

BRADFORD DISTRICT

Advisory Emissions Reduction Pathway and Associated Co-Benefits*

Report for: City of Bradford Metropolitan District Council (CBMDC)

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*Advisory document only. Targets within are assumptions, not adopted Bradford Council targets

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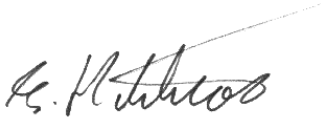

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1. INTRODUCTION

The City of Bradford Metropolitan District Council (CBMDC) declared a climate emergency in 2019. To support its ambition of achieving net zero by 2038, with substantial progress by 2030, the Council is developing a series of Climate Action Plans (CAPs) up to 2038 with the first covering the period 2025–2028. This particular CAP focuses on the specific actions the Council will take over the next three years. Given the rapidly evolving nature of climate science, technology, policy, and local priorities, adopting a shorter time frame allows the Council to remain responsive and adaptable, ensuring its CAPs stay relevant and actionable.

Task 1 assessed the existing climate policy landscape at national and local levels, identified key stakeholders for the development and delivery of the CAP, and established a robust greenhouse gas (GHG) emissions and air quality (AQ) baseline for the district. This report builds on this foundational analysis, using the GHG and AQ baselines as a critical input, to address the following questions:

1. What might emissions look like in Bradford if no further mitigation action is taken locally, regionally, or nationally?
2. What is a realistic pathway for Bradford to achieve its net zero ambitions, and what level of emissions reduction is achievable under this scenario?
3. What are the wider social, environmental, and economic co-benefits associated with implementing the net zero pathway in Bradford?
4. How might changes in emissions from the net zero pathway affect air quality across Bradford?

To address the first two questions, two pathways have been modelled for Bradford (Task 2). This includes a business-as-usual (BAU) scenario, where no additional local, regional, or national mitigation efforts beyond what has already been realised are included, and a net zero scenario, which includes cross-sectoral local mitigation efforts. These pathways are critical for understanding how Bradford can deliver local actions to address its long-term climate targets by illustrating what is needed to achieve net zero, including key sectors, measures, and timelines.

To provide a holistic evidence base for developing Bradford's CAP, it is also important to consider the potential co-benefits that the modelled net zero measures could deliver, beyond the objective of reducing emissions. Task 3, therefore, provides an overview of the potential co-benefits that could be realised across the economy, society, and environment due to the net zero pathway, assessing the strength of these benefits through a local lens. Capitalising on co-benefits when delivering net zero ambitions is key to securing political and public buy-in, providing grounds for investment, and incentivising action across society.

A key co-benefit of net zero is often improvements in air quality, due to sources of GHG emissions often also generating air pollutants such as nitrogen oxides (NO_x) and particulate matter (PM). Building upon the air quality baseline for 2023, air quality emission rates and local concentrations under the net zero scenario were assessed for different air quality pollutants, in order to better understand how they will respond under these future conditions.

2. NET ZERO MODELLING

During Task 2, two scenarios were modelled: a BAU scenario and a single net zero scenario. The BAU scenario provides the baseline for the net zero modelling. The net zero scenario aims to achieve deep emissions reductions, making significant progress to net zero by 2030 and 2038 respectively within the realms of technological, financial, and practical feasibility.

The scenarios were modelled using the Ricardo Net Zero Projections Tool (NZPT), which enables users to model the impact of implementing mitigation measures on a local authority area's GHG emissions over time. It is a flexible tool that can be quickly configured to model the change in energy use and GHG emissions by specifying the breakdown of the energy and non-energy related emissions that aligns with the area's base year datasets and reporting requirements, whilst also factoring in changes in demand (e.g., due to population or economic growth) and emission factors over time.

The tool is designed to enable the development of scenarios for reaching net zero by any given target year and allows the user to define mitigation measures for each line in the energy and emissions inventory. These scenarios can be used to build a baseline projection, assess the likely impact of planned measures and model the impact of alternative strategies to reach net zero. The scenarios can also be used to undertake sensitivity testing around the impact of changes in assumptions.

The tool is essentially a 'What if?' calculator that relies on the external validation of inputs, assumptions and outputs to make sure its projections are sensible. At its core, the tool is an accounting system that calculates the change in energy use and fuel mix as a result of a series of mitigation measures.

2.1 THE BUSINESS-AS-USUAL SCENARIO

2.1.1 Data sources and methodology

The BAU scenario is intended to show the changes that could occur if no additional local, regional, or national action were taken to mitigate GHG emissions in Bradford, beyond the impact of key drivers such as national-level economic and demographic trends, along with projected energy prices and weather changes.

To model a detailed scenario that not only accounts for singular drivers such as population growth, the BAU growth assumptions are based on the DESNZ Energy and Emissions Projections (EEP). The EEPs include more sophisticated drivers such as winter degree days, technological improvements, and the anticipated GHG reductions that are expected to occur due to adopted Government policies *'where funding has been agreed and where decisions on policy design are sufficiently advanced to allow robust estimates of policy impacts to be made'*.[1] To avoid double-counting with the mitigation measures, the impact of emissions on these policies has been removed, leaving an adjusted BAU scenario. This was done by utilising the Climate Change Committee's (CCC) Seventh Carbon Budget Baseline Scenario, which uses the EEPs as the underlying data but removes "emissions savings associated with any policies that go beyond those already being realised today"[2]. For surface transport, the CCC used the Department for Transport's (DfT) National Road Traffic Projections.

The EEP data incorporates a range of information, including projections for:

- Annual growth rates for population and number of households
- Annual growth rates for economic parameters:
  - Real UK GDP
  - GDP Deflator
  - Real household disposable income
  - Industrial production
- Weather changes (winter degree days)
- Retail and wholesale energy prices, carbon prices, and exchange rates

Prior to using the EEP and CCC data, a sense-checking exercise was carried out to assess whether it was appropriate to apply these national trends at a local level – for example, by cross-checking national population growth projections with those for Bradford.

The Office for National Statistics (ONS) projections released in 2018[3] indicate that the population of Bradford would increase from 537,173 in 2018 to 560,133 in 2038, an increase of 4.3% overall.[4] This is significantly below the UK projection of 12% during the same 20 years[5] (see Figure 2-1) which suggests that EEP values may overestimate fuel consumption and GHG emissions if applied to Bradford.

[1] For further information, see https://www.gov.uk/government/collections/energy-and-emissions-projections

[2] CCC (2025). The Seventh Carbon Budget. Available at: https://www.theccc.org.uk/publication/the-seventh-carbon-budget/

[3] Note that the is the most recently available data with a new (provisional) dataset due to be released in June 2025.

[4] Office for National Statistics (ONS) (2020). Population projections – local authorities: SNPP Z1. Available at: https://www.ons.gov.uk/peoplepopulationandcommunity/populationandmigration/populationprojections/datasets/localauthoritiesinenglandz1

[5] Office for National Statistics (ONS) (2025). National population projections: 2022-based. Available at: https://www.ons.gov.uk/peoplepopulationandcommunity/populationandmigration/populationprojections/bulletins/nationalpopulationprojections/2022based

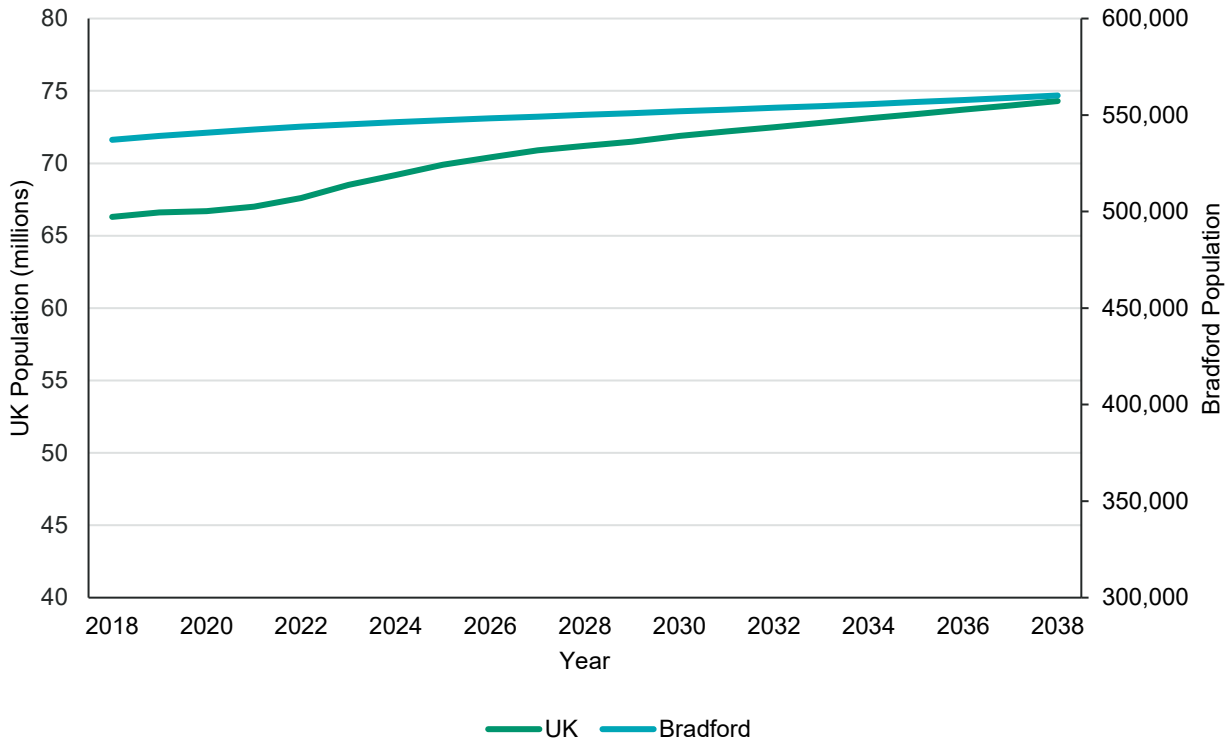

Figure 2-1: Bradford and UK Population Projections 2018 - 2038. Source: ONS.

A comparison of projected population estimates and actuals[6] over a recent five-year period; however, showed that Bradford has been outpacing these projections by a significant margin, reaching the projected 2038 value in 2023 (see Figure 2-2 below). As such, it is reasonable to assume that the underlying population drivers for Bradford are not dissimilar to wider UK trends, despite the discrepancy in the projections, making the EEPs, and by extension, the CCC's baseline scenario, an appropriate data source for Bradford's BAU scenario. If population growth is to slow down in Bradford, is it still preferable to use a conservative (i.e. higher) growth estimate to avoid underestimating emissions.

This data highlights the uncertainty with local projections, even for relatively straightforward 'one variable' projections[7], such as population.

[6] Office for National Statistics (ONS) (2024). Estimates of the population for England and Wales. Available at: https://www.ons.gov.uk/peoplepopulationandcommunity/populationandmigration/populationestimates/datasets/estimatesofthepopulationforenglandandwales

[7] In reality, there are many underlying drivers that impact population changes.

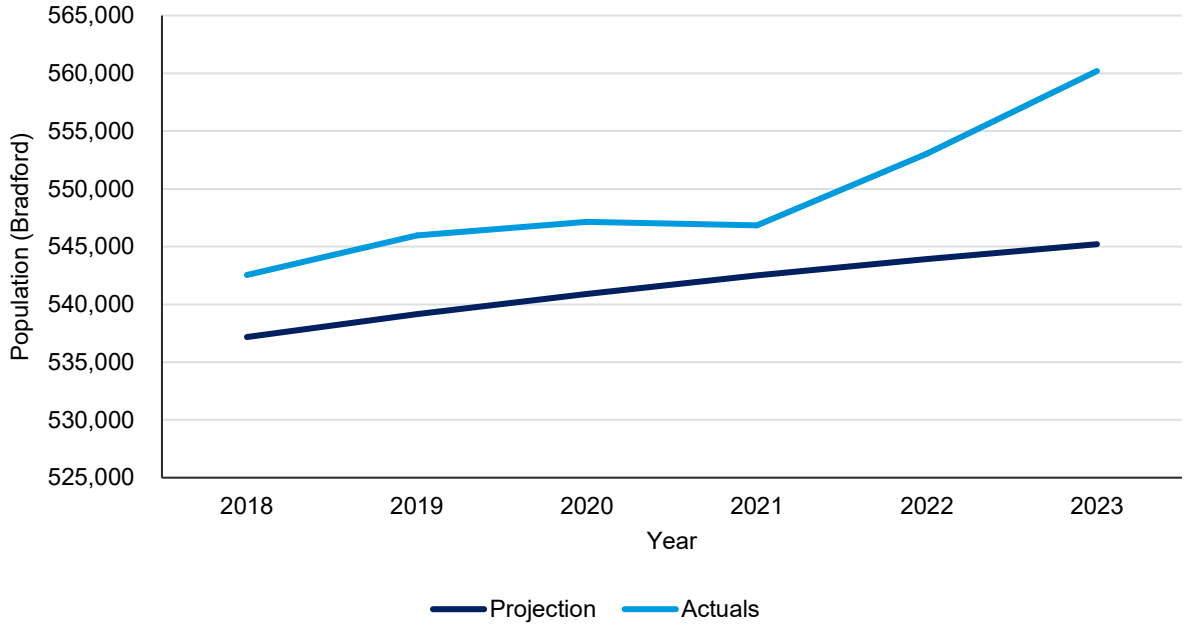

Figure 2-2: Bradford Population Projections vs Actual Statistics (2018 – 2023). Source: ONS.

Following the sense-checking exercise, the EEPs were deemed an appropriate dataset for Bradford and further tailored to the local context before their inclusion in the BAU scenario.

To estimate future energy use and GHG emissions under the BAU scenario, local 2022 energy data (as estimated in Task 1 using the Local Authority GHG inventory and other national datasets) were used as the baseline, and growth assumptions were applied up to 2038. These trends reflect how different fuels are expected to increase or decrease over time, based on structural factors like population growth, energy prices, and technology changes.

Minor adjustments were made to the CCC values considering Bradford's local context and the different modelling scale more generally, such as:

- Land Use, Land Use Change, and Forestry (LULUCF) emissions were assumed to remain constant rather than rising, due to the overall positive trends in this sector locally.
- F-gases were projected to decrease as this is strongly driven by national policy, so the 'existing measures' policy figure from the EEPs were chosen here.
- The decarbonisation of the electricity grid was assumed to be the same across both scenarios for ease of comparison between the two scenarios. This modelling choice was made as grid decarbonisation is driven at the national level, with Bradford having limited influence over changes to the emissions intensity of the grid. Assuming a different decarbonisation trajectory, while more realistic under BAU assumptions, would make it challenging to assess the impact of local measures on Bradford's modelled future emissions and therefore compromise the benefits of the net zero modelling.

Care was taken in the net zero scenario to avoid any double-counting between any BAU reductions and the mitigation measures, e.g. by incorporating the emissions savings from the F-gas measures into the more ambitious F-gas mitigation measures.

2.1.2 Results

In the BAU scenario, GHG emissions in Bradford would fall by roughly 7.8% by 2030 and 12.6% by 2038 (see Figure 2-3). This is under the assumption that there are no additional mitigation measures at the national or local level beyond the decarbonisation of the electricity grid, which was assumed to be the same across the BAU and net zero scenarios.

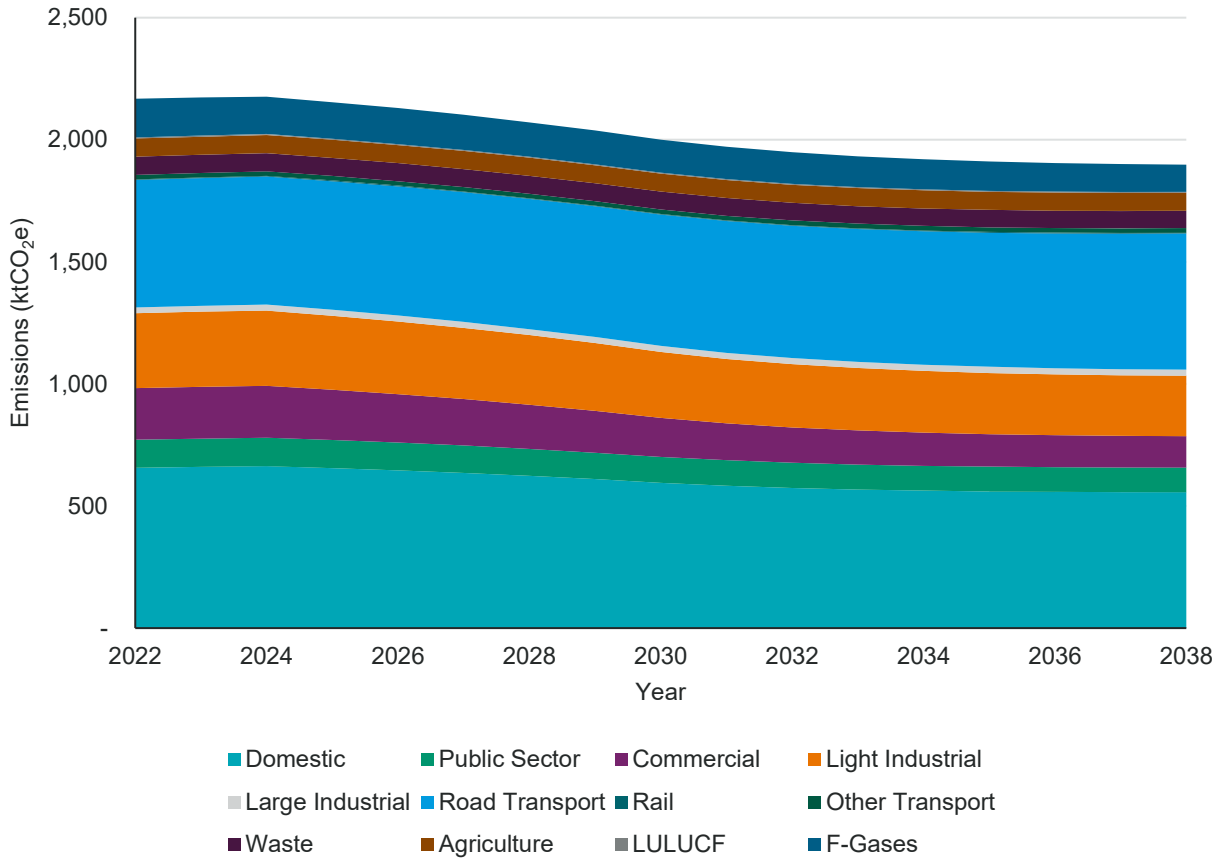

Figure 2-3: GHG emissions by Sector under the BAU Scenario. Source: NZPT.

Under this assumption, fuel consumption increases by around 4% by 2030 and 8% by 2038 compared to the 2022 baseline, as shown in Figure 2-4.

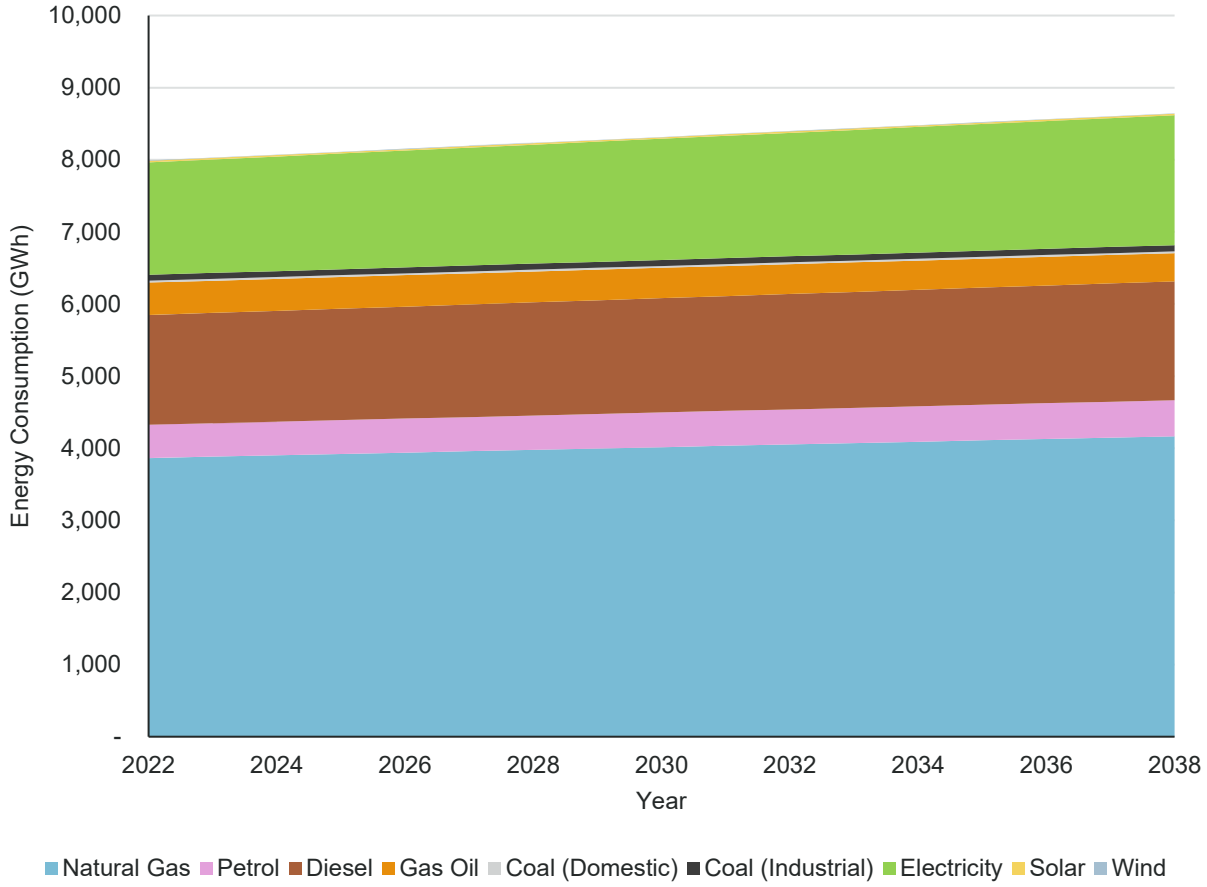

Figure 2-4: Energy Use by Fuel Type under the BAU Scenario. Source: NZPT.

