ARUP

Stratford-on Avon District Council & Warwick District Council

South Warwickshire Local Plan

Estimation of emissions for proposed growth options and new settlements

Reference: 287045-00

1 | 01 November 2022

Job number 287045-00

Ove Arup & Partners Limited
8 Fitzroy Street
London
W1T 4BJ
United Kingdom
arup.com

Document Verification

Project title	South Warwickshire Local Plan
Document title	Estimation of emissions for proposed growth options and new settlements
Job number	287045-00
Document ref	287045-00
File reference	4-02

Revision	**Date**	**Filename**	2022-10-20_SWLP_EmissionsEstimates_Issue.docx		
Draft		**Description**	Model methodology and results commentary		
			Prepared by	**Checked by**	**Approved by**
		Name	Harrison King	Laura Frost, Craig Rowbottom	Laura Frost
		Signature			
Draft – new settlements		**Filename**	2022-10-20_SWLP_EmissionsEstimates_Issue.docx		
		Description	Model methodology and results commentary		
			Prepared by	**Checked by**	**Approved by**
		Name	Harrison King	Laura Frost, Craig Rowbottom	Laura Frost
		Signature			
Final Document	01/11/2022	**Filename**	2022-10-20_SWLP_EmissionsEstimates_Issue.docx		
		Description	Model methodology and results commentary		
			Prepared by	**Checked by**	**Approved by**
		Name	Harrison King	Craig Rowbottom	Craig Rowbottom
		Signature			

Issue Document Verification with Document ✓

Contents

1.	Introduction	1
1.1	South Warwickshire Local Plan vision	1
1.2	Site overview and growth options	1
1.3	Scope of this study	2
2.	Growth options emissions comparison	3
3.	Analysis of each Growth Option	4
3.1	Rail Corridors	4
3.2	Sustainable Travel	7
3.3	Economy	10
3.4	Sustainable Travel & Economy	13
3.5	Dispersed	16
3.6	Conclusions	19
4.	Analysis of each new settlement	20
4.1	A1: Henley-in-Arden	21
4.2	B1: Hatton Station	22
4.3	C1: Kingswood	23
4.4	F2: Depper's Bridge	24
4.5	E1: Long Marston Airfield / Meon Vale	25
4.6	F1: Wood End	26
4.7	F3: GLH Gaydon / Lighthorne Heath	27
4.8	Conclusions	28
5.	Model Methodology	29
5.1	Methodology introduction	29
5.2	Model structure	29
5.3	Model inputs	29
5.4	Defining scenarios	30
5.5	Calculation method	32

Appendices

A.1	Input data	35
A.2	References	36

1. Introduction

1.1 South Warwickshire Local Plan vision

Stratford-on-Avon and Warwick District Councils (SDC and WDC) are aiming to gain an understanding of the emissions associated with proposed growth options for the future development of South Warwickshire. Arup have created a high-level emissions model for the entire South Warwickshire area which calculates forecasted emissions for each of the five growth options and new settlements until 2050. Each growth option has a total of 35,000 new homes and 330 ha of new employment land. The aim of this model is to provide an emissions evidence base to support the decision-making process and allow SDC and WDC to alter inputs in the model to see the effect of their planning decisions. The findings will be taken into account in decisions for the South Warwickshire Local Plan.

1.2 Site overview and growth options

The South Warwickshire boundary is shown in Figure 1 below which is a diagram of Growth Option 1 – Rail Corridors. Whilst the total number of homes and employment land is the same across each of the five growth options, their spatial placement differs.

In Growth Option 1 we see development focussed on the existing **Rail Corridors** in South Warwickshire, particularly around existing railway stations, but also anticipating the possibility of new stations on existing lines, or re-opening closed lines.

In Option 2 – **Sustainable Travel**, we build upon Option 1, recognising that in many parts of South Warwickshire bus travel is the only viable public transport option. Utilising the main bus corridors relieves some of the pressure on Green Belt land, shifting the balance of growth away from the North and West of the South Warwickshire area.

In Option 3 – **Economy** the focus is to locate development close to existing jobs and potential new job locations; and to tackle socio-economic disadvantage through the benefits development can bring. These benefits could be in the form of Developer Contributions towards infrastructure and providing affordable housing.

In Option 4 – **Sustainable Travel and Economy** the aim is to provide best aspects of Option 2 and 3, to address the main aims of each individual option. This means a balance of growth at existing main settlements, some growth at new settlement scale on the rail lines, and more modest growth in smaller settlements.

Option 5 – **Dispersed** enhances the vitality of individual settlements, bringing in new customers to rural facilities, but at the cost of harder to implement infrastructure improvements and discouragement of sustainable shared travel. Arup assumes higher reliance on the private car in this option.

New Settlements are also one of several options also being considered in order to deliver the amount of growth required over the plan period, contributing towards the overall housing and employment land requirements. The number and location of new settlements vary depending on the growth options, with seven areas being considered.

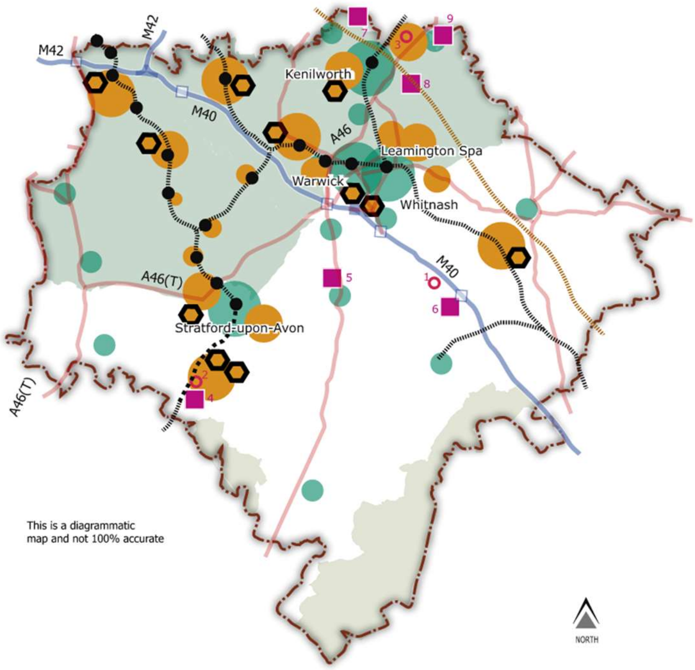

Figure 1 – South Warwickshire map showing Growth Option 1 – Rail Corridors

1.3 Scope of this study

This study has developed an operational carbon model that allows Stratford-on-Avon and Warwick District Councils to assess carbon emissions at a strategic level and test how the development of five growth options performs against each other. Each growth option is modelled as a scenario where various levers and inputs reflect different policy and design decisions and changes in the market.

The model is based on current Government and existing Local Plan policies as set out in section 5. The results of the scenario modelling give a better understanding of which levers will have the greatest impact on future carbon emissions of each growth option.

Section 2 provides a high-level comparison of the estimated emissions associated with each growth option, annually and cumulatively between 2025 and 2050. Section 3 presents additional insight into the baseline data, assumptions, and findings for each growth option in turn. Section 4 presents additional insight into the analysis of each of the proposed new settlements, with each modelled under the growth options for which they are included. Section 5 describes the data that has been used and calculations undertaken to reach these outputs, with key inputs in Appendix A.1.

1.4 Potential next steps

This study and supporting model reflect the information available at the South Warwickshire Local Plan Issues and Options stage. It is only one source of evidence being used to inform the development of the Local Plan, with the Councils having other sources of information as part of the evidence base that will inform which growth options and new settlements to include in the next stage of Local Plan development.

The model has been built in a flexible manner to allow more detailed data to be easily added at these future stages. This could include additional site specific information and other or updated sources of information, such as further data released from Census 2021 - like travel mode split.

In particular, the model could also reflect emerging policy direction at each stage of the Local Plan preparation to help refine options, including details on phasing, housing trajectory, densities, and energy efficiency standards. The study highlights potential interventions that can be used to inform the development of policies in the emerging South Warwickshire Local Plan.

2. Growth options emissions comparison

This section provides a high-level overview of the findings from the emissions modelling across all the growth options. Cumulative and annual emissions are compared in Section 2.1.1 and a summary of the key differences assumed when modelling each of the growth option scenarios is provided in Section 2.1.2.

2.1.1 Growth options emissions results

Table 1 - Comparison of emissions between Growth Options in 2050

Growth option	Cumulative emissions in 2050 (tCO_2e)	Annual emissions in 2050 (tCO_2e)
Rail	3,530,000	18,400
Sustainable travel	3,530,000	18,100
Economy	3,470,000	18,000
Sustainable travel & economy	3,560,000	17,700
Dispersed	3,740,000	19,600

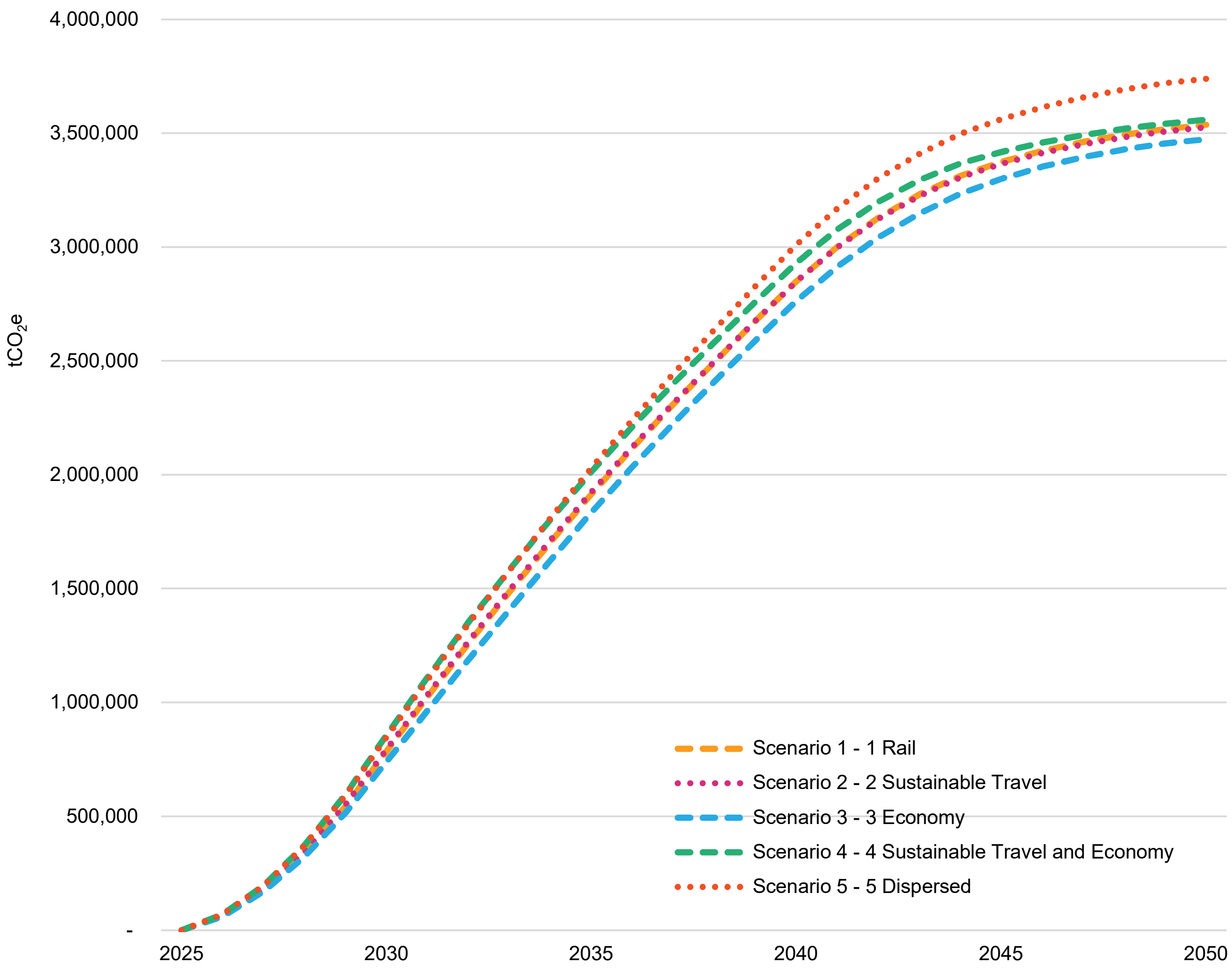

Figure 2 - Cumulative emissions comparison (tCO_2e)

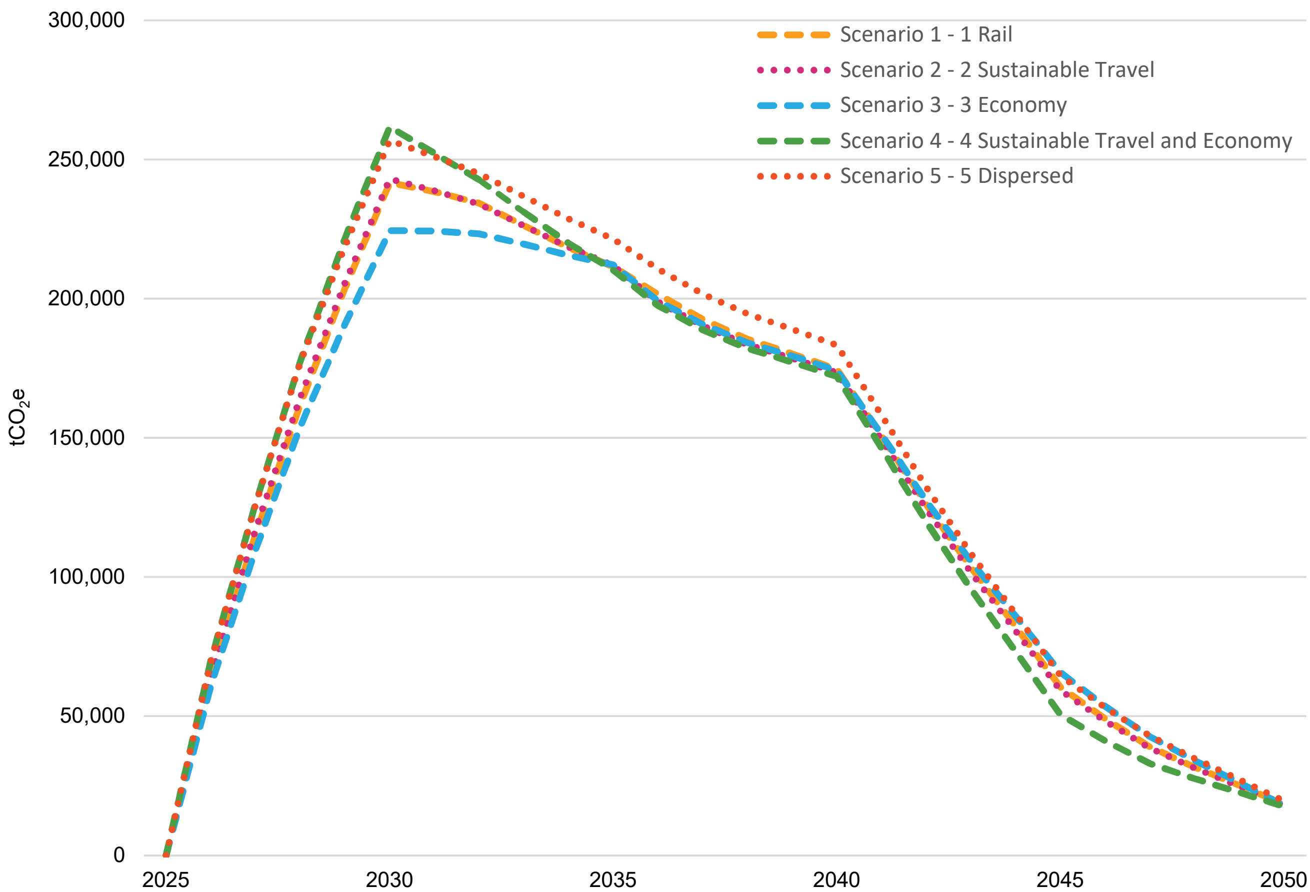

Figure 3 - Annual emissions comparison (tCO_2e)

Table 1 summarises the cumulative and year on year annual emissions for the five potential growth options in South Warwickshire. The cumulative emissions pathway is shown in Figure 2 whilst the annual emissions pathway is shown in Figure 3. From this we can determine that the Sustainable Travel & Economy growth option resulted in the lowest final annual emissions in 2050 (17,700 tCO_2e) compared with the alternative options, whilst the Dispersed option has the highest emissions (19,600 tCO_2e) compared with the alternatives. Despite having the lowest annual emissions in 2050, cumulative emissions for the Sustainable Travel & Economy growth are higher in 2050 than many other growth options. This is due to the Sustainable Travel & Economy growth option's emissions peaking higher than all other options in 2030 (Figure 3). The total area under this emissions pathway curve is therefore greater than many of the other growth options resulting in higher cumulative emissions by 2050.

2.1.2 Growth option inputs comparison

The following table provides a high-level comparison of the differences in growth option model inputs, providing explanation of the differences in emissions over time.

Table 2 - High level comparison of growth options interpretation in model

Growth Options	Buildings	Transport
Rail Corridors	Decarbonisation in line with national policies Carbon sequestration in line with local policy Lower retrofit and renewables deployment	Equal best reduction in car trips Lower uptake 20-minute neighbourhoods Equal EV Uptake
Sustainable Travel	Decarbonisation in line with national policies Carbon sequestration in line with local policy Lower retrofit and renewables deployment	Good reduction in car trips Equal best uptake of 20-minute neighbourhoods Equal EV Uptake

Growth Options	Buildings	Transport
Economy	Decarbonisation in line with national policies Carbon sequestration in line with local policy Higher retrofit and on-site renewables	Lower reduction in car trips Equal best uptake of 20-minute neighbourhoods Equal EV Uptake
Sustainable Travel and Economy	Decarbonisation in line with national policies Carbon sequestration in line with local policy Higher retrofit and on-site renewables	Equal best uptake of 20-minute neighbourhood Equal best reduction in car trips Highest EV Uptake
Dispersed	Decarbonisation in line with national policies Carbon sequestration in line with local policy Lower retrofit and renewables deployment	Lower uptake of 20-minute neighbourhoods Lowest reduction in car trips, although fewer commuter trips Equal EV Uptake

Table 2 highlights the key differences assumed when modelling each of the growth option scenarios, indicating where some of the best or highest uptake of measures to reduce carbon emissions have been assumed, and those with better or higher and a lower or lowest uptake. Further details are provided in Section 3.

