BERWICK BANK WIND FARM

STATEMENT OF NEED

Document Status

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ACRONYMS

Acronym	Definition
AGR	Advanced Gas-cooled Reactor
AR4	(CfD) Allocation Round 4
BEIS	Department for Business, Energy and Industrial Strategy
BESS	British Energy Seurity Strategy
CCA	Climate Change Act 2008
CCC	Committee on Climate Change
CC(S)A	Climate Change (Scotland) Act 2009
CCS / CCUS	Carbon Capture (Use) and Storage
CES	Crown Estate Scotland
CfD	Contract for Difference
COP	The UN's Conference of the Parties
DSR	Demand Side Response, an ancillary service
ESC	Energy Systems Catapult
ETYS	NGESO's annual Electricity Ten Year Statement
EV	Electric Vehicle
FES	NGESO's annual Future Energy Scenarios
FID	Financial Investment Decision
FR	Frequency Response, an ancillary service
GB / UK	Northern Ireland operates under a different electricity market framework to the rest of Great Britain (GB). Great Britain (GB) is referenced in relation to electricity generation and transmission, and Scotland, or the UK, are referenced as the nation(s) which have legally committed to Net Zero carbon emissions.
GDA	Generic Design Assessment (for nuclear reactors)
GHG	Greenhouse Gas
HND	Holistic Network Design, part of the Offshore Transmission Network Review
HVDC	High Voltage Direct Current
IPCC	Intergovernmental Panel on Climate Change
LCOG	Levelised Cost of Generation
LCTP	The UK's Low Carbon Transition Plan
NDC	Nationally Determined Contributions (to the Paris Agreement)
NEPC	National Engineering Policy Centre

Acronym	Definition
NETS	National Electricity Transmission System
NGESO	National Grid Electricity System Operator
NIC	The UK's National Infrastructure Commission
NOA	NGESO's annual Network Options Assessment
NPS	National Policy Statements for Energy Infrastructure
NTS	National Transmission System (for Gas)
ONR	Office for Nuclear Regulation
OWF	Offshore Wind Farm
OREC	Offshore Renewable Energy Catapult
PfG	Scottish 2021/22 Programme for Government
RES	Renewable Energy Sources
SMR	Small Modular Reactor
SOF	NGESO's System Operability Framework
STW	Scottish Territorial Waters
TCE	The Crown Estate
TEC	Transmission Entry Capacity

1. EXECUTIVE SUMMARY

1. This Statement of Need (the Statement) accompanies the application submitted to Marine Scotland Licencing Operations Team (MS-LOT) by Berwick Bank Windfarm Limited (the Applicant), to support the applications made under Section 36 of the Electricity Act 1989 for consent to install and operate Berwick Bank Wind Farm and associated infrastructure with a generation capacity exceeding 50 megawatts (MW) (the Project) and application for marine licences pursuant to the Marine (Scotland) Act 2010 and the Marine and Coastal Access Act 2009.

2. The Project will include offshore and onshore infrastructure including an offshore generating station (array), offshore export cables to landfall and onshore transmission cables leading to an onshore substation with electrical balancing infrastructure, and connection to the electricity transmission network. The offshore components of the Project seaward of MHWS are referred to as the Proposed Development.

3. The array comprises 307 wind turbines, with an estimated capacity of 4.1 gigawatt (GW). The array will be approximately 47.6 km offshore of the East Lothian coastline and 37.8 km from the Scottish Borders coastline at St, Abbs. It lies to the south of the offshore wind farms known as Seagreen and Seagreen 1A, south-east of Inch Cape and east of Neart Na Goaithe.

4. As the majority of the Project is located in Scottish Waters, the Scottish Ministers are the primary Regulatory Authority in respect of the necessary consents and licences required for the construction and operation of an offshore wind farm project. To allow the Scottish Ministers to properly consider the development proposals, developers are required to provide information which demonstrates compliance with the relevant legislation and allows adequate understanding of the material considerations.

5. Consent is required under Section 36 of the Electricity Act 1989, as well as a Marine Licence obtained under the Marine (Scotland) Act 2010 and the Marine and Coastal Access Act 2009. Habitats Regulations Appraisal consent is also required under The Conservation (Natural Habitats, & c.) Regulations 1994 as amended, The Conservation of Habitats and Species Regulations 2017 (both referred to as the "Habitats Regulations") and the Offshore Marine Conservation (Natural Habitats &c) Regulations 2007 / The Conservation of Offshore Marine Habitats and Species Regulations 2017, as amended (referred to as the "Offshore Habitats Regulations"). Where an offshore energy project, such as an offshore wind farm, requires Section 36 Consent and a Marine Licence, MS-LOT, on behalf of the Scottish Ministers, can process both consent applications jointly

6. The Project has secured Grid Connection Offers from National Grid Electricity System Operator (NGESO) for 4.1GW of Transmission Entry Capacity.

7. This Statement for offshore wind describes how and why the Proposed Development addresses all relevant aspects of established and emerging Scottish government and UK government Policy.

8. The case for need is built upon the contribution of the Project to the three important policy aims of decarbonisation:

- Net Zero and the importance of deploying zero-carbon generation assets at scale;
- Security of supply (geographically and technologically diverse supplies); and
- Affordability.

9. **Section 2** provides an overview of legislation relevant to Scotland, principally the commitment made through the Climate Change (Emissions Reduction Targets) (Scotland) Act 2019, to reduce emissions of all major greenhouse gases by at least 100% by 2045 from 1990 levels. UK legislation is also discussed, to the extent it relates to the legal commitment made by the UK government, covering England, Scotland, Wales and Northern Ireland, to achieve Net Zero by 2050, thereby ending the UK's contribution to global warming within 30 years.

10. **Section 3** describes how decarbonisation in Scotland and the wider UK has been achieved to date, and sets out why further decarbonisation is needed urgently to meet national climate commitments. The section also includes descriptions of the key policies in place for both Scotland and the UK to drive to their respective Net Zero targets. The section concludes that all new low carbon power generation projects which will make valuable contributions to achieving Net Zero, should be delivered as soon as possible. Many more projects than those currently in development pipelines will be required under all potential future scenarios of how to meet Net Zero.

11. **Section 4** analyses future Scottish and UK electricity demand and concludes that it will grow significantly through strategic actions to achieve decarbonisation-through-electrification of other industry sectors, and this underpins the urgent need for significant new low carbon electricity generation developments in Scotland and the UK.

12. **Section 5** provides an up-to-date view of the past and potential future contributions of key technologies to decarbonisation in the UK, and describes expert future views of what constitutes a Net Zero consistent energy system, and the considerations needed now to balance decarbonisation with security of supply and affordability.

13. **Section 6** describes in detail how the Project supports decarbonisation through an assessment of its contribution to the various quantifiable 2030 targets set by the Scottish and UK governments as a pathway to meeting their climate change commitments.

14. **Section 7** analyses the contribution of offshore wind generation to security of supply, from the perspectives of sufficient electricity supply, and of system operation. The section concludes that the Project, if consented, would make a significant contribution to an adequate and dependable GB generation mix.

15. **Section 8** provides an analysis of commercial aspects of large-scale offshore wind, as a future contributor to a low carbon GB electricity supply system, in comparison to alternate technologies.

16. **Section 9** lists the conclusions of this Statement of Need. Namely, that significant capacities of low carbon offshore wind generation are needed in Scotland and in the UK. Therefore, the Project, if consented, will help meet Scottish government and UK government objectives of delivering sustainable development to enable decarbonisation, ensuring our energy supply is secure, low carbon and provides benefits to GB consumers.

17. It is the view of the author of this report that the Project presents a significant low regrets opportunity for Scotland to make progress against its 2045 legal commitments, by bringing to operation a large capacity of low carbon power generation from the mid 2020s. The Project will enable Scotland to reduce further the carbon content of the power it consumes, as well as to enable the decarbonisation of Scottish heat and transport energy consumption either directly or through growth in Scottish hydrogen electrolysis facilities. Without the Project, Scotland will require more imports of electricity from the wider UK for longer to meet its growing electricity demand. Because Scotland is already further ahead than the wider UK in decarbonising its electricity supply, imported electricity is likely to have been

generated with a higher carbon content, therefore potentially jeopardising Scotland's progress to Net Zero by 2045.

18. Scotland is also a key contributor to efforts to decarbonise the wider UK, and if a significant capacity of offshore wind generation is not built out to a scale comparable with that in the projections provided by NGESO and others, then the UK will be highly unlikely to continue to reduce its carbon emissions over the coming decade, and ultimately may fail to meet its legally binding decarbonisation targets.

19. The Project will provide a significant and vital contribution towards meeting Scottish policy objectives for the energy sector, the Scottish need and the UK need for renewable energy, and the ambitions of the Offshore Wind Sector Deal for sustainable growth and economic benefit.

20. The Project is a low-risk, low regrets opportunity because of its proposed location and selected technology. If delivered, it will make a significant and important contribution to decarbonisation, security of supply and affordability in the appropriate timeframes, especially if positioned against other technologies and/or development which currently carry more development or economic risk, and/or deliver over longer timescales. The Project is wholly consistent with Scottish Energy Strategy and UK energy policy, and its development will be critical if Scottish policy aims, and UK-wide policy aims, are to be achieved.

21. This Statement has been prepared by Si Gillett, M.A.(Oxon), M.Sc.(Dist) and sets out the case for why offshore wind is a critically important generation technology to include within the future generation mix of both Scotland and the UK. This Statement predominantly calls on established and emerging primary analysis and opinion by respected experts, to support the case that the Project will help Scotland and the UK meet their legally binding carbon emissions targets, while enhancing national security of supply, and at a cost which, in relation to other electricity generation infrastructure developments, provides value for money for end-use consumers.

2. LEGISLATION LANDSCAPE

2.1. OVERVIEW

22. This section describes the legislative landscape relevant for low carbon electricity generation asset development and describes the legal commitments made by both the UK and Scotland to deliver against climate change targets.

23. Legal decarbonisation commitments have been made by Scotland and also by the United Kingdom of Great Britain and Northern Ireland (UK). The UK commitment covers Scotland, Wales, England and Northern Ireland.

24. Electricity generation is an important sector for climate change, because although historically it has been a significant carbon emitter, it is now the critical enabler of deep decarbonisation across society. Electricity generation and supply in Scotland, Wales and England are connected by the National Electricity Transmission System (NETS), and the same set of operating and commercial rules applies across the NETS (although there are some geographical differences).

25. While Northern Ireland is attached to the mainland NETS through two interconnectors, it operates under a different electricity market framework. This Statement of Need therefore refers to Great Britain (GB) in relation to electricity generation and transmission, and we refer to Scotland, or the UK, as the nation which has legally committed itself to Net Zero carbon emissions.

2.2. CLIMATE CHANGE (SCOTLAND) ACT 2009

26. The Climate Change (Scotland) Act 2009 (CC(S)A) creates the statutory framework for greenhouse gas emissions reductions in Scotland by setting interim and ultimate targets for emission reductions. CC(S)A also provides the power for interim targets to be varied based on expert advice, and requires the Scottish Ministers to set annual targets, in secondary legislation, for Scottish emissions from 2010 to 2050. Scottish Ministers take advice from the Committee on Climate Change (CCC, see **Section 2.3**) on the targets they set, although a Scottish Committee on Climate change may be established to provide such advice.

27. Secondary legislation has been made under CC(S)A to set annual targets, establish a framework for carbon accounting and introduce legislation requiring regular reporting on compliance with climate change duties among other requirements. Scotland's initial targets were to reduce emissions by 42% for 2020, and 80% by 2050, from 1990 levels.

2.3. CLIMATE CHANGE ACT 2008

28. The UK government, through Climate Change Act 2008 (CCA), made the UK the first country in the world to set legally binding carbon budgets, aiming to cut emissions (versus 1990 baselines) by 34% by 2020 and at least 80% by 2050, “through investment in energy efficiency and clean energy technologies such as renewables, nuclear and carbon capture and storage.” [1].

29. CCA committed the UK to sourcing 15% of its total energy (across the sectors of transport, electricity and heat) from renewable sources by 2020 and new projects were expected to need to continue to come forward urgently to ensure that this target was met. Government projections made in 2011 suggested that by 2020 about 30% or more of GB electricity generation – both centralised and small-scale – could come from renewable sources.

30. CCA is underpinned by further legislation and policy measures. Many of these have been consolidated in the UK Low Carbon Transition Plan [1], and UK Clean Growth Strategy (2017) [2]. A statutory body, the CCC, was also created by CCA, to advise the United Kingdom and devolved governments and Parliaments on tackling and preparing for climate change, and to advise on setting carbon budgets.

31. The UK government has set five-yearly carbon budgets which currently run until 2037, the process for setting the sixth carbon budget having concluded in April 2021. The UK met its first and second carbon budgets and is on track to outperform the third (2018 to 2022) – partly attributable to effective policy, but also attributed to changes in the applicable Emissions Trading Scheme(s) and the impact of COVID-19 on emissions [3].

32. The CCC also report regularly to the Parliaments and Assemblies on the progress made in reducing greenhouse gas emissions.

2.4. COP21 / UNFCC PARIS CONVENTION AND SUBSEQUENT ACTIONS

33. The global context for the need for greater capacities of low carbon generation in Scotland, the wider UK and elsewhere to come forward with pace, has developed significantly over the last seven years. In 2015, at the 21st Conference of the Parties (COP21), for the first time ever, every country agreed to work together to limit global warming to well below 2ºC and to aim for 1.5ºC; to adapt to the impacts of a changing climate; and to make money available to deliver on these aims. The commitment to aim for 1.5ºC is important because every fraction of a degree of warming will result in many more lives lost and livelihoods damaged. Importantly therefore, every delay to decarbonisation action, because it allows for carbon emissions and therefore global warming to continue, also results in lives lost and livelihoods damaged. The Paris Agreement sets out that every 5 years countries must set out increasingly ambitious climate action, hence the need for internationally available plans for reducing emissions, known as Nationally Determined Contributions (NDCs) [4].

34. In October 2018, following the adoption by the UN Framework Convention on Climate Change of the Paris Agreement, the Intergovernmental Panel on Climate Change (IPCC) published a “Special Report on the impacts of global warming of 1.5°C above pre-industrial levels”. The report concluded that human-induced warming had already reached approximately 1ºC above pre-industrial levels, and that without a significant and rapid decline in emissions across all sectors, global warming would not be likely to be contained, and therefore more urgent international action is required. The ambition against which CC(S)A and CCA were established had been extended, and carbon emissions reduction targets in Scotland and the UK have subsequently been tightened.

35. In response to the IPCC report, in May 2019, the CCC published "Net Zero: The UK’s contribution to stopping global warming.” [5]. The report recommended extensions to the ambition established in existing legislation.

36. In recognising that Scotland has a "greater relative capacity to remove emissions than the UK as a whole" CCC recommended a Net Zero date of 2045 for Scotland [6]. As a result, CC(S)A was amended by Climate Change (Emissions Reduction Targets) (Scotland) Act 2019 to reduce emissions of all major greenhouse gases by at least 100% by 2045 from 1990 levels, with interim targets of at least:

- 56% by 2020;
- 75% by 2030; and
- 90% by 2040.

37. Scottish Government has also published an indicative Nationally Determined Contribution: "A 2030 target to reduce emissions of all major greenhouse gases by at least 75%, compared to a 1990/1995 baseline. This target is legally binding in Scotland's domestic law and was set in direct response to the aims of the Paris Agreement." [7]. Scotland's targets and delivery plans are reflected in the UK's Nationally Determined Contribution. On the "GHG Account" basis, against which performance against the legislated targets is assessed, the CCC assessed Scotland's 2019 emissions at 51.5% below 1990 levels, meaning that Scotland missed its 2019 annual target for a 55% reduction.

38. The CCC also recommended that "The UK should set and vigorously pursue an ambitious target to reduce greenhouse gas emissions (GHGs) to Net Zero by 2050, ending the UK's contribution to global warming within 30 years." The CCC believed that this recommendation was "necessary [against the context of international scientific studies], feasible [in that the technology to deliver the recommendation already exists] and cost-effective", reporting that "falling costs for key technologies mean that … renewable power (e.g. solar, wind) is now as cheap as or cheaper than fossil fuels". Importantly, the CCC recommendation identifies a need for low carbon infrastructure development and points to an increased urgency for action.

39. The UK implemented the CCC's recommendation into law by the laying of a statutory instrument in UK Parliament in June 2019, which amended CCA. The UK thus became the first major economy to pass laws to end its contribution to global warming by 2050.

40. Also in May 2019, the CCC reported to Parliament that "UK action to curb greenhouse gas emissions is lagging behind what is needed to meet legally-binding emissions targets" [8]. The UK is on track to outperform its third Carbon Budget (2018 to 2022), but is not currently on track to meet the fourth (2023-2027) or fifth (2028-2032). Recognising the need for progress in decarbonisation to continue, the CCCs recommendations for a sixth carbon budget, running from 2033 – 2037, included measures which, when delivered, will result in a 78% reduction in UK territorial emissions between 1990 and 2035, in effect, bringing forwards the UK's previous 80% target by nearly 15 years [3].

41. In December 2020, the UK formally submitted its NDC to the UNFCCC under the Paris Agreement. The UK commitment covers England, Scotland, Wales and Northern Ireland and the commitment is an at least 68% economy-wide net reduction in GHG emissions by 2030 compared to reference year levels [9], and CCC's recommendations for the Sixth Carbon Budget were legally adopted in April 2021. **Figure 2-1** shows the CCC's advice on the level of the Sixth Carbon Budget. The Sixth Carbon Budget will require emissions to reduce by 2035 to 78% below 1990 levels, including the UK's share of international aviation and international shipping emissions. The budget equates to a 63% reduction on 2019 emissions, by when emissions had already fallen around 40% since 1990.

2.5. COP26: UNITING THE WORLD TO TACKLE CLIMATE CHANGE

42. The 26th UN Climate Change Conference of the Parties (COP26) was held in Glasgow on 31 October – 13 November 2021. COP26 brought parties together to accelerate action towards the goals of the Paris Agreement and the UN Framework Convention on Climate Change. As the first COP since the first NDCs had been published since Paris, the run up to COP26 in Glasgow was a critical moment in the world's mission to keep the hope of

limiting global temperature rises to 1.5°C alive [4]. International pledges could be reviewed and amalgamated, and a view of global commitments made towards limiting carbon emissions and adapting to climate change could be created for the first time.

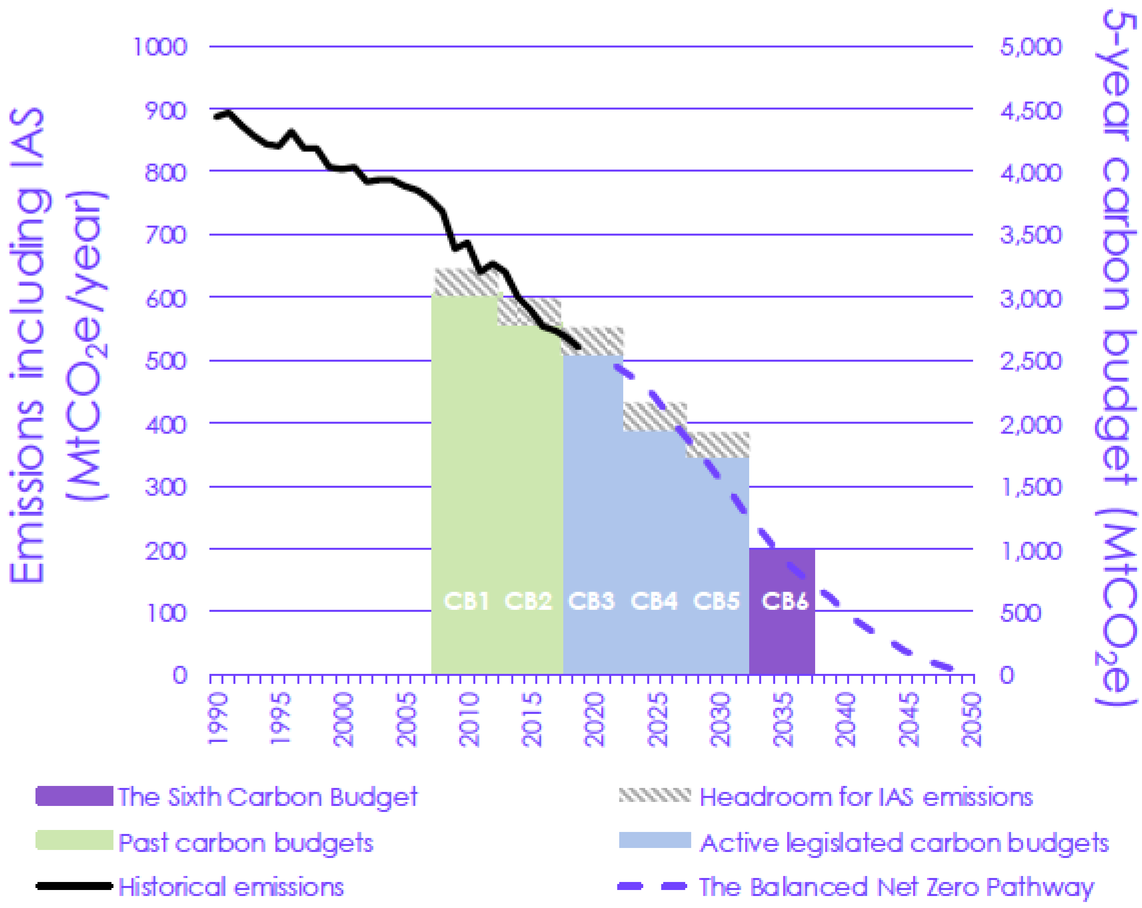

Figure 2-1: The UK's six Carbon Budgets and trajectory to Net Zero 2050

[3]

43. Agreements were reached on many themes at COP26, including: science and urgency; adaption; adaption finance; mitigation; finance, technology transfer and capacity-building for mitigation and adaptation; loss and damage; implementation; collaboration; and confirmation and developments of elements of the Paris rulebook.

44. Of greatest relevance to this Statement of Need, specifically because collective progress to date to reduce emissions has not been sufficient, are the outcomes agreed at COP26 relating to mitigation: setting out the steps and commitments that Parties will take to accelerate efforts to reduce emissions "to keep 1.5°C in reach". Key achievements at COP26 under the theme of mitigation include [10]:

- Over 90% of world Gross Domestic Product and around 90% of global emissions are now covered by net zero commitments and 153 countries have put forward new or updated emissions NDCs, which collectively cover around 80% of the world's greenhouse gas emissions. Net Zero is a global endeavour and the world is getting on board;
- The importance of action now to address the urgency of climate change and drive emissions down before 2030 was cemented in an agreement from all parties to revisit and strengthen their current emissions targets to 2030, in 2022;
- The role of clean electricity in delivering climate action, and the importance of driving down emissions from fossil fuel generators as well as increase capacity of renewable generators, was acknowledged in the negotiated agreement by 190 countries at COP26 to "phase down coal power". Further commitments to cease international coal finance and direct public support of unabated fossil fuel energy, by the end of 2021 and 2022 respectively, will free funds to be redirected for deployment in renewable energy;
- Accounting for over 10% of global greenhouse gas emissions, and around half the world's consumption of oil, road transport is a critical sector to decarbonise with pace. Agreement was reached by countries, cities, companies, investors and vehicle manufacturers to target all new car and van sales to be zero emission by 2040 globally and 2035 in leading market, and ultimately to phase our fossil fuelled vehicles. Electrification of transport is inevitable, underway and accelerating. Low carbon electricity supply must keep growing to provide the energy to enable the rapid displacement of oil.

45. It is appropriate that COP26 was held in Scotland, because of the significant leadership and progress shown by Scotland through its climate actions and ambitious climate change targets. And as the COP26 Outcomes report reminds its readers: "we must continue the work of COP26 with concerted and immediate global effort to deliver on all pledges" in order to keep alive the hope of limiting the rise in global temperature to 1.5°C.

46. The Project presents an opportunity for Scotland to underpin its delivery on the COP26 mitigation pledges:

- Scotland has its own indicative NDCs, and the Project is a critical measure in support of achieving those commitments, by providing new low carbon electricity generation facilities in Scotland to power heat transport and industrial demand and save emissions;
- The Project will generate low carbon power in the critical 2020s and therefore before the current emissions targets date of 2030. Early action to decarbonise is important in the climate fight;
- The Project will generate power in Scotland, meaning that less power generated in the UK needs to flow north at times of higher demand and lower supply, bringing with it the carbon emissions associated with an electricity mix which currently still includes fossil fuel fired power stations;
- Scotland is leading the way globally in electrifying vehicles and the Project will be an essential source of low carbon power to keep Scottish people and businesses moving in new electric vehicles while at the same time, saving carbon emissions.

47. A comparable analysis illustrates that the Project brings comparable support to the UK's decarbonisation plans.

3. HISTORICAL DECARBONISATION AND POLICIES FOR THE FUTURE

3.1. NATIONALLY DETERMINED CONTRIBUTIONS

48. NDCs are stepping stones to achieving Net Zero commitments and policies are therefore in place to support Scotland (and the UK) to the progressive achievement of Net Zero. This section describes how Scotland and the UK have performed against their legislative targets to date; and sets out the current plans and policies in place to deliver further decarbonisation. It lists those Scottish (and UK) policy positions which are driving emissions to Net Zero and which are relevant to the Project.

49. The Scottish government has its own statutory emissions reduction targets. The Scottish NDC publication quoted above also refers to the Scottish NDC (which align with the commitments made in the Climate Change (Scotland) Act 2009 as amended) and were informed by the Paris Agreement. Progress towards these targets also contributes to achievement of UK-wide targets. The decision on the UK's NDC headline target was led by BEIS and agreed through UK Government governance structures at official and ministerial levels. The target level in the UK's NDC was informed by the UK's commitments under the Paris Agreement, the legally-binding net zero commitment, and guidance from the CCC.

3.2. HOW DECARBONISATION HAS BEEN ACHIEVED TO DATE

50. UK territorial greenhouse gas emissions, including those from power generation, have reduced since 1990, as shown in **Figure 3-1**. Over the period 1990 to 2021, power station emissions reduced to just 26% of their 1990 value while emissions from other sectors reduced to 61% of their 1990 value [11]. This was despite Total Final User Electricity Consumption (a BEIS definition) in the UK increasing from 274.4TWh to 286.1TWh over the same period [12]. Reductions in the UK power sector have been achieved through many initiatives and circumstances.

51. Electricity volumes generated from coal and gas fired power plants has reduced. The Large Combustible Plant Directive (aiming to improve air quality but also having significant carbon reduction benefits) required the clean up or time-limited operation of coal-fired power generation prior to 2016. Between 2012 and 2015, at least 11.5GW of coal plant decommissioned as a result of the Directive and Scotland's last coal fired power plant closed in 2016.

52. GB's second-generation nuclear fleet (9GW) has operated significantly past its original decommissioning dates. Nuclear provided 16% of electricity demand in 2020 from two stations in Scotland (2.3GW) and six stations in England (6.8GW), all with low carbon emissions [13], however the decommissioning of existing plants commenced in 2021 including 1.0GW in Scotland and 2.1GW in England. Advances in new nuclear plants to replace the existing fleet have been slower than was originally foreseen (see **Section 5.3.2**).

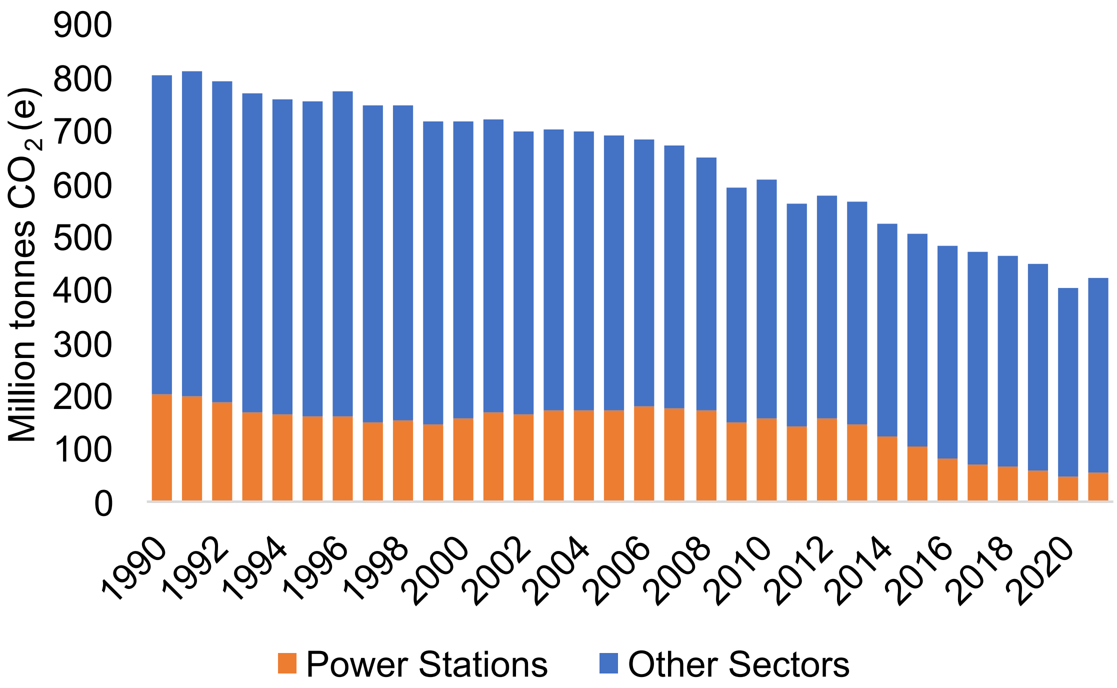

Figure 3-1: UK territorial greenhouse gas emissions 1990 to 2021

[11]

53. The transformation of Scottish electricity generation capacity over the last six years has been charted in **Figure 3-2**. Scotland's last coal fired power plant closed in 2016. Hunterston and Torness nuclear power stations have run on past their original end of life estimates. Hunterston has just recently closed after more than 45 years of low carbon electricity generation, and Torness is currently capable of operating at full power 1.3GW). As of March 2022, Scotland had 13.3GW of renewable electricity generation capacity, of which 8.7GW was onshore wind and 1.9GW was offshore wind [14]. The CCC recognise that there are now only limited further reductions possible from electricity generation, so meeting Scotland's climate change targets now requires significant progress on decarbonisation across a range of other sectors including the electrification of transport, heat and industrial demand, which in turn requires an increase in low carbon electricity generation capacity [15].

54. Decarbonisation of electricity generation in the UK has been achieved in very similar ways, see **Figure 3-3.** In late 2017, UK government announced a commitment to a programme that will phase coal out of all electricity generation by 2025, a date which during 2020 was brought forwards to 2024. National carbon pricing aims to attribute additional marginal costs (see **Section 8.2**) to coal plant, therefore signalling their dispatch only when other less carbon intensive assets have been exhausted. In June 2020, Britain ended a record run of not generating any electricity from coal for 1,630 consecutive hours – the longest period since the 1880s. In 2019, many asset operators announced the closure of their coal generation assets. Just one coal station (Ratcliffe, 2.0GW) remained commercially operational beyond September 2021 with four other units (two at West Burton A and two at Drax, with a combined generation capacity of 2.2GW) responding to system stress events only since 1st October 2021 until their closure (currently scheduled for March 2023). Ratcliffe is currently signalling that it will close by [Author Analysis].

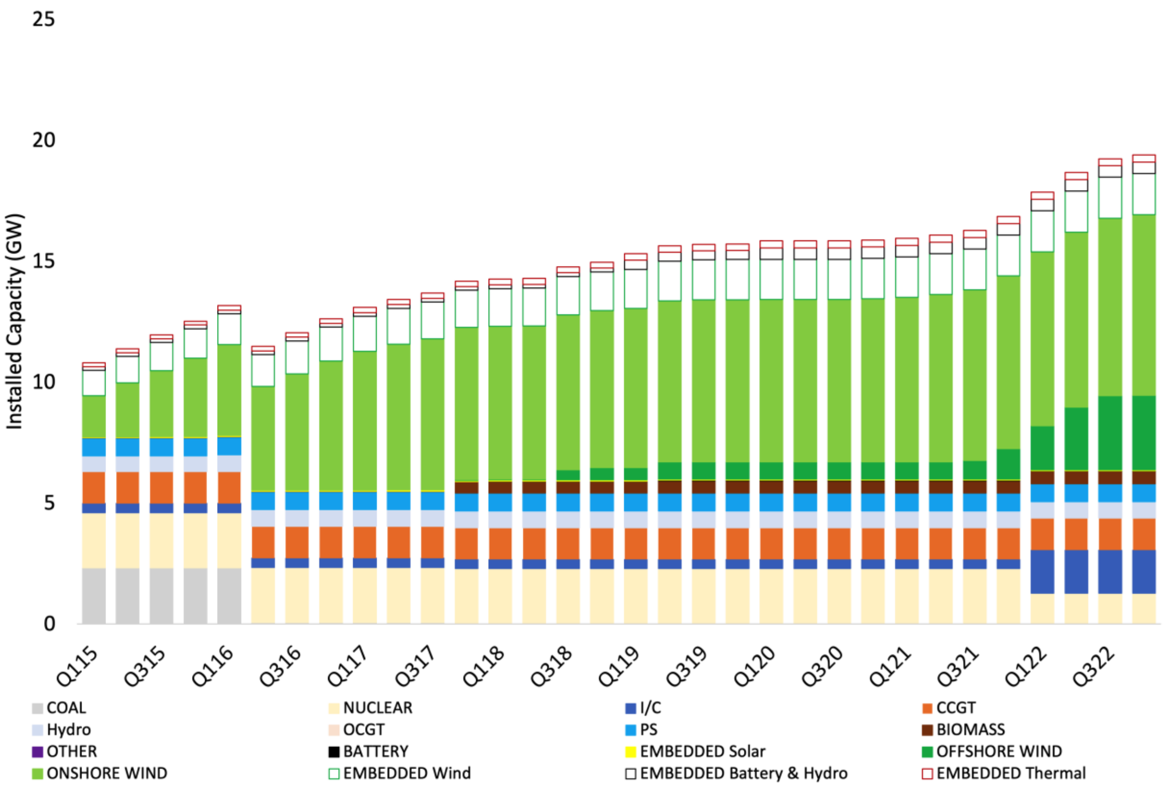

Figure 3-2: Estimated Scottish commercially operational capacity, Q115 - Q422

[Author Analysis]

55. Low carbon variable generation, predominantly wind and solar, has been deployed to the GB grid more quickly and more widely than originally projected. At the time of writing this report, 13GW of offshore wind and 13.6GW of onshore wind has already been "built" and connected to the NETS as at July 2022 (i.e. is in an operational status), with a further (estimated) 13.8GW of solar PV connected to distribution networks [107].

56. Investors have increasingly been attracted to technologies (such as renewables) which are eligible for government-backed support programs (such as the Contract for Difference), which address the market risk and long-term price uncertainty associated with the GB electricity market. Interest from investors and developers in these technologies has driven technical development and competition on cost. Consequently, UK government has repeatedly confirmed the important role the CfD mechanism plays in bringing forwards new large-scale low carbon generation, and Allocation Round 4 (AR4) contracts were awarded in the summer of 2022. As an indicator of the importance of wind as a technology class within the evolving GB electricity system, and an indicator of the competitive cost of the technology, over 8.5GW of wind capacity across 22 projects secured Contracts for Difference (CfD) in AR4, at an initial strike price ranging from £37.35/MWh (Offshore Wind) to £87.30/MWh (Floating Offshore Wind). All CfDs commence in either 2024/25 (Onshore Wind) or 2026/27 (all Offshore Wind technologies).

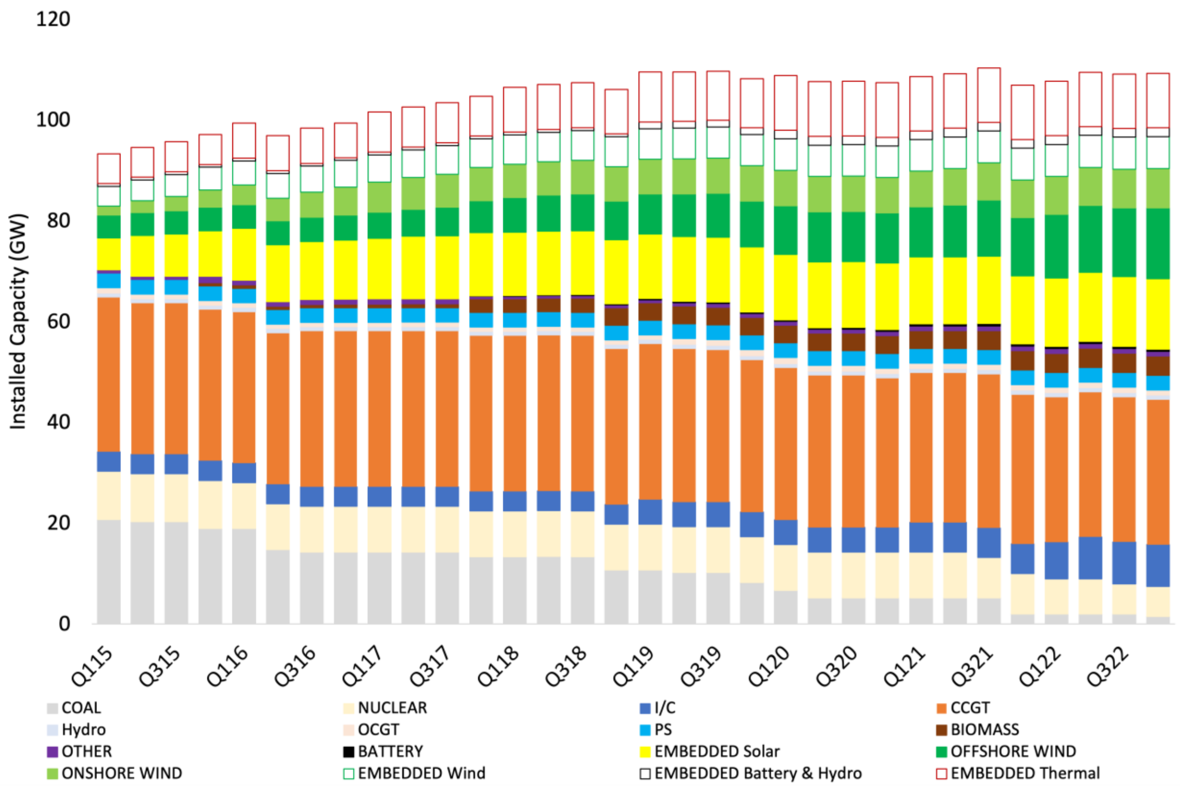

Figure 3-3: Estimated UK commercially operational capacity, Q115 - Q422

[Author Analysis]

3.3. THE URGENT NEED TO DECARBONISE

57. The timescales for building out new, large-scale generation projects are generally long. Those in planning today may not generate their first MWh of carbon-free electricity for a further 5 or more years. However the need for decarbonisation grows stronger each year, because every year during which no action is taken, more carbon is released into the atmosphere, global temperatures rise and the global warming effect accelerates. Therefore early action will have a correspondingly more beneficial impact on our ability to meet Net Zero targets than will later action. The Project is already well progressed in development, so can deliver much needed large scale capacity much sooner than other projects moving into development. In June the International Energy Agency (IEA) issued a call to arms on energy innovation, stating that the world “won’t hit climate goals unless energy innovation is rapidly accelerated ... About three-quarters of the cumulative reductions in carbon emissions to get on [a path which will meet climate goals] will need to come from technologies that have ‘not yet reached full maturity” [17]. DNV GL expressed this observation in a different way: "Measures today will have a disproportionately higher impact than those in five to ten years’ time” [18].