The major factor driving these changes is the decarbonisation of the electricity grid, which is assumed to fall from 0.211 kgCO_2e/kWh in 2022; 0.085 kgCO_2e/kWh in 2030 and 0.008 kgCO_2e/kWh in 2038.[8] This can clearly be seen when comparing Figure 2-4 above and Figure 2-5 below, which looks at energy use and GHG emissions by fuel type. The energy use is projected to increase between 2022 and 2038, which is mainly driven by an increase in electricity use (around 16%), followed by natural gas, petrol, and diesel at similar rates of around 8%. Due to a decrease in grid electricity emissions, overall emissions would nevertheless continue to decrease by over 12% between 2022 and 2038 under the BAU assumptions, despite the increase in fuel consumption. However, it is also clear that grid decarbonisation alone will not get Bradford anywhere close to its net zero target of 2038.

[8] Note: The 2022 emissions factor is taken from the 'UK local and regional greenhouse gas emissions estimates for 2005-2022: Technical Report' (published by DESNZ). Available here: https://assets.publishing.service.gov.uk/media/667ad7a7c7f64e234208ffc2/local-authority-ghg-technical-report-2022.pdf and the emission factor trajectory is based on the HM Treasury Green Book supplementary appraisal guidance on valuing energy use and greenhouse gas (GHG) emissions (published by DESNZ). Available here: https://www.gov.uk/government/publications/valuation-of-energy-use-and-greenhouse-gas-emissions-for-appraisal

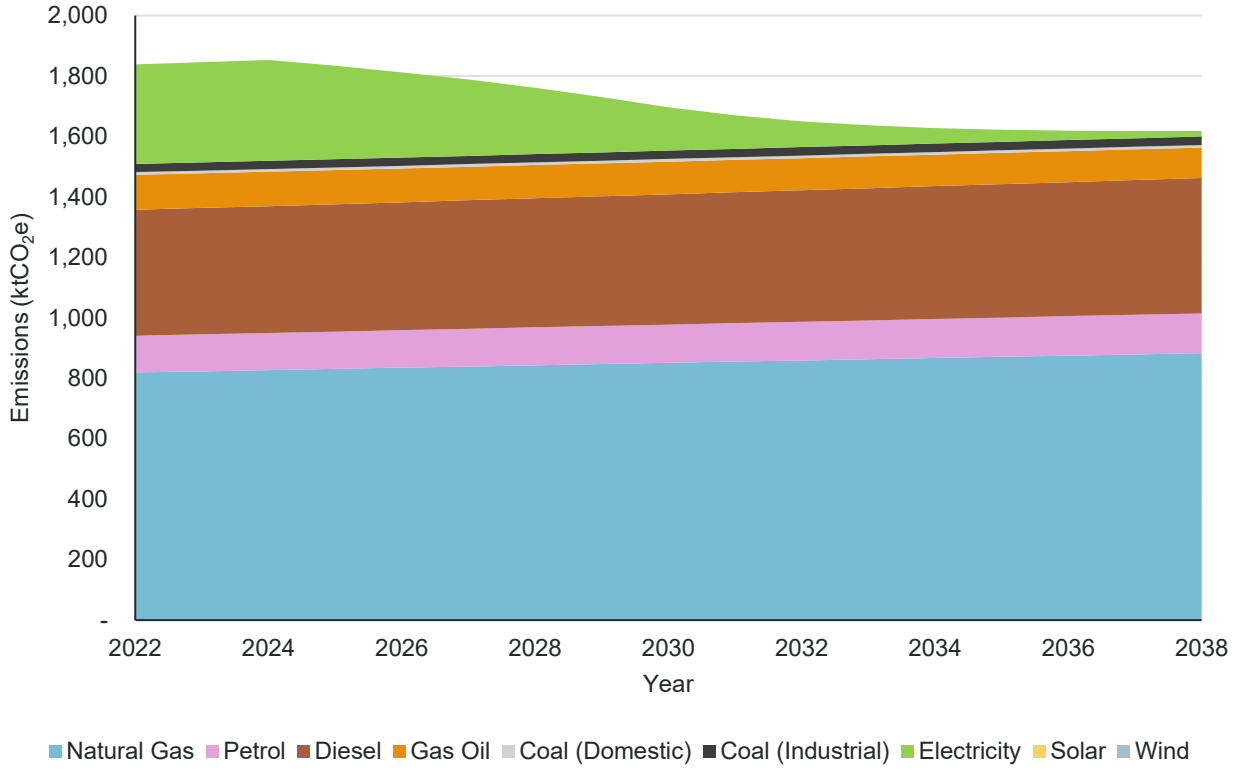

Figure 2-5: Emissions by Fuel under the BAU Scenario. Source: NZPT.

The cumulative emissions over this time period amount to approximately 34,400 $ktCO_2e$ under the BAU Scenario. The cumulative GHG emissions from fuel use would amount to approximately 29,600 $ktCO_2e$, and the estimated CO_2 emissions from energy to approximately 28,700 $ktCO_2e$, meaning the Paris Agreement-aligned carbon budget [9] for the time period through the year 2,100 would be used up by 2026.[10, 11]

Overall, the BAU results highlight the fact that local GHG mitigation efforts will be necessary to ensure that the net zero target in Bradford can be met and cumulative emissions reduced. However, it should be noted that drastic and likely unfeasible actions would be required to stay within the Paris-aligned carbon budget, as only one year remains from the writing of this report. The most significant future trend that is likely to contribute to a decrease in emissions is the decarbonisation of the electricity grid. However, for this to have a sufficient impact on Bradford's total energy emissions, current fossil fuel use has to be reduced through demand reduction, fuel switching measures, or both. In addition to this, the precise timing and scale of the grid decarbonisation is uncertain, and grid decarbonisation alone will not be enough to reach net zero. A major effort to reduce energy demand and then switch to renewable energy is therefore critical.

Even if 100% of energy demands were met with renewables, with an emission factor of 0 kg CO_2e/kWh[12], only an 88% reduction in emissions would be achieved. This is because the remaining emissions, which include waste and wastewater treatment, agriculture, LULUCF, and F-gases, are not associated with energy use. Different strategies are therefore needed to tackle these sources of emissions. These will be addressed in the following sections.

[9] An assessment of what Bradford's 'fair contribution' to the Paris Agreement would be. For more info, see the University of Manchester, 'Setting Climate Commitments for Bradford' (updated May 2025). Available at: https://carbonbudget.manchester.ac.uk/reports/E08000032/

[10] The Carbon Budget is based on energy emissions only; therefore, these have been presented separately. Note that this further only relates to emissions from CO_2. As emissions have been forecast in CO_2e, capturing all GHGs, it cannot be said what the precise CO_2 emissions from energy use will be in future years; however, as it is assumed that the same proportion from the base year was maintained throughout future years, meaning that 97% of fuel-related emissions are from CO_2. This was accounted for in the estimations above.

[11] Note that while the source indicates a baseline of 13.3 $MtCO_2e$, when acknowledging Bradford district's emissions since the baseline was completed (as per the annual LAGHG data), this has been recalculated at a remaining 9 $MtCO_2e$

[12] Note that in reality, emission factors of >0 are used for a de factor decarbonised electricity grid.

2.2 NET ZERO SCENARIO

2.2.1 Methodology

The net zero scenario, referred to as the Future-Ready Pathway, represents a technically robust and politically realistic trajectory towards Bradford's 2038 climate target. Designed to be ambitious yet feasible, this scenario combines cost-effective interventions with strategic co-benefits, grounded in Bradford's local strengths and challenges. It begins with immediate action and progressively ramps up mitigation efforts through to 2038, utilising a blend of demand reduction, fuel switching, energy efficiency improvements, and enabling measures such as planning, partnerships, and community engagement. This scenario reflects a 'no regrets' approach and 'best value' pathway that simultaneously reduces emissions, builds local resilience, and unlocks green investment. The Future-Ready Pathway is a statement of responsible leadership, aligning long-term mitigation targets with short- and long-term co-benefits.

The net zero scenario was modelled by applying mitigation measures across all sectors to the baseline or BAU scenario. It further includes changes in the emissions intensity of the modelled fuels, such as grid electricity, hydrogen, and district heating.

In order to apply mitigation measures to the appropriate baseline activity, the 2022 fuel consumption was disaggregated by end use using the DESNZ Statistics on Energy Consumption in the UK (ECUK).[13] These statistics provide an indication of the proportion of a fuel that is used within the stationary energy sectors, such as how much natural gas is used for heating in domestic properties. This then allowed us to apply relevant mitigation measures, such as demand reduction from retrofitting buildings and fuel switching from natural gas to electricity, to these proportions of baseline energy use. It should be noted that using national-level statistics of energy end-use is associated with a degree of uncertainty, as it cannot be said definitively whether these proportions also apply to Bradford. As such, this uncertainty should be considered when evaluating the emissions impact of the mitigation measures.

The mitigation measures were developed through a combination of desk-based research and stakeholder engagement. The main sources for the mitigation measures are:

1. The West Yorkshire Carbon Emissions Reduction Pathways 2020 Modelling Report[14,15]
2. The Climate Change Committee (CCC) Sixth Carbon Budget[16]
3. The Climate Change Committee (CCC) Seventh Carbon Budget[17]
4. The Bradford Manufacturing Futures (BMF) Study by Arup[18]

These key sources were supplemented and validated by stakeholder input and a range of additional, credible sources, such as the LETI Climate Emergency Retrofit Guide[19]. Care was taken to tailor the measures to Bradford's locally specific context, where possible. The detailed assumptions underlying the modelling are laid out in Section 2.2.2 below.

In addition to the mitigation measures, changes in emissions are also influenced by changes in the emissions intensity of fuels, expressed through changes in emission factors (EFs). This includes the decarbonisation of the electricity grid[20], district heating (in line with the decarbonisation of the grid), and hydrogen (albeit from an already ambitious low-carbon baseline given the planned hydrogen production facility in Bradford). Key emission factors and their respective 2022 and 2038 values are shown in Appendix 1.

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[13] DESNZ and BEIS (2024). Energy Consumption in the UK. Available at: https://www.gov.uk/government/collections/energy-consumption-in-the-uk

[14] elementenergy (2020). West Yorkshire Carbon Emissions Reduction Pathways. Available at: https://www.westyorks-ca.gov.uk/media/4277/west-yorkshire-carbon-emission-reduction-pathways-technical-report-draft-v7-1.pdf

[15] While a more recent modelling exercise has been undertaken, the assumptions for this could not be obtained. As such, the 2020 modelling was used and reasonable adjustments made (such as accounting for changes to homeworking since the Covid-19 lockdowns).

[16] Climate Change Committee (2020). Sixth Carbon Budget. Available at: https://www.theccc.org.uk/publication/sixth-carbon-budget/

[17] Climate Change Committee (2025). Seventh Carbon Budget. Available at: https://www.theccc.org.uk/publication/the-seventh-carbon-budget/

[18] Not published, shared via CBMDC

[19] https://www.leti.uk/retrofit

[20] Note that the same assumption was used for the BAU and Net Zero Scenario

Finally, it should be noted that changes in fuel consumption and, therefore, emissions are also influenced by changes in the efficiency of different heating, lighting, or cooling systems and transport modes. This has been considered in the modelling, and key underlying assumptions are presented in Appendix 1 as well.

Limitations of the modelling: The modelling, as the GHG Baseline compiled under Task 1, only considers Scope 1 and 2 emissions (see Table 2-1) due to the challenges associated with estimating Scope 3 emissions. However, it is still crucial to reduce Scope 3 emissions, and this was done through a prioritisation of demand reduction measures. Fuel switching measures were only employed once demand reduction measures had been exploited as far as possible within the technological, financial, and behavioural limitations present.

Consideration of Embodied Emissions

As explained in Task 1, this analysis follows a sector-based emissions accounting approach in line with the Global Protocol for Community-Scale Greenhouse Gas Emission Inventories. This is a global reporting standard for cities and communities, ensuring comparability and avoiding double-counting between different cities and communities. However, this does also mean that certain emissions are not included in the inventory and emissions scenarios (BAU and net zero). These emissions are also referred to as 'embodied' or 'embedded' emissions.

Embodied emissions refer to the greenhouse gases that have arisen during the production and transportation of goods and services.

For example, if the emission factor for grid electricity is zero (because 100% of electricity is produced by renewable energy installations), this means that driving an electric car and heating a home with an air-source heat pump[21] is modelled with zero emissions. In reality; however, the production and waste management of wind turbines, solar panels, and electric vehicles (which we assume will not be produced within the local authority area) will still be associated with some emissions – especially while industrial processes and product use are still emissions-intensive. As such, any reduction in energy and product demand goes hand in hand with a global emissions reduction – even if this is not reflected in Bradford's emissions inventory.

A reduction in embodied emissions will not be seen directly in the outputs of the net zero pathway – however, they can be inferred from the energy consumption outputs.

Table 2-1: Definitions and examples of Scope 1, 2 and 3 emissions in Bradford's Net Zero Scenario.

Type	Definition	Examples
Scope 1	Direct emissions from fuel combustion and fugitive emissions within the local authority boundary.	• Fuel combustion in buildings and road vehicles. • Emissions from agriculture, waste and wastewater treatment, or landfill activities taking place within Bradford.
Scope 2	Indirect emissions from purchased electricity, heat, steam, or cooling that is generated elsewhere.	• Emissions from grid electricity and district heating consumed in Bradford.
Scope 3	All other indirect emissions.	• Waste or wastewater treatment *outside* of Bradford (of waste arisen within Bradford). • Transmission and distribution losses from the grid. • Transport of fuels that are used within the city. • Supply chains for food, products, and materials. • Journeys to/from the city that are outside the local authority boundary.

[21] In the case of a heat pump, it is technically near zero as there are still some emissions by F-gas leakage, but this figure is negligible compared to fossil fuel heating systems.

- Shipping and aviation.

2.2.2 Assumptions about future changes

The Future-Ready Pathway includes the same core assumptions about population, weather, fuel prices and economic trends that are used in the BAU scenario, which is used as the starting point for the analysis. As noted in Section 2.1, the BAU scenario utilises the CCC baseline data as its primary input alongside the 2022 baseline GHG data.[22]

All other changes are modelled as mitigation measures that would need to be adopted, whether via additional government policies, local/regional initiatives, or through voluntary changes in consumer behaviour, business, and industrial practices. Table 2-2 below summarises the mitigation measures that are modelled in each scenario.

Table 2-2: Overview of underlying assumptions.

Sector / Category	Summary of key assumptions
Domestic energy in buildings	• Uptake of retrofitting measures to reduce heating demand by improving building efficiency. Full adoption of smart heating controls delivering small efficiency gains. • Significant reduction in household water usage and resultant energy savings. • High adoption of LEDs for substantial energy savings from lighting. • Most households shift to energy-efficient appliances. • Significant portion of homes shift from fossil fuels to heat pumps, and a portion of gas-heated homes shift to heat networks. • Some households switch to or retain electric heating systems. • Near-complete transition from gas to electric cooking.
Non-domestic energy in buildings	• Reduction in heat demand through retrofitting in the public sector and commercial buildings. Full uptake of smart heating controls, near full uptake of LED lighting and energy efficient appliances. • Moderate uptake in water efficiency measures. • Majority of buildings shift to low-carbon heating (heat pumps, district heating, and electric heating). • Small portion of properties adopt or retain biofuel heating. • Widespread switch from fossil fuel cooking to electric alternatives. • Partial switch to electricity for fringe fossil fuel uses.
Industry	• Fuel switching to grid electricity, solar, wind and hydrogen aligned with separate Bradford Manufacturing Futures (BMF) study. • Demand reduction measures aligned with the separate BMF study.

[22] Bar certain adjustments, such as the decarbonisation of the electricity grid.

Sector / Category	Summary of key assumptions
Energy system	• Grid decarbonisation is in line with national modelling and targets. • Ramping up of rooftop solar PV deployment in domestic, commercial and public buildings. • On-site onshore wind generation displaces a portion of industrial fossil fuel use.
Transport	• Avoidance of car journeys through car sharing and lifestyle changes. • Modal shift from cars to walking, cycling, bus, and rail by 2038. • Strong push for electrification by 2038: Electric vehicles (cars, buses, motorcycles, LGVs, HGVs), electrification of railways. • Adoption of hydrogen vehicles, particularly buses. • Improved HGV efficiency, shift of freight from road to rail, use of cargo-bikes for last-mile delivery.
Waste	• Emissions reduction from landfills through waste reduction measures and gas (methane) capture. • Improved composting management. • Improved wastewater management.
Agriculture and land use	• Emissions from agricultural machinery reduced through switching from natural gas, gas oil, and coal in favour of electricity and hydrogen. • Emissions savings through soil and livestock measures. • Scaling up of tree planting initiatives for carbon sequestration. • Restoration of degraded peatlands to reduce emissions and enhance storage.
Other	• Reduction in F-gas emissions, partially driven by existing national policies.

The net zero pathway is intended to highlight the scale and direction of changes that could occur if the above measures were implemented. It is **not** intended as a projection or forecast of future energy use and emissions. It is also worth noting that implementing these types of changes would almost certainly lead to dynamic impacts across different activities and sectors, thus affecting wider trends such as fuel prices. Those interactions are highly complex and have not been quantified in this study. Nonetheless, the scenario provides a useful way to assess and prioritise potential interventions and understand CBMDC's level of influence when it comes to achieving net zero emissions.

The detailed assumptions can be found in Table 2-3 below. Where possible, actions were brought forward to 2030, providing modelling assumptions for both the interim and the target year. However, in some sectors, short-term uptake will be challenging with an acceleration of actions not being feasible. In these instances, a linear uptake between the baseline and the target year has been assumed.

Table 2-3: Detailed Pathway Assumptions.

Measure	Net Zero Scenario		Source and Rationale
	2030 Assumption	2038 Assumption	
Energy in Buildings: Domestic			
Retrofitting measures	Linear uptake to 2038.	75% of buildings achieve an average 40% reduction in energy demand, achieving a city-wide saving of around 30% for all heating-related domestic energy consumption.	Uptake rate based on baseline analysis in Task 1. There is no singular value for demand reduction from retrofitting across the entire building stock. The LETI guide suggests that demand reductions of 30% to 83% are feasible; however, the higher end of this range is associated with challenging and costly retrofits, which were not chosen from a co-benefits perspective. All values in the LETI guide showcase ambitious energy savings. Source: LETI Guide
Uptake of smart heating controls	Full uptake assumed for both fossil fuel and electric properties, with average savings of 2% and 3% for properties heated with natural gas and electricity, respectively.	Assumed full uptake has already been achieved by 2030.	Note that given the relatively high baseline value, full uptake means around 47% of gas-heated properties and 43% of electricity-heated properties. This is based on national figures in the absence of local values. Source for smart meter uptake: Smart-Energy news article Source for savings from smart meters: BEIS Smart Meter Roll-Out Cost-Benefit Analysis
Energy savings from water efficiency measures	Linear uptake to 2038.	A water consumption target of between 90 and 110 l/p/d is achieved for 60% of Bradford households.	Sources: LABC news article: Domestic water usage for new dwellings, Manchester University blog: Can we reduce water demand to 80 litres a day? And what can the government do to support?, and Yorkshire Water Annual Impact and Public Value Report
Energy savings from LED lighting	Linear uptake to 2038.	75% energy saving, reaching 95% household uptake (79% increase compared to the baseline).	Sources for energy saving: US Department of Energy: LED Lighting and Nesta: The rapid shift to LEDs and ultra-efficient lighting Source for uptake rates: Meteor Electrical blog - LED lighting key statistics

Measure	Net Zero Scenario		Source and Rationale
			Assuming that around 16% of households already have LED lighting as of 2022.
Energy savings from energy-efficient appliances	Linear uptake to 2038.	Assuming near full uptake with savings of 15% for households that currently don't have energy-efficient appliances.	Note that there are no clear statistics on the proportion of households with predominantly energy-efficient appliances – either locally or nationally. As such, a conservative assumption was made that around 75% of households already have energy-efficient appliances (with white goods making up the bulk of energy consumption), with realistic full uptake being 95%. Source for energy savings: IEA article - A call to action on efficient and smart appliances
Switching from fossil fuel heating systems to heat pumps	Linear uptake to 2038.	Assumed that around 105,800 heat pumps will be installed, translating to around 45% of households or 50% of households on the gas grid will have a heat pump by 2038.	Source for ambition: CCC Seventh Carbon budget, which indicates that around 50% of households will have a heat pump by 2040 under their balanced pathway.
Switching from natural gas to heat networks	Linear uptake to 2038.	Assumed that around 20% properties on the gas grid switch to district heating by the target year.	Sources: West Yorkshire Carbon Emissions Reductions Pathways and 1 Energy - Bradford Energy Network Note that while the BEN is currently purely non-domestic, this indicates a broader shift in Bradford's energy system.
Remaining on / switching to direct electric heating systems	Linear uptake to 2038.	Assumed that around 15% of households remain on or switch to other electric heating systems, such as electric storage heaters or underfloor heating.	Source for ambition: CCC Seventh Carbon Budget

Measure	Net Zero Scenario		Source and Rationale
Switching fossil fuel cooking systems to electric alternatives	Linear uptake to 2038.	Assume that 95% of remaining fossil fuel cooking systems switch to electric alternatives.	Assumption that 95% is functionally full uptake, accounting for fringe uses.
Energy in Buildings: Non-Domestic			
Retrofitting measures	Linear uptake to 2038.	Public sector and commercial buildings achieve a 25% reduction in heat demand.	Source: CCC Sixth Carbon Budget
Uptake of smart heating controls	Full uptake assumed for both fossil fuel and electric properties, with average savings of 4.5% and 2.8% for properties heated with natural gas and electricity, respectively.	No additional measures needed.	Note that given the relatively high baseline value, full uptake means around 47% of gas-heated properties and 43% of electricity-heated properties. This is based on national figures in the absence of local values. In the absence of domestic and non-domestic values, the same values were used across both sectors. Source for smart meter uptake: Smart Energy article - Over 31.3 million smart meters in GB Source for savings from smart meters: BEIS Smart Meter Roll-Out Cost-Benefit Analysis
Energy savings from water efficiency measures	Linear uptake to 2038.	A water consumption reduction of 10% (for heated water) and an uptake of 30%.	Lower uptake is assumed, as we have conservatively assumed a higher baseline for non-domestic properties to avoid overestimating energy savings. Source: Better Buildings Partnership - Responsible property management toolkit
Energy savings from LED lighting	Linear uptake to 2038.	75% energy saving, reaching 95% household uptake (79% increase compared to the baseline).	Sources for energy saving: US Department of Energy: LED Lighting and Nesta: The rapid shift to LEDs and ultra-efficient lighting Source for uptake rates: Meteor Electrical blog - LED lighting key statistics Assuming that around 16% of properties already have LED lighting as of 2022.

