Hornsea Project Three
Offshore Wind Farm

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Response to the Secretary of State's Consultation
Appendix 1 Annex C: Statement of Need – Planning Act 2008

Date: February 2020

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Ørsted

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Hornsea 3
Offshore Wind Farm

Ørsted

Planning Act 2008

Hornsea Project Three Offshore Wind Farm

Statement of Need

New Stream Renewables
February 2020

Executive Summary

1. Ørsted Hornsea Project Three (UK) Limited ('Ørsted') is seeking a Development Consent Order ('DCO') for an offshore wind farm in the order of 2.4 GW which could be built out in one or two phases in the North Sea, approximately 120 km off the north Norfolk coast.

2. This Statement of Need for offshore wind builds upon and updates the arguments made in the 2011 National Policy Statements ('NPSs') and describes how and why the proposed project addresses all relevant aspects of established and emerging Government Policy.

3. The case for need is built upon the contribution of the proposed development to the three important national policy aims of decarbonisation (Net-Zero and the importance of developing bulk zero-carbon generation assets); security of supply (geographically and technologically diverse supplies) and affordability.

4. A case for need was included in documentation submitted with the Hornsea Project Three ('Hornsea Three') DCO application in May 2018, in particular [APP-057] - 6.1.2 ES Volume 1, Chapter 2, Policy and Legislation, and [APP-177] - 8.3 Planning Statement. This Statement of Need extends the case made in those submissions.

5. Chapter 1 provides a recap of the Policy framework established by the NPSs, and the arguments set out within them, which support the need for significant new low-carbon electricity generation infrastructure in order to meet the UK's legal decarbonisation targets.

6. Chapter 2 sets out the legal requirement for decarbonisation in the UK and explains how that requirement has developed based on an increased need and urgency for decarbonisation in order to meet the UK's obligations under the Paris Agreement (2015).

7. Chapter 3 provides an up-to-date view of how decarbonisation in the UK has been achieved to date, through substantial reduction in coal-fired generation and the deployment of significant numbers of wind and solar installations, and explains why a number of assets as foreseen in previous carbon plans (and for which the NPS were largely written) have hitherto lagged behind these in terms of deployment.

8. Chapter 4 confirms that future electricity demand will grow significantly through the decarbonisation-through-electrification of other industry sectors (the same reasons as those stated in the NPS), and therefore that significant new low-carbon electricity generation developments are required to meet that demand and deliver decarbonisation.

9. Chapter 5 explains the contribution of offshore wind generation to security of supply, both from an availability and a system operation perspective, and concludes that Hornsea Three, if approved, would contribute to an adequate and dependable Great Britain ('GB') generation mix.

10. Chapter 6 provides an analysis of the economic viability of large-scale offshore wind, as a future contributor to a low-carbon GB electricity supply system.

11. Chapter 7 concludes that significant capacities of low-carbon offshore wind generation is needed in the United Kingdom ('UK'), and that developing Hornsea Three as planned will help meet Government objectives of delivering sustainable development to enable decarbonisation, ensuring our energy supply is secure, low-carbon and provides benefits to GB consumers.

12. It is the view of the author of this report that if a significant capacity of offshore wind generation is not built out to a scale comparable with that in the projections provided by National Grid and others, then the UK will be highly unlikely to continue to reduce its carbon emissions over the coming decade, and ultimately fail to meet its legally binding decarbonisation targets. Hornsea Three will provide a significant and vital contribution to GB's incredibly important offshore wind ambitions.

Introduction

13. Ørsted Hornsea Project Three (UK) Limited ('Ørsted') is seeking a Development Consent Order ('DCO') for an offshore wind farm in the order of 2.4 GW which could be built out in one or two phases in the North Sea, approximately 120 km off the north Norfolk coast. At this scale, Hornsea Three could be the world's largest offshore wind farm, providing green electricity to well over 2 million UK homes per year. Hornsea Project One and Hornsea Project Two have both received planning consent and are either commercially operational or under construction. Ørsted is now developing Hornsea Three to the east of these. This Statement of Need supports the DCO application submitted by Ørsted and in particular supports IROPI (imperative reasons of overriding public interest) arguments to be made in response to the letter dated 27/09/19 from the Secretary of State ('SoS') for Business, Energy and Industrial Strategy ('BEIS') requesting further information under Article 6(4) of the Habitats Directive and section 126(7) of the Marine and Coastal Access Act 2009.

14. Offshore wind projects fall under the Nationally Significant Infrastructure Planning ('NSIP') regime and the need for such projects is covered by the National Policy Statements ('NPS') EN-1 [1] and EN-3 [2]. The NPS were finalised in 2011, and many of the arguments made within them can be refreshed, in order to take into account current legislation, regulation, policy, technology and market developments. This Statement of Need for offshore wind, builds upon and updates the arguments made in the NPS documents, and describes how and why the proposed project addresses all relevant aspects of established and emerging Government Policy.

15. The case for need is built upon the contribution of the proposed development to the three important national policy aims of decarbonisation (Net-Zero and the importance of developing bulk zero-carbon generation assets); security of supply (geographically and technologically diverse supplies) and affordability. This Statement of Need includes a description of how decarbonisation has so far been achieved in GB, and where policy at the time when the NPS were written, has not delivered, underpinning the need for the at-scale, urgent delivery of consentable and affordable projects which make best use of GB's natural low-carbon energy resources. The nuances of the fundamental arguments made in the 2011 NPSs have shifted in the last 12 months, and Government, industry and international attention in the area of decarbonisation is presently strong.

16. A case for need was included in documentation submitted with the Hornsea Three DCO application in May 2018, in particular [APP-057] - 6.1.2 ES Volume 1, Chapter 2, Policy and Legislation, and [APP-177] - 8.3 Planning Statement.

17. This Statement of Need extends the case made in those submissions, and predominantly calls on established and emerging primary analysis and opinion by respected third parties, to support the case that Hornsea Three will help GB meet its 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 GB end-use consumers.

18. This Statement has been prepared by Si Gillett, M.A.(Oxon), M.Sc.(Dist) of New Stream Renewables ('NSR')[1] and updates the case set out in the 2011 NPS for why offshore wind is an important generation technology to include within the future GB generation mix.

[1] Further credentials are provided in Chapter 8

19. The conclusion reached is that significant capacities of low-carbon offshore wind generation is needed in the United Kingdom ('UK'), and that developing Hornsea Three as planned, will help meet Government objectives of delivering sustainable development to enable decarbonisation, ensuring our energy supply is secure, low-carbon and provides benefits to GB consumers.

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Chapter 1 The National Policy Statements (NPSs)

1.1 Establishing the basis provided by the 2011 NPSs

20. The NPSs were established against obligations made as part of the Climate Change Act 2008 ('CCA2008') – see Section §2.1 following. The overarching National Policy Statement for Energy (NPS EN-1) [1] sets out national policy for energy infrastructure in GB. It has effect, in combination with NPS EN-3 (for renewable energy infrastructure) [2] and NPS EN-5 (for electricity networks) [14], on recommendations made by the Planning Inspectorate ('PINS') to the SoS for BEIS on applications for energy developments that fall within the scope of the NPSs [1, Para 1.1.1]. These NPSs, when combined with the relevant technology-specific energy NPS, provide the primary basis for decisions by the SoS. The NPS set out a case for the need and urgency for new energy infrastructure to be consented and built with the objective of supporting the Government's policies on sustainable development, in particular by:

- Mitigating and adapting to climate change, and
- Contributing to a secure, diverse and affordable energy supply. [2, Para 1.3.1].

21. The NPS for renewable energy infrastructure cover those technologies which, at the time of publication in 2011, were technically viable at generation capacities of over 50 MW onshore and 100 MW offshore. Critically, this includes offshore wind, and as such the need for this technology is fully covered by the NPS. However, a number of the arguments made nearly 9 years ago have shifted as a result of a growing urgency (informed by developing scientific opinion) to reduce carbon emissions globally and locally; and the progress made by low-carbon technologies and initiatives which were expected to deliver a low-carbon electricity system.

22. That said, the arguments which support a national need for low-carbon infrastructure made today are consistent with those arguments contained in the NPSs, and indeed:

> *The Secretary of State is of the view that the NPSs clearly set out the specific planning policies which the Government believes both respect the principles of sustainable development and are capable of facilitating, for the foreseeable future, the consenting of energy infrastructure on the scale and of the kinds necessary to help us maintain, safe, secure, affordable and increasingly low carbon supplies of energy* [15, Para 4.13].

23. This Statement of Need therefore extends the analysis contained in the NPS documents to cover low-carbon electricity generation against today's climate, security of supply and cost of generation status. It develops the arguments made within EN-3 for large offshore wind technology, and extends them to demonstrate firstly that there is now even more need for this technology in GB; secondly that this technology is now even more technically and economically feasible than it was in 2011; and thirdly, that large-scale offshore wind can and will bring benefits for GB. These benefits manifest in terms of the technology's contribution to legal decarbonisation targets; security of supply; and affordability of electricity for GB consumers.

24. The NPSs set out the national case and establish the need for certain types of infrastructure, as well as identifying potential key issues that should be considered by the decision maker. S104 of the Planning Act (2008) makes clear that where an NPS exists relating to the development type applied for, the SoS must have regard to it. The NPSs provide specific policy in relation to offshore wind development, and the policies set out in NPS EN-1, 3 and 5 therefore apply, and unquestionably are 'important and relevant', to which significant weight should be afforded. In

light of the treatment of relevant NPSs in the consideration of previous DCO applications, the urgent national need for energy generating stations set out in both NPS EN-1 and EN-3 is of great significance to the determination of Hornsea Three. The test as relevant to Hornsea Three therefore becomes whether the need for the development at the national level is outweighed by other material considerations.

25. Policies within NPSs EN-1 (Energy), EN-3 (Renewable Energy Infrastructure) and EN-5 (Electricity Networks) are important and relevant to this proposal. The policies which are of particular relevance and importance to this examination are set out in Section §1.2.

1.2 A synthesis of the 2011 National Policy Statements EN-1 and EN-3

26. At the time the NPSs were published, scientific opinion was that, to avoid the most dangerous impacts of climate change, the increase in average global temperatures must be kept to no more than 2°C. Global emissions must therefore start falling as a matter of urgency [1, Para 2.2.8].

27. The energy NPSs were intended to speed up the transition to a low carbon economy and help the UK to realise its climate change commitments sooner than would a continuation under the current planning system [1, Para 11.7.2]. They recognise that moving to a secure, low carbon energy system to enable the UK to meet its legally binding target to cut greenhouse gas emissions by at least 80% by 2050, compared to 1990 levels, is challenging, but achievable. This would require major investment in new technologies to electrify heating, industry and transport, and cleaner power generation [1, Para 2.2.1]. Under some 2050 pathways, electricity generation would need to be virtually emission-free, because emissions from other sectors were expected still to persist [1, Para 2.2.6]. Consequentially, the need to electrify large parts of the industrial and domestic heat and transport sectors could double electricity demand by 2050 [1, Para 2.2.22].

28. The NPS conclude that the UK needs sufficient electricity capacity from a diverse mix of technologies and fuels [1, Para 2.2.20], and therefore the UK also needs all the types of energy infrastructure covered by the NPSs in order to achieve energy security at the same time as dramatically reducing greenhouse gas emissions [1, Para 3.1.1]. Thus, all applications for development consent for the types of infrastructure covered by the energy NPSs should be assessed on the basis that the Government has demonstrated that there is a need for those types of infrastructure and that the scale and urgency of that need is as described within EN-1 Part 3. Substantial weight should therefore be given to the contribution which projects would make towards satisfying this need when considering applications for development consent under the Planning Act 2008 [1, Paras 3.1.3, 3.1.4]. The economic feasibility of harvesting sufficient available natural resource will be an important driver for proposed locations of renewable energy projects [2, Para 2.6.57].

29. To hit the target of UK commitments to sourcing 15% of energy from renewable sources by 2020, and to largely decarbonise the power sector by 2030, the NPSs conclude that it is necessary to bring forward new renewable electricity generating projects as soon as possible. The need for new renewable electricity generation projects is therefore urgent.

30. Offshore wind farms are expected to make up a significant proportion of the UK's renewable energy generating capacity up to 2020 and towards 2050 [2, Para 2.6.1].

Chapter 2 The United Kingdom has a legal commitment to decarbonise

31. This chapter sets out the obligations of CCA2008, against which the NPSs (2011) were established. It then outlines the UK's 2019 legally binding commitment to achieving 'Net-Zero' carbon emissions by 2050, against which the need for future electricity generation developments should be assessed.

2.1 Climate Change Act 2008

32. The Government, through CCA2008, made the UK[2] 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' [11, Five Point Plan].

33. CCA2008 is underpinned by further legislation and policy measures. Many of these have been consolidated in the UK Low Carbon Transition Plan ('LCTP') [11], and UK Clean Growth Strategy [16]. A statutory body, the Committee on Climate Change ('CCC'), was also created by CCA2008, to advise the UK and devolved Governments and Parliaments on tackling and preparing for climate change, and to advise on setting carbon budgets. The CCC report regularly to the Parliaments and Assemblies on the progress made in reducing greenhouse gas emissions. The UK government has set five-yearly carbon budgets which currently run until 2032. The UK has met its first and second carbon budgets and is on track to outperform the third (2018 to 2022). However, is not on track to meet the fourth (2023-2027) or fifth carbon budget.