3. Analysis of each Growth Option

This section provides further insight into the assumptions and outputs from each option. Each subsection contains a tabular summary of the main input variables affecting results in each growth option scenario. Following this, the resulting graphs show the breakdown of carbon emissions across sites within that growth option. This includes annual emissions broken down by categories (e.g., buildings and transport emissions), buildings emissions broken down by sub-categories (e.g., residential gas emissions or non-residential electricity emissions), and transport emissions broken down by mode (e.g., car driver emissions or rail emissions).

Across all scenarios, sequestered and waste emissions are included in the model calculation for each growth option and the methodology for this is explained in Section 5, however the magnitude of these values are considerably smaller than the magnitude of emissions from transport and buildings and they are therefore undetectable in the summary graphs.

3.1 Rail Corridors

3.1.1 Rail inputs and assumptions

Table 3 - Summary of data and assumptions applied for Rail option (all constant values are outlined in Appendix A)

Sector	Variable	Baseline value	Change to baseline for Rail option	Assumptions
Buildings	Additional on-site renewable deployment	50 kWp/year	No change	Lower as not economic hub focussed scenario
Buildings	Years after construction to retrofit residential	20 years	No change	Slower rate in non-economic hub focussed development
Buildings	Residential retrofit standard	Light Retrofit	No change	Light retrofit in non-economic hub focussed development
Buildings	Years after construction to retrofit non-residential	50 years	No change	Slower rate in non-economic hub focussed development
Buildings	Non-residential retrofit energy reduction	10%	No change	Lower energy reduction in non-economic hub focussed development
Transport	Private car EV % of total mode share in 2035	5.4%	59.6% (+65%)	Equal adoption due to focus and incentives on sustainable travel
Transport	Servicing LGV EV % of total mode share in 2035	1.0%	49.0% (+50%)	Equal adoption due to focus and incentives on sustainable travel
Transport	Servicing OGV EV % of total mode share in 2035	0%	50.0% (+50%)	Equal adoption due to focus and incentives on sustainable travel
Transport	Reduction in commuter trips from working from home	20%	No change	Assumed lower 20% value for all but dispersed
Transport	Reduction in overall trips in 2050 from 20-minute neighbourhood	0%	5%	Focus on better long distance trip connection
Transport	Reduction in car mode share long distance trips in 2050	0%	10%	Highest due to focus on rail links
Transport	Reduction in car mode share short distance trips in 2050	0%	10%	Highest due to focus on rail links

3.1.2 Rail results

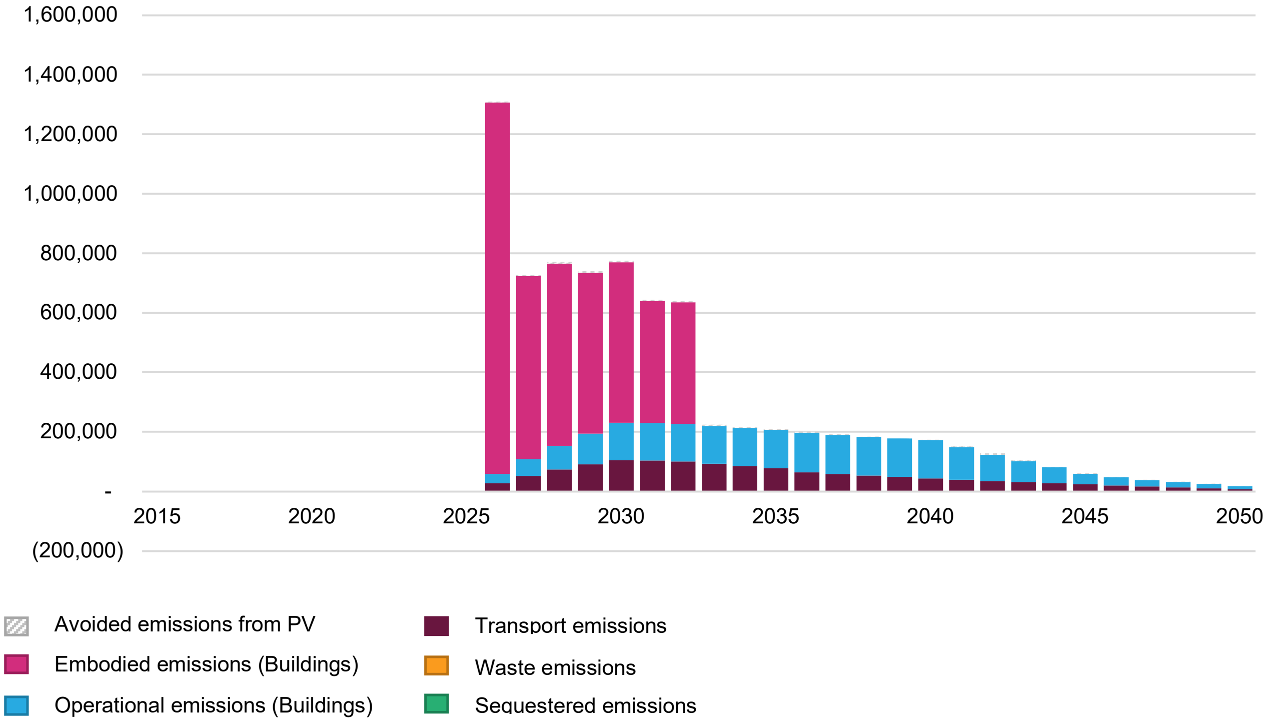

Figure 4 - Rail annual emissions including embodied emissions (tCO_2e)

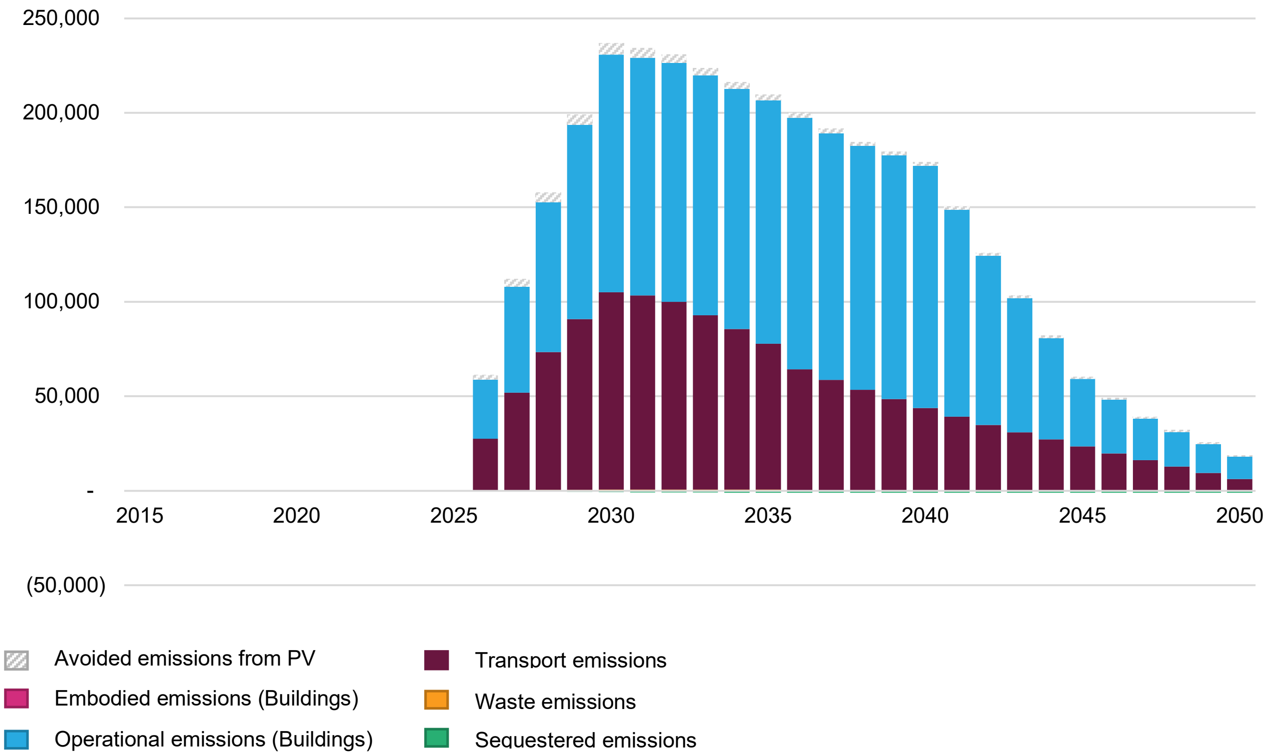

Figure 5 - Rail annual emissions excluding embodied emissions (tCO_2e)

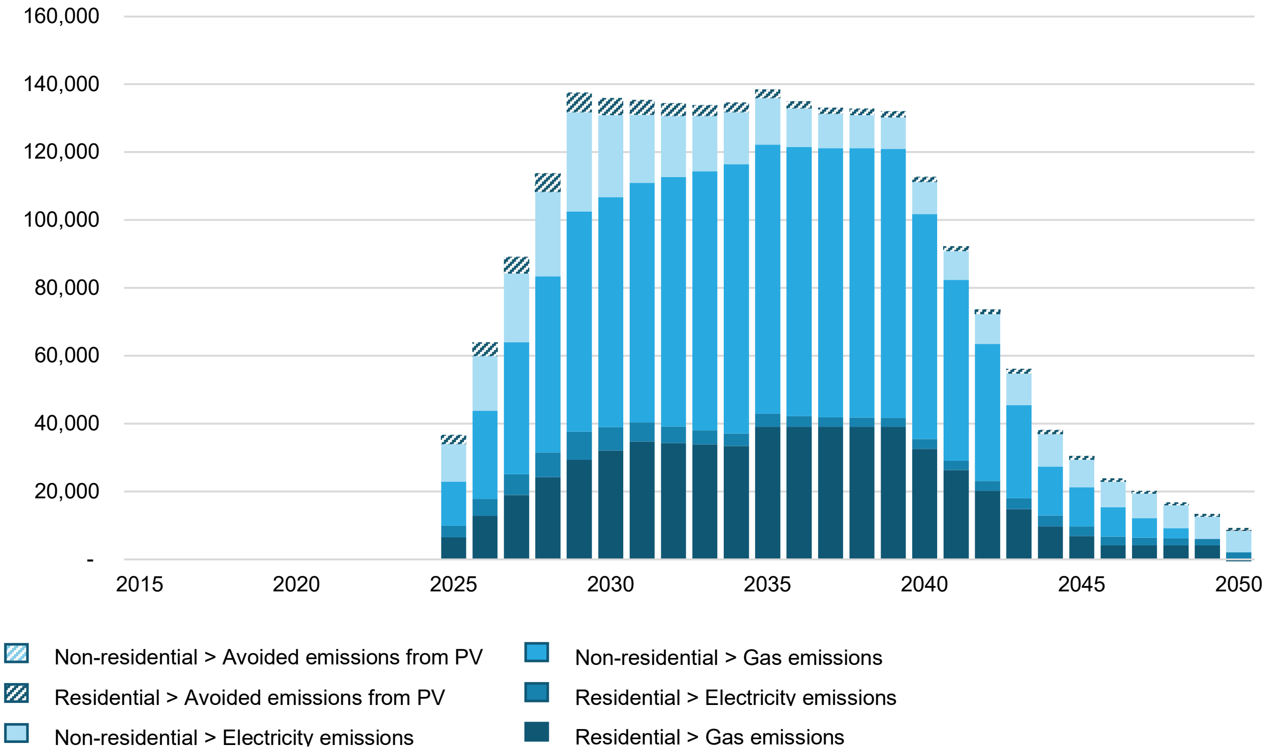

Figure 6 - Rail annual buildings emissions by sub-category (tCO_2e)

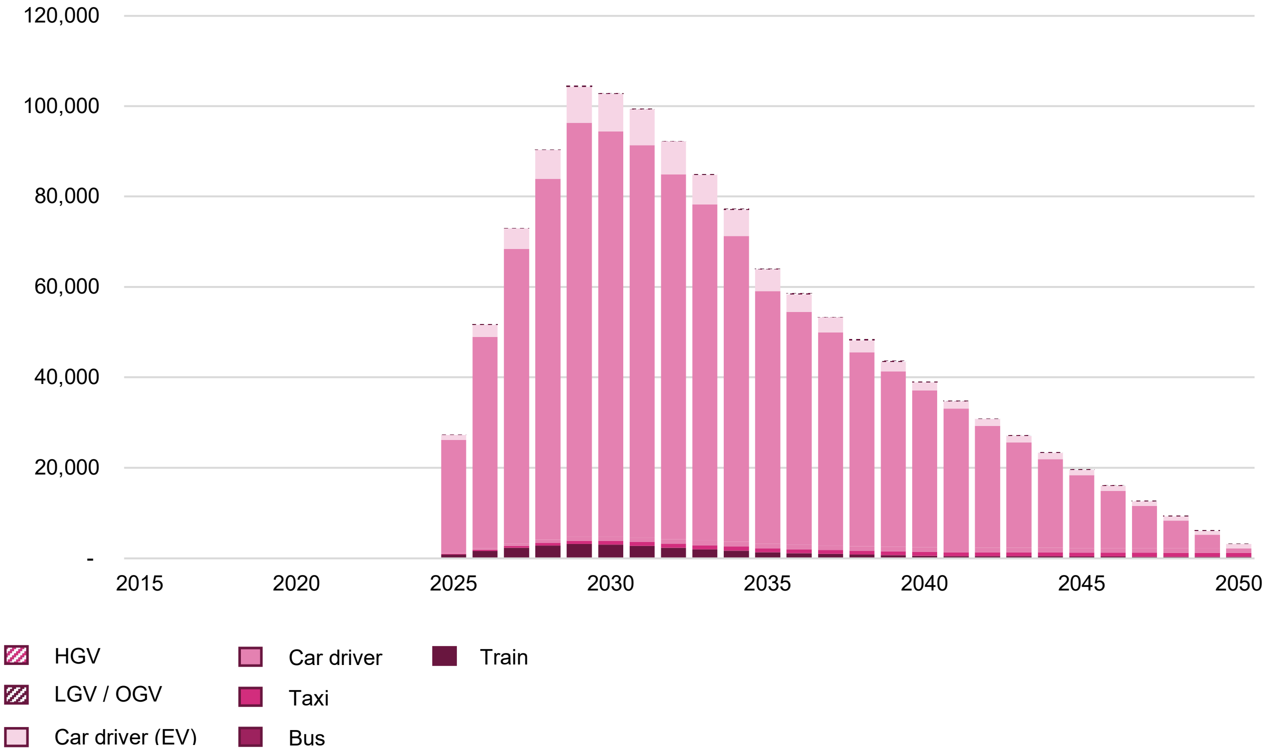

Figure 7 - Rail annual transport emissions by mode (tCO_2e)

3.1.3 Rail results commentary

Transport and operational buildings emissions slowly decrease in the Rail growth option in line with the decarbonisation of the national grid as shown in Figure 4 and Figure 5, however operational buildings emissions decrease at a slightly slower rate than other growth options.

In the Rail growth option, slightly lower values were assumed for buildings related input variables. For example, Table 3 shows that a slower retrofit rate of 20 years after construction was assumed and that retrofit would only be a light retrofit level rather than deep retrofit. This was due to the growth option being less focussed on creating an economic hub where higher levels of investment in retrofit was assumed. Because of this, the improvement in operational buildings emissions was generally lower than other growth options due to lower overall energy efficiency performance of buildings. EV assumptions were equal to all other growth options (apart from Sustainable Travel & Economy which assumed a slightly higher rate of adoption). This is reflected in Figure 7 which shows a similar transport decarbonisation pathway to the Sustainable Travel growth option.

3.2 Sustainable Travel

3.2.1 Sustainable Travel inputs and assumptions

Table 4 - Summary of data and assumptions applied for Sustainable Travel option (all constant values are outlined in Appendix A)

Sector	Variable	Baseline value	Change to baseline for Sustainable Travel option	Assumptions
Buildings	Additional on-site renewable deployment	50 kWp/year	No change	Lower as not economic hub focussed scenario
Buildings	Years after construction to retrofit residential	20 years	No change	Slower rate in non-economic hub focussed
Buildings	Residential retrofit standard	Light Retrofit	No change	Light retrofit in non-economic hub focussed
Buildings	Years after construction to retrofit non-residential	50 years	No change	Slower rate in non-economic hub focussed
Buildings	Non-residential retrofit energy reduction	10%	No change	Lower energy reduction in non-economic hub focussed
Transport	Private car EV % of total mode share in 2035	5.4%	59.6% (+65%)	Equal adoption due to focus and incentives on sustainable travel
Transport	Servicing LGV EV % of total mode share in 2035	1.0%	49.0% (+50%)	Equal adoption due to focus and incentives on sustainable travel
Transport	Servicing OGV EV % of total mode share in 2035	0%	50.0% (+50%)	Equal adoption due to focus and incentives on sustainable travel
Transport	Reduction in commuter trips from working from home	20%	No change	Assumed lower 20% value for all but dispersed
Transport	Reduction in overall trips in 2050 from 20-minute neighbourhood	0%	10%	Focus on better internal trips within villages such as bus routes
Transport	Reduction in car mode share long distance trips in 2050	0%	8%	High due to focus on sustainable travel but still some private car reliance
Transport	Reduction in car mode share short distance trips in 2050	0%	8%	High due to focus on sustainable travel but still some private car reliance