Measure	Net Zero Scenario		Source and Rationale
Energy savings from HVAC upgrades	Linear uptake to 2038.	36% energy savings for 91% of properties with less than B efficient ratings.	Source: IEA report - The future of cooling
Energy savings from energy-efficient appliances	Linear uptake to 2038.	Assuming near full uptake with savings of 15% for properties that currently don't have energy efficient appliances.	Note that there are no clear statistics on the proportion of commercial and public sector properties with predominantly energy-efficient appliances – locally or nationally. As such, a conservative assumption was made that around 75% of properties have energy-efficient appliances (with white goods making up the bulk of energy consumption), with realistic full uptake being 95%. Source for energy savings: IEA article - A call to action on efficient and smart appliances
Fuel Switching for non-domestic properties – overarching assumption	Linear uptake to 2038.	Assumed that around 90% of non-domestic properties will have a low-carbon heating source by 2038.	Source for ambition: CCC Seventh Carbon Budget
Public Sector: Switching from fossil fuel heating systems to heat pumps	Linear uptake to 2038.	Around 52% of natural gas properties and 55% of coal and gas oil-heated properties switch to heat pumps.	Source for ambition: CCC Seventh Carbon Budget
Commercial Sector: Switching from fossil fuel heating systems to heat pumps	Linear uptake to 2038.	Around 52% of natural gas properties and 55% of coal and gas oil-heated properties switch to heat pumps.	Source for ambition: CCC Seventh Carbon Budget
Public Sector: Switching from natural gas to heat networks	Linear uptake to 2038.	Assumed that around 30% of public sector properties on the gas grid switch to district heating by the target year.	Sources: West Yorkshire Carbon Emissions Reductions Pathways and 1 Energy - Bradford Energy Network
Commercial Sector: Switching from natural gas to heat networks	Linear uptake to 2038.	Assumed that around 25% of commercial properties on the gas grid switch to district heating by the target year.	Sources: West Yorkshire Carbon Emissions Reductions Pathways and 1 Energy - Bradford Energy Network

Measure	Net Zero Scenario		Source and Rationale
Public Sector: Switching to and remaining on direct electric heating	Linear uptake to 2038.	Assumed that around 45% of coal/gas oil fuelled properties switch to electric heating systems and that 45% of current electric heating systems remain on electric ones with the remainder switching to heat pumps.	Source: CCC Seventh Carbon Budget
Commercial Sector: Switching to and remaining on direct electric heating	Linear uptake to 2038.	Assumed that around 45% of coal/gas oil fuelled properties switch to electric heating systems and that 45% of current electric heating systems remain on electric ones with the remainder switching to heat pumps.	Source: CCC Seventh Carbon Budget
Commercial Sector: Biofuels	Linear uptake to 2038.	Assuming that around 2% of commercial properties remain on biomass and that 5% switch from natural gas to biogas.	Sources: Stakeholder input and CCC Seventh Carbon Budget
Switching to electric cooking systems by target year	Linear uptake to 2038.	Assume that 95% of remaining fossil fuel heating systems switch to electric alternatives.	Assumption that 95% is functionally full uptake, accounting for fringe uses. Source: Global Cooksafe Coalition Report
Switch proportion of unassigned fossil fuel use to electricity	Linear uptake to 2038.	50% of remaining (fringe) fossil fuel use switched to electricity.	Illustrative assumption in the absence of more robust local fuel consumption data.
Industry			
Fuel Switching	Linear uptake to 2038.	Switching most fossil fuels to renewable alternatives, with the 2038 fuel mix being 37% grid electricity, 35% solar,	Source: Arup BMF Study

Measure	Net Zero Scenario		Source and Rationale
		8% wind, 10% low-carbon hydrogen, and 10% natural gas.	
Energy Savings	Linear uptake to 2038.	Energy savings of around 10%.	Source: Arup BMF Study
Energy System[23]			
Grid decarbonisation	Assuming a carbon factor of 0.085 kg CO_2e/kWh	Assuming a carbon factor of 0.008 kg CO2e/kWh	Source: DESNZ
Domestic Rooftop Solar PV	10% of buildings to install an average domestic PV array size (kWp) of 3.5, generating 57,506 MWh / year.	20% of buildings to install an average domestic PV array size (kWp) of 3.5, generating 115,012 MWh / year.	This additional local energy generation displaces around 12-13% of the remaining electricity in the target year for the commercial and public sectors, respectively. Note that this outpaces the Northern PowerGrid Scenarios, as Bradford will need to ramp up its local renewable energy generation to achieve the earlier net zero target.
Commercial and Public Sector Solar PV	15% of buildings to install an average domestic PV array size (kWp) of 10, generating 17,857 MWh / year.	30% of buildings to install an average domestic PV array size (kWp) of 10, generating 35,715 MWh / year.	This additional local energy generation displaces around 20% of the remaining electricity in the target year. Note that this was estimated as 'rooftop' solar based on the number of buildings, but this is likely to be a mixture of roof and ground-mounted PV.
Industrial Solar PV	Linear uptake to 2038.	Assuming total solar generation of 368,923 MWh, displacing current fossil fuel use.	Source: Arup BMF Study Note that the values don't match exactly due to differences in our industry baseline and the BMF study baseline. The proportional energy changes between the baseline and target year are aligned with the BMF study.

[23] Note that energy storage systems and hydrogen production were not specifically modelled as this is a consumption-based pathway. However, both of these form critical elements of the success of this pathway and will be covered as enabling actions under Task 4.

Measure	Net Zero Scenario		Source and Rationale
Onshore Wind	Linear uptake to 2038.	Assumption on-site wind generation of 85,185 MWh, displacing current fossil fuel use.	Source: Arup BMF Study Note that the values don't match exactly due to differences in our industry baseline and the BMF study baseline. The proportional energy changes between the baseline and target year are aligned with the BMF study.
Transport			
Avoidance of car journeys through new ways of living and working	2% reduction in vehicle kilometres (vkm) travelled.	Rising to a 3% reduction in vkm travelled.	Source: West Yorkshire Carbon Emissions Reductions Pathways Assumed that these gains are limited due to changes already realised following the lockdowns. The 2020 WYCA modelling suggests a 15% reduction in travel demand, but as this does not account for post-lockdown changes, it is assumed that a significant proportion of this potential has already been realised. This is broadly in line with the CCC's assumptions, which are significantly lower than those used in the WYCA modelling.
Avoidance of car journeys through car sharing	6.5% reduction in vkm travelled.	11.7% reduction in vkm travelled.	Sources: Transport Study in Support of the Bradford City Centre AAP 2015 for the vehicle occupancy factor and the CCC's Sixth Carbon Budget for the target values. Assumed that vehicle occupancy rises from 1.33[24] to 1.7 by 2030 and 1.8 by 2038, and that there is a 20% 'detour' factor, meaning a slight increase in travel demand due to car sharing. These ambitious values require significant changes in how car ownership and sharing are viewed, but not impossible given much higher vehicle occupancy in decades prior.
Switching from car travel to walking and wheeling	Shifting 0.8% of car vkm travelled.	Shifting a further 0.3% by 2038, reaching a total shift of 1.1%.	Source: 2021 census data on average journey lengths in Bradford, modal shift totals to 30% as per stakeholder consultation.

[24] https://www.bradford.gov.uk/documents/citycentreactionplan/2 publication draft/evidence base/transport study.pdf

Measure	Net Zero Scenario		Source and Rationale
			Assuming that this effectively only applies to journeys of between 0 and 5 km. Note that the proportion of walking is already reasonably high, and the short journey length means that fewer vehicle kilometres (vkm) are saved than for cycling or public transport.
Switching from car travel to cycling	Shifting 4.2% of car vkm.	Shifting a further 1.8% car vkm, reaching a total shift of 6%.	Source: 2021 census data on average journey lengths in Bradford, modal shift totals to 30% as per stakeholder consultation. Assuming that this applies to journeys between 0 and 30 km, further assuming that around 50% of the cycling uptake applies to journeys shorter than 5km, around 33% to journeys between 5 and 10 km, and around 17% to journeys between 10 and 30 km.
Switching from car travel to bus travel	Shifting 6.3% of vkm.	Shifting a further 2.7% of vkm to buses, reaching 9% total.	Source: 2021 census data on average journey lengths in Bradford, modal shift totals to 30% as per stakeholder consultation. Assuming that car travel shifting to bus travel accounts for journeys of under 30 km.
Switching from car travel to rail travel	Shifting 9.8% of vkm.	Shifting a further 4.2% of vkm to rail, reaching 13.9% total.	Source: 2021 census data on average journey lengths in Bradford, modal shift totals to 30% as per stakeholder consultation. Assuming that car travel shifting to trains mainly accounts for journeys over 10 km – this, for example, includes journeys between Bradford and Leeds.
Ambitious uptake of EVs for remaining car journeys, both private and shared	Achieving 35% EV uptake, 14% HEV, and 7% PHEV, as well as 1% hydrogen fuel cell.	Rising to 82% EV uptake, 7% PHEV, and 2% hydrogen fuel cell.	Source: West Yorkshire Carbon Emissions Reduction Pathways 2020 Modelling Report and validation against Future Energy Scenarios (FES). Note that a small adjustment was made to remove HEVs in 2038 and replace these with EVs, making the total zero-emission vehicles 84% as per updated (draft) WYCA modelling.

Measure	Net Zero Scenario		Source and Rationale
Ambitious uptake of electric motorcycles	Assuming 40% uptake by 2030.	Rising to 85% by 2038.	Source: CCC Seventh Carbon Budget, indicates 89% by 2040.
Improving HGV efficiency through technology improvements and driver training initiatives	Assuming 15% savings and 50% uptake.	Assuming full update achieved in 2030 with no further uptake required.	Source: CCC Sixth Carbon Budget Report, Surface Transport Summary. Assuming that around 50% uptake has already been realised, given the early target years in the CCC report.
Freight avoidance (HGVs) through trip consolidation and changes in logistics	8% reduction in HGV journeys.	Additional 2% uptake, bringing the total reduction to 10%.	Source: CCC Sixth Carbon Budget, Surface Transport Summary
Freight shifted from road (HGVs) to rail	Assuming 15% shift from road to rail.	Increasing to 50% by 2038.	Sources: The West Yorkshire Combined Authority Rail Strategy suggests *at least* a 10% increase, but the UK aims for at least 75% nationally by 2050. With this vast range, a moderate value of 50% was chosen for the 2038 target year.
Electrification of railways	Assuming linear uptake to the target year.	Assuming near-full electrification by the target year.	Source: The West Yorkshire Combined Authority Rail Strategy from 2024 suggests that the railway lines in and around Bradford are either already electrified or prioritised for electrification.
Switching from LGVs to cargo bikes	2% uptake of last-mile solutions such as cargo bikes.	Rising to 5% uptake by the target year.	Source: West Yorkshire Carbon Emissions Reduction Pathways 2020 Modelling Report 2030 value taken from WYCA modelling and 2038 value aligned with the CCC's modelling, which assumes a moderate value of 3% by 2035 – a more ambitious value was chosen due to Bradford's urban environment. Cargo bikes modelled as electric LGVs with a small fraction of the original energy consumption.
Switching from petrol and diesel LGVs to electric LGVs	35% uptake by 2030.	Rising to 82% by the target year.	Source: West Yorkshire Carbon Emissions Reduction Pathways 2020 Modelling Report 2030 value taken from WYCA modelling and 2038 value aligned with the CCC's modelling, which assumes a

Measure	Net Zero Scenario		Source and Rationale
			moderate value of 3% by 2035 – a more ambitious value was chosen due to Bradford's urban environment.
Uptake of electric buses	25% switched to electric and 5% HEVs.	Fully electrified buses rising to 66% by 2038, removing the need for HEVs.	Source: West Yorkshire Carbon Emissions Reduction Pathways 2020 Modelling Report Note that it is currently unclear whether the main decarbonisation solution for buses will be electric or hydrogen, but the latter may be a significant option given Bradford's location; however, uptake of hydrogen is generally expected to increase in the 2040s.
Uptake of hydrogen buses	12% switched to hydrogen.	Rising to 34% in the target year, enabling a fully zero-carbon fleet.	Sources: West Yorkshire Carbon Emissions Reduction Pathways 2020 Modelling Report and Stakeholder Consultation. Note that it is currently unclear whether the main decarbonisation solution for buses will be electric or hydrogen, but the latter may be a significant option given Bradford's location. As such, the values chosen here far outpace those in the FES, but this may be feasible given Bradford's local circumstances. Alternatively, electrification would need to be scaled up.
Uptake of electric HGVs	18% switch to electric.	Reaching 79% electric HGV uptake.	Source: West Yorkshire Carbon Emissions Reduction Pathways 2020 Modelling Report. The FES suggest electrification uptake of around 10% by 2030 and 59% by 2038, making this a particularly ambitious assumption, relying on local innovation.
Uptake of biomethane HGVs	22% switch to biomethane.	Lowering to 14% by 2038 in place of electricity.	Source: West Yorkshire Carbon Emissions Reduction Pathways 2020 Modelling Report and Transport and Energy article – CNG opens West Yorkshire biofuel hub This assumption appears regionally appropriate given a refuelling station in West Yorkshire.
Uptake of hydrogen HGVs	0.6% switched to hydrogen,	Reaching 2% hydrogen HGV uptake,	Sources: Future Energy Scenarios (FES) for the 2030 figure (holistic evolution scenario) and West Yorkshire

Measure	Net Zero Scenario		Source and Rationale
			Carbon Emissions Reduction Pathways 2020 Modelling Report for the 2038 figure (the corresponding FES value is 1.4%, indicating no significant discrepancy). Note that under the FES hydrogen evolution scenario, it is estimated that hydrogen HGVs could make up 8.5% of total HGVs. Hydrogen uptake is expected to accelerate in the 2040s.
Waste			
Landfill	c. 35% emissions reduction by 2030.	c. 37% additional emissions reduction by 2038.	Source: CCC Seventh Carbon Budget
Composting	c. 20% reduction of current composting emissions.	c. 14% additional emissions reduction by 2038.	Source: CCC Seventh Carbon Budget Note that this differs from the WYCA pathway, which assumes that composting remains constant; however, the CCC assumes that with the right methods, significant reductions can be made
Wastewater	c. 12% reduction by 2030.	c. 14% additional emissions reduction by 2038.	Source: CCC Seventh Carbon Budget This is higher than the WYCA modelling, which assumes a more conservative 11%.
Agriculture and Land Use			
Agricultural Machinery	Linear uptake to 2038.	Switching away from natural gas, gas oil, and coal in favour of electricity and hydrogen. Around 50% of gas oil remains by the target year.	Source: CCC Seventh Carbon Budget 66% of current agricultural fuel use is from gas oil, which is typical of mechanised livestock and mixed farming, albeit on a small scale.
Soil Measures	c. 15% emissions savings by 2030.	c. 16% additional emissions savings by 2038.	Source: CCC Seventh Carbon Budget
Livestock Measures	c. 12% emission savings by 2030.	c. 12% additional emission savings by 2038.	Source: CCC Seventh Carbon Budget

Measure	Net Zero Scenario		Source and Rationale
Tree Planting	42 tCO_2e by 2030 as a result of 5,553 hectares.	8,344 tCO_2e by 2038 as a result of 6,260 hectares.	Assuming that a 20% tree cover target is achieved by 2050, with annual tree planting of around 88.4 ha between 2021 and 2050. A conservative estimate was made using the Woodland Carbon Code Calculator, which includes emissions from soil disturbance and a 20% buffer. Sources: Bradford Council article – Tree planting – how we can work together and UK Woodland Carbon Code
Peatland Restoration	Linear uptake to 2038.	48% reduction in current LULUCF net emissions.	Assuming that the current trend continues as a result of ongoing restoration efforts. It is possible that more ambitious savings can be made, but peatland restoration can also be a major source of emissions if not done right; as such, more ambitious reductions were not included in the pathway. Source: UK local authority and regional greenhouse gas emissions statistics - GOV.UK
Other			
F-Gases	Linear uptake to 2038.	68% reduction in F-Gas emissions by 2038, around 45% of this reduction is driven by existing national policies.	Sources: Energy and emissions projections: 2023 to 2050 - GOV.UK and CCC Seventh Carbon Budget

In addition to these mitigation measures, there are also a range of technical assumptions that are detailed in Appendix 1.

2.2.3 Results

After the realisation of all mitigation measures detailed in Table 2-3, emissions in Bradford would be reduced by 40% by 2030 and 82% by 2038 compared to the 2022 baseline (see Figure 2-6). While not reaching zero emissions in the target year, this is a very ambitious emissions reduction, which is aligned with broader net-zero efforts in the West Yorkshire area with the same target year.[25] This level of emissions reduction was deemed ambitious but feasible with significant financial, technological, behaviour change and commitments. Larger reductions could be achieved through more ambitious fuel switching measures.

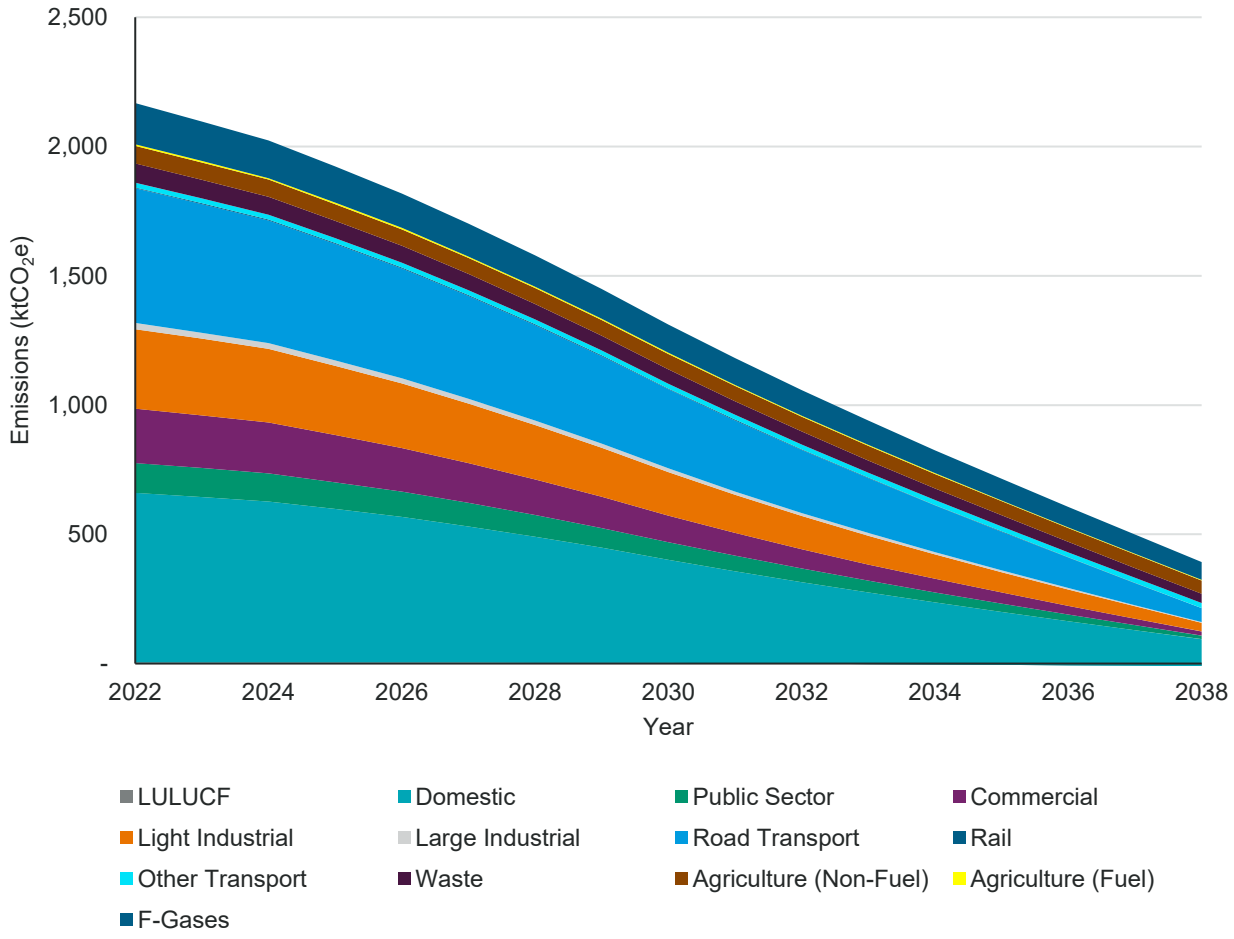

Figure 2-6: Emissions by Sector under the Net Zero Scenario. Source: NZPT.