34. Up to 2019, the UK had made progress with its carbon reduction obligations, as shown in Figure 2.1, through significant reductions in the power, industry and waste sectors. CCA2008 obligations translate to a total emissions target of ~550 $MtCO_2e$ in 2020, and ~165 $MtCO_2e$ in 2050. The main driver of UK carbon reduction to date has been the power generation sector. Overall carbon intensity from power generation has fallen significantly in recent years, with (virtually) carbon-free generation (wind, solar, hydro, bioenergy, and nuclear) accounting for around 54% of electricity generation in 2019 [17]. CCA2008 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, compared to 6.7% in 2009 [1, Para. 3.4.1].

35. All industry sectors have important roles to play in decarbonisation, but so far carbon reductions outside of power, industry and waste have been small. Electrification of non-power sectors is therefore an important part of the realisation of overall carbon emission reductions. Indeed:

> *Moving to a secure, low carbon energy system is challenging, but achievable. It requires major investment in new technologies to renovate our buildings, the electrification of much of our heating, industry and transport, prioritisation of sustainable bioenergy and cleaner power generation*. [1, Para 2.1.1].

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[2] The commitment to decarbonise extends across the United Kingdom of Great Britain and Northern Ireland. Northern Ireland is interconnected with the mainland power system through interconnectors, but is operated under a different electricity market framework. Therefore, hereinafter we refer to Great Britain ('GB') in relation to electricity generation and transmission, and the UK, to refer to the nation which has legally committed itself to Net-Zero carbon emissions by 2050

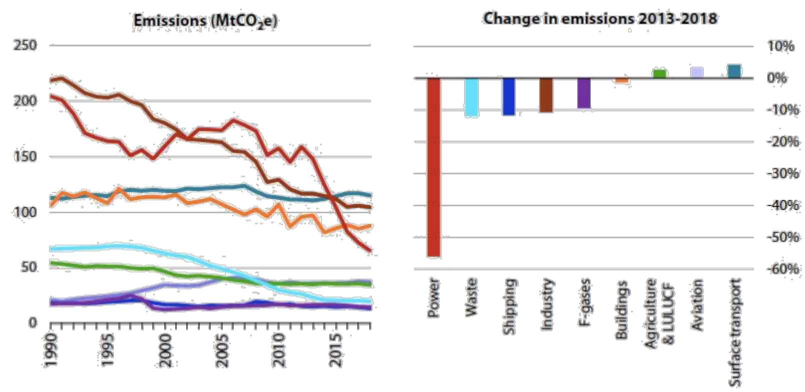

Figure 2.1: UK greenhouse gas emissions by source sector, 1990 - 2018. [3].

36. Decarbonisation of transport will be supported by removing internal combustion engines from roads, potentially by introducing electric vehicles (in private, public and commercial vehicles), and/or by improving electrified rail services as an efficient substitute to road freight. Residential savings in carbon emissions are currently being pursued by research into the substitution of gas (currently used in homes for space and water heating and cooking) for electricity (or hydrogen) – see Chapter 4. In order to deliver those savings, it is vitally important to ensure that GB is capable of meeting an increased demand for electricity in a secure way, with a significantly lower carbon intensity even than current levels.

37. The future characteristics of GB's electricity demands are described through a set of possible scenarios developed (through industry consultation) on an annual basis by GB's Electricity System Operator and statutory undertaker, National Grid Electricity System Operator ('National Grid ESO'). This annual publication is called Future Energy Scenarios ('FES') (see [6]). In completing their work National Grid ESO look at a number of inputs including legislation, policy, technology and commercial drivers. Consumer behaviour is also considered. The speed of decarbonisation is a key feature in both the 2018 (vs. CCA2008) and 2019 (vs Net-Zero – see Section §2.2) publications of FES, with two of the four scenarios meeting the 2050 carbon reduction target via distinct pathways: requiring heavy investment in either energy efficiency, or electricity decarbonisation. In reality, these pathways are not mutually exclusive, and Government and industry are currently pursuing initiatives which cover both.

38. Both the future scenarios in Figure 2.2 show that, consistent with the NPS, the UK's pathway to a successful 2050 carbon budget must still involve wider transitions outside of the power generation sector: decarbonisation of transport, industry, agriculture and the home, remains required to reduce non-power sector emissions. To enable these transitions, it is clear that the power generation sector must increase in capacity and reduce in carbon intensity on an unprecedented scale. This has been a consistent theme since the first FES was published in 2012. Importantly, both successful scenarios shown in Figure 2.2 include the commissioning of large capacities of low-carbon (solar, offshore wind and/or nuclear) power generation, among other initiatives to facilitate emissions reduction in other industrial sectors.

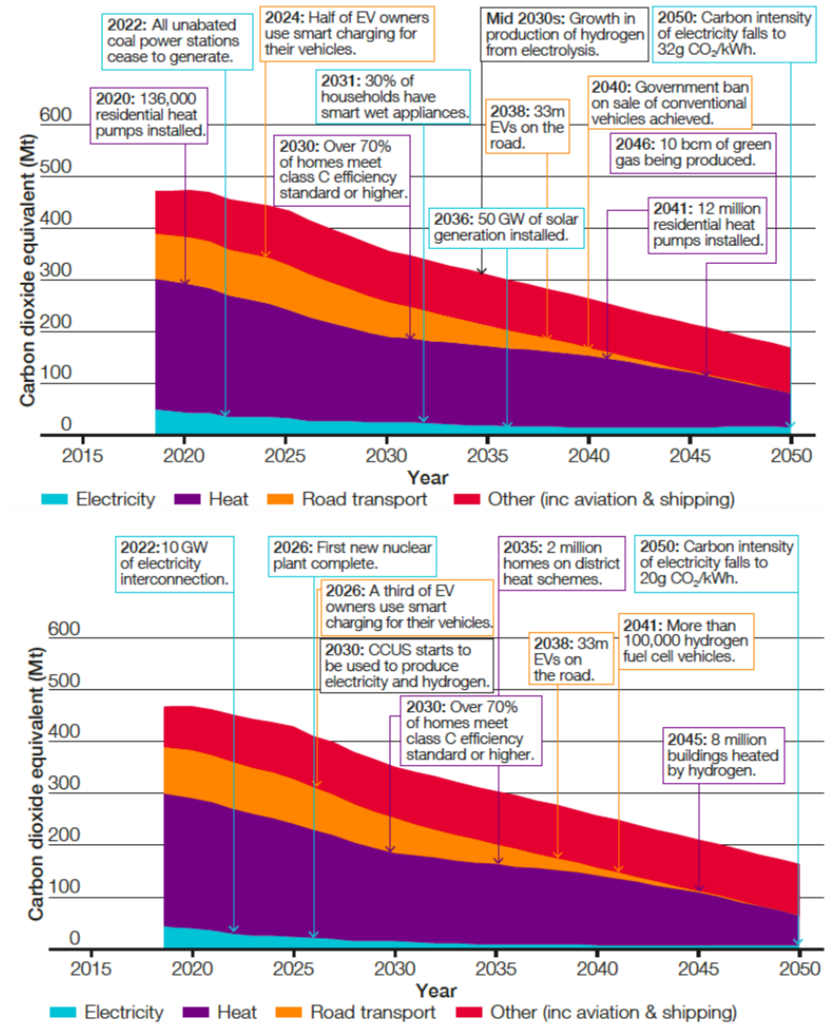

Figure 2.2: Successful pathways to 2050 commitments, showing the importance of a whole-society approach to decarbonisation and low carbon electricity generation [4, Figures 3.1, 3.2].

2.2 Recent enhancements of existing UK Government policy on climate change: Net-Zero

39. The UK context for the need for greater capacities of low-carbon UK generation to come forward with pace, has continued to develop through 2018/19. 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'. This report concludes that human-induced warming had already reached approximately 1ºC above preindustrial 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.

40. In response, in May 2019, the CCC published their report called: 'Net-Zero: The UK's contribution to stopping global warming.' [3]. This report recommended that government extend

the ambition of CCA2008 past the delivery of net UK greenhouse gas savings by 80% from 1990 levels, by 2050. The CCC recommend 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 believe that this recommendation is '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 which is consistent with the need case set out in NPS EN-1, but points to an increased urgency for action.

41. In June 2019, the Government announced the laying of a statutory instrument in Parliament, which amends CCA2008, in order to implement the CCC's recommendation into law. In July 2019, the UK became the first major economy to pass laws to end its contribution to global warming by 2050. In the same month, the CCC also reported to Parliament that 'UK action to curb greenhouse gas emissions is lagging behind what is needed to meet legally-binding emissions targets' [18]. The UK has met its first and second carbon budgets and is on track to outperform the third (2018 to 2022). However, is not on track to meet the fourth (2023-2027) or fifth carbon budget 2028-2032).

42. Earlier (in March 2019) Government announced its ambition to deliver at least 30 GW of offshore wind by 2030, as part of the Offshore Wind Sector Deal (the 'Sector Deal') [19]. The Sector Deal reinforces 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.' Within supplementary documents to the Queens Speech, December 2019 [53, p116], Government committed to 'increase [their] ambition on offshore wind to 40GW by 2030, and enable new floating turbines'. Table 3.1 shows that GB currently has 9.2 GW of Transmission Entry Capacity already allocated to offshore wind developments with a status of 'built'; with projects totalling a further 34.5 GW currently with status of either 'scoping', 'awaiting consents', 'consents approved' or 'under construction / commissioning' [12].

43. The inclusion of a project on a 'future project pipeline' – for example, a list of projects which have applied for a DCO, or the scoping / consents / construction pipeline included in Table 3.1 does not indicate that the project will go ahead, or if it does, at a particular generation capacity. 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 Hornsea Three[3], it is very possible that delivery of the Sector Deal and the UK government's 2030 ambition will fall short.

44. Figure 2.1 illustrates the reduction in carbon emissions from electricity generation which has been achieved since 1990. Despite this reduction, the CCC conclude that extending the ambition of CCA2008 is not credible unless decarbonisation progresses with far greater urgency than currently exists, not just within electricity generation, but also in other energy uses, including low-carbon heating systems in the built environment, and the electrification of transport, with most sectors needing to reduce emissions to close to zero. The increased electrification of primary

[3] Which holds a Grid Connection Agreement, is listed on National Grid's TEC Register under the status 'Scoping', and which could be built out in one or two phases by the mid 2020s.

energy use will double-down on the requirement to reduce carbon emissions from electricity generation even further than that which has already been achieved. The CCC describes one scenario (consistent with National Grid ESO's FES): that of 'extensive electrification, particularly of transport and heating, supported by a major expansion of renewable and other low-carbon power generation.' The report goes on to describe that 'the scenarios involve around a doubling of electricity demand, with all power produced from low-carbon sources (compared to 50% today)' [3, p23] This, coupled with National Grid ESO's own forecasts of the deployment of low-carbon generation in the UK, leads to the conclusion that, in order for the UK to achieve Net-Zero, all possible use is made from the resources and infrastructure available for low-carbon developments.

45. The decarbonisation of GB's electricity generation assets is therefore of vital importance in meeting the UK's legal obligations on carbon intensity. The 2019 update to FES was published around the same time that Government implemented the CCC's recommendation in law. FES 2019 analysis is therefore aligned with that of the CCC and provides an approach to achieve Net-Zero emissions by 2050. National Grid ESO conclude that the 80% decarbonisation target can be reached through multiple technology pathways, but that achieving Net-Zero requires greater action across all solutions. Action on electrification, energy efficiency and carbon capture will all be needed at a significantly greater scale than assumed in any core scenarios [6, Page 2].

46. Five important predictions from National Grid ESO's analysis[4] [6] are that, by 2030:

- GB electricity demand will grow up to 5% by 2030 as a result of electrification of transport & home heating, with demand up by between 30 and 50% by 2050;
- GB installed generation capacity will need to increase (from 110 GW today) to 130 – 160 GW by 2030 to meet demand (i.e. a 36 – 66 GW increase, following nuclear (8 GW) & coal closures (also 8 GW) pre 2030), with indicatively 53-66% of that capacity being low-carbon (vs. 48% today);
- Installed capacity will need to grow even further after 2030 to meet demand and carbon targets;
- That there are potentially many ways to meet the CCA2008 2050 80% reduction target – but critically that not all pathways will meet this target, therefore work remains to be done in decarbonisation; and
- That in order 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.

47. Three important points arising from this study are:

- Experts have concluded, and Government has agreed, that decarbonisation in the UK needs to be deeper and broader than it has previously been considered;
- Broad electrification is a fundamental requirement for broad and deep national decarbonisation; and
- More low-carbon generation, from diverse sources, along with energy efficiency and electricity storage is required to meet the anticipated increase in electricity demand.

[4] FES 2019 includes early sensitivity analysis for reaching Net-Zero by 2050

2.3 UK demonstrating global leadership on climate action

48. Government policy on climate change does not stop at our national borders, indeed since 2010, government has included within its policy actions, 'driving ambitious action on climate change at home and abroad' [1, Para 2.2.3]. In this regard, the CCC states:

> *Whether the world achieves the long-term temperature goal of the Paris Agreement will depend on the actions of other countries alongside the UK. A large-scale shift in investment towards low-carbon technologies is needed and emissions need to stop rising and to start reducing rapidly. Falling costs for key technologies mean that the future will be different from the past: renewable power (e.g. solar, wind) is now as cheap as or cheaper than fossil fuels in most parts of the world.* [20, pp83-84]

49. And further, sets out an ambitious course for the UK to lead, internationally, in climate change mitigations and actions:

> *More rapid electrification must be accompanied with greater build rates of low-carbon generation capacity, accompanied by measures to enhance the flexibility of the electricity system to accommodate high proportions of inflexible generation (e.g. wind). The Energy White Paper planned for 2019 should aim to support a quadrupling of low-carbon power generation by 2050. While key options like offshore wind look increasingly like they can be deployed without subsidy, this does not mean they will reach the necessary scale without continued Government intervention (e.g. continued auctioning of long-term contracts with subsidy-free reserve prices).* [20, p178]

50. Importantly, this recognises offshore wind as an important technology for low-carbon generation: a position consistent with that of the Applicant, and against this context, the urgent need for large capacities of low-carbon generation is clear. Specifically, Hornsea Three will be a necessary part of the future generation mix, and as such will make a valuable contribution in the direction of adopted UK Government policy and achievement of decarbonisation commitments.