3.2.2 Sustainable Travel results

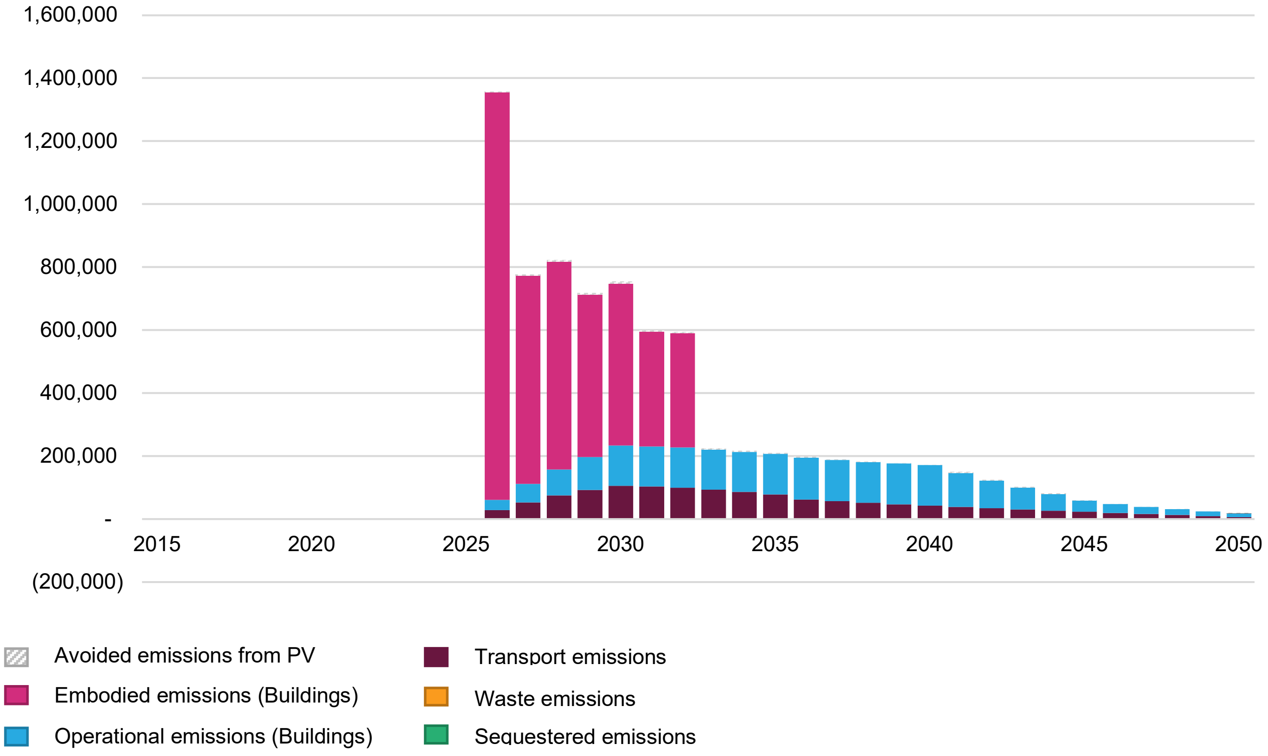

Figure 8 - Sustainable Travel annual emissions including embodied emissions (tCO2e)

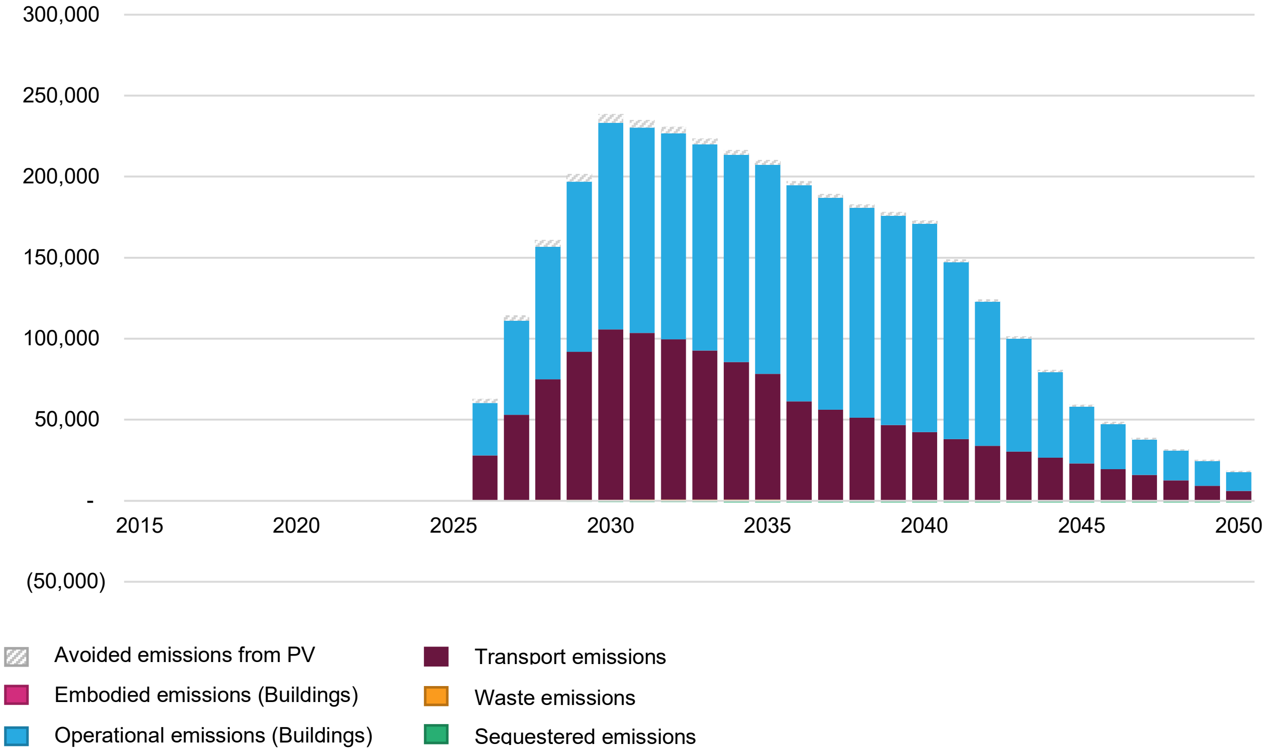

Figure 9 - Sustainable Travel annual emissions excluding embodied emissions (tCO2e)

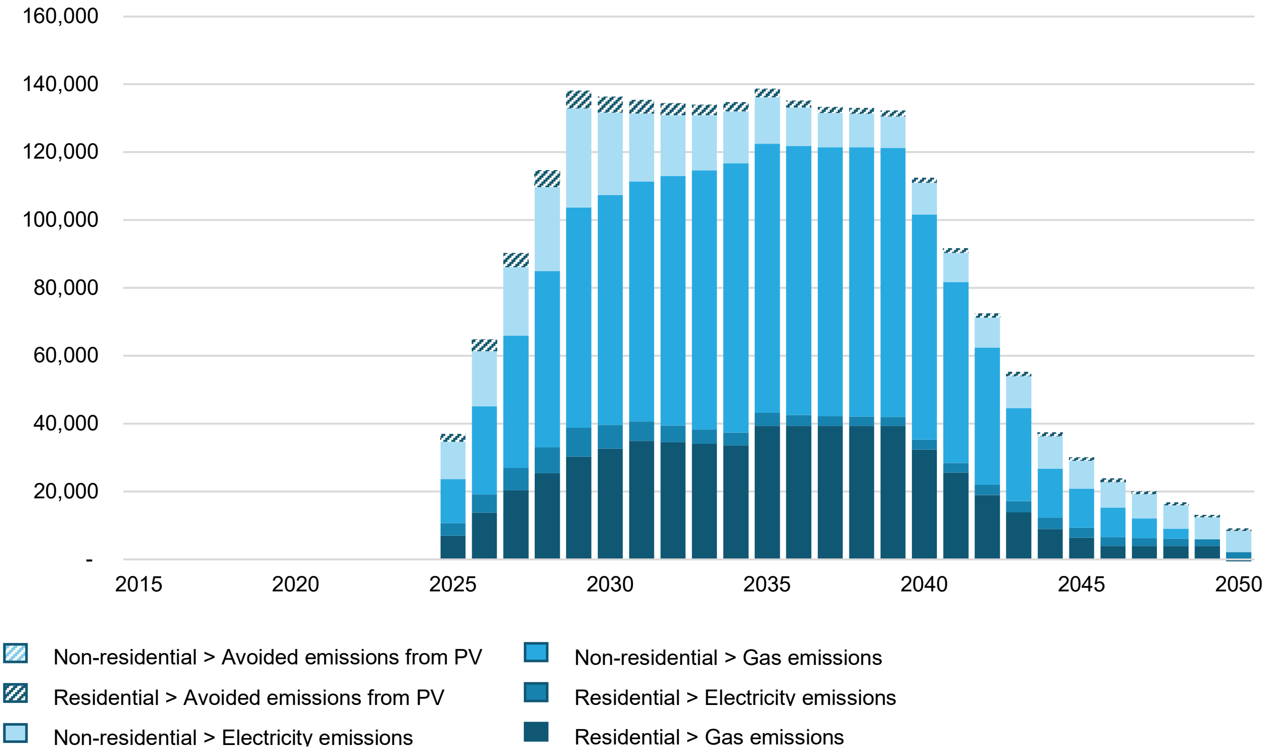

Figure 10 - Sustainable Travel annual buildings emissions by sub-category (tCO2e)

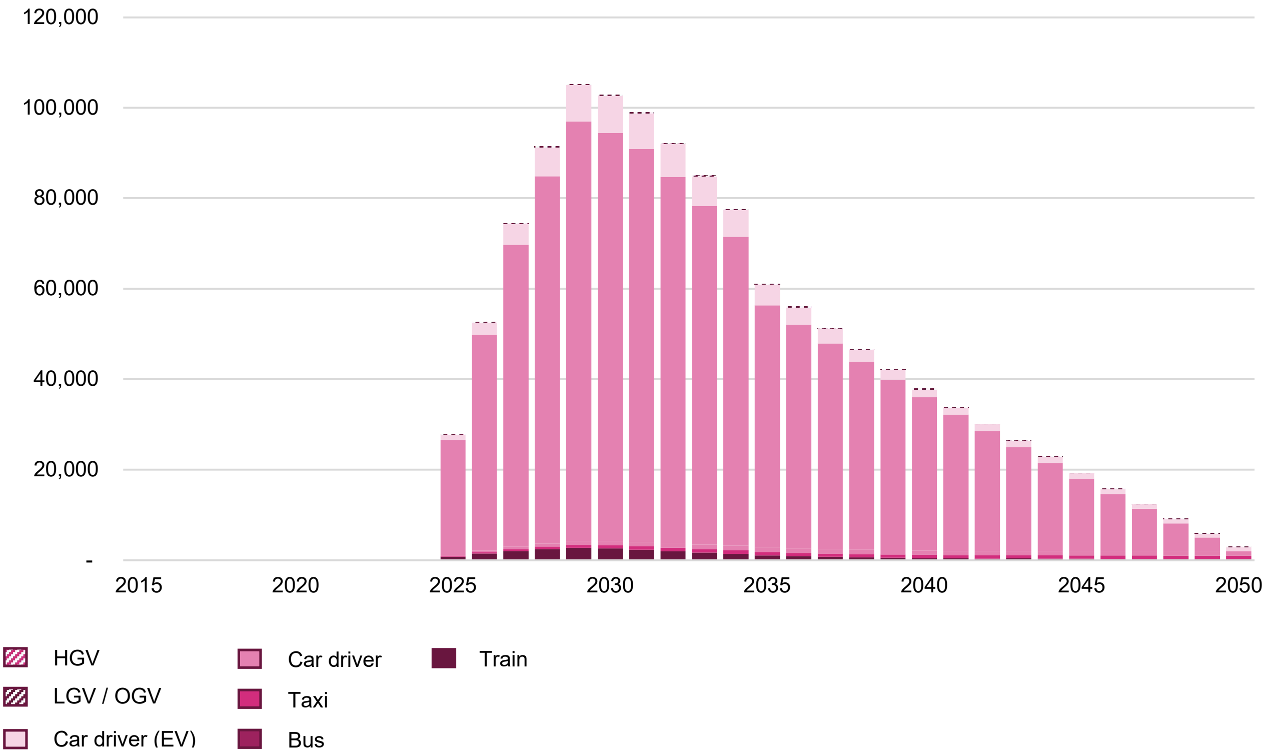

Figure 11 - Sustainable Travel annual transport emissions by mode (tCO2e)

3.2.3 Sustainable Travel results commentary

The Sustainable Travel option was understood to build upon the Rail option, and this was reflected in some of the inputs and results from this option. The emissions trajectory has a similar profile to the Rail option however transport and buildings operational emissions fall slightly faster and by a greater amount (Figure 8 and Figure 9).

In terms of transport emissions, long and short distance trip car mode share reduction in 2050 was assumed to be 8% (Table 4) compared to 10% in the Rail option, as more new settlements were assumed to still be on the road network, slightly higher private car use is still assumed. With a higher private car reliance assumed, naturally higher EV uptake rates were assumed as shown in Table 4. Ultimately the higher EV rates meant that 'Car driver' emissions began to fall in-line with the carbon intensity of the grid which meant that total transport emissions fell at a faster rate despite 'Car driver' still taking up the highest percentage of the transport mode split by 2050.

The final reduction in overall trips due to 20-minute neighbourhoods was also assumed to be higher in the Sustainable Travel option compared to the Rail option (10% compared to 5%). This was due to an assumed internalisation of trips within the sites, with enhanced land use planning, increased density of settlements and better access to amenities within the development.

3.3 Economy

3.3.1 Economy inputs and assumptions

Table 5 - Summary of data and assumptions applied for Economy option (all constant values are outlined in Appendix A)

Sector	Variable	Baseline value	Change to baseline for Economy option	Assumptions
Buildings	Additional on-site renewable deployment	75 kWp/year	No change	Higher as economic hub focussed scenario
Buildings	Years after construction to retrofit residential	15 years	No change	Faster rate in economic hub focussed
Buildings	Residential retrofit standard	Deep Retrofit	No change	Deep retrofit in economic hub focussed
Buildings	Years after construction to retrofit non-residential	40 years	No change	Faster rate in economic hub focussed
Buildings	Non-residential retrofit energy reduction	15%	No change	Higher energy reduction in economic hub focussed
Transport	Private car EV % of total mode share in 2035	5.4%	59.6% (+65%)	Equal adoption due to focus and incentives on sustainable travel
Transport	Servicing LGV EV % of total mode share in 2035	1.0%	49.0% (+50%)	Equal adoption due to focus and incentives on sustainable travel
Transport	Servicing OGV EV % of total mode share in 2035	0%	50.0% (+50%)	Equal adoption due to focus and incentives on sustainable travel
Transport	Reduction in commuter trips from working from home	20%	No change	Assumed lower 20% value for all but dispersed
Transport	Reduction in overall trips in 2050 from 20-minute neighbourhood	0%	10%	Better neighbourhood provision of services with investment
Transport	Reduction in car mode share long distance trips in 2050	0%	6%	Second lowest due to less of a focus on sustainable travel
Transport	Reduction in car mode share short distance trips in 2050	0%	6%	Second lowest due to less of a focus on sustainable travel

3.3.2 Economy results

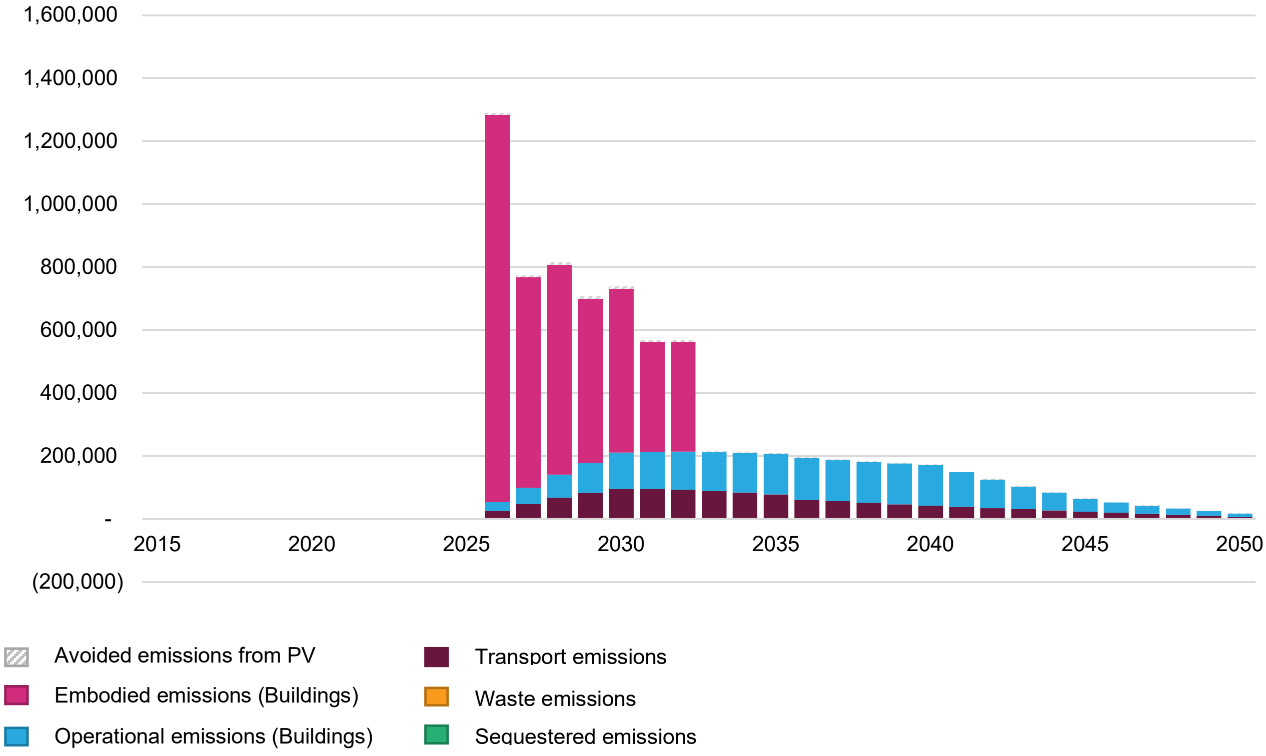

Figure 12 - Economy annual emissions including embodied emissions (tCO2e)

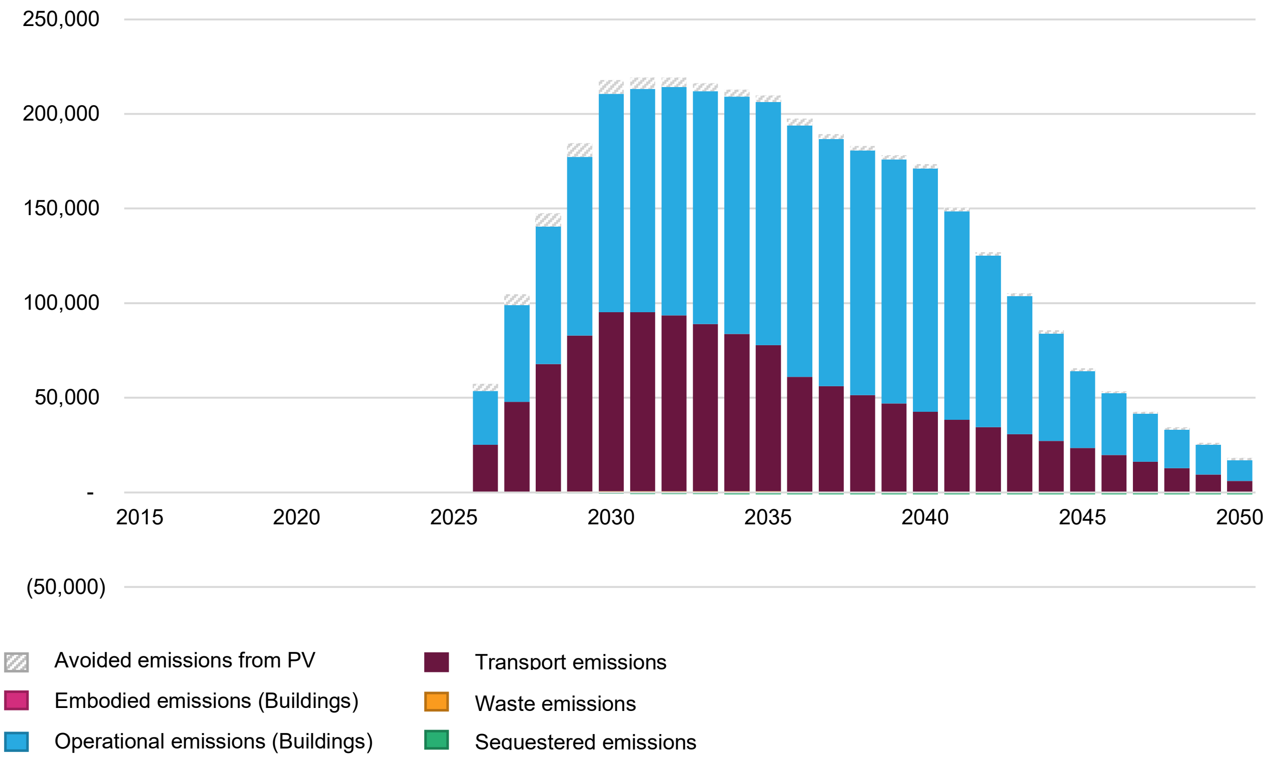

Figure 13 - Economy annual emissions excluding embodied emissions (tCO2e)