The resulting fuel consumption changes can be seen in Figure 2-7 below. It is apparent that fuel use, while showing a significant decrease, does not match the scale of emissions reduction. This is because fuel consumption is both reduced and switched to low-carbon alternatives such as decarbonised grid electricity, low-carbon hydrogen, and local renewables such as solar and wind.

[25] Arup (2024). Carbon Emissions Reduction Pathways – West Yorkshire Update. Available at: https://westyorkshire.moderngov.co.uk/documents/s40037/Item6CarbonEmissionsReductionPathwaysWestYorkshireUpdate.pdf

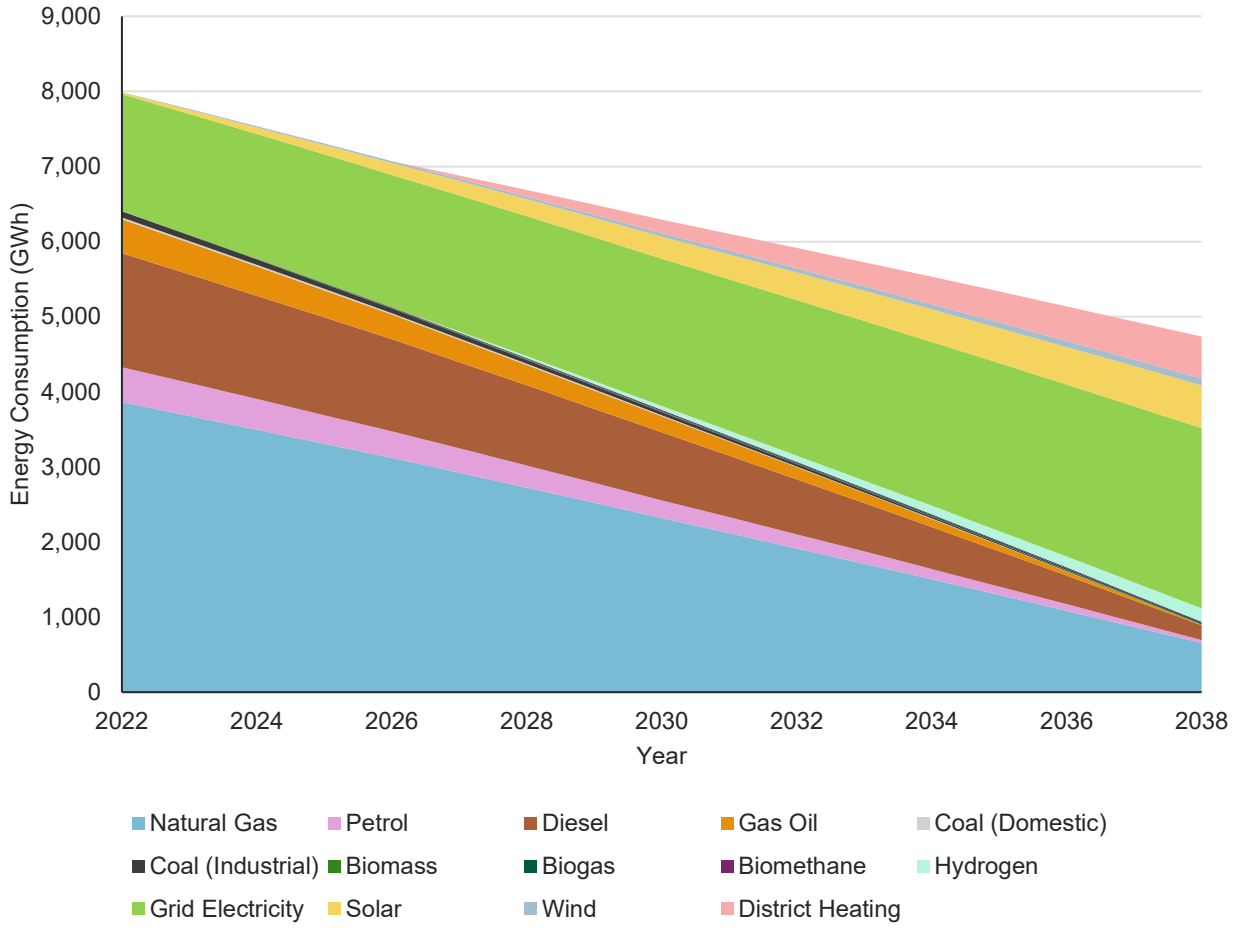

Figure 2-7: Energy Use by Fuel under the Net Zero Scenario. Source: NZPT.

Figure 2-8 below highlights the importance of decreasing the emission intensity of future fuel use through a shift to low-carbon alternatives such as renewable electricity and hydrogen. It should be clarified that while most fuels shown in Figure 2-7 and Figure 2-8 are energy sources, we have also captured some energy carriers alongside this, namely hydrogen and district heating. Hydrogen stores energy, but this energy first needs to be generated – in this case, we have assumed the energy input to be low-carbon electricity. Similarly, district heating or networked heat was assumed to mainly use renewable electricity as its input, with supplementary gas boilers to ensure a reliable provision of heat when it is required. As such, the emissions intensity of district heat decreases in line with the grid decarbonisation profile.

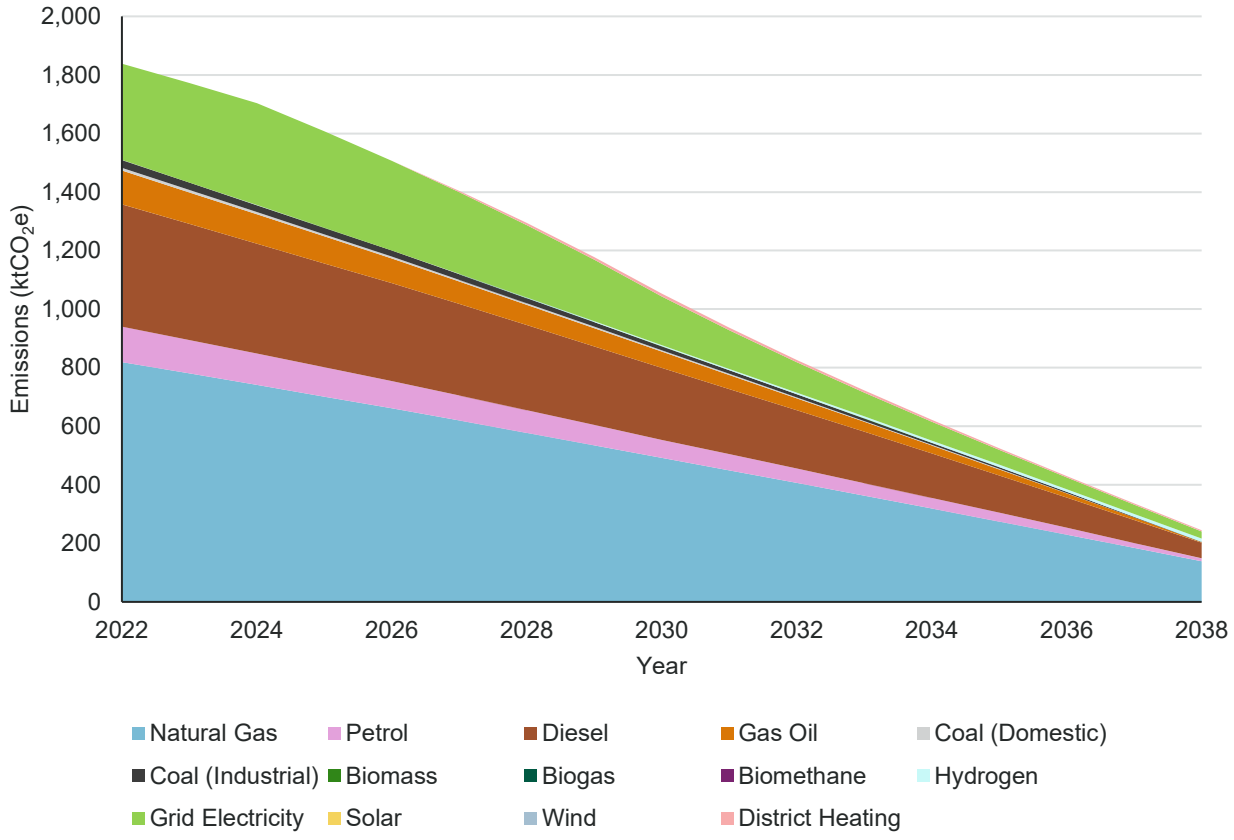

Figure 2-8: Emissions by Fuel in the Net Zero Scenario. Source: NZPT.

Figure 2-9 summarises emissions reductions by sector between 2022 to 2030, and 2022 to 2038. Between 2022 and 2030, the most significant reductions are projected to be for Commercial (-51%), Industry (-45%), and the Public Sector (-41%) categories, with the Domestic and Transport sectors also targeting substantial decreases (-39% and -40% respectively).

In contrast, Agriculture (-13%) and LULUCF (Land Use, Land-Use Change, and Forestry) (-25%) show more modest reductions during this interim period, reflecting either slower mitigation timelines, for example due to lag times between tree planting and measurable carbon sequestration benefits, or more structural challenges in decarbonising these areas.

By 2038, the reductions become significantly more ambitious, reflecting the net zero goal. Commercial emissions are expected to fall by 92%, while Industry, Transport, and Public Sector emissions are targeted for reductions of around 88–89%. Notably, the LULUCF sector shows a dramatic shift with a projected -360% change, indicating a transition from a net emitter to a substantial net carbon sink.

Agriculture and Waste also see stepped-up reductions by 2038 (-26% and -52% respectively), although they show a comparatively less significant reduction than other sectors. F-Gases are projected to reduce by 56%, highlighting ongoing challenges in completely phasing out these potent greenhouse gases.

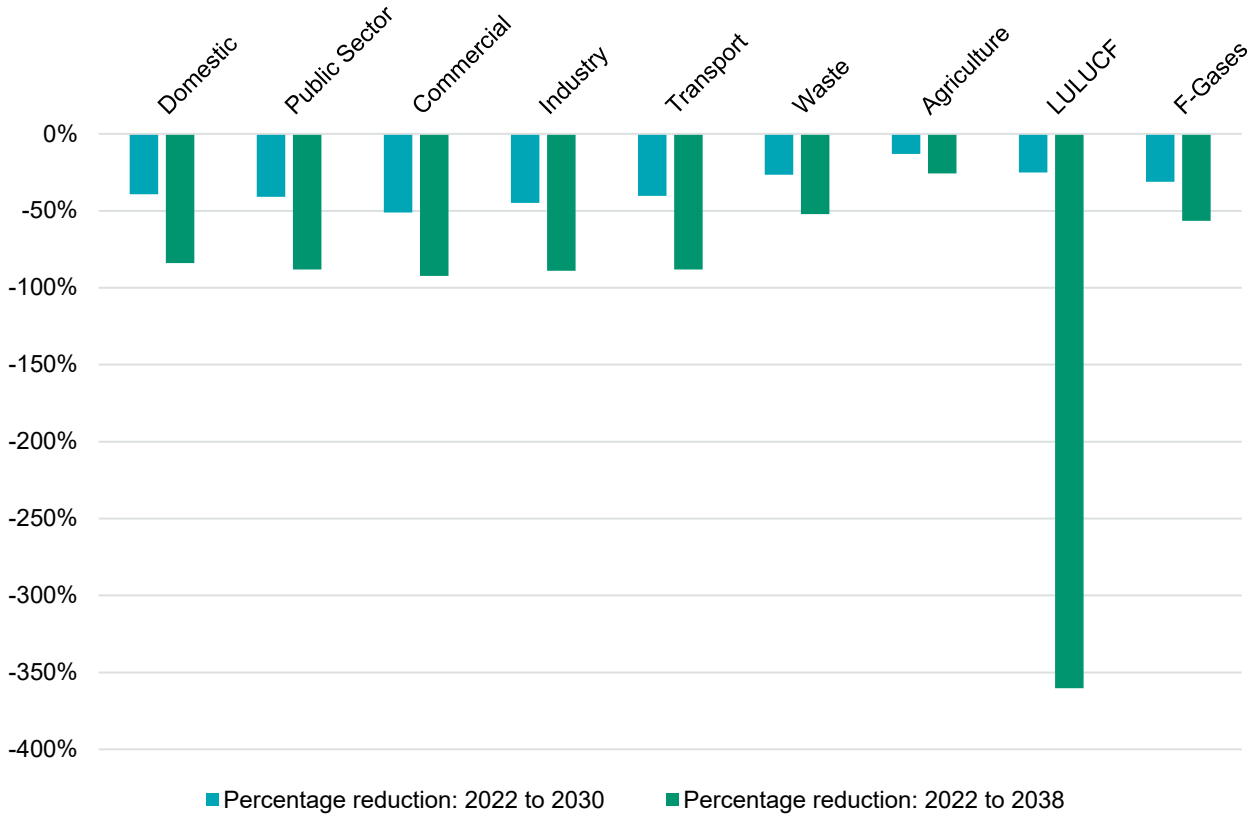

Figure 2-9: Total emissions reductions by sector for the years 2030 and 2038.

Figure 2-10 illustrates the impact of grouped mitigation measures on annual emissions in Bradford for the 2038 target year. The largest emissions reductions are projected from Transport Technology Switching and Domestic Fuel Shifting, reflecting the shift to EVs and low-carbon heating technologies. Measures in the industrial sector and domestic demand reduction also make significant contributions. Although some demand reduction measures, such as commercial and public sector demand reduction, show smaller impacts in 2038, they are critical when implemented early, as they reduce energy consumption before the energy system is fully decarbonised. It is important to note that this modelling does not include Scope 3 emissions (see Table 2-1). From a global GHG perspective, this means that absolute demand reductions (i.e. reducing the need for energy and materials altogether) are more impactful than fuel switching alone, as they help avoid emissions both inside and outside the local boundary.

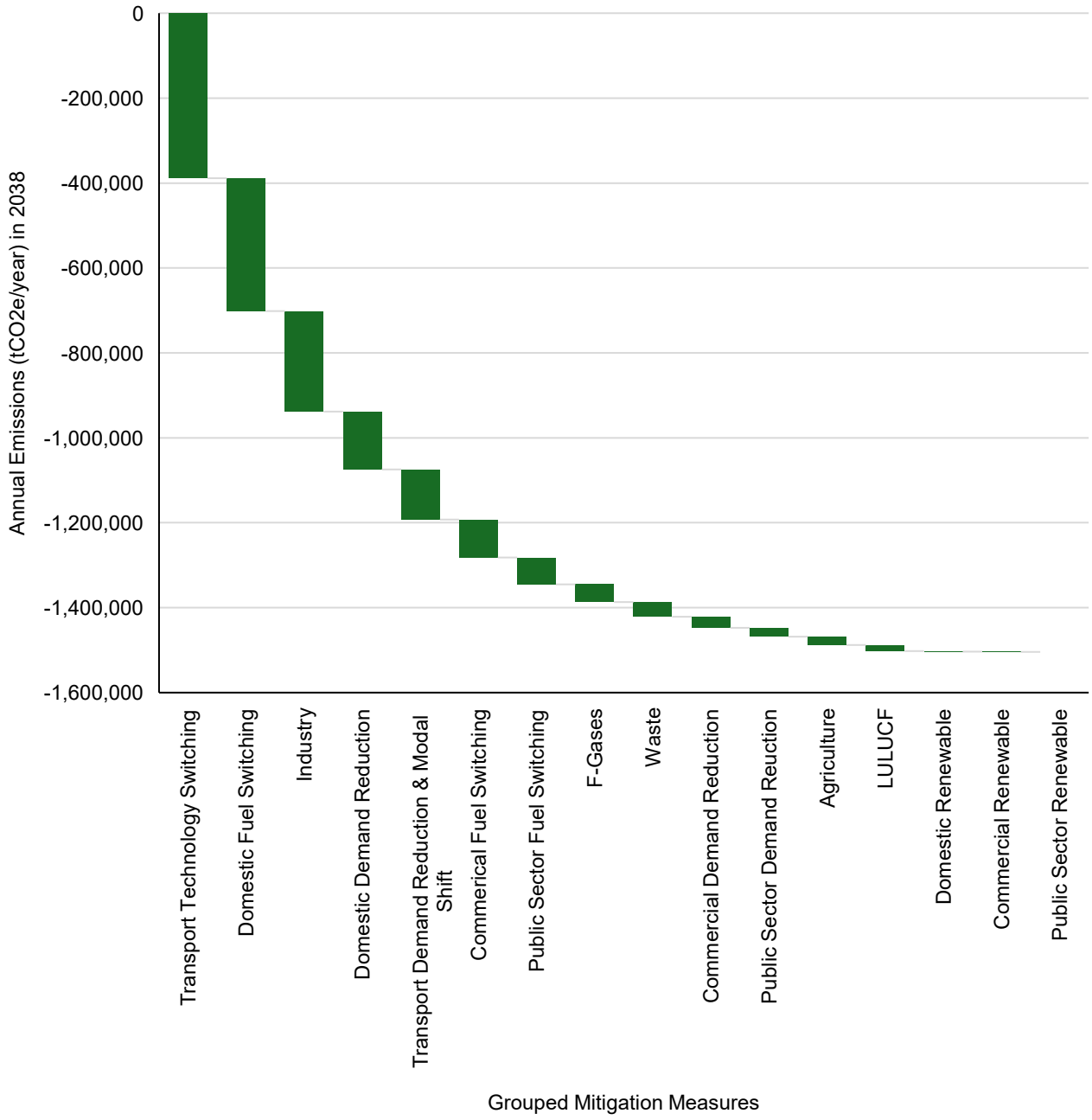

Figure 2-10: Emissions reductions from grouped mitigation measures in 2038.

2.2.3.1 Domestic Buildings

Domestic Buildings currently make up 31% of total emissions in Bradford and are the highest-emitting sector as of 2022. The domestic buildings sector comes with several key challenges, as actions are mainly driven by the property owners. In addition, practical considerations such as fuel poverty, investment costs, and availability of local tradespeople also need to be considered. During the first stakeholder engagement workshop, Bradford stakeholders highlighted that a skills gap in retrofit, a lack of funding for training schemes, and a lack of trust in existing installers are key barriers to realising important mitigation actions in the domestic buildings sector.

The actions to reduce direct emissions in the domestic and non-domestic buildings sectors have been modelled according to the energy hierarchy (see Figure 2-11). This means that overall energy demand should first be reduced – e.g., through better building insulation or reduction in hot water demand –, followed by more efficient energy use. The remaining energy should then be switched to renewable sources – e.g., switching

from gas heating to heat networks or heat pumps. Of course, these actions will not happen in this precise order; this is merely the overarching concept that was applied to the measure selection.

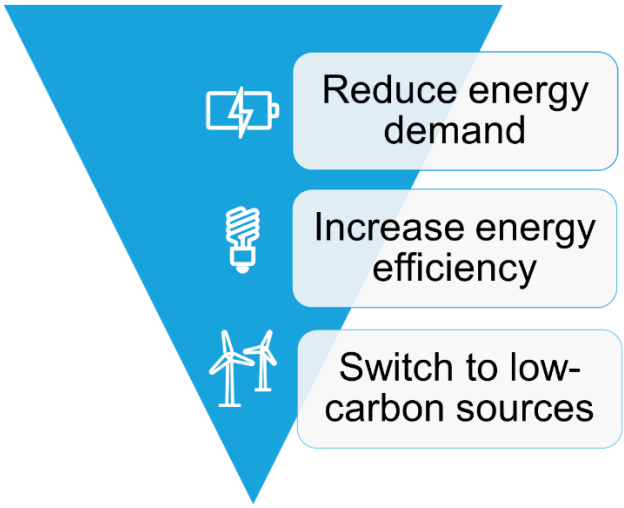

Figure 2-11: The Energy Hierarchy.