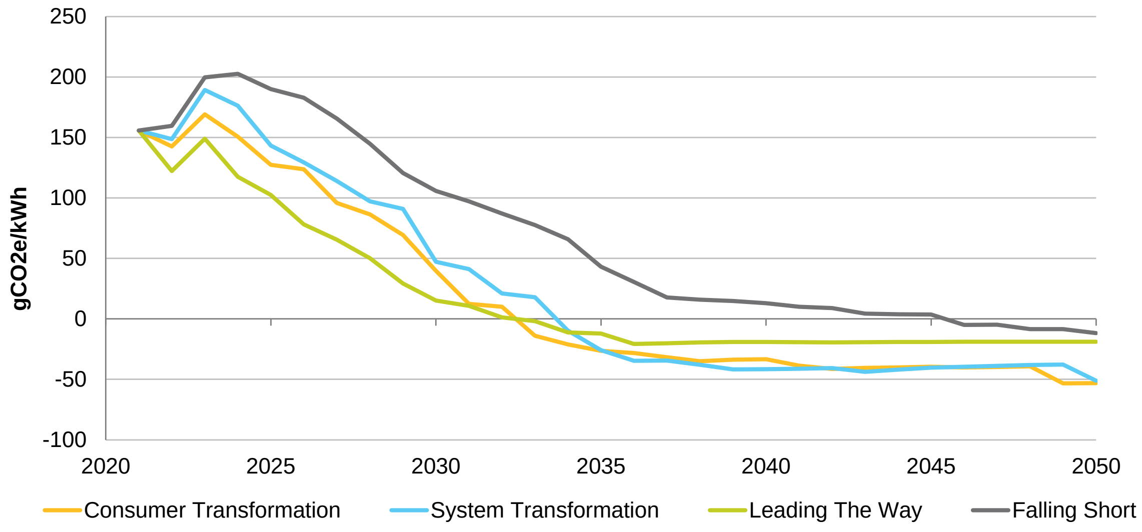

Figure 3-4: Power generation emissions must reduce to negative in the early 2030s in order to meet 2050 Net Zero targets

[107]

58. **Section 4.3** will explain that the pathway for both Scotland and the UK to achieve Net Zero must involve wider transitions outside of the power generation sector. Therefore, the power generation sector must first decarbonise in order to enable the successive decarbonisation of transport, industry, agriculture and the home. While the CCC have suggested that this is already the case in Scotland [15] they have also noted the significant progress required in decarbonising other Scottish sectors, and therefore new low carbon generation capacity is required in Scotland in order to meet additional demand for electricity. Not only will new low carbon generation in Scotland reduce electricity imports to Scotland from the rest of the UK (which has higher average carbon emissions than indigenously generated Scottish low carbon generation) but also will act to reduce the UK's average power sector carbon emissions further. NGESO analysis points to the requirement to reduce emissions from the UK power generation sector to below zero in the early 2030s, as shown in **Figure 3-4**. The scale and pace of change required within this sector, in order to meet a negative emissions target, is immense.

59. Put simply, the urgency with which the power sector is required to be decarbonised is immense and actions must proceed with unrelenting pace. Any delay in reducing carbon emissions today results in more carbon to be emitted to the atmosphere, and global temperatures will rise. The speed with which subsequent carbon emissions must be halted therefore increases, or else the Paris Agreement aim of 1.5°C temperature rise versus pre-industrial levels comes under threat. A rise in global temperatures above 1.5°C comes with the potential for irreversible climate change, the potential for widespread loss of life and severe damage to livelihoods, and an urgent increase in the deployment of adaptive technologies to protect human existence from climate change. Any delays incurred now, make the challenge increasingly more difficult for the years ahead.

60. The UK Industrial Decarbonisation Strategy [19] clearly states the objective for the 2020s, which “will be crucial ... to lay the bedrock for industrial decarbonisation. Over the next decade ... the journey of switching away from fossil fuel combustion to low carbon alternatives such as hydrogen and electrification [will begin, alongside] deploying key technologies such as carbon capture, usage and storage”. In conclusion, to address the ongoing climate emergency, it is critical that the UK develops a large capacity of low carbon generation, and it is critical that this development occurs urgently – in the near-term and not just later – to facilitate wider decarbonisation actions. It is also important for schemes with long development timescales to continue progressing their plans to achieve carbon reduction in decades to come.

61. Developments with the proven ability to achieve savings in this decade, and even more importantly in the early part of this decade, must be consented. It is these developments which are most critical to keeping the world to its required carbon reduction path. An actual, potential or aspirational pipeline for longer term low carbon generation schemes presents additional opportunity for future decarbonisation, but does not present a valid argument against consenting and developing projects with proven near-term deliverability, and dependable decarbonisation benefits.

62. The Project is a viable proposal, with a strong likelihood of near-term deliverability, which will achieve significant carbon reduction benefits through the deployment of a proven, low-cost technology in a very suitable location. As such, the Project possesses exactly those attributes identified as being required both in the near-term and in the future in order to continue to make material gains in carbon reduction.

3.4. CURRENT SCOTTISH POLICIES TO MEET NET ZERO

63. Scotland has declared a climate emergency. As host of the Conference of the Parties 26 (COP26), held in Glasgow in November 2021, Scotland demonstrated its position of international leadership on climate change. In August 2021, the Scottish First Minister sent a letter to the Prime Minister [20]. The letter confirmed Scotland’s position at the “forefront of global efforts to achieve the aims of the UN Paris Agreement”; recognised that climate change, as an inherently global issue, “can only be addressed through co-ordinated international effort and working with others” and urged “all of us who hold positions of leadership to consider what more we can, and must, do to meet [the challenge to limit global temperature rise to 1.5°C in the longer term]”. Scotland has established legally binding targets to meet Net Zero by 2045 at the latest with a world-leading interim 2030 target (which is also Scotland's legally binding indicative Nationally Determined Contribution) of a 75% reduction in emissions against a 1990/95 baseline [7]. Scotland's updated Climate Change Plan [21] sets out how Scotland will deliver that ambition. Scotland's targets and delivery plans are reflected in the UK's NDC commitments and as such Scotland is a critical contributor to the achievement of the wider UK’s NDC commitments.

64. Scotland has progressively established policy positions related to climate change and the delivery of a just transition to incorporate and embed low carbon living into its social and environmental fabric. The Scottish government also recognises the benefits associated with capturing opportunities for growth in offshore wind and related services, including for domestic and international deployment. Since launching the Offshore Wind Sector Deal in March 2019, the Scottish and UK governments have worked together with the offshore wind sector to make progress on delivering the commitments that it contains. The Scottish government is represented across all main Sector Deal work streams, and is working closely with the UK government to deliver a number of key outputs from the Sector Deal because delivering against the Sector Deal commitments will help unlock Scotland's potential [22].

65. Scottish Energy Strategy (2017) [23] established 2030 whole-system targets for Scotland. These were:

- The equivalent of 50% of the energy for Scotland’s heat, transport and electricity consumption to be supplied from renewable sources; and

- An increase by 30% in the productivity of energy use across the Scottish economy.

66. Scotland's overall approach to energy within the context of Net Zero is driven by the need to decarbonise the whole energy system, in line with emissions levels set out in the Climate Change (Scotland) Act. The strategy recognises that “No-one can be certain what that future system will look like. However, we should be confident and ambitious about what we can achieve and deliver over the short to medium term, and focus on the areas where we know there are likely to be low or no regrets options.” A framework for the categorisation of options as being “low or no regrets” is included at **Section 3.6**.

67. Future uncertainty in energy system evolution is modelled through two future scenarios: an “electric future” and a “hydrogen future”. In the electric future scenario, electricity generation accounts for around half of all final energy delivered. Electricity demand is consequently 60% higher than it was in 2015 and Scotland remains an integral part of the GB electricity system. In the hydrogen future, hydrogen is produced from strategically placed electrolysers and Steam Methane Reformation plants with Carbon Capture and Storage (CCS). While the strategy acknowledges that Scotland’s energy system in 2050 is unlikely to match either of these scenarios, it recognises that it will probably include aspects of both. Against this context, the development of a large, deliverable, cost-efficient offshore wind asset is a low regrets enabler of both.

68. The strategy describes how the Scottish Government will continue to champion and explore the potential of Scotland’s huge renewable energy resource, and its ability to meet local and national heat, transport and electricity needs – helping to achieve Scotland's ambitious emissions reduction targets. The strategy also places a firm emphasis on the energy sector’s economic role, benefits and potential, from established technologies to those that are new or still emerging. Scotland continues to lead global efforts to decarbonise and tackle climate change, and to be recognised internationally for doing so.

69. In 2021, Scottish Government released a position statement which provides an update on those policies set out in the Scottish Energy Strategy (2017). It reinforces Scottish commitment to remain guided by the key principles set out in Scotland’s Energy Strategy in 2017 and the importance the Scottish Government attaches to supporting the energy sector in its journey towards Net Zero. Scotland's Energy Strategy Position Statement [24] describes the continued growth of Scotland’s renewable energy industry as fundamental to enabling the creation of sustainable jobs as well as enabling the transition to net zero. The Scottish Offshore Wind Policy Statement [22] and Sectoral Marine Plan for Offshore Wind Energy in Scotland [25] describe the importance of offshore wind to Scotland’s economy.

70. The Scottish Offshore Wind Energy Policy Statement sets out Scotland's ambition to capitalise on the potential that offshore wind development can bring, and the role that the technology could play in meeting Scotland's commitment to reach net zero by 2045. It explains that Scottish offshore wind generation will play a vital part in helping Scotland meet its hugely challenging climate change targets, effectively and affordably, while taking into account wider environmental factors and the interests of other users of the sea. Offshore wind is stated as being one of the lowest cost forms of electricity generation at scale, offering cheap, green electricity for consumers. It is also recognised in the Scottish Offshore Wind Energy Policy Statement, that offshore wind has the important potential for connection with green hydrogen production at scale, which adds another potential layer to Scotland’s rich energy portfolio. The Scottish Offshore Wind Policy Statement supports the development of between 8 and 11GW of offshore wind capacity by 2030, and the Sectoral Marine Plan supports the Scottish government's view that this capacity of offshore wind capacity is possible in Scottish waters by 2030. This Plan recognises that Scottish waters offer significant potential to maximise opportunities to deliver a green recovery, meet Scotland's ambitious targets for Net Zero and build a Blue Economy (defined by the World Bank as the “sustainable use of ocean resources for economic growth, improved livelihoods, and jobs while preserving the health of ocean ecosystem”). The Plan provides the framework for the pivotal role that offshore wind energy will play in redeveloping Scotland’s energy system over the coming decades.

71. However the Sectoral Marine Plan also recognises that as the amount of planned and constructed offshore wind development increases, opportunities to install offshore wind farms close to shore and/or in shallower waters will decrease, resulting in the need to explore opportunities to develop sites located further offshore and/or in deeper waters in order to capitalise on the potential that offshore wind offers to Scotland. The Sectoral Marine Plan provides the strategic framework for the first cycle of seabed leasing for commercial-scale offshore wind by Crown Estate Scotland (CES), the “ScotWind” leasing round, for which Plan Options have been identified across four deeper water regions (see **Figure 3-5**). Results of the ScotWind leasing round were announced in January 2022 and an analysis of the results is at **Section 3.7**.

72. Offshore wind developments which are sited either further offshore or within deeper water locations are described in the Sectoral Marine Plan as posing technical and financial constraints which are “new” - i.e. are not present in closer to shore and/or shallower water developments. Such constraints will need to be overcome in order to secure the success of deeper water projects.

73. Scotland's Climate Change Plan 2018 - 2032 (published in 2018) was updated during 2020 [21]. It sets out in detail the role that electricity generation will have in the wider energy system and restates Scotland's commitment not only to deliver to its decarbonisation targets, but also to continue to ensure a future with a sustainable security of electricity supply. The update states that carbon capture and storage is essential to reach net zero emissions and includes the focussed contemplation of negative emission technologies and hydrogen to deliver clean cross-sector energy supplies. Specifically, the update envisions that in 2032, at least 50% of Scotland's energy demand across heat, transport and electricity will be met from renewable sources; and that there will be a substantial increase in renewable generation particularly through new offshore and onshore wind capacity. Passenger travel by rail and private road transport will also be largely decarbonised and home energy use will also be on a path to the adoption of electricity-based solutions for heat which take advantage of the large potential for growth of onshore and offshore wind capacity in Scotland.

74. Recognising that the decarbonisation of heat, industry and transport are now priorities and require a broader range of technologies, strategies and energy systems, Scotland's Hydrogen Policy Statement [26] recognises the abundance in Scotland of the ingredients in green hydrogen production - water and wind - and seeks to enable Scotland to become producer of the lowest cost hydrogen in Europe by 2045. The scale of the hydrogen market depends on its cost, so driving down the cost of offshore and onshore wind electricity production will be key to cost-effective green hydrogen production. Recognising that large scale renewable hydrogen production may also provide essential energy balancing and flexibility functions to integrate the expected large increases in offshore wind into the UK energy system, Scottish Government will work with the UK Government to ensure alignment of policies and to ensure that market mechanisms are developed in tandem to reflect this system need.

75. Scotland currently opposes the build of new nuclear stations using current technologies because of the poor value for consumers that the Scottish Government believes they provide. However, the Scottish Government recognises an increasing research and industry interest in the development of new nuclear technologies such as Small Modular Reactors. Scotland's policy position is therefore is that it has a duty to assess all other new nuclear technologies based on their safety, value for consumers, and contribution to Scotland’s low carbon economy and energy future.

3.5. CURRENT UK POLICIES TO MEET NET ZERO

76. The UK’s NDC draws on the following policy positions, some already in place and others in development or to be developed.

77. The Clean Growth Strategy [2] contains UK Government’s current policies and measures to decarbonise all sectors of the UK economy through the 2020s and beyond. Of particular

relevance to this Statement of Need, are: the roll out of low carbon heating to UK homes; accelerating the shift to low carbon transport; and delivering clean, smart and flexible power, including the development and delivery of an ambitious Sector Deal for offshore wind.

78. In March 2019 the UK government announced its ambition to deliver at least 30GW of offshore wind by 2030, as part of the Offshore Wind Sector Deal [27]. The Sector Deal reinforced the aims of the UK's Industrial Strategy and Clean Growth Strategy, which seeks to maximise the advantages for UK industry from the global shift to clean growth, and in particular: "The deal will drive the transformation of offshore wind generation, making it an integral part of a low-cost, low carbon, flexible grid system." The deal paved the way for further ambition in the offshore wind sector. The Prime Minister's Ten Point Plan [28], which aims to "make the UK the Saudi Arabia of wind with enough offshore capacity to power every home by 2030," confirmed the upward revision of the capacity of offshore wind targeted for deployment in UK waters by 2030 from 30GW to 40GW. The Ten Point Plan also advances the UK's electric vehicle charging infrastructure and battery manufacture capability, and targets investment to "make homes, schools and hospitals greener, and energy bills lower".

79. The 2020 Energy White Paper [29] sets out government's strategy to tackle climate change. It explains how the UK "will generate new clean power with offshore wind farms, nuclear plants and by investing in new hydrogen technologies ... [using] this energy to carry on living our lives, running our cars, buses, trucks and trains, ships and planes, and heating our homes while keeping bills low". The Energy White Paper anticipates that onshore wind and solar will be key building blocks of the future generation mix, along with offshore wind, explaining that the UK needs sustained growth in the capacity of these sectors in the next decade to ensure that it follows a pathway which will meet net zero emissions in all demand scenarios by 2050. Key policy statements include eliminating the use of natural gas to heat our homes; ensuring that clean electricity becomes the predominant form of energy while retaining the essential reliability, resilience and affordability of UK energy supply; and decarbonising transport. Specifically, the Energy White Paper reiterates the revised Offshore Wind Sector Deal target of delivering 40GW of offshore wind by 2030, including an ambition to deploy 1GW floating wind in the same timeframe. As a less-established technology, floating offshore wind will undoubtedly require further demonstration projects to drive down costs, pushing its deployment at scale further into the future.

80. Build Back Greener, HM Government's Net Zero Strategy for the UK [30] reiterates the keystone policies included in other publications and commits to take actions so that by 2035, all our electricity will come from low carbon sources, including offshore wind (importantly aligning with the Sector Deal), onshore wind and solar. The strategy recognises the need to deploy existing low carbon generation technologies at close to their maximum potential to reach the sixth Carbon Budget, as well as improving the cost efficiency of offshore transmission networks and cable routes. The strategy describes an approach for the 2020s of taking "no or low regrets" actions, which are defined as those that are cost-effective now and will continue to prove beneficial in future. They include actions taken to reduce demand and avoid locking in to high-carbon solutions, instead pursuing low carbon alternatives to drive deployment at scale. A framework for the categorisation of actions as "no or low regrets" is included at **Section 3.6**.

81. The step change in low carbon infrastructure development required to meet Net Zero has resulted in the publication of revised draft National Policy Statements (NPS) [31, 32] to support planning decisions in England and Wales. Draft NPS EN-1 sets out the Government's policy for delivery of major energy infrastructure, and EN-3 covers both onshore and offshore renewable electricity generation. Given the increasing urgency of action required to combat climate change, the draft NPSs are recognised as being "transformational in enabling England and Wales to transition to a low carbon economy and thus help to realise UK climate change commitments sooner than continuation under the current planning system." The fundamental need for the large-scale infrastructure which draft NPS EN-1 considers remains the legal commitment to decarbonisation to Net Zero by 2050 in order to hold the increase in global average temperature due to climate change, to

well below 2°C above pre-industrial levels. In noting the crucial national benefits of increased system robustness through new electricity network infrastructure projects, draft NPS EN-1 also recognises the particular strategic importance this decade of the role of offshore wind in the UK's generation mix. Offshore wind "presents the challenge of connecting a large volume of generation located beyond the periphery of the existing transmission network" and therefore sets an "an expectation that there will be a need for substantially more installed offshore capacity … to achieve Net Zero by 2050."

82. In April 2022, the UK government published an urgent British Energy Security Strategy (BESS) [108]. While the BESS is not strictly a policy in support of Net Zero, the measures it seeks to encourage do support Net Zero and increase the case for need for the Project. Key points from the BESS are therefore introduced at this point in this Statement of Need.

83. The BESS is relevant to the case for need for the Project because it explains the important energy security and affordability benefits associated with developing electricity supplies which are not dependent on volatile international markets and are located within the UK's national boundaries. The urgency for an electricity system which is self-reliant and not reliant on fossil fuels is enormous in order to protect consumers from high and volatile energy prices, and to reduce opportunities for destructive geopolitical intrusion into national electricity supplies and economics.

84. The BESS raises the UK's ambitious target of 40GW of offshore wind operational by 2030, by 25% to 50GW, up from 13.6GW in July 2022 [107]. Section 9 following provides an overview of the current The Crown Estate (TCE) Project Listings [10], which show that delivery of 53% of the current forward offshore wind pipeline, at the currently proposed capacities, would be required in order to meet the BESS aims.

85. The clear UK Government policy established in the BESS is being delivered in part via the Energy Security Bill, which was introduced to the UK Parliament on 6th July 2022 and as at October 2022 is progressing through Parliamentary process.

86. With increasingly interconnected markets – in electricity as well as source fuels such as coal oil and gas – market shocks can be felt through neighbouring international markets and more broadly. Oil and coal, historically international markets, drive global prices through supply chains which connect source and need and the many markets and exchanges which allow swaps and trades to be transacted across the world. Although gas has historically been supplied through pipeline (i.e. fixed) infrastructure, Liquefied Natural Gas has become increasingly prominent in connecting gas supplies with markets. Gas is now much more of a global market than once it was.

87. In 2021, BEIS unveiled plans to decarbonise UK power system by 2035 by building a secure, home-grown energy sector that reduces reliance on fossil fuels and exposure to volatile global wholesale energy prices [91].

88. The first quarter of 2022 demonstrated how the UK is exposed to volatile energy prices through international energy markets in gas, oil (and its derivatives) and coal. Energy commodity price rises in 2022 have and will continue to filter through to consumer electricity bills. While the UK once was energy independent, it now is dependent on imports of (in particular) oil and gas. The UK's dependency on imports increases its exposure to volatile international prices, particularly when either demand is high in other markets (e.g. a deep cold period in South East Asia in late 2020) or supply is risked through the weaponization of energy supplies, as has been the case since early 2022.

89. In the BESS, the Prime Minister at the time wrote: "If we're going to get prices down and keep them there for the long term, we need a flow of energy that is affordable, clean and above all, secure. We need a power supply that's made in Britain, for Britain." [108, p3]

90. The BESS sets out the immediate need to manage the financial implications of soaring commodity prices in the near term, on households and businesses which are already feeling economic pain as the post-Covid cost of living has risen: "The first step is to improve energy efficiency, reducing the amount of energy that households and businesses need." [108, p5].

91. However the strategy also sets out the long-term goal of "address[ing] our underlying vulnerability to international oil and gas prices by reducing our dependence on imported oil and gas." [108, p6].

92. The BESS aims to:

- Increase the pace of deployment of Offshore Wind by 25%, to deliver up to 50GW by 2030, including up to 5GW of innovative floating wind. Wind will contribute over half the UK's renewable generation capacity by 2030. [108, p16];
- Consider all options, including Onshore Wind, through the improvement of national electricity network infrastructure and support of a number of new English projects with strong local backing, so prioritising "putting local communities in control" of local onshore solutions. Repowering of existing onshore wind sites is also under consideration. [108, p18];
- Support a 5-fold increase in deployment of solar technology by 2035, recognising the abundant source of solar energy in the UK and an 85% reduction in cost over the last ten years, of solar power;
- Increase UK plans for deployment of civil nuclear to up to 24GW by 2050 – three times more than operational capacity in 2022, and representing up to 25% of our projected electricity demand. This includes the intention to take one project (Sizewell C) to Financial Investment Decision (FID) during the current Parliament, and two projects to FID in the next Parliament, including Small Modular Reactors, subject to value for money and relevant approvals. [108, p21]. The selection process for further UK projects is anticipated to be initiated in 2023 [108, p22]; and
- Double the UK ambition for hydrogen production to up to 10GW by 2030, with at least half of this from electrolytic hydrogen [108, p22], facilitated by bringing forwards up to 1GW of electrolytic hydrogen into construction or operational status by 2025.

93. Section 4.5 of this Statement of Need describes the electrification of GB homes as a key driver of future electricity demand. The BESS pursues this aim with increased vigour: electrification is a key measure not only for decarbonisation but also for energy security and affordability reasons. In the near-term, the BESS sets out a high-level action plan to upgrade the energy efficiency of at least 700,000 homes in the UK by 2025, and to ensure that by 2050 all UK buildings will be energy efficient with low-carbon heating. Further, the BESS sets out an intent to phase out the sale of new and replacement gas boilers by 2035, thereby furthering the electrification of heat in homes. [108, p12].

94. The BESS also notes the improved cost competitiveness of electrically powered heat pumps which can displace natural gas from use in homes and buildings. Government is targeting 600,000 heat pump installations per year by 2028 and aims to expand heat networks and designated heat network zones to further the electrification of home and commercial heating. A "Rebalancing" of the costs placed on energy bills away from electricity is also intended to incentivise electrification across the economy and accelerate consumers and industry's shift away from volatile global commodity markets over the 2020s. [108, p12].

95. Supporting the rollout of electric vehicles as part of Government's electric vehicle infrastructure strategy, will also increase demand for electricity in future years, from potentially as early as 2023.

96. The Society of Motor Manufacturers and Traders reported a 100% increase in Battery Electric Vehicle (BEV) sales in the UK in the year-to-date (end March-22) versus the same period last year, and over 16% of all new vehicle purchases in the UK in March-22 were BEV. Ongoing grants (available until at least March-23) and cheaper running costs are anticipated to continue to push EV market share over the coming years. [109].

97. Government is also facilitating the adoption of electricity into transport through its Electric Vehicle Infrastructure Strategy (March 22) which sets out the expectation, by 2030, of there being around 300,000 public chargepoints as a minimum in the UK [up from just 30,000 in

the first quarter of 2022], but there potentially being more than double that number, delivering “Effortless on and off-street charging for private and commercial drivers" [110, pp4&5].

98. The rollout of a significantly higher capacity of renewable generation is therefore required to meet decarbonisation as well as energy security aims and the urgency for delivery as increased.

99. Carbon Capture Usage and Storage (CCUS) retains its important potential role in a decarbonised economy. Government aims to deliver on their £1 billion commitment to four CCUS clusters by 2030, with the first two sites selected in the North East and North West currently proceeding through Track 1, with the Scottish Cluster in reserve. [108, p15].

100. CCUS retains its important place within the BESS although it has not attracted a more prominent role relating to energy security than that with which it has already been tasked in the Energy White Paper and the Prime Minister’s Ten Point Plan, This is because CCUS is an enabler of eliminating carbon emissions from fossil fuel use, rather than providing a power source which does not require fossil fuels as an input energy source.

101. Nuclear is poised for its third UK renaissance, but would only deliver its first megawatthours from the middle of the 2030s – and due to prevalent Scottish policy – not in Scotland. The UK’s nuclear renaissance of the 2000s resulted in the construction (currently ongoing) of just one nuclear power station, Hinkley Point C, which would currently not be completed until June 2027 with the possibility of a further 15-month delay to September 2028 [111].

102. Although the BESS includes an aim to achieve a FID at one more nuclear power station by the end of the current parliament, it is important to recognise the significant political, financial and delivery risk associated with nuclear development. There is a long road ahead before any clean energy generated from nuclear technologies can be “banked" in the fight against climate change.

103. The BESS recognises the critical role of renewables in accelerating the transition away from fossil fuels, and notes that renewable capacity in the UK is currently set to increase by a further 15% by the end of 2023. However further and faster actions are required to increase our national energy security and reduce our dependency on fossil fuels, and the exposure consumers currently have to their volatile prices.

104. Accelerating the domestic supply of clean and affordable electricity also requires accelerating the connecting network infrastructure to support it, and the BESS also includes measures designed to increase the pace of improvements and enhancements to the NETS to enable the connection of the required level of renewable generation capacity both within the 2030 timeframe and beyond.

105. Work has already commenced in this regard with the formation of a Future System Operator (a national organisation taking over the role of Electricity System Operator, currently carried out by National Grid) and programs of action such as the annual Network Options Assessment (NOA) and (ongoing at the time of writing) Holistic Network Design (HND), part of the Offshore Transmission Network Review, which aims to develop a strategy to coordinate interconnectors and offshore networks for wind farms and their connections to the onshore network and bring forward any legislation necessary to enable coordination. See also **Section 9** below.

106. The path to national control of nationally generated electricity and reduction of exposure to the volatile prices associated with international supplies of fossil fuels, and the path to a low-carbon energy system of the future, which minimises potentially catastrophic changes to the global climate, are the same path.

107. The BESS provides an increase to the requirements for both the scale and the urgency of delivery of new low carbon generation capacity, by refocussing the requirement for low-carbon power for reasons of national security of supply and affordability, as well as for decarbonisation.

108. The increase in ambition for hydrogen generation as set out in the BESS further supports the development of greater capacities of renewable generation and with greater urgency.

109. Consenting the Development will be an essential boost to meeting the urgent need for low-carbon sources of electricity in the UK to meet growing electricity demand and the BESS ambitions for electrolytic hydrogen production by 2030.

3.6. LOW AND NO REGRETS OPTIONS

110. Both the Scottish Energy Strategy [23] and the Net Zero Strategy for the UK [30] introduce the concept of "low and no regrets" options and actions. In 2021, the National Engineering Policy Centre (NEPC) authored and published a framework for rapid low regrets decision making for net zero policy [33]. The framework includes a definition for low regrets decisions as "urgent decisions that must and can be made now to have a significant impact on decarbonisation". Such decisions would be expected to unlock pathways towards net zero, provide options and flexibility and not close off options. NEPC's framework includes four essential criteria and one desirable criteria for low regrets decisions, included at **Table 3-1**. Although the framework is designed to be applicable across the UK, it is here proposed that it is applicable also to Scottish decisions for Scotland, and therefore provides support in favour of the case for consent of the Project.

CRITERIA	EXAMPLE
Essential Criteria	
The policy or technology introduced will play a major part in reducing UK carbon emissions.	There is no credible route to a net zero UK which does not require a smart grid.[13] Therefore, decisions which enable the development of a smart grid would meet this criterion. The same can be said for energy demand reduction and energy efficiency, which are included in all credible paths to net zero.
The policy or technology introduced will not result in technological lock-in to high-carbon technologies, instead unlocking low-carbon pathways and making other low-carbon interventions feasible in the future:	Decisions on locations for housing developments can lock in dependence on private transport for decades.[14] Therefore, making decisions that enables housebuilding in locations that are already served by multiple forms of mobility would meet this criterion.
The policy or technology, while incurring costs today, will reduce costs for the future. Note: It is important here to account for the costs associated with a failure to decarbonise as well as any identifiable positive co-benefits.	Modular infrastructure which may be more expensive in the short term but that can be more easily retrofitted, adapted or disassembled in the future (including for re-use of constituent parts and components) can provide carbon and cost savings over the whole life-cycle of the infrastructure asset for marginal additional up-front expense. Decisions that enable the building of such infrastructure and consequently enable reduced carbon and economic costs over the longer term, would meet this criterion.
Where the policy or decision involves the use or consumption of a limited resource, the policy or decision makes or facilitates the best use of this resource. For example, prioritising uses where no other low-carbon option feasibly exists.	Hydrogen has been suggested to have a wide range of applications. However, there are certain applications, such as industrial processes, where there are fewer low-carbon alternatives to hydrogen. To classify as low regrets, policy decisions would need to ensure that hydrogen (which is likely to be of limited availability for the short- to medium-term) is available to those areas lacking other low-carbon alternatives.
Desirable Criteria	
The policy or technology has clear co-benefits or synergies with other policy objectives, for example, job creation, reduced pollution and impact on conservation and biodiversity.	An early switch away from fossil fuels for urban transport has strong co-benefits in terms of air quality and health.[15] Therefore, decisions that enable a switch to low-carbon transport and as result reduce air pollution would meet this criterion.

Table 3-1: Framework for low regrets decisions

[33]

111. This Statement of Need makes the case that consenting the Project is a no or low regrets decision for Scotland for the following reasons:

- **Section 6.2**, **Section 6.3** and **Section 6.5** illustrate that offshore wind will play a major part in reducing Scottish carbon emissions, and the Project is an essential element of the future Scottish offshore wind project pipeline;
- **Section 5.5** illustrates that rather than locking in high carbon technology, the Project helps lead away from high carbon technology, for example, **Section 4.7** describes the important role of offshore wind generation in the production of green hydrogen in Scotland. Further, **Section 8.4** describes the beneficial effect a large fixed-bottom offshore wind fleet is expected to have on rapidly reducing the costs anticipated for floating offshore wind projects, therefore increasing the pace with which this nascent technology may come to market at scale;
- The Project, as well as supporting future cost reductions in floating offshore wind, will reduce the future cost of electricity to consumers. **Section 8.2** describes how deploying higher capacities of offshore wind will displace more expensive generation technologies from the grid and therefore reduce the marginal price of power in Great Britain;
- The Scottish Offshore Wind Policy Statement sets out Scotland's near-term ambitions for the sector, and the Scottish Offshore Wind Green Hydrogen Opportunity Assessment articulates the important role offshore wind is expected to play in Scotland over the longer term. Seabed generally is in abundance in Scotland, however there are no seabed areas other than the proposed location of the Proposed Development which are of the required size and characteristics to host 4.1GW of low carbon offshore wind generation. The proposed seabed area should therefore be used for the important purpose of generating significant quantities of low carbon power. **Section 3.7** and **Section 7.9** describe that, if consented, the Project would become operational earlier than any other available options; that no other available options have been demonstrated to attract less environmental harm than the Proposed Development, and the Proposed Development is likely to be completed for a lower cost than other options of the same capacity, due to the water depth and seabed structures at the location, its proximity to viable grid connection points, and achievable scale.
- The Project has clear co-benefits in that the power it would generate would increase indigenous Scottish low carbon electricity sources, for use in the substitution of fossil fuels from use in the heat and transport sectors as described in **Section 4**.

3.7. THE SCOTWIND LEASING ROUND

112. The primary purpose of ScotWind Leasing is to grant property rights for seabed in Scottish waters for new commercial scale offshore wind project development. Marine Scotland, part of Scottish Government and the planning authority for Scotland's seas and custodian of the National Marine Plan, leads in the identification of potential areas suitable for commercial scale offshore wind development.

113. The first cycle of ScotWind Leasing - the first in a decade - opened for registration in 2020. Up to 8,600 square kilometres of Scottish seabed was available across multiple Plan Option Areas, with the expectation that ultimately, in total up to 10GW of offshore wind capacity would be developed within them [34]. Scotland's Sectoral Marine Plan for Offshore Wind Energy [25] noted that limiting the scale of development under the Plan to 10GW was required to reduce or offset the potential environmental effects of development. The Option Period associated with each lease is 10 years, after which time a lease cannot be requested so a project cannot be constructed.

114. The first leasing round concluded in January 2022 with the award of 17 leases covering 7,343 square kilometres and a maximum potential capacity estimate of 24.8GW.

115. For comparison, the Proposed Development is proposed to install 4.1GW of offshore wind over a total area of 1,314 square kilometres of varied seafloor morphology with sea depths ranging from 32.8m to 68.5m (measured against Lowest Astronomical Tide). The average sea depth across the Proposed Development Array Area is 51m.

116. By awarding leases for significantly greater generation capacity development than the 10GW limit established in the Sectoral Marine Plan, CES has increased its ambition for the delivery of new offshore wind projects but also has allowed for attrition rates which will be likely due to the nature of the leasing and development processes. Scottish Renewables recommended a 30% MW attrition rate in their 2018 “An industry view of the Draft Sectoral Marine Plan for Offshore Wind” in order to reflect the more challenging conditions in Scottish offshore waters relative to the rest of the UK, particularly regarding water depth, ground conditions and grid charges.

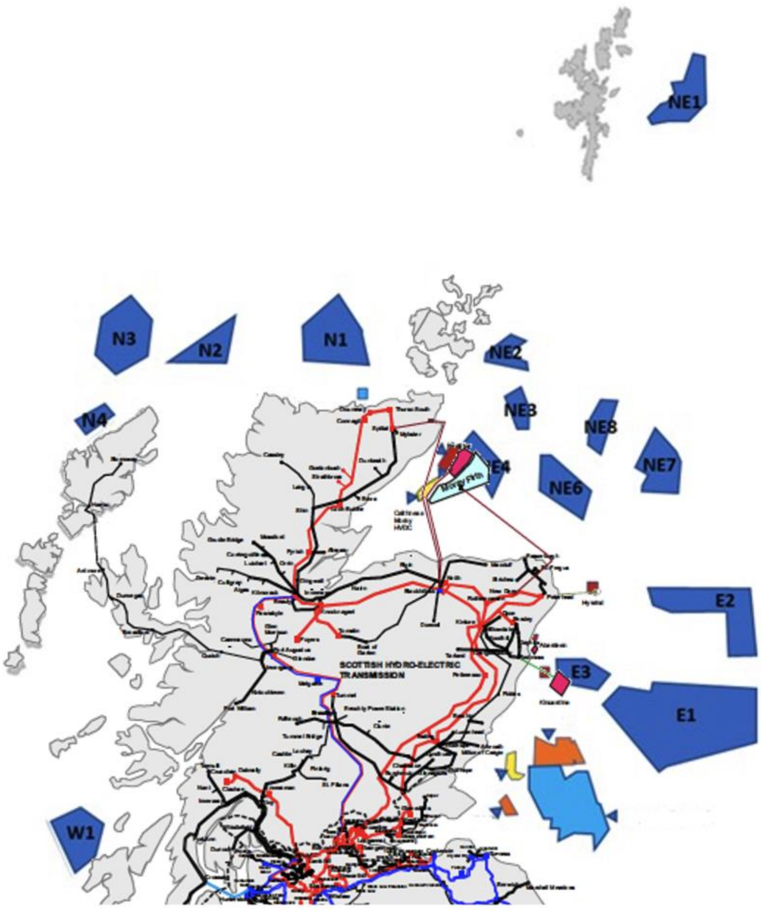

Figure 3-5: ScotWind Lease Round 1 Plan Option Areas and Scotland's onshore transmission network

Adapted from [35, 36, https://www.offshorewindscotland.org.uk/scottish-offshore-wind-market/]

117. ScotWind Leases have been awarded to 9.8GW of fixed bottom offshore wind, 14.6GW of floating offshore wind (FOW), and 0.5GW in a Plan Option Area with mixed technology. Although the Plan Option Areas with fixed bottom technology are generally located closer to shore than those with floating technology, 6.4GW of fixed bottom wind is proposed in areas with average sea depth greater than 60m, a depth which is technically achievable for fixed bottom wind, but potentially with greater complexity and therefore associated cost and time, than installation in shallower seas. 3.4GW of fixed bottom offshore wind is proposed for Plan Option Areas with a depth comparable to that of the Proposed Development Array Area (<60m).

