Local Plan 2040: Development options carbon emissions

Technical report on the evaluation of greenhouse gas emissions for Local Plan development options based on spatial development proposals.
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Executive Summary

The greenhouse gas emissions (also referred to as carbon emissions) generated by constructing (embodied emissions) and operating (operational emissions) new development and infrastructure are significant contributors to the district's overall carbon footprint.

This evaluation compares the projected greenhouse gas emissions from the five broad development options proposed for the Canterbury District Local Plan 2040 and finds that:

- The cumulative construction emissions through to 2040 will add around 5% to the carbon footprint of the district through that period if current construction methods and building energy standard are applied
- The emissions generated from residential construction are the largest proportion of the development emissions
- The cumulative greenhouse gas emissions through to 2040 from new development can be reduced by about 30% by setting high energy efficiency standards now, and this will have a benefit beyond the 2040

The report recommends:

- Implementing policy for planned developments to evaluate the embodied carbon emissions
- The planning authority to maintain a register of embodied carbon emissions from approved and completed developments
- The Local Plan set net zero operational emissions standards for new development in the district
- Life cycle carbon assessments are undertaken for the road infrastructure schemes as per Highways England SA 119 Climate in order to determine their contribution to district emissions reduction

Background

National guidance on the development of local plans gives explicit instructions that plans should be used as a key mechanism for addressing climate change. A comprehensive outline of the principles are given on the relevant Ministry for Housing, Communities and Local Government web pages[1].

There are two key aspects to the challenges of climate change:

- Mitigation - reducing the causes of climate change
- Adaptation - making our society, systems and infrastructure more resilient to the consequences of climate change

This document focuses on mitigation and sets out the tools for estimating carbon dioxide emissions relating to proposed developments. In this document, carbon dioxide emissions is used as a shorthand for all greenhouse gas emissions expressed as carbon dioxide equivalent emissions and includes other greenhouse gases such as refrigerants and methane.

The impacts of transport associated emissions, and the potential for changes in the district transport strategy to affect overall emissions, such as by facilitating more active and electric travel, are considered separately.

New developments - the construction of buildings and associated infrastructure like transport links, utilities and landscaping - generate carbon emissions. These emissions can be broadly categorised into:

- Embodied emissions - the carbon emissions resulting from everything involved in constructing the development to the point that it is ready to be used
- Operational emissions - the carbon emissions generated from using the development - the heat and power needed to run and service the building and the activities that the building enables - like the transportation that the building occupants will use

In real development cases there is lots of complexity to evaluating their emissions because there are so many different components to the problem; the timescales are long with lots of uncertainty and choices that will be made along the way and the end-of-life (what happens when the building has reached the end of its useful function) is unclear at the point of planning the project.

The current best full development lifecycle analysis evaluates that for a typical project, 20 to 40% of the overall emissions for a building are generated during the construction process. This is highly dependent on the type of building, but most traditional UK building is highly carbon intensive: the manufacture of steel, brick, concrete and cement generate significant emissions.

