EAST CLAYDON BATTERY ENERGY STORAGE SYSTEM (BESS)

Environmental Statement: Appendix 9.1.3 - GHG Calculations

NP13033
V2
October 2023

Document status

Version	Purpose of document	Authored by	Reviewed by	Approved by	Review date
1	Draft	SR	AP		-
2	Final Issue	SR	AP	AT	26/10/2023

Approval for issue

Andrew Tasker	[redacted]	26 October 2023

Prepared by:

RPS

Alice Paynter
Senior Consultant – EIA and Sustainability
RPS Consulting UK & Ireland

Prepared for:

Statera Energy Limited

Chris Palmer

1st Floor, 145 Kensington Church Street
London, W8 7LP

Contents

Tables

Graphs

1 GHG CALCULATIONS

1.1.1 This Appendix includes further technical detail regarding the methodology and calculations outlined within Volume 9, Chapter 1: Climate Change. For ease of understanding, the headings used within this Appendix follow those used within the main EIA chapter.

1.2 Baseline Environment

Future Baseline Conditions

1.2.1 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.

1.2.2 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.

1.2.3 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 (BEIS, 2022) by 2035 has been calculated.

1.2.4 **Table 1.1** displays the estimated baseline carbon intensity of peaking plants for the duration of the Proposed Development's indicative operational phase.

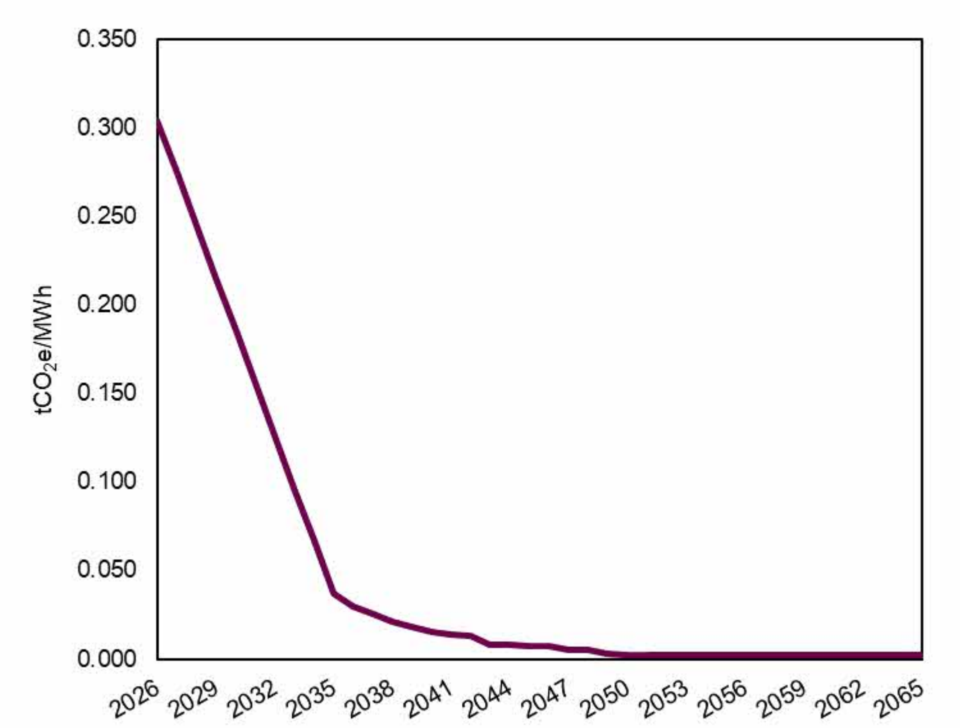
Table 1.1: Future Carbon Intensities of Peaking Plants

Year	Peaking Plant Carbon Intensity (tCO_2e/MWh)
2026	0.304
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
2038	0.021
2039	0.018
2040	0.015
2041	0.014

Year	Peaking Plant Carbon Intensity (tCO_2e/MWh)
2042	0.013
2043	0.008
2044	0.008
2045	0.007
2046	0.007
2047	0.005
2048	0.005
2049	0.003
2050	0.002
2051	0.002
2052	0.002
2053	0.002
2054	0.002
2055	0.002
2056	0.002
2057	0.002
2058	0.002
2059	0.002
2060	0.002
2061	0.002
2062	0.002
2063	0.002
2064	0.002
2065	0.002

1.2.5 **Graph 1.1** displays the estimated baseline carbon intensity of peaking plants for the duration of the Proposed Development's indicative operational phase.