118. The total Development Plan Option area identified in the Sectoral Marine Plan covered 12,810 square kilometres across 16 identified areas, with a maximum development scenario of 26GW, likely delivering in the early 2030s. The significant majority of successful projects marry up to entries on the TEC Register [16], leading to the conclusion that offers for sufficient grid connection capacity to accommodate wind capacity delivered under ScotWind Lease Round 1 have already been issued to and accepted by developers. The majority of grid connection dates are currently scheduled for 2033.

119. Large (>100MW) generators generally require connection to higher voltage (>=275kV) circuits to be able to export their power in a safe secure and efficient manner. **Figure 3-5** shows an overlay of Scotland's onshore transmission network on the locations of the Plan Option areas, with 275kV circuits coloured red and 400kV circuits coloured blue. It is clear that some Plan Option Areas are less accessible to suitable grid connection points than others, and in the detailed studies to follow a further level of attrition may occur. In any event, longer grid connections tend to be more expensive and the reliability of High Voltage DC (HVDC) cables decreases with their length. **Section 7.8** also provides an overview of the outcomes of National Grid’s Holistic Network Design the challenges associated with connecting generation above National Grid boundaries in Scotland, related to grid constraints and the grid strengthening required to enable larger power flows from north to south in future years.

120. A comparison of the number of different planning considerations highlighted as potentially significant in Scotland's Sectoral Marine Plan for Offshore Wind Energy identifies that some Plan Option Areas require detailed study and analysis to understand and mitigate potential harm arising from development, a process which in at least some cases may take many years.

121. Potentially significant planning considerations include visual amenity (both seascape and landscape impacts), shipping and navigation, MoD impacts (including facilities and radar interactions), fish spawning and habitation as well as commercial fishing grounds, bird populations (including five areas to the north east which have been classified as being “subject to higher levels of ornithological constraint”, benthic seabed areas and in one instance, noise (due to proximity to human populations). Many of these considerations are common across multiple Plan Option Areas, and some are common also with factors which have been addressed in the process of preparing a planning application for the Proposed Development.

122. A summary of this qualitative analysis is included at **Table 3-2**.

123. The following assessment criteria drive the colour coding in **Table 3-2**.

- Average Sea Depth. Green: Mainly <60m. Amber: mainly 60 - 100m. Red: mainly >100m. FOW not graded.
- Planning Considerations. Green: <3 significant topics. Amber: 3 or 4 significant topics. Red: 5 or more significant topics. Gravity of significant topic not assessed.
- Grid Connection. Green: shortest distance from Plan Option Area to closest point of connection (POC) on existing 275kV or 400kV point of connection (POC) is comparable to the Project’s Branxton POC distance. Amber: shortest distance is greater than the Project’s Branxton POC distance. Red: shortest distance is significantly greater than the Development's POC distance. Actual cable route not considered.

Assessment of ScotWind Lease Round 1 Plan Option Areas relative to each other and to the Development

Plan Option Area	Area (sq Km)	Capacity (GW)	Type	Average Sea Depth	Planning Considerations	Grid Connection Assessment	MW / sq Km
E1	1,998	6.7	Mixed				3.4
E2	1,060	2.8	Float	NA			2.6
E3	187	1.0	Fixed				5.4
NE2	200	1.0	Float	NA			5.0
NE3	256	1.0	Float	NA			3.9
NE4	429	1.0	Fixed				2.3
NE6	134	0.5	Float	NA			3.7
NE7	684	3.0	Float	NA			4.4
NE8	330	1.0	Float	NA			2.9
N1	657	2.0	Fixed				3.0
N2	390	1.5	Float	NA			3.8
N3	103	0.5	Mixed				4.8
N4	161	0.8	Fixed				5.2
W1	754	2.0	Fixed				2.7
The Development	1,314	4.1	Fixed				3.1

Table 3-2: Assessment of ScotWind Lease Round 1 Plan Option Areas relative to each other and to the Project

[25, 35, 16, Author Analysis]

124. Against this context, the results of the first leasing round broadly match the required maximum development scenario (24.8GW for leases offered vs. 26GW identified) but on a smaller leased Development Plan Option area (7,343 vs. 12,810 square kilometres) suggesting that a degree of attrition has already occurred in the selection of suitable seabed. However this has been partially offset by an increase in potential capacity installed per square kilometre. Indeed, the development scenarios were predicated on the installation of 2MW generation capacity per square kilometre, however the offered leases average 3.4MW generation capacity per square kilometre.

125. The challenges of sea depth, grid connection and environmental impacts suggest that further attrition is possible in Lease Round 1 projects over the coming years – i.e. that not all of the issued leases (24.8GW) will be delivered.

126. The environmental, technical and decarbonisation characteristics and impacts associated with the Proposed Development are well advanced in their understanding in relation to comparable assessments of the ScotWind Lease Plan Option Areas, and the Proposed Development therefore compares well in terms of the risk associated with its delivery (quantum and timing) against the possible future projects progressing under ScotWind Lease Round 1.

127. Further, there is no project or collection of projects coming forward under ScotWind which will deliver a comparable capacity of offshore wind generation as the Project (4.1GW) with technical, environmental or commercial risk profiles which are sufficiently advantageous relative to those of the Project and which therefore could objectively justify not consenting the Project, given the early stage of detailed feasibility analysis of the ScotWind projects. Therefore the decision to consent the Development will not result in a lock-in to a technology which cannot today guarantee the same decarbonisation benefit for lower environmental or commercial cost as future identified options.

128. Against this context, it is the opinion of the Author of this report, that consenting the Project should be regarded as a low regrets decision.

3.8. CONCLUSIONS ON HISTORICAL DECARBONISATION AND CURRENT POLICIES

129. Progress in UK decarbonisation to date has been achieved by “off plan” means. Renewable generation has delivered more capacity and generated more carbon-free electricity than was foreseen to be required due to the planned development of other low carbon technologies. However nuclear and CCUS have not delivered as was foreseen in the early years of the 2010s.

130. Significant growth has been realised in now proven renewable technologies (onshore & offshore wind, solar) and this has made up for the contributions which nuclear and CCUS were expected to make to decarbonisation.

131. Current decarbonisation plans for the UK and for Scotland rely on the deployment of proven renewable technologies (with offshore wind at the forefront) as well as unproven technologies, including CCUS, hydrogen and (for the UK but not currently for Scotland) nuclear. (Also see **Section 5.6** for an analysis of FOW potential in Scotland and the UK).

132. Scottish and UK policy both recognise an increased urgency in the need for low carbon electricity generation capacity deployment. Action during the 2020s will be critical to meet the 2050 Net Zero target, and electrification is the primary strategy going forwards both to decarbonise the current electricity system and also to provide low carbon energy to decarbonise other sectors, including transport, heat and industry.

133. Lower-risk, short-timescale, large-scale proven-technology generation projects will be well placed to support many aspects of the whole-system solutions required to meet decarbonisation targets.

134. Scotland, itself an instrumental contributor to the UK NDC, has set its own legally binding target of achieving Net Zero by 2045, and of achieving a 75% reduction in emissions against a 1990/1995 baseline by 2030.

- The Scottish Energy Strategy (2017) [23] establishes targets for 2030 to supply the equivalent of 50% of the energy for Scotland’s heat, transport and electricity consumption from renewable sources; and to increase by 30% the productivity of energy use across the Scottish economy.
- The Scottish Offshore Wind Policy Statement [22] supports the development of between 8 and 11GW of offshore wind capacity by 2030.

135. The UK has made international commitments to achieve Net Zero by 2050 and to achieve economy-wide reductions in GHG emissions of at least 68% versus reference year levels, by 2030.

- The Offshore Wind Sector Deal [27] is a critical policy instrument which will drive the deployment of low carbon offshore wind to a target of 40GW of operational offshore wind capacity by 2030, in order to support the UK's NDC commitments;
- Government’s ambition, as described in the BESS, is to increase further the deployment of low-carbon offshore wind to 50GW by 2030, in order to support both the UK’s NDC commitments and improve the UK’s energy security position [108].

136. Scotland holds a position of international leadership on Climate Change. Scottish policies position offshore wind as a key area for economic and environmental growth, and the Scottish government has committed to work with the UK government on climate change actions to support the UK’s wider policy and legal commitments, including meeting the Offshore Wind Sector Deal & 2030 NDC commitments.

137. The 2030 targets are commitments in law. They do not in themselves assure that Net Zero will be delivered, but are critical stepping stones on the way to achieving Net Zero over committed timeframes. Governments and industry must strive hard to meet the 2030 targets in order to continue succeeding against the global climate emergency. However governments and industry must also look beyond the 2030 targets to determine what

actions can be taken today which will de-risk further progress along the path to Net Zero. Not least because there is a duty on the UK government to ensure that the 2050 targets are met. Low carbon solutions must be delivered urgently now, and post 2030, and both the 2020s and 2030s are critical decades during which progress must be made.

138. Whether a development is critical or not in order to achieve Scottish or UK 2030 targets is one element of the justification for its need. A further, equally important justification is the contribution a development will make to future decarbonisation, and the de-risking of future actions which have an identified need but whose delivery is not yet sufficiently assured. Scotland and the UK cannot afford to miss their respective 2030 targets, but they also cannot afford to miss the more demanding targets which are sure to follow after.

139. The need for a development should therefore be assessed both in terms of its contribution to Scotland and the UK's 2030 targets but also its critical contribution to the longer-term climate change Net Zero commitments for Scotland by 2045 and for the UK by 2050.

4. ELECTRICITY DEMAND MUST GROW TO STOP CLIMATE CHANGE

4.1. WHOLE-SYSTEM ENERGY TRANSFORMATION

140. The annual demand for energy from all sources in the UK in 2021 was 1,355TWh, with 20% (272TWh) in the form of electricity [107]. While current projections are that total energy demand must reduce significantly by 2050 in order to meet climate change targets, electricity demand is expected to grow as carbon-intensive sources of energy are displaced by electrification of other industry sectors, and electricity is used to produce other energy vectors (e.g. hydrogen) which will enable the deep decarbonisation of hard to reach sectors. The scale of energy transformation required to deliver Net Zero in the UK is illustrated in **Figure 4-1**.

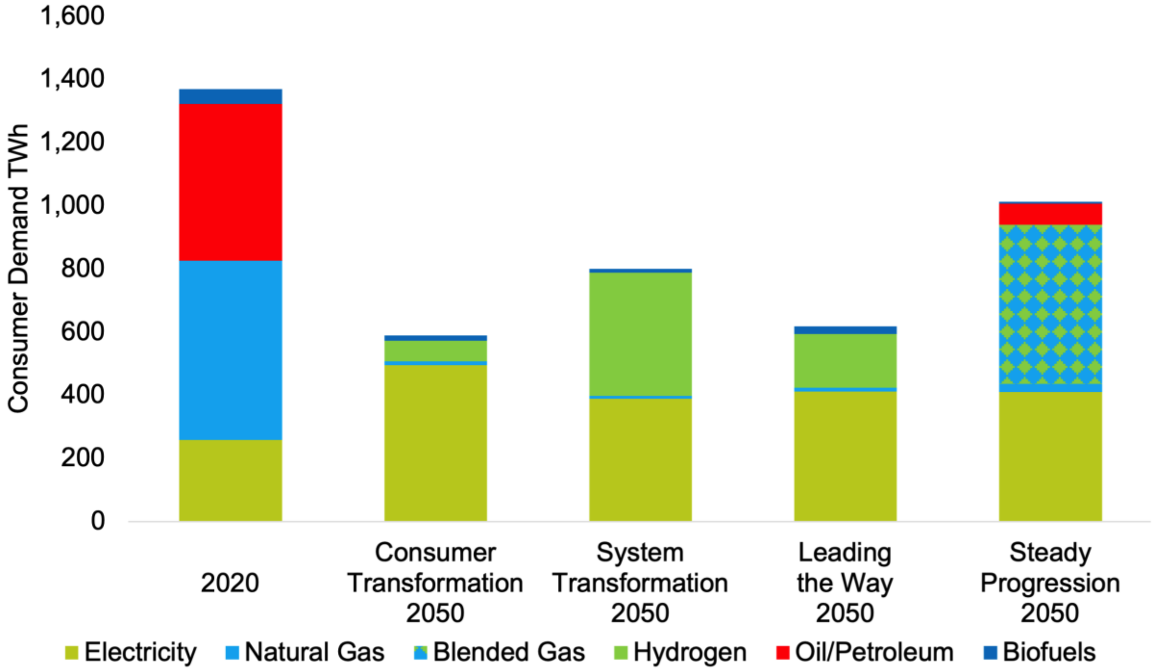

Figure 4-1: Annual UK end consumer energy demand in 2020 and 2050

Adapted from [107]

141. The future characteristics of the UK's energy and electricity demands are described through a set of possible scenarios developed (through industry consultation) on an annual basis by Great Britain's Electricity System Operator and statutory undertaker, National Grid ESO (NGESO). This annual publication is called Future Energy Scenarios (FES), see [13] for the most recent publication. In completing their work NGESO look at a number of inputs including legislation, policy, technology and commercial drivers and consumer behaviour. NGESO state that "All our scenarios consider energy demand and supply on a whole system basis, incorporating gas and electricity across the transmission and distribution networks. We continually develop all aspects of our Future Energy Scenarios process ensuring that the outputs are as rich and robust as possible to provide a sound reference point for a range of modelling activities. This includes extensive stakeholder consultation and detailed network analysis, which enables NGESO to identify strategic gas and electricity network investment requirements for the future".

142. Of the four scenarios shown in **Figure 4-1**, three are compatible with the UK's Net Zero commitments. The fourth, called Steady Progression, does not meet those commitments. FES have been published annually since 2012. Since the 2018 publications, the speed of decarbonisation has been a key feature in each FES. The three scenarios which meet Net Zero follow distinct pathways but each requires significant investment in energy efficiency, electricity decarbonation, and/or new or enhanced energy vectors (e.g. hydrogen). In reality, these pathways are not mutually exclusive, and government and industry are currently pursuing initiatives which cover all possible stepping-stones to Net Zero.

143. **Figure 4-2** shows how sectoral carbon emissions will evolve in NGESO's System Transformation scenario (which meets UK Net Zero 2050) and in Steady Progression (which does not).

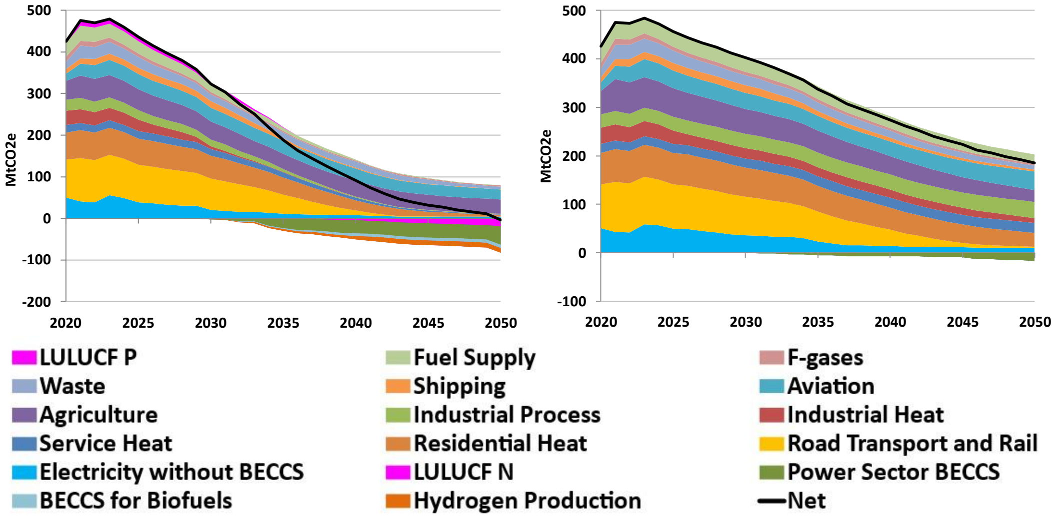

Figure 4-2: NGESO scenarios, showing the importance of a whole-society approach to decarbonisation and low carbon electricity generation

Adapted from [107]

144. An important development in FES since 2020, and a direct result of the increasing urgency of the requirement to meet Net Zero, is the growing prominence of a hydrogen economy in those scenarios which achieve the 2050 requirement. Hydrogen has time been acknowledged as having the potential to facilitate deep and broad decarbonisation by providing "difficult to reach" sectors with access to zero-carbon fuels, and it therefore has been attributed a significant role in achieving Net Zero in the UK and elsewhere. The relevance to the Project of the hydrogen economy, and the potential for hydrogen to play an increasingly important role in the energy ecosystem of the future, is that the increased use of hydrogen as a low carbon energy vector will increase the demand for electricity. For more information see **Section 4.7**.

145. The 2021 FES brings together future operation of existing generators, and future trends in the demand for energy, to conclude that:

- Net emissions from the power sector likely must be net negative from the early 2030s to achieve Net Zero (see **Figure 3-4)**;
- Hydrogen and carbon capture and storage are likely to be required to achieve Net Zero, with in excess of 29TWh of electricity demand required by 2040, and in excess of 95TWh by 2050, for hydrogen production (including electrolysis connected to non-networked offshore wind). This is likely to increase the need for low carbon electricity generation over and above that needed to meet other growth in electrification; and

- Offshore wind is, based on current economics, likely to be the most significant (and one of the cheapest) source(s) of electricity in the 2050 energy mix. A diverse mix of low carbon generation is required to meet national decarbonisation targets.

146. In March 2020 the Energy System Catapult (ESC) published a report, “Innovating to Net Zero” which summarised the results of an update to their national Energy System Modelling Environment [37]. The report considered and evaluated potential pathways to 2050 in order to support the identification of technologies, products and services which will be most important to achieving the Net Zero target. The ESC’s analysis provides a useful independent analysis of the trends described in the FES and therefore provides useful confirmation of some points, while drawing different conclusions on others. The ESC’s analysis adds breadth and depth to the consensus of how best to achieve the Net Zero target. Other professional organisations also share their views of future demand and these are discussed in **Section 4.3**.

4.2. TRENDS IN SCOTTISH AND UK ELECTRICITY DEMAND

147. Scotland has its own legal commitments to decarbonise and has developed an overarching national strategy to deliver those commitments. There are similarities however between UK-wide and Scottish progress to date in decarbonisation; and many principles for delivering further decarbonisation are also consistent between the two nations. **Figure 3-2** and **Figure 3-3** show that electricity supply in Scotland and the UK have evolved in similar ways since 2015, and **Figure 4-3** shows that the demand for electricity in Scotland and the UK have also followed similar trends at the sectoral level although the average annual decline in consumption in Scotland has been at a marginally higher rate than in the UK as a whole. In the domestic sector, Scottish electricity consumption has declined over the period 2005 - 2019 by 1.6% per annum, while the decline in the UK has averaged 1.0%. In the non-domestic (industrial and commercial) sector, Scottish consumption has declined by 1.3% annually while in the UK decline has been 1.1% per year.

148. National strategies for decarbonisation influence future demand. **Figure 4-4** shows that the Scottish strategy for delivering Net Zero is through the displacement of carbon intensive fuels by electricity or by hydrogen. In the first case, the demand for electricity will grow 62% (20TWh) above the 2015 baseline demand, and in the second, assuming that hydrogen production is half green and half blue (see **Section 4.7**) demand for electricity will be 117% (37TWh) above 2015. Applying the same assumptions to data from **Figure 4-3** and **Section 4.2**, implies that UK electricity demand will grow between 50% and 113% above 2015 UK demand.

149. The strategic drivers for future electricity demand evolution in Scotland and the UK, and the high-level strategies which affect demand in both nations are similar. Scottish and UK future energy scenarios anticipate similar levels of electricity demand growth in aggregate over the 2050 timeframe. Through the remainder of this Statement, as is required and for simplicity, only UK-level future demand forecasts are included but it is concluded that any high-level implications of decarbonisation-through-substitution which apply to the UK's decarbonisation challenge, will be equally relevant for Scotland.

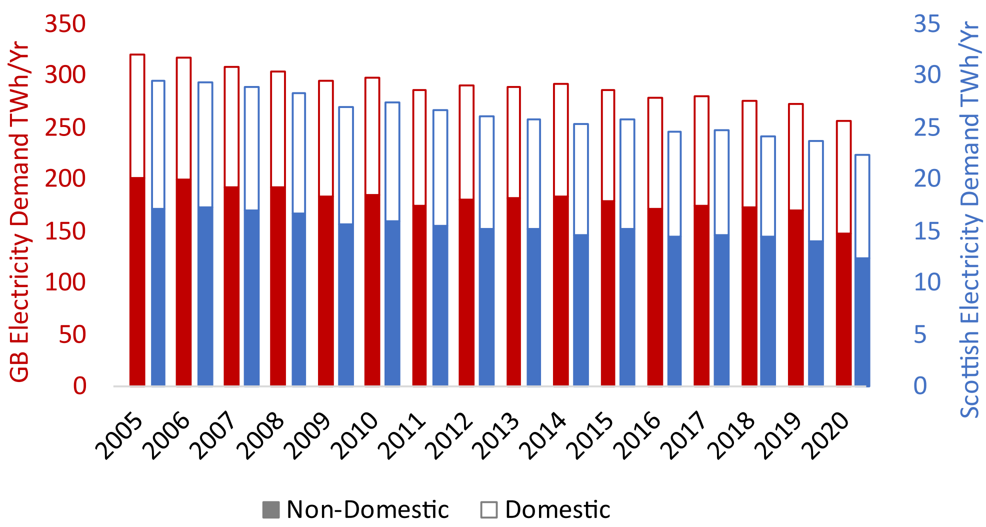

Figure 4-3: Consumer demand for electricity in Scotland and the UK, 2005 - 2020

Adapted from [38]

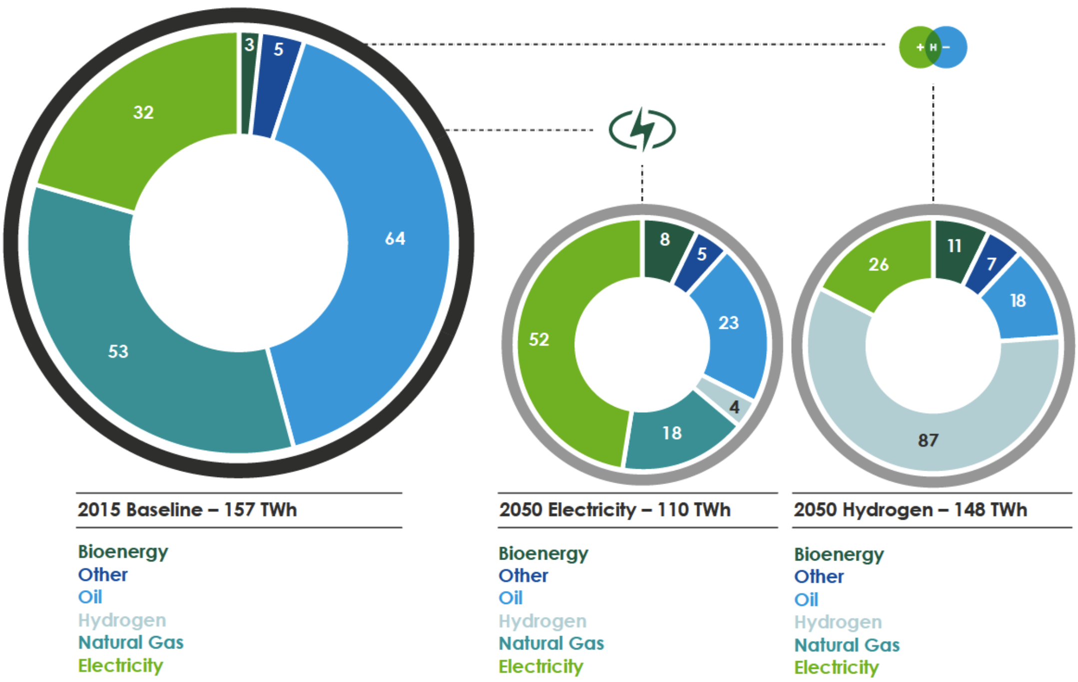

Figure 4-4: Scottish energy flows, 2015 and 2050

[23]

4.3. NET ZERO SOCIETIES WILL USE MORE ELECTRICITY

150. In the 1990s and early 2000s, electricity demand in the UK grew only slowly. Since 2005, demand has fallen. The trend in reducing underlying demand has been influenced by three factors:

- A decline in economic growth rate (particularly with the recession of 2009);
- A reduction in the level of electricity intensity as the UK economy has shifted to less energy-intensive activities; and

- The introduction of energy efficiency measures, especially more efficient lighting within the last seven years.

151. Today's view of future demand remains uncertain, but is growing:

- The switching of sources of final use power for heating and transport from carbon-intensive sources to electricity, the generation of which can be decarbonised using technologies already available today, will put upward pressure on demand;
- The least-cost energy efficiency measures, such as introduction of low-voltage LEDs for lighting, have now been implemented across business and domestic sectors; and
- Economic restructuring in the UK away from manufacturing to a service-based economy has largely occurred, however the growth of new high-technology and highly skilled manufacturing, both contributing to national economic growth and prosperity, is likely to place additional pressures on the electricity sector.

152. These observations are consistent with those made by NGESO in FES 2020 [39], FES 2021 [13] and FES 2022 [107]. Each FES analyses four scenarios. Following the UK's adoption of Net Zero as a legal target, NGESO have described in each annual FES, three scenarios which meet Net Zero and one (called Falling Short – previously Steady Progression) does not.

153. There are many expert projections of electricity demand in 2050, and the majority of forecasts are for UK electricity demand to increase (from today's level of circa 300TWh). The amount by which demand is forecast to increase varies according to the level of decarbonisation of non-energy sector demand, and the source for that decarbonisation. For example hydrogen is an important energy vector which is primed to deliver the decarbonisation of hard to reach sectors of transport, space heating and heavy industry. Off-grid production of green or blue hydrogen would require the generation of low carbon power but this may be counted in addition to the electricity transmission system demand projections for 2050 presented below:

- The UK National Policy Statements foresaw a doubling of current demand [40], i.e. to circa 600TWh;
- NGESO present a range from 565 – 716TWh, excluding electricity demand for the purposes of producing hydrogen [107];
- The National Infrastructure Commission forecasts 465 – 595TWh [41];
- The Energy Systems Catapult forecasts 525 – 700TWh [37];
- The CCC's sixth carbon budget presents a range from 550 – 680TWh [3];
- The BEIS impact assessment for CB6 presents a range from 610 – 800TWh [42]; and
- The 2020 Energy White Paper presents a range from 575 – 665TWh [29].

154. The ESC underpin their scenarios with the premise that "Net Zero requires switching to low carbon technologies wherever we can" including hard-to-treat activities as well as carbon sequestration. Critically the ESC conclude that Net Zero requires society-wide adoption of low carbon heating and transport technologies as well as continuing to drive "upstream" changes in the electricity mix and reduced energy use in industry [37].

155. In the ESC scenarios, population growth and societal habits drive underlying demand growth, with either centralised or society-led decarbonisation supporting their demand forecasts. Industrial demand for energy is forecast to decrease by between 20% and 30% due to a move away from energy-intensive industry and an adoption of energy efficiency measures wherever possible.

156. Further similarities between the ESC report and the FES are that a hydrogen economy must be created to decarbonise hitherto "hard to reach" end uses; the production of hydrogen through electrolysis may act to increase further electricity demand; and the transport sector, which also requires fundamental transformation, will need to be a strong adopter of

hydrogen (for heavier freight) if emissions are to fall. Other predictions, including those which inform the Scottish Energy Strategy [23], are also closely aligned with these macro trends.

157. On the basis that electricity demand in the UK is predicted to increase, it remains prudent to plan on a conservative basis to ensure that there is sufficient supply of electricity to meet demand across a wide range of future scenarios, including where the use of hydrogen is limited.

4.4. DECARBONISING TRANSPORT WILL INCREASE ELECTRICITY DEMAND

158. The emissions from passenger cars and light goods vehicles make up over two thirds of all transport emissions, so decarbonising those forms of transport is a priority [29].

159. In Scotland, surface transport accounted for approximately 30% of emissions in 2019 [113] and surface transport has been Scotland's highest emitting sector since 2015. Surface transport was the largest source of UK greenhouse gas emissions in 2021 (accounting for 22.6% of emissions [112]). At the time of writing, the CCC have not yet published an assessment of 2020 or 2021 sectoral emissions in Scotland.

160. A rapid shift to low emission vehicles will give a significant boost to the enduring decarbonisation of our economy. Growth in the use of Electric Vehicles (EVs) is expected to create significant new demands on our supply of electricity.

161. The decarbonisation of transport is prominent in Scottish climate change plans. Scotland's Inward Investment Plan identified the decarbonisation of transport as an area of competitive strength for Scotland [21]. The Scottish government has committed to phasing out the need for new petrol and diesel cars and vans by 2030, and will work with public bodies to phase out the need for new petrol and diesel light commercial vehicles by 2025.

162. The market for electric vehicles in Scotland is growing rapidly, and sales of ultra-low emission vehicles in Scotland more than doubled in 2020. Scotland now has over 2,500 public charging devices, of which over 650 are rapid chargers. To support the shift away from petrol and diesel cars and vans, Scotland is investing £30 million in an electric vehicle charging network (the fourth largest in the UK), in line with recommendations tabled by the Just Transition Commission. Further work with the Scottish Futures Trust is considering and developing new financing and delivery models for electric vehicle charging infrastructure in Scotland. Infrastructure deployment to date has already been supported by the Scottish government’s investment in the ChargePlace Scotland network, and on a per-capita basis Scotland is ahead of England, Wales and Northern Ireland in both total public charge points and rapid devices.

163. Buses which run on hydrogen are already serving the streets of Aberdeen, and Scotland's rail services will be decarbonised by 2035: a joint government, enterprise and academia study has been funded to understand the application of hydrogen fuel cell technology to rail traction.

164. The UK government has proposed a ban on the sale of all new petrol and diesel vehicles to be effective from 2030 [45], bringing further forwards a prior indication of 2035. The Prime Minister’s November 2020 announcement, confirmed alongside a ban on sales of new hybrid vehicles by 2035 within the Energy White Paper [29], brought emerging UK government policy more into line with the CCC’s recommendation that the date for phasing out petrol and diesel cars and vans (including hybrids) should be brought forwards to no later than 2032, with EVs supported by detailed policy arrangements to be able to fill the light transport gap this would create [44]. Innovation is bringing affordable and highly desirable low emission private road vehicles to market, with almost every major brand now sporting a fully electric model and EV costs reducing. In September 2020, market frontrunners TESLA unveiled a new EV battery design which “will enable the company to

produce a $25,000 electric car in the next three years" [46] and generally the price of EVs is reducing and their range is increasing.

165. The UK has placed leadership of transport revolution at the heart of its Industrial and Clean Growth strategies, with investment being directed into both electric vehicle manufacturing, battery manufacturing and grid recharging points. In late June 2020, the Prime Minister committed to backing the vision of the UK becoming a global leader in developing batteries for electric vehicles [47]. Specifically, commitments were made to:

- Make funding available to attract investment in "gigafactories", which mass produce batteries and other electric vehicle components, enabling the UK to lead on the next generation of automotive technologies;
- Make £10m of funding immediately available for the first wave of innovative R&D projects to scale up manufacturing of the latest technology in batteries, motors, electronics and fuel cells, and nearly £500m for battery manufacture in the UK; and
- Provide additional funding to allow the progression of initial site planning and preparation for manufacturing plants and industry clusters, with sites under consideration across the UK – forming part of the government commitment to spend up to £1 Bn to attract investment in electric vehicle supply chains and R&D to the UK [48, 49].

166. These commitments came on top of the over £1 Bn provided at the Spring Budget 2020 to support the rollout of ultra-low emission vehicles in the UK via support for a super-fast charging network for electric vehicles, and extension of the Plug-In Grant schemes. EVs are already a critical new technology and are vital in the fight against climate change. The commitments described above from both the Scottish and UK governments are evidence that there is strong political support for the rapid development and rollout of EVs. Work to upgrade utility supply networks and boost EV charging infrastructure is already being planned and undertaken in cities across Scotland and the wider UK, e.g. ChargePlace Scotland and [50]. Such works are examples of the tangible actions already on track for delivery which will reduce transport carbon emissions, increase Scottish and UK demand for electricity and therefore underpin the urgent requirement for the development and delivery of new electricity generation at scale.

167. EVs are predicted to play a major part in the future GB electricity mix as a result of their energy demand requirements and potentially also their electricity storage capabilities. Ofgem, the independent energy regulator for Great Britain, have announced a plan to "Enable drivers to go electric by supporting an energy network that can power 10 million electric vehicles by 2030" [51] and anticipate that the number of electric vehicles on UK roads may grow from 320,000 at June 2020 [29], to 46 million by 2050 [51]. Other forecasts range between 20 – 33 million cars on UK roads in 2050, adding approximately 100TWh to electricity demand annually [107].

168. Hydrogen (see **Section 4.7** for more information) is well placed to help decarbonise hard to reach sub-sectors of transport (particularly larger, long-haul, road freight vehicles) and is making tangible steps towards mainstream use in this and other transport sub-sectors, e.g. in Aberdeen. In September 2020, the first UK train journey was powered by hydrogen. In the same month, the maiden flight by a hydrogen-powered commercial aeroplane was made [52, 53]. Annual electricity demand from road transport as a whole (i.e. incorporating both EVs and vehicles powered by hydrogen) could be 126 – 240TWh by 2050 in scenarios which meet Net Zero [107]. This projection shows greater upside potential than previous projections from 2019, 2020 and 2021 [39], [54], [55] and [13]. Decarbonisation of road transport has gained significant momentum over a number of years and has growing credibility to succeed.

169. To support efforts in the decarbonisation of heavy-duty transport, government pledged to invest £20 million in freight trials to pioneer hydrogen and other zero emission truck technologies; and £120 million to start the delivery of the 4,000 zero emission buses [29].

170. Electricity demand will significantly increase as a result of measures already delivered and many others already in flight. The use of hydrogen in rail and air travel will increase the demand for electricity (for hydrogen production) even further.

171. Similarly, the ESC scenarios also foresee the decarbonisation of transport as a major influence to future electricity needs, anticipating approximately 35 – 40 million battery EVs on the roads by 2050 and only small numbers of Plug-in Hybrid Electric Vehicles or other hybrid vehicles remaining operational. Hydrogen is anticipated by the ESC to be the major fuel for heavy transport [37].

4.5. HEATING HOMES AND SPACES WITH LOWER CARBON EMISSIONS

172. Reducing dependency on natural gas and thereby reducing carbon footprint further, requires gas to be substituted from home and industrial / commercial heating, cooking and water heating.

173. The Scottish 2021/22 Programme for Government (PfG) was published in September 2021 and shows a move to integrate Net Zero in all areas of policy across the economy. The PfG announced £1.8 billion of funding towards decarbonising buildings, which was later reiterated in the Scottish Heat in Buildings strategy. The Scottish government has made other commitments to further the decarbonisation of homes and spaces through a number of targets for 2030. These are:

- To develop around 5TWh of low carbon heat networks;
- To install 80,000 - 100,000 heat pumps over the period 2021 - 2026;
- To achieve 170,000 heat pump installations in 2030. [15]

174. However CCC analysis concludes that the Scottish legislated carbon reduction targets require more rapid emissions reductions in the 2020s than are achieved in the current policy pathways and more rapid emissions reductions must be enabled by more rapid low carbon electricity capacity development.

175. The UK's strategy to displace gas demand for heating homes and spaces is through electrification, either indirectly using electricity to produce hydrogen or through other renewable technologies, for example electrification of the home or installation of heat pumps. Coupled with governmental plans for new homes in Scotland, Wales and England, electrification of home and space heating will increase GB's demand for electricity. For every household that is supplied with electricity, an average additional burden of approximately 3.8MWh per year could be placed on the grid [38] and more as gas use in homes is substituted for electricity as suggested. In 2019, research by Homes for Scotland revealed that a further 25,000 homes are needed each year to keep up with housing demand and recognised a backlog of 80,000 homes created by a shortfall in the supply of housing since 2008 [56]. The need for new homes in Wales has been estimated at 7,300 new homes per year to 2024, reducing to 4,500 per year to 2039 [57]. Estimates have put the number of new homes needed in England at up to 345,000 per year, accounting for new household formation and a backlog of existing need for suitable housing. Projections therefore imply a potential additional increase in electricity demand in Great Britain of at least 41TWh per year by 2050.