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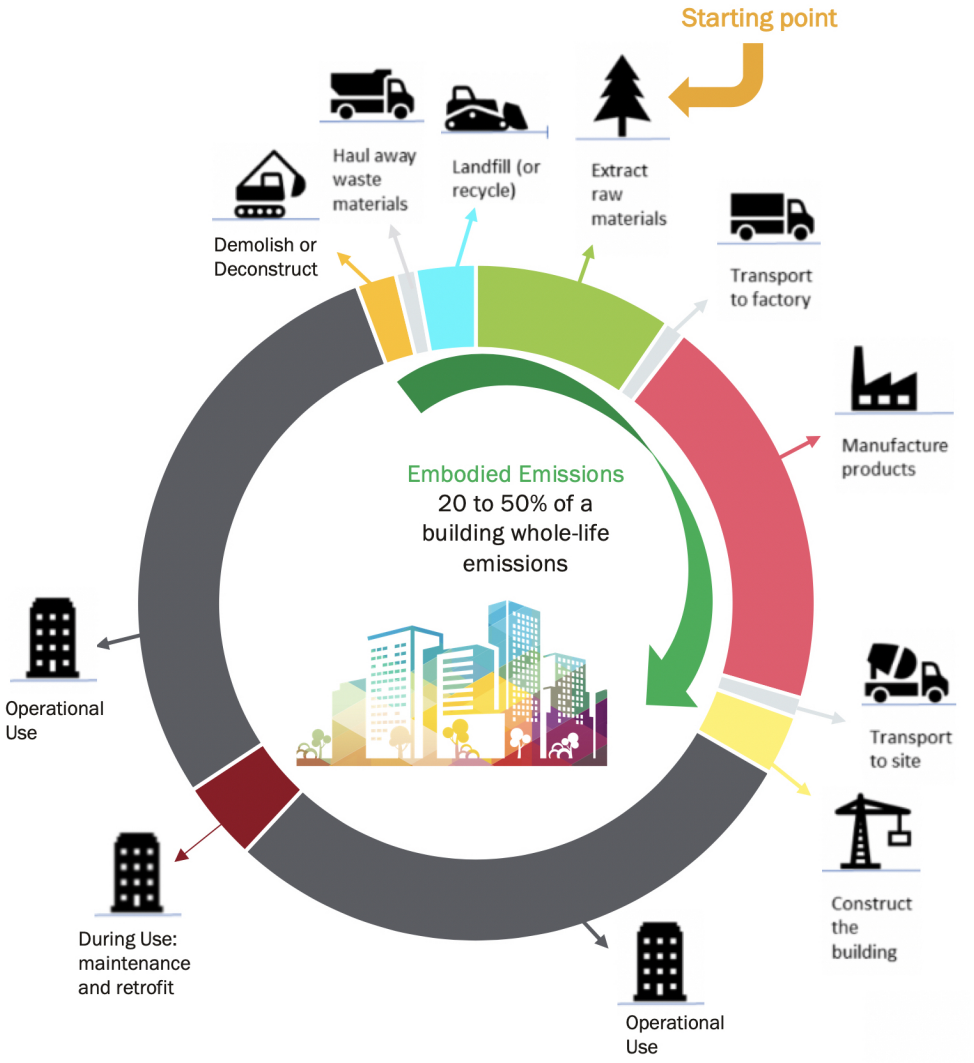
1 https://www.gov.uk/guidance/climate-change#how-can-the-challenges-of-climate-change-be-addressed-through-the-local-plan

Figure 1: Illustrated embodied and operations carbon emissions from a building life cycle



Source: C40 Cities

Detailed evaluation of existing and current development projects where carbon emissions have been calculated using quantity surveying, building information management and building standard accreditation provides data that can be applied to planned future projects.

This paper sets out a model for providing estimated carbon emissions for future developments.

Aim and objective

The aim of this analysis is to compare and contrast the impact on the district greenhouse gas emissions from the development options to inform decision making at the options stage of the Local Plan 2040 process.

The objective is to provide a quantitative evaluation of, and a comparison between the high-level development options.

Best practice for greenhouse gas emissions assessments

The Greenhouse Gas Protocol is the global standard for evaluating greenhouse gas emissions. The approach used in this evaluation is based on guidance from the protocol and includes all scopes of emissions: emission from energy and fuel consumption and emissions from the supply chain required to construct and operate the developments. However, some crucial types of greenhouse gas emissions are excluded, which fuller methodologies should include.

Table 1: Emissions sources during building life cycles

Emissions source associated with new developments	**Type of greenhouse gas emissions**	**Scope** 1=fuels used on site 2=electricity generation and off gases 3=supply chain and materials	**Included / Excluded**
Ground works and infrastructure	Emissions from materials and construction processes	1,2 & 3	Included
Construction	Emissions from materials and construction processes	1,2,3	Included
Operation of the developments	The energy used to heat and power the developments to 2050	1,2	Included
Activities associated with using the developments	Energy for transport, distribution, consumption and supply chains	3	Not included
End of life for the developments	Demolition of the developments	1,2,3	Not included
Land use change	Development of previously undeveloped land usually also adds to greenhouse gas emissions	3	Not included