Chapter 3 Progress against the Low Carbon Transition Plan

> *The UK needs to wean itself off such a high carbon energy mix: to reduce greenhouse gas emissions.* [1, Para 2.2.6].
>
> *The Overarching National Policy Statement on Energy EN-1 sets out how the energy sector can help deliver the Government's climate change objectives by clearly setting out the need for new low carbon energy infrastructure to contribute to climate change mitigation.* [1, Para 2.2.11].
>
> *It is for industry to propose new energy infrastructure projects within the strategic framework set by Government.* [1, Para 3.1.2].

51. In 2011, approximately 75% of GB's electricity came from carbon-based fuels; and contributed over a third of UK greenhouse gas emissions. Since then, carbon emissions from electricity have reduced, but mainly through measures other than those as described in the LCTP.

3.1 Progress to date in achieving emission reductions in GB

52. Figure 2.1 shows the trend in reductions in carbon emissions in the UK, including from power generation, since 1990. A monthly view of the carbon intensity of electricity generation from 2013 to 2017 is shown at Figure 3.1. Reductions have been achieved through many initiatives and circumstances, including:

    1. Electricity volumes generated from coal and gas fired 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 11.5 GW of coal plant decommissioned as a result of the Directive. Further, in late 2017, Government announced a commitment to a programme that will phase coal out of all electricity generation by 2025. National carbon pricing ensures that coal assets have unfavourable marginal costs (see Section §6.1) and are therefore dispatched only when absolutely necessary. In April 2018, Britain did not generate any electricity from coal for more than three consecutive days – the longest period since the 1880s. During 2019, the closure of 3.5GW of coal generation assets has been reported. In February 2019, EDF Energy announced the closure, by October 2019, of the 2.0 GW Cottam Power Station. In June 2019, SSE announced the proposed closure of the 1.5 GW Fiddlers Ferry Power Station by March 2020. In August 2019, RWE announced the closure of their 1.6 GW Aberthaw B coal plant; this took effect in December 2019. In 2019, GB went 83 days without burning coal for electricity generation [17]. Just 4 coal stations are forecast to remain operational beyond 2020 with a combined generation capacity of 6.2 GW [12].
    2. GB's second-generation nuclear fleet (9 GW) has so far continued to operate past its original decommissioning dates. Nuclear continues to provide approximately 20% of electricity demand with zero carbon emissions. Advances in new nuclear plants to replace the existing fleet have been slower than was originally envisioned (see Section §3.3.2 and Section §3.3.3); and the decommissioning of the existing plants is likely to commence before 2025 (see Section §3.3.5).
    3. Low carbon variable generation, predominantly wind and solar, has been deployed to GB grid more quickly and more widely than originally projected.

53. The GB energy market is complex with long-term price uncertainty. Within it, multiple players are developing assets in response to market signals rather than as a result of a centrally coordinated asset development program) [27, p80]. Long-term electricity price uncertainty does not provide sufficient confidence for private investment into in high-capital, large generation assets. Very few are being progressed without some mechanism to manage forward revenue risk.

54. Consequently, investors have increasingly been attracted to technologies (such as renewables) which are eligible for government-backed support programmes (such as the Contract for Difference), which address market risk. Interest from investors and developers in these technologies has driven technical development and competition on cost.

55. Government support is important for technologies other than renewables too. 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 [23] 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.* [23, p38].

56. As conventional plants in GB have closed, new conventional low-carbon plants have not yet opened. By contrast, Renewable Energy Sources ('RES', including solar PV, onshore wind and offshore wind) are being deployed because of their successful subsidy frameworks.

Technology	January 2011	January 2020	Projects under scoping / application / construction
Solar	0.0	13.1	0.35[5]
Embedded Wind	1.7	6.3	0.1[6]
Onshore Wind	3.8	5.9	8.8
Offshore wind		9.2[7]	34.5
Total	**6.5**	**36.5**	**41.8**

Table 3.1: Historical capacities of renewable generation deployment and sites under scoping / application /. Construction (GW). Adapted from [12]

3.2 Many technologies foreseen in the LCTP are unlikely to reduce carbon emissions during the critical 2020s

57. Table 3.2 shows elements of the Government's 2009 LCTP, which were expected to make significant contributions to reducing the carbon intensity of electricity generation. A current status on these initiatives is also included. While a number of the major initiatives detailed in the LCTP have yet delivered, carbon reduction targets for power generation are being met, largely through the development of high capacities of RES. The development of RES has provided a major contribution to the UK's current 'on-track' performance versus its legal obligations. However, as previously noted, FES 2019 [6] describes many pathways to meet 80% reduction in emissions; however, in order to meet 100% reductions in 2050 or before, radical change is

[5] Includes only those projects which have made applications under the Feed in Tariff (FiT) programme or have received Grid Connection Agreements from National Grid

[6] As Footnote 5

[7] Includes projects classified as "Built" on National Grid's TEC Register [12]

required, in parallel across many industry sectors. The Net-Zero commitment underpins the urgency for new low carbon generation infrastructure to be built and commissioned.

58. Grid-scale Carbon Capture Usage & Storage ('CCUS') from power generation has not yet been proven in Europe[8]. FES 2012 [21] estimated that between 5 GW and 14 GW of CCUS could be operational (across coal, gas and biomass plant) by 2030. As of today, 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. Indeed, in their 2019 consultation document on financing models for CCUS [22], BEIS do not foresee CCUS to make any contributions to carbon reductions until the 2030s. This position was clarified in the December 2019 Queen's Speech [53, p115].

59. The NIC are less favourable to CCUS in their 2018 assessment of national infrastructure [23], concluding from their analysis, that CCUS will only become useful for decarbonisation of the electricity generation sector in the 2040s and beyond, when the decarbonisation and adequacy of electricity generation must already have been largely achieved in order to support decarbonisation in other sectors.

60. 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 [24]. Early predictions on future rollout of wave / tidal power were large but varied, ranging from 0.5 GW to 4.5 GW by 2030 [21, p54]. Tidal power remains difficult to consent, and expensive to deliver in comparison to the cost of offshore wind, as demonstrated by the planning decision on the Swansea Bay Tidal Lagoon in June 2018 [25].

61. Nuclear power has attracted significant government attention over the last decade, including a plan for 16 GW of new build capacity by 2030, as described in the 2013 Nuclear Industrial Strategy [26]. Until recently nuclear projects have made more progress than have alternative large-scale low-carbon generation technologies. Two recent events however have called into question the timeliness and quantum of any such contribution. These will be discussed in the following Section §3.3.

62. Large-scale electricity generation projects attract both delivery and timing risk. In 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 has stressed the importance of urgent action to decarbonise electricity generation, and the CCC have reported that the UK is off-track for the 4th and 5th carbon budgets[9]. The development of proven technologies, such as offshore wind, is a pathway for delivering low-carbon generation both now and for the longer term.

[8] Only two large-scale CCUS for power generation are currently operational. Boundary Dam (Canada) and Petra Nova (USA) [56]

[9] These were originally set when the UK was working towards an 80% reduction target in 2050.

Initiative	Projection	Status at January 2020
New Nuclear	2013: construction of new nuclear commences. 2018: first new nuclear operational (of up to 16 GW fleet)	2017: Hinkley Point C construction commenced, with Commercial Operation currently not before 2025 2018: Government advised to permit only one more GW+ nuclear before 2025 [23, pp10, 42]. Existing nuclear stations edging closer to decommissioning
Wave / Tidal	2014: Larger-scale wave and tidal energy generation (>10 MW) starts to be deployed	2019: No larger-scale wave and tidal energy generation yet to be deployed. The second Severn Estuary / Swansea proposal has previously been denied public funding
CCUS	2020: Up to 4 CCUS demonstration projects operational in the UK	2019: No CCUS projects yet operational in GB.
Renewables	2020: Around 30% of electricity	2019: Wind, solar, hydro, bioenergy accounted for 37% of GB generation. Nuclear accounted for 17%

Table 3.2: Projections from 2009 for a low carbon power sector, summarised from [11]; and a 2018/19 status [NSR Analysis]

63. Offshore wind power generation has global momentum and is already delivering GW-scale projects in GB. Offshore wind can already be classified as a large-scale renewable technology.

64. Neither nuclear power nor carbon capture and storage are likely to play a significant role in furthering decarbonisation before the 2030s (see Section §3.3 for more detailed analysis of nuclear projects).

65. The role that offshore wind has played in decarbonising GB's electricity generation to date is transparent within Table 3.2. Offshore wind has undergone significant technological advances in scale and efficiency, and the UK has 40% of Europe's wind resource [1, Para 3.4.3]. 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.

66. Offshore wind generated nearly 40 TWh of power in 2019 [National Grid market data]: a significant proportion of national demand. It is well placed to continue to play an important role in decarbonisation into the future, and Chapters 4 and 5 of this report expand on the reasons behind this statement. Hornsea Three should therefore be considered to be an important project at this stage of GB's journey to Net-Zero.

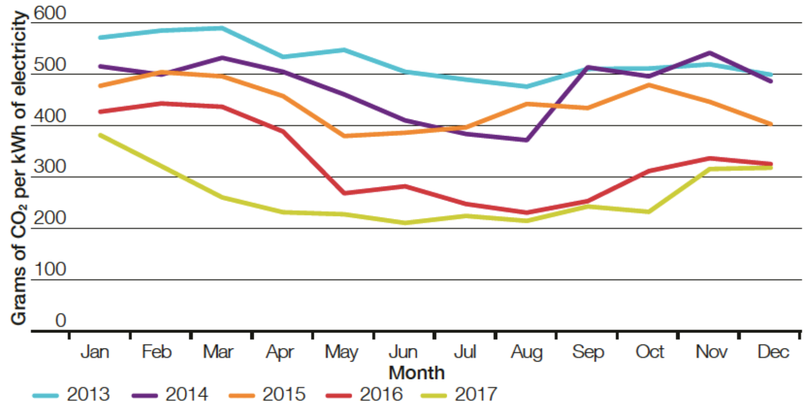

Figure 3.1: Carbon intensity of GB electricity generation 2013–2017 [4, Figure 3.3]

3.3 The potential contribution of GB new nuclear to UK carbon emissions in the 2020s

67. Nuclear is an important existing generator of low-carbon power (currently meeting 17% of GB demand, but anticipated to reduce as existing stations close – see Section §3.3.5). Nuclear development projects are ongoing. This is important because nuclear is currently the only available large-scale dispatchable low-carbon power generation technology. It is therefore important to set out and assess the projected contribution of nuclear power to the reduction of UK carbon emissions within the context of current policy and project developments.

68. Given recent events relating to the bringing forward of large-scale nuclear power generation projects in the UK, any contribution new nuclear power may make to the GB power mix is likely to be significantly later than even the most recent plans. If (as this section seeks to demonstrate) nuclear power is not able to make significant additional contributions to decarbonisation, security of supply or energy affordability over the next decade, it is vitally important that other deliverable, fundable, affordable and beneficial technologies are consented as a priority. This directly strengthens the importance of current Government policy on offshore wind to meeting our UK Net-Zero legal commitments.

69. The 2019 BEIS Consultation on new nuclear financing includes statements on forecast energy growth and the importance of renewable generation (alongside nuclear) in meeting that demand:

> *Meeting Net-Zero will require emissions from the power sector to be reduced to low levels and the deployment of negative emissions technology to offset emissions from those sectors that cannot be completely decarbonised. It is likely that electricity demand will grow significantly by 2050 as other sectors of the economy such as transport and heat are electrified, potentially nearly doubling (or more) from today's levels. To meet this increasing demand, whilst reducing emissions to low levels, there will need to be a substantial increase in low carbon generation – the Committee on Climate Change estimate a four-fold increase may be needed. This is at a time when seven out of eight of our existing nuclear power plants – important contributors to our low carbon generation – are due to come offline by 2030 as they reach the end of their operational lives. As the cost of renewable technologies such as offshore wind and solar continues to fall, it is becoming clear that they are likely to provide the majority of our low carbon generating capacity in 2050.* [28, p7]

70. It is important to clarify that this section does not seek to justify or promote the exclusion of any generation technologies from the future generation mix. This Statement of Need concludes that the Hornsea Three offshore wind project is needed in the UK, and developing the asset as planned, will meet Government objectives of delivering sustainable development, ensuring our energy supply is secure and providing benefits to GB consumers. The timing risks associated with the current forward nuclear capacity projections strengthen this conclusion.

3.3.1 Nuclear projects have long development timeframes

71. A series of Government white papers and consultations through 2007/8 was precursor to an enabling framework for a Great British nuclear renaissance. Over the subsequent 5 years, Government removed successive barriers to nuclear development. This covered: site selection (the National Policy Statement for Nuclear Power Generation); regulatory approval of reactor designs (the Generic Design Assessment 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. 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 however is neither easy, nor short.