Energy savings from retrofitting are highly dependent on the age, type, and condition of a property (see Figure 2-12). While EPC ratings can give an indication of this, they often contain errors and don't adequately assess the condition of the property.[26] As such, these should not be used as the definitive energy efficiency potential of a property or an area but only as an indicative guide. With this in mind, an indicative 75% uptake rate for deep energy savings of 40% was chosen for Bradford's Net Zero Scenario.

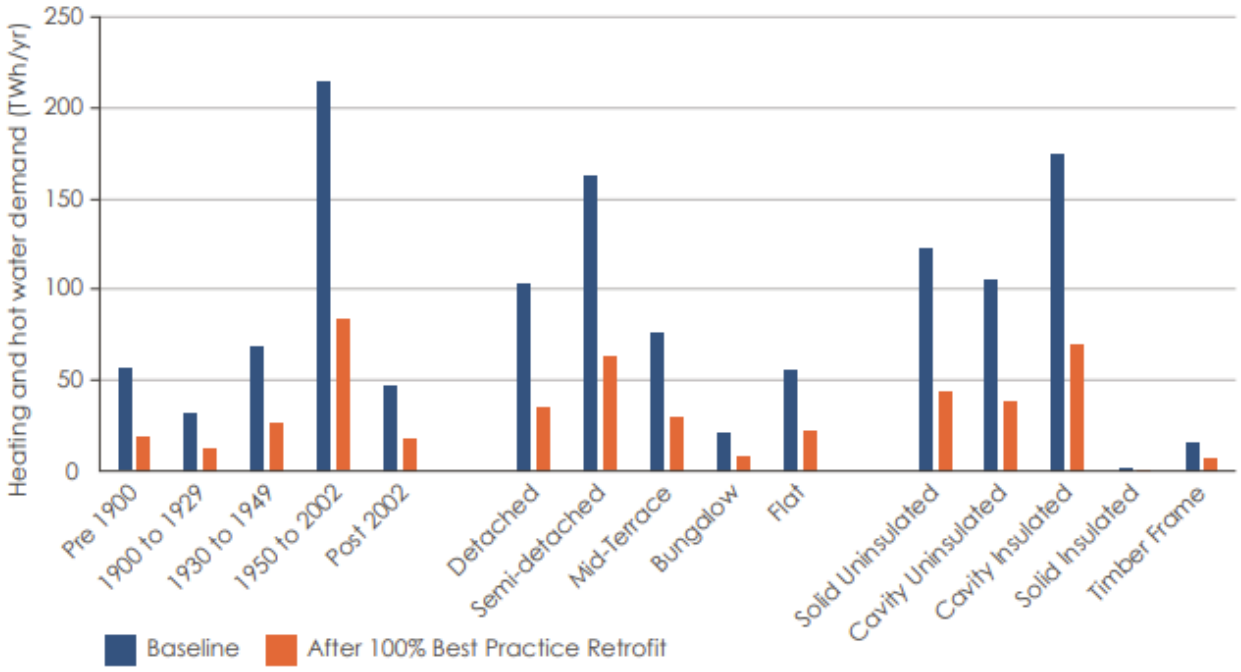

Figure 2-12: Impact of LETI Best Practice Retrofit on Space and Hot Water Heating Demand. Source: LETI[27].

There is no singular value for demand reduction from retrofitting across the entire building stock of an area. The LETI guide suggests that demand reductions of 30 to 83% are technically feasible; however, the higher end of this range is associated with challenging and costly retrofits, which were therefore not chosen from a

[26] https://www.which.co.uk/news/article/the-problem-with-energy-performance-certificates-a9oer6w1bgEI
[27] LETI (N.D.). Climate Emergency Retrofit Guide. Available at: https://www.leti.uk/retrofit

co-benefit's perspective, especially given Bradford's earlier net zero target date. The value chosen sits between the 'Do minimum' and 'LETI best practice constrained' scenario (see Figure 2-13), although it should be noted that the 'Do minimum' scenario assumes significant wall, roof, floor, window, and other retrofitting measures, and the resulting savings are still more ambitious than what is considered in other UK-wide scenario modelling, such as the CCC's Sixth Carbon Budget Balanced Pathway.[28]

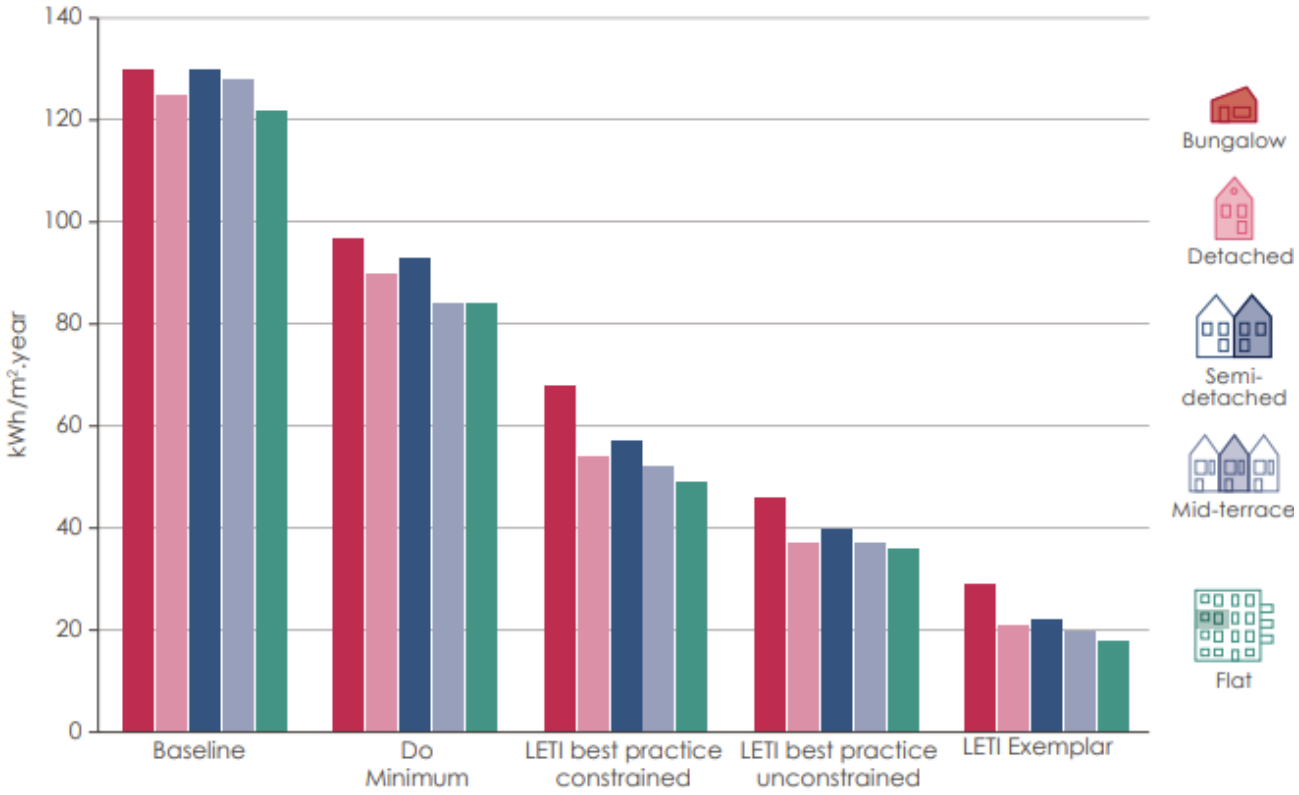

Figure 2-13: Effect of varying retrofit scenarios on space heating demand. Source: LETI[29].

In addition to space heating, water heating also makes up a significant proportion of current domestic energy use. Energy use and associated emissions from water heating can be reduced by reducing the amount of water, specifically heated water, that is being consumed. In Yorkshire, 2022 water consumption sat at around 131 l/p/d[30], a significant reduction from 2021 when it was around 10 litres higher.[31] This shows both a positive trend and potentially significant year-on-year variation, which must be accounted for in the modelling. It was assumed that 60% of households achieve a water consumption target of between 90 and 110 l/p/d by 2038. This would not only help reach Bradford's net zero target but also help deal with increasing pressures on the water system, which are exacerbated by climate change[32] – GHG savings are, however, a welcome co-benefit of this climate adaptation measure (and vice versa). Other local authorities across the UK have explored even more ambitious targets of 85 or 80 l/p/d in response to pressures on the water system.[33,34] More details on how and why reducing water consumption is crucial are provided in Box 1.

[28] CCC (2019). Sixth Carbon Budget. Available at: https://www.theccc.org.uk/publication/sixth-carbon-budget/
[29] LETI (N.D.). Climate Emergency Retrofit Guide. Available at: https://www.leti.uk/retrofit
[30] Yorkshire Water (2022). Our Contribution to Yorkshire. Annual impact and public value report. Available at: https://www.yorkshirewater.com/media/udajx4fd/ocy22-report-final.pdf
[31] Yorkshire Water (2021). A summary of our performance 2020/2021. Available at: https://www.yorkshirewater.com/media/mvxpmpks/yorkshire-water-a-summary-of-our-performance-2021.pdf
[32] CCC (2019). Water Stress and Resilience. Available at: https://www.theccc.org.uk/wp-content/uploads/2019/07/Outcomes-Water-stress-case-study.pdf
[33] JBA Consulting (2021). Water Neutrality Study: Part A – Individual Local Authority Areas. Available at: https://www.horsham.gov.uk/__data/assets/pdf_file/0019/104482/EYP-JBAU-XX-XX-RP-EN-0001-A1-C03-Water_Neutrality_Assessment_Part_A.pdf
[34] Greater Cambridge Shared Planning (2021). Greater Cambridge Local Plan First Proposals. Available at: https://consultations.greatercambridgeplanning.org/greater-cambridge-local-plan-preferred-options/supporting-documents#a7

Box 1: Approaches to and the importance of reducing water consumption.

Reducing water consumption is key to achieving GHG reduction targets by reducing the amount of water that needs to be heated in the first place, but it also brings a range of co-benefits such as increased resilience to climate change and reduced costs.

There are a range of actions that can be taken to reduce water consumption, including:

1. Water-efficient fittings – both through retrofitting and requirements for new-builds
2. Rainwater harvesting – including very simple and cost-effective solutions such as water-butts
3. Greywater recycling systems – both building-level and large-scale systems

A study by JBA Consulting suggests that fittings, including water-efficient taps, showers, baths, toilets, etc. can be retrofitted for c. £350-430/dwelling. More complex rainwater harvesting and/or greywater recycling systems can cost around £1,500-£4,000 per property.[35]

While Yorkshire is not traditionally a water-stressed area, droughts are becoming increasingly common and at the time of writing this report, the region has entered drought status along with most of the UK.[36]

As such, both individual and large infrastructural solutions (including addressing leaks) will become more and more important as the effects of climate change can be felt across the UK, including West Yorkshire.

While heating systems make up the large majority of current fossil fuel consumption, other energy uses also need to be addressed in order to reach net zero emissions. Lighting makes up around 14% of domestic electricity use according to DESNZ Statistics on Energy Consumption in the UK (ECUK).[37] The adoption of LED lighting has increased significantly, with an estimated 16% of British households using LEDs in 2022, up from 14% in 2020 and reaching 18% in 2023. Switching to LED lighting offers significant energy savings, as LED bulbs consume up to 80% less energy than traditional incandescent bulbs.[38] Although LED bulbs have a higher upfront cost, the long-term savings are substantial. Over its lifetime, one LED bulb can save almost £150 in energy costs compared to incandescent bulbs.[39] As such, the scenario assumes near-full uptake of LED lighting by the target date, which is supported by market trends of LED sales.[40]

The main challenge with remaining electricity use lies in unregulated electricity consumption. 'Unregulated' consumption refers to anything that doesn't result from fixed building services and fittings, such as space heating, water heating, and lighting. Remaining electricity use is commonly grouped under 'appliances', but these can be anything from large whitegoods such as refrigerators, freezers, and washing machines to TVs and a range of smaller devices such as laptops or gaming consoles.[41] Energy-efficient appliances can deliver substantial energy savings, but due to the uncertainties associated with the energy efficiency baseline of unregulated energy use, a 20% uptake rate was chosen as 'full uptake' to ensure that the scenario does not assume unrealistic savings. This is still viewed as a very ambitious measure despite what appears to be a low uptake rate.

It is assumed that following these ambitious demand reduction measures, remaining fossil fuel use is switched to low-carbon alternatives, mainly heat pumps and heat networks.

Heat pumps are a highly energy-efficient solution for heating homes as they have an efficiency of over 300% (compared to 80-90% for gas boilers, 70% for coal furnaces, and 100% for direct electric heating).[42] This

[35] JBA Consulting on behalf of Crawley Borough Council, Chichester District Council, and Horsham District Council, 'Water Neutrality Study' (2022). Available at: https://www.horsham.gov.uk/__data/assets/pdf_file/0004/120397/EYP-JBAU-XX-XX-RP-EN-0004-A1-C02-Water_Neutrality_Assessment_Part_C.pdf

[36] https://yorkshirebylines.co.uk/news/environment/yorkshires-reservoirs-plunge-as-drought-tightens-grip/

[37] DESNZ and BEIS (2024). Energy Consumption in the UK. Available at: https://www.gov.uk/government/collections/energy-consumption-in-the-uk

[38] https://www.meteorelectrical.com/blog/led-lighting-key-statistics-england.html

[39] https://www.simplyled.co.uk/info/led-savings/

[40] https://www.iea.org/energy-system/buildings/lighting

[41] Designing Buildings (2020). Regulated and unregulated energy consumption. Available at: https://www.designingbuildings.co.uk/wiki/Regulated_and_unregulated_energy_consumption

[42] CCC (2019). Sixth Carbon Budget, Charts and Data in the Report. Available at: https://www.theccc.org.uk/publication/sixth-carbon-budget/

means that from a running-cost perspective, heat pumps can significantly bring down fuel costs – however, high upfront costs need to be considered and addressed through funding support, such as grants.

The heat pump uptake figure chosen is in line with the CCC's target for over 50% of existing households to have a heat pump as their main heating source by 2040.[43] Because we do not assume the premature removal of functioning gas boilers, our modelling accounts for the natural replacement cycle of heating systems. As a result, there is an inherent lag in switching to heat pumps, meaning installations cannot be accelerated beyond the CCC's already ambitious uptake rate — even though their balanced pathway targets net zero by 2050, 12 years later than Bradford's goal.

To compare this figure with other local and regional net zero modelling, the Northern PowerGrid's (NPG) local authority data dashboard was explored, which, building on Future Energy Scenario (FES), illustrates key mitigation actions for local authorities in England's Northeast, including Bradford.[44] The modelled heat pump uptake under the 'Reference' scenario, which achieved net zero by 2050, is shown in Figure 2-14 below. This shows that heat pump uptake is fairly slow at first, with an average installation of c. 1,871 heat pumps per year, which changes after 2035 when it reaches an average of c. 7,828 heat pumps per year. However, given Bradford's 2038 net zero target, a faster uptake rate is needed.

The main alternatives to this faster uptake would be to:

1. Rely more strongly on district heating, but it is unlikely that such a vast district heating network can be created by 2038, although local feasibility studies would provide better insight.
2. Switch a significant proportion of natural gas and other fossil fuels to direct electric heating systems. However, this is not preferable from a fuel poverty perspective as direct electric heating is less than 1/3rd of the efficiency of air-source heat pumps, which translates to much higher energy bills for occupiers.
3. Switch a significant proportion of natural gas and other fossil fuels to biomass. However, this is not preferable from an air quality perspective and should only be done in areas that do not pose a significant impact on air quality. Any biofuel use further requires significant land allocation. Estimates in the CCC's Seventh Carbon Budget suggest that meeting biomass demand for Bioenergy with Carbon Capture and Storage (BECCS) under the Balanced Net Zero Pathway could necessitate converting up to 700,000 hectares of land to energy crops, which equates to almost 3% of UK land area.[45] The scale of land use could reduce the area available for food production, potentially leading to agricultural intensification and conversion of valuable habitats. It is generally assumed that biofuel use will be limited to relatively niche applications in industry and agriculture, with other sectors prioritising electrification.

It is not realistic for Bradford to achieve the 2050 heat pump target in 2038 without a substantial increase in Government funding, as the upfront costs for heat pump installations will not be viable for a large number of households. However, accelerated uptake is possible, with the CCC suggesting that around half of UK households can and should have a heat pump by 2040.[46] As such, an ambitious 45% uptake by 2038 has been modelled. This means switching an additional 44% of households currently on fossil fuel heating systems to heat pumps by 2038 (assuming, based on the NPG data for 2023, that around 1% of Bradford households have a heat pump).

[43] CCC (2025). The Seventh Carbon Budget. Available at: https://www.theccc.org.uk/publication/the-seventh-carbon-budget/
[44] NESO. Future Energy Scenarios (FES). Available at: https://www.neso.energy/publications/future-energy-scenarios-fes
[45] CCC (2025). The Seventh Carbon Budget. Available at: https://www.theccc.org.uk/publication/the-seventh-carbon-budget/
[46] CCC (2025). The Seventh Carbon Budget. Available at: https://www.theccc.org.uk/publication/the-seventh-carbon-budget/

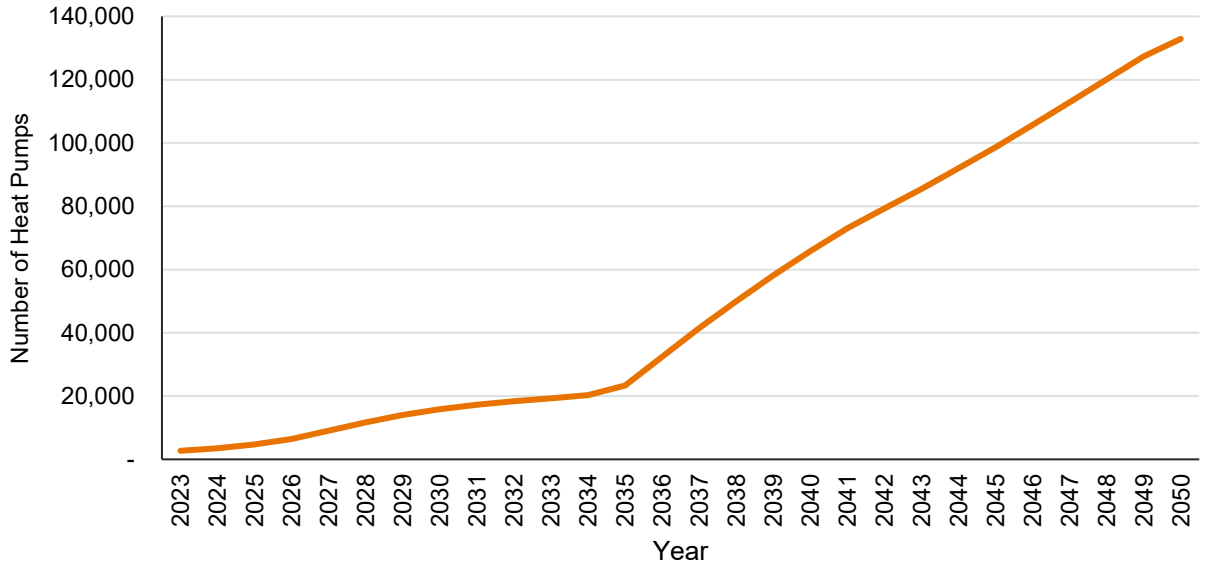

Figure 2-14: Projected Heat Pump Uptake under the NPG Reference Scenario (2023 – 2050). Source: Northern PowerGrid.

District heating (often referred to as heat networks) is a system in which heat is generated in a centralised location – using low-carbon energy sources, waste heat recovery, or combined heat and power (CHP) plants – and then distributed through insulated pipes to multiple buildings. The primary goal is to replace fossil fuel-based heating systems with more efficient, sustainable, and lower-carbon alternatives.

One heat network is already under construction in Bradford and is due to go live in Summer 2027.[47] Currently, this only includes commercial and public sector customers, but this may be expanded to domestic buildings, or a similar heat network may be developed for Bradford's domestic building stock.

Heat networks can be a very efficient way of decarbonising dense urban areas. They are designed to utilise energy more effectively by capitalising on economies of scale. For example, using waste heat from industrial processes or power generation boosts overall efficiency and dramatically reduces carbon emissions when compared to individual boilers. By reducing reliance on individual fossil fuel combustion, these networks could support local air quality by helping to reduce emissions of pollutants such as nitrogen oxides (NO_x) and particulate matter (PM), leading to cleaner urban environments. Although the upfront capital costs might be high, centralised generation and distribution typically result in long-term operational savings and lower energy bills for users through efficient energy management and economies of scale. Especially in dense urban areas, centralised heat production can reduce the space needed for individual heating systems and boilers, freeing up room in residential and commercial properties.

Due to Bradford's old housing stock and high proportion of terraced houses, stakeholders proposed 'street-level heat networks', often also referred to as 'networked heat pumps' (see Box 2). This innovative solution is proving effective for the UK's housing stock.

[47] https://1energy.uk/networks/bradford-energy-network/

Box 2: Networked heat pumps.

Networked heat pumps mimic the familiar gas grid model, whereby each building has an individual heating appliance which is connected to a shared network of pipelines in the ground to supply energy to the appliance. Specifically, a ground-source heat pump replaces the gas boiler, and the heat pump network replaces the gas pipelines. Low-temperature heat is sourced from the ground throughout the year.