An example of similar analysis of the greenhouse gas emissions impacts of development options for Local Plan purposes was published for the Greater Cambridge Local Plan in November 2020. Entitled ‘Greater Cambridge Local Plan - Strategic spatial options appraisal: implications for

carbon emissions[2]' used a methodology that assessed the embodied and operational carbon emissions from the residential development plus the in-use transport emissions. The Greater Cambridge analysis specifically compared the effects of rural vs. urban development on transport emissions (from commuting) and the emissions reduction from applying net zero operational emissions standards to new development. It concluded that both urban-focussed development - reducing the need to travel - and net-zero building standard were necessary approaches to reducing emissions. However, the Greater Cambridge analysis chose to discount construction emissions by spreading them over the lifetime of the building - dividing them over 60 years - instead of including the construction emissions when they occur (when the building is constructed).

The decision of where to draw the boundary for the analysis, defining which emissions to include and which to exclude, is therefore complicated and subjective. Residential and commercial development leads to growth in volumes of activity that includes infrastructure, consumption of materials, goods and services, energy and transportation. The emissions from construction and energy usage comprise around 40-50% of the total carbon emissions footprint of the UK based on BEIS and DEFRA data.

Therefore evaluating the construction and operational emissions of the development options is a starting point for comparing the greenhouse gas emissions impact, but does not reflect the totality of emissions that are generated though development.

Methodology

Evaluating greenhouse gas emissions is complex and includes many facets and factors. An accurate emissions analysis would require detailed design details, location and infrastructure as well as a comprehensive projection of all of the aspects that influence operational emissions into the future.

There are two broad approaches to evaluating greenhouse gas emissions:

1. Top down approach
2. Bottom up approach

Top down approach

This approach uses summary volumes of activity and emissions factors to calculate greenhouse gas emissions. It is appropriate for initial evaluations, providing comparisons to inform further detailed investigation and for informing strategic decisions.

Bottom up approach

This approach requires detailed material, energy and fuel quantities as well as details of supply chains and operating conditions in order to aggregate greenhouse gas emissions from all the

[2] Bioregional, on behalf of Greater Cambridge Shared Planning Authority November 2020 https://www.greatercambridgeplanning.org/media/1389/gclp-strategic-spatial-options-assessment-implications-for-carbon-emissions-nov2020.pdf

source activities associated with a development. This approach is appropriate for detailed emissions minimization work at an individual building or development site level.

For this analysis the top-down approach is used, using quantities of development (number of dwellings, commercial floorspace, length of new road infrastructure) and applying carbon emissions factors from national research.

Consideration of potential Local Plan emissions reduction policies

Within the Local Plan policy options are potential actions to reduce emissions from construction activities across the district, to increase renewable energy production and to make changes to the transport system to assist with work towards net zero greenhouse gas emissions.

The scope of this analysis does not include evaluating the impact of those policy options on reducing emissions at a district level; the evidence for those options is presented elsewhere.

However, since the application of district energy standards is an important consideration for new development, all development options are evaluated using current Building Regulations Part L, the proposed 2021 uplift to Building Regulations Part L and the implementation of a Net Zero operational carbon emissions policy to new development. The evaluation of these options helps to show the impact of applying improved buildings energy efficiency standards on district construction and affects the emissions from operating the buildings once they are constructed.

There are no known existing UK national policies to regulate the embodied carbon which are defined as the greenhouse gas emissions generated during the construction process from the materials and energy that are required to make a building. The Royal Institute for British Architects (RIBA) has called for the UK Government to include embodied carbon standards within planning law. Both RIBA and the Royal Institute of Chartered Surveyors have targets and methodologies to evaluate and reduce emissions from the construction process. The London Assembly has completed a public consultation on the proposed requirement for life cycle assessments which evaluate the total embodied and operational carbon for a building over its lifetime to be included in planning proposals. The life cycle analysis approach is designed to balance trade-offs between the construction type and materials and the energy efficiency of the building.

