position to respond to a scenario in which the transition does not follow the path detailed by United Nations Framework Convention on Climate Change (UNFCCC) or the Climate Change Act 2008.

It is notable that the report concludes that SSE's existing business model stands up well to all of the scenarios considered. The combination, and balanced range, of valuable distribution, transmission and generating assets are found to be vital to GB's electricity system over the long term and in every scenario. The report also finds that the optionality SSE has within its development pipeline puts it in an advantageous place to respond to new opportunities that climate change mitigation might bring.

In other words, the report concludes that SSE's existing, resilient, portfolio of assets can respond to the various scenarios assessed; and its diverse range of future development options provide many potential opportunities for the future..

SSE has long argued that the existence of a carbon price that properly and accurately reflects the true cost of carbon should be at the heart of frameworks to deliver a secure, low carbon electricity system. SSE will therefore continue to work with investors and other stakeholders to make the case for enhanced policy and market signals that will create an economic environment for the most cost effective transition to a secure, low carbon electricity system in GB.

This report represents a first attempt by SSE to properly assess and disclose its resilience to different pathways to decarbonising the energy industry in the Great Britain; and because it is a first attempt, SSE is very keen to receive feedback from interested parties on the content of the report, with a view to undertaking further analysis and disclosures in the years to come. Comments should be emailed to sustainability@sse.com.

1.0 Introduction and context

The political and market environment in which SSE operates influences the action it takes in moving towards a low carbon electricity system. Now, with agreement on the scale of the action required, there is increasing attention from investors who want to understand how SSE is able to respond to these changes.

The Global and UK context

At the 2015 United Nations Climate Change Conference in Paris, the international community committed to a new universally applicable climate agreement, effective from 2020. The Paris Agreement aims to keep greenhouse gas (GHG) emission reductions to levels that are designed to ensure global average temperature changes stay within 2.7-3°C of pre-industrial levels, with the long term objective of temperatures "well below 2°C", aiming towards 1.5°C.

In the UK, the Climate Change Act 2008 establishes a unilateral carbon reduction target of 80% by 2050 on 1990 levels. In June 2016, the UK Government accepted the advice of the Committee on Climate Change to set the fifth carbon budget which aims to reduce UK GHG emissions in 2030 by 57% relative to 1990.

Increasing investor scrutiny

The Paris Agreement on climate change is proving to be a pivotal moment in stimulating additional investor interest into company strategies for managing climate change risks and opportunities. Given the risk of climate change, investors want to understand how companies are developing and adopting strategies for resilience at a 2°C or <2°C warming scenario. In particular, the Institutional Investors Group on Climate Change (IIGCC) coalition is engaging with utility companies. As part of this engagement work, SSE has been working closely with the IIGCC coalition to understand the resilience of its business to market and policy changes that may result from international and national carbon reduction ambitions.

In addition to this increasing investor interest, in December 2015, Mark Carney as Chair of the Financial Stability Board (FSB), convened the Task Force on Climate-related Financial Disclosures to address concerns by G20 Finance Ministers and Central Bank Governors that without sufficient information, financial market participants were unable to analyse and price in climate risks. The Task Force aimed to develop recommendations on climate disclosure for companies and investors that would firstly promote better informed investment lending and insurance underwriting decisions and secondly enable stakeholders to understand the financial system's concentrations of exposure to climate risks. The industry-led Task Force developed a set of recommendations on climate disclosure which emphasised financial disclosure as well as the use of scenario analysis and the disclosure of its results.

These recommendations published in December 2016 are closely related to the work being undertaken by SSE's investors, including participants in the IIGCC as well as other climate reporting activities by CDP (formerly Carbon Disclosure Project), Climate Disclosure Standards Board (CDSB), World Resources Institute (WRI) and World Business Council for Sustainable Development (WBCSD).

SSE's sustainability business strategy

SSE's strategy is to support transition to a low carbon electricity system by reducing the carbon intensity of the electricity it generates, at the same time as building, strengthening and re-enforcing an electricity grid in the north of Scotland that transmits renewable sources of energy to the population centres where demand must be met.

To bring about this change SSE has:

- invested significantly in renewable energy, over £3.2bn since April 2010, and has one of the largest renewable energy capacities in the UK and Ireland at over 3,300MW (including pumped storage);
- transitioned away from coal generation, with the closure of Ferrybridge power station, and reduced its carbon intensity (in 2016/17 coal output contributed 3.4% of total generation output , compared to 22% in 2015/16); and
- enabled more renewable generation to connect to the electricity transmission network by investing close to £1.9bn in new electricity infrastructure since the RIIO T1 price control began in 2013.

By doing this, SSE is undertaking its own, and supporting a wider, strategic shift away from the most carbon intensive fossil fuel generation towards electricity generation from renewable sources. At its core is a long-standing commitment to reduce the carbon intensity of its electricity generation by 50% by 2020, using 2006 performance as its baseline. SSE's performance in managing climate change impacts has led CDP to award SSE an A- in 2016 and include it in the global Climate Disclosure Leadership Index.

As a result of its long term commitment to contribute to the management of climate change, SSE welcomed the challenge by investors to review the business portfolio against a series of climate change scenarios and report this publicly to its stakeholders.

Aim

Therefore, this paper aims to:

1. Stress test SSE's business against climate change scenarios of 2°C and 1.5°C warming scenarios, a business as usual scenario where the UK fails to meet its contribution to international climate change targets, and low nuclear versions of each of these three scenarios; and
2. Describe how SSE's business model is resilient to each of these scenarios.

The objective is to communicate the findings of this analysis to investors and wider stakeholders.

Scope

This report focuses on the material parts of SSE's business that are at most risk from the impact of market and policy changes associated with carbon reduction ambitions: SSE's Wholesale, Transmission and Distribution businesses.

This scope also reflects investor requests that the scenario tests should consider impacts other than simply SSE's electricity generation business, in particular the long term future of SSE's transmission assets.

With activity in GB accounting for over 90% of SSE's group enterprise value, this report will consider the market context in GB only, but may refer to SSE generation capacity and output as a whole, including its Irish businesses. This report focusses on electricity generation, transmission and distrbution meaning that SSE's interests in gas distribution, gas storage and gas production are not included.

2.0 Building the scenarios

Three scenarios were established by using publicly available data from National Grid's Future Energy Scenarios. These scenarios have taken account of the whole energy system (electricity, heat and transport) to allow an understanding of what will feature in the GB generation portfolio to meet demand and how transmission and distribution will respond to the changes in demand and supply to deliver the different scenario end points. For all of these scenarios National Grid forecasts its figures to 2040 and SSE has projected these figures out to 2050 using the same assumptions. In all of this, it needs to be borne in mind that policy and market signals will have a major impact on what electricity infrastructure is retained and developed in the future.

The scenarios that were assessed are:

Gone Green

This scenario assumes that GB will decarbonise in line with the Climate Change Act, with total carbon emissions falling from around 450MtCO2e/year to around 100MtCO2e/year between 2015 and 2050, and that the 2°C temperature scenario will be reached by 2100. The scenario assumes that there will be high income growth and population growth, with the resulting energy consumption being partly offset by further energy efficiency improvements. There will be no coal beyond 2020; renewables will provide 33% of electricity supplied by 2020 and around 41% by 2040, with three new nuclear power plants coming online in the 2020s followed by further build-out in the 2030s. Carbon capture and storage (CCS) will be available from 2029 on gas-fired power stations and there will be a programme of new gas-fired power stations with CCS technology to provide flexibility and security of supply. CCS gas generation will make up around 17% of electricity supplied in 2040, with unabated gas power stations contributing less than 6% by this time as they increasingly exit the system. Carbon and gas prices will be very high favouring new renewables, such as tidal, and low carbon enabling technologies, such as battery storage and hydrogen, from the 2040s.