72. From a regulatory perspective, the Generic Design Assessment (‘GDA’) of a reactor is a voluntary process undertaken by the ONR taking 4–5 years to complete and may be applied for ahead of an application[10] for a site-specific Nuclear Site Licence (‘NSL’), granted by ONR. GDA gives a clear indication of whether the design would meet regulatory requirements, and simplifies the consenting process.

73. Aside from achieving these consents, the applicant must confirm its commercial arrangements. These must address (at least) revenue certainty and protection against political risk. Once secured, the real task of digging dirt and pouring concrete can begin. During construction and commissioning, the NSL introduces at least 5 separate hold points. These may only be moved past when consent has been granted by the ONR.

3.3.2 EDF’s project development timeline for the Hinkley Point C EPR

74. Hinkley Point C (HPC) is currently under construction in the UK by an EDF Energy / China General Nuclear (CGN) partnership: Nuclear New Build Generation Company (NNB). The technology employed will be a UK EPR, designed by EDF and Areva. The GDA process commenced in 2007, and nuclear (as opposed to civil) construction commenced in late 2018 – a project development timeframe lasting 11 years. Commercial Operation is now forecast for late 2025 / early 2026 [29, 30].

75. In 2016, HPC signed a CfD, guaranteeing power price for a 35-year term. Since signing this agreement, there has been a shrinking appetite for another HPC-style CfD contract in the UK energy market, and a growing view that a different approach is needed.

[10] ONR may take up to 18 months to assess the capability and resources of the applicant organisation, the site safety case and other site-specific factors.

76. The timeline for this project has been illustrated in Figure 3.2.

Figure 3.2: HPC Timeline [NSR Analysis]

77. Sizewell C ('SZC'), also EDF/CGN, is progressing through its development phase. A Government consultation regarding a suitable financing model is ongoing and has not yet concluded (see [28]). Being the second UK EPR, SZC may proceed through planning, consenting and construction more rapidly than HPC. SZC has unofficially been forecast to come on-line by 2031 [31], however EDF have formally stated that: 'the project does not currently have a timeline ... although construction work could overlap with Hinkley Point C' [29]. The timelines above suggest that the unofficial forecast is feasible.

78. In summary, potential earliest commercial operation dates for these reactors may be:
    - Hinkley Point C, 3.2 GW, 2026;
    - Sizewell C, 3.2 GW, 2031.

3.3.3 Delivery of other new nuclear projects before 2030 now appears less likely

3.3.3.1 Moorside

79. Toshiba planned to develop three Westinghouse AP1000 reactors at Moorside in Cumbria, commissioning from 2026 onwards. In March 2017, the failure of two AP1000 developments in the US 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. International AP1000 construction experience outside of the US has also been challenging with four AP1000s finally achieving commercial operation in late 2018 / early 2019; a construction duration of approximately 10 years for each reactor: more than twice their initial planned durations. A divestment of the UK project was at this time all but inevitable. Unable to find a new owner (both CGN (China) and KEPCO (South Korea) were reportedly interested in the site for their own technologies, but neither has signed a deal). Toshiba announced their withdrawal from the project in November 2018.

80. By March 2017 the AP1000 had secured GDA approval and other regulatory requirements were being progressed, placing them on a timeline to commence nuclear construction in around 2024, with commercial operation being achievable at the *earliest* in the early 2030s. With Toshiba's exit, a different reactor design (if any) would likely be constructed at Moorside. The clock will reset on GDA. Planning and consenting processes will also restart, introducing (based on HPC) an indicative 11 year wait until nuclear construction commences.

81. In summary, potential earliest commercial operation dates for this reactor may be:
    - Moorside, 3.0 GW, 2039.

3.3.3.2 Wylfa Newydd and Oldbury

82. Hitachi are the parent owners of Horizon Nuclear Power, who until recently have been developing a project to construct and operate two ABWR[11] at Wylfa Newydd on Anglesey. The ABWR is not a new reactor design: 4 Japanese plants have already commenced operation, and more are under construction internationally. Critically, each of the 4 completed reactors were built in less than 5 years. The ABWR received its GDA in late 2017, and secured many of the necessary EA permits and started funding discussions with Government in June 2018. Horizon's forecast commissioning date for Wylfa remained at or around 2026 throughout this time. Discussions with Government concluded without agreement in 2019 however, prompting Hitachi to announce a suspension of the project under grounds of 'economic rationality as a private enterprise' [32] however the site's DCO application remains ongoing with the SoS. Greg Clarke, the then Energy Secretary, presented to the House of Commons the UK government significant commercial offer:

    - Government was willing to consider taking a one third equity stake in the project, alongside investment from Hitachi and Government of Japan agencies and other strategic partners;
    - Government was willing to consider providing all of the required debt financing to complete construction; and
    - Government agreed to consider providing a CfD to the project with a strike price expected to be no more £75 per megawatt hour. [33]

83. The search for a funding solution between Government and industry is set to continue for new nuclear and will be of critical importance to the progression of development plans for these projects.

84. Wylfa Newydd was seen by many as the brightest light in the UK new nuclear world, being unique in the build list. Because Horizon was only trying to do something that has successfully been done before, their progress was swift and their proposition compelling. Given project momentum and past history, commissioning Wylfa Newydd in the mid-2020s was a distinct possibility, with a second location, Oldbury, following shortly after. Following Hitachi's suspension however, a 2033 timeframe now looks more sensible as an earliest possible commission date for a reactor at Wylfa. This estimate assumes that Hitachi restart the project within 2 years, and allows time for the remobilisation of resource, supply chain and planning activities as well as agreeing the commercials in order to commence construction.

85. In summary, potential earliest commercial operation dates for these reactors may be:
    - Wylfa Newydd, 2.6 GW, 2033;
    - Oldbury B, 2.6 GW, 2038.

[11] Advanced Boiling Water Reactor.

3.3.3.3 Bradwell B

86. CGN have taken the lead on the Bradwell B project from partners EDF. GDA on their reactor design started in 2017, with conclusion anticipated in 2021 / 2022. No indications of intended project timelines have been published by the developer.

87. An assessment of potential earliest commercial operation date for this reactor, based on development durations of other projects, may be:
    - Bradwell B, 3.0 GW, 2037.

3.3.4 Small Modular Reactors (SMR)

88. 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 can achieve this through either the delivery of larger projects (see Section §3.3) or SMRs. SMRs aim for cost improvements through the production of multiples of units rather than an increase in scale. In 2015, the Energy Technologies Institute (ETI) published a report into the enabling framework required to realise such a vision. This included a 'manufacturing line' capability to deliver efficiency and accuracy in the modular construction techniques [34]. ETI's analysis showed (for a more conventional water-based reactor design) a minimum 17-year development timeframe from the initial design concept through to commissioning of the first production unit. ETI do note that some SMR concepts may already have progressed along this timeframe.

89. SMRs have been the subject of international attention, both in the East (China, Russia) and the West (Canada and the US). Both North American governments have recently made announcements in support of SMRs through design approval, and budgets for funding technical development. The major global contenders for SMR development (TerraPower, Terrestrial Energy, Moltex and NuScale) are therefore focussing on these markets for their manufacturing facilities and first deployments. The earliest delivery of a first of a kind SMR is therefore not likely to be before 2037, although ETI consider that this timeframe may be up to 9 years longer for more evolutionary designs.

90. In summary, potential commercial operation dates for these reactors may be:
    - LWR SMR, 0.5 GW, 2037, with 0.5 GW every other year thereafter (water-based design)

3.3.5 Decommissioning GB's existing nuclear power stations

91. By their initial lifetime expectations, almost all of the UK's existing reactors should by now have closed. However, successive lifetime extensions have kept them running for longer than expected. Current operator expectations for plant closure dates for the Advanced Gas-Cooled Reactor ('AGR') fleet are displayed in Figure 3.3. The one UK Pressurised Water Reactor, Sizewell B (not shown), is currently scheduled to close after 40 years operation, in 2035, but 20-year life extensions to PWRs are globally commonplace.

92. Further life extensions may be possible at the AGR, but they should not be viewed as a certain, or firm, option. Any contribution made by extending operation of the existing fleet to a shortfall in new build nuclear capacity coming forwards will be limited by plant reliability and safety case

justifications for continued operation. A current 'best-case' view of reducing AGR capacity due to decommissioning is shown in Figure 3.4.

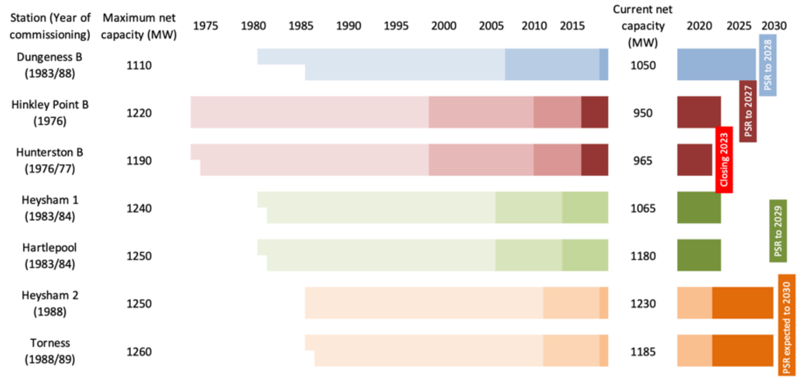

Figure 3.3: Generating capacities and announced closure dates for each AGR station [www.edfenergy.com]

3.3.6 A synthesis of new nuclear commissioning date projections

93. Toshiba withdrew from Moorside. Hitachi suspended Wylfa and Oldbury. Discussions on the funding and development of SMR are ongoing with Government. Hinkley Point C construction and Sizewell C development are progressing, with commissioning now 6 years away at Hinkley. The long lead times and significant public / private funding complexities of all of these projects, coupled with the inevitable decommissioning of the existing fleet, leads to the conclusion that nuclear power might not be as strong a contributor to low carbon generation in GB over the critical pre-2035 timeframe, as it has been to date.

94. This analysis is illustrated in Figure 3.4, which shows a gap between projections made in 2016 and projections made today. This point is of relevance to the Hornsea Three project, because of the importance of urgently bringing forward significant capacities of deliverable low carbon power with urgency, so it might contribute to the UK's legal carbon reduction targets.

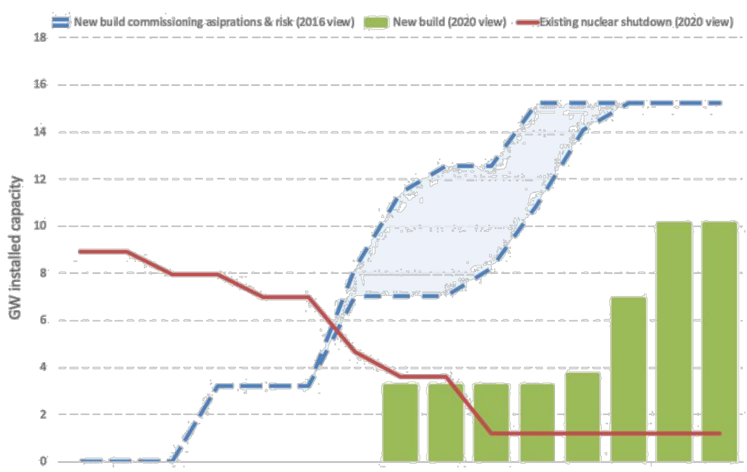

Figure 3.4: Projections of nuclear new Build capacity (2007, 2016, 2019) and existing station closures. Source: [NSR Analysis] and [4, 5]

Chapter 4 Future demand for electricity will grow significantly

> *[Government] expect[s] that demand for electricity is likely to increase, as significant sectors of energy demand (such as industry, heating and transport) switch from being powered by fossil fuels to using electricity. As a result of this electrification of demand, total electricity consumption . . . could double by 2050* [1, Para 3.3.14].
>
> *Whilst no such projections of the UK's future energy mix can be definitive, they illustrate the scale of the challenge the UK is facing* [1, Para 3.3.21].

95. The annual demand for energy from gas and electricity in GB in 2018 was 1,089 TWh, with 26% (283 TWh) in the form of electricity [6, p45]. While our total energy demand will have reduced by 2050, electricity demand is expected to grow steadily from the 2030s onwards. The FES reports provide critical information on these points.

4.1 National Grid ESO's Future Energy Scenarios

96. National Grid ESO publish FES annually[12]. On their website they state:

> *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 National Grid to identify strategic gas and electricity network investment requirements for the future.*

97. FES publications go back to at least 2012 (see http://fes.nationalgrid.com/fes-document/fes-archives/). The most recent FES [6] brings together future operation of existing generators, and future trends in the demand of electricity, to conclude that:(i) Significant capacities of new generation are required over the next 10 years to meet demand; and (ii) A diverse mix of low-carbon generation is required to meet national decarbonisation targets.

4.2 Future electricity demand

98. Since the 1990s, GB electricity demand has grown only slowly, and (since 2005) has fallen. This trend in underlying demand reduction reflects three drivers:

    1. A decline in economic growth rate (particularly with the recession of 2009);
    2. A reduction in the level of electricity intensity as the economy has shifted to less energy-intensive activities; and
    3. The introduction of energy efficiency measures, especially more efficient lighting within the last seven years.

99. Today's view of future demand remains uncertain, but growing, for the same reasons as those stated in the 2011 NPS documents:

[12] http://fes.nationalgrid.com

1. Gross Domestic Product is forecast to return towards 2% per annum growth in 2020;
2. The switching of sources of final-use power for heating and transport from carbon-intensive sources (hydrocarbons) to electricity, the generation of which can be decarbonised using technologies already available today, will put upward pressure on demand. Projections of electricity demand in 2050 range from 370 – 422 TWh[13] [6, pp46-47]; a doubling of current demand [1, Para 2.2.22] and [3, p23]; and 645 TWh [35, p12];
3. 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
4. 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 pres-sures on the electricity sector.

