# Appendix: Climate Change

## Annex 1: Climate Change Technical Note
## Annex 2: Policy and Guidance Background
## Annex 3: Greenhouse Gas Calculations

# ANNEX 3 – GREENHOUSE GAS CALCULATIONS

1.1 This appendix includes further technical detail regarding the methodology and calculations outlined within **ES Volume 1, Chapter 5: Climate Change**. This assessment follows the same approach and methodology as previously undertaken operational GHG assessments for BESS schemes for the Applicant by RPS, such as the Grendon Lakes BESS GHG assessment[1].

## Baseline Environment

### Future Baseline Conditions

1.2 It is anticipated that in the absence of the Proposed Development, periods of low renewable energy supply and high demand will be met via gas-fired peaking plants. In order to provide a conservative assessment, and not overstate the potential benefits of the Proposed Development, potential trends in decarbonisation of the peaking power supply in the future baseline scenario have been considered.

1.3 The Climate Change Committee's (CCC) (2020) Sixth Carbon Budget states that unabated gas generation (including peaking plants) should be phased out by 2035. The CCC recommends the implementation of policy to ensure that the carbon intensity of electricity generation tends to zero by 2035. Furthermore, the Environment Agency's (2021) latest advice regarding post-combustion carbon capture mandates at least a 95% capture rate.

1.4 As such, it will be necessary for peaking plants to decarbonise (if not displaced by alternatives such as battery storage). Projections specific to the carbon intensity of peaking power generation (rather than grid average) are not available. As such, in order to determine the future baseline conditions, and subsequently the emissions that will be offset through the Proposed Development, a simple linear reduction in the carbon intensity of peaking plants from present-day values to converge with the BEIS projected factors[2] by 2035 has been calculated.

1.5 Table 1.1 displays the baseline carbon intensity of peaking plants throughout the duration of the Proposed Development's operational phase up until the end of the Sixth Carbon Budget (2037).

**Table 1.1: Future Carbon Intensities of Peaking Plants**

| Year | Peaking Plant Carbon Intensity ($tCO_2e/MWh$) |
|---|---|
| 2027 | 0.274 |
| 2028 | 0.244 |
| 2029 | 0.215 |
| 2030 | 0.185 |
| 2031 | 0.155 |
| 2032 | 0.126 |
| 2033 | 0.096 |
| 2034 | 0.067 |
| 2035 | 0.037 |
| 2036 | 0.030 |
| 2037 | 0.025 |

[1] RPS (2022) Grendon Lakes Battery Storage Facility. Environmental Statement Chapter 8: Climate Change. Prepared for Statera Energy Limited

[2] BEIS (2021) Valuation of Energy Use and Greenhouse Gas: Supplementary guidance to the HM Treasury Green Book



## Assessment of Operational Effects

### Assessment of Effects on Climate Change

### Magnitude of Impact

1.6 The magnitude of impact of the Proposed Development is determined by the electricity source from which the BESS are charged, the quantity of peaking plant generation it displaces, and the associated GHG impacts of both.

1.7 It is expected that over the Proposed Development's lifetime, the BESS will be charged both from a) renewable energy to avoid curtailment, and b) grid electricity during periods of low renewable energy supply (assuming the average generation mix at the time of import). Both scenarios have been assessed below. Given it is not known to what extent each scenario will apply over the lifetime of the Proposed Development, it is assumed that operational will lie between those calculated for each scenario.

1.8 The quantity of renewable energy enabled and peaking plant energy displaced is determined by the total annual energy input and output values for the Proposed Development (see Table 1.2). The associated GHG emissions are determined by the GHG intensity of the enabled and displaced sources of generation.

1.9 Table 1.2 displays the annual energy input and output values for the battery and the parameters by which they are determined by.