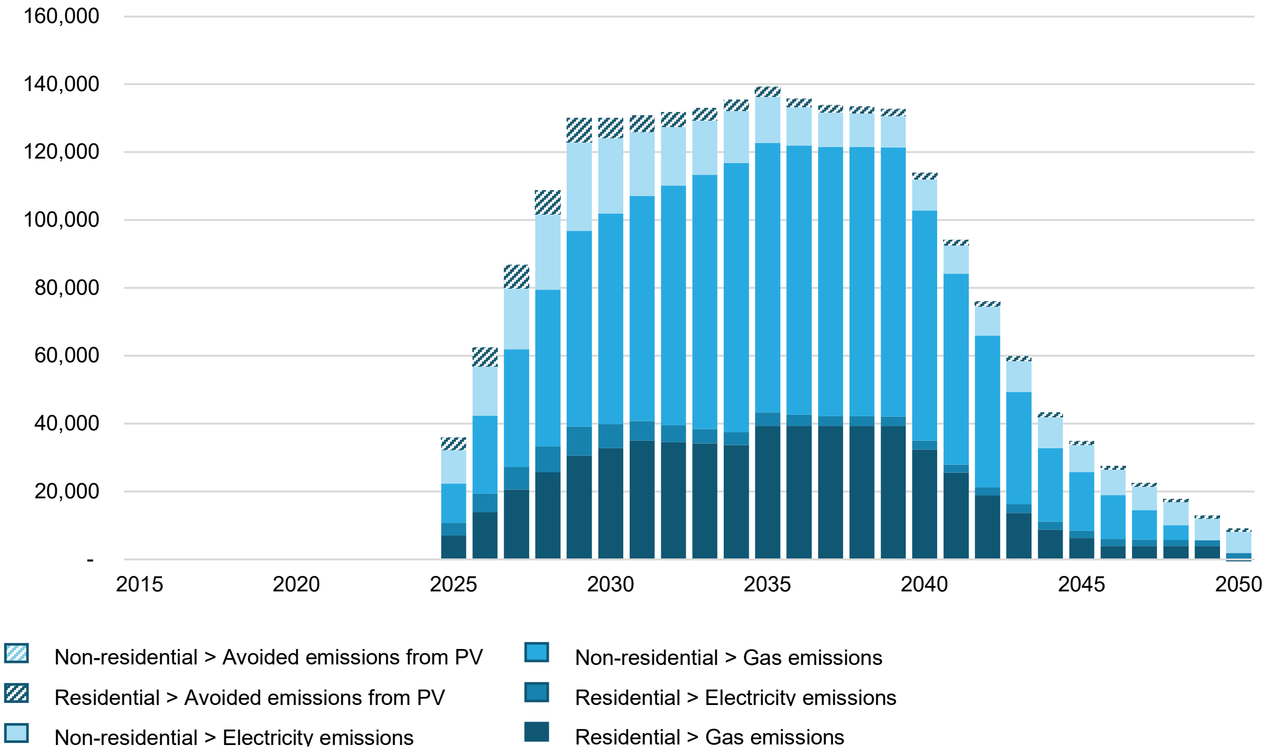

Figure 14 - Economy annual buildings emissions by sub-category (tCO2e)

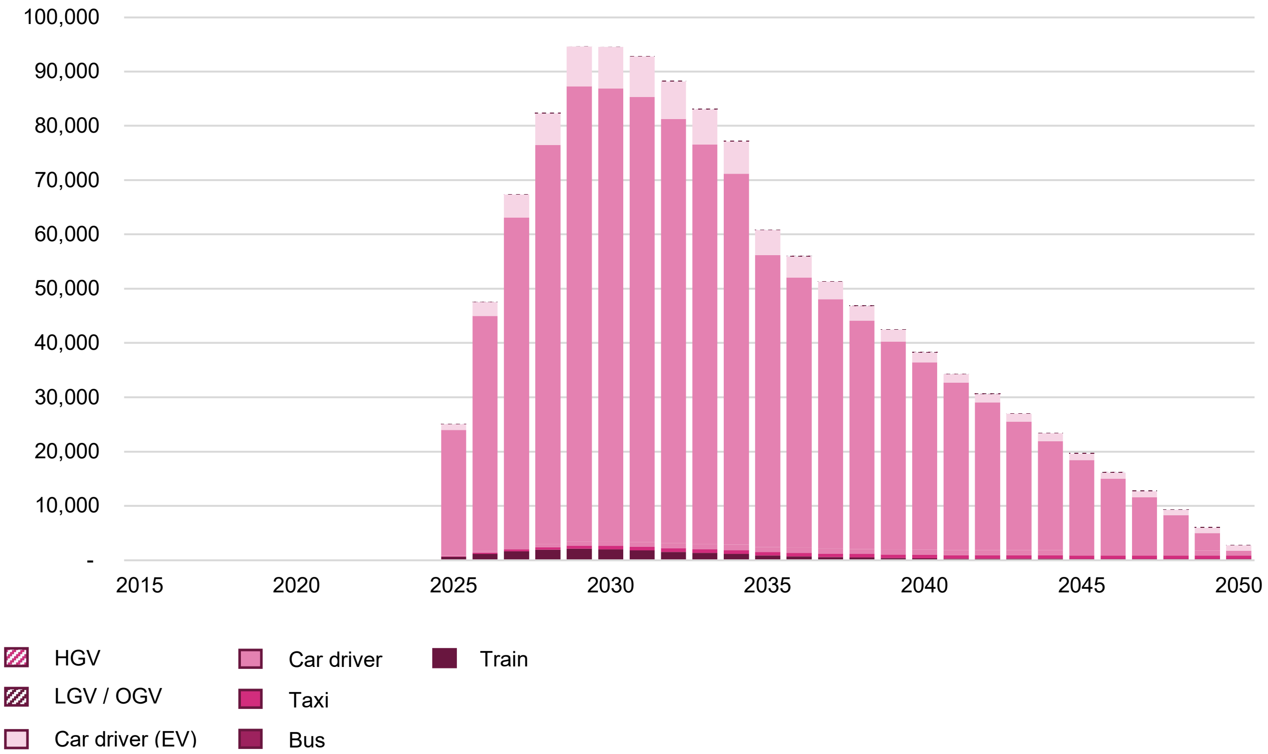

Figure 15 - Economy annual transport emissions by mode (tCO2e)

3.3.3 Economy results commentary

There is less of a peak in buildings operational emissions around 2030 compared with the Rail, Sustainable Travel, and Dispersed options; total emissions also therefore peak lower than these options. This is shown in Figure 12 and Figure 13.

The Economy growth option has the aim of locating homes close to existing jobs and potential new job locations. Potential benefits from this could be developer contributions towards infrastructure and helping the provision of affordable housing. Because of this assumed increase in investment around the economic hubs we assumed slightly more ambitious housing performance summarised in Table 5. For example, that residential dwellings have a retrofit rate of 15 years instead of 20 in the alternative scenarios and that this retrofit is deep rather than light. For non-residential this is a rate of 40 instead of 50 years.

The energy reduction for non-residential buildings from retrofit is assumed to be 15% for Economy scenarios instead of 10% due to the assumed increased economic interest from developers. This resulted in operational buildings emissions falling slightly faster than in alternative scenarios as shown in Figure 14.

50% more additional on-site renewable electricity would be deployed each year in the economic hub focussed scenarios (75kWp/year) compared with the other scenarios (50kWp/year) due to more potential investment, however the overall effect of this was marginal in comparison to other emissions contributions.

3.4 Sustainable Travel & Economy

3.4.1 Sustainable Travel & Economy inputs and assumptions

Table 6 - Summary of data and assumptions applied for Sustainable Travel & Economy option (all constant values are outlined in Appendix A)

Sector	Variable	Baseline value	Change to baseline for Sustainable Travel & Economy option	Assumptions
Buildings	Additional on-site renewable deployment	75 kWp/year	No change	Higher as economic hub focussed scenario
Buildings	Years after construction to retrofit residential	15 years	No change	Faster rate in economic hub focussed
Buildings	Residential retrofit standard	Deep Retrofit	No change	Deep retrofit in economic hub focussed
Buildings	Years after construction to retrofit non-residential	40 years	No change	Faster rate in economic hub focussed
Buildings	Non-residential retrofit energy reduction	15%	No change	Higher energy reduction in economic hub focussed
Transport	Private car EV % of total mode share in 2035	5.4%	59.6% (+65%)	Equal adoption due to focus and incentives on sustainable travel
Transport	Servicing LGV EV % of total mode share in 2035	1.0%	59.0% (+60%)	Slightly higher adoption due to economic incentives
Transport	Servicing OGV EV % of total mode share in 2035	0%	60.0% (+60%)	Equal adoption due to focus and incentives on sustainable travel
Transport	Reduction in commuter trips from working from home	20%	No change	Assumed lower 20% value for all but dispersed
Transport	Reduction in overall trips in 2050 from 20-minute neighbourhood	0%	10%	Better neighbourhood provision of services with investment
Transport	Reduction in car mode share long distance trips in 2050	0%	10%	Highest due to focus on rail links and sustainable travel
Transport	Reduction in car mode share short distance trips in 2050	0%	10%	Highest due to focus on rail links and sustainable travel

3.4.2 Sustainable Travel & Economy results

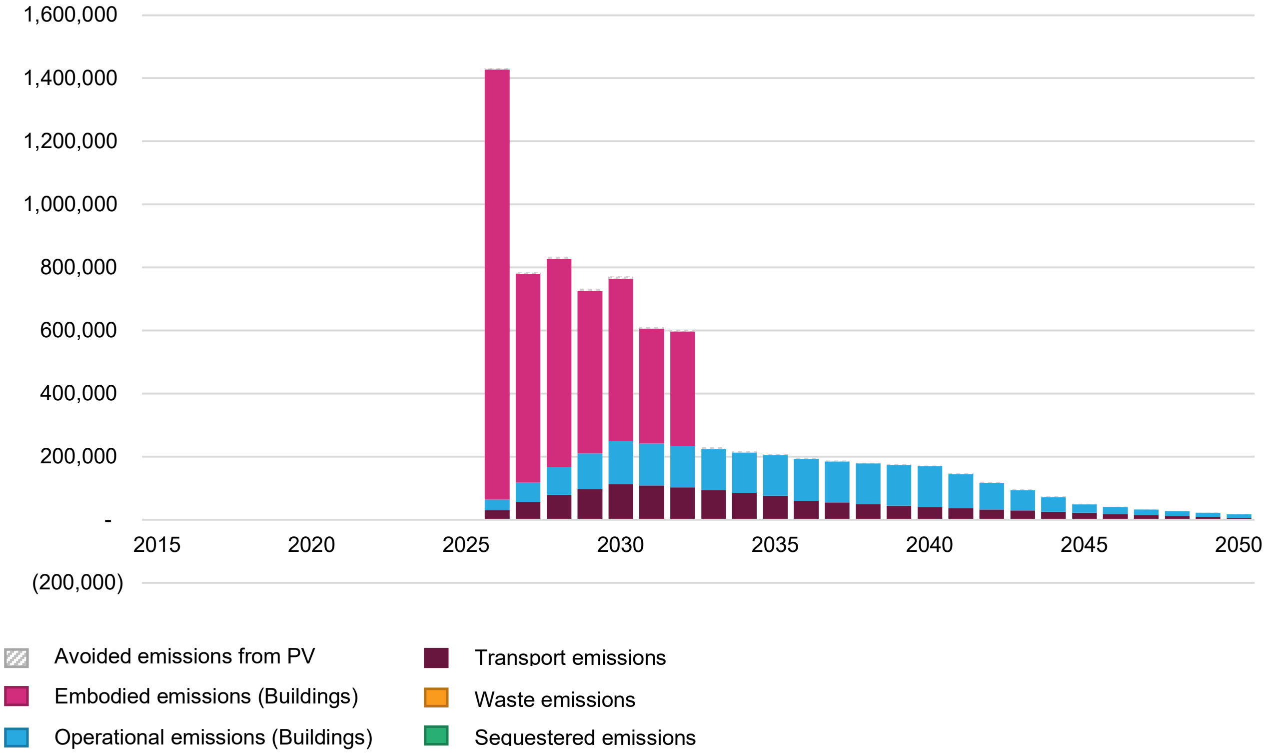

Figure 16 – Sustainable Travel & Economy annual emissions including embodied emissions (tCO2e)

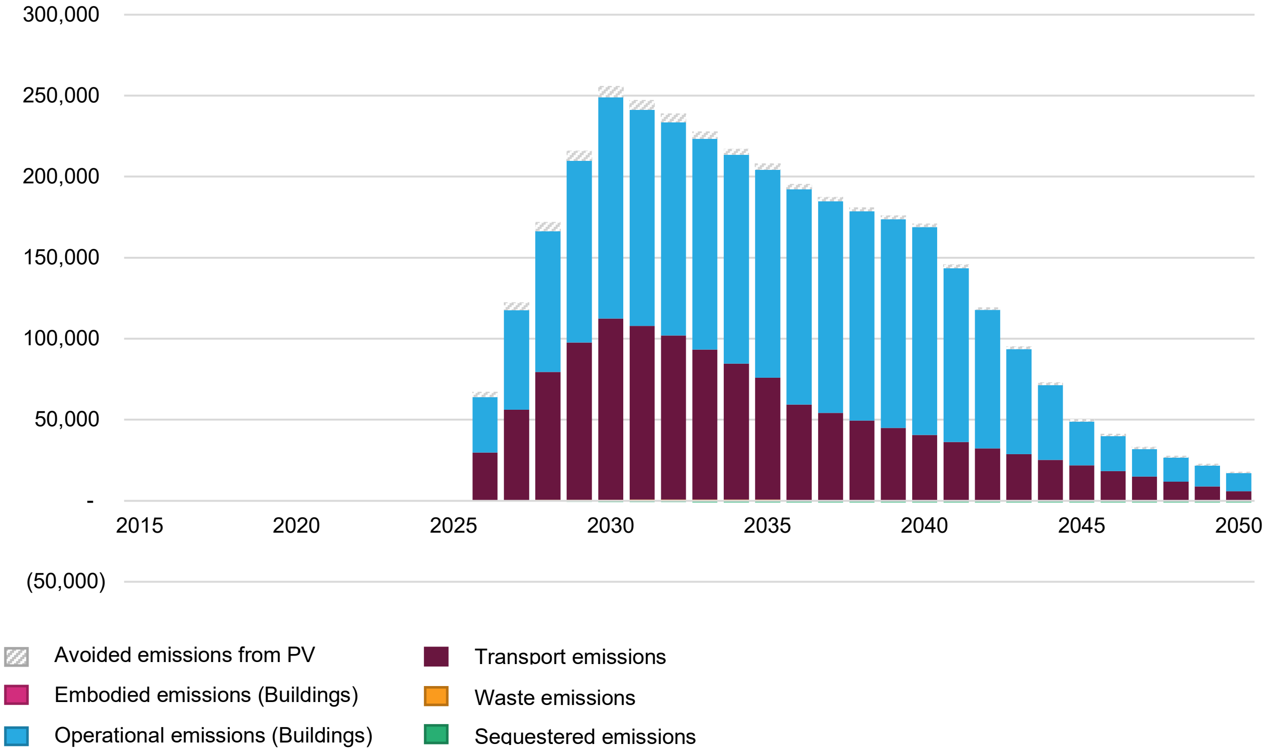

Figure 17 - Sustainable Travel & Economy annual emissions excluding embodied emissions (tCO2e)

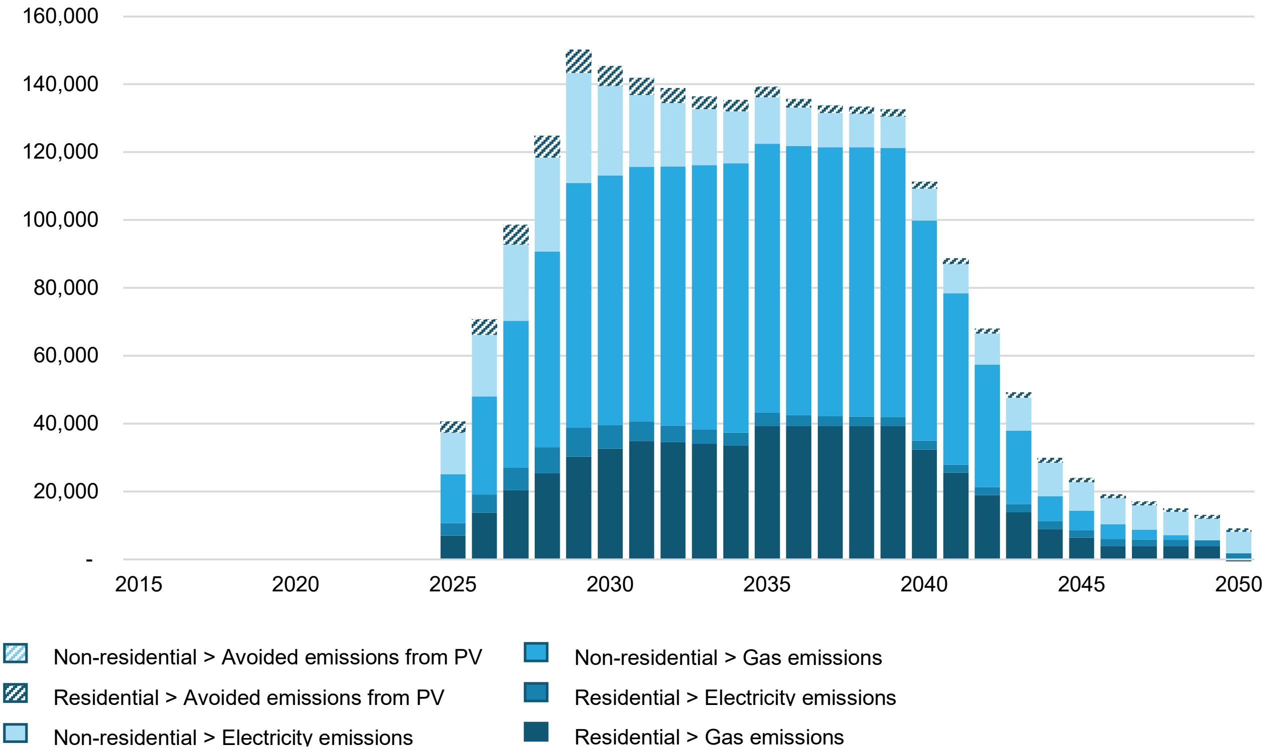

Figure 18 - Sustainable Travel & Economy annual buildings emissions by sub-category (tCO2e)