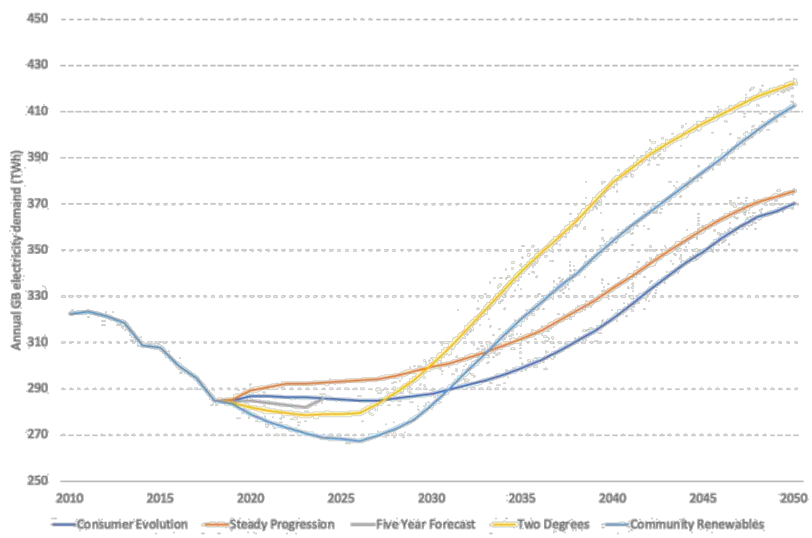

Figure 4.1: Annual GB electricity demand scenarios. [6, Table 4.1]

100. This view is shared by National Grid ESO and is described in the various scenarios within FES 2019. Figure 4.1 shows the output of National Grid's analysis. The next sections provide further detail on key drivers of electricity demand.

4.2.1 Transport

101. Growth in the use of electric vehicles ('EVs') is expected to create significant new demands on our supply of electricity. The UK government has proposed a ban on the sale of all new petrol and diesel vehicles from 2035 at the latest (subject to consultation) [52]. Innovation is bringing affordable and highly desirable low emission vehicles to market, and the UK has put leadership of transport revolution at the heart of its Industrial and Clean Growth strategies, with investment being directed into both vehicle manufacturing and grid recharging points. Transport is currently the largest source of UK greenhouse gas emissions and a rapid shift to low emission vehicles will give a significant boost to the decarbonisation of our economy. Therefore, growth in the number of EVs on our roads is certain, but the trajectory and timing of that growth has until recently been

[13] Excluding losses and exports.

less clear. EVs are predicted to play a major part in the future GB energy mix as a result of their energy demand requirements and potential energy storage capabilities. Ofgem 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, p7] and anticipate that the number of electric vehicles on UK roads may grow from 230,000 today, to 46 million by 2050 [51, p4].

102. Annual electricity demand from road transport could be between 100 and 150 TWh [6, p77]. This represents both direct power supply to EVs or via hydrogen electrolysis. 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 [36].

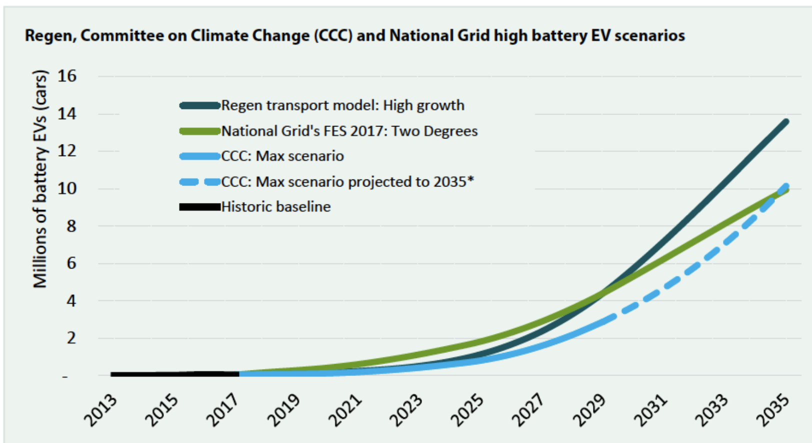

Figure 4.2: Potential growth in EVs in GB to 2035 [7, p9]

103. The future daily profile of demand is much less easy to forecast, with peak demand in 2050 ranging from 68 GW - 83 GW [6, p48] to 150 GW [35, p12]. National Grid foresee the importance of Vehicle-to-Grid (V2G) charging technologies, meaning that EV owners will be able to use their vehicles to support grid balancing as well as optimise charging according to the price of power at the time, Figure 4.3 illustrates the potential impact of V2G and smart charging on peak demand. EVs and Hydrogen vehicles therefore not only require the deployment of significant additional electricity generation capacity, but also act potentially as an integration measure for all renewable and baseload generation technologies.

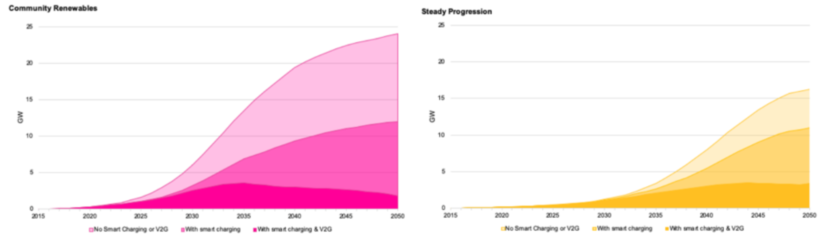

Figure 4.3: Future net peak electricity demand from vehicles [6, Figure 4.24].

4.2.2 Home heating

104. In order to reduce the UK's dependence on natural gas thereby reduce further our carbon footprint, the long-term need to diversify to low- or zero- carbon home and industrial / commercial heating, either directly through electrification or indirectly using electricity to produce Hydrogen, would also increase demands on the National Electricity Transmission System ('NETS'). This, coupled with meeting the Government's plans for new homes, is anticipated to drive electricity demand growth. For every household that is supplied with electricity, an average additional burden of 4MWh per year could be placed on the grid [37, p9]. Some projections are that UK should be building at least 200,000 new homes a year [37, p7], implying a potential additional increase in electricity demand by up to 24 TWh per year by 2050. Ofgem have committed to 'support government and industry to develop affordable low-carbon heating options' to support this drive for decarbonisation [51, p7]. Even if GB is currently able to meet its 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 deployment of significant capacities of new low- or zero- carbon generation.

4.3 Future electricity supply

> *Depending on the choice of how electricity is supplied, the total capacity of electricity generation (measured in GW) may need to more than double to be robust to all weather conditions.* [1, Para 3.3.14].

105. Each FES scenario 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. 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[14].

[14] Analysis of the CfD Register shows that 16 projects with CfDs have registered a reduction to the capacity of the CfD Unit to date. They are: offshore wind: 2 projects, 76 MW reduction (11% of initial installed capacity); onshore wind: 10 projects; 66 MW (12%); biomass conversion: 1 project, 13 MW (3%); solar PV: 2 projects, 4 MW (14%); advanced conversion technology: 1 project, 3 MW (10%). Further, 6 projects have had their CfD terminated, including 4 advanced conversion technology projects, (52 MW), 1 biomass with CHP project (85 MW), and one solar PV project (12 MW). [10]

106.However, each year all 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.

107.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 against a national policy perspective. The 2019 FES foresees that two of four scenarios (those which do not pursue rapid low-carbon generation deployment) miss the legally binding national decarbonisation targets in 2050. These are the two scenarios with the slowest growth in renewable electricity generation capacities.

108.From their analysis, National Grid conclude that electricity generation capacity needs to increase from the ~110GW level today to between 130 and 160GW to meet anticipated GB demand in 2030, this being a 35 to 55GW increase on existing generation capacity following decommissioning of around 8GW of nuclear and 8GW of coal generation before that date. 50% to 60% of that installed generation will need to be low carbon generation in order to meet Net-Zero targets, pointing to a significant growth in low-carbon generation over carbon intensive generation. Further, National Grid analysis demonstrates that between 160 and 220 GW of generation capacity will be required to meet demand by 2050, with approximately 80 - 95% being low-carbon [6, Table 5.1].

109.As an example, the CCC suggest that in order to meet a doubling of electricity demand from 100% low-carbon sources up to 75 GW of offshore wind could be required by 2050 [3, p23]. Further, 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, p5], 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.

110.Many forms of low-carbon generation will be required to meet the UK Climate objectives. This is discussed further in Chapter 5. 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 2019, GB sourced nearly 40% of its electricity from renewables, and approximately 20% from wind alone [National Grid market data]. In 2019, Denmark sourced 47% of its electricity needs from wind alone, demonstrating that high proportions of renewable generation can be accommodated within national electricity systems [38], and GB can learn how to do this from other nations which are further ahead in this regard.

4.4 Demand response

111.Energy demand management (Demand Side Response (‘DSR’) also could 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, but DSR on its own will be unlikely to deliver a decarbonised electricity system. Currently DSR capacity is estimated at just 1.0 GW nationally. FES scenarios forecast between 1.4 GW and 4.5 GW may be operational by

2030, rising to between 2.1 GW and 6.7 GW by 2050. The significance of the scale of growth of DSR as an enabler of a low-carbon energy system must be viewed within the context of a further c. 15 GW of coal and nuclear generation coming offline before 2030 and additional GB generation required to meet the demand growth as described in Section §4.2. Therefore, DSR is unlikely to be a significant contributor to the delivery of UK decarbonisation before 2030, further underpinning the need for low-carbon generation to come to market within this timeframe.

4.5 Decarbonisation of other sectors requires the development of significant capacities of low-carbon generation

112. Because electricity can be generated from low-carbon technologies, the demand for electricity in GB will grow as electricity contributes to the decarbonisation of other sectors. The need for significant growth in new generation assets, including well-proven offshore wind, is therefore clear. Not only is offshore wind required to meet additional anticipated demand, but it is also needed to offset the supply drop due to closures of many existing generation assets, either because of environmental regulation or technological lifetime limits.

Chapter 5 Decarbonisation can maintain or enhance security of supply

113. Decarbonisation is just one of the three pillars of GB 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. This chapter demonstrates how offshore wind has contributed, and will continue to contribute, to security of supply in Great Britain.

> *The Government needs to ensure 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.* [1, Para 3.3.2]
>
> *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.* [1, Para 3.3.3]
>
> *A diverse mix of all types of power generation. . . helps to ensure security of supply.* [1, Para 3.3.4]

114. 'Security of supply' means keeping the lights on and has two main components.

1. Ensuring that there is enough electricity generation capacity available to meet demand (adequacy); and
2. 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.

115. 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 with regards to system adequacy and system operation are presented. Specifically:

- The planned development of an offshore wind farm, Hornsea Three, will contribute in the order of 2.4 GW to national system adequacy targets;
- The diversification of GB's electricity supplies through the commissioning of offshore wind assets (such as that planned for Hornsea Three) 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 [39];
- 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 [54]; and
- A program of grid investment and operational development by National Grid, regulated by Ofgem, is aiming for safe and secure operation of the NETS by 2025 at zero-carbon [6, p1].

116. To provide appropriate context and understanding we set out in brief an introduction to a number of high-level concepts of power system operation.

5.1 An introduction to power system operation

117. 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.

118. Governments define policy to ensure that there is sufficient generating capacity[15] available to meet maximum expected demand. This is called adequacy.

119. Key power quality characteristics (including frequency, voltage and power shape) must be controlled at all times to ensure the NETS operates as required. National Grid 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' [40, p5]. Protecting the operation of a system when an asset operates outside of normal expected parameters is also important, and individual transmission-connected generators, such as is planned at Hornsea Three, must operate within parameters set by National Grid in order to protect the electricity system.

120. National Grid 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.

121. 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.

122. System frequency must also be maintained[16]. 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[17], generators which are able to provide FR will usually determine the price they would accept to provide the service.

123. 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 [40, p43]. System inertia is a phenomenon uniquely important to NETS because of its relatively low levels of interconnection to other, larger, electricity systems such as is the case, in particular, across Europe. Ancillary services are all those services which support NETS stability and operability.

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[15] i.e. The maximum achievable level of power generation which may be connected to the NETS

[16] The NETS operates at a nominal 50 Hz

[17] Output remains the main source of generator income

5.2 Connecting generators to the power grid

124. The electricity system in GB operates at two levels: the high-voltage NETS, and the lower-voltage Distribution Networks. The NETS is mainly made up of 400 kV, 275 kV and 132 kV 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.

125. Connect and Manage offers are given to those customers who request a connection date ahead of when the 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 ('SQSS') which once approved allows for a connection to be made ahead of those wider transmission reinforcement works.

126. 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.

127. In 2019, National Grid recommended an investment of £59.8m in 2019/20 across 25 asset-based projects to maintain the option to deliver projects costing almost £5.4 bn. This would allow them to manage the future capability of the GB transmission network against an energy landscape which is set to evolve significantly over the coming decades [41, p4]. 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.

128. 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. Ofgem have prioritised their work to support the development of an offshore grid to enable 40 GW of offshore wind generation connecting before 2030 [51, p7].

5.3 Centralised and decentralised generation

129. In all 2019 FES scenarios, decentralisation of generation is expected to increase, driven by the growth in smaller scale renewable generators, such as solar and wind farms. These generators do not connect directly to the high voltage transmission system, but rather to the medium or low voltage distribution systems [4, p34]. Currently nearly 30% of all generation capacity is connected to the distribution networks, and this number is foreseen to grow to between 35% and 58% by 2050 [6, Table 5.1]. Because distribution networks operate at a lower voltage, 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.