Evaluating potential routes to reducing embodied carbon is beyond the scope of this analysis and therefore the methodology uses the current average embodied carbon emissions per unit area of building for residential and commercial types.

Inputs

Development options

The residential development options for development to 2040 are defined as:

Table 2: Local Plan 2040 high level development options

Development options	Traffic Schemes	Development in around Canterbury	Development in Whitstable	Development in Herne Bay	Total additional development, including villages and baseline
Option 1	Baseline	4000	500	1500	9,000
Option 2	Whitstable Bus Route Chestfield New Link & Junction Whitstable Park & Ride	2000	2000	2000	9,000
Option 3	Clean Air Zone Removed A2 Off Slip Bus Lane Approach Whitstable Bus Route New Wincheap Multi Storey Thanington 4th Slip Hospital Access Signalised Junctions 4th Park & Ride	4000	1000	1000	9,000
Option 4	Clean Air Zone Removed A2 Off Slip Bus Lane Approach Western & Eastern Bypass New Wincheap Multi Storey Thanington 4th Slip Hospital Access Signalised Junctions 4th Park & Ride	9000	1000	1000	14,000
Option 5	Shared Streets Removed A2 Off Slip Bus Lane Approach Western & Eastern Bypass New Wincheap Multi Storey Thanington 4th Slip Hospital Access Blockers & Corridors 4th Park & Ride	9000	1000	1000	14,000

Commercial and business space options are not expressed in the same way; the Economic Development and Tourism Study (2020) projects a need for 136,700 m^2 of business space development through the Local Plan 2040. The transport modelling and this work is based on delivering 48,500 m^2 of business space to 2040.

Note that these options do not include all district development:

- In addition to the residential, commercial and road infrastructure, options include other infrastructure including schools and health facilities. These have not been included in this model.
- There will also be underlying infrastructure changes, modification of existing buildings, domestic and commercial extensions which are not included in the strategic planning data. All of this additional development is included in national and regional energy and consumption emissions data, but it is not currently possible to evaluate this in detail at a district level.

Emissions factors

The following emissions factors have been used for the evaluation:

Table 3: Emissions factors for construction of buildings and roads, and operation of buildings

Activity	**Emissions factor**	**Source**	**Notes**
Embodied emissions (domestic) Emissions from constructing a typical brick UK home (including groundworks and local infrastructure)	42.5 tonnes CO_{2e} for the average UK house of 85m^2 usable floor area 650 $kgCO_{2e}/m^2$ is the RIBA target value for 2025 = 38.5 tCO_{2e} for the average 85m^2 house	Atkins / RICS / CITU	Typical range 500-1000 $kgCO_{2e}/m^2$ during the construction process (Atkins/RICS) for all 1-3 storey housing types. Note that apartments and more than 3 storeys have higher embodied emissions. Includes the groundworks and local infrastructure for the development.
Operational emissions (domestic) Emissions from heating and powering homes	2.4 tonnes CO_{2e} per year (for typical current new build home EPC B) (28 $kgCO_{2e}/m^2/y$) 0 tonnes CO2e per year for Net Zero / Passive House build	Domesticenergymap.uk + UK EPC Register on epc.opendatacommunities	The emissions from running gas central heating and the electricity to power the home. This is equivalent to a typical 85m^2 home of EPC efficiency
Embodied emissions (non-domestic)	50 - 1000+ $kgCO_{2e}/m^2$ 650 $kgCO_{2e}/m^2$ is the RIBA target value for 2025	RICS / Atkins / RIBA	Embodied emissions for non-domestic buildings vary widely from low for light industrial shed type to high for multiple storey office or hotel construction
Operational emissions (non-domestic)	10 - 20 $kgCO_{2e}/m^2.yr$	Commercial EPCs at level A performance (2020)	Commercial EPCs based on metered usage and 2020 UK greenhouse gas emissions factors for gas and electricity
Embodied emissions (road and associated infrastructure)	4,500 tCO_{2e} / Lane.km (New road infrastructure) 1,000 tCO_{2e} / Lane.km (Modification to existing road infrastructure)	Highways England data for other UK road schemes. Estimate.	Schemes differ significantly in complexity and especially where bridge building, embankments and cuttings are required. Data for modifications to existing road e.g. junction alterations are not currently readily available. Each scheme should have a more detailed estimate using the Highways England carbon calculation tool.