**Table 1.2: Proposed Development Energy Flows**

| Parameter | Value | Unit |
|---|---|---|
| Rated power | 500 | MW |
| Discharge time | 7 | hrs |
| Storage capacity | 3,500 | MWh |
| Round trip efficiency (RTE)[3] [4] | 0.85 | |
| Depth of discharge[5] [6] | 0.80 | |
| Annual cycles | 365 | |
| **Annual energy input** | 1,022,000 | MWh |
| **Annual energy output** | 868,700 | MWh |

*Scenario A: BESS charged from renewable energy sources*

1.10 In 2023, wind power generated the largest share of British electricity for the first time in history, overtaking gas as the largest source of power[7]. Wind energy generation accounted for 32.4% of UK total electricity generation (including both renewables and non-renewables) in the first quarter of 2023; with onshore and offshore windfarms generating 9.6 TWh and 14.4 TWh respectively. Its dominance within the non-dispatchable renewable energy sector is likely to continue, with an additional 40 GW of offshore wind planned to be constructed by 2030[8], and 140 GW offshore wind recommended to be deployed by 2050[9]. As such, it is expected that this is the source of renewable energy that is most likely to be curtailed during periods of surplus demand. Therefore, for the purposes of this assessment the indirect GHG emissions associated with charging the battery are assumed to be equal to those associated with the operation and

*[3] The RTE of a battery refers to the ratio of energy required to charge a battery compared to the available energy during discharge. The source used in this assessment for determining RTE has considered a range of recent and relevant published RTE values and selected a mid-point value. The RTE includes losses associated with cooling systems and battery control equipment; as such, this assessment takes into account the implications of the operational energy use of onsite electrical equipment.*

*[4] Cole, Wesley, and A. Will Frazier (2019) Cost Projections for Utility-Scale Battery Storage. Golden, CO: National Renewable Energy Laboratory. NREL/TP-6A20-73222. https://www.nrel.gov/docs/fy19osti/73222.pdf.*

*[5] Depth of discharge (DoD) refers to the ratio of the battery capacity that is utilised to the actual nameplate capacity.*

*[6] IEA (2020) Environmental LCA of Residential PV and Battery Storage Systems. [Online] available at: https://iea-pvps.org/key-topics/environmental-life-cycle-assessment-of-residential-pv- and-battery-storage-systems/*

*7 Staffell, I., Green, R., Green, T., Johnson, N., Jansen, M. and Gross, R. (2023). Electric Insights Quarterly. [Online] 230523_Drax_23Q1_00481.pdf (electricinsights.co.uk)*

*8 HM Government (2021) Net Zero Strategy: Build Back Greener. [Online] https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/1033990/net-zero-strategy-beis.pdf*

*9 Committee on Climate Change (2020) The Sixth Carbon Budget: The UK's path to Net Zero. [Online] https://www.theccc.org.uk/wp-content/uploads/2020/12/The-Sixth-Carbon-Budget-The-UKs-path-to-Net-Zero.pdf.*

maintenance of offshore wind.

1.11 The current literature surrounding Life Cycle Analysis (LCA) for wind turbines is characterised by a high degree of variability in the published GHG figures and, therefore, a high degree of uncertainty occurs in selecting any one of these figures as a means of analysing the operational emissions resultant from wind generation. As a means of dealing with this uncertainty, the primary source of emissions factors was a study by the National Renewable Energy Laboratory (NREL, 2013) Life Cycle Assessment Harmonization Project[10], and Dolan and Heath (2012)[11].

1.12 The NREL (2013) study was based on the output of the Dolan and Heath (2012) paper, and as such the Dolan and Heath paper has been referenced hereafter. This study (Dolan and Heath, 2012) conducted an exhaustive literature search, extracting normalized life cycle GHG emission estimates from published LCA literature. Data was screened to select only those references that met stringent quality and relevant criteria.

1.13 The median estimates of GHG emissions intensity figures were identified for both onshore and offshore wind across the whole life-cycle (Dolan and Heath, 2012). The NREL (2013) study further broke down and detailed the separation of intensity across each life cycle stage, attributing 9% of life-cycle emissions to operation and maintenance activities. This estimated percentage has been applied to the Dolan and Heath intensity (11 $gCO_{2e}$/kWh), to give an operational emissions intensity of 0.99 $gCO_{2e}$/kWh, which is then applied to the estimated energy input required to charge the BESS over its lifetime.