Graph 1.1: Linear Projected Future Carbon Intensities of Peaking Plants



1.3 Assessment of Construction Effects

Assessment of Effects on Climate Change

1.3.1 The following sections detail the methodology used to calculate the construction stage emissions associated with the Proposed Development. The development has been broken down into discrete categories, identified within the sections below, in order to distinguish between the methodologies used.

1.3.2 The construction stage emissions cover carbon LCA stages A1-A3, i.e., the emissions associated with the extraction, processing and manufacturing of materials. In addition, emissions associated with the transport of materials and technology to site (within the UK) has been investigated.

Battery Packs

1.3.3 Owing to its charge capability, energy density, round-trip efficiency and falling costs, lithium-ion batteries (LIB) are the most commonly employed battery technology for stationary applications. At this stage, this is the technology type being considered in this assessment.

1.3.4 More specifically, as circa 60% of grid-scale batteries are currently nickel-manganese-cobalt (NMC) cathode material blends (IEA, 2020a), it is the carbon intensity of these materials – and the carbon intensity of the associated manufacturing processes – that have been considered in this assessment.

1.3.5 There are several carbon-intensive processes that take place in the manufacturing of a NMC LIB, that make up the majority of their associated embodied carbon emissions. These processes are as follows.

The mining and refining of raw materials: the energy intensity varies greatly depending on the type of mine and type of ore being mined.

Cathode production: cathodes are made via the production of NMC powder, an energy-intensive two-stage process involving co-precipitation and calcination. The co-precipitation step consumes 42.6 MJ of heat to produce 1 kg of NMC precursor, and the calcination step consumes 25.2 MJ of electricity to produce 1 kg of NMC powder (Dai et al, 2019).

Anode production: anodes are composed of graphite and a polyvinylidene difluoride binder; to ensure the absence of any oxygen impurity in the graphite, it is baked at 1100 °C in an inert or reducing atmosphere (Accardo et. al., 2021).

Dry room: because moisture is detrimental to the electrochemical performance of LIBs, the cell assembly process needs to occur in a dry room with strictly controlled humidity levels. Dry room operation has been identified as a predominant driver of energy use for cell production (Dai et al, 2019).

Production of non-cell materials: this involves the production of cell containers, separator, battery management system (BMS), cooling system, and final packaging.

1.3.6 The carbon intensity of the production of NMC LIBs used for the purposes of this assessment has been informed by Lithium-Ion Vehicle Battery Production: Status 2019 on Energy Use, CO_2 Emissions, Use of Metals, Products Environmental Footprint, and Recycling (Emilsson and Dahllöf, 2019), an IVL Swedish Environmental Research Institute study carried out in cooperation with the Swedish Energy Agency.

1.3.7 The study analysed the most up-to-date published data regarding the energy use associated with the production of LIBs. The study uses published heat and electricity consumption data for the various processes involved in LIB manufacturing to calculate the GHG intensity values which have been used in this assessment.

1.3.8 The study notes the potential uncertainty in estimating LIB production GHG emissions due to the variability of the penetration of renewables in the energy supply mix (both electricity and heat) at different geographical locations.

1.3.9 As such, a range of GHG intensities was stated; assuming a 100 % electricity powered cell manufacturing and battery pack assembly process (i.e. using electricity for heat and power), the electricity emissions factor ranged from a 100% renewables mix (0 kgCO_2e/kWh) to a fossil fuel-rich mix (1 kgCO_2e/kWh). Under this range of carbon intensities of battery pack production, the GWP of the manufacturing battery cells and packs is in the range of 2 – 47 kgCO_2e/kWh battery capacity.

1.3.10 When accounting for further emissions of 59 kgCO_2e/kWh battery capacity owing the sourcing of upstream materials (taken from Dai et al, 2019), a range of 61 – 106 kgCO_2e/kWh battery capacity can be stated (with a mid-point of 83.5 kgCO_2e/kWh).

1.3.11 If the heat demand was to be supplied by an 80% efficient natural gas boiler, a narrower range of 70 – 77 kgCO_2e/kWh could be stated.

1.3.12 This range of GHG values accounts for the emissions associated with the upstream supply of raw materials, battery cell production and battery pack assembly.

1.3.13 **Table 1.2** displays the benchmark carbon intensities that have been used in assessing the magnitude of impact of the GHG emissions from the production of the battery packs being used in the Proposed Development.

1.3.14 The lifetime of the battery packs is dependent on the average depth of discharge (DoD)[1]; while in reality this may vary depending on the state of the electricity market at any given moment, the current assumed average DoD for the Proposed Development is 80%. Based on published literature values, a DoD of 80% would result in an expected lifetime of 5,000 cycles (IEA, 2020b). Therefore, over the forecasted 40 year assessment period and assuming one full cycle per day (as per the current design strategy), the battery packs would have to be replaced circa three times. This has been accounted for in the embodied carbon values in **Table 1.2**. To be conservative, present-day values are used for the carbon intensity of battery pack production even for future replacements.

