Appendix 10.1 GHG Emission Calculations

10.1 Introduction

10.1.1 This technical appendix to the Environmental Statement (ES) details the calculation of construction-stage and operational-stage greenhouse gas (GHG) emissions from the Proposed Development.

10.1.2 It should be read alongside Chapter 10 of the ES, which sets the magnitude of GHG emissions in a policy context to judge the significance of effects on climate change.

10.1.3 Note that the benchmarks used to assess embodied and operational carbon emissions in this appendix may differ from those applied in the carbon calculations presented within the Climate Change Statement. While this assessment aims to establish a conservative (worst-case) scenario for emissions over time, it does not account for the energy efficiency measures and sustainable building practices that are incorporated into the design and are detailed within both the Climate Change Statement and the Sustainability Statement.

10.2 Phasing

10.2.1 The following reporting calculations have been adjusted to follow the indicative phasing of the wider development within the Loddon Valley Garden Village:

- Commencement of development – 2027
- First completion of approximately 50 dwellings – 2028
- Completion of development – 2042

10.2.2 Construction emissions for the year 2027 are not reported, as significant construction activity is not anticipated to commence during this initial phase of the Proposed Development.

10.3 Construction

Emission Sources

10.3.1 Description of the Proposed Development are set out earlier within the ES. Construction of these elements will cause direct and indirect GHG emissions from the fuel and energy used by construction plant and in the 'embodied carbon' of materials used. The embodied carbon refers to the indirect emissions in the supply chain for those materials: extracting and transporting the raw materials, manufacturing them into products, and delivery of those products to site.

10.3.2 Together with the assembly work on-site, this comprises modules A1 to A5 in the terminology used to describe life-cycle carbon assessment. A1-3 refers to the materials manufacturing supply chain; A4 is delivery to site; and A5 is assembly on site.

10.3.3 As the use of benchmarks are integral to this assessment of GHG emissions and because these benchmarks differ between residential, retail, industrial, and school buildings, GHG emissions arising from each component will be assessed separately.

10.3.4 The main built elements of the development relevant to construction-stage GHG emissions are as follows:

- foundations (substructure);
- structure, façade and roof;
- mechanical and electrical (M&E) plant/hot water and heating system;
- other fixtures and fittings;
- external civil works such as access, drainage and hardstanding; and
- landscaping.

Construction embodied carbon benchmarks

10.3.5 At this early stage of masterplan design for the site, with an outline application being made on a parameters basis, no detailed bill of quantities of materials is established. Construction-stage GHG emissions have therefore been estimated from published benchmarks for development of this type. Where the benchmarks reflect 'business as usual' (BAU) construction practice, the potential for further mitigation has also been considered, on the basis of recommended performance targets and with respect to specific possible actions that could be undertaken through subsequent detailed design and construction stages, which are discussed further in the mitigation section of Chapter 10.

Residential benchmarks

10.3.6 Available residential-related benchmark sources are reviewed in Table 10.1.

Table 10.1 Construction Activity and Embodied Carbon Benchmarks for Dwellings

Description and Source	Intensity (kgCO2e/m2)	Scope	Notes
OneClick database [1]: western Europe residential developments (median)	552	A1-A3	Including estimated 20% uplift for fit-out, services and external works
RIBA [2] domestic/residential metric: BAU	1,200	A1-A5, B1-B5, C1-C4	Also includes in-life maintenance and construction waste (B and C modules)[1]
RIBA [2] domestic/residential metric: 2025 target	<800		
RIBA [2] domestic/residential metric: 2030 target	<625		
LETI [3] residential metric: BAU	800	A1-A5	–
LETI [3] residential metric: 2020 target	500		
LETI [3] residential metric: 2030 target	300		
UK Net Zero Carbon Buildings Standard (UKNZCBS) [4]: 2025 target for single family homes	430	A1-A5	Upfront carbon limits for new works if conforming with standard
UKNZCBS [4]: 2030 target for single family homes	290	A1-A5	

[1] In-life maintenance and construction waste (B and C modules) occur during the operational stage of development, however, we have reported them within the construction embodied emissions for simplicity and complicity with the way the benchmarks are presented.

10.3.7 As can be seen, there is variability both in the BAU benchmarks and in the recommended forward-looking performance benchmarks. This likely reflects differences between the scopes included within each benchmark by each organisation (i.e. the RIBA benchmark includes more than the LETI benchmark and UKNZCBS benchmark, and hence is higher). The OneClick [1] data is based on projects that have used that lifecycle assessment tool to calculate emissions and may represent a more recent BAU for projects under design and development, compared to existing (historical) building stock with poorer performance.