130. However, although distributed generation will grow, the replacement and growth of transmission connected assets is also foreseen. The current assumed emphasis on decentralised generation should be understood in the context of having a national electricity system, with 77 GW of generation currently connected to the transmission network and 31 GW to the distribution network. All FES 2019 scenarios [6] show that capacity connected to the distribution networks will continue to grow at a faster rate than that connected to the transmission network. However, despite this trend, it should be noted that all the four scenarios include future projections of significant capacities of generation remaining connected to the transmission network from wind, CCUS, nuclear, solar, biomass and other technologies. National Grid scenarios indicate a total of 72 - 135 GW installed capacity remaining at the transmission connected level in 2050. This represents at least a hold-firm lookahead in Transmission-connected generation capacities against today's position.

131. Distribution Networks were not originally designed to incorporate plentiful electricity generation connections. By virtue of their role in transferring power from the bulk NETS to businesses, built facilities and houses, many are located in built up areas, or at least away from areas of large natural resource potential. Geographical and technical constraints may therefore arise as generators continue to be connected to these networks, applying upward pressure to the costs and durations required to grant a connection agreement. This can have significant cost, timing and complexity considerations both for asset developers as well as for consumers who ultimately pay for the developments and the operation of the complex distribution systems which result. Further:

> *Government does not believe that decentralised and community energy systems are likely to lead to significant replacement of larger-scale infrastructure. Interconnection of large-scale, centralised electricity generating facilities via a high voltage transmission system enables the pooling of both generation and demand, which 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.*
> [1, Para 3.3.29]

132. National Grid ESO has also made many public statements on their position in relation to the connection of generation utilising diverse technologies and of sufficient capacities to the electricity network, for example [6]. The conclusion is that the need for additional distribution connected generation is in addition to, not instead of, the need for additional transmission connected generation. And as such, Hornsea Three will be well placed to support grid adequacy through its proposed transmission network connection.

5.4 Operating high-RES electricity transmission systems

133. In his 1991 paper, Grubb discusses the integration of RES and their likely effect on electricity transmission systems [42]. He foresaw that capacities of renewable generation will not be limited; and therefore that 'proper management' of those capacities (alongside any remaining conventional capacities) must be carried out in order to maintain a stable electricity system. This topic is not new. The electricity industry has, over the last nearly 30 years, implemented new processes and technologies to achieve stable low-carbon electricity systems. For example, in 2019, Denmark sourced 47% of its electricity needs from wind alone, demonstrating that high proportions of renewable generation can be accommodated within national electricity systems [38].

134. In foreseeing a need for maintaining the quality of electricity supplies, Grubb identified important considerations for system operation[18], and explains how renewable generation influences each one. He sees the critical issue as being the determination of how important each ancillary service becomes in a future energy system, and how capable the generation assets connected to that system are to provide that service.

135. The activities associated with integrating renewables into the GB electricity system will increase with their penetration [43, p2]. 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.

136. Importantly however, the dynamic behaviour characteristics for a high-RES system are well understood. National Grid's System Operability Framework [44, 45] describes these in specific relation to the GB electricity system.

137. Further, 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.

138. System stability services are already being provided by fast response batteries, for example National Grid's Enhanced Frequency Response service, tendered for in 2016 and currently operational in GB. More recent advances have been made in installing power electronics on low-carbon generation assets to enable them to provide important system services [54].

139. Further, it is possible to provide system stability services at offshore wind farms, by reprogramming the digital power inverters attached to wind turbines, so that they 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.

5.5 Transmission connected generation assets integrate to electricity systems more transparently than distribution connected generation

140. As previously described, large generating assets are connected to transmission systems and many smaller generators are linked either to customer connections or distribution networks. Some of the most relevant differences between transmission- and distribution- connected generator characteristics are listed in Table 5.1.

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

1. Transmission connected assets provide visibility of their expected generation to the national energy market and System Operator as part of their licence to operate. This

[18] Rate of change of frequency; system operational control and fault containment; and reserve operation.

increases transparency in the market and allows sensible economic decisions to be made by all market players, including the System Operator, in both planning and operational timescales to ensure that power demand and system security needs are met with the least possible cost;

2. Transmission connected assets are required to be available for instruction by National Grid. They are required to participate in National Grid's Balancing Market, 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;
3. 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 (see Chapter 6 for more detail);
4. 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.

	Transmission	**Distribution**
Description	Connected to ETS 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 (100's 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 with known reliability by the Transmission System Operator	Locally dispatched with unknown reliability outside the control of the TSO
Measurement	Output visible in real-time to TSO, to a high degree of accuracy, availability and forecast output signalled to TSO	Output not generally visible to TSO, indications of availability, forecast output not required to be provided to TSO

Table 5.1: Characteristics of transmission- and distribution- connected generators

142. Decentralisation is not in itself a strategy or a requirement of the energy system but is a trend which will go some way to delivering a flexible, low-carbon and affordable energy system. Continued operation of the NETS however does remain an important policy to maintain inter-regional connectedness and support the meeting of demand from geographically disparate sources [3, p182].

143. Further, by connecting more assets at the distribution level, less power flows on the transmission system, meaning that the unit costs of running GB's NETS increase. 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.

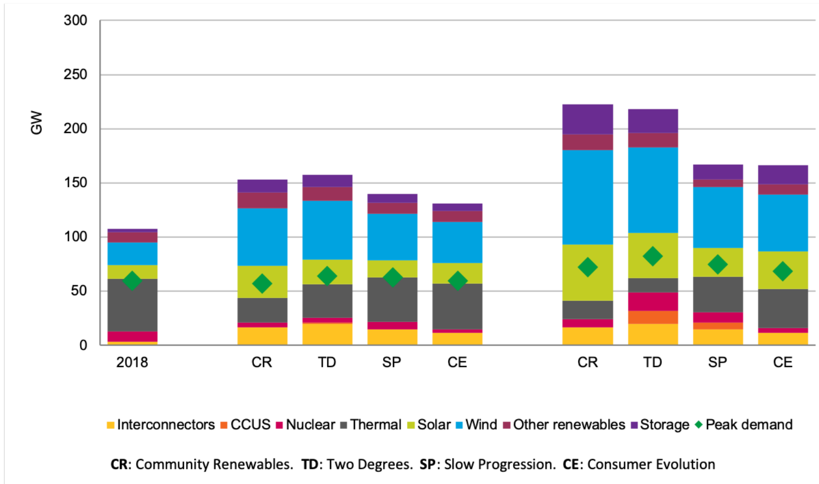

Figure 5.1: Generation capacity by technology type and amount of renewable capacity for 2030 and 2050 [6, Figure 5.1]

144. The interaction of embedded 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 proposed Hornsea Three development contributes to that diversity by replacing closing transmission-connected assets, while transparently conforming to Grid Code operability requirements.

5.6 Offshore wind is necessary to meet decarbonisation targets

145. Historically generation assets in GB have been 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. Generally capacity utilisations[19] have been high, and national electricity demand has been met by a lower total installed generation capacity. Figure 5.1 shows a scenario from National Grid on how generation capacity may evolve between 2030 and 2050 to meet a growing electricity demand, and a decreasing carbon budget. As GB progresses towards its legal decarbonisation targets, through the installation of more renewable generation capacity, total installed capacity will rise in proportion.

146. 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. Government's position on the wider benefits of renewable generation is clear:

[19] This is usually expressed as a quotient, calculated as {Total energy generated in a year [MWh]} divided by {Maximum power output [MW] x 8760 (hours in the year [h])}

Increasing the amount of energy from renewable and low carbon technologies will help to make sure the UK has a secure energy supply, reduce greenhouse gas emissions to slow down climate change and stimulate investment in new jobs and businesses. [46]

147.National Grid data shows that offshore wind generated nearly 40 TWh of electricity during 2019 [National Grid market data] from 9.2 GW of built capacity [12]. This makes offshore wind the third largest power generation technology in GB. Critically, with 40% of Europe's wind in GB waters, offshore wind is a technology with future potential, and need, for further growth. The first-place technology (gas) is not low-carbon, so continued gas generation is not currently consistent with Net-Zero requirements. The changing contribution of second place technology (nuclear) to low-carbon generation in the coming decade, is shown in Figure 3.4.

148.Chapter 3 describes why it is unlikely that decarbonised carbon-intensive generation will play a major role in continuing to reduce carbon emissions in the UK in the next twenty years. Section §3.3 describes the reasons why the development of nuclear generation is also not progressing at a pace which will enable it to lead in the delivery of Net-Zero. GB must therefore be ready for the development of significant additional renewable generation capacity to play a major role in the decarbonisation our economy, both while dispatchable low-carbon technology developments continue, and on an enduring basis, to meet foreseen electricity demand growth.

149.It is the view of the author of this report, that if a significant capacity of offshore wind generation is not built out to a scale comparable with that in the projections provided by National Grid and others, then the UK will be highly unlikely to continue to reduce its carbon emissions over the coming decade, and ultimately meet its legally binding decarbonisation targets.

150.This view is evidenced in Figure 5.2. In this Figure, the green line shows forecast average GB electricity generation carbon intensity under the least carbon intensive National Grid FES 2019 scenario. The yellow line shows the same metric, but the future projection of offshore wind generation capacity growth beyond 2019 has been substituted for additional gas capacity (at 300 gCO2/kWh higher than generation from offshore wind). An important observation from this Figure, is that the gap between the two carbon intensity trajectories widens through the mid 2020s and 2030s and does not close again, effectively putting a halt to further reductions in the UK's carbon emissions. As the leading low-carbon generation technology in GB, it is critical that offshore wind generation continues to grow to move the country towards meeting its Net-Zero commitments.

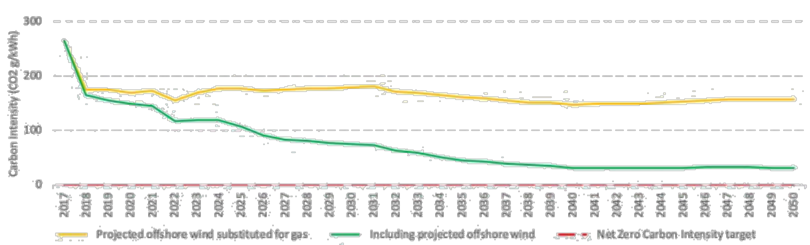

Figure 5.2: The effect on carbon intensity, of removing additional offshore wind generation from the future GB generation mix (adapted from [4, 6])

5.7 Offshore wind supports security of supply

151. As described in Table 5.2, a long-standing challenge to the ability of wind generation to play a significant role in electricity supply relates to the uncontrollable nature of the weather. The variability of wind generation can be mitigated by developing larger generation capacities (to maximise output during periods of low wind); by connecting assets to different parts of the NETS; by developing projects with complementary profiles (for example solar: see below); or by developing integration technologies. There are a number of other technologies which can be used to compensate for the intermittency of renewable generation, such as electricity storage, interconnection and demand-side response [1, Para 3.3.12].

5.7.1 Important considerations when introducing RES to power systems

152. Ueckerdt et al [13, p2] describe, from an analytical basis, important considerations for the introduction of RES to power systems. These are described in Table 5.2.

Consideration	Description	Implication
Uncertainty	Weather forecasts incur an inherent unpredictability bringing uncertainty to both demand and supply sides of the power balance equation.	Power cannot be stored. Therefore, balancing activities will grow as renewable generation capacities increase.
Local specificity	Renewable assets must be built to complement the local environment, in order to maximise yield.	A localised preference for most suitable technologies will emerge, diversity should be built in where possible.
Variability	While weather forecasts incur uncertainty, the weather itself is also variable.	Over timescales from hours to seasons, generation from renewable assets may be very different. A larger portfolio of RES will provide a larger dependable power level than a smaller portfolio.

Table 5.2: Complexities associated with RES variability in power systems [13, p2]

153. Uncertainty may manifest in that the level of the demand or supply of power may be higher or lower than was expected. Yet it is a fundamental property of all electricity systems that demand and supply must be balanced at delivery. Improvements in demand and supply forecasting are already helping to minimise balancing effort, and 'integration measures' are working as part of, and alongside, renewable generators to provide necessary upward and downward regulation.

154. An example of local specificity is that South East Britain has better potential for plentiful solar generation because of its high irradiance levels than the West Coast of Scotland, which may be better suited to wind generation.

155. Variability is best described by the difference between summer and winter power demand, or generation. Generation variability is broadly forecastable. In order to improve the likelihood of being able to ensure system adequacy from renewable generators in all but the most unlikely of meteorological situations, a large portfolio of interconnected assets from as broad as possible a range of technologies and geography may be beneficial. Hornsea Three is an important part of the growing offshore wind generation portfolio, whose dependable output is growing (see §5.9).

5.7.2 The location of Hornsea Three

156.Offshore wind developments in GB are permitted only in areas of seabed which have been identified and allocated to potential developers by The Crown Estate[20]. Further detail on the process used by The Crown Estate, and the history of zone level planning within the former Hornsea Zone, can be found in Sections 4.4 and 4.5 of [APP-059] - 6.1.4 ES Volume 1 - Chapter 4 - Site Selection and Consideration of Alternatives.