Table 1.2: Construction-stage GHG Intensity and Impact of the Battery Pack Element of the Proposed Development

	Lower limit	Mid-point	Upper limit
Output capacity (MW)	500	500	500
Discharge Time (hrs)	7	7	7
Number of battery pack replacements for Proposed Development's assumed lifetime	2.92	2.92	2.92
Carbon intensity of battery pack manufacturing (kgCO_2e/kWh)	61	83.5	106
Battery packs embodied carbon (tCO_2e)	**623,420**	**853,370**	**1,083,320**

Substation (including busbars and BoS components and additional transformers)

1.3.15 There is limited design data and few published LCAs from which to calculate the embodied emissions associated with the substation, busbars and BoS components. Data from an environmental product declaration (EPD) for a 16 kVA – 1000 MVA transformer (ABB, 2003) has therefore been used to provide an approximation of the potential order of magnitude of emissions, as transformers are among the major substation plant components and have a relatively high materials and carbon intensity, including the copper or aluminium winding.

1.3.16 The LCA listed a manufacturing GWP of 2,190.04 kgCO_2e per MW. This was scaled by the Proposed Development's total transformer MVA rating of 600 MVA (4 no. 150 MVA transformers proposed within the substation compound) to give an estimated embodied emission value of 1,314 tCO_2e. This value includes lifecycle stages A1-A3.

1.3.17 In comparison to the emissions associated with the battery packs, this value is negligible, but has high uncertainty and does not account for all substation equipment, or additional transformers not located within the substation compound. To consider whether the full balance of plant in the substation components and additional transformers is likely to make a material contribution to the total construction-stage carbon, a materiality threshold[2] of 5% of the total known construction-stage GHG emissions has been considered[3]. This totals **31,916 tCO_2e**, more than 24 times greater than the estimated embodied carbon for the transformer equipment located within the substation compound.

[1] DoD refers to the ratio of the battery capacity that is utilised to the actual nameplate capacity. Reducing the DoD increases the number of available charge and discharge cycles that can be carried out during the assumed lifetime of the battery before its capacity is unacceptably degraded.

[2] a term often used in greenhouse gas accounting for very minor emission sources, either not appreciably affecting the total or likely to be within its uncertainty range

[3] using the lower estimate for the embodied emissions of the battery packs, to be conservative, and including calculated emissions resultant from the supporting infrastructure

1.3.18 On this basis, it is considered unlikely that the embodied emissions associated with the substation equipment, including additional transformers (not located within the substation compound), busbars and other BoS, will exceed the 5% materiality threshold of the battery packs' embodied carbon. As such this emission source will not materially contribute to the total emissions inventory and has not been assessed in further detail.

Supporting Infrastructure

1.3.19 Other infrastructure for the Proposed Development includes the following:

- switch and control units (7 no., approximately 13m long and 5m wide);
- inverter houses (38 no., approximately 12m long and 9.5m wide);
- battery containers (comprising 888 no. shipping containers, 6.35m long, 2.44m wide and 2.8m high);
- storage containers providing welfare facilities and spare parts storage (4 no., approximately 12m long, 2.44m wide and 2.8m high);
- concrete foundations for both the battery containers and substation compound;
- loose permeable gravel upon which battery storage containers will be installed; and
- 5.5m wide crushed stone access track and several access tracks throughout the site.

1.3.20 The switch and control units and inverters are housed within simple buildings on the site. At this stage of design, material estimates have some uncertainty in terms of their quantities. As such, published benchmarks for the embodied carbon associated with industrial/utilities/specialist uses (RICS, 2012) have been used to estimate possible emissions associated with such structures. The carbon intensity of 545 $kgCO_2e/m^2$ was scaled by the maximum area of proposed buildings (4,787 m^2) to give the embodied carbon value of **2,609 tCO_2e**.

1.3.21 The embodied carbon of each of the remaining elements has been calculated by scaling their estimated weight with an associated embodied carbon factor listed within the Inventory of Carbon and Energy (ICE) (Jones and Hammond, 2019). This is detailed within Table 1.3**.**

1.3.22 The weight of each element (excluding the container crates, for which values could be found for weight per container) was estimated by applying the area covered by each item to an assumed material depth. This was then scaled by a typical weight per m^3.