10.3.8 From this range of data, the RIBA 2025 target of **800 kgCO2e/m²** has been used to represent the assumed the BAU design case in this assessment of residential buildings for both Option 1 and Option 2: this is similar to the OneClick data but slightly higher due to including A4 and A5 impacts, B1-B5 impacts and C1-C4 impacts, so is a reasonably conservative position for current design but not excessively worst-case. The RIBA 2025 target is also consistent with the LETI BAU target.

Construction-stage GHG emissions summary

Elements of the Proposed Development

10.3.9 The only building use class proposed by the development is *Residential*.

Construction-stage GHG emissions summary

Residential

10.3.10 The GIA of the Proposed Development is up to **43000** m^2, which at a BAU embodied carbon intensity in the order of **800** $kgCO_2/m^2$ would be **4000** tCO_2e for the 2028 phase and **30,400** tCO_2e for the 2042 phase, totalling to **34,400** tCO_2e.

10.4 Operation

Emission Sources

10.4.1 For all components of the Proposed Development, the two main emission sources in the operational phase would be from generating and supplying energy used in the homes and from fuel and electricity used in vehicles by residents.

10.4.2 Supply of potable water, treatment of wastewater and treatment of household waste from tenants are all also associated with indirect GHG emissions. However, the carbon intensity of water supply and wastewater management is low relative to energy and transport, so has been considered de minimis and not assessed further at this outline design stage, as agreed through the EIA scoping process.

10.4.3 The generation of household waste and its management by the responsible local authority is not a factor influenced significantly by the development design or location, and so effects on this caused by the Proposed Development are also considered de minimis and not assessed further, as agreed through the EIA scoping process.

10.4.4 There could also be embodied carbon from maintenance and refurbishment work during the buildings' lifetime. This would be dependent on resident choices and is difficult to estimate at an outline planning stage. Given the expected UK-specific trajectory of decarbonisation to 2050, future maintenance and refurbishment is likely to have substantially lower carbon intensity than

the initial construction stage (assessed above), so has not been separately estimated in this assessment.

GHG emissions from energy use

10.4.5 At this early stage of masterplan design for the site, with an outline application being made on a parameters basis, operational-phase GHG emissions have been estimated from published benchmarks and targets for developments of this type. Like the construction emission benchmarks, operational-phase benchmarks were chosen to reflect BAU design practices to ensure conservative estimates within the assessment.

10.4.6 Residential, primarily considers RIBA [2] 2030 and LETI [7] targets to reflect BAU practices.

10.4.7 Wokingham Borough Council's Local Planning Update (LPU) [6] also sets out energy demand targets irrespective of renewable energy generation as maximum limits for residential developments referenced within chapter 10. These are also averaged in within all the chosen benchmark values.

10.4.8 The expected energy demand enables the electricity required from the grid to be estimated, and GHG emissions calculated based on the carbon intensity of typical electricity generation.

Residential benchmarks

10.4.9 As the scheme is only at the outline stage, no detailed energy modelling of the scheme has been undertaken. Available residential benchmark sources are set out in Table 10.2.

Table 10.2 Residential Electricity Demand Benchmarks

Description and Source	Intensity (kWh/m$^{2/}$annum)	Notes
CIBSE [5] TM46:2008: Long term residential	485	Noted to have 24-hour serviced spaces
RIBA [2] domestic/residential metric: BAU	120	–
RIBA [2] domestic/residential metric: 2025 target	60	–
RIBA [2] domestic/residential metric: 2030 target	35	–
UKNZCBS [4]: 2025 target for single family homes	45	Energy use intensity limits for new buildings. As with LETI target, this is intended to be delivered alongside a target for on-site renewable generation
LETI [7] 2030 target for housing	35	LETI target is intended to be delivered alongside provision of renewable such that total annual energy requirement is generated on-site
LPU energy demand target: residential	60	–

10.4.10 The RIBA domestic/residential BAU energy intensity figure of 120 kWh/m^2/annum is based on an average new-build which satisfies the minimum regulatory compliance at the time [8]. The CIBSE TM46:2008 intensity of 485 kWh/m^2/annum provides an extreme conservative benchmark based upon continuous running of building services within the home. It is based on

existing building data and other standards such as CIBSE guide F [9]. The benchmark also accounts for both electricity and fossil-fuel usage, which further amplifies its conservative approach. Both of these benchmark, and LPU target, which indicate higher energy consumption than the RIBA 2035, UKNZCBS 2025 target, and RIBA 2030 target are based on current housing stock and are therefore not likely to be fully representative of new building performance. The LPU target is similar to the RIBA 2025 target, and takes priority within the assessment as it is an outlined requirement within local policy.

10.4.11 for EIA purposes it is necessary to use conservative estimates which do not underestimate potentially significant effects. As achievement of the RIBA 2025 and LPU targets is dependent upon the final specifications and energy strategy used for the residential units, an assumed energy intensity of **90 kWh/m^2/annum** has been used in this assessment. This is an average of the RIBA BAU and LPU targets, i.e. representing a transition towards a higher baseline of performance but not necessarily securing achievement of the future specified LPU target.