This system also delivers cooling and air conditioning as heat pumps cool by operating in reverse – the heat by-product is then absorbed into the ambient loop and recycled.[48,49,50]

Heat networks require more coordination and rely on significant infrastructure development compared to individual low-carbon heating solutions, such as air-source heat pumps (ASHP). However, they can provide further cost savings of around 40% per building and therefore help alleviate fuel poverty and free up purchasing power for other elements of the market.[51]

In line with the CCC's Seventh Carbon Budget, it was further assumed that around 15% of total properties will remain on or switch to direct electric heating systems, which includes all current gas oil and coal heating systems. Rather than model a proportional switch across all fossil fuel heating systems (i.e., the same 44% heat pump uptake across natural gas, coal, and gas oil heated properties), coal and gas oil were prioritised for the fuel switch due to their high emissions intensity and air pollution impacts. This is an illustrative modelling choice to highlight the importance of prioritising these fuels – in reality, these properties won't all switch to the same alternative heating source, and more efficient solutions, such as heat pumps, should still be prioritised.

Following the implementation of all mitigation measures in the domestic sector, emissions in this sector would have decreased by 84% by 2038. While larger emissions reductions would be possible, e.g. by switching all natural gas heating systems to direct electric heating, this course of action was not chosen as this would mean that co-benefits are neglected in favour of reaching the net zero target. Instead, it was assumed that the remaining natural gas-heated properties would switch to heat pumps or connect to heat networks in the 2040s, ensuring that these residents would not have to switch to an inefficient heating technology. While some properties are well-suited for direct electric heating, such as small, new flats with low heat demand, forcing non-suitable properties to switch to this heating technology would likely have adverse impacts on fuel poverty.

2.2.3.2 Non-Domestic Buildings

The commercial and public sectors together make up around 15% of baseline emissions in 2022 (10% from the commercial and 5% from the public sector). The action development in the non-domestic sector properties was approached in a similar way to the domestic sector, with measures also following the Energy Hierarchy in Figure 2-11.

In line with the CCC, it was assumed that domestic and public sector buildings could achieve energy reductions of around 25% across the entire building stock.[52] This means that building-level energy reductions will be higher as this accounts for a proportion of the building stock with already high thermal efficiency, not requiring additional measures. While it is more challenging to identify hot water consumption baseline and projections data for the non-domestic sector, based on analysis in the domestic sector, it was cautiously yet ambitiously assumed that a 10% reduction can be achieved for 30% of non-domestic properties. The uptake rate was chosen to be relatively low to conservatively account for a high baseline value in the absence of robust local data.

In addition to reducing emissions from heating, energy demand from cooling systems should also be reduced in the non-domestic sector. The IEA estimates that by 2038, ambitious HVAC upgrades can save as much as

[48] https://www.nesta.org.uk/data-visualisation-and-interactive/a-networked-approach-to-low-carbon-heat/
[49] https://kensa.co.uk/networked-heat-pumps
[50] https://www.dgcities.com/blog/networkedheatpump
[51] Adur & Worthing Councils (N.D.) Worthing Heat Network. Available at: https://www.adur-worthing.gov.uk/worthing-heat-network/
[52] CCC (2019). Sixth Carbon Budget. Available at: https://www.theccc.org.uk/publication/sixth-carbon-budget/

36% of energy, which was assumed for the majority of non-domestic properties as less than 10% meet the B efficiency rating and 0.01% the highest efficiency standards.[53]

As with the domestic sector, non-domestic demand reduction measures are strengthened through better energy monitoring, specifically through the increased uptake of smart meters for all properties, with varying saving estimates depending on the fuel source of the property.

As no data on the adoption of energy-efficient lighting in commercial buildings for Bradford or the UK is available, the same baseline and uptake rates were modelled as in the domestic sector. Adopting LED lighting in commercial and public sector buildings offers many of the same benefits seen in domestic buildings, such as increased efficiency leading to energy savings, cost savings and carbon savings.[54] However, the scale of use in larger buildings such as offices, hospitals, and schools means that the financial and environmental impact is magnified, hence the case for energy-efficient lighting is even more compelling in non-domestic settings. The return on investment is quicker for commercial buildings than for domestic ones, due to higher lighting intensity and longer operating hours. Furthermore, public sector buildings often benefit from government support or funding schemes, lowering the initial financial barriers.

The fuel switching measures in the non-domestic sectors were also aligned with the CCC's Seventh Carbon Budget modelling. Specifically, the CCC assumed that over 90% of non-domestic properties will have a low-carbon heating source by 2040[55] – accordingly, a 90% target was set for 2038. This marks a more ambitious uptake rate than the domestic sector, and with sufficient local ambition, this could be pushed to near 100%; however, this would naturally come with heightened financial challenges and has therefore not been assumed for Bradford's Net Zero Scenario.

Specifically, it was assumed that 52% of natural gas and 55% of coal and gas oil-heated properties would switch to heat pumps by 2038. While the assumptions in the two non-domestic buildings sectors are broadly aligned, some distinctions were made between public sector and commercial mitigation measures. It was assumed that a greater proportion of public sector buildings would connect to the Bradford Energy Network (BEN), with around 30% of public sector buildings on the gas grid, compared to around 25% of commercial properties. It was also assumed that around 2% of commercial properties continue to use biomass and that 5% switch from natural gas to biogas by 2038. Direct electric heating is assumed to support the removal of high-emission and high-polluting fossil fuel heating systems, such as gas oil and coal.

Finally, it was assumed that nearly all fossil fuel cooking systems would switch to electric alternatives, with around 5% of fossil fuel use retained for fringe cases that cannot be switched.

In the non-domestic sector, a small proportion of fossil fuel use cannot be assigned to any specific uses in the ECUK statistics – as such, an illustrative 50% reduction measure was applied in the absence of more robust data. A better understanding of current fossil fuel uses in the commercial and public sector, e.g. by engaging with stakeholders via existing commercial decarbonisation networks, can both instil confidence in this ambition and identify ways to go further and achieve even deeper emissions savings, getting Bradford even closer to its 2038 net zero target.

2.2.3.3 Transport

The transport sector was the second largest emitter in 2022, with around 25% of total emissions. Decarbonising the transport sector, similar to the buildings sector, requires ambitious demand reduction and fuel switching measures. The transport measures follow the sustainable transport hierarchy (see Figure 2-15) and therefore prioritises reduction of private vehicle travel by first avoiding the need for travel and then switching to walking, wheeling, and public transport before switching to low- and zero-carbon fuels.

[53] https://neosnetworks.com/resources/blog/the-public-building-energy-efficiency-report-where-can-improvements-be-made-to-meet-net-zero-decarbonisation-targets/

[54] BEIS (2016). Building Energy Efficiency Survey 2014-15 Overarching Report. Available at: https://assets.publishing.service.gov.uk/media/5a75964540f0b67f59fce0d4/BEES_overarching_report_FINAL.pdf

[55] CCC (2025). The Seventh Carbon Budget. Available at: https://www.theccc.org.uk/publication/the-seventh-carbon-budget/

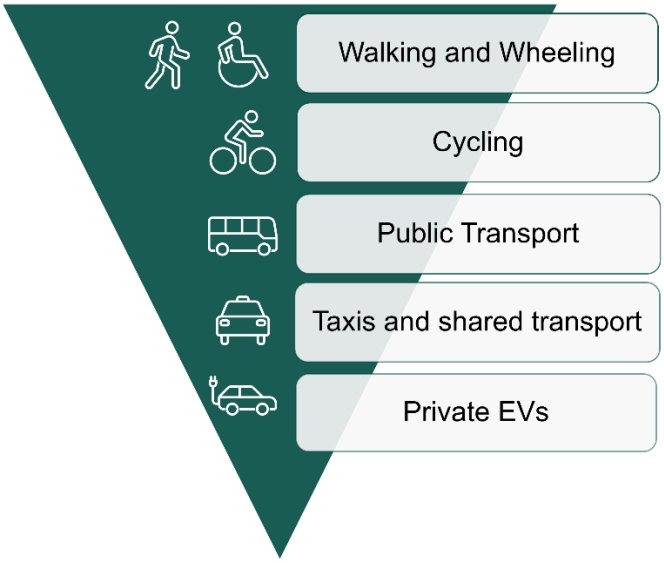

Figure 2-15: The Sustainable Transport Hierarchy.

As evidenced by the Covid-19 pandemic and associated lockdowns, travel demand can be significantly reduced through new ways of living and working. The 2020 West Yorkshire Carbon Emissions Reduction Pathways Modelling assumed a 17% demand reduction through similar measures;[56] however, in light of the far-reaching changes in society since the lockdowns, a much more conservative value was chosen for Bradford's net zero pathway to avoid overestimating additional savings from homeworking and similar measures.

In addition to this, it was assumed that significant demand reductions can be realised by increasing vehicle occupancy from 1.33 to 1.7 in 2030 and 1.8 in 2038 (see Figure 2-16). This cannot be assumed to realise proportional savings, as car sharing generally results in detours to drop off passengers or the vehicle itself (depending on the type of car sharing). As such, a 20% pick-up/drop-off factor was applied, resulting in vehicle kilometre (vkm) savings of 6.5% and 11.7% respectively.

While this is an ambitious increase in vehicle occupancy, average vehicle occupancy used to sit around 2 in the 1970s in Europe.[57] As such, while this action would require a significant trend reversal, it is technically and behaviourally feasible with the right enabling actions.

[56] elementenergy (2020). West Yorkshire Carbon Emissions Reduction Pathways. Available at: https://www.westyorks-ca.gov.uk/media/4277/west-yorkshire-carbon-emission-reduction-pathways-technical-report-draft-v7-1.pdf
[57] https://www.eea.europa.eu/publications/ENVISSUENo12/page029.html

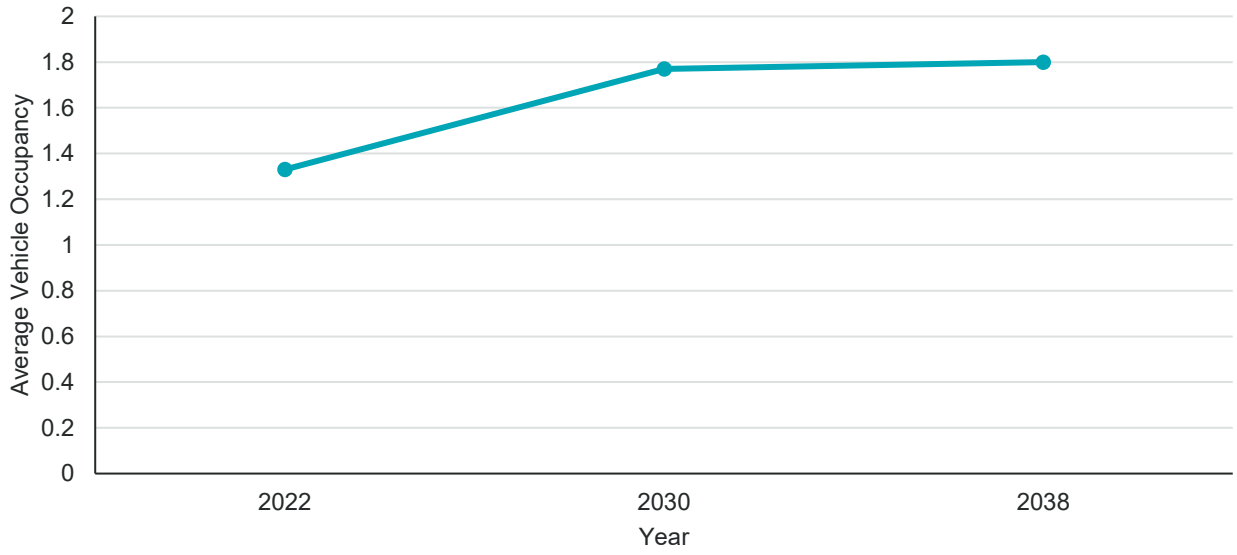

Figure 2-16: Modelled Vehicle Occupancy.

Following this reduction in car travel demand, ambitious switching to walking, wheeling, and cycling was modelled (see Table 2-3) for more detail. It was further assumed that 9% of car travel is switched to buses (electric and hydrogen) and 14% to rail travel (electrified). This means that a total modal shift of 30% in terms of the proportion of original fuel consumption is achieved.

In line with regional WYCA modelling, it was assumed that local buses can be fully decarbonised by 2038, shifting to electricity and hydrogen. This results in emissions savings due to the use of low-carbon fuels, but also due to the higher per-passenger efficiency of remaining fuel use. As with other modes of public transport, it is essential to switch passengers to rail as this is a more efficient way of travelling, resulting in fewer kWh consumed per person compared to private vehicles. As shown in Figure 2-17, the passenger rail network around Bradford is already mostly electrified, and the electrification of the network around Bradford is prioritised. As such, it was assumed that near-full electrification of the local rail network is feasible by 2038 in line with regional priorities. This means that even if the number of rail traffic needs to be increased proportionally to the number of people switching from cars to rail, the emissions increase will far outweigh the emissions savings in the cars' subsector.

As with buses, to ensure that future energy consumption is not underestimated, it was assumed that additional rail traffic is not realised through an increase in vehicle occupancy but rather through additional rail services while accounting for the efficiency gains of rail compared to private cars. However, in reality, it would be favourable to action this through a mixture of increased vehicle occupancy and the provision of additional services for additional energy savings.

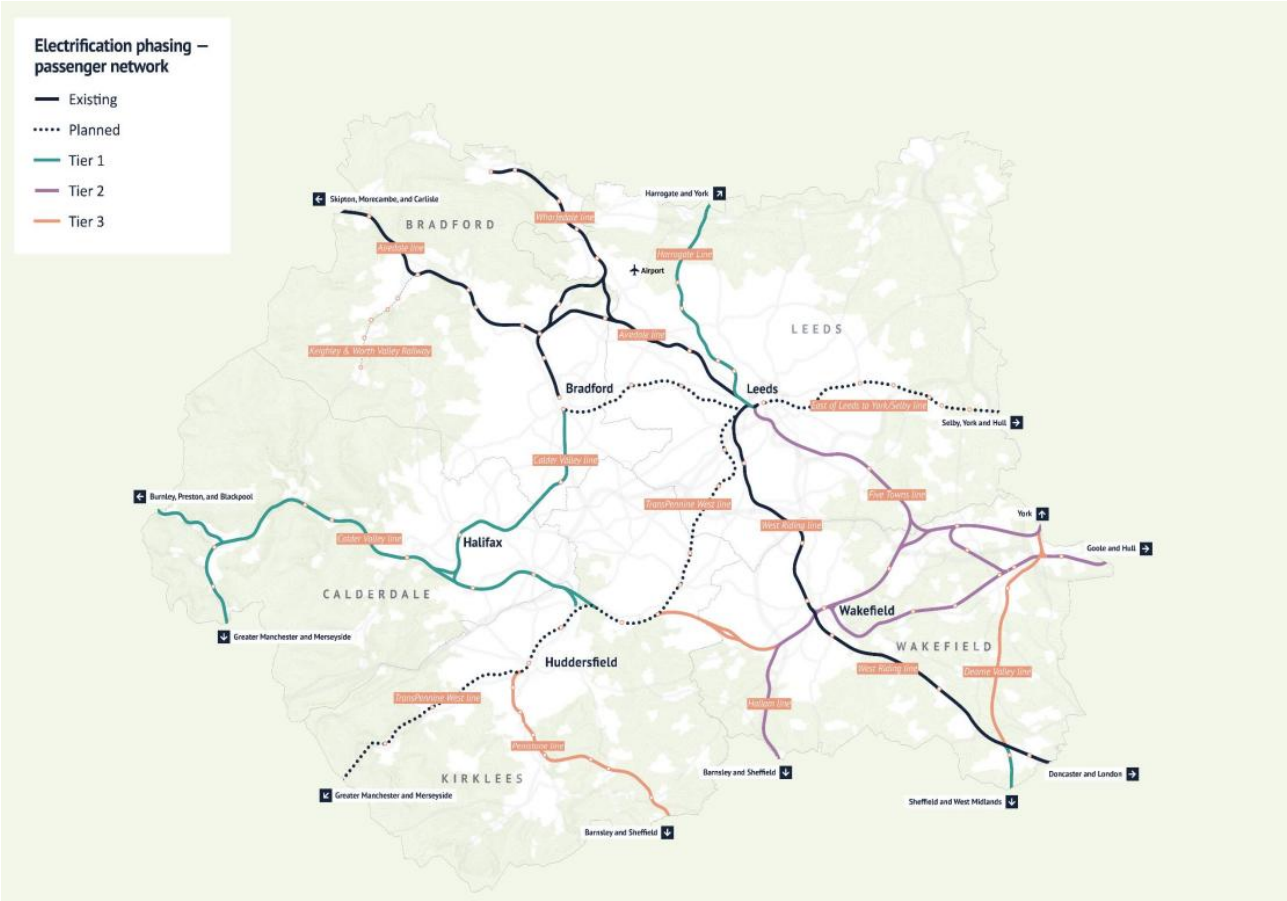

Figure 2-17: Electrification Phasing for West Yorkshire's Passenger Rail Network[58].

Following demand reduction measures and switching to public transport vehicles, low-carbon alternatives, it was assumed that an ambitious shift to ultra-low emission vehicles (ULEVs) would be achieved, utilising hybrid electric vehicles to achieve intermediary reductions by 2030, but ultimately shifting to EVs (see Figure 2-18). These assumptions were aligned with the regional WYCA modelling. By 2038, only 9% of conventional cars remain under these assumptions, requiring a rapid uptake of ULEVs.

[58] WYCA (2024). West Yorkshire Combined Authority Rail Strategy. Available at: https://www.westyorks-ca.gov.uk/media/12101/wyca-rail-strategy-final-version.pdf

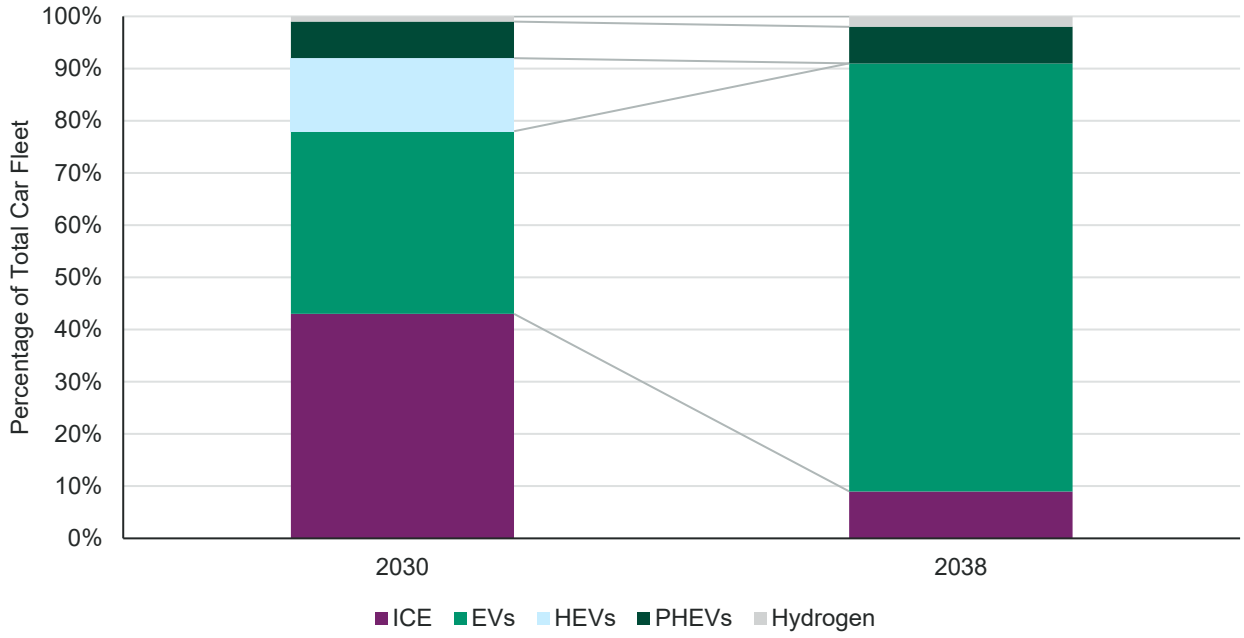

Figure 2-18: Types of Cars by 2030 and 2038.[59]

For light goods vehicles or LGVs, we have assumed that 5% can be switched to electric cargo bikes for last-mile deliveries. As cargo bikes are not a mode of transport in our model, we have assumed that petrol and diesel LGVs are switched to electric ones at a fraction of the energy use. The remaining LGVs are assumed to achieve an 82% electrification, a similar ambition level to that of passenger cars.

In the freight subsector, there of potential for HGV logistics measures to reduce miles driven by lorries, through measures such as expanded use of consolidation centres, extended delivery windows, higher loading and reduced empty running. In addition to this, driver training is assumed to achieve savings of 15% as per the CCC.[60] We have further assumed an ambitious 50% shift from freight on the road to rail freight. The West Yorkshire rail strategy suggests at least a 10% increase[61], but the UK aims for at least 75% nationally by 2050.[62] With this vast range, a moderate yet ambitious value of 50% was chosen for the 2038 target year.