Table 1.3: Construction stage GHG Intensity and Impact of the Supporting Infrastructure of the Proposed Development

	Weight (kg)	Embodied Carbon Factor ($kgCO_2e$)
Shipping Containers	1,941,960	2.73
Concrete Foundations	7,855,793	0.103
Loose Permeable Gravel	6,278,945	0.00747
Stone Access Tracks	1,892,581	0.00747

1.3.23 Construction-stage emissions associated with the supporting infrastructure totals **8,781 tCO_2e**.

1.3.24 These values include lifecycle stages A1-A3. However, in the case of the container crates this will underestimate construction stage emissions – while the manufacturing emissions associated with the steel used to make the container crates is included, the emissions associated with the manufacture of the crates themselves and potential waste materials is not.

Transportation

1.3.25 As the construction stage carbon values for the above-described technologies include only lifecycle stages A1-A3, emissions associated with their transport to site is not included within these values.

1.3.26 Based on construction traffic estimates outlined within the Construction Traffic Management Plan, prepared in support of the application, and assuming a maximum, construction duration of 18 months, the emissions associated with the delivery of materials to site has been calculated.

1.3.27 An estimated distance of road travel to the site for HGVs (national-scale journeys) and cars/vans (local journeys) (as informed by RICS, 2017 guidance) was assigned to each type of vehicle and scaled by the anticipated number of vehicles and GHG conversion factors (DESNZ and Defra, 2023).

1.3.28 For HGV journeys two conversion factors were used, one for a 100% laden HGV (1.02944 $kgCO_2e/km$) and one for a 0% laden HGV (0.67032 $kgCO_2e/km$). Each trip distance was multiplied by both conversion factors to estimate emissions associated with the fully-laden trip to the site from the materials source, and the empty return trip.

1.3.29 The GHG conversion factor for vans (0.23128 $kgCO_2e/km$) was used to calculate the emissions associated with the movement of cars and vans to and from the site.

1.3.30 **Table 1.4** details the key parameters used.

Table 1.4 : Key parameters for Transport Emissions Calculation

Vehicle	No. of journeys per day	Number of vehicles	Estimated Distance Travelled (one-way) (miles)
HGV	24	11,280	300
Car/Van	56	26,320	50

1.3.31 The total emissions arising from construction traffic was calculated to be **6,116 tCO_2e**.

Carbon Storage and Sequestration

1.3.32 The Proposed Development includes areas of new woodland planting, which will deliver on-site carbon sequestration and storage over the lifetime of the Proposed Development. As trees grow, they absorb (or sequester) CO_2 from the atmosphere through photosynthesis, and store it both in the woody biomass parts of the tree and in the topsoil thereby reducing the concentration of atmospheric CO_2 (Woodland Trust, 2013).

1.3.33 The amount of carbon that can be sequestered by trees is highly dependent on species type, location, soil quality, and management activities. To provide a representative estimate of the carbon sequestered within the proposed woodland planting, Natural England's guidance on carbon storage and sequestration (Natural England, 2021) has been used to inform calculations.

1.3.34 The factor for carbon stored within the soil and vegetation for 30-year mixed broadleaved native woodland (to 15 cm soil depth) (169 t C/ha) was scaled by the total maximum area of new woodland planting (3.47 ha) and then converted to tCO_2 (multiplied by 3.67). This value provides an estimate for the total amount of CO_2 sequestered by the woodland planting over an initial 30-year lifetime, and totals **2,147 tCO_2**.

1.3.35 It is important to note that:

Active management of the woodland, e.g. regular thinning, felling, removal of dead wood etc, will somewhat reduce the maximum carbon sequestration potential depending on the intensity of this management.

To provide long term carbon sequestration and reach the value predicted over 30 years, the newly planted woodland must remain in situ in perpetuity so that this carbon stock is maintained.

1.4 Assessment of Operational Effects

Assessment of Effects on Climate Change

Magnitude of Impact

1.4.1 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.

1.4.2 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.

1.4.3 The quantity of renewable energy enabled/grid electricity stored and peaking plant energy displaced is determined by the total annual energy input and output values for the Proposed Development (see **Table 1.5**Table 1.5). The associated GHG emissions are determined by the GHG intensity of the enabled and displaced sources of generation. Further, the magnitude of the GHG impact of displacing peaking plant generation depends on its carbon intensity. This has been discussed in the future baseline sections (section 1.2).

1.4.4 **Table 1.5** displays the annual energy input and output values for the battery and the parameters by which they are determined by.

Table 1.5: Proposed Development Energy Flows

Parameter	Value	Unit	Source
Input Parameters			
Rated power	500	MW	Proposed Development design parameters
Discharge time	7	Hrs	Proposed Development design parameters
Storage capacity	3500	MWh	Proposed Development design parameters
Round trip efficiency (RTE)[4]	0.85		Cole & Frazier, 2019
Depth of discharge	0.80		IEA, 2020
Annual cycles	365		Proposed Development design parameters
Output Parameters			
Annual energy input	1,022,000	MWh	
Annual energy output	868,700	MWh	

[4] 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.