Super Green

This scenario assumes that GB will decarbonise ten years in advance of the Gone Green scenario and that total carbon emissions will fall from around 450MtCO2e/year to 50MtCO2e/year between 2015 and 2050, and that the 1.5°C temperature scenario will be reached by 2100. It is widely understood that this will be an extremely challenging target to meet. This scenario assumes there will be high income growth and population growth which will be partly offset by further energy efficiency improvements. There will be no coal beyond 2020; renewables will provide 50% of electricity supplied by 2030, falling to 37% by 2040 due to high penetration of new nuclear capacity. CCS will be available from 2025 on gas-fired power stations, which will contribute 19% of supplied electricity in 2040. Carbon and gas prices will be very high favouring new renewables, such as tidal, and low carbon enabling technologies, such as battery storage and hydrogen, from the 2030s.

No Progress

This scenario is viewed as a credible, business as usual scenario which assumes decarbonisation continues up to 2030 and that total carbon emissions fall from around 450MtCO2e/year to 340MtCO2e/year between 2015 and 2050, consistent with 4°C warming by 2100. Renewables will provide 29% of the supplied electricity by 2030 as a result of historic and current investment in low carbon generation, reaching 34% of supplied electricity in 2040. This limited growth is due to a lack of further investment in these technologies beyond 2030 in GB. Instead, gas remains the main electricity source, supplying around 35% of the mix by 2030 and around 41% by 2040. There is no development of CCS technology or low carbon enabling technologies (such as battery storage and hydrogen) because policy and market conditions do not provide sufficient incentives for low carbon technology. Gas prices are competitive and electricity demand is stagnant because gas remains a key heat and transport source and economic growth is low. There is no new nuclear except Hinkley Point C in the 2020s and around two or three new nuclear developments are built in the 2030s.

For further detail on each scenario, see Appendix 1.

Nuclear sensitivity analysis

While the focus of this report is SSE's resilience to different degrees of decarbonisation, it is considered prudent to undertake a sensitivity analysis of one particular feature of that decarbonisation: the extent to which nuclear power contributes to GB's generation fleet. In a case where the GB's electricity generation mix would not have any new nuclear beyond 2030, it is assumed that this baseload would be replaced by a

combination of wind and gas. The rate of decarbonisation would remain at the same levels described above, however instead of nuclear providing a decarbonisation option this would be replaced by renewables and gas with CCS (Gone Green and Super Green) and gas (No Progress).

Core assumptions for each scenario

Table 1 outlines the assumed levels of electricity demand, generation output and decarbonisation, as a result of the trends and characteristics of each scenario.

Table 1: assumptions* underpinning each GB scenario

	Units	2015 (baseline year)	Super Green 2040	Gone Green 2040	No progress 2040
Electricity					
Annual demand	TWh	334	380	384	331
Annual Output	TWh	342	585	465	352
Gas generation	TWh	112	1	26	138
Coal generation	TWh	58	0	0	0
CCS	TWh	0	122	80	0
Hydro	TWh	5	6	6	5
Wind (onshore and offshore)	TWh	37	148	99	80
Nuclear	TWh	62	195	119	31
Storage	TWh	3	11	10	3
Other renewables	TWh	41	61	87	35
Net Imports	TWh	24	41	38	60
Total installed capacity	GW	97	207	187	108
Low carbon capacity	GW	39	149	132	44
Interconnector capacity	GW	4	23	23	14
Total storage capacity	GW	3	14	11	4
Decarbonisation					
Renewable energy	% output	24	37	41	34
Reduction in carbon emissions from electricity generation vs 2010	%	37	99	93	68
Carbon intensity	gCO_2e/kWh	290	2	24	142
Carbon emissions from electricity generation	$MtCO_2e$/ year	96	1	11	50
Total GB Carbon emissions	$MtCO_2e$/ year	443	105	175	348

* This data is derived from National Grid's Future Energy Scenarios 2016 report for the 2015 baseline, Gone Green 2040 and No Progress 2040. The Super Green 2040 scenario uses the Gone Green scenario projected out to 2050, and projects out that decarbonisation will be accelerated by ten years in the Super Green scenario in order to achieve the 1.5°C warming scenario.

3.0 SSE electricity generation

3.1 2010-2020

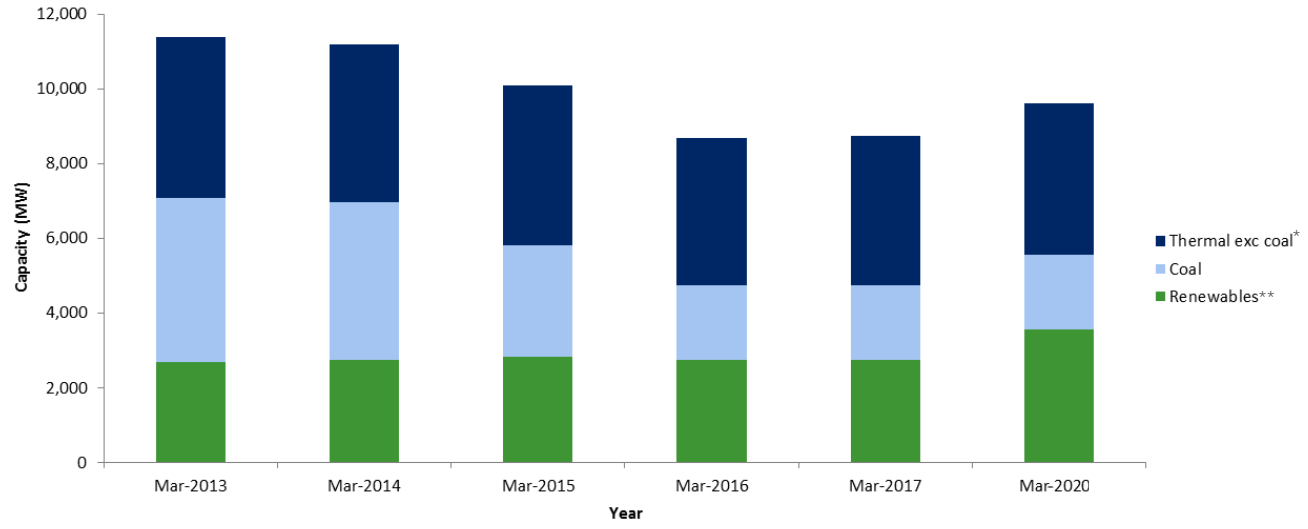
In the short term, it is possible to estimate the ongoing decarbonisation of SSE's electricity generation portfolio with a high degree of confidence. SSE's current investment cycle is defined as being between 2016 and 2020, with a target capital investment of £6bn over those years with around £5bn already committed. Around two-thirds of this investment is likely to be in either electricity networks or in renewable energy.

SSE's generation capacity and output

The capacity and output of SSE's generation portfolio for the last five years is outlined in Graph 1 and Graph 2 below.