As with other vehicles, it was assumed that HGVs would shift to low-carbon alternatives, with most HGVs shifting to electric alternatives, but also to biomethane and hydrogen as per WYCA modelling. There are already existing biomethane production facilities in West Yorkshire.[63]

It should be noted that in the emissions modelling, fuel switching measures, such as ULEV uptake, appear to make the most significant dent into current transport emissions in Bradford; however, this does not include embodied emissions from ULEVs, such as the production of the vehicles and mining for batteries. The greater the shift away from private car use and the larger the increase in both active travel and public transport, the greater the decrease in overall emissions – and general resource requirements – arising from transport activities in the local authority. However, this is not to say that electric vehicles are not an important part of the net zero journey – even when considering embodied or life-cycle emissions of electric vehicles, they still far outperform conventional petrol or diesel cars.

Figure 2-20 shows the lifecycle emissions of electric vehicles compared to standard internal combustion engine (ICE) cars – with EVs clearly outperforming even smaller ICE cars. Figure 2-19 illustrates how emissions could develop if not only the electricity grid were decarbonised but also the electricity used in vehicle production. This highlights the importance of decarbonising the electricity grid to decarbonise the transport sector. It should

[59] ICE = internal combustion engine; EV = electric vehicle; PHEV = Plug-in Hybrid Electric Vehicle
[60] Climate Change Committee (2020). Sixth Carbon Budget, Available at: https://www.theccc.org.uk/publication/sixth-carbon-budget/
[61] WYCA (2024). West Yorkshire Combined Authority Rail Strategy. Available at: https://www.westyorks-ca.gov.uk/media/12101/wyca-rail-strategy-final-version.pdf
[62] UK Department for Transport (2023). Government sets ambitious target to grow rail freight by at least 75%. Available at: https://www.gov.uk/government/news/government-sets-ambitious-target-to-grow-rail-freight-by-at-least-75
[63] https://www.energyassets.co.uk/pontefract-biomethane-meets-the-energy-needs-of-6000-homes/

also be noted that generally, the smaller the EV, the smaller its carbon footprint. Therefore, the uptake of smaller vehicles should be encouraged, whereas other modes of transport higher up on the transport hierarchy cannot be chosen.

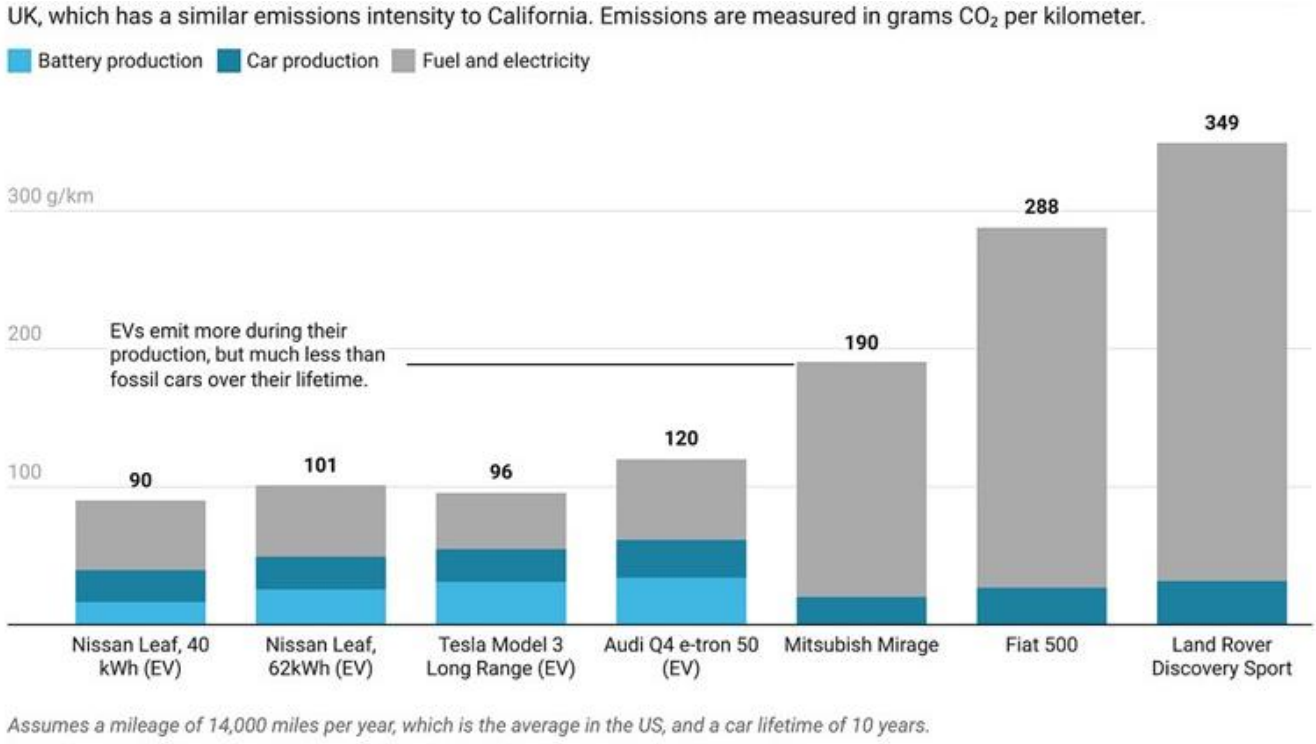

Figure 2-19: Lifecycle emissions of electric vs fossil fuel cars: running on UK energy grid[64].

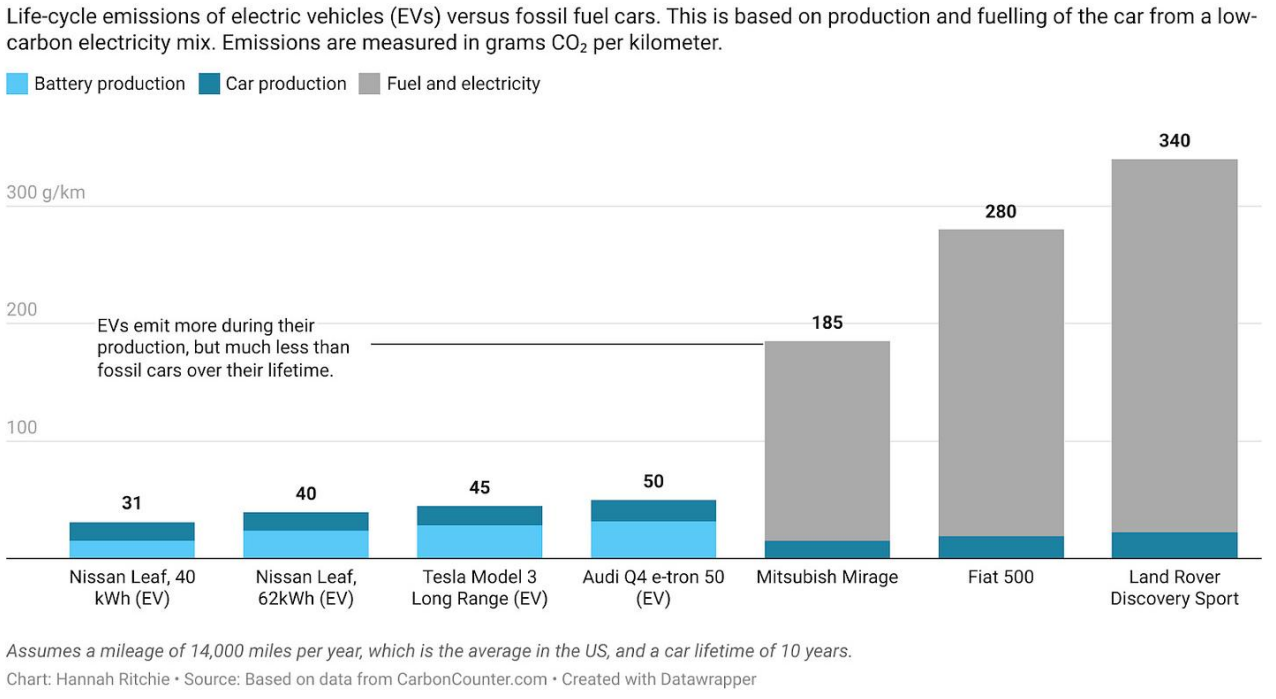

Figure 2-20: Lifecycle emissions of electric vs fossil fuel cars: running on low-carbon energy mix.

[64] https://www.sustainabilitybynumbers.com/p/ev-fossil-cars-climate

2.2.3.4 Industry

Industry has long been central to Bradford's economic and cultural identity. From its historic roots in the textile trade to its present-day strength in manufacturing and innovation, the sector continues to drive success in the district. Today, Bradford is home to over 1,220 manufacturing businesses providing around 13% of local employment. The district's industrial base is broad and diverse, encompassing food and drink manufacturing, precision engineering, chemicals, digital technologies, and energy and utilities. These businesses are integral to regional and international supply chains in strategic sectors such as automotive and healthcare, emphasising the continued importance of Bradford's industrial economy to the wider Leeds City Region and the UK as a whole.

However, industrial emissions form a substantial share of Bradford's overall emissions, and the sector now faces growing pressure to transition to net zero while maintaining competitiveness. Energy costs are already a concern for businesses and are compounded by uncertainty around government policy, a lack of sector-specific guidance, and broader challenges such as capital constraints, skills gaps, and change management.

Decarbonising industry is inherently complex, particularly in regions like Bradford, where industrial activity is dispersed across many sites and business types. The CCC in its Sixth Carbon Budget report emphasises the importance of adopting electrification, low-carbon hydrogen, or carbon capture and storage (CCS) to achieve industrial emissions reductions. It also warns that the structural characteristics of local industry, including the prevalence of small- and medium-sized enterprises, may lead to slower progress in areas like Bradford. Electrification is the most dominant abatement method proposed in the CCC's Seventh Carbon Budget report, with CCS, hydrogen, fuel switching to bioenergy, and resource efficiency playing important supporting roles. Grid infrastructure updates and growth in workforce skills and numbers are needed to facilitate this transition in the industrial sector. Both reports highlight the risk of carbon leakage, where industries relocate abroad to avoid stricter emissions regimes. This risk necessitates careful design of carbon pricing mechanisms and complementary policies such as border adjustment tariffs or product standards. It is important to acknowledge that our current modelling does not account for this potential carbon leakage, and while such a scenario might improve Bradford's apparent carbon footprint, it would not reduce global GHG emissions and is therefore an unfavourable outcome.

Recognising the strategic importance of reducing industrial emissions, CBMDC partnered with local manufacturers and technical experts to assess pathways to decarbonisation. This work was delivered under the Bradford Manufacturing Futures (BMF) programme, supported by the Department for Energy Security and Net Zero's Local Industrial Decarbonisation Plan (LIDP) scheme. The resulting BMF Decarbonisation Masterplan, developed by Arup, sets out a roadmap to reduce manufacturing emissions in Bradford by 95% by 2038. Based on a geospatial model of energy use and informed by public data, site visits, and stakeholder engagement, the Masterplan outlines the scale and combination of technologies needed to achieve this ambition, including electrification, hydrogen fuel switching, process efficiency measures, and clean heat systems.

This study provides a foundation for targeted action in the sector and offers a model for how place-based industrial decarbonisation planning can align economic and environmental priorities. The overarching results are presented in Figure 2-21.

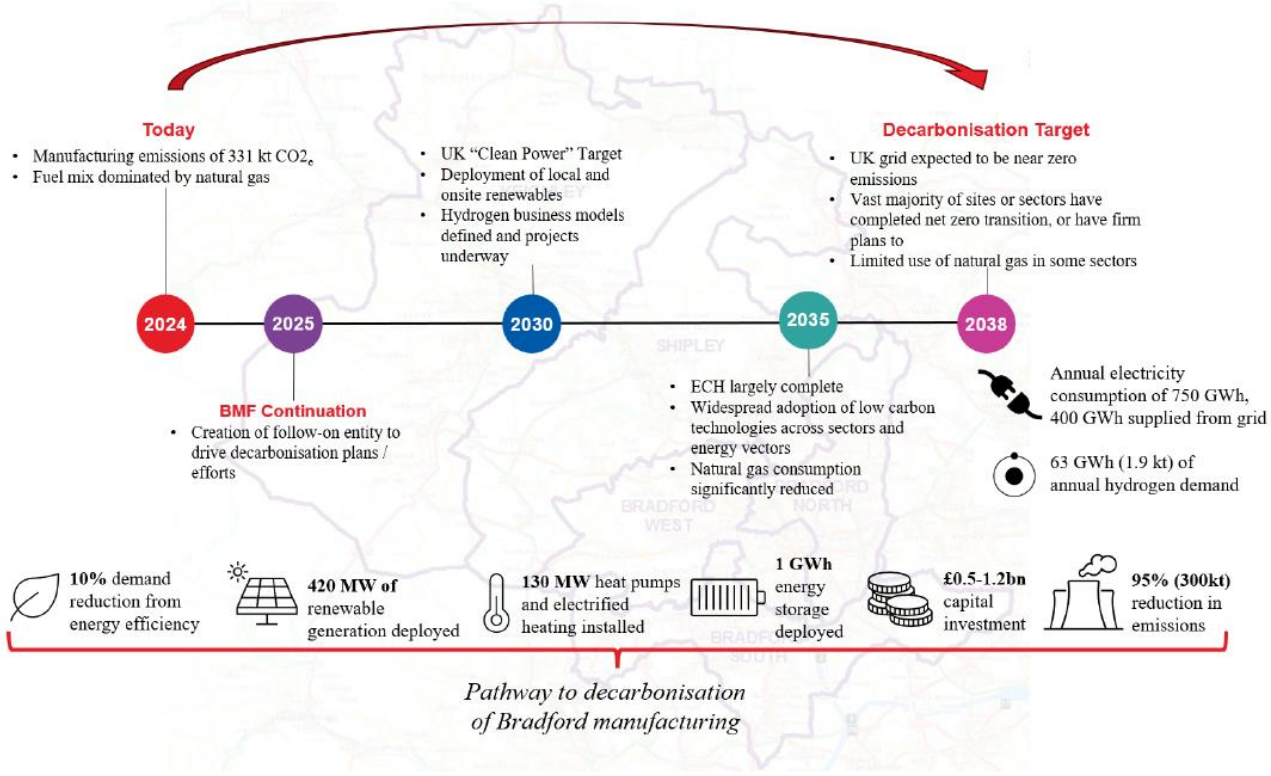

Figure 2-21: Bradford's manufacturing roadmap for decarbonisation. Source: Arup.

Bradford's industrial sector plays an important economic role but also accounts for around 16% of the district's GHG emissions (excluding F-Gases). With the district's 2038 net zero target approaching, ambitious and coordinated action is needed to decarbonise its 1,220 manufacturing businesses, including those located within the five Clean Growth Hubs, which together generate approximately 56% of industrial emissions.

The BMF study suggests that achieving the 2038 target will require a mix of technologies distributed across the district. Key approaches identified include:

- **Resource and energy efficiency**: Implementing measures to monitor, optimise, and reduce energy consumption in existing facilities and processes. This aligns with international standards, such as ISO 50001. Energy efficiency is noted as a 'no regret' action expected to be implemented early.
- **Electrification**: This is expected to be the predominant pathway, including the electrification of process heat via heat pumps and direct electric technologies, and requiring substantial new capacity.
- **Fuel switching**: Transitioning away from fossil fuels to low-carbon alternatives such as hydrogen, biomass, and biogas. Hydrogen and biofuels are expected to play a role in the future energy mix. Biogas production, potentially from sources within the Bradford region, could help mitigate residual natural gas emissions.
- **Carbon capture, utilisation, and storage (CCUS)**: While not modelled as extensively for the 2038 Bradford target as other technologies, CCUS is listed as a potential intervention group at both site and system levels. Nationally, the CCC report highlights CCUS as a necessary technology alongside electrification or hydrogen for industrial decarbonisation.
- **Carbon removal**: Including Engineered Carbon Removal like Direct Air Carbon Capture and Storage (DACCS), and Natural carbon removal measures like afforestation, enhanced terrestrial weathering, and peatland restoration. BECCS is also referenced in the context of engineered removal pathways.

To align the Bradford-wide modelling with the BMF study, we applied modelled changes in the fuel consumption and fuel mix to achieve the same final fuel mix as the BMF study. While there is a minor difference

in the baseline due to different methodological approaches, the values are broadly consistent. These small changes also resulted in different emissions reduction values – of around 89% in the case of our industrial emissions reductions. However, this is still an incredibly ambitious figure for the industrial sector, even if it does not meet the full 95% of the BMF study. Figure 2-22 shows the energy mix in the industrial sector in 2038.

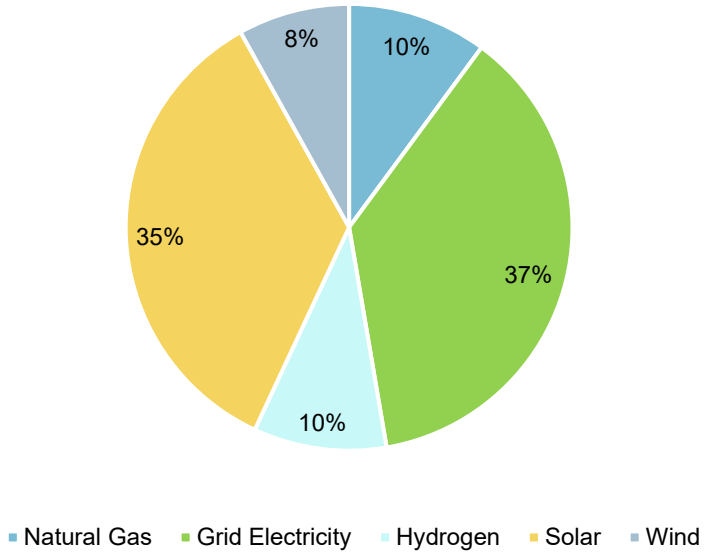

Figure 2-22: 2038 Industrial Fuel Consumption.

In addition to fuel switching and energy efficiency improvements, the BMF study recognises the importance of supporting actions such as energy storage. Storage capacity will be a key enabler for integrating increased local renewable generation and ensuring grid stability, particularly as demand shifts toward electricity. The scale and profile of energy consumption, especially at larger industrial sites, are likely to drive innovation and skills development around renewable energy and storage technologies in the region. Coordination across businesses and stakeholders is also essential, particularly where shared infrastructure such as grid upgrades and centralised energy assets is required to support widespread low-carbon adoption.

2.2.3.5 Energy System

The energy system is key to decarbonising Bradford's current fuel mix and getting the local authority on track for net zero, even more so for an ambitious 2038 target date. As explored under the BAU and net zero scenarios, the decarbonisation of the electricity grid is the main driver for helping Bradford reach close to net zero by 2038, reaching an effectively net zero grid by the target year. Specifically, the carbon intensity of the grid is modelled to fall from 0.211 $kgCO_2e/kWh$ in 2022[65] to approximately 0.085 $kgCO_2e/kWh$ in 2030 and 0.008 $kgCO_2e/kWh$ in 2038.[66] This trajectory is illustrated in Figure 2-23 below.

As circa 88% of the baseline emissions rely on decarbonisation through a switch from fossil fuels to low-carbon alternatives, and most of this is modelled to be replaced with grid electricity, this means relying on national action. Despite cross-party commitments to decarbonise the grid, this is always associated with a certain level of uncertainty as it means that local success is reliant on national-level action. In addition to this, the electrification of a range of processes means that there will be additional pressure on the grid. As such, supporting the energy transition through local efforts is in the best interest of both local and national interests, both for the sake of carbon reduction and energy security.

[65] UK local and regional greenhouse gas emissions estimates for 2005-2022: Technical Report' (published by DESNZ). Available here: https://assets.publishing.service.gov.uk/media/667ad7a7c7f64e234208ffc2/local-authority-ghg-technical-report-2022.pdf

[66] This emission factor trajectory is based on the HM Treasury Green Book supplementary appraisal guidance on valuing energy use and greenhouse gas (GHG) emissions (published by DESNZ). Available here: https://www.gov.uk/government/publications/valuation-of-energy-use-and-greenhouse-gas-emissions-for-appraisal

Part of mitigating against this reliance on grid decarbonisation is through energy efficiency measures. We have assumed ambitious measures in that area through retrofitting buildings, switching to more efficient heating, cooling, and lighting systems and switching to more efficient modes of transport with a reduced energy consumption per passenger.

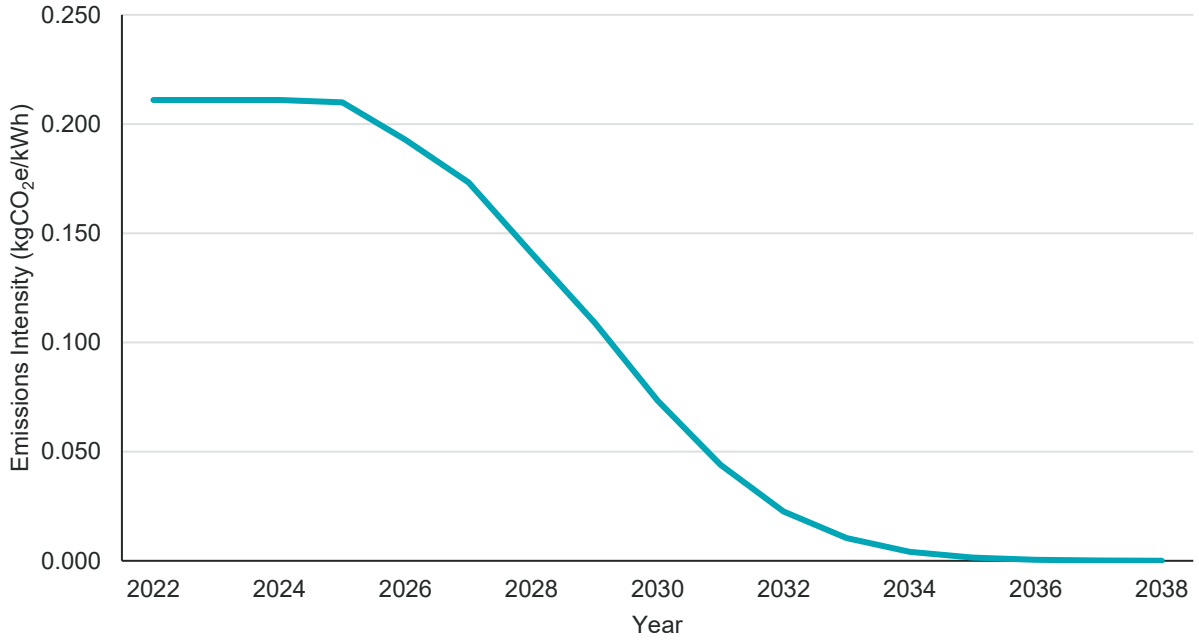

Figure 2-23: Modelled Electricity Grid Decarbonisation Trajectory. Source: DESNZ.