Scenario A: BESS charged from renewable energy sources

1.4.5 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 (Staffell et al., 2023). 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 (HM Government, 2021), and 140 GW offshore wind recommended to be deployed by 2050 (CCC, 2020). As such, it is expected that this is the source of renewable energy that is most likely to be curtained 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 maintenance of offshore wind.

1.4.6 The current literature surrounding LCAs 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, and Dolan and Heath (2012).

1.4.7 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.

1.4.8 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

1.4.9 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.

1.4.10 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.

1.4.11 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 (BEIS, 2022), which account for year on year decarbonisation of grid electricity towards the UK's committed net zero 2050 pledge.

Results

1.4.12 **Table** 1.6, **Graph 1.3** and display 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 (2022) long run marginal projections. Graph 1.4 displays the difference between the two scenarios.

1.4.13 In summary, the magnitude of impact for the operational phase of the Proposed Development has been calculated to be between 513,766 tCO_2e and 1,621,819 tCO_2e of avoided emissions over its 40-year operational lifetime, dependant on how the batteries are charged. **Table 1.6** displays the cumulative GHG impacts for the Proposed Development's assumed operating lifetime, over the two scenarios.

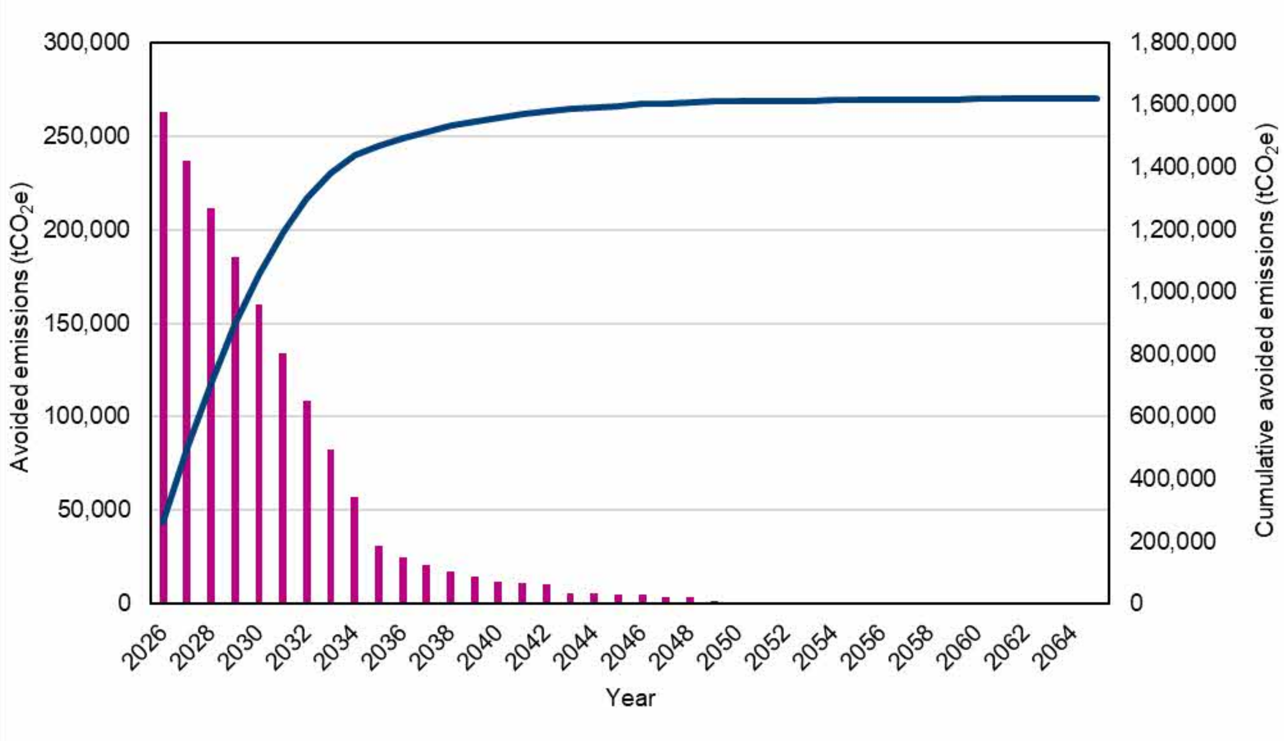
Table 1.6 : Annual Operational GHG Impacts