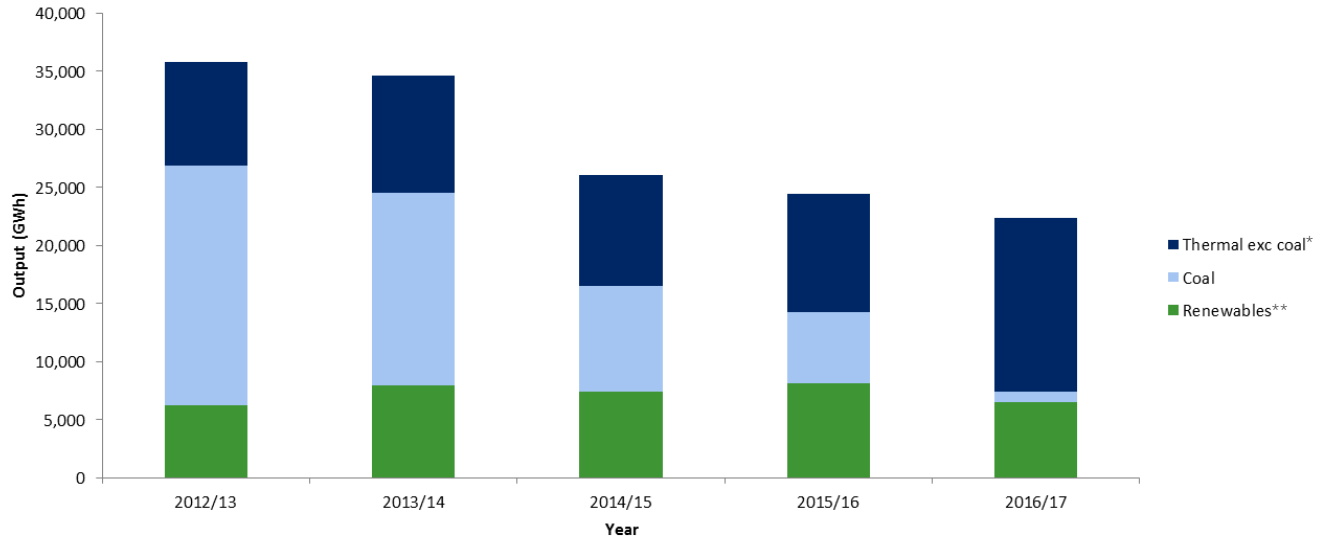
SSE's expected GB generation mix by March 2020, based on wholly owned plant and SSE's share of joint ventures is outlined in Graph 1. This also includes SSE's ownership share of projects currently in construction for onshore and offshore wind and multifuel.

Graph 1: SSE GB generation capacity (MW)



* Thermal non-coal is mainly gas-fired CCGT's with c.150MW of island diesel generation and up to 70MW of multifuel generation.
** Renewables includes hydro, on and offshore wind, biomass, anerobic digestion and pumped storage.

Graph 2: SSE GB generation output (GWh)



* Thermal non-coal is mainly gas-fired CCGT's with c.150MW of island diesel generation and up to 70MW of multifuel generation.
** Renewables includes hydro, on and offshore wind, biomass, anerobic digestion and pumped storage.

SSE's projected generation output from coal at Fiddlers Ferry is expected to continue to decline towards 2020 and depending on economic conditions, primarily provide backup generation and security of supply support. This will also be influenced by whether Fiddlers Ferry secures any contracts in the next rounds of the Capacity Auction. SSE's coal-fired power station, Ferrybridge (1,995MW) ceased generation on 31 March 2016 and Uskmouth (360MW coal-fired) was sold in 2014.

SSE's renewable generation output (including Ireland) is expected to grow from around 8,500GWh per annum in a typical year to over 11,000GWh, as its 1GW of onshore and offshore wind farms that are currently in construction come into operation in the years up to 2020.

SSE will continue to provide flexible gas-fired generation to support security of supply and complement variable renewable output which is supplied mainly from SSE's fleet of CCGTs (3.7GW).

SSE's carbon emissions from electricity generation between 2006 and 2017

As coal generation is, in due course, expected to come to an end and its output substituted with less carbon intensive sources, carbon emissions from the SSE portfolio are expected to remain around similar levels achieved in 2016/17, if not lower. Between 2006 and 2017, SSE's carbon emissions from its generation in GB have fallen by around 70% due to the switch from a generation mix weighted towards coal and gas to one weighted towards gas and renewables. SSE's carbon emissions for GB generation output between 2006 and 2017 are outlined in Table 2.

Table 2: SSE's carbon emissions for GB generation output

Year	2006/07	2012/13	2013/14	2014/15	2015/16	2016/17
SSE's carbon emissions from GB generation output ($ktCO_2e$)	25,210	24,297	20,634	12,958	10,392	7,076
SSE's carbon intensity from GB generation output (gCO_2e/kWh)	622	683	589	497	425	316
Average grid intensity in GB (gCO_2e/kWh)	473	445	445	494	290	267

The GB electricity grid in the Gone Green scenario will be at 113gCO_2e/kWh in 2020 (37gCO_2e/kWh in 2030) and No Progress will be at 245gCO_2e/kWh in 2020 (152gCO_2e/kWh in 2030). The potential reduction in SSE's carbon intensity is driven by the continued change in the fuel mix with lower carbon sources replacing higher carbon emitting power generation output. This is evidenced through the change in SSE's generation capacity mix between 2017 and 2020 during which time over 1GW of onshore and offshore wind capacity is due to come on line.

The National Grid Future Energy Scenarios take account of UK Government stated decarbonisation targets and assume that for all scenarios there is a requirement for gas from both conventional gas plant (in the 2020s) and new build (beyond 2030). The level of the gas requirement depends on: the investments made in new renewables beyond 2020 as well as the development of CCS technology from 2029; the competitiveness of other sources of flexibility, such as storage; and imports via interconnectors. However, it is assumed by National Grid that gas (or gas with CCS) will be used for balancing the grid as a flexible technology and for security of supply in all scenarios.

3.2 2020-2030

In 2009, in light of the UK's Climate Change Act 2008, SSE set itself a clear and simple target to halve the carbon intensity of its electricity generation from 2006 data by 2020. This target could be set with reasonable confidence because the framework for remunerating renewable energy, particularly through the ROC regime, was clear. The increase in renewable generation output and capacity are clearly demonstrated in Graphs 1 and 2. In addition, the importance of reliable, flexible gas-fired generation, partly due to varying weather conditions leading to lower renewable output, can be seen in SSE generation output in 2016/17.

The level of policy certainty is not as clear through the 2020s. Nevertheless, SSE strongly believes the country requires the continued expansion of its lower carbon energy generation capability and SSE has a pipeline of potential projects it could deliver in order to support any UK wide ambition. All projects are subject to varying degrees of further development and final investment decisions and would require the right economic conditions to progress. For example, the offshore projects will require some sort of incentive such as a Contract for Difference (CfD) which is yet to be agreed. SSE's pipeline of potential GB generation developments includes the projects outlined in Table 3.

Table 3: Pipeline of potential SSE Generation projects in GB

Project	Technology	Total Expected Capacity (MW)	Status	SSE ownership (%)
Dogger Bank	Offshore wind	Up to 4,800	Consents for 2 phases gained with a total of 4 x 1,200MW projects.	37.5
Firth of Forth/ Seagreen	Offshore wind	Phase 1 up to 1,050	In appeal for two projects up to 525MW each.	50
Abernedd	Gas-fired power station	870	870MW CCGT consented, with application being processed to enable either a 870MW CCGT or a 299MW OCGT to be deployed at Abernedd.	100
Keadby Power station (2)	Gas-fired power station	820	Consented.	100
Coire Glas	Pumped storage	Up to 600	Consented.	100
Viking	Onshore wind	Up to 370	Consented.	50
Strathy South	Onshore wind	Up to 133	Awaiting consent decision from Scottish Government following public enquiry in 2015.	100
Hadyard Hill Extension	Onshore wind	Up to 88	Currently in planning regime.	100
Gordonbush Extension	Onshore wind	Up to 56	Awaiting consent decision from Scottish Government.	100
Tangy III	Onshore wind	Up to 34.5	Consented.	100
Slough Multifuel	Multifuel	50	Consented.	100

This pipeline is a deliberate mix of renewable projects of varying scale: from the strategically significant offshore wind projects like Dogger Bank to the incremental development of existing onshore wind sites.