These emissions factors are based on the best available evidence; the level of accuracy is likely to be ±25% and the estimated emissions values should therefore be used as guidance only in the relative impacts between options.

Assumptions

The following assumptions have been used for this evaluation:

Table 4: Model assumptions

Assumption	**Notes**
Options are comparable in embodied and operational emissions standards	The assumption is that the choice of quantity and spatial development is independent from the implementation of higher energy efficiency standards and the changes to heating and energy technology; the comparison between options is therefore assumed to be unaffected by this.
Operational emissions are based on 2021 energy systems; different options do not impact the future energy system mix	The assumption is that the spatial allocation of development is independent from the change to the energy systems and does not affect the ability of the district to deliver renewable energy projects; the comparison between options is therefore assumed to be unaffected by this
Rate of development is the same under all options	The choice of spatial allocation and targets does not affect the rate of development and targets are assumed to be met. If one option were to appreciably slow or accelerate the rate of development compared to other options, this would have an impact on the rate of production of greenhouse gas emissions.
Rate of development is linear	The Local Plan does not directly specify the rate of development; it sets policy for how development planning should proceed. Analysis of development from 2009 to 2019 shows between year variability with a consistent underlying trend of 493 new residential properties per year (not including student accommodation developments). For this evaluation, a linear development from 2022 to 2040 is assumed.

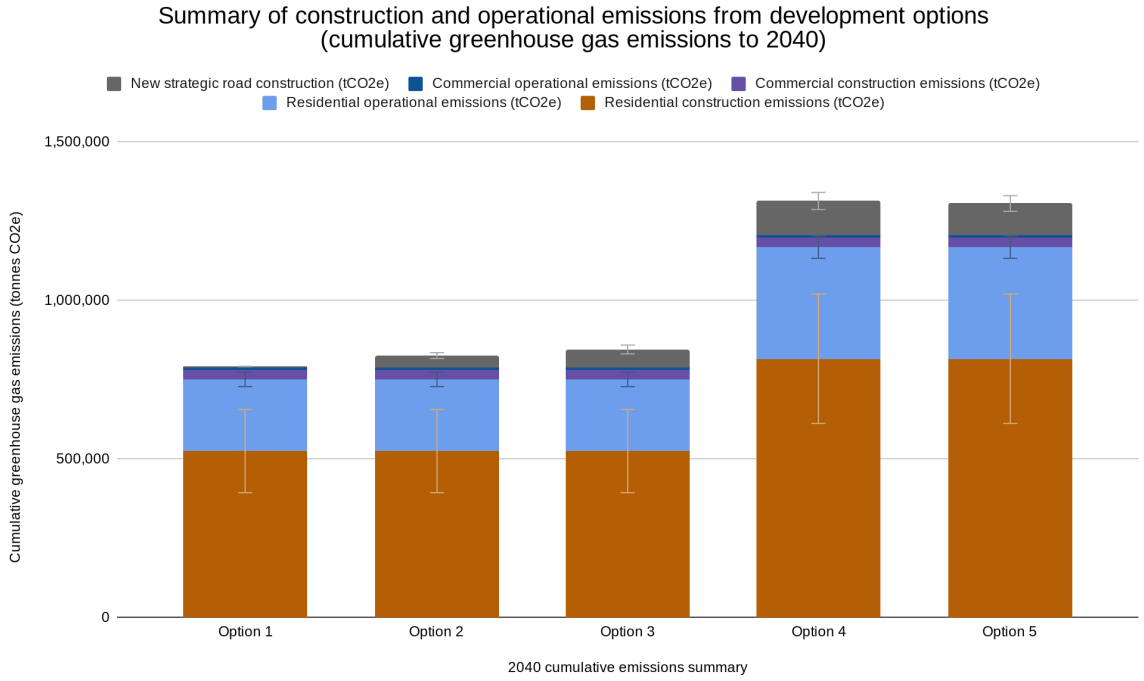
Evaluation

The emissions arising from the local plan options residential and commercial construction operation and the construction of the associated transport infrastructure are as follows:

