Stonestreet Green Solar

Environmental Statement
Volume 4: Appendices
Chapter 15: Climate Change
Appendix 15.2: GHG Footprint Methodology

PINS Ref: EN010135
Doc Ref. 5.4
Version 1
June 2024

APFP Regulation 5(2)(a)
Planning Act 2008
The Infrastructure Planning (Applications: Prescribed Forms and Procedure) Regulations 2009

Table of Contents

List of Tables

Appendix: 15.2 GHG Footprint Methodology

1.1 Introduction

1.1.1 This appendix sets out the methodology for the calculating the baseline Greenhouse Gas ('GHG') footprint, and GHG footprint for the Project. It covers the following GHG emissions sources:

- Construction: embodied carbon, construction transport and site plant and machinery;
- Operation: repair, maintenance and replacement, and transport;
- Decommissioning: Emissions at the end of life of the Project; and
- Energy intensity/energy offset.

1.1.2 The GHG footprint has been calculated for the lifetime of the Project, which includes a 12-month construction period (assumed to occur in 2026) and then a 40-year operational period from 2027 onwards.

1.1.3 Details of the methodology to calculate the GHG emissions from each of the emission sources included in the GHG footprint is provided below.

1.2 Construction Phase

Embodied Carbon

1.2.1 Embodied carbon emissions from the construction phase of the Project have been estimated based on extensive data and information provided by the Applicant, including:

- Plans and area schedules for the Project;
- Quantities (mass and/or volume) of key construction materials such as concrete for hard surfaces, and steel for PV mounting structures;
- Dimensions of key structures on-site including the Project Substation, Sellindge Substation extension works, Inverter Stations and Intermediate Substations;
- Numbers, sizes, weights, dimensions for key components of the solar and BESS systems including PV panels, inverters, transformers, switchgear, battery cells, DC-DC converters and Heating Ventilation and Air Conditioning ('HVAC') systems;
- Lengths, type and specifications of cabling to be used throughout the Project; and
- Dimensions, type and materials used for fencing and CCTV infrastructure.

1.2.2 These input data have been processed and combined with embodied carbon emissions factors from a number of sources to model the embodied carbon emissions.

1.2.3 A summary of the sources and assumptions used in the calculation of embodied carbon emissions is presented in **Table A15.1**.

Table A15.1: Sources and Assumptions of Emissions Factors for Embodied Carbon

Component	GHG Emissions Factors Source and Assumptions
PV Panels	GHG emissions factor of 287 $kgCO_2e/MWp$ calculated using an Environmental Performance Declaration ('EPD') for Jolywood JW-HD156N-158.75 monocrystalline solar panels (manufactured in China)[1].
PV Mounting Structures	GHG emission factor for electro galvanised steel obtained from Bath University Inventory of Carbon and Energy ('ICE') 3.0 database[2].
Cables	Material composition of cables assumed from the Lifecycle Carbon Impact Assessment of the Respond Project Report[3]. GHG emission factors for aluminium, copper, and plastics (XLPE and MDPE) obtained from ICE 3.0 and ICE 2.0 databases[4].
Inverters	GHG emissions factor of 83 $kgCO_2e/kWp$ calculated using an Environmental Performance Declaration ('EPD') for GoodWe inverter[5].
Transformers	Typical material composition of transformers obtained from lifecycle analysis of power transformers[6] and emissions factors for steel, copper and insulating paper taken from ICE 2.0 and 3.0.
Switchgear	GHG intensity of switchgear and DC-DC converters assumed from the Lifecycle Carbon Impact Assessment of the Respond Project Report.
DC-DC Converters	
Battery Cells	GHG emissions factor of 172 $kgCO_2e/kWh$ calculated using an EPD for Huawei battery cells[7].
HVAC Systems	GHG emissions factor for HVAC systems obtained from embodied carbon in HVAC system lifecycle analysis[8] and applied to total area of all battery containers.
Battery Containers	GHG emissions calculated based on size of structures using GHG emissions factors obtained from RICS guidance[9] for specialist buildings/structures.
Substations[1]	
Fencing	

[1] Project Substation, Intermediate Substations and Sellindge Substation extension works

Component	GHG Emissions Factors Source and Assumptions
CCTV	GHG emission factors for general concrete, timber and steel obtained from ICE 3.0 database
Hard Surfacing	

1.2.4 The resultant embodied carbon emissions for the Project are provided in **Table A15.2**.

Table A15.2: Embodied Carbon Emissions (TCO_2e)