There is also the opportunity to extend the life of existing onshore and hydro sites or repower them completely with new turbines which could increase their capacity and output.

Based on the premise that as GB's reliance on intermittent wind energy grows, the requirement for highly efficient and flexible generation also grows. Therefore this pipeline is balanced, including both new gas-fired generation and a potential new, large scale, pumped storage asset in the north of Scotland.

4.0 Scottish and Southern Electricity Networks

In addition to its portfolio of electricity generating assets, SSE is the sole-owner of three economically-regulated electricity network licensees that are jointly operated under the brand of Scottish and Southern Electricity Networks (SSEN). The three networks are:

1. Scottish Hydro Electric Transmission plc (SHE Transmission) which owns the high voltage network in the north of Scotland.
2. Scottish Hydro Electric Power Distribution plc (SHEPD) which owns the low voltage network in the north of Scotland.
3. Southern Electric Power Distribution (SEPD) which owns the low voltage network in central southern England.

Taken together, the combined regulated asset value of the three networks is around £6bn. SSE has owned these networks since privatisation and has a strong track record of investment to meet the changing demands of customers, including in recent years the connection of low carbon generation.

4.1 Maintaining and investing in networks

Between 2005 and 2015, the capacity of low carbon generation that has connected to SSE's electricity networks in the north of Scotland increased significantly. Table 4 outlines the scale of the additional generation each year. This covers a diverse range of low carbon technologies including onshore and offshore wind, solar, hydro, tidal and biomass but demonstrates the overwhelming dominance of onshore wind.

Table 4: annual volume of total generation capacity added to the transmission network and embedded generation added to the distribution network in the north of Scotland (MW), 2005-2015

Technology	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	Total
Onshore wind	70.8	169.9	99.1	71.1	346.4	128.4	463.1	222.1	455.1	114.2	265.6	**2,406**
Hydro	1.3	0.1	6.7	105.7	6.6	9.6	18.0	19.4	7.4	18.3	27.2	**220**
Solar PV	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.1	0.6	1.1	20.1	**22**
Tidal	0.0	0.0	4.0	0.0	0.0	0.0	0.0	0.0	14.9	0.5	0.0	**19**
Biomass	0.5	1.0	0.0	0.0	7.0	0.0	8.0	0.0	0.0	0.0	0.0	**17**
Biogas	0.3	0.3	1.0	1.2	1.1	0.0	0.8	0.0	0.0	0.4	0.0	**5**
Biodiesel	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.5	**1**
CHP	0.1	0.2	3.0	0.0	0.0	0.3	0.9	0.0	0.2	0.0	9.9	**15**
Other	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.0	0.0	0.8	1.0	**4**

Electricity networks are regionally-defined businesses that operate under licence governed by statute. The Electricity Act 1989 places obligations on licenced networks to make timely offers to connect new generation and to maintain security of supply to customers. As a consequence, all three of SSE's networks have forward business plans that accommodate the range of climate change scenarios. Strong and stable economic regulation, governed by the independent industry regulator Ofgem, both incentivises network licensees to take action to invest for changing network use and ensures that the companies can achieve reasonable returns for efficient investment and operation. This regulatory framework, called the RIIO model of price control regulation, provides a stable platform to manage uncertainty.

For the remainder of the RIIO T1 price control, SHE Transmission is forecast to grow its asset base, largely through investment in new transmission infrastructure to accommodate the connection of low carbon generation. Since the start of the RIIO T1 price control in 2013, SHE Transmission's capital investment in its transmission network has totalled close to £1.9bn, with around a further £800m planned by March 2021. This investment is a combination of new build local connections, new build or upgraded shared infrastructure and three major strategic infrastructure investments (the Beauly Denny overhead line, the Kintyre Hunterston subsea cable and the Caithness Moray HVDC project).

SHE Transmission also has an active portfolio of future network investments that are in development. Table 5 provides examples of these projects, along with examples of completed and ongoing projects. The lead time for taking a project into construction can be over five years, hence the objective of this development work is to ensure that SHE Transmission is in a position to begin construction when the need is demonstrated and the necessary approvals confirmed. The suite of development projects has been identified through a combination of known planned generation schemes along with scenario planning for the period to 2030.

Table 5: examples of completed, ongoing and potential future major capex projects (subject to Ofgem approval) in the north of Scotland, 2013-2021

Generation connections projects	Connection year	Capacity rating (MW)
Berry Burn	13/14	72.5
Clashindarroch	14/15	37
A'Cruach	15/16	49.9
Dunmaglass	16/17	94
Aberdeen Offshore	17/18	99
Dorenell	18/19	220
Stronelairg	19/20	227
Meygen	20/21	15

Infrastructure works projects	Connection year	Rating (MVA)
Foyers Knocknagael	15/16	470
Fort Augustus	16/17	240
Kintyre Dyce	17/18	43
Beauly Tomatin	18/19	782
Keith Blackhillock	20/21	960

* MVA is the volt-ampere rating which takes into account both the current and voltage performance of the infrastructure works.

In the period between 2015 and 2023, the distribution price control (RIIO ED1) period, SSEN's two electricity distribution networks are forecast to invest around £1.5bn in maintenance and growth. Much of the growth has been driven by the need to connect low carbon generation. For SHEPD this is predominately hydro and wind and for SEPD this is predominantly solar. Looking forward, future investment is also expected to accommodate storage technologies and changes in the transport infrastructure.

4.2 Innovating to support change

A significant factor in SSEN's approach to managing the uncertainty of climate change scenarios is innovation to meet future challenges. Such innovation can take many forms, incorporating commercial, technological and operational approaches and two key approaches are:

1. The identification and deployment of new technology. An example being SHE Transmission using Aluminium Conductor Composite Core (ACCC) Monte Carlo conductor and composite pole technology in order to speed up the delivery of connections mainly for new low carbon generation. We see this as a economic and sustainable way to increase generation capacity with reducing the need for additional costly infrastructure.

2. The development of new business models, in particular the transition in electricity distribution from a passive Distribution Network Owner (DNO) to an active Distribution System Operator (DSO). SSEN has a suite of innovation projects and trials to assess the opportunities, risks and technical requirements of making this transition. Table 6 describes some of the key projects implemented by SSEN which will help it deliver improved flexibility and responsiveness across its power networks.

Table 6: key projects to assess opportunities, risks and technical requirements of transitioning from passive DNO to active DSO

Project	Project details	Project outcomes
New Thames Valley Vision (NTVV)	This project trialled new technologies and practices to develop sophisticated modelling to improve the operation and planning of the network.	By using these systems expensive network reinforcement is avoided.
Northern Isles New Energy Solutions (NINES)	This project which took place in Shetland, deployed large and small scale energy storage solutions with a new monitoring and control system to enable more active network management.	This enabled a 200% increase in renewable energy output on Shetland by helping to manage grid constraints more efficiently.
My Electric Avenue	This project was a partnership between SSEN and EA Technology. It reviewed the impact of Electric Vehicles (EVs) on the distribution network. The project found that clusters of EVs may put strain on the existing network in the 2020s and if mass uptake occurs then reinforcement of the transmission network may also be required.	To mitigate the impact of EVs SSE used this project to show how EVs can be used to soak up excess low carbon electricity by acting as storage for low carbon energy output. SSE is now working on the Smart EV project which aims to provide an industry wide engineering solution for managing EVs on the network.