*Scenario B: BESS charged directly from grid electricity*

1.14 As the penetration of non-dispatchable renewable energy resources in the UK grid increases, energy market price mechanisms will be in place to ensure that, insofar as is possible, stationary grid-scale batteries will charge using surplus renewable energy.

1.15 However, it is not certain that this would be the case in all market conditions. During periods of low renewable energy supply, the BESS are likely to be charged directly from grid electricity, assuming the average generation mix at the time of import (i.e. including generation sources such as coal, gas and nuclear), releasing such energy during times of peak demand.

1.16 As such, under this scenario and for the purposes of this assessment the indirect GHG emissions associated with charging the BESS are assumed to be equal to those associated with grid electricity, which accounts for the emissions intensity of its constituent generation sources. Such emissions have been sourced from BEIS long run marginal grid intensity figures[12], which account for year-on-year decarbonisation of grid electricity towards the UK's committed net zero 2050 pledge.

*Results*

1.17 Table 1.3 displays the varying magnitudes of GHG impacts when the energy source for battery charging is varied between the carbon intensity of offshore wind and the BEIS long run marginal projections.

1.18 The magnitude of impact for the first 11 years of the operational Proposed Development's lifetime (reaching the end of the Sixth Carbon Budget) has been calculated to be between 431,003 $tCO_2e$ and 1,251,986 $tCO_2e$ of avoided emissions. This timeframe has been adopted as the significance of the Proposed Development has been assessed in the context of the UK national carbon budgets and the Oxford budget.

**Table 1.3: Annual Operational GHG Impacts**

| Year of Operation | Year | Output (MWh) | Peaking Plant carbon intensity ($tCO_{2e}$/MWh) | Cumulative avoided GHG impacts - offshore wind ($tCO_{2e}$) | Cumulative avoided GHG impacts - grid electricity ($tCO_{2e}$) |
|---|---|---|---|---|---|
| 1 | 2027 | 868,700 | 0.274 | 236,921 | 77,479 |
| 2 | 2028 | 868,700 | 0.244 | 448,119 | 149,674 |
| 3 | 2029 | 868,700 | 0.215 | 633,592 | 218,629 |
| 4 | 2030 | 868,700 | 0.185 | 793,342 | 286,389 |
| 5 | 2031 | 868,700 | 0.155 | 927,367 | 343,754 |
| 6 | 2032 | 868,700 | 0.126 | 1,035,669 | 388,682 |
| 7 | 2033 | 868,700 | 0.096 | 1,118,247 | 418,105 |
| 8 | 2034 | 868,700 | 0.067 | 1,175,101 | 431,003 |
| 9 | 2035 | 868,700 | 0.037 | 1,206,231 | 431,003 |
| 10 | 2036 | 868,700 | 0.03 | 1,231,280 | 431,003 |
| 11 | 2037 | 868,700 | 0.025 | 1,251,986 | 431,003 |

1.19 From year 8 the avoided GHG impacts of the Proposed Development are considered, conservatively, to have become negligible. This is the point at which, under the simple linear reduction trend for peaking plant carbon intensity assumed, and the BEIS projection of grid average and marginal generation plant carbon intensity, there is anticipated to be little remaining difference between the carbon intensity of different generation sources.

1.20 The Proposed Development's supply and demand balancing function would still be crucial, but under these assumptions, significant ongoing carbon savings due to the balancing function after this time are less likely.

1.21 In effect, given the expected decarbonisation of grid electricity generation to meet national net zero targets, it is anticipated that energy storage facilities will become part of 'business as usual' in order to enable the growth in renewable energy sources and maximise the amount of their energy available to the grid during times of peak demand.

10 NREL (2013) Wind LCA Harmonization.[Online] https://www.nrel.gov/docs/fy13osti/57131.pdf
11 Dolan, S.L & Heath, G.A (2012) Life Cycle Greenhouse Gas Emissions of Utility-Scale Wind Power. Journal of Industrial Ecology. Volume 16 Number S1
12 BEIS (2022) Valuation of Energy Use and Greenhouse Gas: Supplementary guidance to the HM Treasury Green Book.