Table 5: Cumulative emissions summary

2022-2040 cumulative emissions summary (approximate)	Option 1	Option 2	Option 3	Option 4	Option 5
Residential construction emissions (tCO2e)	525,038	525,038	525,038	816,725	816,725
Residential operational emissions (tCO2e)	226,170	226,170	226,170	351,820	351,820
Commercial construction emissions (tCO2e)	31,525	31,525	31,525	31,525	31,525
Commercial operational emissions (tCO2e)	7,275	7,275	7,275	7,275	7,275
New strategic road construction (tCO2e)	2,250	36,450	55,700	107,000	99,000
Total construction and building infrastructure emissions (tCO2e)	792,258	826,458	845,708	1,314,345	1,306,345

For comparison, the 2017 greenhouse gas emissions from consumption for Canterbury district (i.e. the total carbon footprint of the district) was 1,500,000 tCO2e (DEFRA data using population pro-rata method). The district carbon footprint includes all greenhouse gas emissions of which the construction and operational emissions are a subset.



Discussion

It is important to note that these evaluations are approximate based on the defined options. The calculated emissions are based on the size of the developments and only include the developments themselves and the defined associated major transport infrastructure schemes. This evaluation is for option comparison purposes: The actual emissions could be significantly higher or lower depending on multiple factors including the rate of development, the type of development and construction methods employed, regulations on the primary heating technologies for new developments and the selected energy efficiency standards within the Local Plan.

The cumulative emissions from the development options through to 2040 is in the range 790,000 - 1,300,000 tonnes carbon dioxide equivalent. This is similar to the total carbon footprint of the Canterbury district for one year.

- The evaluation shows that the projected emissions from the construction of residential buildings are the largest cumulative source of greenhouse gas emissions under all development options. In order to proceed with the development under all options, it will be necessary to significantly reduce construction emissions and this is most likely to be achieved by using non-traditional construction materials and methods with much lower embodied carbon emissions.

- The operational emissions from the residential development are the second largest source of greenhouse gas emissions, and these emissions will continue beyond 2040. Of the sources of greenhouse gas emissions, the residential operational emissions are the easiest

to reduce by constructing the developments to a net zero energy emissions standard. This approach would reduce the ongoing emissions from the development options to effectively zero emissions per year. The most efficient modern developments in the UK use no fossil fuels for heating and power are net exporters of renewable energy to the grid and therefore contribute to reducing emissions.

- The commercial development emissions are projected to be a very small component of the overall emissions.

- The strategic transport infrastructure components of the options are small for option 1 (baseline) and significant (~5%) for option 2, and large (~10%) for options 3-5. The construction of major additional road transport infrastructure is a large source of greenhouse gas emissions. The impacts on greenhouse gas emissions from the use of the roads is evaluated in a separate report. The proposed schemes under all options will require more specific and detailed life cycle assessment as per Highways England LA 114 Climate (October 2019) which sets the methodology for evaluating and reducing emissions from road construction.

- As noted above, the figures do not reflect the wider impact of changes in travel patterns, such as increased active travel, which would be realised through the new transport strategy. The transport modelling (Stage 3 Report - May 2021) suggests that Option 5 leads to the greatest level of mode shift.

The evaluation shows that the carbon emissions associated with constructing and operating new development within the local plan will be significant under all the potential options. This will add to the challenge of reducing district emissions by 75% during the plan period in line with UK Government targets: in order to meet these targets, the embodied and operational emissions from the selected development options must be minimised and they must enable further emissions reductions from the existing district systems, for example by new developments being net generators of renewable energy or by enabling an existing neighbouring development to reduce car usage.

Conclusions

This evaluation demonstrates that the cumulative greenhouse gas emissions associated with making and operating the proposed residential, commercial developments and constructing the major transport infrastructure is large under all options.