Year of operation	Year	Output (MWh)	Peaking Plant carbon intensity (tCO_2e/MWh)	Cumulative avoided GHG impacts - offshore wind (tCO2e)	Cumulative avoided GHG impacts – grid electricity (tCO2e)
1	2026	868,700	0.304	262,645	82,763
2	2027	868,700	0.274	499,566	160,242
3	2028	868,700	0.244	710,764	232,437
4	2029	868,700	0.215	896,237	301,392
5	2030	868,700	0.185	1,055,987	369,152
6	2031	868,700	0.155	1,190,012	426,517
7	2032	868,700	0.126	1,298,314	471,445
8	2033	868,700	0.096	1,380,892	500,868
9	2034	868,700	0.067	1,437,746	513,766
10	2035	868,700	0.037	1,468,876	513,766
11	2036	868,700	0.03	1,493,925	513,766
12	2037	868,700	0.025	1,514,631	513,766
13	2038	868,700	0.021	1,531,862	513,766
14	2039	868,700	0.018	1,546,487	513,766
15	2040	868,700	0.015	1,558,506	513,766
16	2041	868,700	0.014	1,569,656	513,766
17	2042	868,700	0.013	1,579,937	513,766
18	2043	868,700	0.008	1,585,875	513,766
19	2044	868,700	0.008	1,591,813	513,766
20	2045	868,700	0.007	1,596,882	513,766
21	2046	868,700	0.007	1,601,951	513,766
22	2047	868,700	0.005	1,605,283	513,766
23	2048	868,700	0.005	1,608,614	513,766
24	2049	868,700	0.003	1,610,209	513,766
25	2050	868,700	0.002	1,610,934	513,766
26	2051	868,700	0.002	1,611,660	513,766
27	2052	868,700	0.002	1,612,385	513,766
28	2053	868,700	0.002	1,613,111	513,766
29	2054	868,700	0.002	1,613,837	513,766
30	2055	868,700	0.002	1,614,562	513,766
31	2056	868,700	0.002	1,615,288	513,766
32	2057	868,700	0.002	1,616,014	513,766
33	2058	868,700	0.002	1,616,739	513,766
34	2059	868,700	0.002	1,617,465	513,766

Year of operation	Year	Output (MWh)	Peaking Plant carbon intensity (tCO_2e/MWh)	Cumulative avoided GHG impacts - offshore wind (tCO2e)	Cumulative avoided GHG impacts – grid electricity (tCO2e)
35	2060	868,700	0.002	1,618,190	513,766
36	2061	868,700	0.002	1,618,916	513,766
37	2062	868,700	0.002	1,619,642	513,766
38	2063	868,700	0.002	1,620,367	513,766
39	2064	868,700	0.002	1,621,093	513,766
40	2065	868,700	0.002	1,621,819	513,766

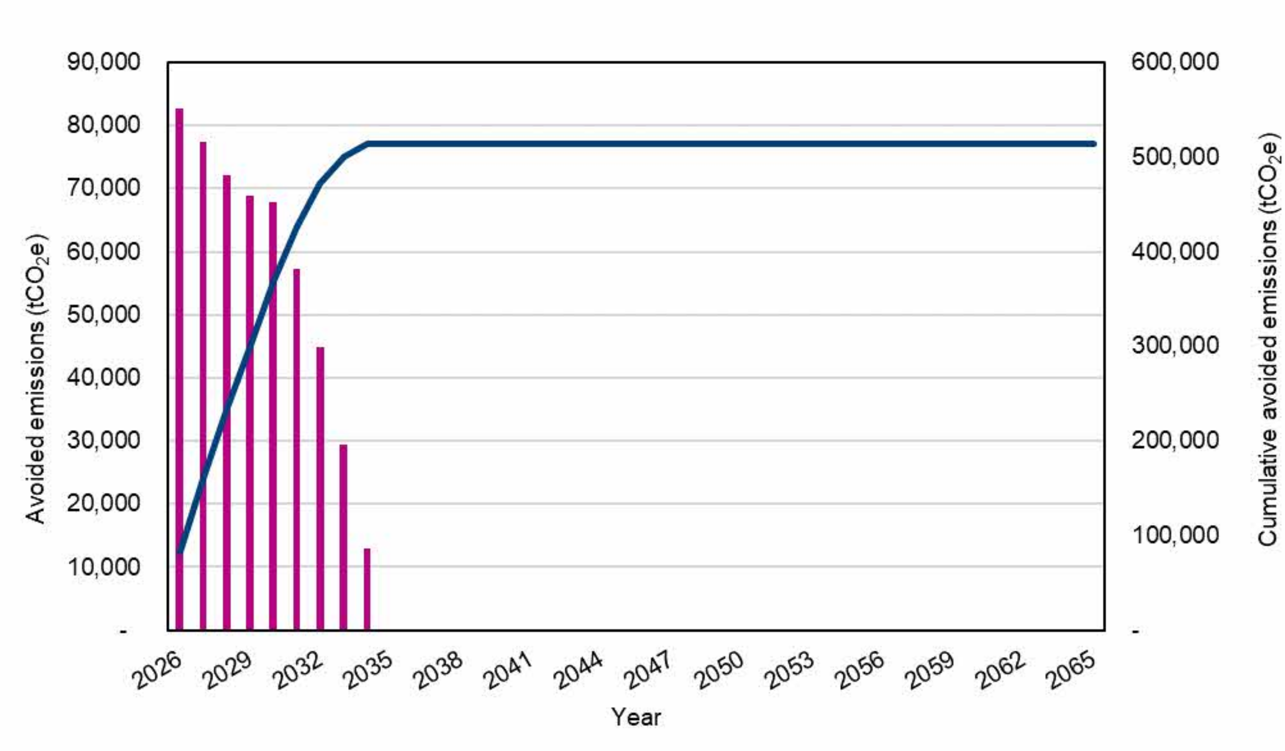
1.4.14 Graph 1.2 below, offers a visual representation of the GHG emissions provided in **Table** 1.6**,** displaying the anticipated annual avoided emissions, and cumulative avoided emissions over the Proposed Development's lifetime under the offshore wind scenario.