176. The ESC anticipates a hybrid approach to home and space heating, with electric heat pumps being installed in thermally efficient homes, and hydrogen or electricity providing heating for peak periods and/or cold spells. These measures are also included in the Energy White Paper: the UK government aims to grow the installation of electric heat pumps from 30,000 per year to 600,000 per year by 2028; and will consult on whether it is appropriate to end gas grid connections to new homes by 2025, in order to open the market of homes not on the gas grid to heat pumps or other clean energy alternatives, representing some 50,000 to 70,000 installations a year [29]. Homes currently consume, on average, three times as much energy from gas as they do from electricity, increasing the potential

incremental electricity demand in 2050 versus 2020 from new homes from 41TWh by over 100TWh per annum if all gas demand is successfully substituted for electricity.

177. District heat systems present an alternative opportunity to decarbonise home heating. District heat captures process heat from thermal power plants or industrial applications, thereby increasing the efficiency of the application and presenting an overall reduction in carbon emissions associated with the combined need to carry out the source application and heat nearby buildings. District heat without carbon removal therefore presents opportunities to reduce carbon emissions, but such emissions cannot be removed entirely unless the source of the heat is itself low carbon. Industrial-scale low carbon heat sources could either use hydrogen as a low carbon fuel, or apply technology to capture and store carbon emissions associated with burning gas to generate heat or power. [37].

178. Even if Scotland and the UK are currently able to meet current electricity needs and share of renewable generation targets now, it will be very difficult – if not impossible – to do so into the medium and long term, without the significant growth in new low- or zero-carbon generation capacity.

4.6. PEAK ELECTRICITY DEMAND WILL GROW

179. The future daily profile of electricity demand is less easy to forecast, but anticipated peak demand remains a key determinant for future installed generation capacity requirements.

180. **Figure 4-5** illustrates the potential peak demand for GB power (using NGESO's Average Cold Spell methodology) to 2050. In the four scenarios, peak demand is anticipated to be 62.7 – 68.4GW by 2030 (for comparison, 2020: 58.8GW), and 97.5 – 114.3GW in 2050 [107]. Despite NGESO anticipating flat growth or a decline in peak demand until 2025 in all Net Zero compliant scenarios, all scenarios show an increase in peak demand thereafter, driven by underlying industrial and commercial demand growth as well as the electrification of heating and transport.

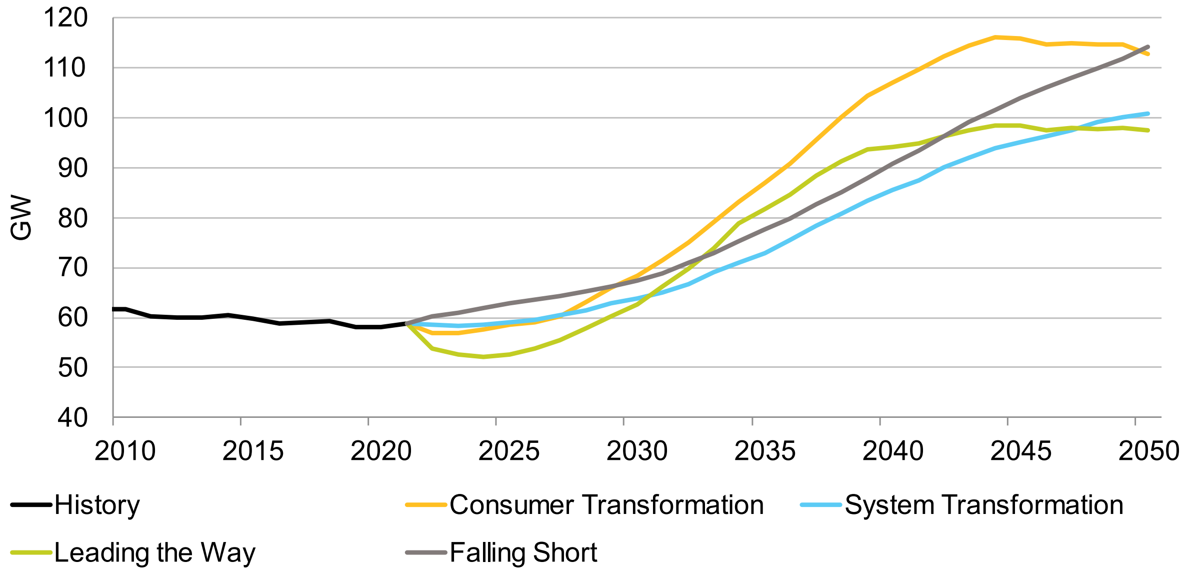

Figure 4-5: Future net peak electricity demand

[107]

181. EVs and hydrogen vehicles require the deployment of significant additional electricity generation capacity, and may also act as integration measures for all renewable and baseload generation technologies, capable of shifting load from when demand is high, to periods where supply is high. Until recently, system peak demand has been expected to reduce in the future, with Vehicle-to-Grid technologies working alongside enormous national-level batteries, helping keep peak electricity demand down as well as providing income for vehicle owners. More recently, NGESO have updated their analyses to incorporate consumer behaviour, noting that many cars will be on the road returning children from school and workers to their homes, during peak periods. They conclude that V2G is less likely to be a significant contributor to peak demand shaving than previously thought. Vehicle-to-grid may have a lower utility than previously thought because although vehicle-to-grid has significant capabilities, cars will not be constantly plugged in.

182. Ofgem announced a new Strategic Innovation Fund in August 2021. The £450M fund is being deployed over five years as part of the regulated price controls for the electricity system operator, and for the network companies which operate GB's energy networks. The fund, and its source, further signals the significant and imminent changes required to continue the journey to Net Zero. Ofgem stated that the fund would help GB "find greener ways to travel, and to heat and power Britain at low cost. Britain's energy infrastructure will play a pivotal role in cutting net zero greenhouse gas emissions". Growth in electricity

demand through the electrification of heat and transport, and the introduction of versatile energy vectors, such as hydrogen, which will be produced with the help of low carbon electricity generation capacity, to decarbonise industry and hard-to-reach sectors, is certain. An increase in the complexity of operating the electricity system and in the future an integrated whole-energy system is likely, but must be overcome in order to meet Net Zero. The Strategic Innovation Fund, and others like it, will work to ready our energy networks for the growth in low carbon generation required to meet future estimates of electricity demand.

4.7. THE ROLE OF HYDROGEN IN A LOW CARBON WORLD

183. The prominence of a hydrogen economy has increased in subsequent FES since the 2019 edition. This is a direct result of the requirement to meet Net Zero, and hydrogen is an important constituent of those scenarios which meet the 2050 carbon emissions reduction target. Although the public prominence of hydrogen has recently grown, it has been forerun by a longer acknowledgement of its potential to enable deep and broad decarbonisation. As described by the Union of Concerned Scientists: “Hydrogen is an important energy vector which may be able to help decarbonise homes and buildings, and power road transport, however hydrogen needs to be made through large-scale industrial processes, which require significant amounts of energy. Thus, in order for hydrogen to contribute to decarbonisation, the energy source for hydrogen production must itself be low carbon” [58].

184. The major potential uses of hydrogen are:

- A further development of existing technologies such as liquefied petroleum gas and compressed natural gas will enable hydrogen’s use in road transport, reducing the carbon intensity of freight haulage and public road transport, enabled by a national supply infrastructure;
- Hydrogen, when blended with mains gas into the GB National Transmission System (NTS), will reduce the carbon intensity of current gas use (industrial use, power generation, home and commercial heating and home cooking);
- A greater share of hydrogen in a blended natural gas mix will provide greater decarbonisation, leading effectively to a substitution of natural gas by hydrogen in industrial, service, commercial and domestic applications, as well as heavy transport, wherever opportunities exist. An upgrade to the NTS would be required but would be cheaper than building a new network;
- This also opens up the use of hydrogen as a power generation vector: substituting the current Combined Cycle Gas Turbine fleet (c. 394gCO_2/kWh) and Open Cycle Gas Turbine fleet (c. 651gCO_2/kWh) for a zero-carbon dispatchable generation technology, covering both baseload and peaking (flexibility) needs [114]. For example, the Intermountain Power Project (Utah, USA), which is replacing 1.8GW of coal generation with 0.8GW of CCGT plant, capable of burning up to 30% hydrogen, 70% natural gas before 2025, and 100% hydrogen by 2045;
- Potentially only minor changes would be required to enable existing home appliances (boilers, cookers) to run on a blended fuel, especially one with only low (c. 10%) amounts of hydrogen in the blend however detailed studies are yet to confirm this fact;
- Hydrogen is a highly suitable energy vector for inter-seasonal energy storage. By using excess low carbon electricity generation to produce hydrogen to send to storage, that hydrogen can later be released for other application when needed. Because of the low unit costs of keeping hydrogen in storage, this technology is particularly well suited to long-term use.

185. Methane cracking is the predominant hydrogen production technology in use today, however carbon is emitted as a by-product of the process. Hydrogen produced by methane cracking requires CCUS facilities to achieve Net Zero carbon, hence the close links in

government strategy and industrial plans between hydrogen production and CCUS development. Electrolysis currently accounts for only approximately 1% of global hydrogen production, however a growth in electrolysis capability and capacity opens out the prospect of using RES to produce hydrogen, in potentially significant quantities. Electrolytic hydrogen has the lowest carbon emissions over the full life cycle if supplied with low carbon power [59].

186. Hydrogen produced by electrolysis, powered by low carbon (renewable) electricity, therefore has exciting prospects for decarbonising industry; displacing petroleum products from heavy transport; replacing natural gas for heating and home use; and providing an energy vector suitable for long-term zero-carbon energy storage.

187. Actual examples of hydrogen produced by electrolysis from low carbon generation (predominantly in the US) include solar-to-hydrogen at California's Stone Edge Farm Estate (where excess solar generation is used to produce green hydrogen for own-use), and California's SunLine Transit Agency, who have been operating a fleet of 16 hydrogen buses since early 2021 using green hydrogen generated from a 4MW solar array.

188. Scotland's Hydrogen Policy Statement [26] describes Scotland's unique selling points as its natural resources, infrastructure and skilled energy workforce, all of which have the potential to enable Scotland to become the producer of lowest cost hydrogen in Europe by 2045.

189. "Scotland has an abundance of the ingredients in green hydrogen production: water and wind" [26]

190. Scotland's Draft Hydrogen Action Plan [60] establishes the decarbonisation of heat, industry and transport as current priorities which will require a broader range of technologies, strategies and energy systems to deliver on. There is consensus that hydrogen will play a critical role in decarbonisation of the energy system, especially where electrification of parts of that system will be challenging.

191. The Scottish Offshore Wind to Green Hydrogen Opportunity Assessment [61] develops scenarios to ascertain the feasibility of coupling Scotland's extensive offshore wind resource with green hydrogen production, to contribute towards national and international net zero targets by providing green hydrogen for the decarbonisation of hard to reach sectors in Scotland, the UK and continental Europe. The most ambitious 'export' scenario in this assessment assumes that Scotland could credibly reach an installed capacity of 5GW of renewable hydrogen by 2032, and over 25GW by 2045. The analysis was based on a realisation of the current Scottish offshore wind assets pipeline plus a 10GW outcome of the ScotWind seabed leasing round for offshore wind projects but it is noted that the capacity associated with ScotWind leases is currently significantly higher. However, the scale of the hydrogen market depends on its cost. Driving down the cost of offshore and onshore wind electricity generation will be key to cost-effective green hydrogen production. Asset scale and location, including local geological characteristics and cost-effective transmission connections are important aspects of driving down cost. **Section 3.7** lists the competitive strengths of the Project in relation to those projects which together have been granted seabed rights for offshore wind generation capacity through ScotWind.

192. UK government's 2021 Hydrogen Strategy [62] explains that hydrogen has "the potential to overcome some of the trickiest decarbonisation challenges facing our economy" especially in enabling the decarbonisation of industry and land transport, and as a potential substitute for current carbon-intensive marine and aviation fuels.

193. The Industrial Decarbonisation Strategy [19] and Transport Decarbonisation Plan [63] set out the actions government is taking to bring forward hydrogen demand across industry, power, transport and heat to enable decarbonisation.

194. As a result of its geography, geology, infrastructure and capabilities, the UK has an important opportunity to demonstrate global leadership in low carbon hydrogen and to secure competitive advantage. The proposed "twin track" approach to hydrogen production

in the UK capitalises on the UK's potential to produce large quantities of both electrolytic 'green' and CCUS enabled 'blue' hydrogen [62].

195. Hydrogen is making tangible steps towards mainstream use in the decarbonisation of hard-to-reach sub-sectors of transport. In September 2020, the first hydrogen-powered UK train journey was made. In the same month, a hydrogen-powered commercial aeroplane made its maiden flight [52, 53].

196. NGESO estimate that annual electricity demand from road transport as a whole (incorporating both EVs and vehicles powered by hydrogen) could be 120 – 150TWh [107], this is consistent with independent analysis carried out by SNC Lavalin (Atkins) which estimated 150TWh [55]. Both estimates are approximately 50% of current national electricity demand. The potential for use in rail, marine and air travel increase estimates of hydrogen use even further.

197. NGESO estimate that at between 126 and 240TWh of electrical energy will be required annually by 2050 to produce hydrogen to meet its many potential end-uses [107], the wide range is due to different Net Zero compatible scenarios producing hydrogen in different ways. The Energy System Catapult foresee the need for "a new low carbon hydrogen economy ... delivering up to 300TWh per annum, roughly equivalent to electricity generation today" and concluding that "Electricity generation itself may have to double, or even treble if most hydrogen is to be produced by electrolysis." ESC also models over 600TWh of hydrogen storage covering strategic and operational reserves to an acceptable level of security [37, 18]

198. The National Infrastructure Commission have also considered the benefits hydrogen could bring in terms of lowering the overall cost of a highly renewable electricity system: "Highly renewable systems are still a low cost option in a net zero world. The analysis once again finds that electricity system costs are broadly flat across a range of different levels of renewable penetrations. If hydrogen is deployed, providing low carbon and flexible generation, it could further reduce the costs of highly renewable systems ... The conclusions also hold in a lower demand scenario where heating has been decarbonised using hydrogen." [41]

199. The hydrogen economy is set to grow in the UK with recent UK government announcements targeting 5GW of "low carbon" hydrogen production capacity by 2030 and development of the first town heated by the gas by the end of the decade [45, 62]. To support this ambition, UK government is providing £240M for the Net Zero Hydrogen Fund out to 2024/25 for co-investment in early hydrogen production projects, and up to £60M under the Low Carbon Hydrogen Supply 2 competition. A UK standard for low carbon hydrogen has been developed, allowing a UK hydrogen business model to be finalised before enabling first contracts to be allocated from 2023. The UK's "twin track" approach to hydrogen production foresees a significant opportunity for the role of offshore wind in the production of green hydrogen.

200. Further, large scale renewable hydrogen production may provide an essential energy balancing and flexibility function to integrate the expected large increases in offshore wind into the UK energy system.

201. The hydrogen economy, and the potential for hydrogen to play an increasingly important role in the energy ecosystem of the future, is relevant to the case in support of the Project, because the increased use of hydrogen as a low carbon energy vector will increase the demand for electricity. The Project is capable of supplying large quantities of low carbon power required to feed Scotland's hydrogen ambitions.

4.8. CONCLUSIONS ON THE FUTURE OF ELECTRICITY DEMAND

202. The main conclusions from this section are as follows:

- Although energy demand in 2050 will be required to be much lower than it is today in order to meet Net Zero, the electrification of other sectors will mean that electricity demand will grow;
- The decarbonisation of transport, homes and space heating and industry will be a major driver in the growth of electricity demand;
- Scottish demand is anticipated to grow broadly in parallel with UK national demand because the Scottish decarbonisation strategy is broadly consistent with the UK strategy of electrification and substitution of carbon-intensive fuels from other sectors;
- Demand is expected to double, and peak demand is expected nearly to double, in the 2050 timeframe compared to current levels; and
- Hydrogen is an energy vector with application to the decarbonisation of hard to reach sectors. It is anticipated that in the future, a significant proportion of hydrogen will be produced via electrolysis of water, using low carbon electricity as a power source. The growth of a hydrogen economy therefore necessitates growth in electricity demand.

5. DECARBONISING ELECTRICITY SUPPLY

5.1. SETTING THE SCENE

203. To enable the Net Zero transition, it is clear that the power generation sector must both increase in capacity and reduce in carbon intensity on a hitherto unprecedented scale. The 2020 UK Energy White Paper explains that in order to meet a possible doubling of electricity demand by 2050, the capacity of clean electricity generation would need to increase four-fold, and the decarbonisation of electricity will increasingly underpin the delivery of Scotland's and the UK's net zero target. However although measures have been put in place to support the development of specific projects and technologies, government is not targeting a particular generation mix for 2050, trusting instead that the electricity market should determine the best solutions for very low emissions and reliable supply, at a low cost to consumers [29].

204. Equally, it is important to clarify that this report does not seek to justify or promote the exclusion of any generation technologies from the future GB generation mix, but makes the case that the Project is a low regrets opportunity which should be consented because of its capacity to play a major part in reducing carbon emissions from Scotland and the wider UK, commencing in the mid 2020s. The Project will also support the unlocking other low carbon pathways through the potential to provide energy to decarbonise home heat, transport and industrial demand as well as to power green hydrogen production facilities in Scotland and across the UK.

205. The National Infrastructure Commission (NIC) concluded in their 2020 Opportunities for the power sector report [41] that new low carbon capacity is needed over the next decade, and that renewables can deliver.

206. Moreover, the report states that due to current plant retirements, in the 2020s there will be a gap in electricity generating capacity which needs to be filled. Within the context of the need to achieve Net Zero, it must be that low carbon generation fills the gap both in Scotland and in the UK more widely. Given that lead times for renewable developments are generally shorter than low-carbon dispatchable power developments, renewables are ideally placed to fill this gap. With the exception of Hinkley Point C, nuclear power stations would likely only be able to deliver new capacity significantly into the 2030s. It therefore makes sense for government to take action to deploy renewables now.

207. The electricity systems of Scotland, Wales and England are essentially one system. High voltage cables (the NETS) connect major power stations to consumers located across Great Britain. Regional distribution systems are in place to transmit power from the high voltage national system to local consumers. When power demand in Scotland outstrips local supply, power generated in England or Wales will instantaneously flow north to meet that demand. Conversely, when more power is produced in Scotland than is required locally, for example when the wind is strong, power will flow south to England and Wales and offset carbon intensive generation there.

208. Although devolved administrations have set their own decarbonisation targets, the connectedness of the electricity systems across Great Britain means that decarbonisation of the electricity sector needs to be considered at the GB level, especially as the share of low carbon electricity supplied approaches 100%.

5.2. LOW CARBON GENERATION DELIVERY IN THE LAST DECADE

209. **Table 5-1** shows elements of the government's Low Carbon Transition Plan (LCTP), made in 2009, which were expected to make significant contributions to reducing the carbon intensity of electricity generation. A recent status on these initiatives is also included. While a number of the major initiatives detailed in the LCTP have not yet delivered, carbon

emissions from the power generation sector are being reduced, both in Scotland and across the UK. This has provided a major contribution to the current performance of both Scotland and the UK versus their legal decarbonisation obligations, and has been delivered predominantly by the closure of the existing coal fleet as well as an increase in renewable generation capacity.

210. Since 2019, each of NGESO's FES publications has described three pathways involving radical change across many industry sectors, which will deliver the required reductions in carbon emissions across the UK to meet Net Zero, and one scenario which will fall short. The Net Zero commitment underpins the urgency for new low carbon generation infrastructure to be built and commissioned, both in Scotland and across the UK generally, and government support will be critical for these developments to progress to commissioning. The National Infrastructure Commission (NIC, established in 2015 to provide independent, impartial advice on the UK's long-term infrastructure needs) stated in their first National Infrastructure Assessment report [66] that new nuclear power plants and carbon capture and storage infrastructure will not be built by the private sector without some form of government support.

5.3. LOW CARBON GENERATION TECHNOLOGY ASSESSMENTS

5.3.1. CARBON CAPTURE USAGE AND STORAGE

211. FES 2012 [69] included a forecast of between 5GW and 14GW of CCUS being operational (across coal, gas and biomass plant) by 2030. One of the biggest challenges with CCUS at the time of writing the LCTP, was that while each stage – capture, storage and transport – had already been shown to work, it had never been tried at a commercial scale on a power station and never the complete process from start to finish. As of today, Grid-scale CCUS from power generation has not yet been proven in Europe. CCUS technology has not yet progressed to industrial scale, and no new large-scale carbon generating power stations with CCUS capability have yet been constructed in GB. Government do not foresee that CCUS will make any significant contributions to carbon reductions in GB until the 2030s [43, 70] although CCUS remains a key technology in support of climate change and government is developing detailed strategy and support for developing the technology in readiness for the 2030s.

212. The UK chose to largely decarbonise its power sector by adopting low carbon sources quickly. However, being cognisant of the advantages to the UK of maintaining a diverse range of energy sources, and so avoid dependency on a particular fuel or technology type, support for CCUS continued through the 2010s. The NIC concluded in their 2018 assessment of national infrastructure [66], that CCUS would only become useful for decarbonisation of the electricity generation sector in the 2040s and beyond, by which time the decarbonisation and adequacy of electricity generation must already have been largely achieved in order to support decarbonisation in other sectors. Until as recently as 2019, government did not foresee that CCUS would make any significant contributions to carbon reductions in the UK until the 2030s [70, 41] but government is currently working with industry to bring forwards the deployment of CCUS into the 2020s. A 2020 update to NIC's analysis [41] proposes that CCUS should be utilised with bioenergy to generate power at negative emissions, or to produce hydrogen. Crucially the NIC present CCUS as being deployed alongside significant growth in the capacity of Renewable Energy Sources (RES), rather than as a substitute.

Initiative	Projection	Status, October 2022
New Nuclear	**2013**: construction of new nuclear commences. **2018**: first new nuclear operational (of up to 16 GW)	**2017**: Hinkley Point C construction commenced, with a Commercial Operation date currently estimated during 2026 **2018**: Government advised by NIC to permit only one more GW+ nuclear before 2025 **2019/20**: Two GW+ scale nuclear projects abandoned by their proposed developers **2020**: Energy White Paper is consistent with NIC advice **2021/22**: End of life announced for 5 GW of existing nuclear, in 2021 (1.5 GW), 2022 (1.5 GW) and 2024 (2 GW). **2022:** Nuclear Energy (Financing) Bill is adopted. British Energy Security Strategy calls for 24GW of nuclear power by 2050. In **July 2022** Sizewell C received its Development Consent Order although as of September 2022 has not yet taken its Financial Investment Decision
Wave / Tidal	**2014**: Larger-scale wave and tidal energy generation (>10 MW) starts to be deployed	**2022**: No larger-scale wave and tidal energy generation yet to be deployed. The second Severn Estuary / Swansea proposal was denied public funding in 2018.
CCUS	**2020**: up to 4 CCUS demonstration projects operational in the UK	**2021**: No CCUS projects yet operational in GB. National Infrastructure Strategy includes business model blueprints in 2021; two industrial clusters progress with project development with a third cluster designated "reserve" status.
Renewable Energy Share	**2020**: Around 30% of electricity is generated from renewable sources	**2019**: Wind, solar, hydro, bioenergy accounted for 37% of generation. Nuclear accounted for 17%. **2020**: Renewables made up 43% share of GB power generation in 2020. **2021**: NIC conclude that 65% of GB's electricity could be delivered from RES; the CCC highlight the need for of 90 – 175 GW of offshore wind capacity in the UK by 2050. Low carbon produced c.42% of 2021 generation **2022**: British Energy Security Strategy calls for much deeper and faster deployment of renewables, including 50GW of offshore wind by 2030 and a five-fold increase in solar deployment by 2035.

Table 5-1: Projections from 2009 for a low carbon power sector and a 2022 status

[64, 3, 65, 1, 66, 67, 29, 68]

213. The Prime Minister's Ten Point Plan [45] included an ambition to develop "world-leading technology to capture and store harmful emissions away from the atmosphere, with a target to remove 10 million tonnes of carbon dioxide by 2030" and subsequent development has seen that ambition extend.

214. CCUS is prominent in the 2020 National Infrastructure Strategy and Energy White Paper. CCUS is regarded as essential to achieve Net Zero, because of its potential to decarbonise gas fired and biomass power plants, decarbonise industry, produce low-emissions hydrogen and deliver greenhouse gas removal technologies. However such benefits will materialise if and only if projects become operational in time.

215. A commitment to deploy CCUS in a minimum of 2 clusters by the mid-2020s, and 4 by 2030 at the latest, has now been established. Two clusters have been selected: HyNet in the North West of England, and East Coast in the North East. The clusters include the ability to capture and store CO2 from industrial sites and from power generation, produce both green and blue hydrogen (see **Section 4.7**), and enable the use of hydrogen as a substitute for fossil fuels in industrial applications and public transport. These clusters aim to capture and store 20 - 30 MtCO2 per year by 2030 [71] or approximately 5% of UK emissions. A significant pipeline of projects, commissioning in incredibly quick order, will be needed in order for CCUS to become a significant support to decarbonisation efforts in the UK before the mid-2030s, and a Scottish Cluster has been selected as a UK reserve cluster, if a back-up is needed [71]. Two Power CCUS projects, both part of the East Coast Cluster are, as at October 2022, progressing through their Development Consent Order (DCO) planning process. However both the UK and Scottish governments recognise that the technology has not been delivered at scale and significant risks remain.

216. Although further clusters are expected to follow the Track-1 clusters, the Scottish Cluster status as a reserve cluster only in Track 1 means that currently it is unlikely to be delivered alongside HyNet and East Coast by the mid-2020s. The role of CCUS and Greenhouse Gas Removal (GGR) technologies in Scotland's low carbon energy mix before 2030 may therefore be lower than current policy ambitions would deliver. The CCC recommend that "Clear contingency plans will have to be developed for meeting the 2030 target if it should turn out that GGR cannot be delivered at scale on the necessary timetable ... if developments on CCS do not provide confidence that they can deliver by 2030" [15].

5.3.2. NUCLEAR POWER

217. Scotland currently opposes the build of new nuclear stations using current technologies because of the poor value for consumers that the Scottish government believes they provide. However the Scottish government recognises an increasing research and industry interest in the development of new nuclear technologies such as SMRs (Small Modular Reactors) which provide promising but as yet unproven opportunity. Scotland's policy position is therefore that it has a duty to assess all other new nuclear technologies based on their safety, value for consumers, and contribution to Scotland's low carbon economy and energy future.

218. Nuclear power has attracted significant government attention over the last decade, including plans for 16GW of new build capacity by 2030, described in the 2013 Nuclear Industrial Strategy [72]. One new nuclear project (Hinkley Point C) is under construction and government has committed to conclude on a support package for one more large-scale nuclear power plant in the UK. Others either remain in their development phases,or have been abandoned.

219. Nuclear currently provides the largest capacity of dispatchable (i.e .non-renewable) low carbon power generation and therefore is an incredibly important operational generation technology in the context of decarbonisation. Nuclear has historically met approximately 20% of GB demand and because the existing nuclear fleet has been able to continue operating beyond its original closure dates, nuclear has until recently continued to generate approximately a one-fifth share of demand.

220. Existing nuclear is close to the end of its life. At the date of writing this report, Hunterston B (1GW, Scotland), Dungeness B (1GW) and Hinkley Point B (1GW) have closed and firm closure dates have been set for a further 2.4GW of nuclear capacity in 2024 (Heysham 1 and Hartlepool) although operators EDF are currently investigating possible further life extensions. The final two Advanced Gas-Cooled Reactors (AGR, one of which, Torness, is in Scotland) will close in 2028. This information is illustrated in **Figure 5-1**. Of the currently existing UK nuclear fleet, only Sizewell B (1.2GW) will operate beyond 2030.

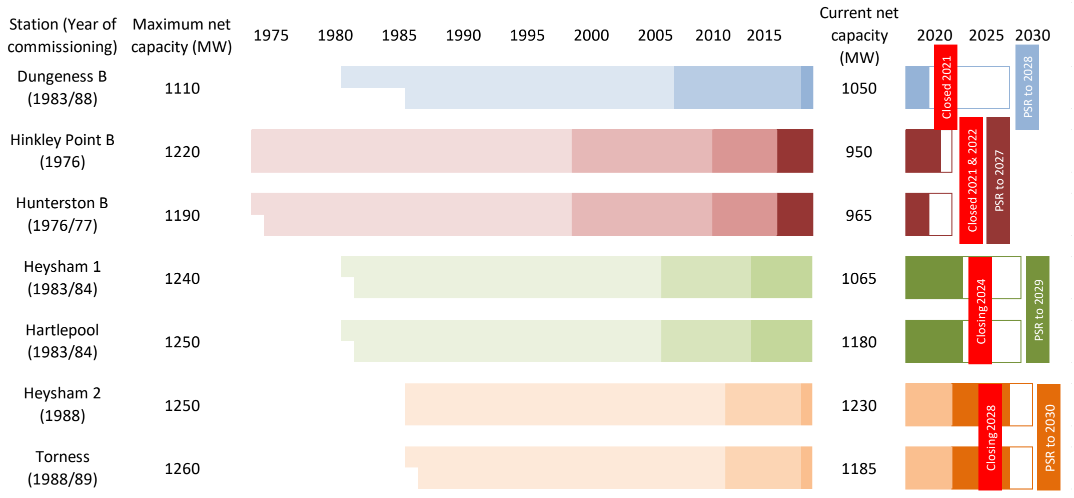

Figure 5-1: Generating capacities and announced closure dates for each AGR station

[Author analysis of data sourced from www.edfenergy.com]

221. Nuclear power has attracted significant government attention over the last decade, including plans for 16GW of new build capacity by 2030, described in the 2013 Nuclear Industrial Strategy [72] and more recently ambition in the BESS for 24GW by 2050 [108]. New nuclear projects are ongoing. Hinkley Point C is currently under construction and other projects are at various stages of development. But it is clear that new nuclear will not be built out at the appropriate rate and scale so to allow it to continue to contribute a one-fifth share of GB demand through the 2020s and into the 2030s. The scale of nuclear's contribution to decarbonisation beyond the 2030s is also currently uncertain, because currently only Hinkley Point C is a confirmed and funded development. **Figure 5-2** charts projections of nuclear capacity out to 2050 based on current end of life dates for the existing fleet as well as scenarios of new nuclear build.

222. Government have removed many barriers to nuclear development over the last 10 years. This includes: site selection (the National Policy Statement for Nuclear Power Generation); regulatory approval of reactor designs (the Generic Design Assessment (GDA) process); and revenue and back-end cost certainty (the Contract for Difference (CfD), a key element of the 2013 Electricity Market Reform, and the Funded Decommissioning and Waste Management Plan). The Energy Act 2013 also created a body corporate, the Office for Nuclear Regulation (ONR) to regulate, in Great Britain, all nuclear licensed sites.

223. These policy instruments clearly signalled that the UK was open to nuclear business and that it was now for commercial entities to bring new nuclear to market. The process which needs to be followed to bring new nuclear to commissioning is neither easy, nor short. Nuclear projects have long development and construction lead times, as illustrated in the development timeline for the Hinkley Point C project (currently under construction and currently forecast by its developer, a joint venture between EDF Energy and China General Nuclear (CGN) to have a commissioning window of June 2027 to September 2028 [110]) shown in **Figure 5-3**.

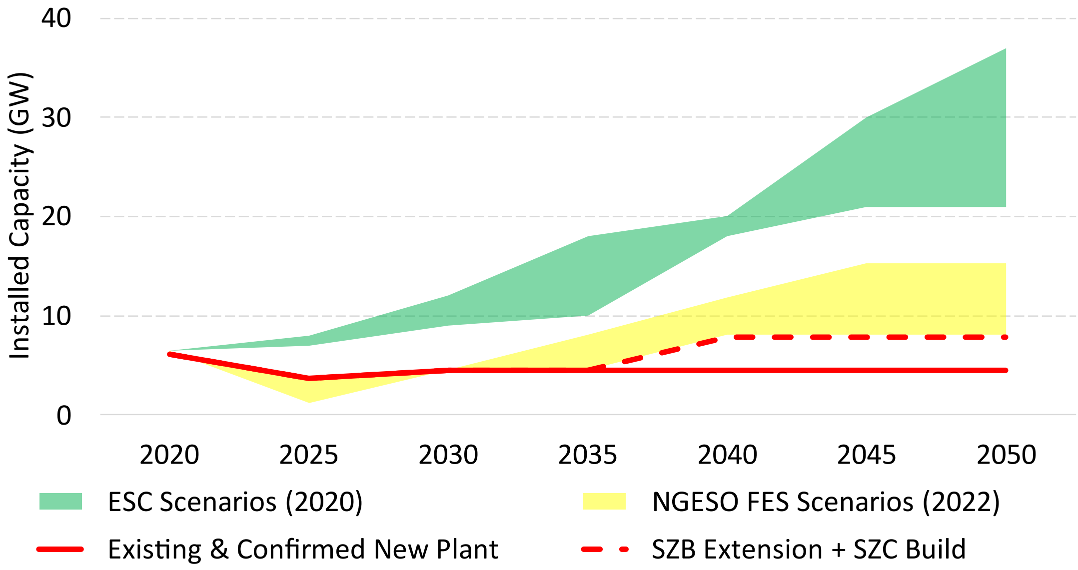

Figure 5-2: Projections of current nuclear capacity as existing stations close

Adapted from [107, 73, 37, 74]

224. Government's Energy White Paper, published in December 2020, sets the scene for further nuclear development in GB and confirms the identification of a "Regulated Asset Base model [which] remains credible for funding large-scale nuclear projects" [29]. The Nuclear Energy (Financing) Act was enacted in 2022, formalising the Regulated Asset Base framework for energy infrastructure in UK legislation.

225. Sizewell C (SZC), also EDF/CGN, is currently progressing through development. In December 2020 government confirmed that it is to enter negotiations with EDF in relation to the Sizewell C project as it considers options to enable investment in at least one nuclear power station by the end of the current Parliament (no later than May 2024). A project aiming to build the third and fourth UK EPR, SZC received its DCO in July 2022 and may proceed through construction more rapidly than HPC, once funding mechanisms have been agreed. EDF have not formally committed to a timeframe for Sizewell C but construction work may last for a decade.

226. CGN have taken the lead on the Bradwell B project. GDA on their reactor design started in 2017, and concluded in February 2022. No indications of intended project timelines have been published by the developer, however an assessment of the potential earliest commercial operation date for this reactor, based on development durations of other projects, may be in the mid/late 2030s.

227. Two other large-scale new nuclear projects have folded without securing agreement to proceed. The first to be abandoned was Moorside, Cumbria. Toshiba planned to develop three Westinghouse AP1000 reactors, commissioning from 2026 onwards. In March 2017, the failure in the US of two AP1000 developments which were unable to keep pace with time and cost schedules, came to a head. This directly resulted in Westinghouse (a Toshiba-owned subsidiary) filing for Ch. 11 bankruptcy in 2017.

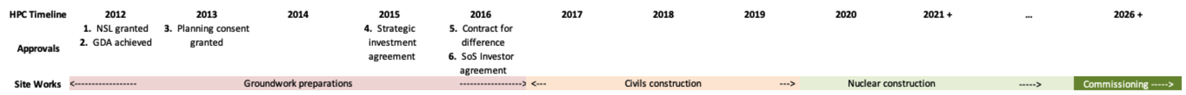

Figure 5-3: HPC Timeline

[Author Analysis]

228. The second abandonment was Wylfa Newydd, Anglesey, Wales. Hitachi, the parent owners of Horizon Nuclear Power, were developing a project to construct and operate two Advanced Boiling Water Reactors (ABWRs). The ABWR is not a new reactor design: four Japanese plants have already commenced operation, and more are under construction internationally. Critically, each of the completed reactors were built in less than 5 years. The ABWR received its GDA in late 2017; secured many of the necessary Environment Agency (EA) permits through 2018; and commercial discussions started with Government on funding arrangements in June 2018.

229. Horizon's forecast commissioning date for Wylfa remained at or around 2026 throughout the project development process, however commercial conversations with Government concluded without agreement in January 2019, prompting Hitachi to announce a suspension of the project under grounds of "economic rationality as a private enterprise." [76]. Horizon withdrew its application for Development Consent Order on 16th January 2021, effectively closing the current chapter of potential nuclear development at Wylfa, citing a lack of "any definitive proposal" to transfer Wylfa to an alternative developer.

230. At the time of writing this report, government has been reported as discussing with developers the very early stages of new plans to build nuclear at Wylfa, however, the earliest possible commission date for new nuclear at Wylfa would now be highly unlikely before the mid/late 2030s as any new proposals will effectively be starting afresh.

231. Government remains committed to ensuring all technologies have a part to play in the future energy mix, providing that they offer value for money for consumers. Nuclear power could achieve this through either the delivery of larger projects or Small Modular Reactors (SMRs). SMRs aim for cost improvements through the production of multiples of units rather than an increase in scale.

232. Government's Industrial Decarbonisation Strategy aspires to have the first SMRs commercially deployed in the UK in the early 2030s, with an operational Advanced Modular Reactor demonstrator deployed at the same time [19]. The roll out of subsequent Next of a Kind schemes would be highly contingent on a large number of technical, commercial and environmental factors. American company NuScale is at the front of the global race to develop and deploy SMR technology and Rolls Royce is developing plans with the UK as its manufacturing base. NuScale plans its first US SMR installation by 2030 [77], three years later than previously planned. At the time of writing this report the GDA process has been readied for the assessment of SMR designs and opened for application in 2021 [29]. Rolls Royce's 470MW Small Modular Reactor design entered GDA on 1st April 2022.