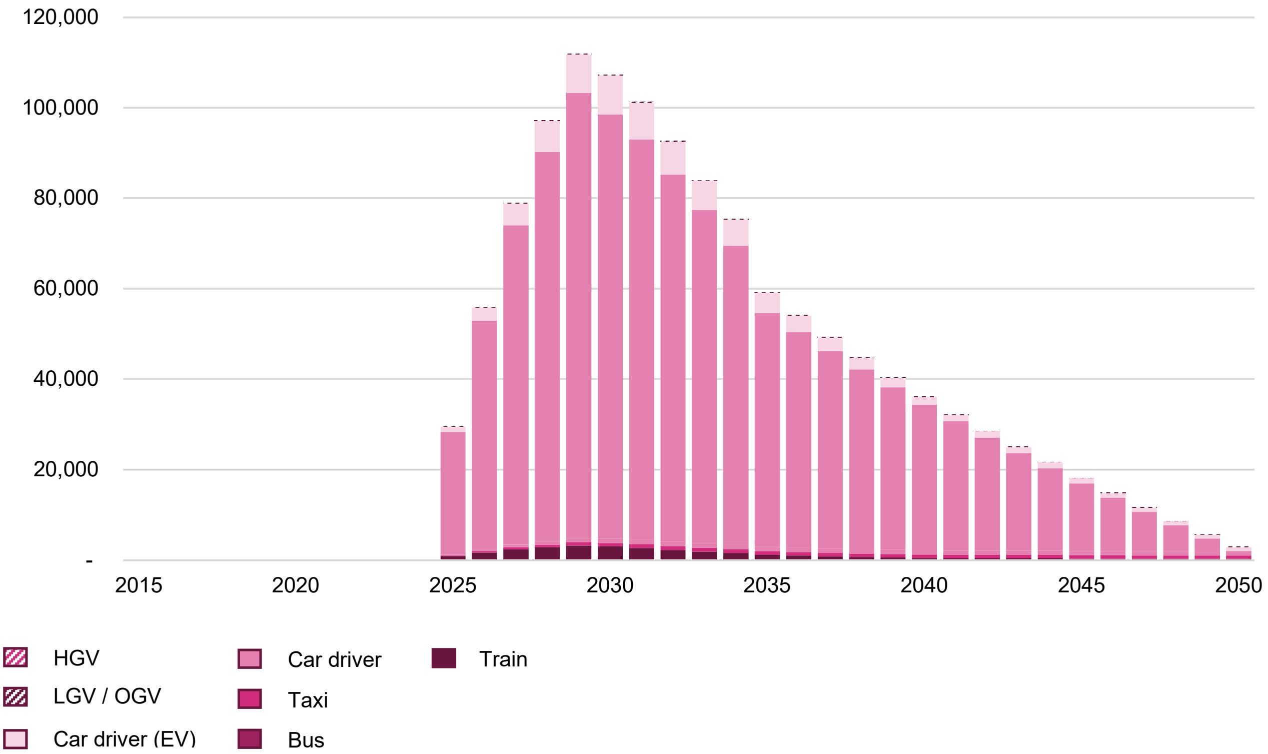

Figure 19 - Sustainable Travel & Economy annual transport emissions by mode (tCO2e)

3.4.3 Sustainable Travel & Economy results commentary

The Sustainable Travel & Economy option was assumed to build upon both the Sustainable Travel option, as well as incorporate some of the vision outlined in the Economy option. This option has a different trajectory compared to the alternative options in that it peaks the highest around 2030 (Figure 16), but that annual emissions by 2050 are the lowest as shown in Table 1.

The rapid decline in emissions is due to a combination of the favourable car mode share reduction and 20-minute neighbourhood inputs from the Sustainable Travel option (10% reduction in car mode share by 2050 and 20% reduction in overall trips by 2050 as described in Table 6). Private electric vehicles in 2035 was also 65%, with servicing LGV and OGV electric vehicles both being 60% in 2035. This was a slight increase over that assumed in the other growth options.

In addition to this, this option assumes the same building related inputs as the Economy option. This means the faster and higher rates of retrofit as outlined in the Economy growth option commentary. The effect of this is a similar buildings emissions profile in Figure 18 to that of the Economy buildings profile in Figure 14. Similarly, the transport emissions profile in Figure 19 is similar to that of the Sustainable Travel transport emissions profile in Figure 11.

3.5 Dispersed

3.5.1 Dispersed results

Table 7 - Summary of data and assumptions applied for Dispersed option (all constant values are outlined in Appendix A)

Sector	Variable	Baseline value	Change to baseline for Dispersed option	Assumptions
Buildings	Additional on-site renewable deployment	50 kWp/year	No change	Lower as not economic hub focussed scenario
Buildings	Years after construction to retrofit residential	20 years	No change	Slower rate in non-economic hub focussed
Buildings	Residential retrofit standard	Light Retrofit	No change	Light retrofit in non-economic hub focussed
Buildings	Years after construction to retrofit non-residential	50 years	No change	Slower rate in non-economic hub focussed
Buildings	Non-residential retrofit energy reduction	10%	No change	Lower energy reduction in non-economic hub focussed
Transport	Private car EV % of total mode share in 2035	5.4%	59.6% (+65%)	Equal adoption due to focus and incentives on sustainable travel
Transport	Servicing LGV EV % of total mode share in 2035	1.0%	49.0% (+50%)	Equal adoption due to focus and incentives on sustainable travel
Transport	Servicing OGV EV % of total mode share in 2035	0%	50.0% (+50%)	Equal adoption due to focus and incentives on sustainable travel
Transport	Reduction in commuter trips from working from home	25%	No change	Higher reduction assumed due to greater resistance to travel for work if dispersed
Transport	Reduction in overall trips in 2050 from 20-minute neighbourhood	0%	5%	Lower reduction due to being further away from essential services
Transport	Reduction in car mode share long distance trips in 2050	0%	2%	Lowest due to reliance on private car from being dispersed
Transport	Reduction in car mode share short distance trips in 2050	0%	2%	Lowest due to reliance on private car from being dispersed

3.5.2 Dispersed results

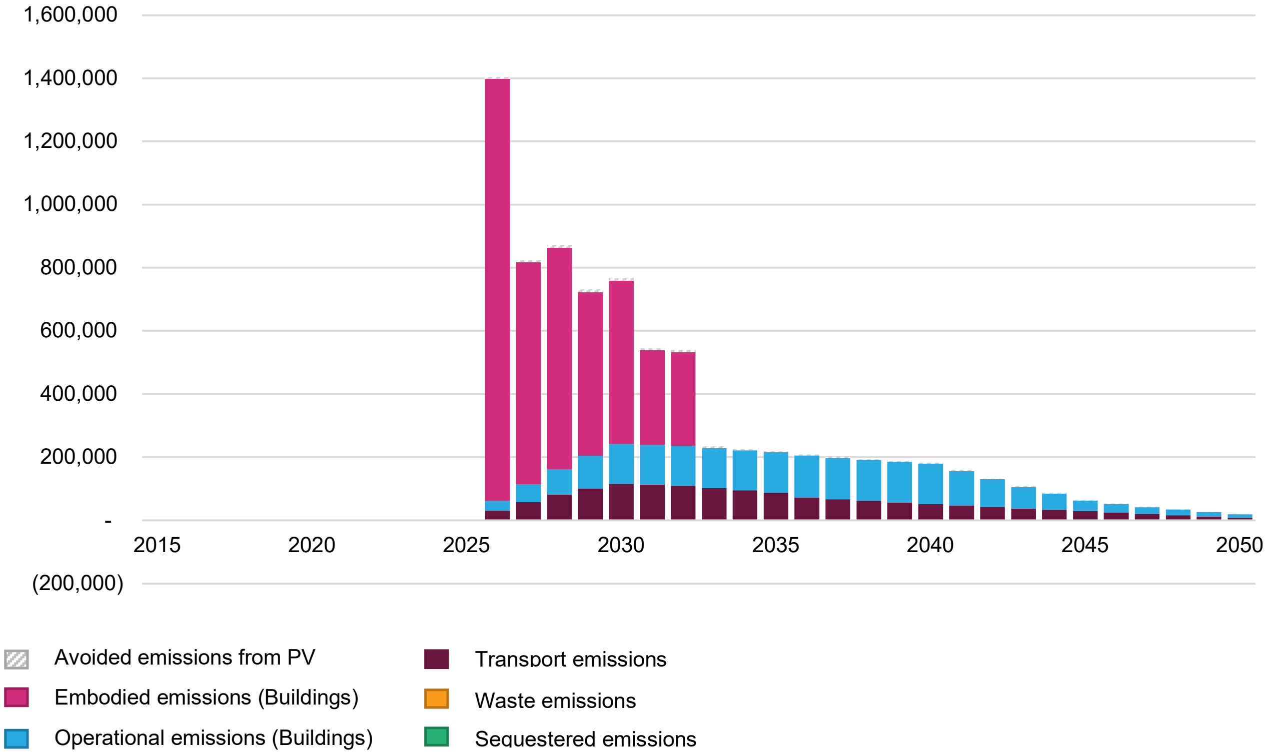

Figure 20 – Dispersed annual emissions including embodied emissions (tCO2e)

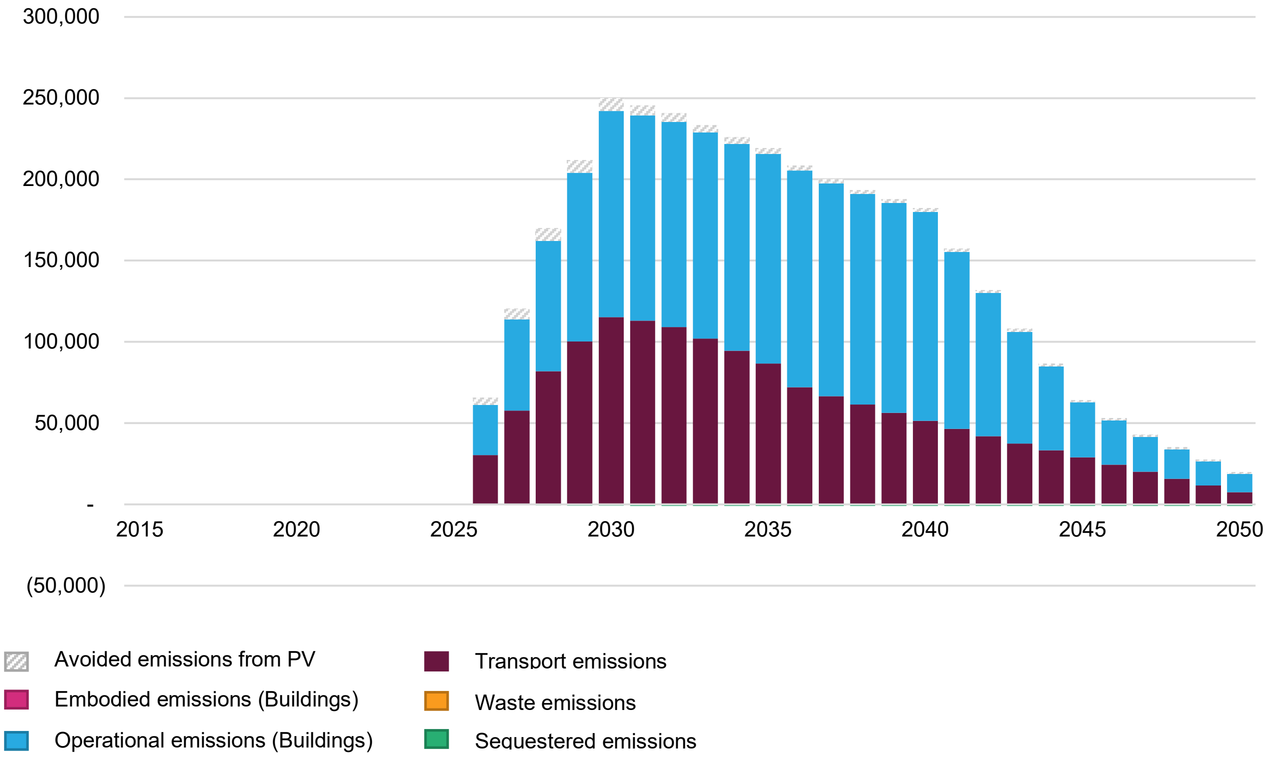

Figure 21 - Dispersed annual emissions excluding embodied emissions (tCO2e)

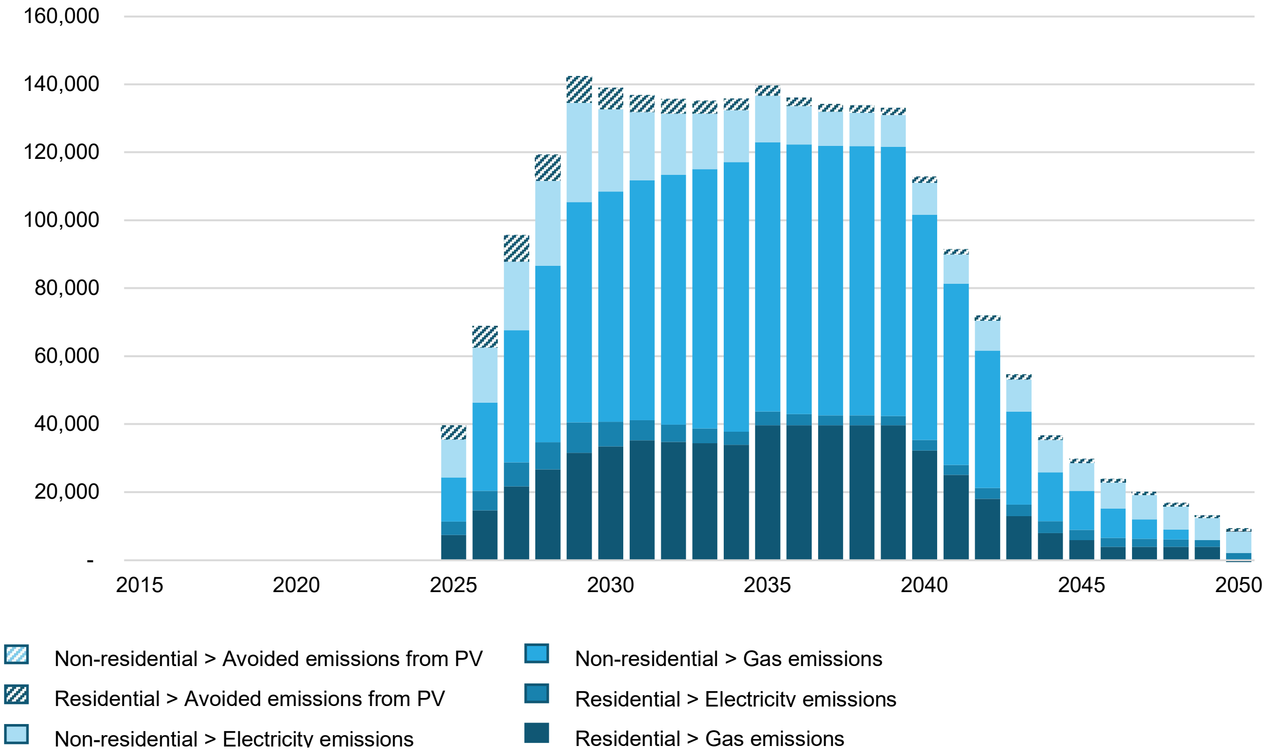

Figure 22 - Dispersed annual buildings emissions by sub-category (tCO2e)

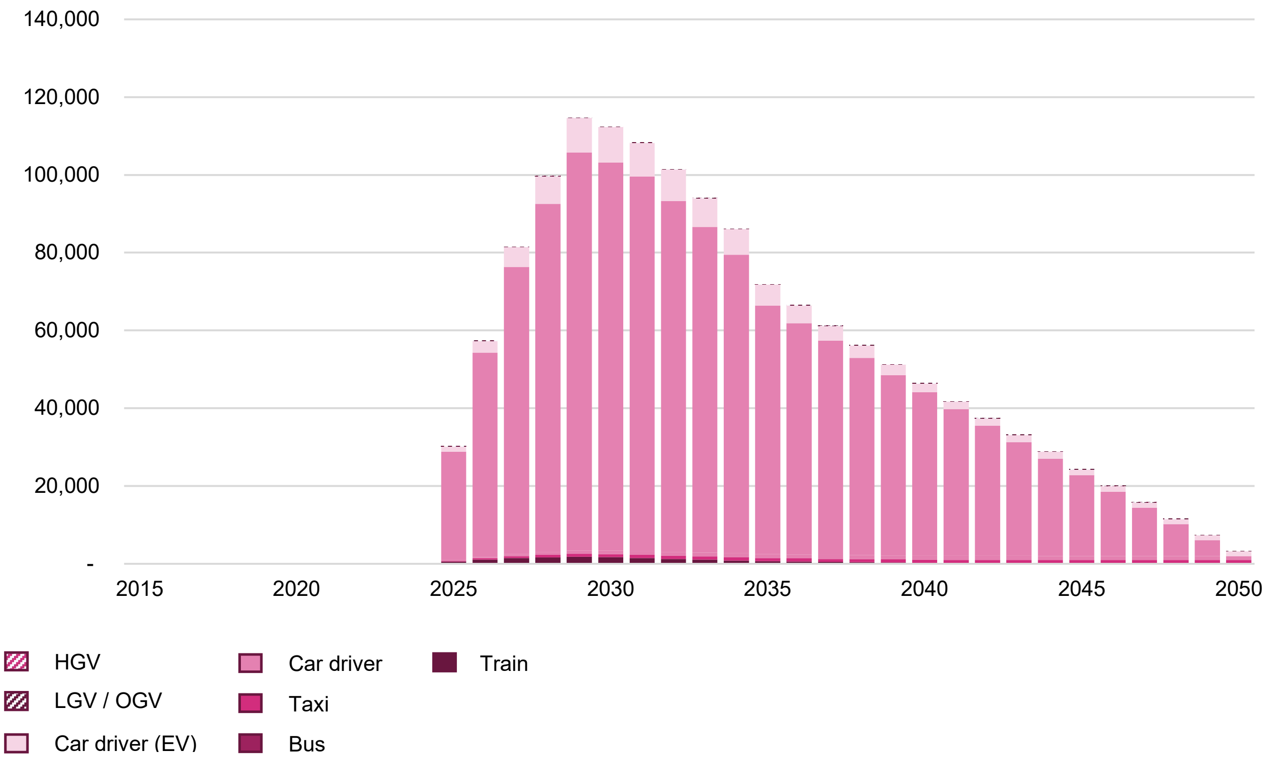

Figure 23 - Dispersed annual transport emissions by mode (tCO2e)

3.5.3 Dispersed results commentary

The Dispersed emissions pathway shown in Figure 21 is similar to that of the Rail pathway (Figure 5) but for some differing reasons. Both transport and operational buildings emissions peak to a similar value around 2030.