Component	Embodied Carbon (TCO_2e)[a]	% of Total
PV Panels	41,856	35.1%
PV Mounting Structures	22,838	19.1%
Cables	8,857	7.4%
Inverters	12,060	10.1%
Transformers	1,087	0.9%
Switchgear	17	0.0%
DC-DC Converters	461	0.4%
Battery Cells	22,066	18.5%
HVAC Systems	301	0.3%
Battery Containers	3,645	3.1%
Substations[2]	2,032	1.7%
Fencing	277	0.2%
CCTV	134	0.1%
Hard Surfacing	3,746	3.1%
TOTAL EMBODIED CARBON	119,375	100.0%

[a] All values rounded to nearest whole number

[2] Project Substation, Intermediate Substations and Sellindge Substation extension works

Construction Transport

1.2.5 The transport movements generated by the Project during the construction phase have been provided by the Applicant. The transport movements included vehicle movements associated with the delivery of goods and materials, and movement of construction workers by private car and minibus.

1.2.6 GHG factors for transport have been obtained from Department of Energy Security and Net Zero ('DESNZ') GHG factors[10] for company reporting, published for 2023. Although the construction works are assumed to occur in 2026, no decarbonisation of construction transport emissions are accounted for and the 2023 GHG factors have been used in the calculation.

1.2.7 Average travel distances for construction transport have been estimated. For vehicles delivering goods and materials, an average travel distance of 114 km (71 miles) on the average distance to the nearest commercial ports of Dover, Folkestone, Port of London, Southampton, Newhaven and Felixstowe.

1.2.8 For construction workers, an average travel distance of 50 km (31 miles) has been estimated, which covers a number of local towns including Ashford, Maidstone, Canterbury and Folkestone.

1.2.9 It is expected that many of the products and materials used within the Project will be manufactured abroad and shipped to the UK for installation. GHG emissions associated with the international shipping of these goods has therefore been accounted for in the GHG footprint. It is likely that the PV panels will be manufactured in China, where other materials such as cables may be sourced more locally (e.g. Europe). To provide a conservative assessment it has been assumed that all imported materials will originate in China.

1.2.10 A summary of the data used for the calculation of construction transport GHG emissions is shown in **Table A15.3**.

Table A15.3: Construction Transport Data

Vehicle Type	No. of Two-Way Movements	Tonnage of Material (T)	Distance Travelled (Miles)	GHG Emissions Factor	GHG Emissions (TCO_2e)
Good and Materials – Articulated HGV	3,674	n/a	71	1.23kgCO_2e/mile	716
Goods and Materials – Rigid HGV	4,392	n/a	71	1.26 kgCO_2e/mile	
Goods and Materials – Vans	620	n/a	71	0.37 kgCO_2e/mile	

Vehicle Type	No. of Two-Way Movements	Tonnage of Material (T)	Distance Travelled (Miles)	GHG Emissions Factor	GHG Emissions (TCO_2e)
Goods and Materials – International Shipping	n/a	13,096 [a]	10,000 [b]	0.01612 $kgCO_2e$/T.km	3,397
Construction Staff – Cars	27,456	n/a	31	0.27 $kgCO_2e$/mile	347
Construction Staff – Minibus	9,984	n/a	31	0.37 $kgCO_2e$/mile	
TOTAL Construction Transport Emissions (TCO_2e)					4,460

[a] Based on mass estimates for PV panels, cables, inverters, transformers and BESS.

[b] Based on distance from UK to China via Suez canal.

Construction Site Plant and Machinery

1.2.11 Emissions from diesel consumed by construction plant and machinery has been estimated based on data from the Applicant in relation to the types of machinery to be used for the construction works. A plan of plant requirements for each of the phases of the work has been provided by the Applicant and is provided as **ES Volume 4, Appendix 14.5: Construction Phase Plant List (Doc Ref. 5.4)**.

1.2.12 Fuel consumption for each machine/plant has been obtained from data in the European Environment Agency/EMEP emissions inventory guidebook[11]. The data provides fuel consumption per hour.

1.2.13 Emissions factors for diesel fuel consumption have been obtained from DESNZ data.

1.2.14 Construction phase emissions are estimated using the following assumptions:

- Numbers of each machine/plant have been estimated based on discissions with the Project Applicant;
- Site operating hours and duration of each work phase are as described in **ES Volume 2, Chapter 3: Project Description (Doc Ref. 5.2);**
- Each machine/plant operates for 50% of available site hours on average; and
- Average engine loading during operation is 50% of full load/power.