233. The 2020 National Infrastructure Strategy [64] confirms government's continued support for the development of nuclear technologies through the provision of funding to bring forward large scale and small modular reactors, but the strategy does not go as far as to indicate a target capacity for future nuclear technology, stating only that "government is pursuing large-scale nuclear projects, subject to clear value for money for both consumers and taxpayers and all relevant approvals".

234. The Energy White Paper sets out government's commitment to aim "To bring at least one large scale nuclear project to the point of FID by the end of this Parliament, subject to clear value for money and all relevant approvals." And the BESS [108] sets out Government's ambition to increase plans for deployment of civil nuclear to up to 24GW by 2050.

235. **Figure 5-2** shows that capacity from current and committed new nuclear projects (at the time of writing: only Hinkley Point C) will reduce from now until 2030. Without a significant and immediate drive from government to commit to further nuclear projects, nuclear capacity will most likely remain lower than current levels until at least 2035. Therefore, although nuclear will play an important role in the generation of low carbon electricity through to the late 2020s, the contribution it will make to achieving Net Zero will be lower in each year from 2023 until at least the mid 2030s, than is currently the case.

236. The gap in low carbon power generation created by the closure of the existing AGR fleet in Scotland and the UK must be closed. The Project is part of the solution to closing that gap.

5.3.3. WAVE / TIDAL POWER

237. Wave / Tidal power has been proposed at a number of locations in the UK, although wave technology development has experienced both cost and operational challenges [78]. Early predictions on future rollout of wave / tidal power were large but varied, ranging from 0.5GW to 4.5GW by 2030 [69]. Tidal power remains complicated to consent, and expensive to deliver, a position made clear by governments' rejection of public funding for the Swansea Bay Tidal Lagoon in June 2018 [79].

5.3.4. DEMAND RESPONSE

238. Energy demand management, which is also called Demand Side Response (DSR) could also play an important role in the future of the energy balance of the UK. DSR is valuable insofar as it is compatible with end-use generation technologies and system-wide commercial drivers. However DSR can neither increase the total amount of electricity generated in the UK, nor reduce the total amount of electricity consumed.

239. Currently industrial DSR capacity is estimated at 6.5GW nationally [107]. FES scenarios forecast 13 – 24GW may be operational by 2030, rising to 16 – 27GW by 2050. Growth in DSR is a reflection on the scale and urgency of decarbonisation actions between now and 2030. DSR must grow alongside the development of solar and other renewable generation assets of all scales in order to stay on a path to achieve Net-Zero. Therefore although DSR may deliver a significant contribution to the delivery of UK decarbonisation before 2030, DSR cannot fully replace the need for new generating capacity to deliver GB's energy objectives, further underpinning the need for low carbon generation to come to market within this timeframe.

5.4. FUTURE LOW CARBON ELECTRICITY SUPPLY

240. Each FES scenario developed by NGESO describes a possible way that the energy system may develop, based on a forecast of demand and government policy. The scenarios do not indicate forecasts of confirmed and consented generation capacities, nor do they seek to imply or impose restrictions on the capacities of generation of particular technologies which may be required, or may be delivered. The FES scenarios therefore do not imply a requirement for particular generation technologies, and nor can their datasets sensibly be disaggregated to indicate need for a single generation technology within a future system scenario.

241. Further, the inclusion of future projects within the planning system does not also indicate a commitment by or obligation on the Applicant actually to deliver that project at all, or if it does, at a particular generation capacity.

242. In the context of Net Zero, the FES are a useful suite of documents to understand whether particular future pathways for electricity generation will be successful from a national policy perspective. The need for more generation capacity to be built has been a consistent theme since the first FES was published in 2012.

243. Each year the FES scenarios have described consistently high capacities of offshore wind generation connecting to the national transmission system, on the basis of objective economic assessment of current and future costs and/or market drivers. The FES scenarios can therefore be regarded as an important point of view, which contributes to an objective assessment of the need for, and scale of, low carbon offshore wind electricity generation developments under different future scenarios of demand and government policy, particularly within the context of Net Zero.

244. In 2022, NGESO published the third edition of the FES since GB adopted Net Zero legal commitments. FES 2022 analyses three scenarios under which Net Zero emissions can be achieved by 2050.

245. Only one of FES 2022 scenario (being a scenario of steady progression rather than rapid low carbon generation deployment) misses the legally binding national decarbonisation targets in 2050. This scenario sees the slowest growth in renewable electricity generation capacities.

246. From their analysis, NGESO conclude that UK installed electrical generation capacity (including storage and interconnectors) needs to increase from 2020's 107GW to 156 – 209GW to meet anticipated demand in 2030, this being an increase of 55 – 109GW on existing generation capacity following the decommissioning of all but 1GW of existing nuclear generation and the closure of all remaining coal generation (5GW) before that date.

247. The most striking insight from the 2022 FES is that by 2030, over 70% of installed generation capacity must be low carbon generation in order to meet Net Zero targets, pointing to a significant growth in low carbon generation in the coming decade. Interconnectors are expected to contribute 7 – 9% of capacity and these will rely on our national neighbours to follow similar decarbonisation plans to the UK for their supply to be low carbon. Only 9 – 17% of GB operational capacity in 2030 will be carbon-intensive generation, down from 38% in 2022.

248. Further, NGESO forecasts that between 310 and 365GW of generation capacity will be required to meet demand by 2050 (continuing the increasing trend from previous forecasts), with no remaining GB operational carbon-intensive generation [107], [13], [39] and [54].

249. The FES scenarios which achieve Net Zero include offshore wind capacities of 40 – 51GW in 2030, 84 – 91GW in 2040, and 89 – 110GW by 2050. In every scenario, a pathway to Net Zero includes a significant increase of offshore wind capacity beyond that predicated in the Sector Deal, and an increase relative to NGESO's forecasts from 2021 [107], [13].

250. Six important predictions from NGESO's most recent analysis [107] are that, by 2030:

- While in all scenarios, GB energy demand is expected to be lower in 2050 than 2021 (by 40 – 56%), GB electricity demand is expected to increase in all scenarios as a result of electrification of transport & home heating, and replacement of fossil fuels with blended, gas, hydrogen or electricity. By 2050, electricity demand is forecast to increase by 62 – 100% versus 2021;
- Storage and interconnection (flexibility) capacity will need to increase (from 10GW in 2021) to 19 – 33GW in 2030 and 48 – 79GW by 2050 to balance supply and demand both within the GB system and across borders;
- Due to the electrification of other sectors, peak demand (FES uses the Average Cold Spell definition which is consistent with the treatment of demand in the electricity Capacity Mechanism) is expected to rise (from 2020's level of ~58.8GW) by 66 – 92% by 2050, even with the storage and interconnection capacities anticipated above to support "peak shaving";
- Therefore GB installed generation capacity will need to increase (from 107GW in 2021) to 171 – 209GW by 2030 to meet demand and remain on track to meet Net-Zero, with 70 – 80% of that capacity being low carbon in 2030 (vs. 56% today), and 100% low carbon by 2050;
- Installed generation capacity will need to grow even further (to 310 – 365GW) by 2050 to meet demand, and must be 100% low carbon to meet Net Zero legal requirements;
- To meet the 'Net Zero' target, a radical transformation to our national energy ecosystem is required, meaning even more low carbon, wind and solar generation capacity than even the most ambitious scenarios currently envisage, will be required to meet the UK's legally binding targets.

251. NGESO are not alone in anticipating the capacity of low carbon generation required to meet Net Zero. The CCC suggest that in order to meet a doubling of electricity demand from 100% low carbon sources, by 2030 up to 60TWh of low carbon generation (equivalent to approximately 15GW offshore wind capacity) will be required, on top of the offshore wind sector deal commitments [43], and up to 75GW of offshore wind could be required by 2050 [5].

252. The NIC scenarios anticipate that 129 – 237GW of renewable capacity must be in operation by 2050, including 56 – 121GW of solar, 18 – 27GW of onshore wind, and 54 – 86GW of offshore wind [41].

253. All three of NGESO's 2050-compliant scenarios include the commissioning of large capacities of low carbon offshore wind among other initiatives to facilitate emissions reduction in other industrial sectors. Research by the ESC corroborates this view, and anticipates broadly similar generation capacities as those proposed by the NIC. The ESC forecast that 165 – 285GW of capacity will be required in 2050, including 33 – 66GW of offshore wind. The ESC is more bullish on future nuclear capacity than other analyses, anticipating 20 – 38GW of nuclear versus 5 – 16GW (NGESO) and just 5GW (NIC) [37]. NGESO align with the ESC on the view that the 80% decarbonisation target could have been reached through multiple technology pathways, but that achieving Net Zero requires greater action across all solutions, including broader system-wide thinking. FES 2019, which was published just weeks after the Net Zero commitment was made, considered that in order to push to 100% decarbonisation, electrification, energy efficiency and carbon capture would all be needed at a significantly greater scale than assumed in any 80% decarbonisation scenarios [54]. Subsequent FES scenarios have progressively borne out that conclusion.

254. Ofgem state that: "The UK has made great progress in developing offshore wind, but capacity will have to increase enormously to achieve net zero" [51], describing in the same document, their plans to "Explore regulatory options to support development of an offshore grid to enable a four-fold increase in offshore wind generation by 2030" – i.e. consistent with current government policy as confirmed in the 2020 Energy White Paper [29].

255. Many forms of low carbon generation will be required to meet the UK Climate objectives. A diverse mix of generation is required to minimise integration costs for those times when variable technologies are not generating electricity, but this does not mean that particular low carbon generation developments should be curtailed to promote diversity. In 2021, GB sourced 42% of its electricity from renewables, and approximately 33% from wind alone [107]. In both 2019 and 2020, Denmark sourced 50% of its electricity needs from renewable generation (wind being the majority contributor) [80, 81], demonstrating that high proportions of renewable generation can be accommodated within national electricity systems. The UK can learn, and is learning, how to do this from other nations which are further ahead in this regard.

256. In summary, experts have concluded, and government has agreed, that decarbonisation in the UK needs to be significantly deeper, broader and more urgent than it has previously been considered, this is evident through FES 2021 by an increase versus previous FES editions of all low carbon generation indicators, and in published analyses by other market experts.

257. A massive move to electrification will be required fundamentally to underpin broad and deep national decarbonisation, and Net Zero requires a "system view" to be taken. This means recognising the importance of whole-system thinking in relation to the decarbonisation of non-energy sectors.

5.5. OFFSHORE WIND IS CRITICAL TO ACHIEVE DEEP DECARBONISATION

258. Because electricity can be generated from low carbon technologies, the demand for electricity in GB will grow as electricity enables the decarbonisation of other sectors. The need for significant growth in new generation assets is therefore clear, not only to meet this additional demand, but also to offset the closures of many existing generation assets, either because of environmental regulation or technological lifetime limits.

259. Historically generation assets in GB have been called 'conventional': predominantly coal, oil, gas, nuclear or hydro-powered. They have been dispatchable assets, meaning that their output and operational schedules are controllable: electricity on demand. Capacity factor is a measure of total actual generation per year as a proportion of total potential output in the year (plant capacity multiplied by 8,760 hours). Generally capacity factors have been high (>80%).

260. **Figure 5-4** shows NGESO's analysis of how generation capacity may evolve between 2030 and 2050 to meet a growing electricity demand, and a decreasing carbon budget. As GB makes progress towards its legal decarbonisation targets through the installation of more renewable generation capacity, total installed capacity rises in proportion. This is firstly because electricity demand is increasing, and secondly because the capacity factor at renewable assets is lower than the capacity factor at conventional assets, therefore relatively more generation capacity is required to meet the same level of demand with the same level of reliability.

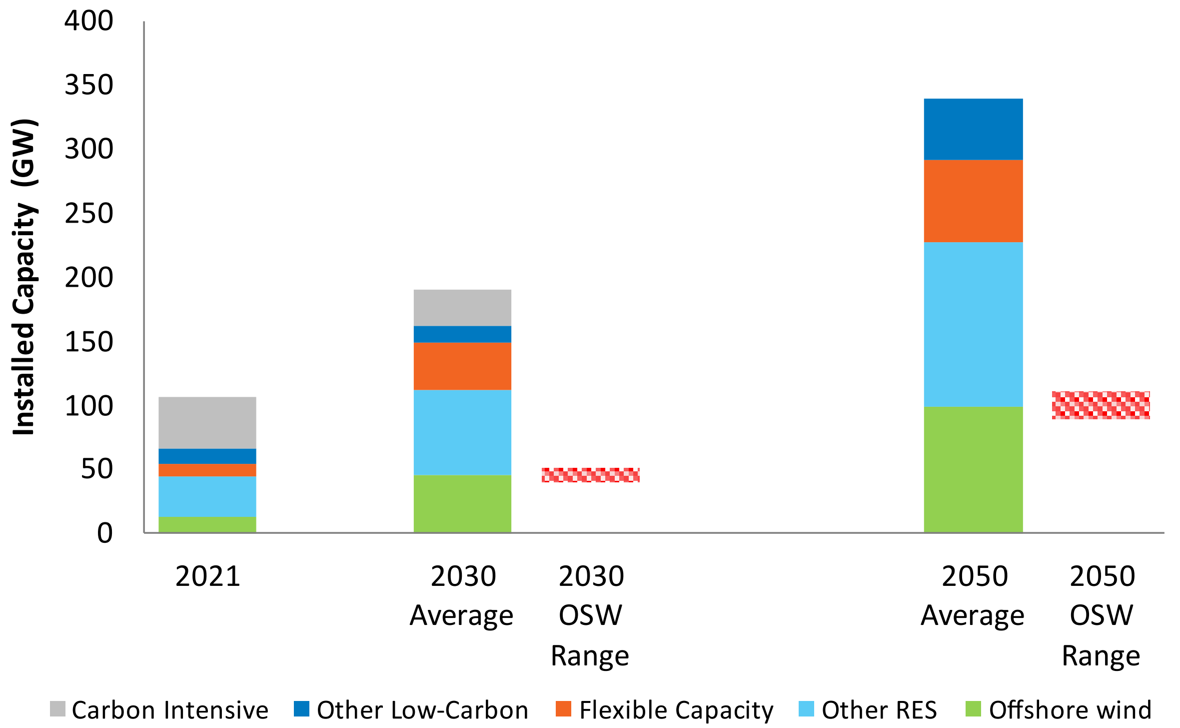

Figure 5-4: Generation capacity by technology type and amount of renewable capacity for 2030 and 2050

Adapted from [107]

261. One of the critical characteristics of the FES scenarios which meet Net Zero, is that the ratio of renewable generation capacity to annual average and peak demand increases from a current level of ~1:1, to ~2:1 and ~3:1 respectively through to 2050. Ratios implied in different FES scenarios are illustrated in **Figure 5-5**. Critically, the Falling Short scenario,

in which installed renewable capacity does not rise above the level of peak demand, or as a ratio of average demand, as high as the other (Net Zero compatible) scenarios. Falling Short is not compatible with achieving Net Zero.

262. It is important to appreciate that of the very many possible future scenarios for future electricity demand and supply, only some will achieve Net Zero. Some scenarios may cause cost-to-consumers to increase, while others may provide efficient and effective solutions. Both the UK and Scottish governments agree that increasing the amount of energy from renewable and low carbon technologies will help to secure energy supplies, reduce greenhouse gas emissions and stimulate investment in new jobs and businesses.

263. In order to meet the anticipated increase in electricity demand, NGESO conclude that the capacity of installed and operational low carbon generation must increase massively from the level which is currently operational. Energy efficiency and electricity storage will also have their roles to play, but societal decarbonisation will occur largely through the production of energy through renewable electricity generation, which will then be stored and/or transmitted to displace the consumption of carbon intensive energy. Alternative energy vectors, for example hydrogen, will be of fundamental importance in the displacement of fossil fuels from industry, transport and homes. Electricity generated from low carbon sources will be an important means of producing hydrogen.

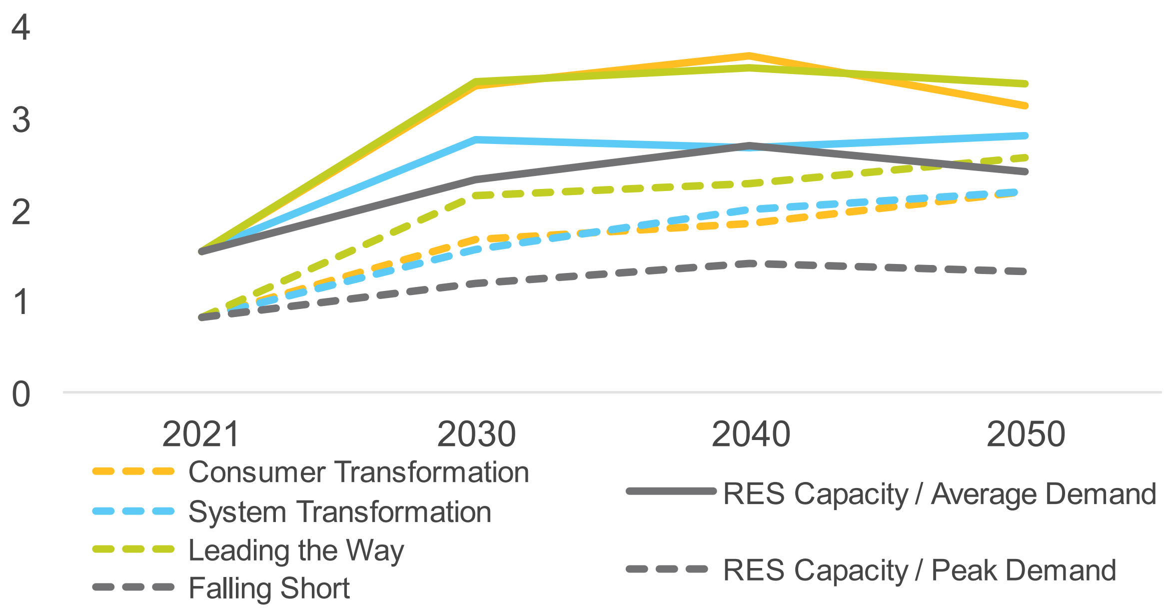

Figure 5-5: Ratio of Installed Renewable Capacity to Average (solid) and Peak (dotted) demand in 2020, 2030 and 2050 (by FES Scenario)

Adapted from [107]

264. NGESO data shows that offshore wind generated 53TWh of electricity during 2021 from 13.1GW of built capacity [107]. This makes offshore wind the largest power generation technology (by output) in GB during 2021. Critically, with 40% of Europe's wind in GB waters, offshore wind is a technology with future potential to meet the need for further growth. The second largest power generation technology, Combined Cycle Gas Turbine (CCGT), is not low carbon, so continued unabated gas generation is not currently consistent with Net Zero requirements. Either the source fuel must be decarbonised (e.g. a move from natural gas to hydrogen) or the power stations must be integrated with a CCUS network in order to remove net carbon emissions. The changing contribution of the third largest technology (nuclear) to low carbon generation in the coming decade, is discussed in **Section 5.2**.

265. **Section 5.3.1** describes why it is not likely that CCUS (the process to decarbonise carbon-intensive electricity generation) will play a significant role in reducing UK carbon emissions in the decade ahead, and **Section 5.3.2** describes why nuclear generation will also not make a net positive contribution to carbon reduction over the same period. Yet **Section 3.3** describes the urgent need for further progress to be made in decarbonisation. The UK must therefore continue to plan to decarbonise on a conservative basis to ensure sufficient supply is built out to meet demand across a wide range of future scenarios. Taking forwards no regrets, or low regrets projects, as described in the Scottish Energy Strategy and the UK Net Zero Strategy, is a key step in that conservative approach.

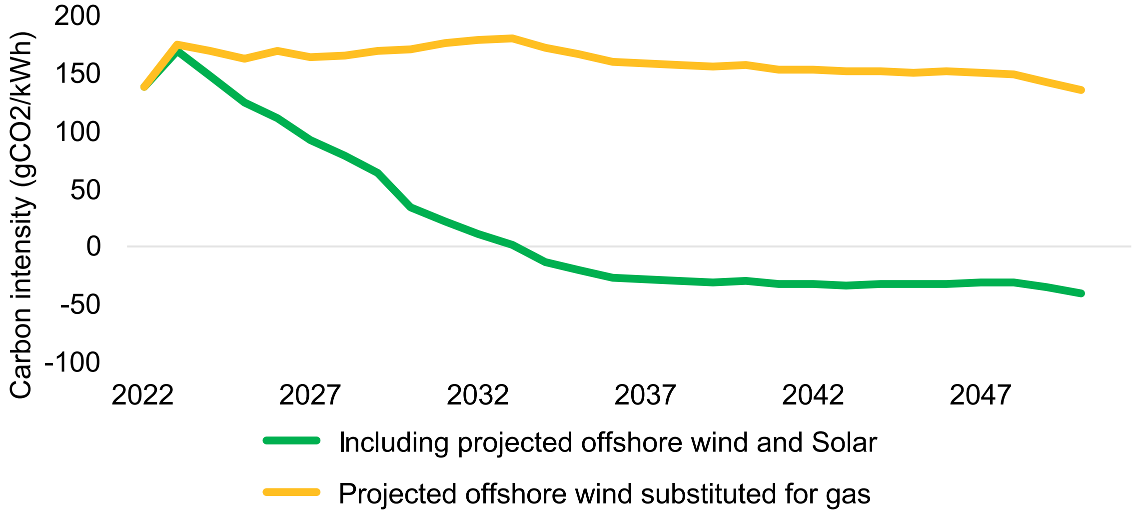

Figure 5-6: The effect on carbon intensity, of removing additional offshore wind generation from the future GB generation mix

Adapted from [107]

266. Hitherto unimagined capacities of renewable generation are therefore required to achieve total decarbonisation, not only as further development in dispatchable low carbon technology continues to bring the technology to operational scale, but also on an enduring basis, to meet foreseen electricity demand growth into and beyond the middle of this century.

267. Error! Reference source not found. shows the evolution of carbon intensity of electricity g eneration under two scenarios. The green line shows forecast average GB electricity generation carbon intensity under the NGESO FES 2022 scenarios which the meet Net Zero target. Critically, the power sector reaches net negative emissions in the early 2030s. The yellow line illustrates the importance of offshore wind to the GB generation mix. By replacing future additional offshore wind generation with CCGT generation (at 394 gCO_2/kWh) [114] the critical importance of additional offshore wind development to the decarbonisation of the GB electricity system becomes very clear. Without the development of additional offshore wind projects, the gap between the two carbon intensity traje ctories widens through until the mid-2030s and does not close again, effectively putting a halt to further reductions in the UK's carbon emissions.

268. Scotland's emissions from the power sector are already very low; Scotland has only one large-scale carbon intensive power station still in operation and approximately 75% of the total fall in emissions in Scotland since 2009 have come from the power sector. So although the CCC state that "Emissions savings from the power sector have largely run out" [15] it is for Scotland to continue to consent and support the development of new low carbon generation assets to ensure that demand can be met and carbon intensity can stay low as electrification expands in the coming decades.

269. Therefore the bringing forwards of offshore wind development projects should be prioritised and progressed with determined rigour and urgency, both for Scotland and for the UK, to enable their timely delivery and to ensure the carbon intensity trajectory illustrated can be achieved or bettered.

270. Both Scotland and the UK require swift and continued deep decarbonisation actions to meet their Net Zero climate commitments. As the leading low carbon generation technology in both Scotland and in the UK, it is critical that offshore wind generation capacities continue to grow.

5.6. FLOATING OFFSHORE WIND

271. Floating Offshore Wind (FOW) is a natural evolution to existing, ground-mounted technology. The market is driven by the prospect of accessing a much larger ocean area with high-quality wind resources, but in water depths that are too deep for conventional fixed-bottom technologies. In Europe, approximately 80% of the total technical offshore wind resource is estimated to be located in water depths which are likely to require FOW technology.

272. FOW may become a critical element of the global generation mix in order to deliver climate change mitigations. However the technology is currently in its early stages, especially when compared to fixed-bottom offshore wind.

273. The US Department of Energy [82] estimate that in 2020 approximately 100MW of FOW was in operation globally with a pipeline of projects with with estimated commercial operation dates of 2026 or earlier totalling approximately 3.5GW.

274. Multiple wind turbine demonstration projects are expected to come online globally through in the 2023 timeframe, with medium- to full-scale commercial projects announced for commercial operation after 2023. The majority of pipeline capacity is estimated to be in South Korea, however because most of these large commercial projects are still in the planning phase, there is a high degree of uncertainty about their economic viability and whether they will become operational or not.

275. Despite the global pipeline for floating offshore wind tripling during 2020 to 26GW, no new installed capacity was added to the global portfolio of operating floating offshore wind farms in that year [82]. Countries pursuing significant capacities of floating offshore wind include those which are concurrently pursuing significant fixed bottom capacities (e.g. South Korea) or those with limited national seabed estate upon which to install fixed-bottom asset (e.g. Norway).

276. As a comparison, the same report estimates total global operational offshore wind capacity at 33GW with a further 23GW under construction as of 2020, and a total global cumulative installed operational capacity of 145GW by 2026.

277. The UK has a large marine expanse with attractive site conditions for FOW, spread across several regions including the east and north east of Scotland, near to the locations of the ScotWind lease options. As such, FOW is likely to be an important element of the Scottish and GB energy mix to meet domestic climate change targets.

278. The Offshore Renewable Energy Catapult (OREC) is the UK's leading technology innovation and research centre for offshore renewable energy and plays a key role in delivering the UK's net zero targets by accelerating the creation and growth of Scottish and UK companies in the offshore renewable energy sector. OREC anticipate the first commercial-scale FOW projects (greater than 0.5GW) to be deployed in UK waters around the turn of the next decade, with an accelerated pathway commencing one year earlier but with double the annual rate of deployment [83]. The recent ScotWind seabed leasing round includes Scottish FOW projects with development timescales which are consistent with OREC's view. OREC's forecasts therefore imply that FOW is unlikely to contribute significantly to either Scottish or UK 2030 climate change targets due to the anticipated timing of delivery of the first and subsequent capacities.

279. The development of fixed bottom offshore wind is therefore preferential to and should be prioritised over FOW development in order to deliver essential decarbonisation benefits earlier than would otherwise be the case.

280. Further discussion is included at **Section 8.4**.

5.7. CONCLUSIONS ON FUTURE DECARBONISATION

281. In summary, despite recent commitments from government to providing continued support for the technologies, neither nuclear power nor carbon capture and storage are likely to play a significant role in furthering decarbonisation in the UK or in Scotland before the 2030s due to the delivery risk and timing constraints associated with both.

282. Half of Scotland's existing nuclear capacity shut down at the end of 2021, leaving just one station (1.2GW) operating until (current forecast) March 2028 [74]. Current Scottish policy does not permit further development of nuclear power using current technologies, however the door is open for the Scottish government to review any new designs if they can be demonstrated to provide good value for consumers. Under current policies, Scotland will be highly unlikely to lead the way on new nuclear development in the UK, and deployment before the 2040s is also unlikely. An important piece of evidence in demonstrating the provision of value for consumers, would be the development, commissioning and operation of a new-technology nuclear plant in the UK market, something which in itself is not likely to occur until the mid 2030s.

283. The flagship Scottish CCUS project, Scottish Cluster, is currently in a reserve position in UK Government's deployment sequencing behind two clusters in the north of England. Both of the prioritised Track-1 clusters are targeted to be operational in the mid-2020s. Therefore unless a different development path is taken, CCUS in Scotland may not deliver significantly earlier than 2030, assuming that Scottish Cluster retains its position as reserve project (and therefore could be expected to be a Track-2 cluster) and that the delivery of the Track-1 clusters remains on track, allowing important lessons to be learnt for incorporation in Track-2 clusters.

284. In the future, more projects, potentially making use of new technologies, may come forwards into Scottish and UK decarbonisation pipelines. However potential, but not yet consented and committed projects do not provide a solid basis on which to build a plan for decarbonisation given the urgency and severity of the global challenge to constrain temperature rises within the next thirty years. The Scottish government, recognising that there is uncertainty in what its future energy system will look like, proposes to focus on what are likely to be low or no regrets options [23].

285. The UK government recognises the prudence of planning “on a conservative basis to ensure that there is sufficient supply of electricity to meet demand across a wide range of future scenarios, including where the use of hydrogen is limited” [31].

286. Offshore wind power generation has global momentum and is already delivering GW-scale projects in Great Britain. With appropriate compensations in place, Offshore wind is a low regret or no regret option. The Offshore Wind Sector Deal celebrates the success story of the offshore wind sector in the UK. The UK has the largest installed capacity of offshore wind in the world and costs have fallen faster than was envisaged possible 10 years ago [27]. Scotland's Offshore Wind Policy Statement notes that offshore wind is one of the lowest cost forms of electricity generation at scale, and underlines Scotland’s huge potential resource. Offshore wind will help achieve deep decarbonisation as well as reduce energy costs for the future. The National Infrastructure Commission (NIC) increased its recommended UK renewables deployment target from 50% to 65% by 2030 [84], and the Scottish Government welcomes this increase in ambition [22].

287. The role that offshore wind has played in decarbonising GB’s electricity generation to date is clear from **Table 5-1**. UK offshore wind generated nearly 40TWh of low carbon electricity in 2019, increasing to 46TWh in 2020 and 53TWh in 2022 [39, 13, 107]: a significant and consistently growing proportion of UK electricity demand. Offshore wind has undergone

significant technological advances in scale and efficiency. The UK has 40% of Europe's wind resource [40] and a significant portion of that resource is located near to Scotland's abundant coastline, to the extent that the Scottish Offshore Wind Green Hydrogen Opportunity Assessment [61] presents scenarios for Scottish installed offshore wind capacity of 36 – 80% of the 75GW UK offshore wind deployment target recommended by the CCC. It is therefore for GB to make best use of this natural, renewable energy resource in order to meet its legal carbon emission reduction obligations.

288. With this context, the attractiveness of offshore wind, a proven technology which will deliver significant benefits to consumers through decarbonisation, security of supply and affordability this decade, becomes clear. The IPCC also stresses the importance of urgent action to decarbonise electricity generation, and the CCC have reported that the UK needs to commission more low carbon generation, and more quickly, to meet its Net Zero obligations. The deployment of new offshore wind generation is an anchor policy of the Scottish decarbonisation strategy and of the UK. The prompt development and deployment of proven technologies, such as offshore wind, is a lower-risk pathway for delivering low carbon generation both now and for the longer term and as such should be prioritised as a tangible low regrets contributor to a solution for climate change.

289. The Project is a "low regrets" project because of its potential to produce significant quantities of low carbon energy through the deployment of a well known and well understood technology in a well known and well understood location and physical environment. It will play a major part in reducing carbon emissions from Scotland and from the wider UK, as well as facilitate a further move away from high carbon technologies and reduce costs for the future.

290. Offshore wind is well placed to play the significant role it has been assigned in the Scottish Energy Strategy, the Scottish Offshore Wind Energy Policy Statement and at a UK level, the Prime Minister's Ten Point Plan, the Energy White Paper and the UK Offshore Wind Sector Deal.

291. The need for the Project has been demonstrated through an illustration of its contribution to decarbonisation in Scotland and at the UK level.

292. The characteristics which demonstrate the contribution the Project can make to Scottish and UK decarbonisation targets are: how much capacity can be delivered; when that capacity can be delivered; and how much energy that capacity is anticipated to deliver (per year). Collectively, these three numbers drive the carbon benefit delivered by the Project.

- Offshore wind technology is well known and well advanced. It is deliverable with a very high degree of confidence. While other low carbon technologies suitable for deployment in Scotland may show promise, they have not yet have been delivered at the scale required, therefore carry potentially high levels of risk associated with their technical delivery and decarbonisation benefits;
- The location is well understood and has been extensively surveyed. Nearby assets are also being developed and some (e.g. Seagreen) are currently being built;
- The location is the last of the near-shore (shallower) seabed sites available including ScotWind leasing areas, which further reduces delivery risk and uncertainty associated with the project over other deeper and potentially less surveyed seabed areas (see **Section 3.7**);
- The Project is therefore likely to offer the earliest potential delivery of the current unconsented pipeline of offshore wind capacity in Scotland and with a lower construction risk. Coupled with its 4.1GW capacity, the Project offers significant and timely decarbonisation benefits to Scotland and the UK in support of the NDCs;
- Further, the quantity of low carbon power deliverable by the Development provides opportunities post 2030 to unlock and make feasible a hydrogen economy for Scotland, and therefore must be a low regret project for Scotland and also for the UK.

293. The Project is an incredibly important scheme because it delivers significant benefits against stated Scottish and UK policy aims. Without it, Scottish and UK offshore wind targets will be much less likely to be met, and as a consequence the likelihood of meeting an already challenging Scottish (and UK) Net Zero target within the legislated timeframes would reduce, potentially to dangerously low levels.

6. PROGRESS AGAINST POLICY COMMITMENTS

6.1. THE OFFSHORE WIND PIPELINE

294. TCE publish project listings on a quarterly basis, the most recent of which [87] was published in July 2022. The listings include all offshore wind projects which have been granted seabed rights through either TCE Allocation Rounds (covering English and Welsh territorial waters) or CES leasing rounds (e.g. ScotWind). National Grid's Transmission Entry Capacity (TEC) Register [16] also provides an early view of potential future generation projects, however a number of projects listed on the TEC Register have not yet been successful in securing seabed rights for their development. We therefore use the TCE Project Listing as a view of the future pipeline of projects, and assume that the small number of projects included in the Project Listings but not identifiable on the TEC register will be successful in securing TEC in due course.

295. However neither the TEC Register nor the TCE Project Listing indicates confirmed generation capacities for projects not yet commissioned, nor does it seek to imply or impose restrictions on the capacities of generation of particular technologies which may be constructed and connected at particular locations.

296. The inclusion of a project in any 'future project pipeline' – for example, a list of projects which have applied for a DCO, the pipeline included in the TEC Register or TCE Project Listings – does not indicate a commitment by or obligation on the Applicant actually to deliver that project at all, or if it does, at a particular generation capacity.

297. As stated by the Scottish Government: "It is worth noting ... that there are a number of factors that mean that projects consented in the pipeline may not progress to commissioning" [14].

298. It is therefore not the case that the ambitions of the Sector Deal, nor the newly adopted government policy, will certainly be met by those projects currently under consideration by developers. Within this context, the importance of all offshore wind projects currently under development, to the achievement of government policy and pledges, is clear. Without the Project, it is very possible that delivery of the Sector Deal and the 2030 ambitions of both the Scottish government and the UK government may fall short.

299. TCE Project Listings categorises projects according to their stage of development. The categories are: Fully Commissioned; Committed - Under Construction; Committed - Government Support On Offer; Under Development – Consented; Under Development - In Planning; Pre-Planning and Future.

300. The Project is listed on TCE's Project Listings as being at the Pre-Planning stage with capacity 4.1GW. National Grid's TEC register currently lists the Project as connecting as follows: 2026: 1.5GW; 2027: 0.9GW (both at Branxton) and 2031: 1.8GW (at Blyth).

6.2. SCOTLAND'S 2030 RENEWABLE SOURCES TARGET

301. The Scottish Energy Strategy (2017) [23] establishes targets for 2030 to supply the equivalent of 50% of the energy for Scotland's heat, transport and electricity consumption from renewable sources; and to increase by 30% the productivity of energy use across the Scottish economy.

302. The following analysis seeks to understand the role of the Project in meeting the Scottish 2030 Renewable Sources Target. To do this, two scenarios are presented.

- Scenario 1 extrapolates forwards the historical rate of reduction in energy consumption which achieved the 2015 energy productivity result and therefore models a 30% energy productivity improvement in 2030 vs. a 2015 baseline.

- Scenario 2 holds energy consumption flat against a 2019 baseline. Importantly, the formulation of Scotland's energy productivity target does not strictly imply that Scenario 2 misses the 2030 energy productivity target but instead would require greater value earned per MWh consumed than would be the case if energy consumption reduced as it did over the period 2005 - 2015. Indeed, the successful deployment of electricity-based heat and transport solutions would increase Scottish electricity demand, and Scenario 2 may therefore present a scenario of more rapid and successful progress towards Scottish Net Zero 2045 goals than a scenario in which demand reduces.

303. Both scenarios assume that all Other Low-Carbon generation capacity which is already built (with the exception of Hunterston and Torness nuclear power stations) continues to operate until 2030.

304. **Figure 6-1** shows Scenario 1, i.e. Scotland's heat, transport and electricity gross consumption from 2013 to 2019 (actuals) and a forecast of 2020 to 2030, assuming that total consumption decreases in the next decade at the same rate as it decreased in the 2010s. Also charted, is the anticipated electricity generated from onshore wind, offshore wind (excluding the Project) and other low carbon and renewable sources, using the assumption that projects listed on the TCE Project Listings are deployed in line with their associated grid connection dates from the TEC Register [16]. Load factors (which convert installed capacity (MW) to annual generation (TWh) have been derived from Scottish Government publications and National Grid industry data.

305. The orange dashed line in **Figure 6-1** shows the 2030 target of 50% of anticipated gross energy demand (in 2030). The dark blue, brown and green lines show the cumulative anticipated supply from Other Low-Carbon, Onshore Wind and Offshore Wind assets respectively, generating from the dates listed in the current TEC Register. Other Low-Carbon capacity includes nuclear generation from Hunterston and Torness nuclear power stations. Hunterston closed in January 2022 and EDF has recently announced that Torness is now expected to close in 2028 [74]. Existing nuclear generation in Scotland will not contribute to achieving the 2030 target.