157.The Hornsea Three array area is a part of the former Hornsea Zone, which was identified in 2009 by The Crown Estate as one of nine zones for Round Three offshore wind farm developments. The timings of subsequent rounds (The Crown Estate anticipate Round 4 rights could be awarded in 2021, with projects becoming operational in the late 2020s [49, p7]) mean that undeveloped array areas within the Round 3 (former) zones are the only areas currently available for developers of offshore wind projects to propose projects capable of delivery in the early to mid-2020s.

158.The proximity of Hornsea Three to the other three Hornsea array areas (all four are located within the former Hornsea Zone) means that the weather conditions are likely to be similar across all, and therefore generation patterns may be similar across all array areas. The development of all array areas within the former Hornsea Zone is important because of the significant low-carbon electricity which will be generated (and otherwise would not). The grid connection route proposed for Hornsea Three, connecting to the NETS in Norfolk. This is different to Hornsea Project One and Hornsea Project Two, which connect to the NETS in Lincolnshire. This helps the operation of the transmission circuits in and around the local areas by providing more routes for power generated in the former Hornsea Zone to flow to where it is needed.

159.Full development of the Hornsea Three array area through the Hornsea Three project, is an important part of delivering GB offshore wind generation at the capacities anticipated to be required to meet the UK's Net-Zero commitments.

5.8 The system adequacy of offshore wind

160.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 installed capacity, can be calculated. Figure 5.3 shows this metric for GB offshore wind generation through 2018 and 2019, expressed at a monthly level.

161.Stable capacity utilisation (here called Generation Dependability) is important, because it relates to the reliability, and therefore ability to depend on, forward forecasts of generation outturn. At the macro level, greater reliability of generation outturn allows for a more efficient and targeted asset development program to be rolled out; and lower requirement for (fossil-fuelled) backup plant (the 'troughs' in Figure 5.3 are less pronounced), without creating excess generation.

162.Figure 5.3 shows that each wind farm stands on its own as a generator of low-carbon electricity, and that, when deployed as part of a portfolio of offshore wind farms, Generation Dependability is naturally improved (i.e. the blue dashed line does not go as high, nor as low, as the individual grey lines). An Imperial College expert analytical team agree in their economic analysis of whole

[20] The Crown Estate is the landowner of virtually the entire seabed out to the 12 nm territorial limit, and has rights under the Energy Act 2004 to issue licences for offshore wind development beyond the territorial waters limit and within the UK Renewable Energy Zone (An area of the sea, beyond the United Kingdom's territorial sea, which may be exploited for energy production)

system costs of renewables, showing that integration costs of RES fall on an absolute basis, as capacity increases from 10 GW up to 50 GW [55].

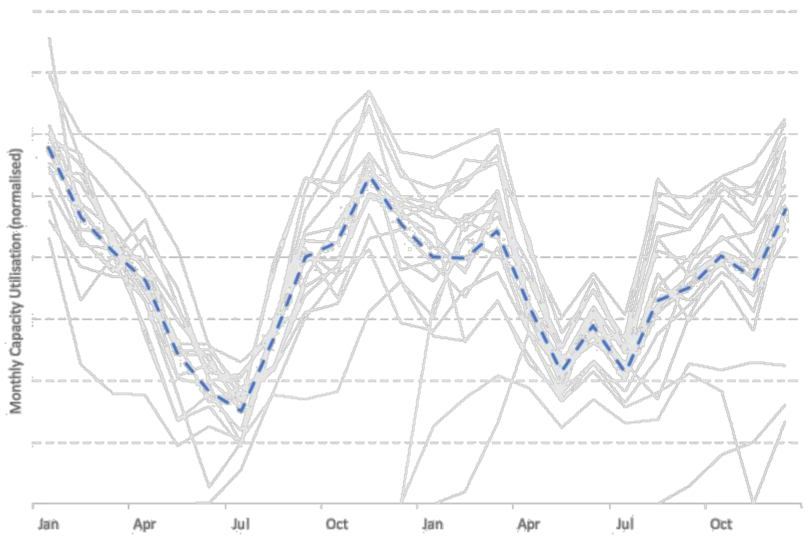

Figure 5.3: Generation dependability for GB's offshore wind portfolio [NSR Analysis]. The grey lines show the traces for individual wind farms, and the dashed blue line shows a normalised average (calculated over commissioned assets only).

163. 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 economic inefficiency (the 'peaks' in Figure 5.3 are also less pronounced), and integration measures are expected to be developed to make use of any over-generation which occurs. Figure 5.3 shows the seasonality of wind load over GB's waters: low in the summer months but higher in the Autumn through Spring. A growing portfolio of solar generation could in theory therefore work with the GB offshore wind portfolio to deliver a combined portfolio of low-carbon generation with a generation dependability which is improved over that of the separate technologies, even before the development and operation of any bespoke integration technologies. This is shown in Figure 5.4.

164. System adequacy is primarily managed through the GB Capacity Market. In return for capacity payments, eligible assets agree to generate at or over a minimum commitment (their 'de-rated capacity') whenever National Grid (subject to a prescribed process) determine additional generation output is required in GB in order to 'keep the lights on.'

165. BEIS have this year included wind technology within the GB capacity market [47]. While this market is not open to assets which hold CfD contracts (e.g. Offshore wind), its inclusion underlines the contribution wind makes 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' [48, p114]. It should be noted that wind power also already participates in capacity mechanisms in other highly volatile electricity markets (e.g. Ireland, and parts of the US).

166. Therefore, it can be concluded that although individual wind farms are variable generators, the generation dependability of the technology class is more stable. There are a number of integration

measures available today to help balance electricity generation from variable generators onto the grid to meet demand, and to ensure that the best use is made of low-carbon electricity when it is being generated in over-supply. These measures include increasing the capacity of offshore wind generation; developing other assets with complementary seasonal generation profiles; and managing shorter-term intermittency through storage or other measures. Offshore wind is an important low-carbon asset class which is needed to contribute to a required level of generation adequacy and generation dependability within the GB energy system.

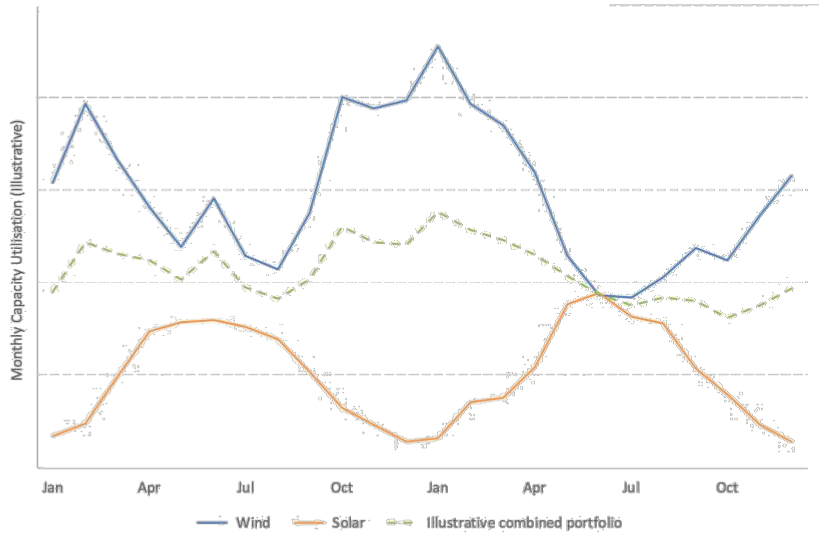

Figure 5.4: Illustrative Generation Dependability for a combined portfolio of solar and wind in GB [NSR Analysis].

5.9 Hornsea Three would make a significant contribution to the adequacy and dependability of the GB electricity system

167. Innovation in generation must not be allowed to challenge security of supply, but a lack of innovation in generation must not be allowed to risk achieving decarbonisation targets. Moreover, whilst the promise of a single saviour technology is exciting, few market commentators or participants have faith in the ability of a single new technology to bridge the energy gap. Many commentators are active supporters of harvesting the UK's rich wind resources.

168. The UK has substantial renewable energy resources, including 40% of Europe's wind resource [1, Para 3.4.3]. This resource must be harnessed to decarbonise our economy. Moreover, in Section §5.6 it was demonstrated that without offshore wind, UK would not meet its decarbonisation targets. Section §5.8.3 showed an analysis of the generation dependability of offshore wind as a technology class, and Section §5.5 described the measures offshore wind assets must deliver to support system operability due to their connection to the GB electricity transmission system.

169. Connection to the transmission system is of significant importance, enabling an unencumbered and efficient transfer of bulk power across the country, in order to provide electricity to wherever and whenever it is needed.

170. Global expertise in the operation of electricity systems with high proportions of RES is growing. Technologies which help the integration of renewable assets to the grid are being developed and

are already in operation in the UK. 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.

171. 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.

172. Hornsea Three, if approved, would contribute to an adequate and dependable GB generation mix, through enabling the generation of more low-carbon power from indigenous and renewable resources. Therefore, the approval, construction and operation of Hornsea Three will make a significant contribution to the UK's energy security and decarbonisation needs.

Chapter 6 Offshore wind is economically efficient in GB

173.The third pillar of GB's energy strategy is economic efficiency.

> *Most renewable energy resources can only be developed where the resource exists and where economically feasible.* [2, Para 2.5.36]
>
> *The UK has 40% of Europe's wind resource.* [1, Para 3.4.3]

174.This section discusses broad principles of economic efficiency, by explaining how the GB electricity market operates and demonstrating how competitive CfD wind assets are because of recent gains in experience, technology and scale.

6.1 An introduction to pricing electricity in the GB power market

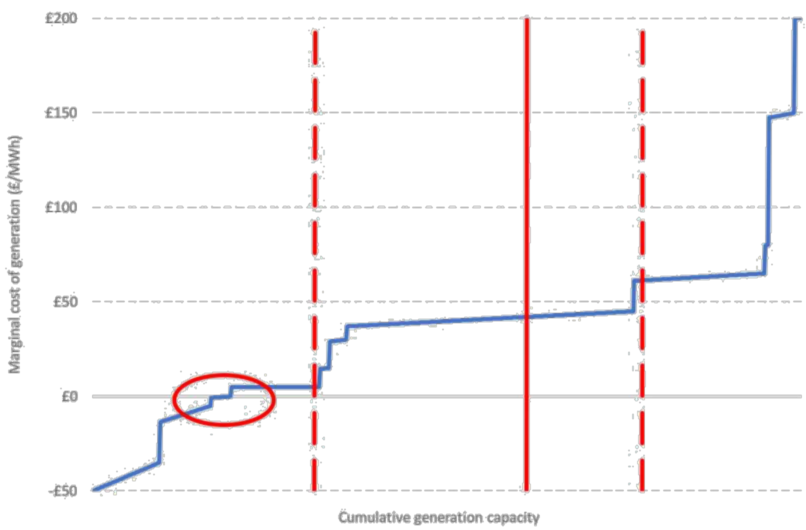

Figure 6.1: Representative marginal cost stack for a future GB electricity system

175.In the liberalised GB energy 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[21]. Each day is broken down into 48 half-hour periods ('Settlement Periods') and power is traded over these periods, or multiples thereof (up to months or seasons ahead). Typically, wind farms have 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 their variable nature, 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 (related to the cost of the fuel they are converting into that additional MWh), therefore require higher market price signals in order to generate. They may also trade power further ahead in order to hedge their income. All generators produce active power (MWs), and to balance the electricity

[21] The cost of generating an additional MWh, usually including variable fuel and transmission costs

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.

176.This market mechanism is illustrated in Figure 6.1. The blue line, increasing from left to right along the x-axis, represents the marginal cost of generation in GB at each level of 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 (here, to about £65/MWh).

177.Critically, the blue line in Figure 6.1 also varies for each half hour settlement period, as generating assets become available or unavailable due to outages, breakdowns or, critically, more or less wind or sunshine is expected or experienced. 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 lowers 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 view of the price of power for the next week, month, quarter or season. The conclusions are the same though: increasing the capacity of renewable assets in GB reduces the traded price of power. This fact has been empirically corroborated by Energy Institute of Haas in their 2018 paper, 'Setting with the sun' – a quantitative analysis of the impact of deep solar penetration in California, an historically conventional generation market. They conclude 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 [50, p26]. This demonstrates that offshore wind power reduces the market price of electricity in GB.

6.2 Levelised cost of offshore wind generation

> *Technological advances in 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 the logistics and maintenance, especially offshore, and new designs of floating platforms add a further opportunity. [48, p67]*

178.The market mechanisms described in Section §6.1 only work if wind projects come to market. This only happens if developers believe they are able to make reasonable returns for their investors. The scale of offshore wind turbines and farms has increased (see Figure 6.2), and as a consequence is now a leading low-cost generation technology (see Figure 6.3).

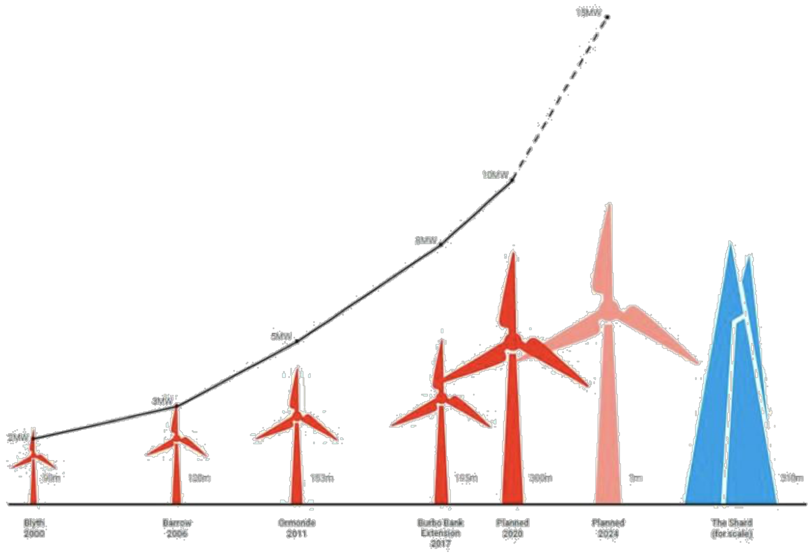

Figure 6.2: The scale of offshore wind turbines as increased significantly since 2000 [8]

179.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. Lazard [9], albeit focussed mainly on the US market, is a globally recognised source of such comparative analysis. The most recent revision of their analysis, published in November 2019, illustrates that wind power is already globally competitive against all other existing forms of generation.