Graph 1.2 : Annual and Cumulative GHG Impacts (Scenario A)



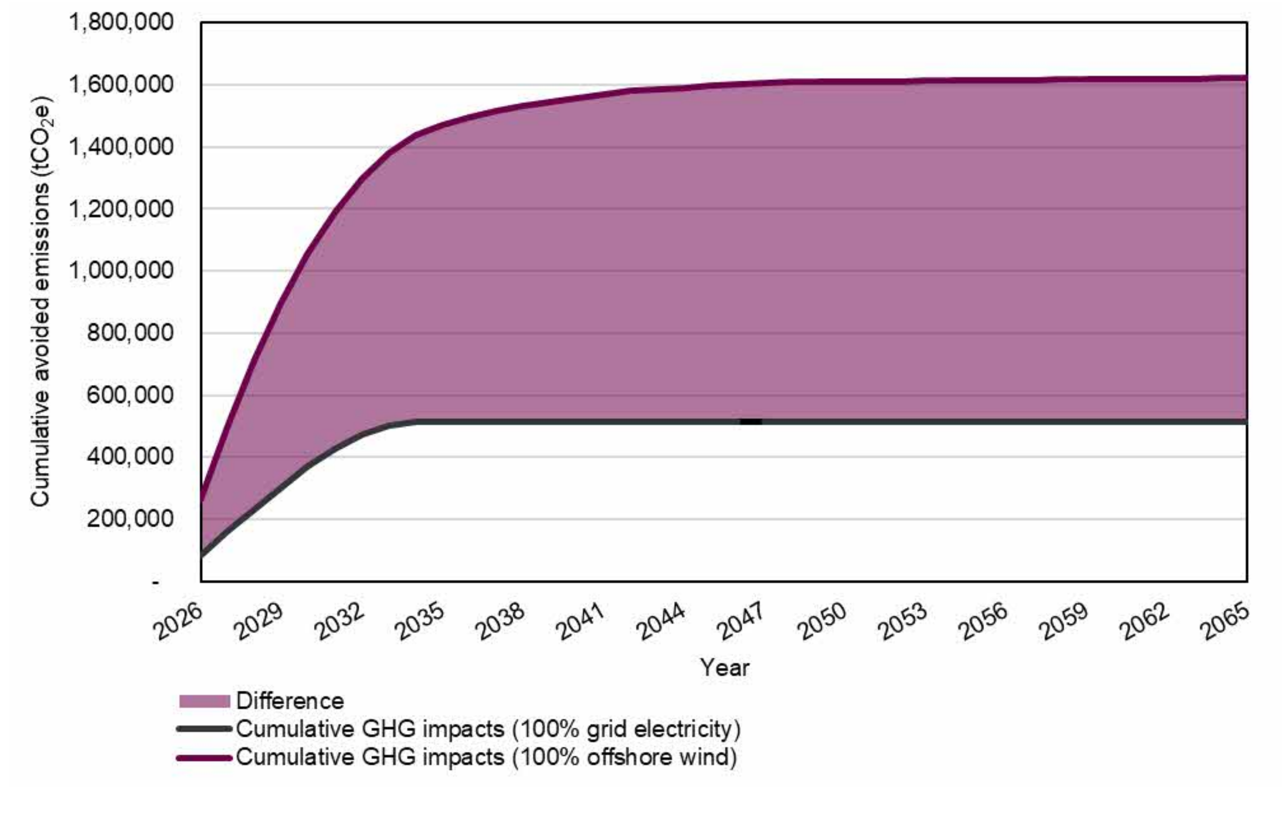
1.4.15 **Graph 1.3** below, offers a visual representation of the cumulative GHG emissions provided in **Table** 1.6**,** displaying the anticipated annual avoided emissions, and cumulative avoided emissions over the Proposed Development's lifetime under the grid long run marginal scenario.