306. **Figure 6-1** shows that the energy generated by projected onshore wind and low-carbon generation assets should be sufficient to meet Scotland’s 2030 Renewable Sources Target, assuming that Scottish energy demand continues to reduce as it has done previously. Total energy consumption in Scotland reduced by 16% from 2005 to 2015, and at the same time energy productivity increased by 31%.

307. **Figure 6-2** shows an alternate scenario in which Scottish energy demand does not reduce in the 2030 timeframe. The orange dashed line in **Figure 6-2** is higher than that in **Figure 6-1**, and both offshore wind and onshore wind projected capacity is required to meet Scotland’s 2030 Renewable Sources Target.

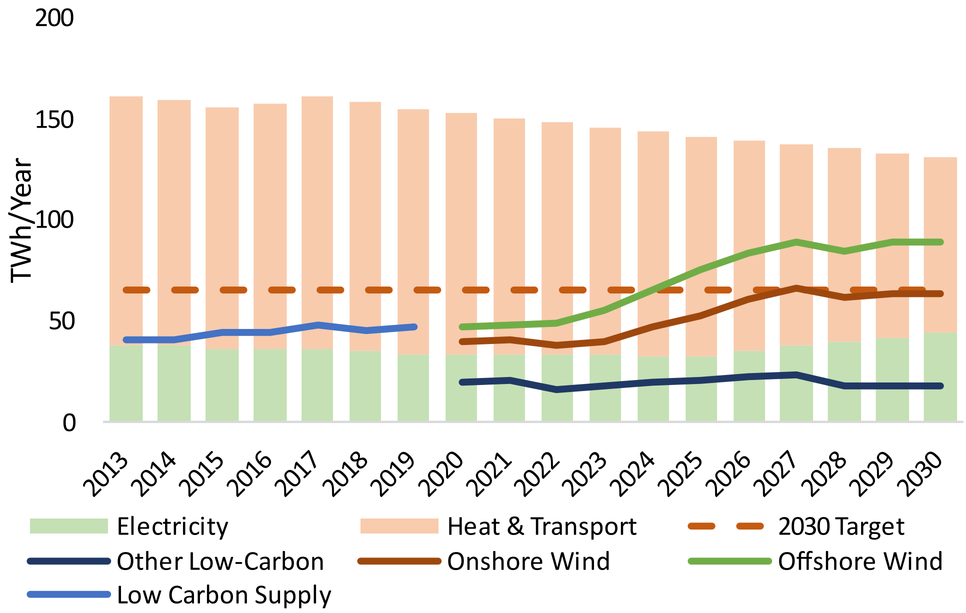

Figure 6-1: Scotland Energy Projection to 2030: Scenario 1

[Author analysis]

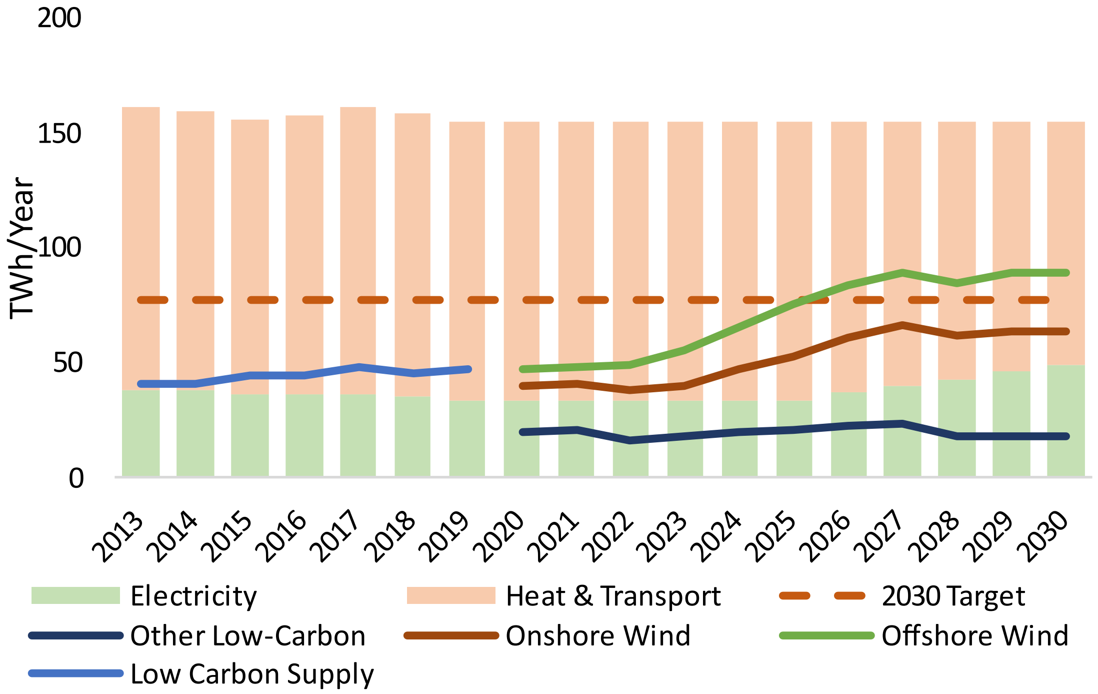

Figure 6-2: Scotland Energy Projection to 2030: Scenario 2

[Author analysis]

308. **Figure 6-1** and **Figure 6-2** show that if all projects listed in TCE Project Listings and National Grid's TEC Register as commissioning in or before 2030 are delivered, then even without the Project delivered at 4.1GW capacity, Scotland's 2030 renewable sources target is achievable, whether demand continues to reduce or not. However an analysis of original estimated installed capacity at the point of lease grant, compared to TCE data on delivered capacity, shows that historically, the attrition rate for offshore wine projects has been

around 30%. This analysis covers projects which have either delivered, or been abandoned, across a total estimate of 22GW of potential capacity across Allocation Rounds 1, 2, 3, Scottish Territorial Waters and Round 1&2 Extension round of which has been delivered. Therefore assuming a 100% success rate for future new projects may be overly ambitious.

309. If the Project was not consented at 4.1GW capacity, a success rate of 57% of the capacity of all Scottish low carbon projects currently listed on the TEC Register, would be required for Scotland to achieve its 2030 energy productivity target (Scenario 1). The percentage success rate has been calculated via the anticipated annual energy generation from the capacity installed. By consenting the Project at 4.1GW, the required success rate under demand Scenario 1 for projects not yet built would need to be 40%, i.e. approximately two-thirds of the required success rate if the Project was not consented. In Scenario 1, consenting the Project therefore significantly reduces the risk of Scotland falling short of its 2030 renewable sources target.

310. If total Scottish energy consumption follows Scenario 2 and the Project was not consented at 4.1GW, then because of higher demand, the required success rate for low-Carbon projects (excluding the Project) to achieve Scotland's 2030 renewable sourcing target would be higher, at 77% - i.e. attrition would need to be lower than the historical average achieved rate of 30%. By consenting the Project at 4.1GW, the required success rates under Scenario 2 for projects not yet built would be lower, at 62%. This is an important analysis because the trajectory of total energy demand in future years is not yet known and therefore planning for success on a conservative basis is prudent.

311. This analysis assumes 2.3GW of connection capacity is operational before 2030, the connection point for 1.8GW into Blyth currently being available from 2031. It is therefore a conservative analysis. However it is the project's ambition, and also in like with UK Government ambition as set out in the BESS, to explore opportunities with NGESO to bring this second connection point forwards into the 2020s. (See **Section 7.9** following for more detail).

312. Importantly not only does a lower required success rate manifest as a greater likelihood of reaching the policy target, protecting against the late or reduced delivery of projects on the current pipeline, but it also manifests as a greater opportunity for over-delivery against the target, and therefore the opportunity to accelerate decarbonisation in Scotland over the legal emissions targets as amended by Climate Change (Emissions Reduction Targets) (Scotland) Act 2019. This is relevant because of the greater ambition shown by the UK Government in increasing the capacity of operational offshore wind farms in the to 50GW by 2030 – and Scottish sites will be an incredibly important part of reaching that ambition. Greater capacities of low carbon generation will also deliver deeper decarbonisation of underlying electricity consumption and also will provide greater confidence in the deployment of new technology to decarbonise heat, transport and industrial demand through the creation of a significant portfolio of low carbon electricity generation assets.

313. This analysis shows that while the Project is not essential for Scotland to achieve its 2030 renewable energy sourcing targets, delivery of the Project is beneficial for Scotland.

314. In a scenario where energy consumption out turns above an extrapolation of historical demand reduction, without the Project, the success rate of future projects in moving from Pre-Planning Application stage to Built stage would need to be higher than has historically been seen in Scotland. However delivering the Project against its TEC Register schedule reduces the required success rate of other projects by c15% in both scenarios.

315. Consenting the Project would provide a significant opportunity for Scotland to increase confidence in the delivery of its 2030 renewable sourcing target and provide a platform of low carbon electricity generation which would increase confidence in the deployment of technology to displace fossil fuels from heat, transport and industrial demand. By doing so, the Project would provide a unique and significant contribution to Scottish decarbonisation efforts.

6.3. SCOTLAND'S 2030 OFFSHORE WIND CAPACITY TARGET

316. The Scottish government's updated Climate Change Plan recommends increased investment in renewable energy as a sector-specific action to contribute to the delivery of its climate change targets. The adoption of electricity-based solutions, for example in heat and transport, which requires delivery of the large potential for renewables growth in Scotland, is a critical element in the chain of reducing consumer emissions [21]. There are also opportunities in Scotland for hydrogen to play an important role in decarbonising energy consumption. Large scale green hydrogen production requires large scale low carbon electricity generation to provide power for electrolysis. Further, hydrogen production and storage facilities would integrate with the electricity sector by providing the balancing and flexibility services which are anticipated to be required in future low carbon electricity systems. Offshore wind is a critical element of Scotland's climate change plan because of the significant natural resource potential available. **Figure 6-1** shows the importance of offshore wind, alongside other low carbon technologies, to meeting Scotland's anticipated energy consumption. The Scottish Offshore Wind Policy Statement [22] supports the development of between 8 and 11GW of offshore wind capacity by 2030.

317. As previously mentioned, the TEC Register [16] provides a snapshot at a point in time, of current projects and their capacities and for future projects, both their capacities and their current estimated connection dates. However some offshore wind projects listed on the TEC Register do not relate to projects which have seabed rights from CES, or TCE (which are listed on [87]). Seabed rights are a mandatory pre-requisite for project development.

318. Offshore wind generation schemes in Scotland can only be developed through the mechanism put in place by CES for leasing areas of the seabed in a structured and timely way. All projects currently holding seabed leases, including those won in the recent ScotWind round, are already listed on the TEC register, therefore any other offshore wind projects which are currently under development must be relying on subsequent ScotWind leasing round(s) to secure seabed leases and can be assumed not to have yet secured a grid connection agreement.

319. Therefore the following analysis excludes any offshore wind farm projects with connection dates before 2033 which do not have seabed rights. This puts their development “behind” projects which already have seabed rights and a grid connection agreement.

320. TCE Project Listings [87] lists 1.9GW of built offshore wind in Scotland, with a further 3.9GW of Consented and/or Committed projects which are currently scheduled to deliver before 2025. These projects include Neart na Gaoithe (0.4GW), Seagreen Phase 1 (1.1GW), Inch Cape (1.1GW), Moray West (0.9GW) and Seagreen Phase 1A (0.4GW). No other offshore wind farms are yet consented in Scottish waters, and importantly none others are currently listed as being in the planning process in TCE’s project listings. The Project is the only Scottish Project with seabed rights with a grid connection agreement connecting before 2030 (2.3GW) with a further 1.8GW currently connecting in 2031 with ambitions to bring the connection date forwards. In addition, 3.7GW of ScotWind sites are listed with connection agreements effective from 2033 although others may have similar connection dates which have not yet made it to the TEC Register. See **Section 7.8** following for more detail on connecting ScotWind sites.

321. There may be other offshore wind projects in Scotland which are not yet listed on the TEC Register. The technical and commercial risks associated with the development of any such projects should not be underestimated. Subsequent steps in their development include securing grid connection agreements, securing a seabed lease, securing funding and planning consent, construction and commissioning. Any offshore wind projects under development which are not already listed on the TEC Register will therefore be highly unlikely to deliver first power before 2030 and therefore will not contribute to Scotland's 2030 offshore wind capacity target.

322. Therefore any developments which make significant contributions to meeting the target capacity in the timeframe required are necessary developments. However developments which are better placed to meet the urgent need for low carbon electricity generation are

more beneficial for Scotland and should therefore attract a greater weight in proportion with that benefit. The Project benefits from already being significantly advanced in environmental studies, feasibility studies and other preparations ahead of making an application for planning consent. The Project is therefore better placed to deliver significantly earlier than those other developments, whether they are listed on the TEC Register or not, and therefore is more necessary than other projects to the achievement of Scotland's 2030 Offshore Wind Capacity Target.

323. In order to meet Scotland's Offshore Wind installed capacity target, between 8 and 11GW of offshore wind must be commissioned before 2030, noting that 11GW is a target and not a limit to Scottish installed offshore wind capacity in 2030. **Figure 6-3** shows that the Project will play a critical contribution to Scotland's offshore wind project pipeline. Without it, Scotland will not meet its lower target of 8GW of offshore wind capacity (red dotted line), and the 11GW target (red dashed line) is unachievable unless project timelines are brought forwards ahead of their current grid connection dates.

324. By consenting the Project, Scotland will meet the 8GW threshold, and will be progressing towards the 11GW target with the connection of the Project's 1.8GW link to Blyth in 2031 (the Cambois Connection) followed in 2033 by the development of other offshore wind projects (assuming they are consented) which are currently in the Pre-Planning Application stage. It is important to note that 11GW is a target, not a limit, for installed offshore wind capacity in Scotland in 2030 and therefore opportunities to bring forwards any or all of the 1.8GW capacity and ScotWind projects (with connection dates currently in the early 2030s) should be pursued. Being well placed to deliver the target increases the opportunity to exceed the target (and so bring forward decarbonisation benefits) but also de-risks Scotland's ability actually to deliver the target itself. The Scottish Energy Strategy describes Scotland's approach to the decarbonisation as being both confident and ambitious while remaining focussed on "low or no regrets options" and enabling the possibility of exceeding 2030 targets through the consent and delivery of the Project aligns with that approach.

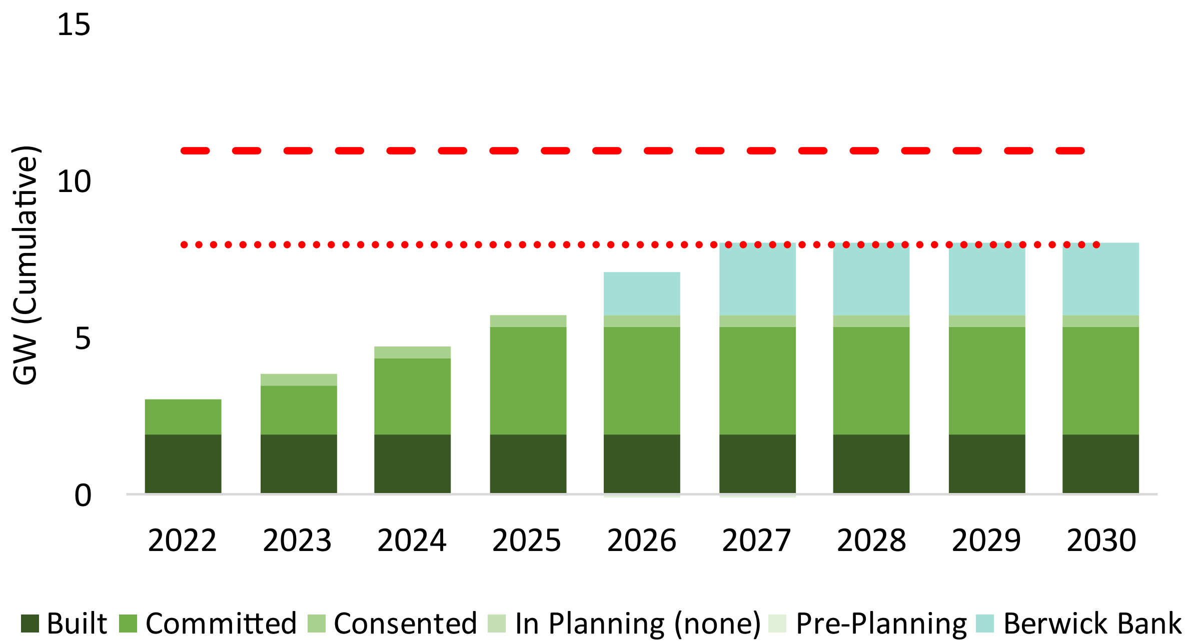

Figure 6-3: Current capacity (GW) and connection date of offshore wind projects in Scotland

Including the Project (blue) [Author analysis]

325. The provision of seabed leases to support 24.8GW of offshore capacity through ScotWind against a proposed 10GW is an example of the confident and ambitious approach taken by CES in the fight against climate change. The 2020s is the decade in which to set in motion the wheels of many projects which have potential to deliver decarbonisation in the 2030s and beyond. However it is also the decade in which to deliver those low and no regrets projects which are critical to reducing carbon emissions as early as possible. This will avoid the additional burden caused by late delivery of such projects, on the development pipeline for the 2030s and beyond. Consenting the Project is consistent with that approach.

326. All offshore wind projects currently listed on TCE's Project Listings have important potential with respect to the contribution they may make to achieving Scottish climate change targets. This Statement of Need does not seek to justify or promote the exclusion of any specific projects from the future generation mix. However some projects listed may be less likely to progress through to commissioning than others, and other projects which do progress may not achieve the timeframes and/or capacities currently proposed.

327. Consenting the Project is essential to meet Scotland's Offshore Wind Policy Statement low 2030 installed capacity target (8GW) and is therefore essential in order to keep open the possibility for Scotland to meet its higher 2030 target (11GW). If the Project was to achieve consent, it would be able to play an essential role in Scotland's decarbonisation efforts. Consenting the Project would be fully compatible with all aspects of current Scottish energy strategy.

6.4. THE UK'S 2030 OFFSHORE WIND SECTOR DEAL TARGET

328. The UK Offshore Wind Sector Deal [27] marked a significant deepening of the partnership between the government and the offshore wind sector, reinforcing the aims of the government's Industrial Strategy to build a Britain fit for the future. The Deal aims to drive the transformation of offshore wind generation, making it an integral part of a low-cost, low carbon, flexible grid system, and a key milestone in furthering the UK's ambition to maximise the advantages for UK industry from the global shift to clean growth. Originally targeting 30GW of offshore wind in UK waters by 2030, the Prime Minister's Ten Point Plan [45] increased that ambition to 40GW (in recognition of the criticality of offshore wind as a source of renewable energy for the UK's growing economy) and including 1GW of innovative floating offshore wind. The British Energy Security Strategy included an ambition to increase the capacity of operational offshore wind in the UK to 50GW by 2030 [108].

329. **Figure 6-4** shows that the Project has an important role to play in achieving the UK's 2030 Offshore Wind Sector Deal target capacity. TCE Project Listings includes 12.3GW of built offshore wind in the UK, with a further 8GW under construction. These include Dogger Bank (3.6GW), Hornsea 2 (1.4GW), Sofia (1.4GW) and Neart na Gaoithe and Seagreen Phase 1 (0.4GW and 1.1GW respectively) in Scotland. Hornsea 2 is currently commissioning therefore partially operational.

330. Additionally, 12.4GW of capacity has been consented but is not yet under construction. These projects are all currently scheduled to deliver before the end of 2030, and include the Scottish projects listed in **Section 6.3**. Other projects include Hornsea Project Three (3GW), East Anglia Three (1.5GW), Norfolk Boreas (1.8GW), Norfolk Vanguard (1.8GW), East Anglia One North and East Anglia Two (each 1GW)

331. Installed and operational capacity from projects which have already received their consent is therefore anticipated to be 32.7GW by the end of 2030, subject to all currently indicated capacity being fully delivered at the current grid connection date.

332. TCE's Project Listing also includes 3.4GW of projects currently in planning (including Awel y Môr and Hornsea 4) Other projects include the ScotWind round winners, and also projects which secured seabed lease options from TCE in England and Wales as part of Allocation Round 4. The total pipeline of projects with seabed leases which have not yet formally entered planning, consists of 33 projects with 44.1GW of potential capacity. Grid connection dates for these projects, with the exception of the first 2.3GW of the Project, are largely

scheduled for the 2030s. The projects cover a range of technologies, including extensions to existing (operational) seafloor mounted offshore wind farms, for example Rampion and Dudgeon, although it should be noted that the extension at Race Bank was dropped from TCE Extensions round, a demonstration of why registers generally could be overly optimistic as forecasts of future capacity. Other technologies at the Pre-Planning Application stage include offshore wind located in international waters (e.g. Icewind Hinkley Point, 1GW); projects connected to more than one market (e.g. Codling Park, 1GW); and at least three floating offshore wind projects currently listed with 1GW capacity.

333. New technology, be that floating offshore wind, connection cables covering thousands of kilometres or generation capacity connected to more than one market, carries associated technical and commercial risk. By contrast, sea floor mounted offshore wind capacity located close to shore and in areas already developed (such as the Project), present lower-risk opportunities for development. Therefore the Project and others like it are both necessary and urgent because of the significant contribution they will make to meeting the target capacity needed in the timeframe required and with lower risk than that associated with projects utilising emerging technologies.

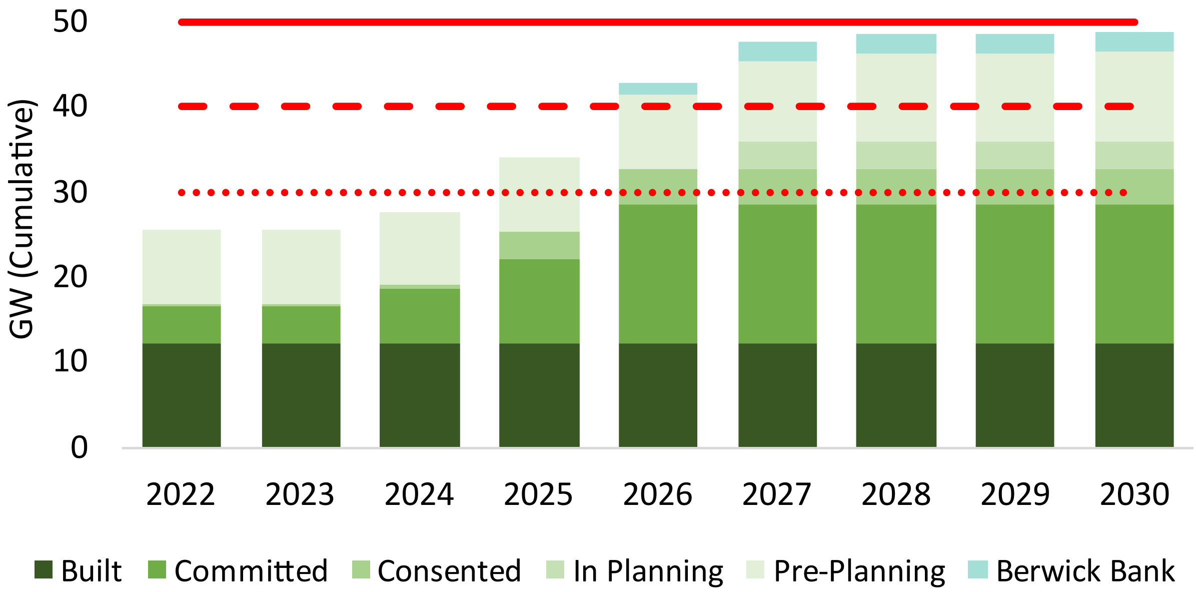

Figure 6-4: Current capacity (GW) and connection date of offshore wind projects in UK

Including the Project (blue) [Author analysis]

334. Offshore wind generation schemes in non-Scottish UK waters can only be developed through the mechanism put in place by TCE for leasing areas of the seabed in a structured and timely way. Any projects not currently holding a seabed lease, including those listed on National Grid's TEC Register [16] must therefore be relying on subsequent Crown Estate leasing round(s) to secure seabed rights.

335. **Figure 6-4** shows the cumulative operational capacity of offshore wind in the UK assuming all projects currently listed are delivered consistent with their current connection dates and capacities, 32.7GW of offshore wind, with connection dates before 2030, has either been consented and is on its way to becoming operational, or is already operational in the UK. Therefore if construction and connection schedules are adhered to, the original UK Sector Deal target of 30GW offshore wind operational by 2030 will be achieved.

336. In order to achieve the enhanced 40GW target if the Project was not consented, 53% of capacity in planning or in pre-planning with a connection date before 2030 must be

delivered. By consenting the Project, the project success rate for other projects could reduce to 33% and the 40GW target could be met. The Project therefore provides a significant opportunity to de-risk the UK's achievement of its offshore wind capacity target for 2030.

337. The British Energy Security ambition of 50GW by 2030 requires all projects currently in planning to be delivered according to their current connection dates and requires some other projects to be brought forwards into the 2020s. Delivering these projects, including the Project, and bringing forward to 2029 the connection date for the second phase of the Project, would reach the 50GW UK ambition. Although a historical industry attrition rate of 30% (as described in **Section 6.3**) would make the target unachievable unless project connection dates and consenting progress were brought forwards.

338. Consenting the Project will make a significant contribution to the delivery of the UK's enhanced 2030 Offshore Wind Sector Deal capacity target and 2030 BESS ambition, and in doing so will make important contributions to reducing further global temperature increases by producing large amounts of low carbon electricity and therefore reducing the need for carbon intensive electricity generation to meet demand.

6.5. RENEWABLE SOURCING IN SCOTLAND BEYOND 2030

339. 2030 is an important stepping stone on the way to Net Zero 2045 and Scotland's 2030 Renewable energy sourcing target is likely to be progressively raised towards 2045, when it is foreseen that Scottish renewable energy generation will significantly outstrip demand, to ensure required levels of security of low carbon supply as well as enable the continued export of low carbon power to the wider UK and adjacent interconnected markets, as part of a collaborative international solution to climate change.

340. The full supply of final energy consumed from low carbon sources, as will be required in or before 2045 in Scotland, requires a very different scale of solution to achieving a 50% supply of final energy consumed from renewable sources (as was illustrated in **Figure 6-1** and **Figure 6-2**). Low carbon generation must be capable of meeting average demand and peak demand, with a headroom for planned and unplanned maintenance as well as seasonal or weather driven surges in demand or reductions in supply. Scotland's Climate Change Plan Update relies on a substantial contribution from greenhouse gas removal technology on its pathway to 2030 and beyond, through the deployment of carbon capture and storage (CCS). In 2021 the UK Government announced that the proposed Scottish CCS cluster is a reserve project, behind two Northern English "Track 1" clusters. Although it is expected that further CCS clusters will follow, lower current levels of support for a Scottish CCS cluster may impact on the timing of the development and delivery of CCS infrastructure. The consequence is that through to and beyond 2030, more carbon reduction must be achieved by substituting carbon-intensive fuels for renewable sources, rather than removing carbon when carbon-intensive energy has been consumed. **Section 5.5** describes the levels of supply anticipated to be required to meet full demand across the UK in the 2050 timeframe.

341. It is therefore important to look beyond 2030 to assess the contribution specific projects will make to strategic aims. The enduring benefit brought by the Project to future Scottish renewable energy sourcing performance and securing Scottish 2045 Net Zero targets, is illustrated in **Figure 6-5**. Author assumptions have overlaid data from the National Grid TEC Register to derive a risked estimate of future renewable energy sourcing against demand, based on historical experience.

342. All projects have economic lives, and at their end may be either decommissioned or repowered. Scotland currently has 8.7GW of installed operational onshore wind capacity [14], but in 2019, Renewable UK [86] predicted that by 2040, up to 5GW of that onshore wind capacity may be lost as assets reach the end of their 25-year lives. Repowering may be possible in some or all cases, and their analysis forecasts that onshore wind installed capacity in Scotland in 2040 could range from 4.3GW (low repowering) to 10.4GW (optimum repowering) with an intermediate forecast of 5.8GW (intermediate repowering), not

including the further development of new assets. Wind Europe's annual trends and statistics report shows that the total capacity of projects repowered in Europe since 2009 is lower than the total capacity of projects decommissioned over the same timeframe. Therefore operational experience is that without the addition of new assets, installed wind capacity decreases over time [88]. **Figure 6-5** includes onshore wind decommissioning rates which match Renewable UK's intermediate forecast levels.

343. Offshore wind generation schemes in Scotland can only be developed through the mechanism put in place by CES for leasing areas of the seabed in a structured and timely way. All projects currently holding seabed leases are already listed on the TEC register, critically this includes 4.1GW of capacity associated with the Project and those projects which secured seabed leases in the January 2022 ScotWind Lease Round 1 result publications. Any other offshore wind projects which are currently under development must be relying on subsequent ScotWind leasing round(s) to secure their seabed rights.

344. CES currently anticipates subsequent rounds to follow ScotWind, and it is likely that any lease option areas made available to bidders in any future rounds will be located in deeper water, and/or further offshore, than areas already leased or offered through ScotWind.

345. **Figure 6-5** illustrates a future scenario for Scottish energy consumption and low carbon supply, assuming asset decommissioning and development success rates for different types of low carbon generation projects.

346. Onshore wind decommissioning has been included in line with the intermediate Renewable UK forecast, taking effect from 2029 onwards. Onshore wind decommissioning therefore reduces the net gain in renewable generation capacity associated with developing new assets in the 2030s and 2040s.

347. Further analysis by Renewable UK [86] concludes that 45% of Scottish repowering projects which have been formally considered have not reached commercial operation. A success factor of 55% has therefore been applied to all onshore developments which are currently in Pre-Planning Application stage but offshore projects and other low carbon developments have been adjusted by the historical 70% success rate derived from TCE data.

348. A representative success factor of 60% has been applied to offshore wind projects connecting beyond 2030. The lower success factor (than the 70% derived from TCE data) recognises the higher risks associated with these projects:

- Some seabed leases have not yet been identified or secured;
- Technologies may be required which have not yet tested at scale;
- Projects may be located in challenging physical and biological environments (for the turbines, the cable route or both); and
- Development cost forecasts may therefore be higher, and/or less certain, for projects which exhibit one of more of the above factors.

349. Any or all of the above factors may reduce the chances of an individual project being progressed through to delivery. Conversely, both the Offshore Wind Sector Deal and Scottish Offshore Wind Policy Statement include measures which may, if successfully applied, improve the chances of success of future projects.

350. 27 offshore wind projects, totalling 37.9GW of capacity are currently listed on the TEC Register as connecting in 2033 with a development status of “Scoping”. Some of these entries are related to successful ScotWind bids, others to unsuccessful bids, and others still are potentially “placeholder” applications for grid connections in anticipation of future offshore seabed leasing rounds. National Grid have declared a “TEC Amnesty” where projects which are no longer being progressed can release their TEC without penalty however the impact of that amnesty period on improving data quality in the TEC Register will not be known until the process concludes in late 2022. Whether or not all or any of these projects will deliver - and if they do, then when - will depend on the success or otherwise of those projects listed on TCE’s Project Listings and National Grid’s TEC Register (high levels of attrition in Scottish offshore wind projects is discussed in **Section**

3.7) and for those not listed, the timing and capacity available in subsequent CES seabed leasing rounds. **Figure 6-5** assumes a phased delivery of 50% of these projects connecting from 2033 at a delivery rate of circa 2.3GW/year. . As a comparison, the connection rate targeted by UK projects already approved and listed in the TEC Register as connecting between 2022 and 2031 averages 1.6GW per year.

351. **Figure 6-5** also assumes a continued increase in energy productivity through to 2045, achieved by reducing Scottish final energy consumption assuming an increase in energy productivity of 30% (2015 to 2030) and a continued increase in productivity at the same rate through to 2045.

352. **Figure 6-5** demonstrates likely levels of low carbon generation over the period to 2045 as electrification progresses and projects on the development pipeline either mature or drop away. By applying the assumptions described above to the capacity forecasts from relevant registers, it is shown that without the Project, future identified projects may generate just enough low carbon power to meet, on average, the forecast Scottish final energy consumption assuming an increase in energy productivity of 30% (2015 to 2030) and through to 2045. During periods of lower wind (as was experienced across the UK in 2021), or of higher demand (e.g. cold, still winter days) this scenario would not provide Scotland with sufficient low carbon electricity to meet demand. **Section 5.5** describes the anticipated relationship between renewable generation capacity and electricity consumption. In future Net Zero consistent scenarios, the installed capacity of renewable generation will be approximately three times the average level of demand, or twice the peak level of demand on the system. If Scotland's energy system was isolated from the UK-wide system, this would imply the need for approximately 27GW of renewable generation by 2030, rising to ~50GW in the 2050 timeframe.

353. It is clear from **Figure 6-5** that in order to meet 100% of consumption from low carbon sources by 2045 or earlier, significantly more renewable generation and other low carbon energy supply technologies will be required to come forwards in the 2030+ timeframe. Delivering the Project would provide an additional c.16TWh of low carbon energy each year post delivery, supporting capacity margins as electrification of final consumption increases during the 2030s.

354. Consenting the Project will significantly de-risk future low carbon energy supply in Scotland, and in doing so reduce the reliance Scotland must place on as yet unproven, and currently unfunded technologies, such as CCUS located in Scotland, to deliver 2045 commitments.

355. Scotland's energy system is also fully integrated into the GB-wide electricity system, and the delivery of offshore wind projects in Scotland contribute capacity to the growing GB offshore wind portfolio, thereby also delivering the 2030 Offshore Wind Sector Deal ambition and enabling the further deployment of offshore wind beyond 2030 to sufficient capacities to enable future Net Zero commitments to be met. It is vital that the Project, because of its potential capacity and deliverability, is consented to enable it to be a part of Scotland's and GB's, offshore wind fleet to enable Net Zero.

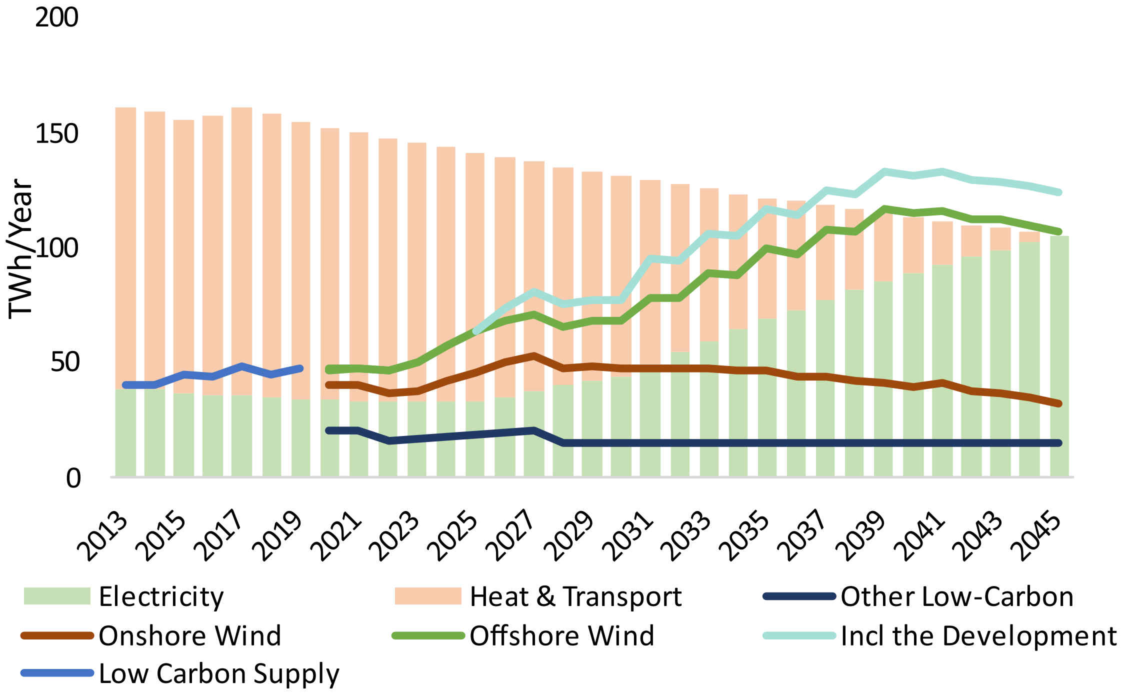

Figure 6-5: Scotland Energy Projection to 2045

[Author analysis]

6.6. CONCLUSIONS ON PROGRESS AGAINST POLICY COMMITMENTS

356. Climate change poses a severe and heightened risk to the planet. Immediate and concerted and coordinated action is needed to reduce emissions and so limit global temperature rise to 1.5C in the longer term. Scotland's 2030 target is committed in law, as is the UK wide target along with the stepping stones on the way to achieving Net Zero.

357. Decarbonisation does not stop in 2030 but continues with urgency until stable global temperatures are achieved, and because of the cumulative warming effect of atmospheric carbon, every moments delay makes that achievement more difficult and potentially further into the future.

358. Without urgent and meaningful action now, actions in the future must deliver greater levels of decarbonisation in order to limit temperature rises to the legal obligations in the Paris Agreement under the United Nations Framework Convention on Climate Change, the Climate Change Act 2008 (as amended), the Climate Change (Scotland) Act 2009 and the Climate Change (Emissions Reduction Targets) (Scotland) Act 2019.

359. Decarbonisation is already the global challenge of our lifetime, but our efforts, and those of future generations, will need to accelerate if urgent and meaningful actions are not set in motion now so that they can deliver in the critical 2020s and beyond. Therefore the benefit of the Project should be assessed both in terms of its contribution to Scottish and UK 2030 targets but also its contribution to the longer-term Net Zero commitments by no later than 2045 for Scotland and by no later than 2050 for the UK.