5.0 Resilience of SSE to each scenario in the long term (2030 and beyond)

The discussion in chapters three and four describes the investment SSE has made in low carbon infrastructure over the past ten years, and the plans to continue that investment to 2020. As would be expected, the short term investment can be described with a high degree of confidence. In the period between 2020 and 2030, while final investment decisions are yet to be made and there remains significant market and policy uncertainty, there is a relative degree of visibility of the sort of investment that may be made, not least because of the relatively developed pipeline of potential investment projects that exists.

The period from 2030 and beyond, is clearly the period where there is far less clarity or certainty. 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 diverse and mixed investments in economically regulated and market based businesses. 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 even in the No Progress scenario.

5.1 Strengths and opportunities

5.1.1 SSE strengths supporting the delivery of the Super Green and Gone Green scenarios

It is worth noting that the difference between the Super Green and Gone Green scenarios is the speed with which the GB economy decarbonises. The Super Green scenario will deliver significantly less cumulative CO_2 emissions, and hence contributes to the core circumstance where global warming is expected to be capped below 1.5°C increase. Therefore the identification of strengths and opportunities for the two scenarios remains the same for SSE, only on a different timing trajectory.

- **Electricity demand** – the impact of income growth, population growth and a switch from gas to electricity for heat and transport sectors (as described in the underlying assumptions in Appendix 1) will provide significant opportunities for SSE to continue to invest in renewable energy, including new build as well as repowering of SSE's existing assets.

- **Right economics and policy framework** – a strong carbon price could support the investment case for SSE to re-invest in its existing renewable assets and invest in new renewable assets. A relatively high gas price could also facilitate this due to its impact on wholesale electricity prices (with the impact on consumers' bills mitigated by energy efficiency where possible). Nevertheless, given the volatility of wholesale electricity prices, continued access to a Contract for Difference or other price stabilisation mechanism could also enable SSE to invest in more projects.

- **Flexibility** – increased variable renewables on the grid requires flexible generation to support electricity supplies when renewable output is low. SSE has extensive experience in providing flexibility and system support from both its gas generation assets as well as pumped storage hydro; SSE operates Foyers, one of only four pumped storage sites in GB and the potential Coire Glas development could more than double the quantity of energy stored by pumping in GB. Other storage technologies, such as batteries and Demand Side Response, are forms of flexibility expected to mature in the future and could provide opportunities for all of SSE's principal businesses.

- **Continued transmission of renewable energy to places of energy demand** – SHE Transmission in the north of Scotland would be fundamental to a low carbon electricity system; without this network there would be no method of transporting electricity to the areas of greatest demand (i.e. southern England).

- **Electrification of transport** – according to the Committee for Climate Change, the heat and transport sectors must undergo significant transformation in the next two decades. The opportunity for transport to decarbonise by using low carbon electricity, rather than fossil fuels, provides a power company with perhaps its greatest opportunity for growth in the long term. These opportunities could present themselves across the electricity supply chain: from increased electricity demand; to the opportunity to manage and shape that demand; and to the provision of new infrastructure to support that electricity demand. SSE's short term strategy is to stay close to the emerging models and patterns of behaviour, particularly in relation to the uptake of electric vehicles (EVs). It is also true that an unmanaged transition to EVs poses challenges for the electricity grid, and SSE has sought to take a leadership role in understanding and sharing the challenges the sector may face, in order to anticipate and prevent problems before they arise.

- **Decarbonising heat** – the electrification of heat could provide similar opportunities to SSE as the electrification of transport does. There is potential growth in electric storage heating or ground source heat pumps, and more efficient use of gas heating, particularly at a district level. While the district heating industry in GB remains niche, SSE has a small but growing district heat business where it designs, builds and operates district heating schemes across GB. There is no clear signal of a whole scale and radical increase in heat networks in GB as yet, however SSE is well positioned with its district heat business to respond to the opportunity if one does.

5.1.2 SSE strengths supporting the delivery of the No Progress scenario

This scenario plays to SSE's strength in gas generation, however, it would provide fewer opportunities for the pipeline of future renewables projects. SSE's existing portfolio of assets could continue to play a role, with SSE using this diverse portfolio and its experience to continue to support the GB electricity system. The existing transmission and distribution system could remain unchanged and investment in this system may continue to be required to support and maintain the electricity system up to 2050.

5.1.3 SSE strengths supporting the delivery of all the low Nuclear Sensitivity scenarios

The low nuclear scenarios for Gone Green, Super Green and No Progress play to SSE's strength in gas generation (for the No Progress scenario) and renewables and gas generation (for the Gone Green and Super Green scenarios). From a decarbonisation perspective, increased renewables output should be needed to compensate for the lack of nuclear output. Gas generation should be needed to ensure security of supply, particularly during winter peaks when there is no solar generation and wind generation output is variable. The existing mixed portfolio of assets could continue to play a role in all of these scenarios to a greater or lesser extent. The level to which each type of fuel in the generation mix plays out would depend on the scenario and SSE has the flexibility to respond to each of the scenarios.

5.1.4 Strengths of SSE's current and existing pipeline of projects

SSE is a vertically integrated business with a mix of generation assets and experience in the development and operation of low carbon infrastructure projects. This portfolio of businesses and its experience in running low carbon infrastructure mean it is well placed for a low carbon future. Table 7 outlines the strengths of SSE's current portfolio and existing pipeline of potentialprojects in relation to each scenario.

The high level of nuclear technology envisaged to be needed in the Gone Green and Super Green scenario is unlikely to play to SSE's strengths, however, if one of the low nuclear scenarios transpires then SSE should be in a good position.

Table 7: key strengths of SSE's current portfolio and existing pipeline of potential projects

Scenarios	Strengths
Gone Green and Super Green	- One of the largest renewable energy capacities in UK - Strong pipeline of future renewable energy projects - Hydro and wind heritage could provide generation capacity up to 2050s along with potential large scale pumped storage capability as an enabling technology for high low carbon generation levels - Fleet of gas plants that could provide security of supply and flexibility for the grid up to the end of the 2020s - Some experience of biomass conversion/projects - Experience of CCS projects for gas - Experienced at transmission system infrastructure programmes to support growth - Experienced at distribution system maintenance programmes to support growth of distributed renewable energy technologies
No Progress	- Fleet of gas plants that could provide security of supply and flexibility for the grid up to the end of the 2020s - Balanced and diverse portfolio of generation options - Experienced at constructing and operating gas plants - Balanced energy group with market-based and economically regulated businesses - Continued investment and maintenance of the existing transmission and distribution system (this scenario is the closest to the infrastructure that exists today)
Low nuclear in all scenarios	- One of the largest renewable energy capacity in UK - Strong pipeline of future renewable energy projects - Balanced and diverse portfolio of generation options - Fleet of gas plants that could provide security of supply and flexibility for the grid up to the end of the 2020s - Experience of CCS projects that could provide gas for security of supply and flexibility in a high renewables and intermittent grid - Balanced energy group with market-based and economically regulated businesses - Transmission and distribution networks - Hydro heritage - Some experience of biomass conversion/projects

5.2 Weaknesses and threats

5.2.1 Gone Green and Super Green scenarios

The Gone Green and Super Green scenarios represent an ongoing and significant transformation of the electricity system in GB. This scale of change poses challenges to SSE and the industry as a whole with potential longer term threats to SSE's business identified below:

- **Growth rates in distributed generation challenge existing national grid infrastructure**

The existing model of a high voltage national grid capable of transmitting large volumes of power over large distances was established to deliver power to homes from large generating stations. In the case of a significantly expanded local and distributed generation, the question arises; will that grid level infrastructure still be required? The full scale development of localised generation connected to the distribution grid, could involve small scale gas plants, combined heat and power plants, perhaps even modular nuclear plants. This scenario, while plausible would require significant change and creation of new policy and regulation as well as favourable economic conditions to make such developments commercially viable.