10.4.12 This intensity is a reasonably conservative position for current design, accounting for a situation where the LPU target isn't achieved while avoiding being excessively worst-case by not considering the CIBSE TM46 benchmark.

10.4.13 The UKNZCBS 2025 target, RIBA 2030 target and LETI target has not been used for assessment as it is considered ambitious in comparison to the RIBA 2025 and LPU targets, but is considered further in the recommended further mitigation discussed in Chapter 10.

GHG emissions from transport

10.4.14 Fuel combustion and electricity use by vehicles accessing the proposed development will cause direct and indirect GHG emissions.

10.4.15 These will largely occur outside the physical site boundary, and although some aspects of development design can influence these emissions – such as its location relative to other potential options for residential development and public transport links; or its provision of electric charging – it is also acknowledged that demand for housing means these emissions may also occur at an alternative site without the proposed development. Nevertheless, being a consequence of operational use of the proposed development, these are included in the assessment.

10.4.16 Annual average daily traffic generation figures for light and heavy vehicles within the Site have been provided by the transport consultants. These have been multiplied up to annual figures on a conservative (maximum-case) basis assuming 365 days of annual travelling.

10.4.17 Commuting distance is based on average trip lengths reported in the Census journey-to-work data [10] for the area of the Proposed Development in Wokingham, which is approximately 19 km.

10.4.18 Emission factors for transport have been taken from DESNZ company reporting factors [11] including scope 3 upstream emissions. An average-sized car and average powerplant (internal combustion, hybrid or electric) from the current UK fleet has been assumed for commuting.

10.4.19 Trip generation, journey lengths and emission factors are shown in Table 10.10. For this assessment, 2026 future forecast data will be used for the 2027 phase, 2028 future forecast data will be used for the 2028 phase, and 2040 future forecast data will be used for the 2028 phase. Representative data sets as close to each phase's year are used due to the provided data not covering every year within the Proposed Development's 2027-2042 construction period.

10.4.20 In intermediate years of work on the phased development before it reaches full completion, there would be a mixture of construction and operational traffic. Construction traffic has not been separately assessed. The consultant has indicated that construction traffic is excluded from the 2026 data set, due to little-to-no construction occurring at that time. The 2028 data set includes construction and operational traffic due to the current progress of the Proposed Development at that time, whereas the 2040 data set only includes operational traffic due to the fully completed Proposed Development. In all phases, the data sets used provide used allow for reasonably conservative traffic emission estimates.

10.4.21 Baseline traffic data is based on the present day 2025 data set for the area of the Proposed Development provided by traffic consultants.

Table 10.3 Transport Emission Calculation Inputs for Indicative Phasing

Transport mode	Trip generation for 2025 phase (annual arrivals and departures	Trip generation for 2027 phase (annual arrivals and departures)	Trip generation for 2028 phase (annual arrivals and departures)	Trip generation for 2042 phase (annual arrivals and departures)	Trip length (km)	Emission factor ($kgCO_2e/v.km$)
Light and heavy (annual average travel estimate)	3.803,787	3,869,574	4,326,380	4,850,937	19	0.2109

Operational-stage GHG emissions summary

Emission factors

10.4.22 Operational-stage GHG emission totals will be reported using both present day and completion year carbon emission factors for all phases except the 2027 phase which will only be reported using present day factors. This is due to the phase being baseline conditions i.e. no operational energy usage other than from the existing *de minimis* buildings on Site. Present day factors are from 2025 DESNZ company reporting factors [11] to represent BAU practices whereas completion year emissions factors for each phase year are taken from DEFRA projected emissions [12].

Table 10.4 Carbon Emission Factors

Phase	Carbon emission factor
2027 (present day)	0.245
2028	Domestic: 0.063
2042	Domestic: 0.015

Residential

10.4.23 Based on the calculated average benchmark value of **90 kWh/m²/annum** for dwellings, the operational emissions from grid-supplied electricity consumption related to the residential element of the Proposed Development would equate to **110-28 tCO_2e/annum** for the 2028

phase (present day emission factor totals and completion year emission factor totals) and **950-55 tCO_2e/annum** for the 2042 phase.

Combined transport

10.4.24 Baseline present day transport emissions from total vehicle trips are estimated to be **8,526 tCO_2e/annum.**

10.4.25 Transport emissions from total vehicle trips of each phase are estimated to be **8,687 tCO_2e/annum** for the 2027 phase**, 9,012 tCO_2e/annum** for the 2028 phase, and **11,140 tCO_2e/annum** for the 2042 phase. This is based conservatively on present-day emissions factors, and is likely to become lower over the Proposed Development's operating lifetime, particularly with the phase-out of new petrol and diesel light vehicle sales expected in the 2030s.