360. Substantial weight should be attributed to the contribution that the Project would make towards meeting the national need for low carbon energy and the substantial contribution it would make towards the delivery of renewable energy, ultimately assisting with the decarbonisation of the economy in line with the UK's legal obligations in the Paris

Agreement under the United Nations Framework Convention on Climate Change and the Climate Change Act 2008 (as amended).

361. The benefits of the Project, in particular its contribution of 4.1GW of renewable electricity to the urgent need to decarbonise electricity supply by deploying low carbon electricity generation in the UK, should be given significant weight in examination.

362. The Project makes a significant contribution towards satisfying the need for offshore wind in both Scotland and the UK

363. Consenting the Project would provide a significant opportunity for Scotland to increase confidence in the delivery of its 2030 renewable sourcing target and by doing so would provide a significant contribution to Scottish decarbonisation efforts.

364. Consenting the Project is necessary for Scotland to meet its low Offshore Wind Policy Statement 2030 installed capacity target (8GW) and provides the opportunity, if grid connection dates are brought forwards on the second phase of the development as well as other projects, to contribute to achieving the higher (11GW) target and in doing so will enable the Project to play an essential role in Scotland's decarbonisation efforts.

365. Consenting the Project will make a significant contribution to the delivery of the UK's 2030 Offshore Wind Sector Deal capacity target, and in doing will make important contributions to reducing further global temperature increases by producing large amounts of low carbon electricity and therefore reducing the need for carbon intensive electricity generation to meet demand. The Project is essential if the UK is to meet the ambition set out in the BESS of delivering 50GW of operational offshore wind in the UK by 2030.

366. Consenting the Project will significantly de-risk future low-Carbon energy supply in Scotland, and in doing so reduce the reliance Scotland must place on as yet unproven, and currently unfunded technologies, such as CCUS located in Scotland, to deliver 2045 commitments.

367. The Project is entirely consistent with the Climate Change (Scotland) Act 2009 and the Climate Change (Emissions Reduction Targets) (Scotland) Act 2019 and Scotland's legally binding indicative NDC (2020). The ongoing need for the Project is established as it is in line with the UK and Scottish needs for offshore wind as part of the transition to a low carbon economy. Granting consent for the Project would be compatible with current climate legislation and policy position.

7. SECURITY OF SUPPLY

7.1. SETTING THE SCENE

368. Decarbonisation is just one of the three pillars of UK energy policy. Low carbon generation of all forms – nuclear, wind and solar included – brings with it new challenges. Current and future energy policy and related actions must also ensure that security of supply is maintained, and that electricity is affordable for all.

369. Security of supply means keeping the lights on and has two main components. These are:

- Ensuring that there is enough electricity generation capacity available to meet demand (adequacy); and
- Ensuring that the quality of electricity supplied to customers falls within a narrow 'quality' band during all reasonably foreseeable operational circumstances, and is resilient during rare excursions from this band.

370. Governments needs to ensure that sufficient electricity generating capacity is available to meet maximum peak demand, with a safety margin or spare capacity to accommodate unexpectedly high demand and to mitigate risks such as unexpected plant closures and extreme weather events. The BESS [108] was published by BEIS against this requirement following emerging concerns on the security of international hydrocarbon supplies and increasingly volatile international markets in early 2022. Key points from the BESS were introduced in **Section 3-5** of this Statement of Need.

371. In general, the larger the difference between available capacity and demand, the more resilient the system will be in dealing with unexpected events, and consequently the lower the risk of a supply interruption. A diverse mix of all types of power generation helps to ensure security of supply, however a low-cost, net zero consistent system is likely to be composed predominantly of wind and solar [29].

372. The NETS is the integrated electricity transmission system for Great Britain. It connects all generators and consumers in Great Britain which means that currently an assessment of security of supply is relevant at the national level, rather than for Scotland as a standalone nation, although of course there are relevant considerations to be had at the local level in relation to how and where the Project will connect to the NETS.

373. In this section, power systems and aspects of their operation will be briefly introduced. Challenges associated with integrating renewable generators into existing systems will be characterised, and key points on the contribution of offshore wind generation to system adequacy and system operation are presented. Specifically:

- The Project will contribute significant capacities of low carbon generation to national system adequacy targets;
- The diversification of the GB's electricity supplies through the commissioning of offshore wind assets (such as the Project) to the NETS, alongside other low carbon generation technologies, provides benefits in the functioning of the NETS and ensuring power is available to consumers across the country when it is required, due to its requirement to operate within the stringent operability and control requirements of the Grid Code [89];
- Technical advances in the field of power electronics and other measures are significantly increasing the utility of power generation assets in the provision of services and protections which support grid operation [90]; and
- A program of grid investment and operational development by NGESO, regulated by Ofgem, is aiming for safe and secure operation of the NETS at zero carbon by 2025 [36] and for a fully decarbonised electricity system by 2035 [91]. The Holistic Network Design workstream, part of National Grid's Offshore Transmission Network Review, is a critical step in the process National Grid are following to connect large capacities

of offshore wind in an economic and efficient manner, the results of which have been incorporated into the 2022 NOA [115] and are discussed in **Section 7.8** following.

374. This section demonstrates how offshore wind has contributed, and will continue to contribute, to security of supply for GB consumers through being a dependable supply of low carbon power. The Project, if consented, would provide a significant and critical contribution to security of supply for the Scotland and for the wider GB. To provide appropriate context and understanding we set out in brief an introduction to a number of high-level concepts of power system operation.

7.2. POWER SYSTEM OPERATION

375. Power systems connect supply (sources of power, largely generators) to assets which demand power (industrial, commercial or domestic customers). Power systems are complex; yet they must be designed and operated safely, securely and economically.

376. Governments define policy to ensure that there is sufficient generating capacity available to meet maximum expected demand. This is called adequacy.

377. Key power quality characteristics (including frequency, voltage and power shape) must be controlled in order to maintain the synchronicity of all assets. NGESO define this topic area as system operability, specifically: "the ability to maintain system stability and all of the asset ratings and operational parameters within pre-defined limits safely, economically and sustainably" [92]. Protecting the safe operation of a power system when an asset operates outside of its normal expected parameters is also important, and individual transmission-connected generators, such as is planned at the Project, must synchronise to the national grid and maintain their own synchronicity with that system when they are operating.

378. NGESO also ensure that power demand, or load, and power supply, remain balanced at all times. Balancing requires the right generating assets to be connected and disconnected to/from the right power levels, and at the right time. This can sometimes be at short notice, in response to emergent (fault) conditions. NGESO call those services which support NETS stability and operability are called Ancillary Services.

379. The voltage level on the system is dependent on the type and quantity of generator and demand load connected to the system at the time. Over-volts occur when power demand is low, and load is too light. Voltage collapse occurs when load (particularly from heavy inductive machinery) is too high. Reactive power helps to maintain voltage levels, and its provision by generators is a mandatory service for transmission-connected generators.

380. System frequency must also be maintained at the UK's operational frequency of 50 Hz. Unless generation is scheduled to match demand, when system load increases, system frequency dips; and when system load is lightened, frequency increases. Because demand fluctuates continuously through the day, frequency must be continuously managed, and generators must therefore provide frequency response (FR) services. Under FR, generator output is raised on receipt of a signal from the system operator of a falling frequency; and reduced on receipt of a signal from the system operator of a rising frequency. Due to the impact of FR on MW output, generators which are able to provide FR will usually determine the price they would accept to provide the service.

381. If a sudden and unexpected disconnection of either demand or generation occurs, frequency may change rapidly. System inertia, a measure of the kinetic energy stored in rotating machines which are directly connected to the NETS, helps protect the system against rapid frequency changes. A system with high inertia is less likely to experience rapid system changes and will therefore be more stable, reducing the risk of faults escalating into wide-ranging effects on generators and customers [92]. System inertia is a phenomenon uniquely important to the NETS because of its relatively low levels of interconnection to other, larger, electricity systems such as is the case, in particular, across Europe.

7.3. OPERATING HIGH-RES ELECTRICITY TRANSMISSION SYSTEMS

382. The integration of RES and their likely effect on GB's electricity transmission system has been studied for over thirty years. In a 1991 paper [93], M.J. Grubb foresaw that “proper management” of renewable generation assets must be carried out in order to maintain a stable electricity system. The electricity industry has progressively implemented new processes and technologies, and stable operation of electricity systems is being achieved with higher shares of renewable generation on an increasingly regular basis. For example, in both 2019 and 2020, Denmark sourced over 50% of its electricity needs from renewable generation [81, 80]. In GB, renewables’ share of electricity generation was 44% during 2020 [13]. These statistics demonstrate that high proportions of renewable generation can be accommodated within national electricity systems.

383. The activities associated with integrating renewables into the GB electricity system will increase with their penetration [94]. Energy balance must be managed at all times; and as renewable capacity increases, more services will be required to regain supply / demand balance and retain system control, particularly when demand is either very high or very low.

384. In order to maintain the quality of electricity supplies, it is critical to determine how important each ancillary service will become in a future energy system, and how capable the generation assets connected to that system will be in providing those services.

385. Importantly, the dynamic behaviour characteristics for a high-RES system are well understood. For example, NGESO’s System Operability Framework (SOF) [92, 95, 96] describe these characteristics in relation to GB's electricity system.

386. Technological advance, in particular the introduction of power electronics into generating assets, is increasing the ancillary services and system stability services available from users of the electricity system, for example, by improving an asset’s fast response to system frequency changes, and their ability to withstand periods of system instability without disconnecting.

387. System stability services are already being provided by many existing and new technologies (e.g. batteries) and more recent advances have been made in the conversion of thermal and pumped storage assets into synchronous inertia providers.

388. The installation of power electronics at low carbon generation assets enable them to provide important system stability services [90]. By reprogramming the digital power inverters attached to wind turbines, they can emulate the behaviour required by the System Operator. Offshore wind farms under development are well placed to incorporate power electronics into their designs, so as to be able to provide important stability services through their operational lives.

7.4. CONNECTING GENERATORS TO ELECTRICITY NETWORKS

389. GB's electricity system operates at two levels: the high-voltage NETS, and the lower-voltage distribution networks. The NETS is mainly made up of 400kV, 275kV and 132kV assets connecting separately owned generators, interconnectors, large demands and distribution systems, and currently consists of approximately 4,500 miles of overhead line, 1,000 miles of underground cable and 350 substations. Applications for connection to the NETS are assessed through the first-come-first-served “Connect and Manage” process. A growing network of offshore transmission cables is also under development to bring the power generated by future offshore wind projects onshore and to consumers.

390. Connect and Manage offers are given to those customers who request a connection date ahead of when any identified wider transmission reinforcement works can be completed. The connection agreements contain the requirement for derogation against the NETS Security and Quality of Supply Standards which, once approved, allows for a connection to be made ahead of those wider transmission reinforcement works.

391. Wider transmission reinforcement works may be required to ensure that, once connected, electricity can flow from generators to where it is needed without constraint or hindrance. Generation connections close to demand centres (e.g. large cities or industrial areas) require the bulk transfer of power over shorter distances and therefore attract both capital and operational cost benefits when compared to generation connections far away from where the power is needed. However, with an ever-growing share of renewable generation capacity on the NETS, the bulk transfer of power over long distances remains vitally important, in order to keep lights on across the whole country when renewable generation output is high only in one area.

392. Recommendations made by NGESO in their annual NOAs are intended, when delivered, to allow them to manage the future capability of the GB transmission network against an uncertain energy landscape over the coming decades In 2022, NGESO recommended £215M of investment across 94 asset-based projects to maintain the option to deliver projects costing almost £21.7bn – a significant increase in the previous NOA's 25 asset-based projects costing an estimated £13.9bn [98]. Investments in 2022 would allow National Grid to manage the future capability of the GB transmission network against an energy landscape of significant decarbonisation over the coming decades [91, p6]. Investments are required to expand the transmission network to ensure that GB has a power system capable of delivering on its 2030 renewables ambitions and the UK's broader net zero target. These costs will ultimately be recovered from consumer bills. As such it is in the interests of consumers to maximise the efficiency and effectiveness of existing and new transmission connections, and ensure value for money is secured for any wider reinforcement works which may be required as a result of new locations.

393. Grid connection is an important aspect of generation project timescales and costs. The selection and utilisation of efficient grid connections in beneficial locations allows projects to come forwards at lower cost of generation and lower overall cost to consumers.

7.5. CENTRALISED AND DECENTRALISED GENERATION

394. Generation assets can be centralised (connecting to the NETS) or decentralised (connecting to the distribution networks).

395. High voltage transmission systems enable the pooling of both generation and demand, by connecting together large-scale geographically diverse electricity generating facilities with widespread consumer locations. This in turn offers a number of economic and other benefits, such as more efficient bulk transfer of power and enabling surplus generation capacity in one area to be used to cover shortfalls elsewhere.

396. Distribution networks were originally designed predominantly to transmit power from nodes on the NETS to consumers. By virtue of their role, many distribution networks are located in built up and heavily populated areas, and away from areas of large natural resource potential. They were not designed for the connection of significant electricity generation capacity, but the location of local energy solutions close to consumers allows for a tailoring of solutions to local need, and local and community participation in important schemes. The right facility in the right location may provide both economic and security of supply benefits to local communities, however geographical or technical constraints may arise if too much generation capacity connects to local networks. This may manifest in an upward pressure to both the cost of a distribution network connection agreement, and the period of time generators may have to wait until they are permitted to connect. This may materialise as significant cost, timing and complexity considerations for asset developers and may not always be good news for consumers who ultimately pay for the developments and the operation of the complex distribution systems which result.

397. The Scottish Government's Local Energy Policy Statement [99] describes the greater role anticipated in Scotland for local energy solutions to meet local energy needs, given the shift away from power generated from centrally located fossil fuel plants and towards substantial increases in renewable generation. However the Scottish Government recognises that local energy cannot be delivered in isolation but must integrate and align with other key Scottish

Government policies. Decentralised and community energy systems have important roles to play in achieving Net Zero but are unlikely to lead to significant replacement of larger-scale infrastructure.

398. As decentralised generation grows, the replacement and growth of transmission connected assets is also foreseen. Although decentralised generation will contribute to meeting carbon emissions targets, increasing energy security and will lead to some reduction in demand on the main transmission system, decentralised generation is not foreseen to replace the need for new large-scale electricity infrastructure to meet UK energy objectives. The recent implicit market preference for decentralised generation connections should be understood in the context of GB's national electricity system, with 74GW of generation currently connected to the transmission network and 34GW to the distribution network [107].

399. In all 2022 FES scenarios, decentralisation of generation is expected to increase, driven by the growth in smaller scale renewable generators. Currently 31% of all generation capacity is connected to the distribution networks and FES scenarios project that by 2050, the proportion may develop to between 23% and 39% [107].

400. Analysis of the FES 2022 scenarios [107] also shows that capacity connected to the distribution networks may grow at similar or higher levels than capacity connected to the transmission network (in 2050, between 2.7 and 4.3 times 2021's decentralised generation capacity may be connected to distribution systems, while the multiplier for transmission-connected assets ranges between 3 and 3.2). However FES scenarios indicate a total of 202 – 239GW capacity installed at the transmission connected level by 2050 for scenarios which are compatible with Net Zero: almost twice the capacity of potential connections at the distribution level in the same timeframe.

401. Distribution networks operate at a lower voltage than transmission networks, so generators which connect to these systems must have smaller capacities than those which connect to the NETS. As a consequence, in order to connect the same total generation capacity, more connections would be required at the distribution network level (at a potentially greater overall cost to consumers) than would be required directly into the NETS.

402. National Grid's Embedded Register [85] lists all connected or contracted to connect large decentralised generation projects in Scotland. A total of 168 onshore wind projects are listed, with a total capacity of 2.9GW. 1.7GW is already connected (108 projects) and a further 60 projects totalling 1.2GW is currently contracted to connect. The average generation capacity of decentralised generators listed on the Embedded Register is 20MW. Over 200 decentralised Scottish wind farms would need to be connected to be equivalent to the capacity opportunity presented by the Project - a four-fold increase in the current pipeline of projects listed on the register. This number is a conservative estimate as offshore wind farms have higher load factors than onshore wind farms, therefore significantly more than 200 average decentralised onshore wind farms would be required to generate the same amount of low-carbon electricity each year as the Project.

403. NGESO has publicly supported the connection of electricity generation technologies which provide a diverse energy mix to ensure that they can continue to manage supply and demand, for example [13, 100]. In conclusion, the need for distribution connected generation is in addition to, not instead of, the need for additional transmission connected generation; and therefore the development of distribution connected generation will not do away with the need for further transmission connected capacities. The UK-wide and Scottish need for large-scale low carbon generation capacity which will be met by the Project, cannot be met by multiple assets connecting to the distribution systems.

7.6. THE CHARACTERISTICS OF TRANSMISSION NETWORK CONNECTIONS

404. Large generators connect to transmission systems and smaller generators connect to distribution networks. Some of the most relevant differences between transmission- and distribution- connected generator characteristics are listed in **Table 7-1**.

405. Distribution-connected generators also contribute to meeting national demand, but because of the way they are connected, they effectively self-dispatch when they are available and offset national demand, thereby reducing the transmission demand level which transmission-connected assets must meet.

	Transmission	Distribution
Description	Connected to NETS at high voltage	Connected to distribution network at lower voltage (distributed) or into end use customer systems (micro). Collectively called Distributed Generation
Size	Typically large (100s of MW).	Typically small (<30 MW) to very small (single kW).
Technical Compliance	Required to conform to regulations and standards for critical service provision and response characteristics including reactive power, frequency response and fault ride-through.	Minimum technical thresholds are not as stringent but are increasing as a result of system interconnection requirements. Conformity with required standards may be harder to enforce.
Dispatch	Centrally dispatched by NGESO with known reliability	Generally locally dispatched with unknown reliability; outside of the direct control of NGESO.
Measurements	Metered to a high degree of accuracy, forecast output signalled to NGESO.	Largely unmetered, indications of availability, forecast output not required to be provided to NGESO

Table 7-1: Characteristics of transmission- and distribution-connected generators

[Author analysis]

406. The connection level of an asset impacts the benefits it brings to bill payers. Four major considerations are:

- Transmission connected assets provide visibility of their expected generation to the national energy market and NGESO as part of their licence to operate. This increases transparency in the market and allows sensible economic decisions to be made by all market players, including NGESO, in both planning and operational timescales to ensure that power demand and system security needs are met with the least possible cost;
- Transmission connected assets are required to be available for instruction by NGESO. They are required to participate in the Balancing Mechanism, making their flexibility available (at a transparent and cost-reflective price) to ensure that supply and demand remain balanced at all times. By contrast, distribution assets are not required to do this, although voluntary balancing markets are currently under development for smaller assets at the distribution level;
- While transmission systems have historically been designed to allow for the connection of large generating assets, distribution systems have not. Connecting generation assets of any meaningful size to distribution systems is becoming more difficult and more expensive;
- The mandatory requirements for a generator to connect to the NETS include minimum requirements for fault protection as well as system ancillary services (e.g. Obligatory Reactive Power Services). Distribution connected assets have different fault protection requirements (which are harder to enforce) however access to system ancillary services is expected to grow into the future. Transmission-connected assets are therefore differentiated in that they are de-facto required to support system operation in many ways as part of their connection agreement.

407. Decentralisation is not in itself a strategy nor a requirement of a low carbon energy system, but is a measure which will contribute to the delivery of a flexible, low carbon and affordable energy system. The CCC maintain that continued operation of the NETS remains an

important policy to maintain inter-regional connectedness and supports the meeting of national demand from geographically disparate sources [5].

408. Electricity consumers, either directly or indirectly, pick up costs through their energy bills related to market inefficiencies, economic decision making, asset investments, balancing actions and transmission and distribution system enhancements. Making best use of existing infrastructure and avoiding the need for expensive local network upgrades is also in the interests of the bill payer.

409. The interaction of decentralised generation with the balancing of the transmission network is complex, which is one reason why it is important to maintain diversity of generation assets across technology choice, scale and connection voltage. The Project contributes to that diversity by replacing closing transmission-connected assets, while transparently conforming to Grid Code operability requirements.

7.7. OFFSHORE WIND CONTRIBUTES TO SYSTEM ADEQUACY

410. In 2013, Electricity Market Reform brought changes to the GB electricity market by introducing a CfD scheme, and a Capacity Market. The CfD scheme encourages assets to come forward by firming up the revenue for assets, thus improving its attractiveness for investors. By bringing more assets forward to commercial operation, system adequacy increases.

411. Outside of the CfD scheme, system adequacy is primarily managed through the Capacity Market. In return for capacity payments, eligible assets agree to generate at or over a minimum commitment (their “de-rated capacity”) whenever NGESO (subject to a prescribed process) determine that additional generation output is required in order to meet demand.

412. Wind and solar technology are now included within the Capacity Market [101] and onshore wind and solar were reintroduced to the CfD mechanism in time for the most recent Allocation Round 4. While the Capacity Market is not open to assets which already hold CfD contracts, the inclusion of renewable technologies in the Capacity Market underlines the contribution renewables can make to system security: “The system is typically better off with intermittent capacity than without it – wind farms, for example, can make a contribution to overall security of supply” [102]. Renewable assets also already participate in capacity mechanisms in other highly volatile electricity markets, such as Ireland’s Single Electricity Market, and in parts of the US.

413. The contribution an asset class makes to overall security of supply can be assessed through its capacity utilisation. By measuring the capacity utilisation of a set of generating assets over a month, the variation in delivered generation from month-to-month as a proportion of total installed capacity, can be calculated. Stable and consistent capacity utilisation is important, because it relates to the reliability of, and therefore NGESO’s ability to depend on, forward forecasts of generation outturn.

414. **Figure 7-1** displays this metric for 15 GB offshore wind farms which operated through two continuous years, aggregated at a monthly level. It shows that each wind farm has its own generation profile. The five wind farms with the greatest variation in monthly capacity utilisation over the two years are plotted with red lines; the five wind farms with the lowest variation are plotted with green lines and the remainder are plotted with amber lines. The aggregated fleet capacity utilisation is plotted in black.

415. Aggregated fleet utilisation varies less from month to month than all but three of the individual wind farms, i.e. on average, the black line will not go as high, nor as low, as any of the individual yellow or red lines, and all but three of the green lines. A similar analysis can be carried out over daily, or even hourly tenors, arriving at similar results.

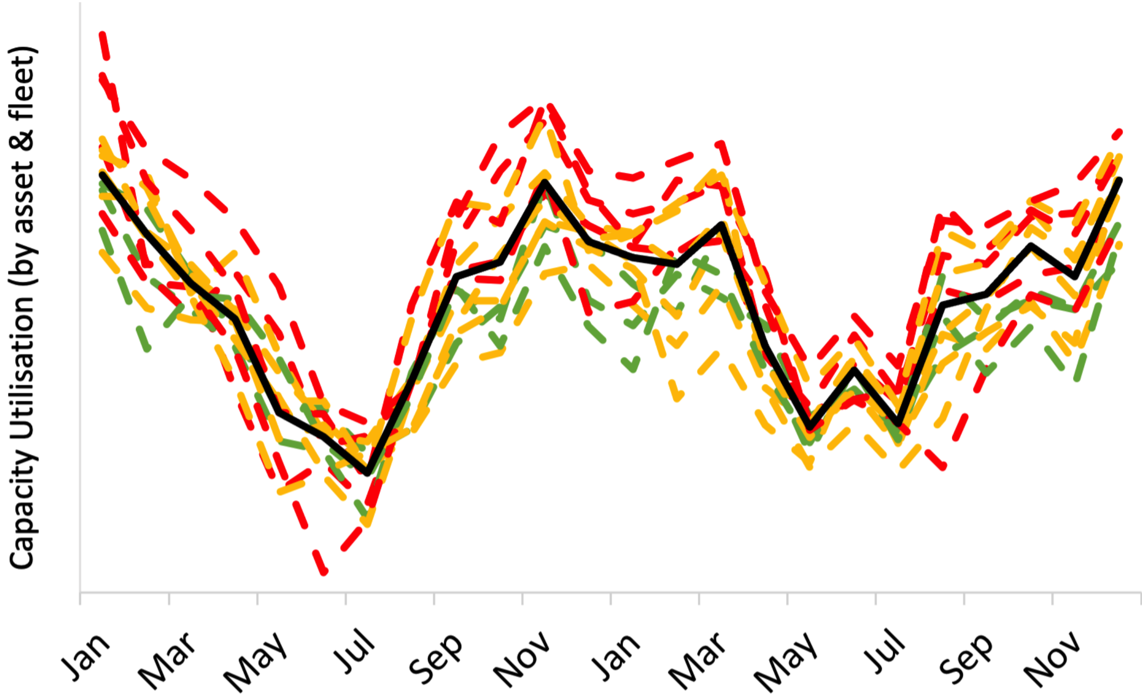

Figure 7-1: Monthly UK offshore wind portfolio capacity utilisation.

[Author analysis]

416. As GB's offshore wind fleet grows, so too will the stability of the capacity utilisation factor of the fleet versus the individual assets.

417. At the macro level, a more stable capacity utilisation improves forecast accuracy and allows for a more targeted specification for and use of backup plant, improving system security without creating an excess of generation capacity. Although of course sensible margins will still need to be applied to cover uncommon events.

418. An Imperial College expert economic analysis of whole system costs of renewables agrees: they show that the integration costs of RES fall on an absolute basis, as capacity increases from 10GW up to 50GW [103].

419. The National Infrastructure Commission also commissioned a whole-system cost analysis, the results of which were published in 2020 [84]. NIC's analysis complements that of the Imperial College team, suggesting that: "that there is no material cost impact, either over the short or long term, of deploying renewables faster. Renewables are now the cheapest form of electricity generation due to dramatic cost reductions in recent years."

420. Developing a generation portfolio with different renewable sources will also contribute to managing the generation dependability of intermittent generators on a national level. Excess generation may require curtailment and incur economic inefficiencies. and integration measures, including electricity storage, hydrogen and interconnection with other markets, are expected to be developed to capture energy during generation peaks and release it during generation troughs.

421. Integration measures already available today help balance variable electricity generation onto the grid to meet variable demand. Integration measures also ensure that best use is made of low carbon electricity when it is being oversupplied, including developing other assets with complementary seasonal generation profiles; managing shorter-term intermittency through storage or other measures.

422. In conclusion, offshore wind is an important asset class which is needed to deliver a required level of generation adequacy in low carbon networks. Although individual offshore

wind farms are variable generators, the capacity utilisation of the technology class is more stable than the capacity utilisation of the majority of the individual assets, and this helps keep system operating costs in check.

423. Increasing the capacity and geographical reach of GB offshore wind generation as the fleet expands to new areas of the Scottish, Welsh and English waters, will increasingly stabilise capacity utilisation. Integration measures will help operate the electricity system at times of very high or very low offshore wind output, and these are already being designed and deployed onto the NETS.

7.8. NETWORK DEVELOPMENT FACILITATES OFFSHORE WIND DEPLOYMENT

424. The Electricity Ten Year Statement (ETYS) sits at the heart of NGESO's network planning process. It uses scenario inputs from NGESO's FES analyses for both demand and supply to identify points on the NETS where investment is required to expand the capability of the network to continue to deliver electricity reliably. NGESO is responsible for the operation of the transmission systems in Scotland, Wales and England, and offshore, and the ETYS therefore covers all relevant transmission networks. NGESO work with all relevant transmission network operators to develop the ETYS.

425. The ETYS is produced annually, and the annual NOA process then identifies and assesses potential solutions to the network needs which have been identified in the ETYS. In 2022 the NOA was reissued, incorporating the impact of offshore coordination resulting from the Offshore Transmission Network Review’s Holistic Network Design workstream, the major outcomes of which are discussed further below.

426. The ETYS is an important element in helping NGESO to achieve the UK ambition of being able to operate a zero-carbon electricity system across Great Britain by 2025: a critical milestone on the UK’s journey to Net Zero by 2050. The most recent ETYS was published in late 2021 [36].

427. The transmission network is designed to provide enough capacity to send power from areas of generation to areas of demand however boundaries, which split areas of the national network into two parts, identify areas of the network which may encounter power flow limitations in the future depending on where, when and how much generation and consumption is anticipated in each area. The ETYS focusses on identifying critical boundaries such that mitigations can be made to improve reliability and cost performance of the national electricity system and for the benefit of all users.

428. **Figure 7-2** shows areas of the NETS which are relevant to the Project and to which the Project will connect. The blue lines are 400kV transmission wires: the backbone of the NETS and the main network through which bulk power is transferred. Red lines are also important parts of the transmission network, these are 275kV wires which are more suitable in Scotland and in other densely populated areas of the UK. The green dashed lines represent the boundaries NGESO consider through the ETYS analysis.

429. Four of the most important transmission boundaries in Scotland are B2, B4, B6 and B7, and the capability of these boundaries is the limiting factor (or enabler) for the flow of low carbon Scottish power south to consumers in England, Wales and Europe.

- Boundary B2 North to South SSEN Transmission. The potential future boundary transfers for boundary B2 are increasing at a significant rate because of the high volume of renewable generation (including both offshore and onshore wind) to be connected above the boundary, driving an increase in flows from north to south to take low carbon electricity to consumption centres. Potential future connections include generation capacities sited in the N- and NE- Plan Option Areas identified in ScotWind Lease Round 1.
- Boundary B4 SSEN Transmission to SP Transmission. The potential future boundary transfers for boundary B4 will include around 2.7GW from CfD Allocation Rounds 1-

3 as well as offshore wind generation capacities proposed in the Scottish territorial waters located off the north, north-east and potentially east coast of Scotland which came forwards under ScotWind (N-, NE- and E- Plan Option Areas).

- Boundary B6 SP Transmission to NGET divides the Scotland area from the North of England area. The anticipated growth of wind generation in Scotland will drive a wide range in boundary power flows over the B6 boundary. When wind generation is low, it will be credible for power to flow from south to north, feeding Scottish demand. This will become more frequent as Scotland's generation portfolio becomes more intermittent, i.e. after the closure of Torness nuclear power plant (and potentially Peterhead CCGT if CCS is not installed). South to north power will likely be low compared to north to south flows because of the significant wind resource potential in Scottish waters and on Scottish land, so boundary transfer capacity will be sized according to future renewable generation capacity in Scotland.

430. The ETYS does not show Boundary B7 as constrained due (among other reasons) to the significant localised industrial demand in the Teesside area.

431. Significant developments relating to the part of the network shown in **Figure 7-2** include the closure of Hunterston B nuclear power station (1.2GW) on the west coast of Scotland north of the B6 boundary in 2021/22; the anticipated closure of Hartlepool nuclear power station (1.2GW) near Teesside, between the B6 and B7 boundaries, in 2024; and the anticipated closure of Torness nuclear power station on the east coast of Scotland north of the B6 boundary in 2028.

432. Westernlink HVDC (2.3GW) is a sub-sea cable which connects Hunterston to North Wales. Westernlink became fully operational in 2019 and increased B6 boundary transfer capacity by approximately 50% of its previous value.

433. The 2021 ETYS reinforces two clear messages. Firstly, that growth in north-south power flows continues with high variability.

434. With proposed renewable generation located primarily in the north, but demand (both UK and internationally through interconnectors) located primarily in the south, the network must be reinforced to be able to transfer without hindrance the significant amount of electricity generated to where it will be consumed. When wind output is low, flows will need to reverse to ensure that security of supply in Scotland is maintained despite low local generation.

435. Secondly, the needs identified in the ETYS can and will be met through the timely delivery of network reinforcements described in the Network Options Assessment (NOA) [98]. The growth in government ambition for renewable generation has increased future ETYS boundary flow requirements. To reduce network constraints, the NOA recommended a number of options which, if implemented in line with the recommended schedule, will significantly reduce boundary flow constraints under all FES generation scenarios. The UK-wide integrated strategy of harnessing power from the winds above our seas and transmitting it to our homes and commercial and industrial properties, to be used for traditional purposes as well as displacing carbon-intensive fuels, is underway. The Project is entirely consistent with that strategy and if developed would provide a significant help to the UK and Scotland to meet their climate change aims.

436. The reinforcement of the transmission system in Scotland and between Scotland and England has already begun, and continued strengthening is essential to deliver the targets set for renewable generation in the Scottish Energy Strategy and Scottish Offshore Wind Policy Statement. Transmission system reinforcement will also provide GB-wide benefits including supporting delivery of the Offshore Wind Sector Deal target of 40GW of offshore wind by 2030, and in so doing will facilitate Scotland and the wider UK in reaching their legally binding NDCs.

437. The HND supports delivery of 2030 offshore wind ambitions and covers onshore and offshore network upgrade options to support the connection of up to 11GW of projects successful in the ScotWind leasing round with capacity located in each of the leasing zones, as well projects successful in TCE Offshore Wind Leasing Round 4.

438. ScotWind lease areas are located to the east, north-east and north of Scotland, with one site to the west, as shown in **Figure 3-5**. All northern and north-eastern sites are located north of the B2 boundary, and the other sites are located north of the B4 boundary. Eastern sites, which are located north of the Proposed Development off Aberdeenshire, will connect above the B6 boundary and possibly above the B4 boundary, although precise grid connection points will need to be confirmed for projects when lease winners progress the design of their grid connection agreements with NGESO in due course.

439. The NOA classifies options which are essential to facilitate the connection of 50GW of offshore wind in the UK by 2030 as "HND essential" options. Some of those options are shown in **Figure 7-3** following.

440. The HND confirms projects such as the Eastern HVDC Link (4GW in total across multiple stages) as key energy developments required to deliver the UK's 2030 offshore wind target and ambition. All such projects will enable the safe and efficient transfer of electricity from where it is generated to where it is demanded, and will help to strengthen the local transmission networks through which the energy will flow.

441. It is clear from **Figure 7-3** that there is a greater requirement to reinforce onshore networks north of the B6 boundary in order to connect new projects than there is further south, implying that projects which connect further south have less associated enabling work and therefore potentially a lower delivery risk profile than northern projects.

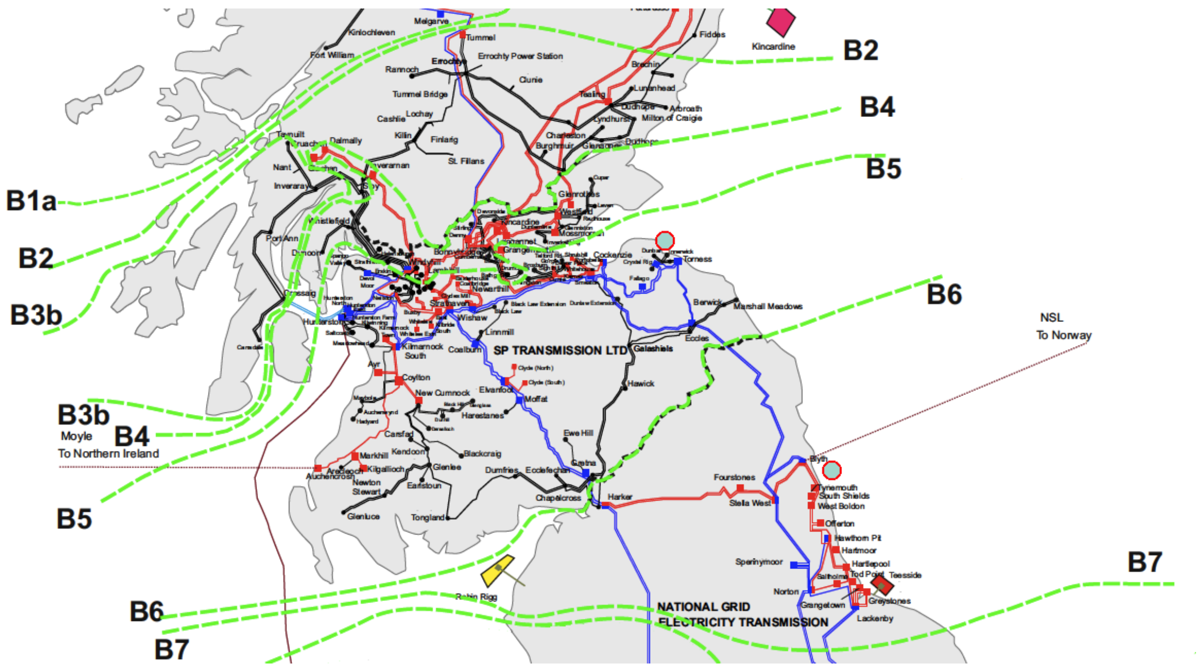

Figure 7-2: The National Electricity Transmission System in Scotland and north England

[36]

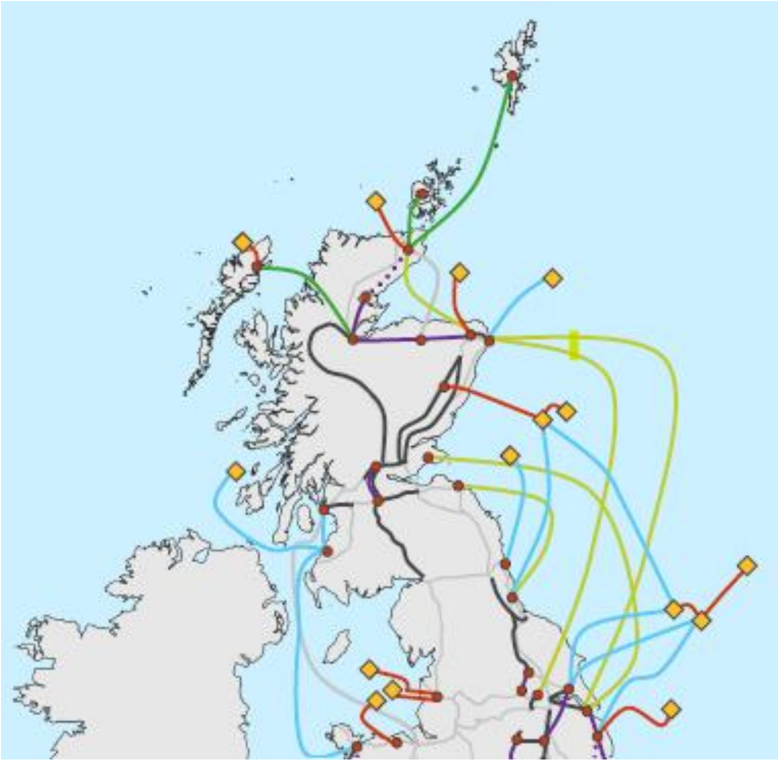

Figure 7-3: Illustrative map of network upgrade options in North Scotland and Central Belt / Anglo Scottish Border areas

[115]

7.9. NETWORK TOPOGRAPHY NEAR THE PROPOSED LOCATION

442. Offshore wind developments in Scotland are permitted only in zones which have been identified and allocated to potential developers by CES (historically: TCE). Offshore wind generation schemes can only be developed through the mechanism put in place by CES for leasing areas of the seabed in a structured and timely way.