Even in this scenario, the nature of SSE's transmission assets in the north of Scotland, where 90% of the power transmitted is from renewable sources, provides some protection. The key feature of renewables is that there are no ongoing fuel costs, making it price competitive, and power is generated when the wind blows and the rain falls. That means it is unlikely that these assets will not continue to make an important contribution to securing electricity supplies in GB even in the case of a dramatic shift towards distributed generation.

It is also unlikely that most areas in GB would be able to maintain security of supply, particularly through the winter without access to and use of the national grid and transmission-connected generation.

Furthermore, SSE's two distribution networks could be key to enabling a transformation to localised generation and a distributed grid to the GB electricity industry model. These businesses may be able to support new consumer-led technologies to work at scale and help communities to optimise their distributed energy resources. Therefore, SSE ought to be able to adapt and respond to the opportunities such a transition could provide.

- **The long term viability of gas generation**

The increase in intermittent renewable generation requires more flexibility from generators able to meet demand when renewable output is low. This has been identified as a priority area by government and regulators in order to deliver ongoing security of supply throughout GB. In the short to medium term, gas generation will replace coal to provide the base load and flexibility. The importance of highly efficient gas generation as a transition technology is well documented.

The long term concern is that without an economic method of CCS there may be a limit to the extent to which unabated gas plants can run, whilst ensuring the carbon emissions meet the stated global and national targets.

5.2.2 No Progress scenario

Finally, the No Progress scenario, assumes a long term trajectory that fails to meet national and international climate targets. If this scenario were to play out then there is the potential for SSE's renewable generation pipeline to be impacted.

For renewable energy projects to continue to be developed, there needs to be either the right policy support or economic or market conditions present to make them viable. In the current market model, this includes: the continued support of renewable energy projects by government through the provision of a route to market such as a Contracts for Difference (CfD); a sustainable carbon price that makes projects economically viable; a high gas price to make the projects economically viable; the development of additional revenue streams (such as producing hydrogen for transport and heat sectors from renewable technology); or the continued cost reduction of projects.

If, for instance, none of the above takes place then there would be limited expansion of SSE's renewable generation pipeline. While this scenario is unappealing to SSE's future low carbon development, SSE would continue to make the economic and environmental case for mechanisms to stimulate a low carbon electricity industry in GB.

6.0 Conclusion: SSE's business model is resilient and can respond to opportunities

The objective of this report is to assess the resilience of SSE's existing business model to three core scenarios: a scenario where GB contributes its share of carbon reduction to global temperature rises of 2°C; a scenario where it contributes to a 1.5°C scenario; a business as usual scenario where emissions would be in line with a 3-4°C warming scenario; and for each scenario a further sensitivity test of a low nuclear alternative. The report shows the likely events that could take place if each scenario plays out and how SSE could respond to these scenarios.

The sensitivity analysis finds that SSE's current mix of economically regulated and market based businesses are important to ensure that GB transitions to a low carbon electricity system. It is also shown that in circumstances whereby the transition does not follow the path detailed by UNFCCC or the Climate Change Act then SSE is also in a strong position to respond.

SSE's existing business model stands up well to each of these core scenarios as the combination and balanced mix of distribution, transmission and generation assets are vital to the GB electricity system over the long term in each of the scenarios. In short, SSE's business model is resilient.

In addition, the optionality SSE has within its development pipeline puts it in an advantageous place to respond to new opportunities climate change mitigation might bring. There could be evolving and new opportunities to invest in renewable sources of energy, in the provision of flexibility for the electricity system, the electrification of transport, the decarbonisation of heat – and in the role of the transmission network in supporting this.

The analysis identifies that SSE's business model should be well placed to respond to these and other opportunities in a low carbon economy; nevertheless, challenges do exist. For instance, it would be significantly more challenging to build out the pipeline of new renewable assets in a No Progress scenario if the combination of policy framework and economic conditions do not support it. It is therefore important that SSE continues to monitor these issues, stays agile, maintains resilience and is a progressive contributor to public policy development – all in pursuit of maintaining and building value for the future, in the interests of energy customers and investors alike.

SSE has long argued that the existence of a carbon price that properly and accurately reflects the true cost of carbon should be at the heart of frameworks to deliver a secure, low carbon electricity system. SSE will therefore continue to work with investors and other stakeholders to make the case for enhanced policy and market signals that will create an economic environment for the most cost effective transition to a secure, low carbon electricity system in GB.

The important conclusion from this review is that SSE's existing, resilient, portfolio of assets can respond to the various scenarios assessed; and its diverse range of future development options provide many potential opportunities for the future.

Appendix 1:

Key characteristics of each scenario at a GB level

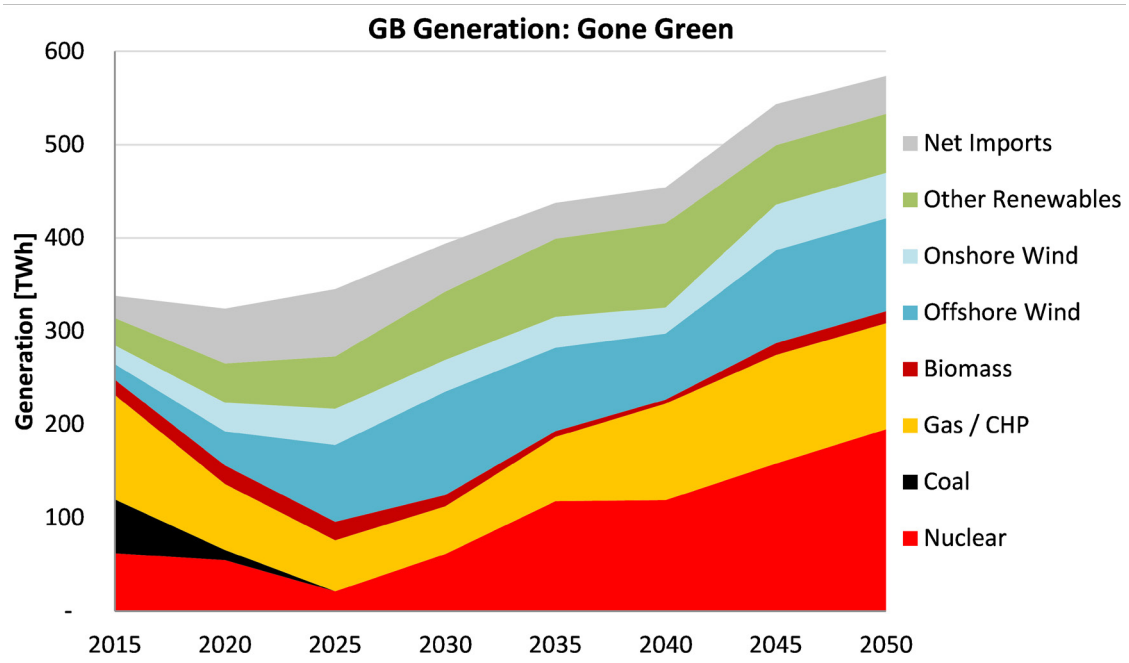
The key characteristics of each scenario are detailed in Table 8 and are based on the analysis and statistics provided by National Grid's Future Energy Scenarios 2016.