From Table 7, 5% less commuter trips were assumed in the Dispersed option due to working from home being favoured instead of long commutes due to weaker transport connections and therefore a higher expected resistance to travelling for work.

For the dispersed scenario only a 2% reduction in private car trips is assumed due to lack of connections to public transport at new developments, meaning a higher expected reliance on the private car. There is still some reduction in trips expected due to increased working from home however, which does somewhat counteract this.

Slower retrofit rates of 20 years for residential, and 50 years for non-residential buildings was also assumed. The level of retrofit for residential was only assumed to be light and a 10% reduction (rather than 15%) in this option due to the assumption that investment in retrofit schemes would be spread across a wider range of small developments rather than a small number of large developments. The result of this is a slower reduction in operational buildings emissions (Figure 22).

3.6 Conclusions

The emissions estimates highlight the critical importance across all growth options of policies to reduce dependence on private car travel, increase the likelihood of active travel choices for local trips (including through 20-minute neighbourhood planning), strengthen intermodal public transport connections and facilitate uptake of electric vehicles. Policies to drive investment in renewable energy generation and improve building operational energy efficiency deeper and faster than national requirements (including through retrofits) will also be fundamental.

4. Analysis of each new settlement

This section provides further insight into the assumptions and outputs from analysis of each of the potential locations for new settlements within the carbon model. Each growth option has a mix of new settlements, and this is reflected by the inputs which were modelled for this analysis. For comparison purposes in this section, it was assumed that each new settlement would have 6,000 homes and 30 hectares of employment land. A summary of each of the new settlements and which growth option scenarios they were considered under is provided in Table 8. Results are similar between the potential locations for new settlements for the same growth options as the calculations used the same model assumptions as the growth options modelled previously. The input variables which changed between the new settlements were the 6,000 homes and 30 ha of employment land.

The resulting graphs in this section show the annual and cumulative carbon emissions trajectories for each of the new settlements across the growth options they are being considered in.

Table 8 - New settlements location classification and summary results

Location	New Settlement Reference	Growth Options considered	Cumulative emissions in 2050 (tCO_2e)	Annual emissions in 2050 (tCO_2e)
Henley-in-Arden	A1	2 - Sustainable Travel 3 - Economy 4 - Sustainable Travel & Economy	440,000 446,000 432,000	2,500 2,500 2,400
Hatton Station	B1	1 - Rail Corridors 2 - Sustainable Travel 4 - Sustainable Travel & Economy	437,000 440,000 432,000	2,500 2,500 2,400
Kingswood	C1	1 - Rail Corridors	437,000	2,500
Depper's Bridge	F2	1 - Rail Corridors 2 - Sustainable Travel 4 - Sustainable Travel & Economy	437,000 440,000 432,000	2,500 2,500 2,400
Long Marston Airfield / Meon Vale	E1	1 - Rail Corridors 2 - Sustainable Travel 3 - Economy 4 - Sustainable Travel & Economy 5 - Dispersed	437,000 440,000 446,000 432,000 464,000	2,500 2,500 2,500 2,400 2,700
Wood End	F1	1 - Rail Corridors 3 - Economy	437,000 446,000	2,500 2,500
GLH Gaydon / Lighthorne Heath	F3	3 - Economy 4 - Sustainable Travel & Economy	446,000 432,000	2,500 2,400

4.1 A1: Henley-in-Arden

4.1.1 A1: Henley-in-Arden inputs and assumptions

Table 9 - A1: Henley-in-Arden housing and employment land assumptions for each growth option scenario

Input	Rail Corridors	Sustainable Travel	Economy	Sustainable Travel & Economy	Dispersed
Number of Homes	0	6,000	6,000	6,000	0
Employment Land (ha)	0	30	30	30	0

4.1.2 A1: Henley-in-Arden results

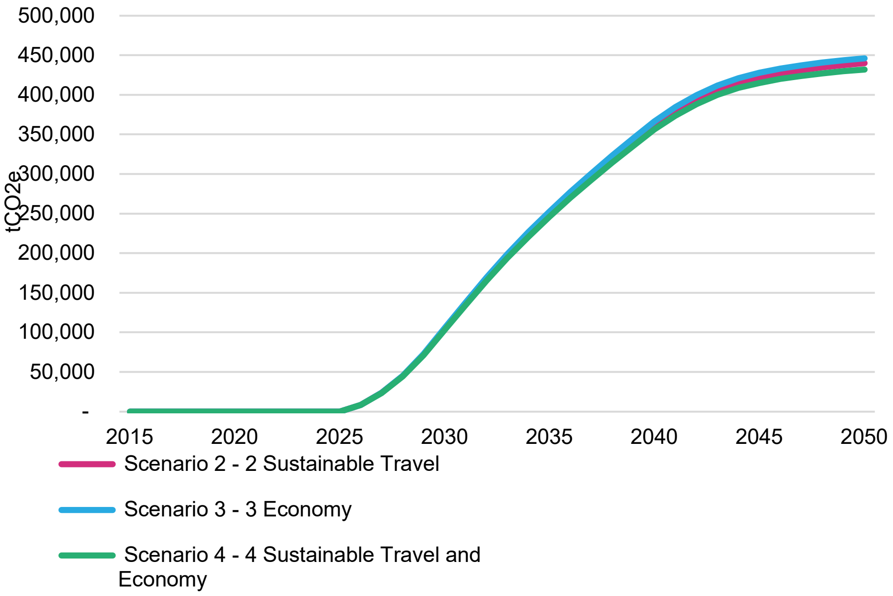

Figure 24 – Henley-in-Arden cumulative emissions (tCO2e)

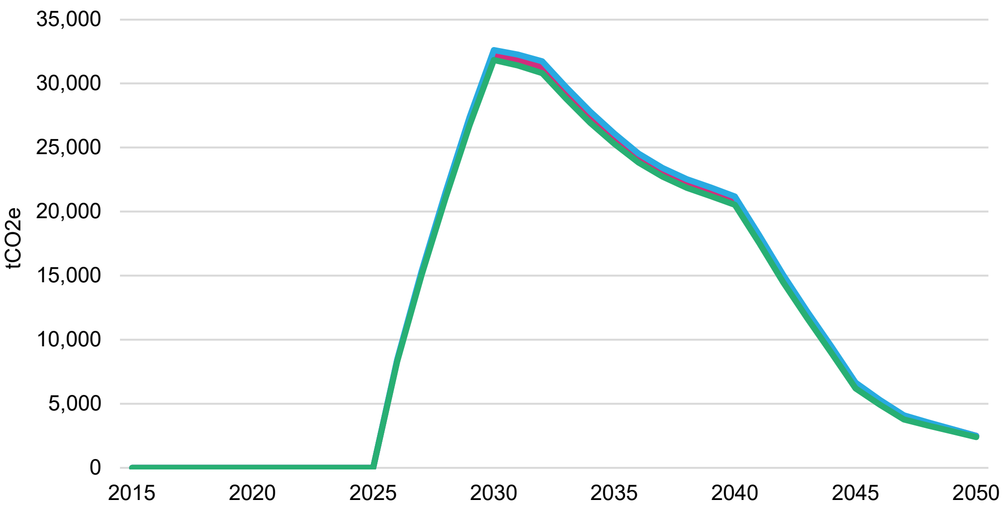

Figure 25 - Henley-in-Arden annual emissions (tCO2e)

4.2 B1: Hatton Station

4.2.1 B1: Hatton Station inputs and assumptions

Table 10 – B1: Hatton Station housing and employment land assumptions for each growth option scenario

Input	Rail Corridors	Sustainable Travel	Economy	Sustainable Travel & Economy	Dispersed
Number of Homes	6,000	6,000	0	6,000	0
Employment Land (ha)	30	30	0	30	0

4.2.2 B1: Hatton Station results

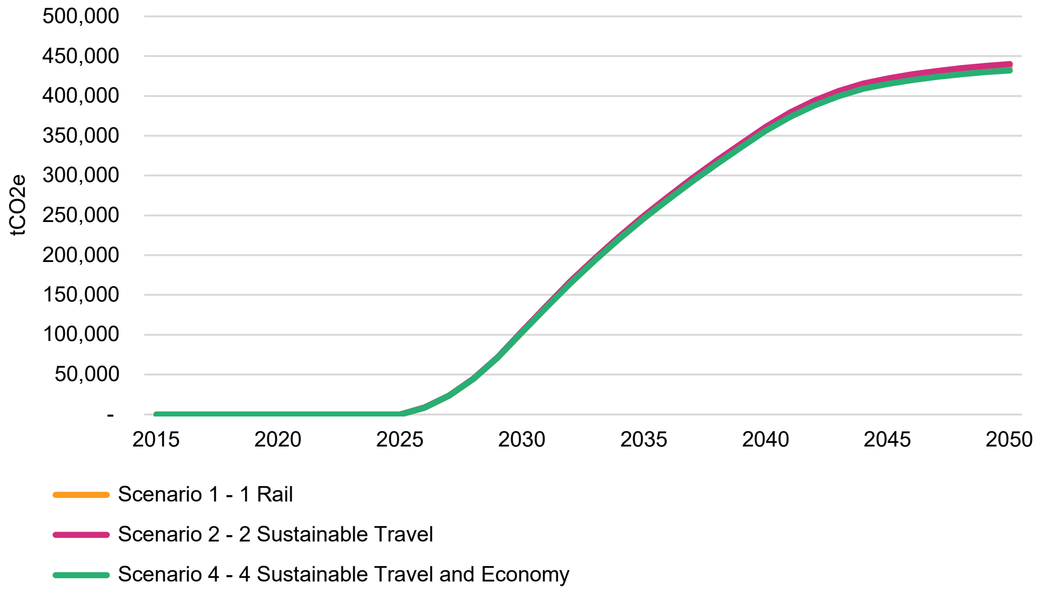

Figure 26 - Hatton Station cumulative emissions (tCO2e)

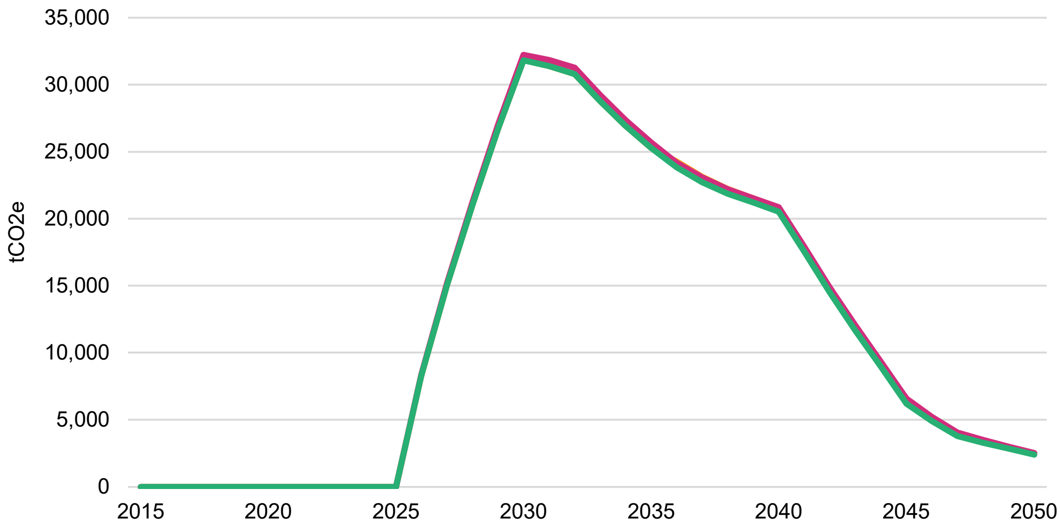

Figure 27 - Hatton Station annual emissions (tCO2e)

4.3 C1: Kingswood

4.3.1 C1: Kingswood inputs and assumptions

Table 11 – C1: Kingswood housing and employment land assumptions for each growth option scenario

Input	Rail Corridors	Sustainable Travel	Economy	Sustainable Travel & Economy	Dispersed
Number of Homes	6,000	0	0	0	0
Employment Land (ha)	30	0	0	0	0

4.3.2 C1: Kingswood results

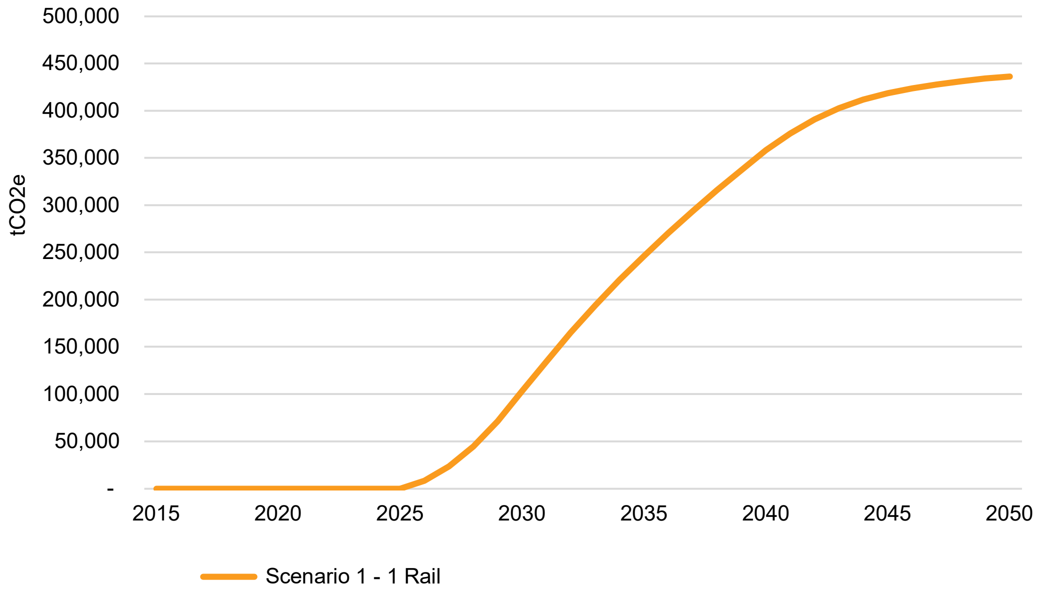

Figure 28 - Kingswood cumulative emissions (tCO2e)

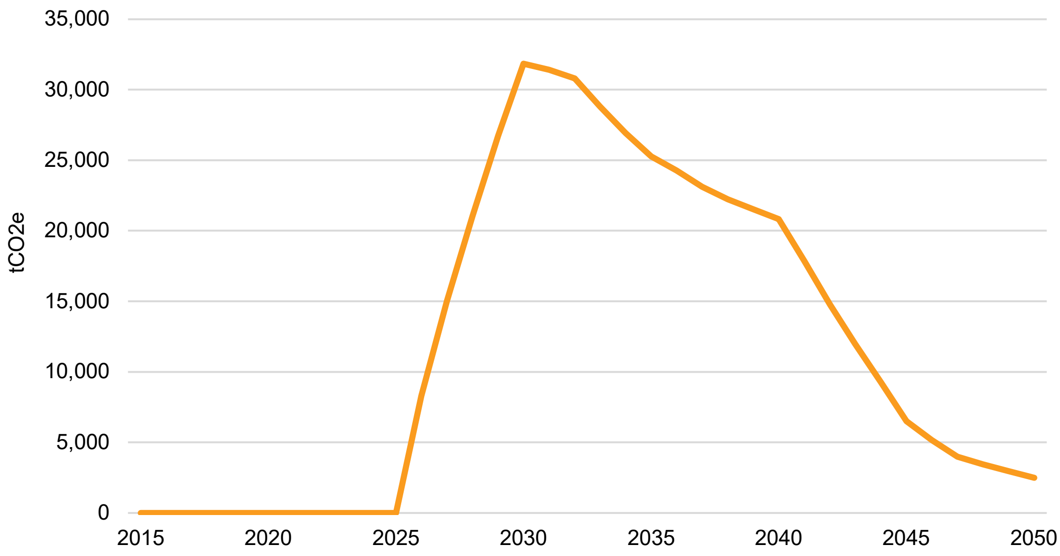

Figure 29 - Kingswood annual emissions (tCO2e)

4.4 F2: Depper's Bridge

4.4.1 F2: Depper's Bridge inputs and assumptions

Table 12 – F2: Depper's Bridge housing and employment land assumptions for each growth option scenario

Input	Rail Corridors	Sustainable Travel	Economy	Sustainable Travel & Economy	Dispersed
Number of Homes	6,000	6,000	0	6,000	0
Employment Land (ha)	30	30	0	30	0