443. The proposed array area for the Proposed Development comprises the former Marr Bank Wind Farm and Berwick Bank Wind Farm proposals into one single opportunity.

444. The Project includes two grid connection points. These are shown by the two teal circles with red borders on the UK east coast in **Figure 7-2**.

445. The first point is at Branxton near Torness in Scotland. The operating nuclear facility at Torness (1.2GW) requires that the grid system surrounding the area is incredibly robust, both in terms of reliability and transmission capacity. Torness nuclear power plant will close in 2028 (current operator forecast [74]) and connecting the Project near to Torness allows for the prolonged utilisation of transmission capacity which will be freed-up when Torness finally closes. It is in the interest of the consumer for new generation assets to connect to existing infrastructure rather than building new, where the existing infrastructure has useful commercial life.

446. Torness is also the site chosen for the northern landfall of 2GW of the Eastern HVDC Link system. Eastern HVDC Link is proposed to start construction in 2024.

447. The second connection point is near Blyth in England. As can be seen from **Figure 7-2**, Blyth is near Hartlepool - the location of another nuclear power plant which is scheduled to close in 2024, also freeing up transmission network capacity when it does. Blyth also connects the UK to Norway through the North Sea Link, a 1.4GW subsea interconnector

which commissioned in 2021. Although generally power flows from Norway to the UK (electricity is currently cheaper in Norway) at times of high wind, the export of power to Norway to be stored in their pumped storage hydro networks is an excellent example of international collaboration and whole-system thinking. The UK has exported power to Norway on frequent occasions during a very dry period for Norway in 2022.

448. Critically, both the Project's grid connection points are located south of the B2 and B4 boundaries, and the English grid connection point is also south of the B6 boundary. This reduces the impact that the Project will have on transmission system flows in Scotland, and any associated works required to reinforce the transmission system.

449. The Project currently holds a Grid Connection Agreement for the Blyth connection which is effective from 2031. This second connection was covered by the HND process and as such a coordinated solution was found to optimise connection routes and dates to support 2030 aims. ScotWind projects also covered by the HND also hold Grid Connection Agreements with similar effective dates.

450. However as shown in **Figure 7-3**, significant onshore network development is required to facilitate offshore wind connections in the north of Scotland, while the onshore works directly required to connect the Project at Blyth are much smaller. Further, some of the enabling works which will facilitate the Project's Blyth connection will also facilitate some ScotWind connections.

451. Previous NOA have identified network strengthening needs further south in England, shown as black and purple lines in **Figure 7-3**. These upgrades will facilitate power flows through England and therefore will enable the connection of many projects around the country – including ScotWind projects and the Project. The need for these upgrades is not necessarily to facilitate any one specific project alone.

452. Diversity in grid connection points for the Project supports the operation of the transmission circuits in and around the local areas by providing multiple routes for power generated by the asset to flow to where it is needed. This also reduces costs associated with connecting and reinforcing single connection points to be able to transfer large power flows, and provides security in diversity should a fault cause one piece of transmission circuit to become unavailable. and minimising the possibility of full curtailment of the Project due to a grid constraint during periods of high wind.

453. **Section 6.3** makes the case that an acceleration in the development of feasible projects is needed to meet Scotland's high Offshore Wind Capacity Target by 2030, covering planning, construction, financing and connection. Considering the topology of the existing transmission network it is likely that the acceleration of any connection works required for ScotWind projects will also enable an acceleration of the Project's second connection point at Blyth. This is because works required to deliver ScotWind projects early will also facilitate the early connection of Blyth.

454. In the worst case therefore, it is likely that the Project would connect no later than the ScotWind projects which have been covered in the HND process. It may be more likely that the Project will deliver ahead of those projects – and other Scottish offshore wind projects – given its advanced stage of project development in comparison to other projects, and with fewer associated enabling connection works. In this regard, the Project presents the lowest risk option for Scotland to meet its 2030 targets and continue the important task of decarbonisation into the 2030s.

455. Consenting and delivering the Project in full, will be a critical element of delivering offshore wind generation at the capacities needed to meet the Net Zero commitments while ensuring that the costs of the transmission system are managed. The Project will make a significant contribution to meeting the target capacity in the timeframe required and therefore should be considered as both necessary and urgent.

7.10. CONCLUSIONS ON SECURITY OF SUPPLY

456. The Project will support UK electricity system adequacy and dependability.

457. **Section 7.7** showed an analysis of the capacity utilisation of offshore wind as a technology class, and **Section 7.6** described the measures required of offshore wind to support system operability due to its connection to the NETS.

458. Growth in offshore wind capacities, and other renewable technologies, is expected to improve the dependability of those assets as a combined portfolio, and this is expected to reduce further any integration costs associated with such growth.

459. Connection to the transmission system is of significant importance, enabling an unencumbered and efficient transfer of bulk power across the country, in order to supply electricity whenever and wherever it is needed. The Project's two separate points of connection are also beneficial from both system reinforcement and system operability cost perspectives.

460. Connection of the second phase of the Project's is currently scheduled for 2031. It is likely that the Project will in its worst (latest) case be connectable at the same as the leading ScotWind projects and therefore should be progressed as a low or no regret option.

461. Global expertise in the operation of electricity systems with high proportions of RES is growing. Offshore wind assets are increasingly able to provide important system services themselves, and integration assets (such as batteries) are being deployed to do the same, as well as to manage short-term supply / demand volatility.

462. Technologies which help the integration of renewable assets to the grid are being developed and are already in operation in GB.

463. Consenting the Project, would contribute to an adequate and dependable Scottish and GB generation mix, through enabling the generation of more low carbon power from indigenous and renewable resources, and would enable the Project to make a significant contribution to Scottish and wider UK energy security and decarbonisation needs.

8. AFFORDABILITY

8.1. SETTING THE SCENE

464. The third pillar of GB's energy strategy, is economic efficiency. The UK has 40% of Europe's wind resource [40] and most renewable energy resources can only be developed where the resource exists and where economically feasible. Scotland, as a part of Great Britain, is served by the GB Electricity Market and therefore an assessment of the affordability of the Project is relevant at the UK level.

465. Analysis [commissioned by the NIC] suggests that there is no material cost impact, either over the short or long term, of deploying renewables faster. Renewables are now the cheapest form of electricity generation due to dramatic cost reductions in recent years. Cost reductions have been greater than was predicted in 2018 when the Commission made its recommendation on what level of renewable generation the government should be targeting. [84]

466. This section discusses broad principles of affordability and economic efficiency, by explaining how the UK's electricity market operates and demonstrating how recent gains in experience, technology and scale have increased the economic efficiency of offshore wind.

8.2. UK ELECTRICITY PRICING

467. In the UK power market, generators schedule themselves to generate in response to whether a market price signal for a specific period is above or below their marginal cost of generation (The cost of generating one additional MWh, usually including variable fuel and transmission costs). Each day is subdivided into 48 half-hour periods (Settlement Periods) and power is traded ahead of delivery for these periods, or continuous groups thereof, from just 90 minutes ahead, up to months or even seasons ahead. Typically, wind farms have very low or zero marginal costs and therefore generate as much as they are able to, when they are available (i.e. whenever the wind is blowing). Because of the variable nature of the wind, they also tend to trade on the near-term power markets, therefore much of their impact on power price is felt in the few days close to delivery. Thermal and hydro plants have higher marginal costs (relating to the cost of the fuel they are converting into that additional MWh), therefore will generally only when the market is providing a higher price signal. They may also trade power and fuel costs further ahead in order to lock in a gross margin. All generators produce active power (MWs), and to balance the electricity system, the active power generated must meet the system load at all times. If wind farms are generating electricity during a settlement period, then less electricity is required from plants with more expensive marginal costs, therefore the price of electricity for that settlement period reduces.

468. This market mechanism is illustrated in **Figure 8-1**.

469. The blue line, increasing from left to right with the x-axis, represents the marginal cost of generation in the UK at each level of generation required to meet anticipated demand. As demand increases, more expensive supply must be scheduled into the market. This is represented by the three red lines. At a mid-level of demand, the solid red line crosses the blue line at about £45 / MWh. This becomes the price of power. If demand falls (e.g. to the left-hand dashed red line), less plant is required to run to meet demand, therefore the marginal cost of the most expensive asset required to run to meet demand is lower. Therefore the price of power reduces (here, to about £10 / MWh). Conversely, as demand increases, (e.g. to the right-hand dashed red line) assets with higher marginal costs of production are required to run; therefore the price of power increases (in this example, to about £65 / MWh).

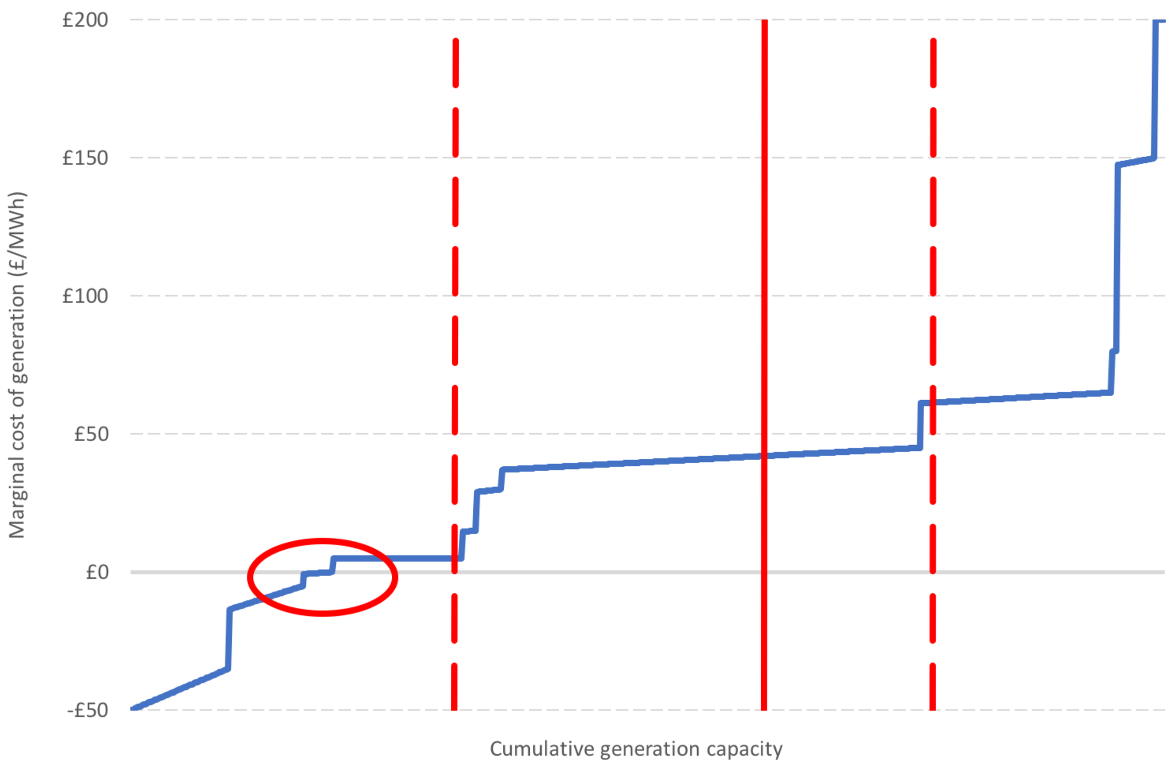

Figure 8-1: Representative marginal cost stack for the GB electricity system.

[Author analysis]

470. Critically, the blue line in **Figure 8-1** also varies for each half hour settlement period, as generating assets become available or unavailable due to outages or breakdowns, or maybe more or less wind is expected than was forecast. Therefore as more electricity is generated by wind, the blue line within the red ellipse (around a zero marginal cost of power) will stretch horizontally, and as a result, the blue line slides to the right for all higher levels of demand. The marginal cost of production to meet demand over these periods will therefore be lower and as a result, the traded price of power will be lower. By running this type of analysis over every settlement period over the future trading horizon, it is possible to derive a power price view for the next hour, day, week, month, quarter or season.

471. The conclusions are consistent though: increasing the capacity of renewable assets in the UK has a reducing effect on power price at delivery. This demonstrates that offshore wind power reduces the market price of electricity in the UK. However the effect is not limited to the UK. The Energy Institute of 104 have quantified the impact of deep solar penetration in California, an historically conventional generation market. Their paper concludes that renewable investment has had a significant impact on power prices, and appears to be responsible for the majority of price declines over the last half-decade in California [104].

8.3. LEVELISED COST OF OFFSHORE WIND GENERATION

472. Technological advances in fixed base wind generation are unfolding, although the scope is limited by the specific nature of wind turbines. The blade design, the steel in the supporting structures, and the efficiency of the conversion to electricity are all areas for incremental improvements. Given that wind is a small-scale and low-density form of generating electricity, many of the cost reductions have come from logistics and maintenance, especially offshore, and new designs of floating platforms may add further opportunity although floating offshore wind is as yet unproven. Although incremental, the cost reductions have been dramatic [102].

473. The market mechanisms described in **Section 8.2** only reduce the price of power if wind projects come to market, or if developers believe they are able to make reasonable returns on their investments. The cost of wind generation is an important enabler of offshore wind development, and the Offshore Wind Sector Deal was struck on the expectation that costs would continue to fall, and UK content would increase for future developments.

474. As well as the incremental cost improvements detailed above, wind turbines have got bigger and more efficient, and are being installed in larger populations to increase the size of wind farms. See **Figure 8-2**. The product of all of these factors is that offshore wind is now a leading low-cost generation technology globally and the UK and Scotland are leading the field. See **Figure 8-3**.

Figure 8-2: Offshore wind turbine generation capacity has increased significantly since 2002.

[27]

475. An important measure of the lifetime cost of wind generation, is its Levelised Cost of Generation (LCOG). LCOG is calculated using a discounting methodology, and is a measure of the lifetime unit cost of generation from an asset. Critically this allows all forms of generation to be compared with each other on a consistent basis.

476. BEIS published Electricity Cost of Generation reports in 2013, 2016 and 2020. These reports provide a comparison of how cost forecasts have evolved over time; how costs of different generation technologies compare to each other; and how costs are expected to evolve into the future. **Figure 8-3** shows data from BEIS' 2020 report [65]. Each triple of blue columns illustrates a forecast range of levelised generation cost for assets commissioned in 2025, 2030 and 2035, for CCGT, Offshore wind, Onshore wind, large scale solar and CCGT + CCS. The red stripes show, for CCGT and CCGT + CCS, those costs vary with price sensitivities applied for fuel and carbon costs. The conclusions are clear: renewable generation assets are significantly cheaper over their lifetimes, than new CCGT stations, whether abated or not. Offshore wind costs reduce in the 2025 - 2030 timeframe as a result of economies of scale and technological advances reducing capital costs and fixed O&M costs.

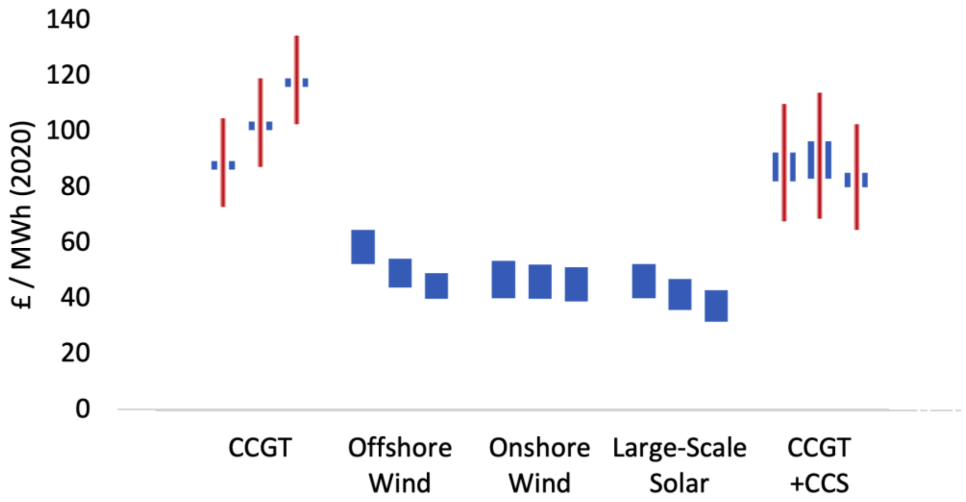

Figure 8-3: BEIS Cost of Generation comparison for technologies deployed in 2025, 2030, 2035.

Adapted from [65]

477. The levelised cost of offshore wind also reduces to be lower than that of onshore wind in the 2030 timeframe, continuing its trend of superior cost reduction performance versus since 2013. **Figure 8-4** shows how levelised cost forecasts have reduced from 2013 (light grey) to 2016 (darker grey) and through to 2020 (blue). The costs of offshore wind have reduced and are forecast to reduce further still.

478. The 2020 cost projections include a high and low range (dots) which also illustrates that the cost certainty of offshore wind has improved significantly and progressively since 2013.

479. The NIC have also concluded that RES represent a most likely low-cost solution for GB electricity generation, over large-scale conventional investments. Their conclusion recognises that more renewables do lead to more money being spent on operating the electricity system and matching supply and demand, but conclude that cheaper capital costs will more than offset these costs to reduce overall electricity and energy system costs for consumers [66].

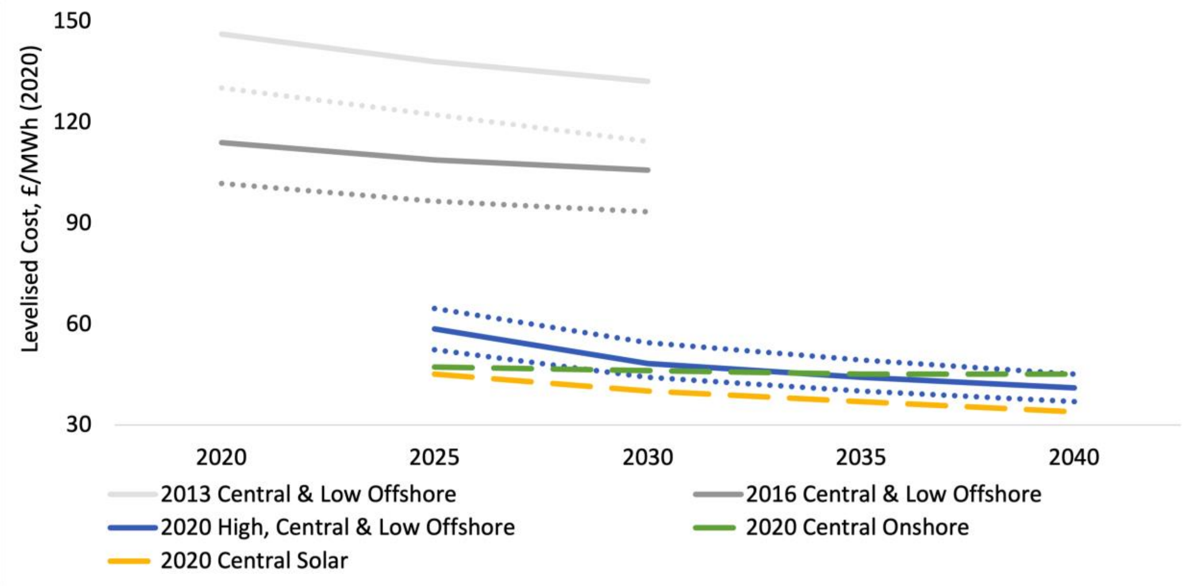

Figure 8-4: BEIS Cost of Generation – Evolution of levelised cost forecasts.

Author analysis from [65]

480. Wind costs are driven by capital infrastructure, development and integration costs, and lifetime O&M. Economies of scale and technological advances have reduced the costs of wind turbines, increased their efficiencies and extended their useable lifetimes. For example, due to improved manufacturing techniques and enhanced material choices, the Project may be expected to have a longer operational life than wind farms already now in operation. Development costs have also reduced as efficiencies in the build process have been captured through prior experience. This fact is also demonstrated in **Figure 8-4**.

481. Other industry-sourced data and opinion concurs with BEIS' findings. For example a CCC illustration of data from IRENA analysis (2020) shows cost reductions in and competitiveness of renewable generation technologies against fossil fuel generation [43]. Lazard [105] are a globally recognised source of such comparative analysis, albeit that their reports focus on the US market, however their conclusions provide a useful global context. The most recent revision of their analysis, published in October 2021, provides additional evidence that offshore wind costs are reducing and that offshore wind is competitive against other forms of generation, particularly carbon intensive assets.

8.4. A COMPARISON OF FLOATING AND FIXED BOTTOM OFFSHORE WIND COSTS

482. The development of floating offshore wind from demonstrator technology to commercial technology is expected to help reduce costs for deployment up to 2030 and beyond, but initial cost estimates for floating offshore wind are currently significantly higher than current fixed bottom installations. **Figure 8-5** shows OREC's forecast for levelised costs of FOW deployed from 2027 onwards. Critically, FOW levelised costs are anticipated to benefit from

a higher deployment of total UK offshore wind capacity due to increased opportunities to share fixed O&M and other supply chain costs over a wider portfolio of projects.

483. **Figure 8-6** compares the cost forecast ranges for fixed bottom and floating offshore wind deployed in UK waters. FOW costs are expected to decrease rapidly because developments can learn from the technology, operational and asset management experience already demonstrated by fixed bottom offshore wind and by the offshore oil & gas industry, for example FOW will likely benefit from using state of the art turbine technology, O&M innovations and floating platform performance and cost enhancements. Much learning is transferable between industries and risks and opportunities are much better understood today than they were when fixed bottom offshore wind was in its infancy. An understanding of risks and opportunities will also drive a reduction in the cost of capital, driving greater forecast cost improvements and paving the way for FOW to benefit from greater levels of competition for project financing.

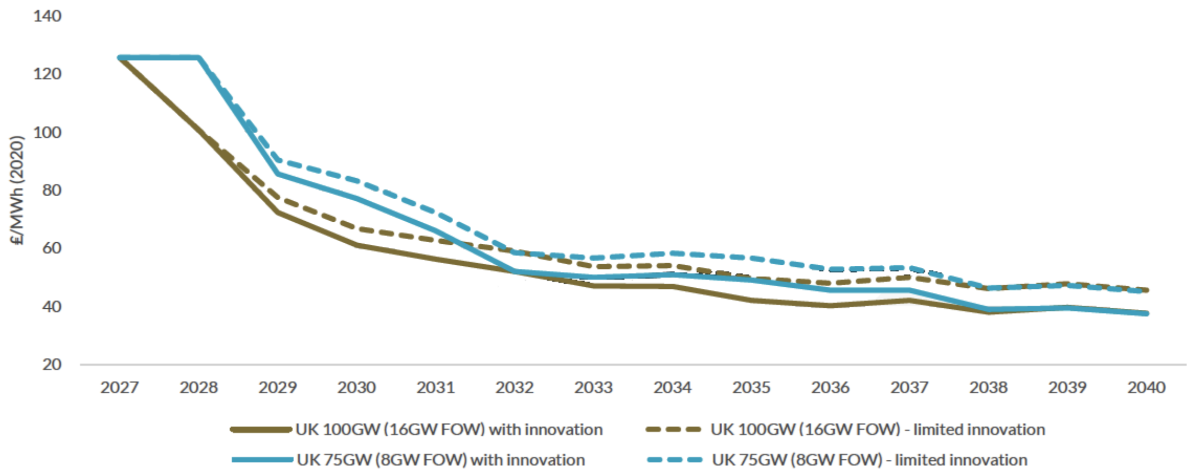

Figure 8-5: UK FOW cost Reduction

Adapted from [83]

484. Fixed bottom offshore wind deployed this decade is likely to be significantly cheaper over its lifetime than FOW deployed over the coming twenty years. In the 2030s, if FOW deployments can expand an already large fixed bottom offshore fleet, significant and rapid cost reductions may be possible to the point of FOW achieving approximate cost parity with fixed bottom wind.

485. As would be expected with a more mature technology, the uncertainty range of current and future fixed bottom costs is smaller than that for FOW. This is partly attributed to the remaining unknowns of floating technology, as well as reflecting the wider possible geographies available for deployment of FOW, and the development costs associated with infrastructure required to bring the generated power to shore. Similar analysis has been undertaken by the United States Department of Energy [82] and their conclusions are consistent with those drawn by OREC relating to FOW deployment and cost reduction opportunities. DoE also see the potential for significant future cost reductions in FOW, but also anticipate fixed bottom assets to remain at a cost advantage to FOW assets through the next two decades.

486. The data presented draws to the conclusion that the development of fixed bottom assets is preferential to and therefore should be prioritised over FOW development in order to deliver earlier decarbonisation benefits as well as create a catalyst for future rapid and significant cost reductions for essential FOW fleet in the decades ahead.

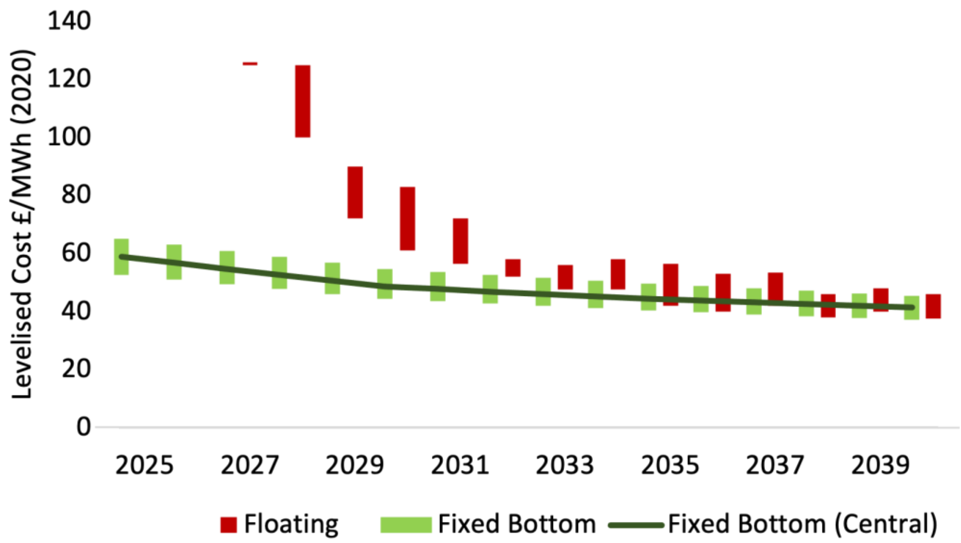

Figure 8-6: Comparison of future fixed bottom and floating offshore wind cost forecasts

Adapted from [83, 65]

8.5. THE CFD AS AN INDICATOR OF UK OFFSHORE WIND COST IMPROVEMENTS

487. CfDs were first awarded to offshore wind projects in 2014 in the first Investment Contract round. Government has subsequently run four competitive Allocation Rounds, awarded in 2015, 2017, 2019 and 2022 respectively. Prior to Allocation Round 4 taking place, the UK Government signalled plans “to double the capacity awarded in the last round with the aim to deploy around 12GW of low-cost renewable generation.” Offshore wind, onshore wind and solar are key building blocks of the future generation mix, and £200 M was allocated to the AR4 offshore wind pot, without a capacity cap being set.

488. **Figure 8-7** illustrates the cumulative capacity of offshore wind contracts awarded by both allocation round and delivery year, and the weighted average strike price (all in 2012 monies) for projects within separate allocation rounds. The reduction in strike prices from round-to-round is very apparent, as is the associated increase in awarded capacity. This figure demonstrates that UK consumers are realising the benefit from offshore wind cost reductions as described in **Section 8.3**.

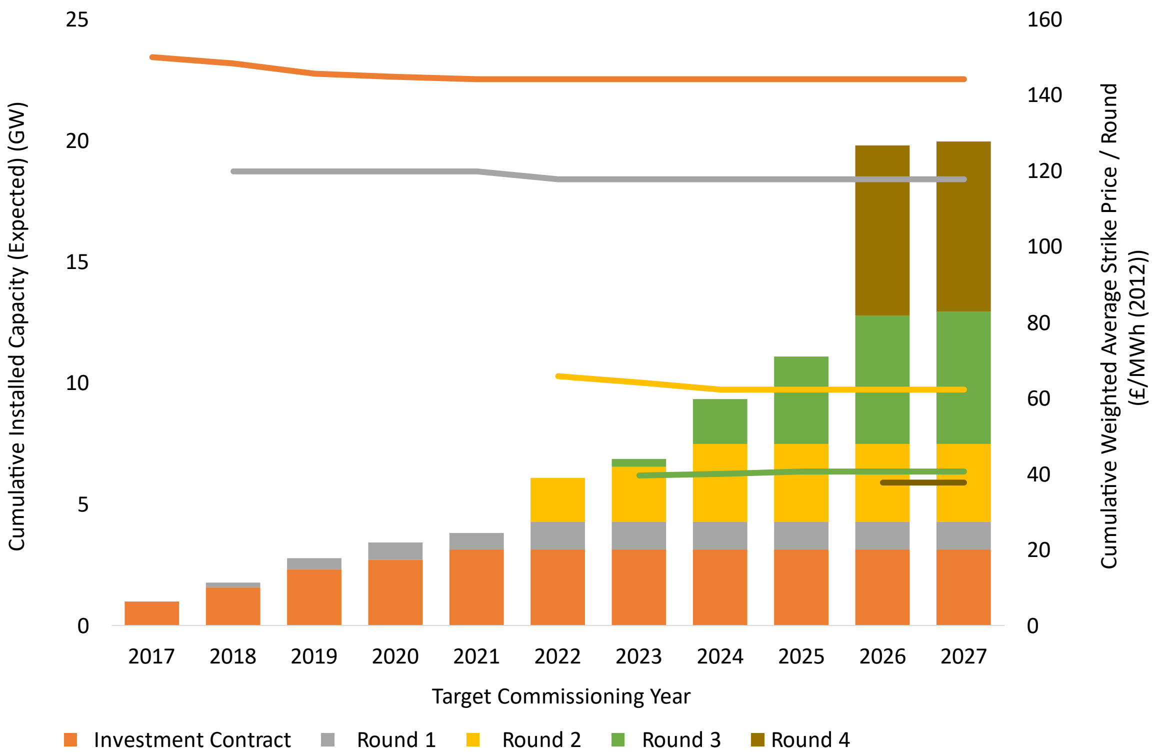

Figure 8-7: CfD capacities and strike price evolution for offshore wind

Author analysis of [106]

489. The results of CfD Round 4 (issued July 2022) demonstrate the importance of offshore wind development to decarbonisation of the electricity system. Offshore wind was the major technology to be awarded a CfD in this round. Of almost 11GW awarded, 7GW went to offshore wind. The strike price for the allocation round was £37.35/ MWh for 2026/27 delivery, representing a significant reduction from the strike prices awarded through previous rounds. This government backed subsidy scheme has contracted projects which, when delivered, will reduce wholesale electricity prices.

490. Factors which contributed to the low price outturn for offshore wind in the latest allocation rounds include:

- Construction risk management of this technology is well advanced in the UK due to significant experience in UK territorial water installations, so developer bids included less allocation to construction risk;
- The technology has evolved over the last 5 + years, making advances in MW capacity and MWh output expectations per unit of infrastructure spend over previous projects; and
- Economies of scale and the development of an advanced supply chain have also contributed to the reduction in cost of offshore wind.

491. Many of the cost savings which have driven CfD prices lower over previous Allocation Rounds are expected to continue to transfer through to subsequent developments, however future developments will incur their own localised construction costs which may be higher or lower than those projects which have already secured CfDs. Nevertheless, it is clear that the industry is in a strong position with regard to unit cost improvements, and is prepared to pass much of this value through to consumers via a CfD. Offshore wind in the UK is currently, and is predicted to remain, super-competitive on a per MWh generated basis versus other low carbon renewable technologies.

492. The Project presents a low regrets opportunity to develop a globally significant low carbon generation asset in well-studied Scottish waters which is well located in relation to available and suitable grid connection capacity. As such, the Project has the potential to achieve a lifetime cost of electricity which is comparable to those achieved in other Scottish projects to date, when accounting for locational and technological differences. The Project will generate low cost, low carbon electricity for Scottish and UK-wide consumers while making a significant and tangible step towards meeting Scottish and UK climate change targets.

8.6. CONCLUSIONS ON AFFORDABILITY

493. The main conclusions of this section, relating to the economic efficiency and affordability of offshore wind and of the Project itself, are as follows:

- Offshore wind power reduces the market price of electricity by displacing more expensive forms of generation from the cost stack. This delivers benefits for electricity consumers;
- Due to technological advances, the costs of offshore wind power are now close to grid parity in the UK;
- Offshore wind power is economically attractive in GB against many other forms of conventional and renewable generation, including floating offshore wind;
- By increasing the offshore wind fleet through fixed-bottom assets, it is anticipated that benefits will flow through to the developing floating offshore sector, enabling more rapid and deeper cost reductions than if would otherwise be the case; and
- Size remains important, and maximising the generating capacity of projects improves their economic efficiency, so bringing power to market at the lowest cost possible.

494. The Project proposes a substantial infrastructure asset, to be located on a well understood and well studied area of seabed. Shallower seas, closer to shore, provide the opportunity for economic benefits against other deeper water projects. The proposed location is possibly the last suitable site available for exploitation by fixed bottom offshore wind in Scottish waters. The Project is capable of delivering large amounts of cheap, low carbon electricity.

495. Maximising the capacity of generation in the resource-rich, accessible and technically deliverable proposed location, is to the benefit of all consumers in the United Kingdom, and the wind industry generally, and is consistent with all aspects of current Scottish and UK energy policy.

9. CONCLUSION

496. This Statement has shown that offshore wind generation is economically and technically viable in the UK and Scotland, and that it is economically and technically preferential against other low carbon options, for the UK and Scottish electricity consumer. More importantly though, this Statement has demonstrated that the Project is critical in order to deliver urgent and necessary decarbonisation actions in order to halt climate change.

- Decarbonisation to Net Zero is legal requirement for Scotland and for the UK and is of global significance. It cannot be allowed to fail, and urgent actions are required in Scotland, in the UK and abroad, to keep decarbonisation on track to limit global warming;
- Wind generation is an essential element of the delivery plan for the urgent decarbonisation of electricity generation in Scotland, and in the UK. This is important not only to reduce power-related emissions, but also to provide a timely next-step contribution to a future generation portfolio which is capable of supporting the massive increase in electricity demand which is expected because of decarbonisation-through-electrification of transport and heat;
- As part of a diverse generation mix, wind generation contributes to improve the stability of capacity utilisations among renewable generators. By being connected at the transmission system level, large-scale offshore wind generation can and will play an important role in the resilience of the GB electricity system from an adequacy and system operation perspective;
- Internationally, and importantly, the UK is leading in this regard. UK offshore wind projects are increasing in capacity, and decreasing in unit cost. Hitherto, each subsequent project has provided a real-life demonstration that size and scale works for new offshore wind, for the benefit of consumers. Other conventional low carbon generation (e.g. tidal, nuclear or conventional carbon with CCUS) remain important contributors to achieving the 2050 Net Zero obligation, but their contributions, although important, will not be significant in the 2020s; and
- Offshore wind is already super-competitive against other forms of conventional and low carbon generation, both in GB and more widely.

497. These general benefits of offshore wind generation in GB also apply specifically to the Project:

- The Project proposes a substantial infrastructure asset, capable of delivering large amounts of low carbon electricity, from as early as the mid 2020s. This is in line with the CCC's recent identification of the need for urgent action to increase the pace of decarbonisation in the GB electricity sector;
- The Project will make an essential contribution to the low 2030 Scottish Offshore Wind Capacity Target of 8GW: without it the target capacity will not be met. The Project is therefore also essential if the high target of 11GW is to be met by bringing forwards its grid connection date and the connection dates of other projects e.g. those within the scope of National Grid's Holistic Network Design;
- Because the Project will connect to the NETS it will be required to play its part in helping NGESO manage the national electricity system. This includes participating in mandatory balancing markets (to help balance supply and demand and provide essential ancillary services) as well as providing visibility to the power market of its expected generation. This means that the low marginal cost wind power it will produce, can be forecast and priced into future contracts for power delivery by all participants, thus allowing all consumers to benefit from the market-price reducing effect of low-marginal cost offshore wind generation;

- The location of the Project’s two connections to the NETS means that it will not the reinforcements across the northern boundaries which other Scottish offshore wind developments will require; and
- Maximising the capacity of generation in the resource-rich, accessible and technically deliverable proposed location, is to the benefit of all GB consumers, and the Scottish offshore wind industry generally.

498. In summary: the Project is capable of making meaningful and timely contributions to Scottish decarbonisation and GB security of supply, while helping lower bills for consumers throughout its operational life, thereby addressing all important aspects of existing and emerging government policy.

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