Table 8: key characteristics of the three scenarios

Scenarios	Demand trends	Policy expectation	Economics
Gone Green	- Income growth - Electrification of heat and transport drives growth in electricity - Population growth - Energy efficiency reduces some demand that arises from income growth, population growth and electrification - Move to battery storage, hydrogen and other new low carbon technologies in the 2040s	- Low carbon technologies increase by 30% (nuclear and renewables) by 2030 - Two carbon capture and storage plants are built by 2030 - Coal is closed or converted to biomass by 2030	- High carbon price - Route to market for all renewables underpinned by the CfD with associated budget - 200TWh of new generation is required to ensure supply meets demand (20GW of additional capacity) by 2030 - High gas price
Super Green	- Income growth - Electrification of heat and transport drives growth in electricity - Population growth - Energy efficiency reduces demand that arises from income growth, population growth and electrification - Move to battery storage, hydrogen and other new low carbon technologies in the 2030s	- Low carbon technologies (nuclear and renewables) increase by 2030 - Two carbon capture and storage plants are built by 2030 - Coal is closed or converted to biomass by 2030	- Very high carbon price - Route to market for all renewables underpinned by the CfD with associated budget - 200TWh of new generation is required to ensure supply meets demand (20GW of additional capacity) by 2030 - High gas price
No Progress	- Low income growth - Population growth - Economy sluggish	- Carbon technology pipeline from 2015 to 2020 is built and renewable energy is high between 2020 and 2030 - No new renewable programmes beyond 2020	- Low or no carbon price - No future support provided to renewables - Gas prices are low

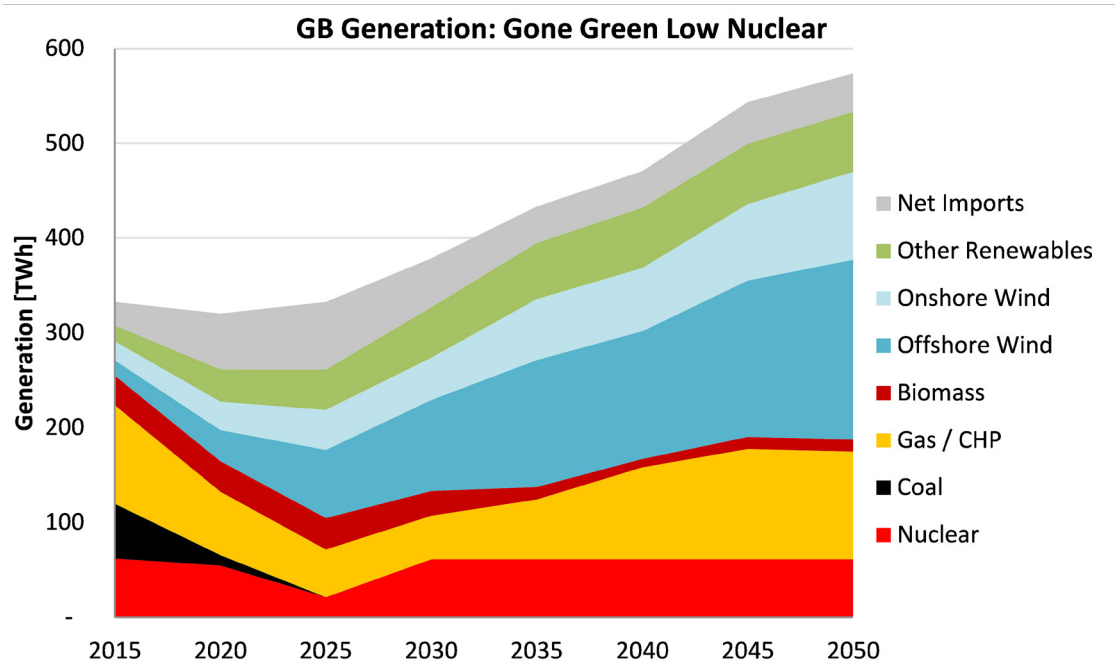
Scenario 1: Gone Green

This scenario mirrors National Grid's Gone Green scenario, which delivers 22GW of nuclear, 20GW of CCS generation, 12 million heat pumps and 35 million electric vehicles by 2050.



Source: National Grid Future Energy Scenarios, 2016, Gone Green scenario with SSE projected figures out to 2050 using the same assumptions.

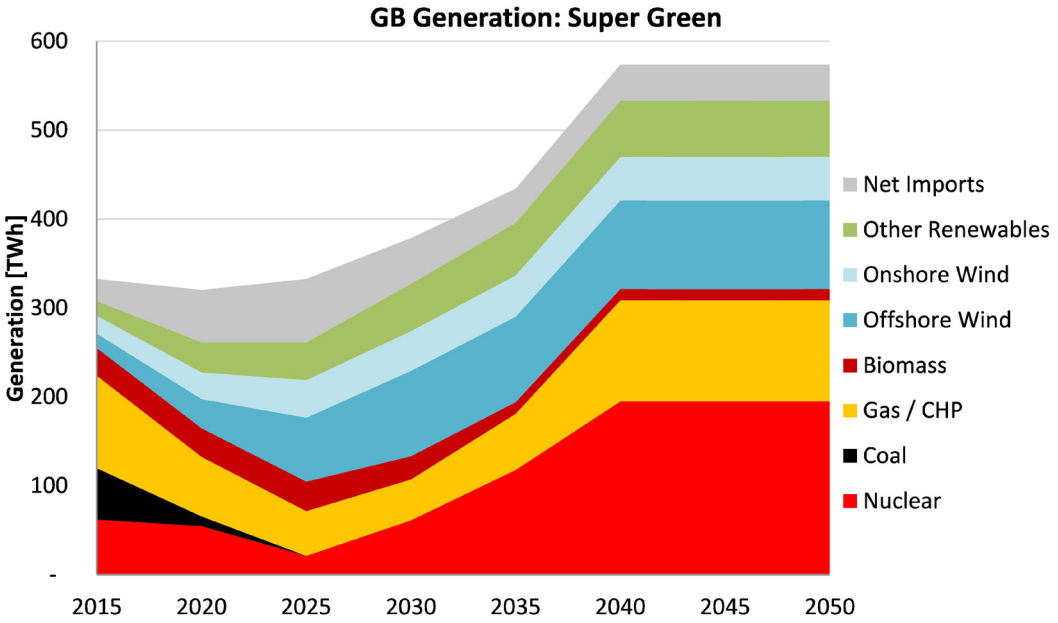
This second graph assumes that, after the three new nuclear power plants which come online in the 2020s, the post 2030 nuclear programme does not take place and that the post 2030 nuclear output in the graph above is replaced by wind, both onshore and offshore as well as gas.



Source: National Grid Future Energy Scenarios, 2016, Gone Green scenario with SSE's model replacing the nuclear from 2030 onwards with a mixture of additional wind and gas generation.