4.4.2 F2: Depper's Bridge results

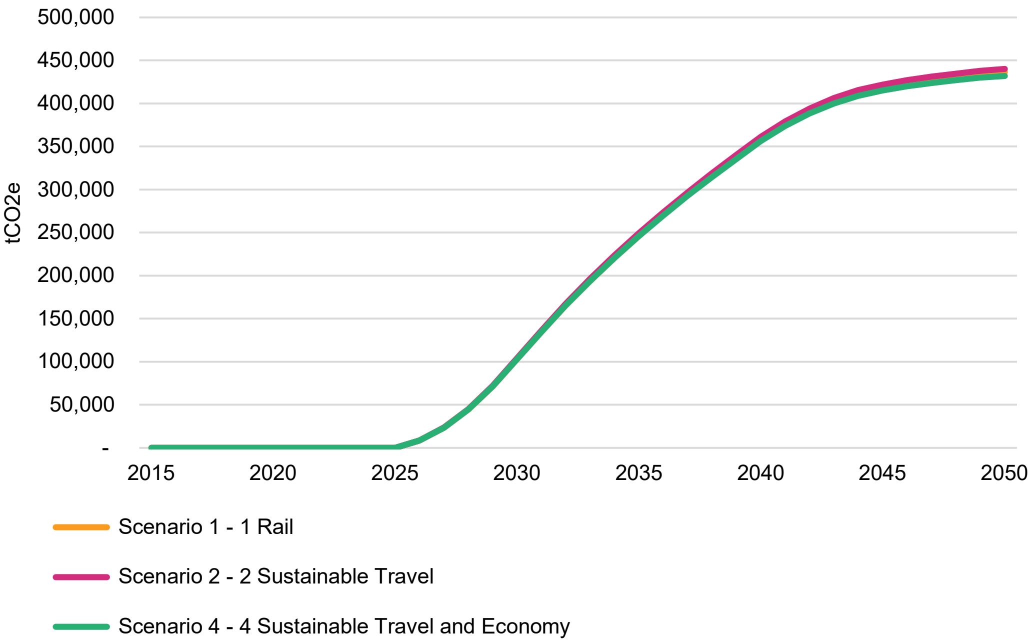

Figure 30 - Depper's Bridge cumulative emissions (tCO2e)

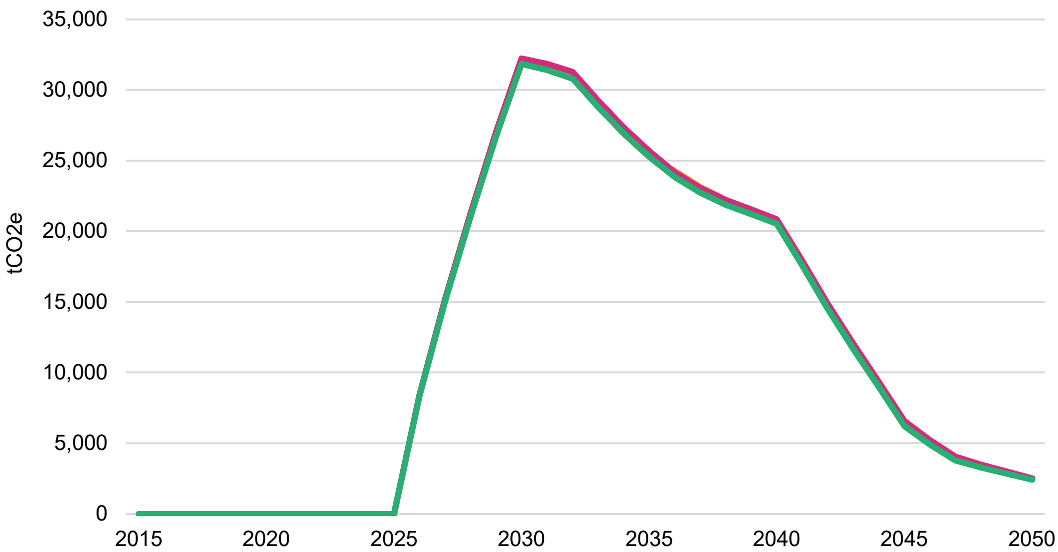

Figure 31 - Depper's Bridge annual emissions (tCO2e)

4.5 E1: Long Marston Airfield / Meon Vale

E1: Long Marston Airfield / Meon Vale inputs and assumptions

Table 13 – E1: Long Marston Airfield / Meon Vale housing and employment land assumptions for each growth option scenario

Input	Rail Corridors	Sustainable Travel	Economy	Sustainable Travel & Economy	Dispersed
Number of Homes	6,000	6,000	6,000	6,000	6,000
Employment Land (ha)	30	30	30	30	30

4.5.1 E1: Long Marston Airfield / Meon Vale results

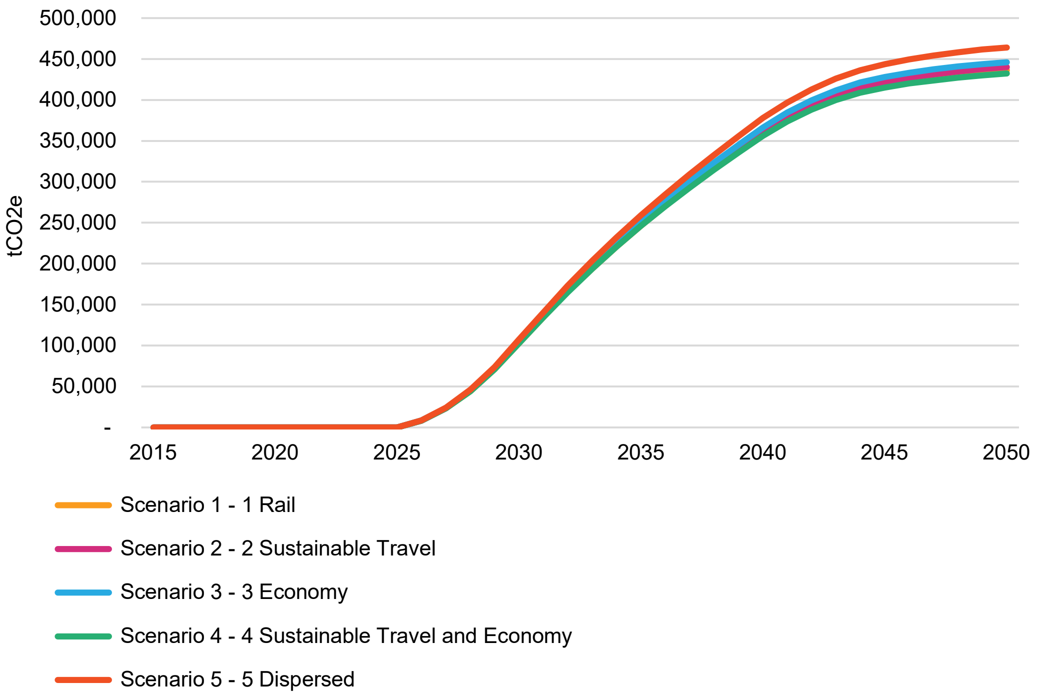

Figure 32 - Long Marston Airfield / Meon Vale cumulative emissions (tCO2e)

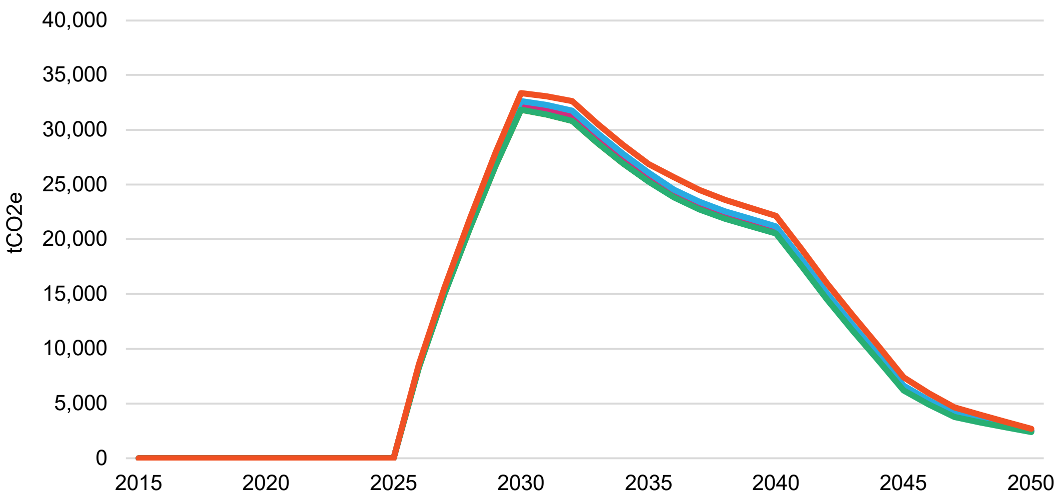

Figure 33 - Long Marston Airfield / Meon Vale annual emissions (tCO2e)

4.6 F1: Wood End

4.6 F1: Wood End inputs and assumptions

Table 14 – F1: Wood End housing and employment land assumptions for each growth option scenario

Input	Rail Corridors	Sustainable Travel	Economy	Sustainable Travel & Economy	Dispersed
Number of Homes	6,000	0	6,000	0	0
Employment Land (ha)	30	0	30	0	0

4.6.1 F1: Wood End results

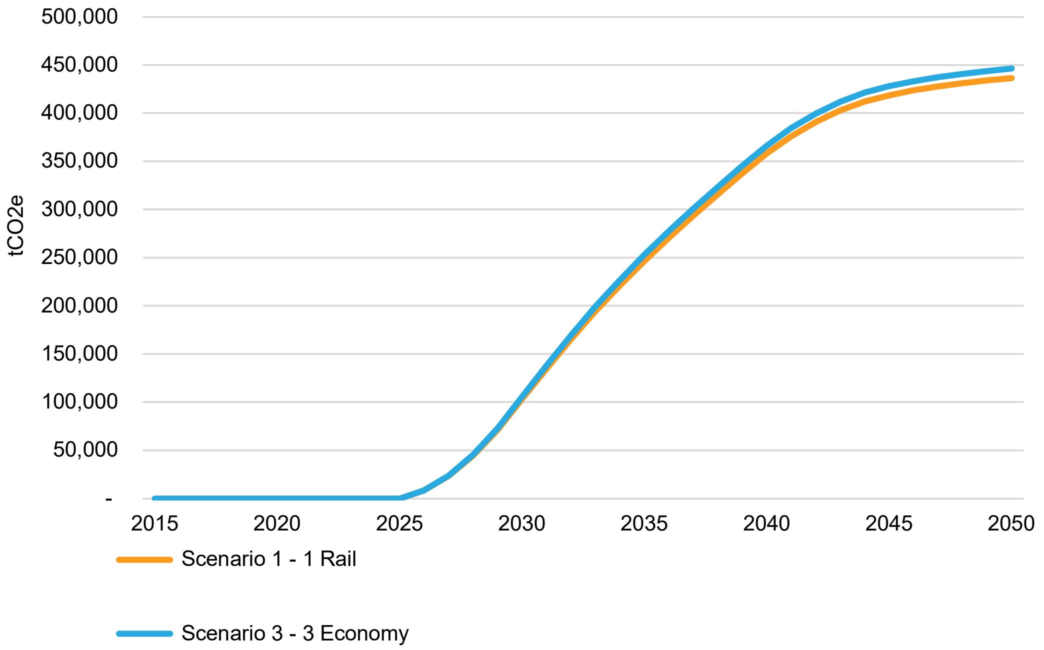

Figure 34 - Wood End cumulative emissions (tCO2e)

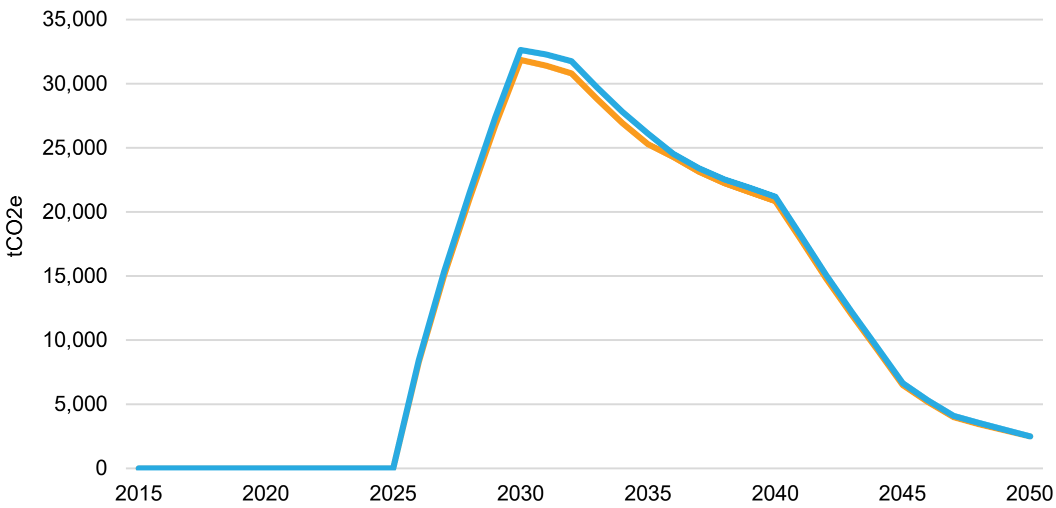

Figure 35 - Wood End annual emissions (tCO2e)

4.7 F3: GLH Gaydon / Lighthorne Heath

4.6 F3: GLH Gaydon / Lighthorne Heath inputs and assumptions

Table 15 – F3: GLH Gaydon / Lighthorne Heath housing and employment land assumptions for each growth option scenario

Input	Rail Corridors	Sustainable Travel	Economy	Sustainable Travel & Economy	Dispersed
Number of Homes	0	0	6,000	6,000	0
Employment Land (ha)	0	0	30	30	0

4.7.1 F3: GLH Gaydon / Lighthorne Heath results

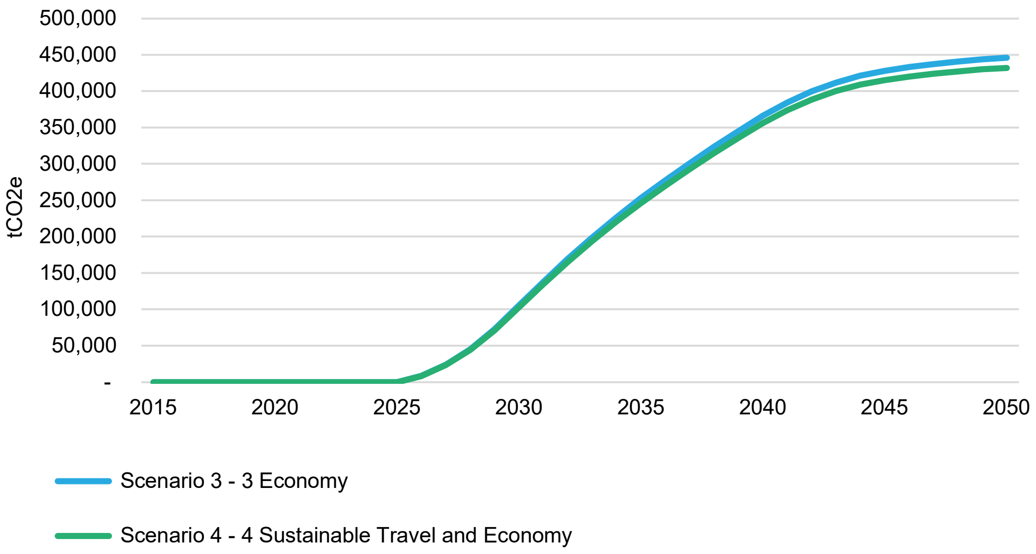

Figure 36 - GLH Gaydon / Lighthorne Heath cumulative emissions (tCO2e)

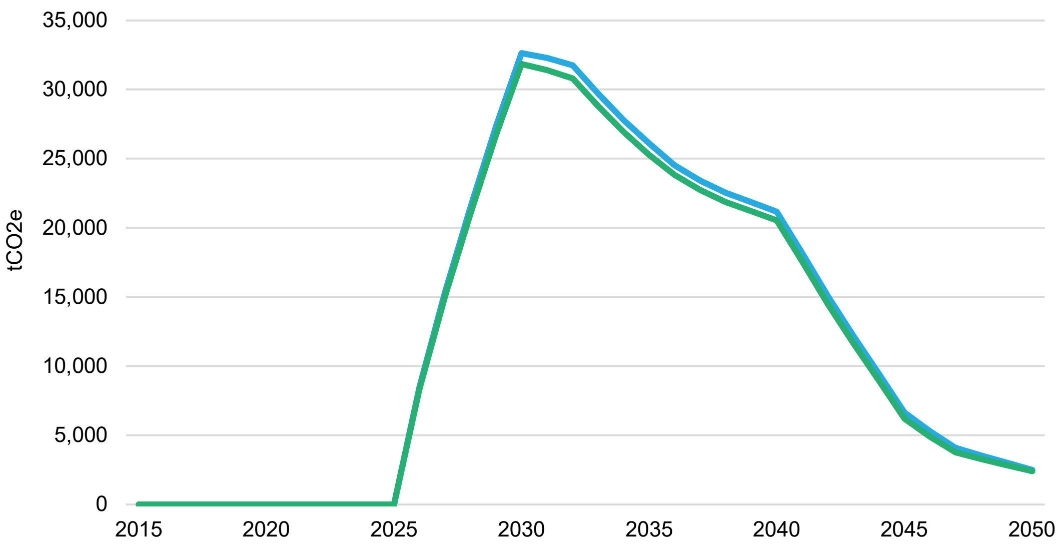

Figure 37 - GLH Gaydon / Lighthorne Heath annual emissions (tCO2e)

4.8 Conclusions

This analysis highlights the critical importance of the growth options in terms of estimating overall carbon emissions for new settlements, with those within growth option 4 - Sustainable Travel & Economy- generally performing better in terms of reduced carbon emissions. Overall, this provides a useful overview and starting point to consider refining options, with the potential for future policies to deliver wider carbon benefits to the development of these new settlements across all the growth areas.

5. Model Methodology

5.1 Methodology introduction

This section explains how the results presented above have been reached, including the key data sources used, scenarios and calculations.

5.2 Model structure

The structure of the model is illustrated in Figure 38.