Graph 1.3 : Annual and Cumulative GHG Impacts (Scenario B)



1.4.16 Graph 1.4 below displays the cumulative impact of both scenarios, with shading to highlight the difference, representing the potential range of avoided emissions that the Proposed Development's operational phase will enable. This highlights the sensitivity of the Proposed Development's operational avoided emissions to the carbon intensity of the energy source used for charging the BESS.

Graph 1.4 : Grid average and offshore wind scenarios – avoided emissions difference.



1.4.17 From year 9 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 electricity intensity and marginal generation plant carbon intensity, there is anticipated to be little remaining difference between the carbon intensity of different generation sources.

1.4.18 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.

1.4.19 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.

References

ABB (2003) Environmental Product Declaration: Power transformer TrafoStar 500 MVA. [Online] https://library.e.abb.com/public/566748ad75116903c1256d630042f1af/ProductdeclarationStarTrafo500.pdf. [Accessed August 2023]

Accardo, A., Dotelli, G., Musa, M. and Spessa, E. (2021) Life Cycle Assessment of an NMC Battery for Application to Electric Light-Duty Commercial Vehicles and Comparison with a Sodium-Nickel-Chloride Battery. *Applied Sciences*, 11(3), p.1160.

BEIS (2022) Valuation of Energy Use and Greenhouse Gas: Supplementary guidance to the HM Treasury Green Book.

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.

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. [Accessed August 2023]

Dai, Q., Kelly, J., Gaines, L. and Wang, M. (2019) Life Cycle Analysis of Lithium-Ion Batteries for Automotive Applications. Batteries, 5(2), p.48.

DESNZ and Defra (2023) UK Government GHG Conversion Factors for Company Reporting. [Online] https://www.gov.uk/government/publications/greenhouse-gas-reporting-conversion-factors-2023. [Accessed August 2023]

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

E.Emilsson and L.Dahllöf (2019) Lithium-Ion Vehicle Battery Production: Status 2019 on Energy Use, CO_2 Emissions, Use of Metals, Products Environmental Footprint, and Recycling. IVL Swedish Environmental Research Institute Ltd. Report number C 444

Environment Agency (2021) Post-combustion carbon dioxide capture: best available techniques (BAT). [Online] https://www.gov.uk/guidance/post-combustion-carbon-dioxide-capture-best-available-techniques-bat [Accessed August 2023].

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 [Accessed August 2023]

IEA (2020a) Energy Storage. [Online] https://www.iea.org/reports/energy-storage. [Accessed August 2023]

IEA (2020b) Environmental LCA of Residential PV and Battery Storage Systems. [Online] https://iea-pvps.org/key-topics/environmental-life-cycle-assessment-of-residential-pv-and-battery-storage-systems/ [Accessed August 2023]

Jones, C and Hammond, G (2019) Inventory of Carbon and Energy. [Online] Embodied Carbon Footprint Database - Circular Ecology [Accessed August 2023]

Natural England (2021). Carbon storage and sequestration by habitat: a review of the evidence (second edition). [Online] NERR094 Edition 2 v2.1 Carbon storage and sequestration by habitat - A review of the evidence (6).pdf [Accessed August 2023]

NREL (2013) Wind LCA Harmonization.[Online] https://www.nrel.gov/docs/fy13osti/57131.pdf [Accessed October 2023].

RICS (2012) RICS Professional Information, UK Methodology to calculate embodied carbon of materials. Available:https://www.igbc.ie/wp-content/uploads/2015/02/RICS-Methodology_embodied_carbon_materials_final-1st-edition.pdf. [Accessed August 2023]

RICS (2017). Whole life carbon assessment for the built environment. [Online] https://www.rics.org/profession-standards/rics-standards-and-guidance/sector-standards/building-surveying-standards/whole-life-carbon-assessment-for-the-built-environment. [Accessed August 2023]

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) [Accessed August 2023]

Woodland Trust (2013). Trees and Carbon. [Online] Trees and carbon (woodlandtrust.org.uk) [Accessed September 2023]