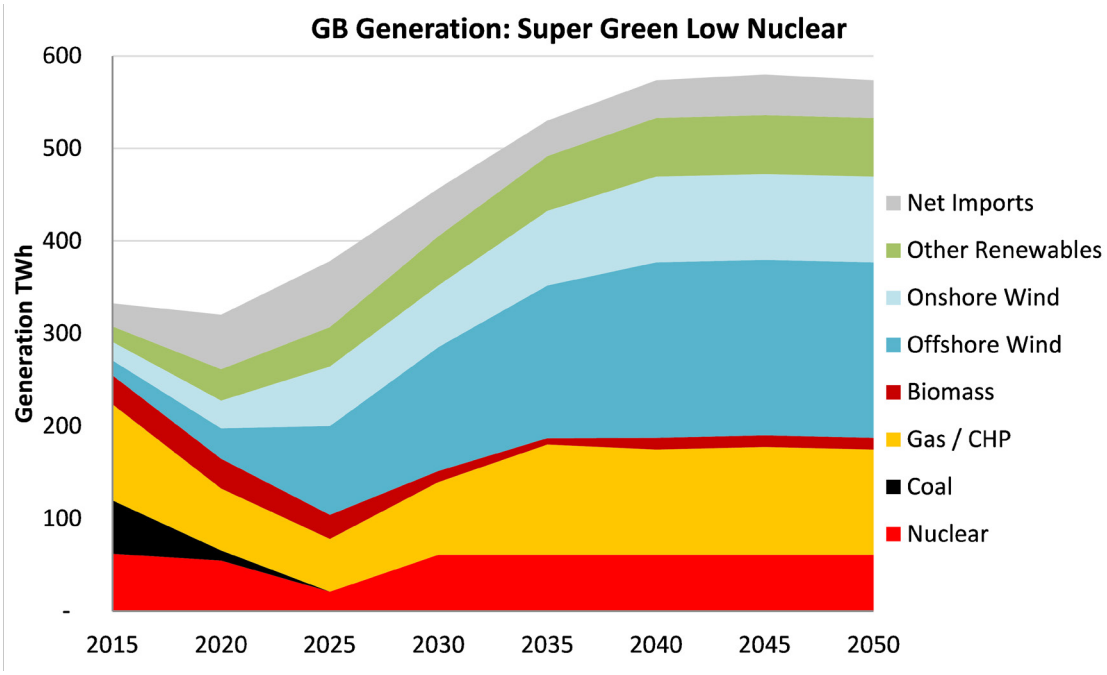
Scenario 2: Super Green

This scenario assumes that the 1.5°C targets are put into legislation globally. This scenario mirrors National Grid's Gone Green scenario but accelerates progress on decarbonisation by ten years. It assumes that by 2040 there will be 22GW of nuclear, 20GW of CCS generation, 12 million heat pumps and 35 million electric vehicles.



Source: National Grid Future Energy Scenarios, 2016. The Super Green scenario assumes that the Gone Green decarbonisation trajectory is accelerated by ten years, and then plateaus from 2040.

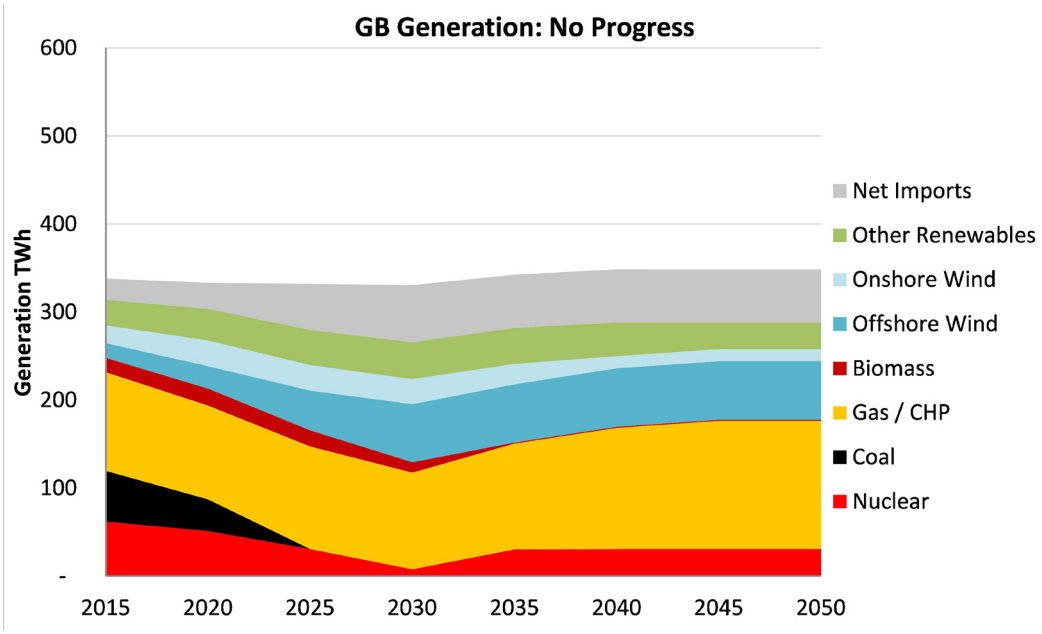
This second graph assumes that, after the three new nuclear power plants which come online in the 2020s, the post 2030 nuclear programme does not take place and that the post 2030 nuclear output in the graph above is replaced by wind, both onshore and offshore, as well as gas.



Source: National Grid Future Energy Scenarios, 2016. The Super Green scenario assumes that the Gone Green decarbonisation trajectory is accelerated by ten years. From 2030 SSE's model replaces missing nuclear with a mix of gas, wind and other renewable generation.

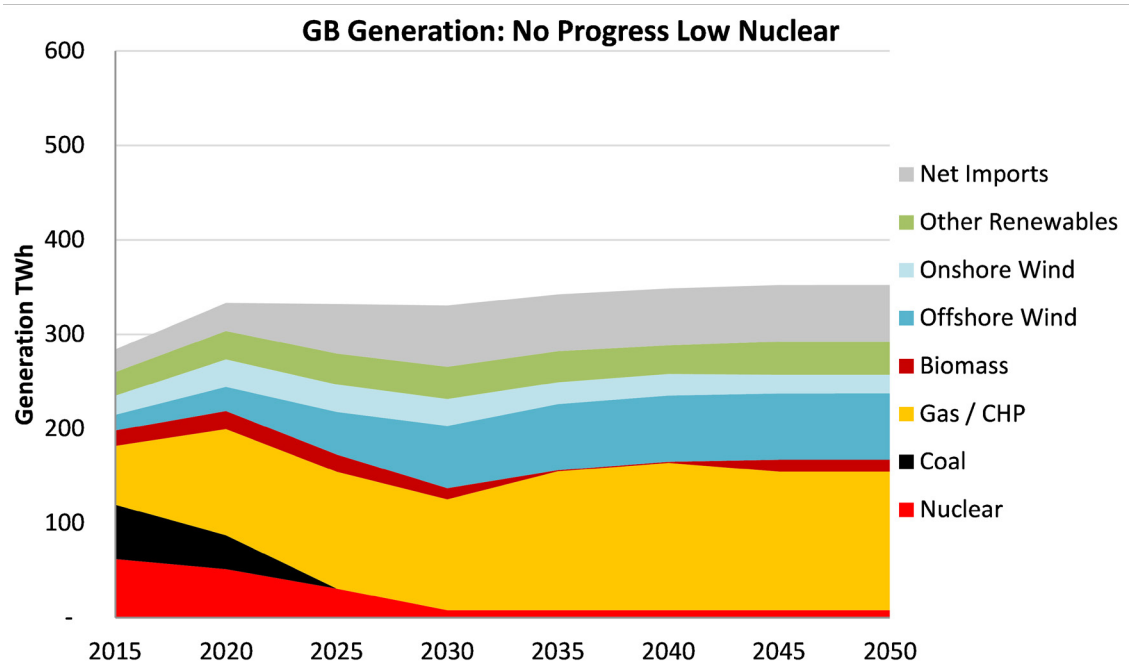
Scenario 3: No Progress

This scenario uses the National Grid's 'No Progress' scenario data. This scenario assumes that traditional forms of generation dominate and that there is no growth in renewable generation beyond the existing roll out rates, whilst the only new nuclear commissioned is Hinkley Point C in 2032 and 2034. Gas is assumed to supply the largest proportion of electricity and is supported by imports.



Source: National Grid Future Energy Scenarios, 2016, No Progress scenario with SSE projected figures out to 2050 using the same assumptions.

This second graph assumes that there is no new nuclear power developed at all. As a result, nuclear output drops from 50TWh in 2015 to a flat 8TWh from 2030 onwards.



Source: National Grid Future Energy Scenarios, 2016, No Progress scenario with SSE projected figures out to 2050 using the same assumptions. From 2030 SSE's model replaces missing nuclear with a mix of gas, wind and other renewable generation.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