180.This comparison is presented in Figure 6.3, with the range representative of different complexities of technical solution.

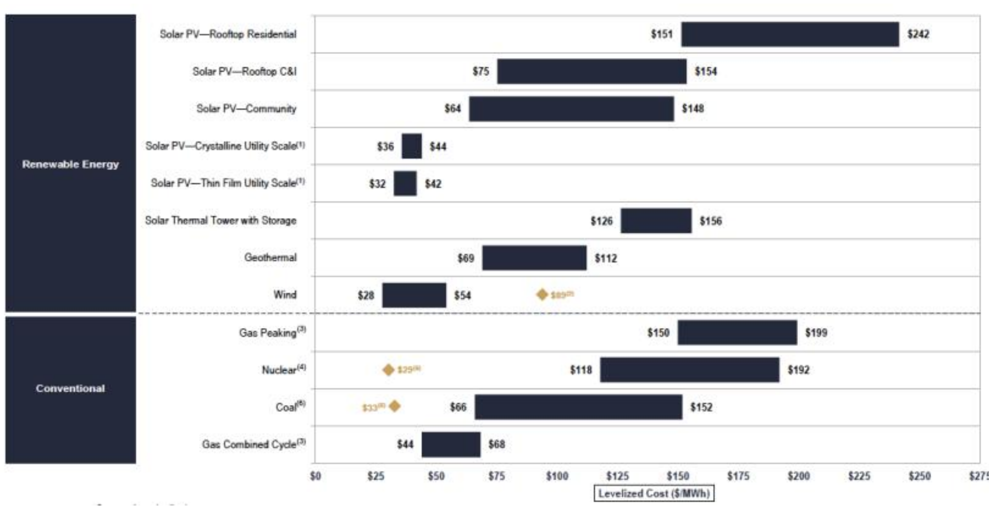

Figure 6.3: Unsubsidised levelised cost of energy comparison [9, p2]

181.The NIC's current view is that RES represents a most likely low-cost solution for GB electricity generation, over large-scale conventional investments:

> *More renewables do lead to more money being spent to match supply and demand: a system with 90 per cent renewables is estimated to cost up to £4.5 billion more per year to balance. But cheaper capital costs are estimated to offset this within the costs for the overall system.* [23, p39]

182.The cost of offshore wind is largely 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. Development costs have also reduced as efficiencies in the build process have been captured through prior experience. This fact is also demonstrated by Lazard in Figure 6.4.

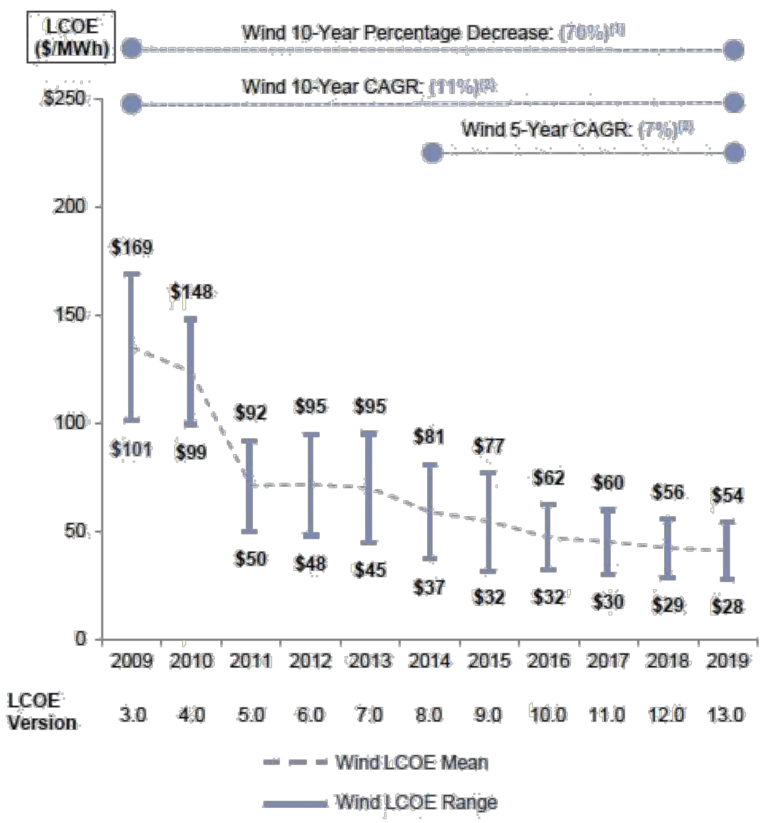

Figure 6.4: Historical reductions in the LCOE of wind generation [9, p8]

183.Industry-sourced data will also confirm Lazard's findings. The factors which have already pushed global prices down — such as technological design, risk mitigation, cheap land, efficient financing, shorter development timelines and a general commitment to tenders from national governments — will continue to shape prices in emerging markets. Wind costs, and offshore wind costs, are falling such that the technology is now economically viable in a large number of markets.

184. As a consequence, the global offshore wind market is growing, and utility-scale project costs (as evidenced by an analysis of the results of the first three rounds of CfD allocation in GB, shown in Figure 6.5) are falling in line with expectations.

6.3 The CfD as an indicator of GB offshore wind cost improvements

185. CfDs were first awarded to offshore wind projects in 2014 in the first Investment Contract round. Government has subsequently run three competitive rounds, Round 1, Round 2 and Round 3, awarded in 2015, 2017 and 2019 respectively.

186. Figure 6.5 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 striking, as is the associated increase in awarded capacity. This figure demonstrates that reductions in the cost of offshore wind as described in Section §6.2, are also being realised in GB.

187. The results of CfD Round 3 (issued September 2019) 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 latest round, with 5.5 GW awarded to the technology, of a total 5.8 GW awarded. The strike price for the allocation round was £39.65/MWh for 2023/24 delivery and £41.61/MWh for 2024/25 delivery, representing a significant reduction from the strike prices awarded through the CfD Round 2 in 2017[22]. This Government backed subsidy scheme has contracted projects which, when delivered, will reduce wholesale electricity prices.

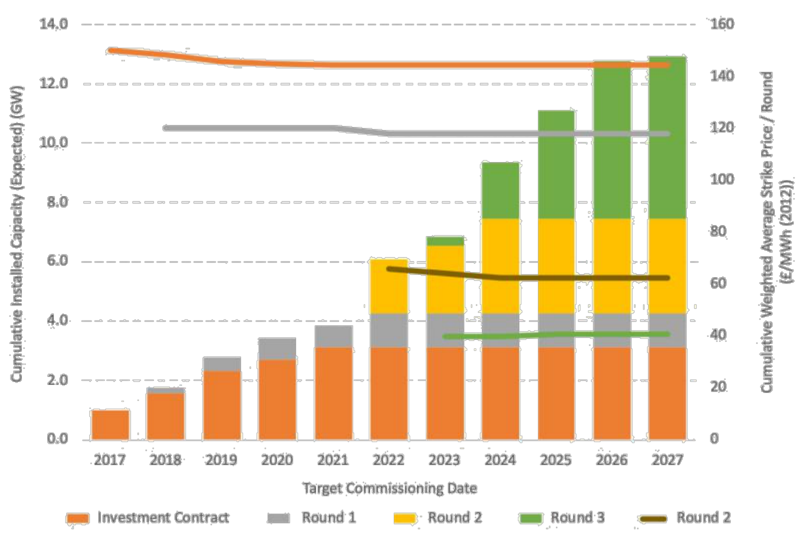

Figure 6.5: Capacities of offshore wind generation awarded CfDs, and weighted average Strike Price, by allocation round and Target Commissioning Date, NSR Analysis from [10]

[22] 2023/24 versus 2021/22 delivery: 47% reduction. 2024/25 versus 2022/23 delivery: 28% reduction.

188. Factors which contributed to the low-price outturn for offshore wind in the latest allocation round include:

- Construction risk management of this technology is well advanced in the UK due to significant experience in North Sea installations, so developer bids included less allocation to construction risk;
- The technology has evolved over the last 5 + years, making both increased MW capacity and MWh output expectations per unit of infrastructure spend; and
- The locations of the wind generators in the Offshore classification are planned to be built, predominantly in shallow waters of Dogger Bank and other accessible areas.

189. Many of the cost savings which have driven CfD prices lower over the last 6 years are expected to transfer through to subsequent developments, however future developments will incur their own localisation of construction costs. 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 on to consumers through the CfD. Offshore wind in GB is currently, and is predicted to remain, super-competitive on a per MWh generated basis versus other low-carbon renewable technologies.

6.4 A conclusion on economic efficiency

190. The main points in summary of this section of the report 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 have dropped in GB, and these assets are now competitive at the current energy market price level;
- Offshore wind power is economically attractive in GB against many other forms of conventional and renewable generation;
- Size remains important, and maximising the generating capacity of projects improves their economic efficiency, so bringing power to market at the lowest cost possible.

Chapter 7 In summary and in support of the case for offshore wind generation assets at Hornsea Three

191. This report has shown that wind generation is economically and technically viable, and that it is economically and technically preferential, to the GB electricity consumer. The summary points are as follows:

1. Decarbonisation is a UK legal requirement and is of global significance. It cannot be allowed to fail, and urgent actions are required in the UK and abroad, to keep decarbonisation on track to limit global warming;
2. Wind generation is an essential element of the delivery plan for the urgent decarbonisation of the GB electricity sector. 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 decarbonisation of transport and heat sectors, through electrification;
3. 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;
4. Internationally, and importantly GB is leading in this regard, offshore wind generation assets are getting bigger and cheaper, providing a real-life demonstration that size and scale works for new offshore wind, and providing benefits to consumers in the process. 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 in the important 2020s is likely to be low; and
5. Offshore wind is already super-competitive against other forms of conventional and low-carbon generation, both in GB and more widely.

192. These general benefits of offshore wind generation in GB also apply specifically to the Hornsea Three project:

1. The Hornsea Three development proposes a substantial infrastructure asset, capable of delivering large amounts of low-carbon electricity – enough to power in excess of 2 million homes each year, 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 (and the Government ambition to deliver 40 GW to offshore wind by 2030);
2. Hornsea Three's connection to the NETS means that it will be required to play its part in helping National Grid manage the electricity system. This includes participating in mandatory balancing markets (to help balance supply and demand on a minute-by-minute basis and provide essential ancillary services) as well as providing visibility to the GB power market of its expected generation. This means that the low marginal cost wind power it will produce, can be forecasted 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;
3. Maximising the capacity of generation in the resource-rich, accessible and technically deliverable former Hornsea Zone, is to the benefit of all GB consumers, and the wind industry generally. The project is technically and economically feasible.

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

Chapter 8 New Stream Renewables

194. New Stream Renewables (‘NSR’), established in 2008, are a specialist consulting and support services group operating in both renewable and traditional energy markets. NSR deliver in-depth market knowledge, to high quality and in response to client needs. NSR have built a unique track record of consistent performance across a wide range of renewable and traditional energy mandates. NSR offers a wide range of pre-commissioning and operational services, including:

- Feasibility studies for prospective assets
- Due diligence reporting for project investors
- Market analyses, insight and commentary
- Active asset management (trading, PPAs and related contracts, including low-carbon benefits schemes and non-energy costs / benefits)
- Power and ancillary services contracting (including Capacity Market, FFR and National Grid bilateral contracts)

195. A selection of relevant projects which highlight our experience and competence in this area include

- 2016, a study into the potential future implications of renewable generation growth within GB on secure baseload power operation, for a large GB baseload power generator. Technical and operational risk mitigations were identified, and plans established to inculcate resilience into future operating plans and procedures for these strategically significant assets.
- 2017, a commercial feasibility study for a potential pumped storage (hydro) facility in Scotland on behalf of a large infrastructure fund. Project specific characteristics and constraints, relevant electricity and related markets and grid connection aspects were reviewed. An evaluation tool was developed, and credible commercial scenarios (i.e. flexing costs, capabilities and revenues) investigated to provide a rounded view of project suitability.
- 2018, a due diligence report for a potential multi-million-pound electricity storage investment. A thorough review of the project economics, locational and grid connection aspects was carried out, and constructive challenge provided on levels of revenue capture and cost across many different aspects of potential operation.

196. This Statement has been authored by Si Gillett of NSR. Simon has European energy sector experience, spanning 20 years of commercial, analytical and consulting roles within Utilities and the Oil & Gas sector. In previous roles, Simon has held responsibility for the commercial operation of electricity generation assets in GB, EU wholesale energy market trading and GB Balancing Mechanism participation. Si specialises in market change readiness and the implementation and performance of energy market regulations. His current focus is forecasting and optimising asset commercial value across many ‘stacked’ revenue streams, within the GB’s rapidly transforming electricity system. He holds a master's degree in Mathematics, from Oxford University, and in Nuclear Safety, Security and Safeguards, from the University of Central Lancashire.

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