1.2.15 The estimate construction phase emissions from site plant and machinery are **2,908 TCO_2e**.

1.3 Operational Phase

Repair, Maintenance and Replacement

1.3.1 Repair, maintenance and replacement of the Project over its 40-year operational lifetime is predominated by the embodied carbon associated with parts and products used for repairs and replacements.

1.3.2 In order to be conservative, the assessment has used the same embodied carbon emissions factors and intensities as used in the calculation of embodied carbon emissions described in **Section 1.2** of this Appendix. This is conservative as it ignores the potential future decarbonisation of the mining, processing and manufacturing sectors.

1.3.3 The data and assumptions used in the calculation of emissions from repair, maintenance and replacement are provided in **Table A15.4**. The replacement frequency/schedule for major Project components has been discussed and agreed with the Applicant.

Table A15.4: Operational Repair, Maintenance and Replacement Assumptions and Data

Component	Estimated No. of Replacements during Project Lifetime	Lifetime Carbon (TCO2e)
PV Panels	0.1	4,186
PV Mounting Structures	0.1	2,284
Cables	0.1	886
Inverters	2	24,120
Transformers	1	1,087
Switchgear	1	17
DC-DC Converters	1	461
Battery Cells	1.5	33,099
HVAC Systems	1	301
Battery Containers	0	0
Substations	0.1	203
Fencing	0.1	28
CCTV	0.1	12

Component	Estimated No. of Replacements during Project Lifetime	Lifetime Carbon (TCO2e)
Hard Surfacing	0.1	375
TOTAL Repair, Maintenance and Replacement (TCO_2e)		67,058

Transport

1.3.4 The Applicant has advised that based on operation of similar schemes, it is likely that the operational transport movements will be limited to 2 vehicles attending the Site each day for service and maintenance (on average).

1.3.5 The operational transport data and assumptions used in the assessment is shown in **Table A15.5.**

Table A15.5: Operational Transport Data and Assumptions

Parameter	Value	Unit	Notes
Number of Trips	2	Per day	From Applicant
Type of Vehicle	Van	n/a	Most common vehicle used for servicing.
Average Travel Distance	100	km	50 km each way.
GHG Factor	0.174	$kgCO_2e/km$	From DESNZ data[10] for 2023.
Annual GHG	12.67	TCO_2e	Assumes no decarbonisation of road transport to be worst-case/for simplicity given the very small emission.
Lifetime GHG (40 Years)	570		

1.4 Decommissioning Phase

1.4.1 Following cessation of energy generation at the Site from the Project, all physical infrastructure constructed as part of the Project, and accounted for in the construction phase assessment will be removed and recycled or disposed of in accordance with good practice, market conditions and available technologies for recycling/reprocessing at that time.

1.4.2 Further detail on decommissioning is provided in **ES Volume 2, Chapter 16: Other Topics (Doc Ref. 5.2)**.

Site Plant and Machinery

1.4.3 It is likely that by the time of decommissioning, that most or all of the plant and machinery used to decommission the Project will be zero tailpipe emission (i.e. electric or similar). However, there is currently uncertainty about the trajectory to zero emissions for heavy non-road mobile machinery and as such a worst-case assumption has been applied that emissions from site plant and machinery during decommissioning are the same as during construction. This assessment is also based on the assumption that the overall timescales and level of activity for deconstruction and decommissioning is broadly similar to that for construction (see **Paragraph 1.2.15**).

1.4.4 The estimated emissions from decommissioning phase site plant and machinery are **2,908 TCO_2e**.

Staff Transport

1.4.5 Private and public transport GHG emissions are likely to have transitioned to zero by the time of decommissioning, however, to provide a worst-case assessment, it has been assumed that the decommissioning phase staff transport emissions are the same as those for construction phase transport. This assessment is also based on the assumption that the overall timescales and level of staff required for deconstruction and decommissioning is broadly similar to that for construction (see **Table A15.3**).

1.4.6 The estimated emissions from decommissioning phase staff transport are **347 TCO_2e**.

Waste Transport and Disposal

1.4.7 The decommissioning phase will involve the removal of all physical infrastructure constructed as part of the Project and accounted for in the construction phase assessment (see section 1.2). These components will be removed and recycled or disposed of in accordance with good practice, market conditions and available technologies for recycling/reprocessing at that time.