Whole site emissions

10.4.26 Baseline present day operational emissions across the whole site due to the International Cocoa Quarantine Centre would equate to **18 tCO_2e/annum**.

10.4.27 Across the whole site, the operational emissions from grid-supplied electricity consumption would equate to **18 tCO_2e/annum** for the 2027 phase**, 29-7 tCO_2e/annum** for the 2028 phase (present day emission factor totals and completion year emission factor totals) and **2,611-153 tCO_2e/annum** for the 2042 phase.

10.5 Carbon Budgets

10.5.1 National- and local-scale carbon budgets, and carbon reduction trajectories or intensity targets, are used as part of the context for judging the significance of effect resulting from the impact of GHG emissions. This is discussed further in Chapter 10; the data referenced is presented here.

10.5.2 Table 10.5 shows the UK national carbon budgets and rate of reduction relative to the baseline of the budget for the 2018-22 period. The tCO2e/annum and the percentage reductions have been calculated as a simple average across each five year budget period, not declining year on year within the period, and are shown as originally published (prior to EU ETS credit or any carbon border mechanism adjustment).

Table 10.5 National Carbon Budgets

Period	tCO_2e	tCO_2e/annum (simple average)	Reduction against 2018-22 as baseline
2018-2022	2,544,000,000	508,800,000	n/a
2023-2027	1,950,000,000	390,000,000	-23%
2028-2032	1,725,000,000	345,000,000	-32%
2033-2037	965,000,000	193,000,000	-62%

10.5.3 Baseline GHG emissions data is available, disaggregated into local authority areas [13] and for certain economic sectors, of which 'domestic' is the relevant to this assessment. Table 10.13 shows the 2022 data (latest available). The 'total under local authority influence' excludes emissions from large industrial sites, railways, motorways, land-use, livestock and soils.

Wokingham Baseline GHG Emissions (2022)

Sector	tCO_2e/annum	tCO_2e/annum under authority influence*
Industry	29,236	28,125
Commercial	82,906	80,616
Public (Non-educational)	14,784	14,405
Public (Educational)	14,784	14,405
Domestic	234,917	227,074
Transport	307,774	172,624
Total	700,240	537,249

* only available as CO_2 (excluding other GHGs)

Sectors of the Proposed Development

10.5.4 The Proposed Development estimated total emissions can be compared against the Wokingham Baseline GHG Emissions for 'Domestic'.

10.5.5 The UK's national carbon budgets are broken down into devolved administration targets but not further to a regional or local authority level. However, the Tyndall Centre for Climate Change Research [14] has recommended local authority-specific carbon budgets up to 2100 that, in its research, are considered to be an equitable distribution and compatible with a 1.5°C-aligned trajectory for the UK. The Tyndall Centre carbon budgets sum to being more stringent than the UK national budgets: the carbon budget for Wokingham would result in achieving zero or near zero carbon no later than 2041 at a carbon reduction rate of -13.9% per year from a 2020 baseline[2].

10.5.6 This is shown in Table 10.6. The annual figures are a simple average across each five yearly budget period (excluding 2048-2100, which is an average across the 53 year time period).

Table 10.6 Wokingham Carbon Budgets

Carbon Budget Period	Recommended Carbon Budget (tCO_2e)	tCO_2e/annum (simple average)
2018 - 2022	3,200,000	640,000
2023 - 2027	1,600,000	320,000
2028 - 2032	800,000	160,000
2033 - 2037	400,000	80,000
2038 - 2042	200,000	40,000
2043 - 2047	100,000	20,000
2048 - 2100	100,000	1,887

[2] The Tyndall Centre defines zero or near zero carbon as achieving CO_2 levels >96% lower than in the Paris Agreement reference year of 2015, excluding non-CO_2 GHGs and aviation and shipping emissions. The carbon budgets are for energy related CO_2 emissions only.

10.5.7 Simple average values are used to establish a carbon budget for each construction phase, as shown in Table 10.7. These budgets provide a benchmark against which the total construction-stage emissions are compared.

Table 10.7 Wokingham Carbon Budgets for Each Phase

Carbon Budget Period	2027 phase		2028 phase		2042 phase		Total construction period	
	Years	Total carbon budget (tCO^2e)	Years	Total carbon budget (tCO^2e)	Years	Total carbon budget (tCO^2e)	Years	Total carbon budget (tCO2e)
2023 - 2027	1	320,000	1	320,000	0	-	1	320,000
2028 - 2032	0	-	1	160,000	4	640,000	5	800,000
2033 - 2037	0	-	0	-	5	400,000	5	400,000
2038 - 2042	0	-	0	-	5	200,000	5	200,000
Totals	1	320,000	2	480,000	14	1,240,000	16	1,720,000

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