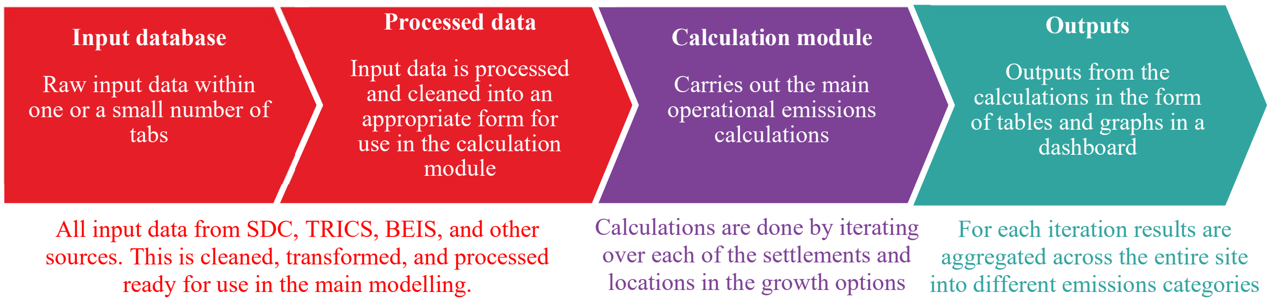

Figure 38 - Model structure

5.3 Model inputs

5.3.1 Data collection strategy

Arup received a set of data from SDC and WDC containing the growth options, housing and employment land schedule, the 2021 Authority Monitoring Report (Warwick District Council, 2021), the 2019 Warwick Open Space SPD (Warwick District Council, 2019), and a series of maps showing the new settlement potential locations with transport corridors. The housing and employment land schedule informed the buildings and energy calculations, with assumptions made about the split in housing typologies, whilst the 2021 Authority Monitoring Report informed the estimated split in non-residential building use classes (e.g., B1, D1 etc.). The total number of residents and employees each year could be calculated based on the estimated number of dwellings and total employment land. This then fed into the waste and open space calculations.

Arup also collated trip rate data from Transport Assessments (TAs) carried out in Stratford-on-Avon (for residential trips) and Warwick (for non-residential trips). This data was accessed using the TRICS (Trip Rate Information Computer System) database commercially licensed to Arup.

Any further data gaps were filled in discussion with SDC.

5.3.2 Key inputs

For site related data, the key data inputs include:

- The growth options housing and employment land schedule containing the total number of homes and employment land in each location for each growth option.
- Residential and non-residential building types including unit sizes. Typical unit sizes for residential buildings were used based on minimum space requirements.
- Estimated population each year, by location. This was calculated from the total number of dwellings each year by using the residential building typologies (e.g., 2B3P denotes a dwelling with 2 beds and 3 people). A split of housing typologies was by Arup based on previous projects.
- Trip rates from TAs in the TRICs database, these were applied to all locations using averages of available TAs from Stratford-on-Avon and Warwick.

For input data related to background trends in the market and electrification, the key data inputs include:

- Target year for gas boiler to electric boiler upgrades and the date at which all new residential construction would have ASHPs. Typically, we would expect this to be between 10-15 years, but this can be altered per growth option scenario when running the model
- The number of years after construction that deep retrofit would take place to improve energy efficiency of buildings, also altered per growth option when running the model.
- The database WP703EW – Method of Travel to Work (ONS, 2011) which has been interrogated to obtain the mode split for residents that live in the combined middle super output areas (MSOAs) that contains the Site. These MSOAs include:
  - E02006504 - E02006518: Stratford-on-Avon 001 - Stratford-on-Avon 015
  - E02006519 - E02006533: Warwick 001 - Warwick 015
- Mode split and travel purpose – extracted from National Travel Survey Table NTS0409 (ONS, 2020) provides mode split for different travel purposes. The travel purposes have then been grouped into 'Commuting', 'Education' and 'Local/shopping' trips to present the trip nature generated within the site.
- The average travel distance for each transport mode has been obtained from Table NTS0303 (Department for Transport, DfT) (ONS, 2020).
- Target year for changes in mode split of transport.
- Electric vehicles uptake percentages and target year for these uptake percentages (based on TAG (Table A 1.3.9)).
- Trip rates for servicing trips are based on servicing survey of an outer London residential development – 0.180 trips per household. This is based on a survey of 72 trips across all modes to a 401-unit development.
- Average travel distance for servicing vehicles have been based on reasonable estimate e.g. circa 3km for local deliveries within the site and circa 8km for HGV deliveries which were assumed to be the distance from central Coventry to the centre of South Warwickshire (24km).
- Additional information on transboundary servicing vehicles has been obtained from EDC. It is understood that there are circa 2,500 HGVs that travel across the site every day (assumed circa 24km – from Coventry to the centre of the site). This has been added to the model with an annualisation factor of 260 (5 days x 52 weeks).

Other key data inputs include:

- BEIS emissions factors.
- SAP10 electricity emissions factor.
- Energy efficiency benchmarks such as Part L 2013, Interim Future Homes Standard 2021, Passivhaus.
- A1-A5 embodied carbon values per square metre.
- CoP and efficiencies of various heating and cooling systems such as ASHPs, WSHPs, gas boilers, electric boilers, water cooled chillers etc.
- Transport emissions factors by transport mode (Department for Business, Energy & Industrial Strategy, 2022)

5.4 Defining scenarios

5.4.1 Updating inputs and model run behaviour in Scenarios

Each time the model is run it calculates emissions for each of the locations across buildings, energy, waste, transport, and land sequestration. These emissions are then aggregated back to report emissions across the entire of South Warwickshire. The entire calculation process is then repeated for each scenario defined in the model. The scenarios represent each of the 5 growth options, with each scenario having its own set of inputs or variables as outlined in Section 3. Across the scenarios not all these variables necessarily change (for example the efficiency of heat pumps), however they can be changed if the model user decides it appropriate for the values to differ between scenarios.

The inputs that have the most effect between scenarios is the performance efficiency of buildings, the rate at which they are retrofit (and to what level), and the changes in mode split to be met in 2035 and 2050 (for example the decrease in long car journeys and resulting increase in rail and bus use). Other variables and inputs do have an effect on total emissions; however, these were altered the most between scenarios based on the growth option descriptions.

5.4.2 Buildings

The following are the building-related interventions modelled in the scenarios:

- **Electricity emissions factors –** use BEIS electricity carbon factor projections, or alternatively test the fixed SAP 10 electricity emissions factor.
- **Energy efficiency improvements –**future energy efficiency standards can be specified for "Standard" developers and "Ambitious" developers looking to push the design and performance of their buildings. It also allows the user to specify the year in which these standards will be adopted in all new construction.
- **Heating decarbonisation –**the heating system which should be used in all new residential new builds and from which year this will take place.
- **Embodied carbon reduction** –the target reduction in embodied carbon for "Standard" and "Ambitious" developers and the target year in which these reductions should be achieved.

5.4.3 Transport

The following are the transport-related interventions modelled in the scenarios:

- **Electric vehicles (EVs)** – includes private vehicles and servicing vehicles (LGVs and OGVs). Based on the assumption that all vehicles will be 100% EVs by 2050. As EVs have different emission factors, the change in EV uptake affects the overall carbon emissions.
- **Working from home** – this considers the proportion of residents that will adopt a working from home model and hence reduces a percentage of commuter trips made per day. For the Dispersed scenario this proportion was assumed to be higher as it may be more attractive to stay at home to work in a Dispersed community.
- **20-minute neighbourhood** – this is influenced by the provision of amenities within 20-minute of walking distance from the locations. This intervention applies a reduction to all trips made per day.
- **Mode share** – this takes into account a natural reduction in car trips, split between long distance (relating to commuters' trips) and short distance trips (related to education, local/shopping trips); where long distance trips are transferred to public transport and short distance trips are transferred to walking/cycling.
- **Transport trips / emissions** – including HGVs that would cross the site each day; this allows the portion of these trips within the boundary to be included in the site-wide emissions calculation.

5.4.4 Waste

The following are the waste-related interventions modelled in the scenarios:

- **Household waste recycling rate –**the recycling rate as a percentage of all household refuse in both 2035 and 2050.
- **Non-domestic waste recycling rate** –the recycling rate of non-domestic waste as a percentage of total non-domestic waste in both 2035 and 2050.

- **Electric refuse collection vehicles (eRCVs) adopted** –the year in which electric vehicles are adopted for use as refuse collection vehicles.

- **Vacuum refuse collection trip reduction –** the resulting reduction in RCV trips from adopting a vacuum collection method.

5.5 Calculation method

5.5.1 Buildings

Buildings and waste related emissions are calculated either using building typologies and floor areas from the growth options housing and employment land schedule, or from the estimated population which is also derived from the same housing and employment land schedule.

The main formula that supports these calculations is:

$$energy\ consumed\ (kWh) \times Emission\ Factor \left(\frac{kgCO_2e}{kWh}\right) = carbon\ emissions\ (kg)$$

The buildings calculation method uses a script which iterates through the list of settlements and locations and exports the red results blocks (Figure 39) to the corresponding scenario results sheet (e.g., “S2” for Scenario 2).

Wootton Wawen	Wootton Wawen	BDG > RES > Cumulative number of homes	No	#
Wootton Wawen	Wootton Wawen	BDG > RES > Cumulative population	No	#
Wootton Wawen	Wootton Wawen	BDG > RES > Heating Demand	No	kWh
Wootton Wawen	Wootton Wawen	BDG > RES > Cooling Demand	No	kWh
Wootton Wawen	Wootton Wawen	BDG > RES > DWH Demand	No	kWh
Wootton Wawen	Wootton Wawen	BDG > RES > Electricity Demand	No	kWh
Wootton Wawen	Wootton Wawen	BDG > RES > Heating Demand Retrofit Saving	No	kWh
Wootton Wawen	Wootton Wawen	BDG > RES > Cooling Demand Retrofit Saving	No	kWh
Wootton Wawen	Wootton Wawen	BDG > RES > DWH Demand Retrofit Saving	No	kWh
Wootton Wawen	Wootton Wawen	BDG > RES > Electricity Demand Retrofit Saving	No	kWh
Wootton Wawen	Wootton Wawen	BDG > RES > Gas Consumption	No	kWh
Wootton Wawen	Wootton Wawen	BDG > RES > Electricity Consumption	No	kWh
Wootton Wawen	Wootton Wawen	BDG > RES > Gas Emissions	No	$kgCO_2e$
Wootton Wawen	Wootton Wawen	BDG > RES > Electricity Emissions	No	$kgCO_2e$
Wootton Wawen	Wootton Wawen	BDG > RES > PV avoided emissions	No	$kgCO_2e$
Wootton Wawen	Wootton Wawen	BDG > RES > Operational Emissions	Yes	$kgCO_2e$
Wootton Wawen	Wootton Wawen	BDG > RES > Embodied Emissions	No	$kgCO_2e$
Wootton Wawen	Wootton Wawen	BDG > RES > Waste emissions	No	$kgCO_2e$
Wootton Wawen	Wootton Wawen	LAND USE > Sequestration	No	$kgCO_2e$

Figure 39 - Red results block excerpt from the model – Buildings

The following components form the calculations:

- **Building types and floor areas** provided by SDC in the growth options housing and employment land schedule. The non-residential building types and percentages were inferred from the 2019 Authority Monitoring Report by assessing the percentage of use classes across new and planned construction. The residential development build out was estimated based on the size of the development. For example, small, medium, and large developments taking 3, 5, and 7 years, respectively.

- Total floor area and estimated population is then calculated using the development build out and the housing typology data.

- **Operational energy benchmarks** taken from LETI, CIBSE, BEIS etc. These operational energy benchmarks are applied to the houses in each of the locations depending on the energy efficiency rating standard defined by either the developer (e.g., “Ambitious” or “Standard”), or in the scenario definition. Operational energy benchmarks were applied to floor areas to calculate the heating, cooling, domestic hot water (DHW), and electricity load demands.

- **Heating and cooling system performance data** is used to convert energy demand loads to energy consumption. By defining the heating and cooling systems, the operational energy demands are converted to find the total electrical loads and gas use in the buildings per location. For example, total gas use is calculated by taking the heating and domestic hot water demands and applying gas boiler efficiency and heat losses values. Similarly, for buildings using air source heat pumps, total electrical loads are calculated by applying the coefficient of performance (CoP) to the heating demand.

- **Grid emissions factor projections** are used to convert energy consumption to carbon emissions. Projections provided by BEIS or SAP 10 emissions factors are applied to calculate the operational emissions from electrical loads. Alternatively, the gas emissions factor is applied to total gas use (kWh) to find the total carbon emissions from gas use.

- **Future building standards and retrofit** is altered in the calculations using parameters set for each scenario, depending on the target dates for improved building standards, or the number of years after construction that retrofit would occur. The calculation block works by looking back to the previous level of demand (15-year prior, for example) and applying reductions in the current year based on improvements in energy efficiency due to retrofit, or eradication of gas due to an electric boiler mandate.

- **Waste emissions** are calculated for residential and non-residential buildings using UK local authority 2021 averages for waste management statistics and emissions intensity of waste from UK government GHG reporting databases. Emissions are calculated on a per-resident basis for residential calculation blocks. For non-residential, the number of employees is first calculated using the assumption of 12.5 m^2 employment area per person. From this, waste arising per employee is assumed using planning guidance published by OPDC in London.

5.5.2 Transport

The main formula that supports the transport assessment is:

$$distance\ (km) \times Emission\ Factor\left(\frac{kgCO_2e}{km}\right) = carbon\ emissions\ (kg)$$

The following components form the calculations:

- **Total trips per day per location** taken from the TRICS database. The trip rates are then processed to provide a uniform set of 'total trips per day per location' for further calculations. The following assumptions are applied:

  - For non-residential uses, where the actual land use and the land use applied within planning application do not match, the closest approximation of land use is applied.

  - The total number of trips is adjusted to the yearly time series by applying an annualisation factor of 365 for residential trips (based on 365 days of travel in an average year by residents); and 308 for non-residential trips (based on an average of operational days for office/retail and restaurants).

- **Mode split** data is obtained from Census (discussed in previous section). Other assumptions such as fleet mix of vehicles, e.g. percentage of electric vehicles are used to establish the baseline using the TAG dataset. Improvement in efficiency is also applied to the time series to take into account technological advancement in battery life and capacity, etc.

- **Servicing trips** are calculated based on trip rate of 0.180 per household (discussed in previous section) multiplied by the number of units. Similarly, an annualisation factor is applied for annual trips (factor of 312 – based on six operational days per 52 weeks).

- **Total average travel distance** is calculated by applying the trip generation and mode split, giving the trip generation by mode. This informs the total distance travelled by each mode.

- **Emission factor per mode** is calculated using the emission factors for different modes (including servicing vehicles) applied to the total distance per mode, arriving at the transport carbon emissions. No emissions are generated by walking and cycling.

The transport calculation method works via a script that runs the same block of calculations for each of the locations. The script iterates through the list of settlements and locations and exports the red results blocks to the corresponding scenario results sheet (e.g., "S2" for Scenario 2).

5.5.3 Waste and Land Sequestration

The main formula that supports the waste emissions is:

$$Number\ of\ employees/persons \times Emission\ Factor \left(\frac{kgCO_2e}{person}\right) = carbon\ emissions\ (kg)$$

The following components form the calculations:

- **Total number of persons** is calculated for each residential settlement and location by using the housing typology split. For example, 25 2B3P dwellings would equate to 75 people. The model does not account for variation in persons (e.g., male, female, child, adult).
- **Total number of employees** is calculated for each non-residential settlement and location by using the total employment land for that location. From this the total number of employees was calculated by applying a 12.5 m^2/person space allocation factor to the commercial floor area (Table 16).
- **Recycling rates** for residential and non-residential to compute the amount of waste going to landfill and therefore contributing to waste emissions each year (Table 16).
- **Emissions intensity of waste** different values were assigned for different type of landfill waste (such as household residual waste, organic food and drink waste, and garden waste (Table 16).

The main formula that supports the land sequestration emissions is:

$$Open\ space\ allocation\ per\ 1000\ people \times Sequestration\ Factor \left(\frac{kgCO_2e}{person}\right)$$
$$= carbon\ sequestered\ (kg)$$

The following components form the calculations:

- **Previously calculated total number or persons and employees**
- **Public open space allocation rates** taken from the Warwick Open Space SPD these lay out the minimum amount of space of residential and non-residential open space per 1000 people/employees (Warwick District Council, 2019)
- **Percentage split in open space typology** taken from the Warwick Open Space SPD (Warwick District Council, 2019) minimum open space requirements by open space typology for residential and non-residential spaces
- **Sequestration rates for woodland park spaces.**

5.6 Model integrity

This model provides a baseline understanding of emissions from the South Warwickshire Local Plan growth options, as well as for individual potential new settlements. Based on the high-level descriptions of the growth options and new settlements at the current stage of plan preparation, it provides a high-level approach which reflects the stage the Local Plan is at, with options for the model to be refined as the plan preparation progresses. At this early stage it is difficult to make more detailed assumptions in the absence of further data and policy direction from the Local Plan. The data that has been used, along with the assumptions over the time period, have been reviewed to offer a reasonable perspective on information and trends, which are considered appropriate for the Local Plan Issues and Options consultation.

All Arup models go through a quality assurance testing process by Arup teams that are external to the project team. This ensures our models are robust, provide opportunity for peer review, and reduces errors.

A.1 Input data

A.1.1 Inputs by sector

Below are some highlights of site-specific inputs used in the model. These values are deemed industry standards.

Table 16 - Key inputs by sector

Constant	Sector	Value	Units
Gas boiler efficiency	Heating and Cooling	92.0	%
Gas boiler heat losses	Heating and Cooling	5.00	%
Electric boiler efficiency	Heating and Cooling	100	%
Electric boiler heat losses	Heating and Cooling	5.00	%
ASHP heating CoP	Heating and Cooling	3.20	N/A
Air-cooled chiller cooling SEER	Heating and Cooling	3.20	N/A
HNDU gas factor	Heating and Cooling	184	gCO2e/kWh
Solar PV annual electricity generation	Electricity generation	850	kWh/kWp
Solar PV efficiency	Electricity generation	7.00	m^2/kWp
Solar PV residential installation size	Electricity generation	4.50	kWp
Waste generation per person	Waste	399	kg/year
Household residual waste	Waste	26.0	kgCO2e/tonne
Organic: food and drink waste	Waste	9.00	kgCO2e/tonne
Organic: garden waste	Waste	9.00	kgCO2e/tonne
Commercial waste generation per employee	Waste	1,900	kg/year
Commercial dry recycling waste	Waste	38.0	%
Commercial food recycling rate	Waste	3.60	%
Commercial other recyclables	Waste	30.7	%
Non-residential floor area per person	Waste/Land Sequestration	12.5	m^2/person

A.2 References

Department for Business, Energy & Industrial Strategy. (2022). *Greenhouse gas reporting: conversion factors 2022.* Retrieved from https://www.gov.uk/government/publications/greenhouse-gas-reporting-conversion-factors-

ONS. (2011). *Method of travel to work (2001 specification) (Workplace population).* Retrieved from Method of travel to work (2001 specification) (Workplace population): https://www.nomisweb.co.uk/census/2011/wp703ew

ONS. (2020). *National Travel Survey: 2020 - GOV.UK.* Retrieved from National Travel Survey: 2020: https://www.gov.uk/government/statistics/national-travel-survey-2020

Warwick District Council. (2019). *Public Open Space SPD.* Royal Leamington Spa: Warwick District Council.

Warwick District Council. (2021). *Authority Monitoring Report.* Royal Leamington Spa: Warwick District Council.