1.4.8 An estimate of GHG emissions from waste transport and disposal has been made using GHG factors for company reporting published by DESNZ[10].

1.4.9 The GHG factors are applied to a mass of the components removed from Site. Masses of componentry are estimated from the data used to calculate the embodied carbon emissions and it has been assumed that 75% of the materials will be recycled and 25% diverted to landfill. This is intended as a worst-case and it is expected that the decommissioning phase will aim to minimise or eliminate diversion of any waste to landfill.

1.4.10 The emissions from waste transport and disposal in the decommissioning phase are presented in **Table A15.6**.

Table A15.6: Waste Transport and Disposal Emissions (TCO_2e)

Component	Mass (T)	GHG Emissions (TCO2e)
PV Panels	8,329	151
PV Mounting Structures	7,538	137
Cables	1,955	36
Inverters	118	2
Transformers	340	6
BESS	1,163	21
Concrete	35,779	651
Aggregates	8,160	148
Other	194	4
TOTAL	63,576	1,156

1.5 Energy Intensity/Offset

1.5.1 The calculation of the lifecycle energy intensity of the Project is calculated using the total lifecycle carbon emissions and the total expected lifetime electricity export. To calculate the lifetime electricity exported, the annual (opening year) value has been extrapolated over 40 years, assuming a PV panel degradation rate of 0.45% per annum.

1.5.2 A summary of the energy intensity calculation is provided in **Table A15.7**.

Table A15.7: Energy Intensity Calculation

Parameter	Value	Unit	Notes
Total Annual Electricity Export	155,794	MWh	PVSyst Simulation Report provided by Applicant.
Annual Degradation Rate	0.45	%	Assumption based on latest available manufacturer estimates and performance data.
Total Lifetime (40-year) Electricity Export	5,714,836	MWh	

Parameter	Value	Unit	Notes
Total Lifetime GHG Emissions	198,782	TCO2e	Sum of data in Sections 1.2 to 1.4 of this Appendix.
Lifecycle Carbon Intensity	34.8	gCO2e/kWh	

1.5.3 Electricity provided by the Project will replace energy generated by other higher carbon means including fossil fuel combustion. A comparison of the energy intensity of the Project to other forms of energy generation are provided in **ES Volume 2, Chapter 15: Climate Change (Doc Ref. 5.2)**. The comparison uses data published by Government in relation to the current carbon intensity of the UK energy grid[12], and the future trajectory for decarbonisation of the UK's energy supply[13].

References

1 Environmental Performance Declaration (2020) Jolywood N-type Bifacial Double Glass PV Modules, valid to Nov 2025: [redacted]

2 University of Bath (2019) Inventory of Carbon and Energy (ICE) Version 3.0.

3 FuturoFirma (2018) Lifecycle Carbon Impact Assessment of the Respond Project: [redacted]

4 University of Bath (2013) Inventory of Carbon and Energy (ICE) Version 2.0.

5 Environmental Performance Declaration (2023) GoodWe Inverter valid to Mar 2028: [redacted]

6 Hong Guo, Yuting Gao, Junhao Li (2022) The greenhouse gas emissions of power transformers based on life cycle analysis. Energy Reports Volume 8, Supplement 15, Pages 413-419.

7 Environmental Performance Declaration (2022) Huawei Digital Power Technologies battery modules valid to Sep 2027: [redacted]

8 Rodriguez Droguett, B (2019) Embodied Carbon of Heating, Ventilation, Air Conditioning and Refrigerants (HVAC+R) Systems. University of Washington.

9 RICS (2012) Methodology for the calculation of embodied carbon in materials. 1st edition.

10 Department for Energy Security and Net Zero (2023) Greenhouse gas reporting: conversion factors 2023: https://www.gov.uk/government/publications/greenhouse-gas-reporting-conversion-factors-2023

11 EEA/EMEP (2019) Air pollutant emissions inventory guidebook 2019, Part 1.A.4 Non road mobile machinery.

12 Department for Energy Security and Net Zero (2023) Fuel Mix Disclosure Data Table 01/04/2022 to 31/03/2023: https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/1175406/fuel-mix-disclosure-data-table-2023.pdf

13 HM Treasury (2023) Green Book supplementary guidance: valuation of energy use and greenhouse gas emissions for appraisal: https://www.gov.uk/government/publications/valuation-of-energy-use-and-greenhouse-gas-emissions-for-appraisal