Given the national, regional and local priorities for reducing greenhouse gas emissions to net zero emission by 2050 and by around 75% during the plan period, it is critical that policies within the Local Plan enable the reduction in emissions from construction and development.

Embodied carbon emissions assessments
Planning proposals for developments of all types should include embodied carbon emissions assessments to evaluate the projected carbon emissions from the developments. The efforts and methods to minimise the emissions from the construction materials and process should be demonstrated. A record of the construction emissions from both planned and delivered projects should be kept by the planning authority in order to inform policy and practice.

Operational emissions standards
This evaluation shows that it is imperative that the energy efficiency standards of both residential and commercial development are set so that the buildings achieve net zero operational emissions. This is a tried and tested approach, will reduce cumulative emissions from all development options by around 30%, and will contribute to reaching net zero emissions beyond the life of the plan.

Minimise infrastructure emissions
Methods for constructing large infrastructure projects without generating carbon emissions do not exist currently. The scale of the projects must therefore be reduced to the minimum to achieve net emissions reduction benefits. All schemes should therefore be assessed as per Highways England carbon emissions life cycle methodology.

Appendices

A1 Source data for operational emissions

BEIS data for average annual domestic energy usage at district, ward and postcode level gives the following energy usage:

Fuel	**Average usage (kWh/y) 2019 per dwelling**	**New build conventional home (kWh/y) 2019 per dwelling EPC B**	**Passive house standard (kWh/y) 2019 dwelling EPC A+**
Gas	13200	8700	-
Electricity	3600	2600	0
Carbon emissions (based on 2020 emissions factors)	3529	2378	0 (Note: A+ rating is net zero operational emissions. Some A+ dwellings are net exporters of energy)

Source: domesticenergymap.uk accessed April 2021

A2 Housing mix

The projected housing mix used for the developments is as follows:

House size	1 bed	2 bed	3 bed	4+bed
Market range	0-5%	26-31%	36-41%	23-28%
Assumed proportion	4%	30%	39%	27%
Assumed build type	Apartment block	50% terraced, 50% apartment	50% attached, 50% detached	100% detached

Source: Market ranges - Housing, homelessness and rough sleeping strategy 2018-23. All others estimated.

A3 Highways construction

Scheme Name	**Approximate Lane-Kilometres and Notes**	**Embodied Emissions (including a worst-case scenario 10% contingency) (tCO_{2e})**	**Embodied** **tCO_{2e} / lane.km**	**Other construction emissions** **tCO_{2e} / lane.km**
Proposed Scheme	4.9km	15,050	3,070	1,535
A14	204 lane kms Including 30 bridges	740,060	3,630	4,785
A737 Dairy Bypass (Scottish Benchmark)	7.6 lane kms One major viaduct	16,090	2,120	2,400
Other international data	-	-	2,140 - 2,875	-
Selected benchmark			4,500 tCO_{2e} / lane.km	

Source: JACOBS 2018;

Glossary of acronyms

BAU Business as usual. Refers to today's current practices in design, construction and transport

BEIS UK national government department for Business, Energy, Innovation and Skills

Building envelope The external elements of a building (external wall, roof, windows)

Carbon intensity Amount of carbon emitted during the production of a unit of energy

CO_2 Carbon dioxide

CO_{2e} Carbon dioxide equivalents - includes other greenhouse gases including methane and refrigerants, expressed as the equivalent warming potential as CO_2 which comprises about 80% of the greenhouse gas emissions.

Energy performance gap The difference between the predicted energy use of a building when it is designed compared to actual use. Usually occurs due to a combination of faults or changes in the construction process, modelling inaccuracies, and unanticipated user behaviours.

Embodied carbon Carbon emissions that already happened during the production, transport and assembly of goods before they are used or operated (such as building materials and construction)

EV Electric vehicle

GB Greenbelt

GHGs Greenhouse gases

kWh Kilowatt-hours (a unit of energy)

Operational carbon Carbon emitted during the operation of a building or vehicle

PV Photovoltaics (solar panels generating electricity) tCO2/y Tonnes of carbon dioxide per year

ZC Zero carbon

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