To further illustrate the importance of electricity decarbonisation, a sub-scenario has been modelled which maintains all the same assumptions as the main net zero scenario, except for grid decarbonisation, which was assumed to remain constant at 2022 levels (see Figure 2-24). In this sub-scenario, total emissions would only be reduced by 27.5% by 2030 and 56.5% by 2038 – compared to the 82% reduction with grid decarbonisation. This scenario still maintains the ambitious implementation of renewable energy installations. However, if all the electricity demand met by local renewables was met by the non-decarbonised electricity grid, the emissions reductions would be even lower, with 24.4% by 2030 and 50.4% by 2038.

This highlights the importance of:

1) National-level action to decarbonise the electricity grid, and;
2) Local-level action to reduce reliance on actions outside of Bradford.

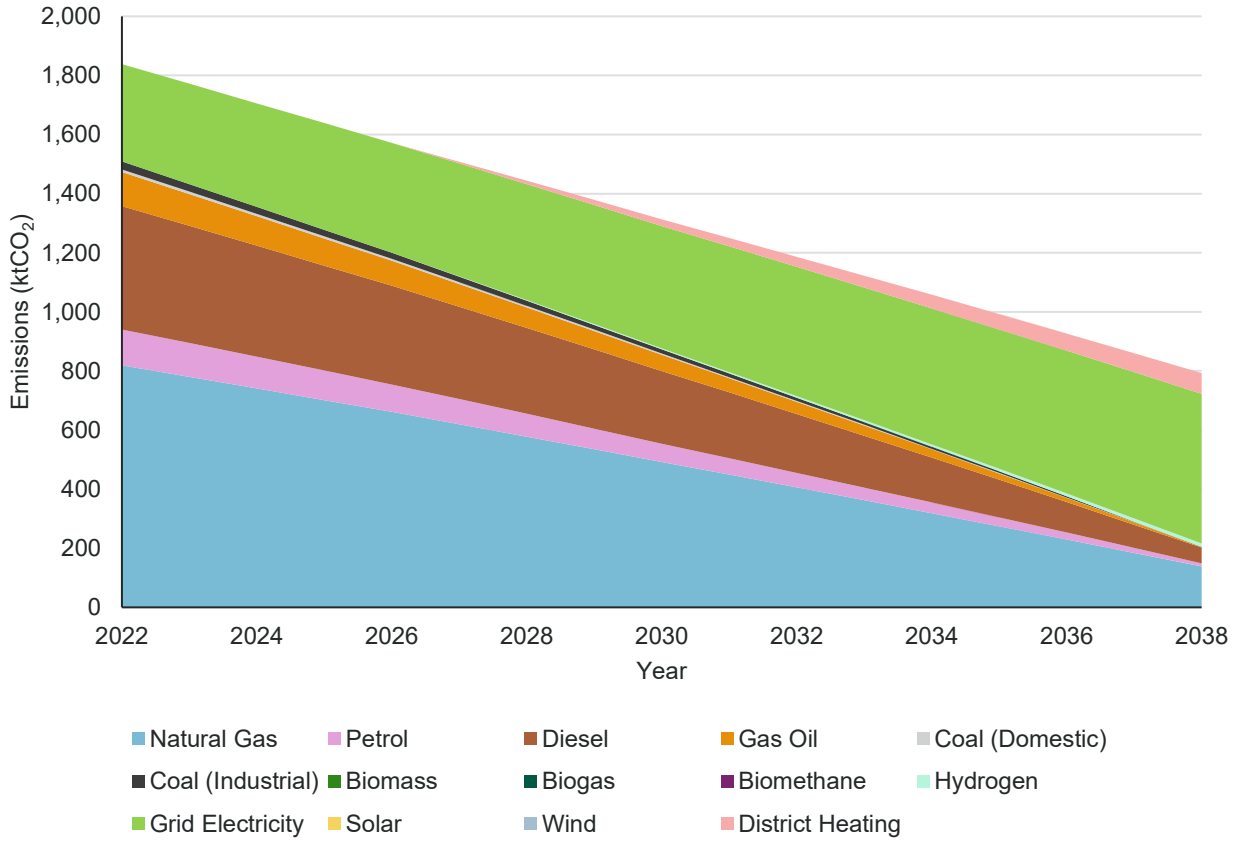

Figure 2-24: Emissions by Fuel in the Net Zero Scenario but without Grid Decarbonisation. Source: NZPT.

Due to Bradford's landlocked nature, two main forms of renewable energy generation were explored: solar photovoltaics (PV) and onshore wind. To ensure a resilient and functioning energy system, a range of enabling actions are also key, such as battery storage systems. These are strongly encouraged but out of scope for the net zero modelling, which focuses on reducing energy demand in the local authority area.

There are already 32 MW of installed renewable electricity capacity and 10 MW of planned renewable electricity capacity in Bradford.[67] However, a significant increase in renewable energy generation is needed to meet Bradford's net zero target, support the decarbonisation of the UK electricity grid, and improve local energy independence to counteract potential challenges with the grid.

Solar panels provide a sustainable solution for both households and businesses by reducing electricity bills, decreasing reliance on the grid, and lowering their carbon footprint.[68] We have assumed that around 10% of households will adopt rooftop solar by 2030, rising to 20% by 2038. This displaces over 20% of remaining electricity consumption after other measures have been applied by 2038, reducing household energy bills and removing pressure from the grid.

Similarly, it was assumed that around 30% of public sector and commercial properties (each) would install rooftop solar PV by 2038, with a larger PV array size of 10 kWp. Again, this would displace a significant proportion of remaining electricity consumption, reducing reliance on the grid.

Industrial solar PV installations can be both rooftop- and ground-mounted, depending on the available space and specific requirements of the industrial site. Ground-mounted solar accounts for around two-thirds of the UK's total solar capacity.[69] Rooftop installations are especially well-suited to urban and peri-urban industrial areas, where large warehouse or factory roofs provide ample surface area. Similar to domestic and non-domestic buildings, these installations offer a reduction in carbon emissions, improvement in energy resilience and a decrease in energy costs. To align the Bradford-wide modelling with an existing decarbonisation study

[67] DESNZ (2024). Regional Renewable Statistics. Available at: https://www.gov.uk/government/statistics/regional-renewable-statistics
[68] https://effectivehome.co.uk/solar/solar-panels-bradford/
[69] https://solarenergyuk.org/uk-solar-energy-industry-comes-of-age/

for Bradford Manufacturing Futures (BMF), the industrial fuel switching measures already account for increased solar and other renewable energy capacity.

Figure 2-25 below illustrates the installed, planned, and modelled solar energy generation in Bradford, showing the scale of action needed by 2038.

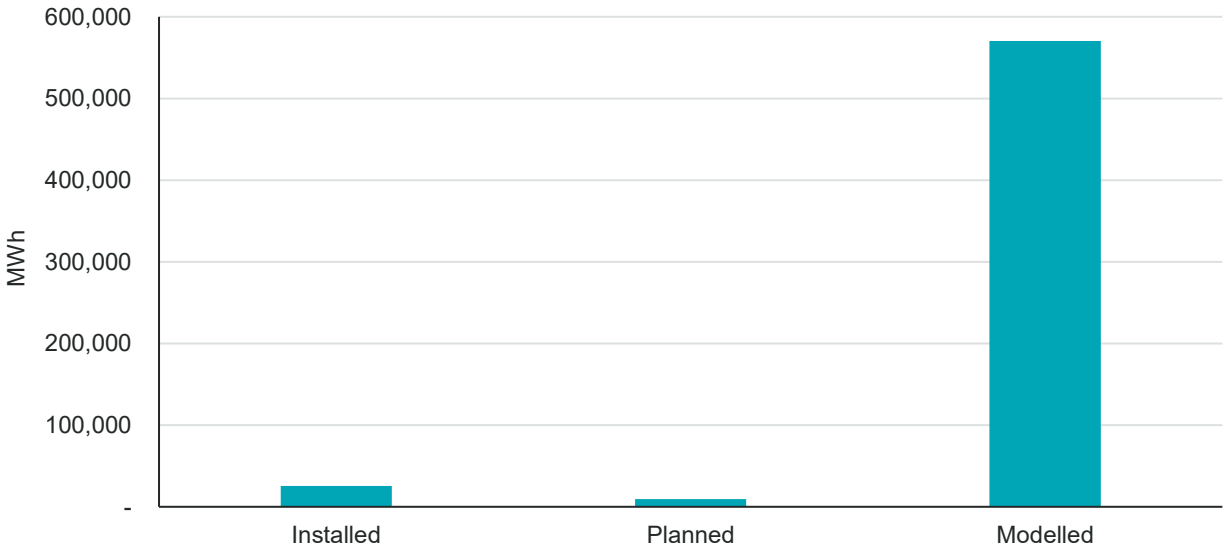

Figure 2-25: Planned, Installed, and Modelled Solar Energy Generation in Bradford.

Onshore wind power is a vital component of the UK's renewable energy mix[70] and will play a key role in decarbonising the grid. However, wind energy is highly location-dependent, so it is more challenging to assume area-wide uptake rates of wind turbines without conducting a site suitability analysis to understand what proportion of the current land area would be suitable for wind energy. Arup assumes, based on its BMF study, that there will be approximately 85,915 MWh of wind energy generation by 2038.

In addition to solar and wind, hydrogen can also form an important part of the future energy system. Hydrogen itself is not a renewable energy source, but it can be a renewably produced energy vector or fuel, used to store and transport energy, specifically when electricity cannot be utilised, such as in heavy industry.

Conventionally, hydrogen is produced via steam methane (CH_4) reforming using fossil fuels such as natural gas – resulting in something called 'grey hydrogen'. This grey hydrogen has been used since the early 20th century for a range of uses[71], such as the following:

1. Hydrogen is a critical feedstock in the Haber-Bosch process for synthesising ammonia (NH_3), which is primarily used in nitrogen-based fertilisers;
2. Hydrogen is essential for removing sulphur from fuels (hydrodesulphurisation) and for breaking down heavy hydrocarbons into lighter, more valuable products like gasoline and diesel;
3. Hydrogen is combined with carbon monoxide (CO) to produce methanol (CH_3OH), used as a chemical feedstock, in plastics, and increasingly as a fuel component or carrier;
4. Hydrogen is used in various chemical processes, including the production of hydrochloric acid, the reduction of metal ores (e.g. in float glass or semiconductor production), and the production of hydrogen peroxide.

In the context of climate mitigation and net zero, the hydrogen referred to as low-carbon hydrogen, such as:

1. Green Hydrogen: Produced via electrolysis of water using renewable electricity (from wind, solar, hydro);
2. Blue Hydrogen: Produced from natural gas via steam CH_4 reforming (SMR) or auto-thermal reforming (ATR) with CCS; or

[70] https://www.renewableuk.com/energypulse/blog/uk-wind-and-global-offshore-wind-2024-in-review/
[71] https://www.thechemicalengineer.com/features/uses-of-hydrogen-in-industry/

3. Other forms of low-carbon hydrogen, such as Turquoise Hydrogen made via CH_4 pyrolysis; or pink hydrogen, which is generated through electrolysis from nuclear energy.

There are two key considerations when it comes to using hydrogen as an alternative to fossil fuels: the amount and type of energy used to produce it.

Hydrogen will be an important part of the energy transition as an energy carrier when it is produced renewably and utilised when there are no suitable alternatives.[72] Hydrogen can:

1. Provide long-term energy storage, storing excess renewable electricity as hydrogen and then reconverted into electricity at a later date, helping balance grids;
2. Be used for heavy industry, such as steelmaking, cement, glass, and chemicals, where it replaces fossil fuels or grey hydrogen;
3. Decarbonise some transport applications, such as trucks, buses, trains, as well as aviation and shipping

Green hydrogen has a minimal emissions impact; however, it requires a lot of energy to produce hydrogen. This is illustrated in Figure 2-26 below, which illustrates this for the domestic sector with 150 GW of renewable electricity needed to produce 70 GW of useful energy after accounting for waste heat at different stages of the process. If domestic buildings were heated with heat pumps instead, only 26 GW of electricity would be needed if the end technology is heat pumps, which take in heat from the environment and therefore operate at more than 100% efficiency (typically between 300% and 350%).

Given this large renewable energy demand and the challenges with decarbonising existing uses of electricity, let alone additional ones, it is crucial to consider energy efficiency both at the source and demand points.

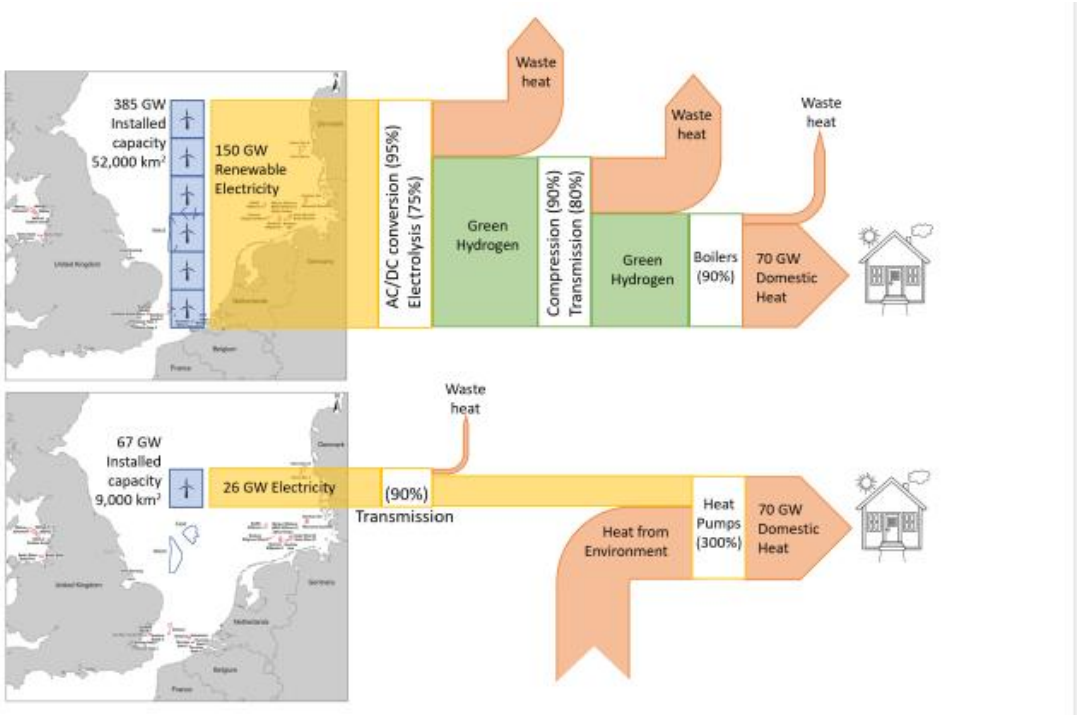

Figure 2-26: Sankey Diagram illustrating the energy required for green hydrogen vs heat pumps for heating domestic buildings. Source: Hydrogen Science Coalition[73].

While these considerations are vital, there are still important uses for hydrogen where it is the best energy carrier, as outlined above and illustrated in Figure 2-27 below. It should be noted that areas of hydrogen applications have been evolving and will remain in flux in line with new research – as such, these applications

[72] Houses of Commons, Science and Technology Committee (2022). The role of hydrogen in achieving Net Zero. Available at: https://committees.parliament.uk/publications/33292/documents/180198/default/

[73] Hydrogen Science Coalition (2022). 'Briefing on the Energy Bill'. Available at: https://h2sciencecoalition.com/wp-content/uploads/2022/09/Energy-Bill-briefing-by-H2SC-2022-08-28-2.pdf

are not definitive but rather broad suggestions. For example, since version 4.0 of the ladder, regional trucks have moved up from an F to an E rating.[74]

Hydrogen use is also likely to be location-specific with hydrogen hubs emerging around the country. Bradford is one of these hubs. N-Gen are developing a Hydrogen Production Facility with the capacity to produce around 24.5 MW of hydrogen (12.5 tonnes per day). The hydrogen produced at this facility is also known as 'green hydrogen' which is produced through electrolysis (see Box 3).

Box 3: Production of Hydrogen through Electrolysis.

Hydrogen can be produced through electrolysis, whereby molecules are split into Hydrogen (H_2) and Oxygen (O_2). Electrolysis is the process of using an electrical current to decompose an electrolyte (in this case, water) into its constituent elements (H_2 and O_2).

In the case of 'green hydrogen', the electricity used in the electrolysis process is generated from renewable energy sources such as: wind or solar, making the production of the hydrogen carbon neutral.[75, 76]

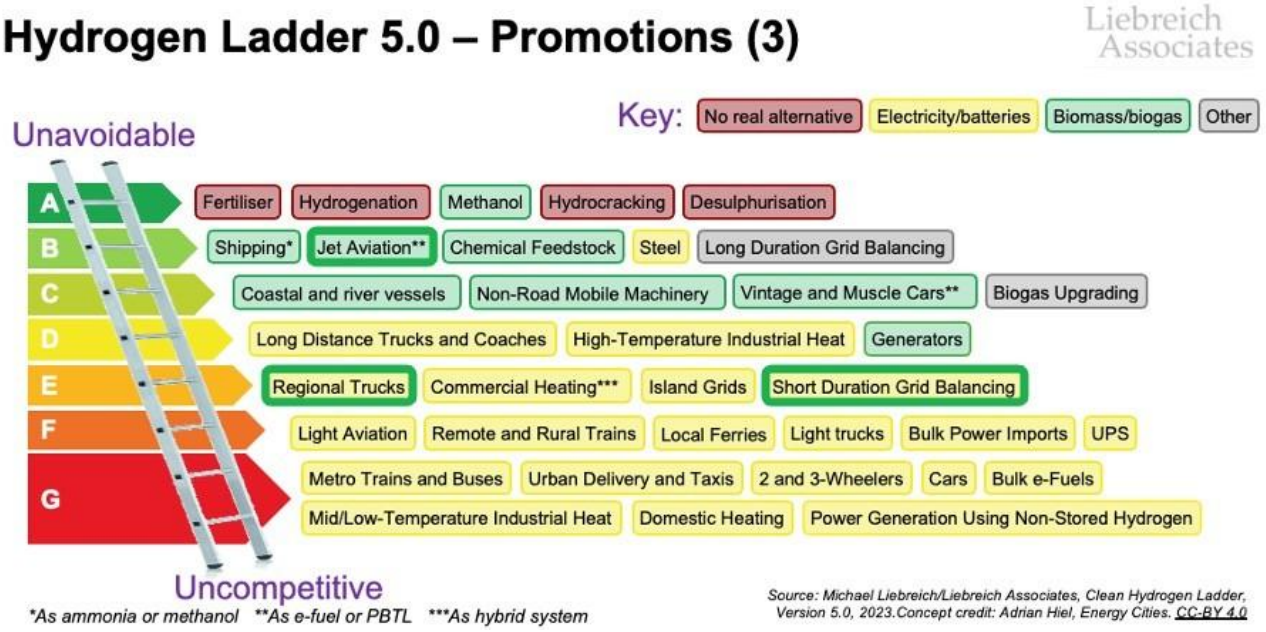

Figure 2-27. The Hydrogen Ladder Version 5.0. Source: Liebreich Associates[77]

2.2.3.6 F-Gases

Fluorinated gases (F-gases) currently represent a relatively small percentage of the UK's total GHG emissions, accounting for less than 2% in 2022. Despite their low volume, F-gases have a significantly high global warming potential (GWP), up to 24,300 times greater than CO_2. GWP is a way to compare how much heat a GHG traps in the atmosphere compared to CO_2, meaning that one tonne of F-gas warms the planet as much as 24,300 tonnes of CO_2 over 100 years. Figure 2-28 shows the GWP of major F-gases compared to CO_2.

[74] https://www.liebreich.com/the-clean-hydrogen-ladder-now-updated-to-v4-1/
[75] Kumar et al. (2022). An overview of water electrolysis technologies for green hydrogen production. Available at: https://doi.org/10.1016/j.egyr.2022.10.127.
[76] Local Government Association (2021). Case Study: Greater Brighton: Hydrogen Sussex. Available at: https://www.local.gov.uk/case-studies/greater-brighton-hydrogen-sussex
[77] https://www.liebreich.com/hydrogen-ladder-version-5-0/

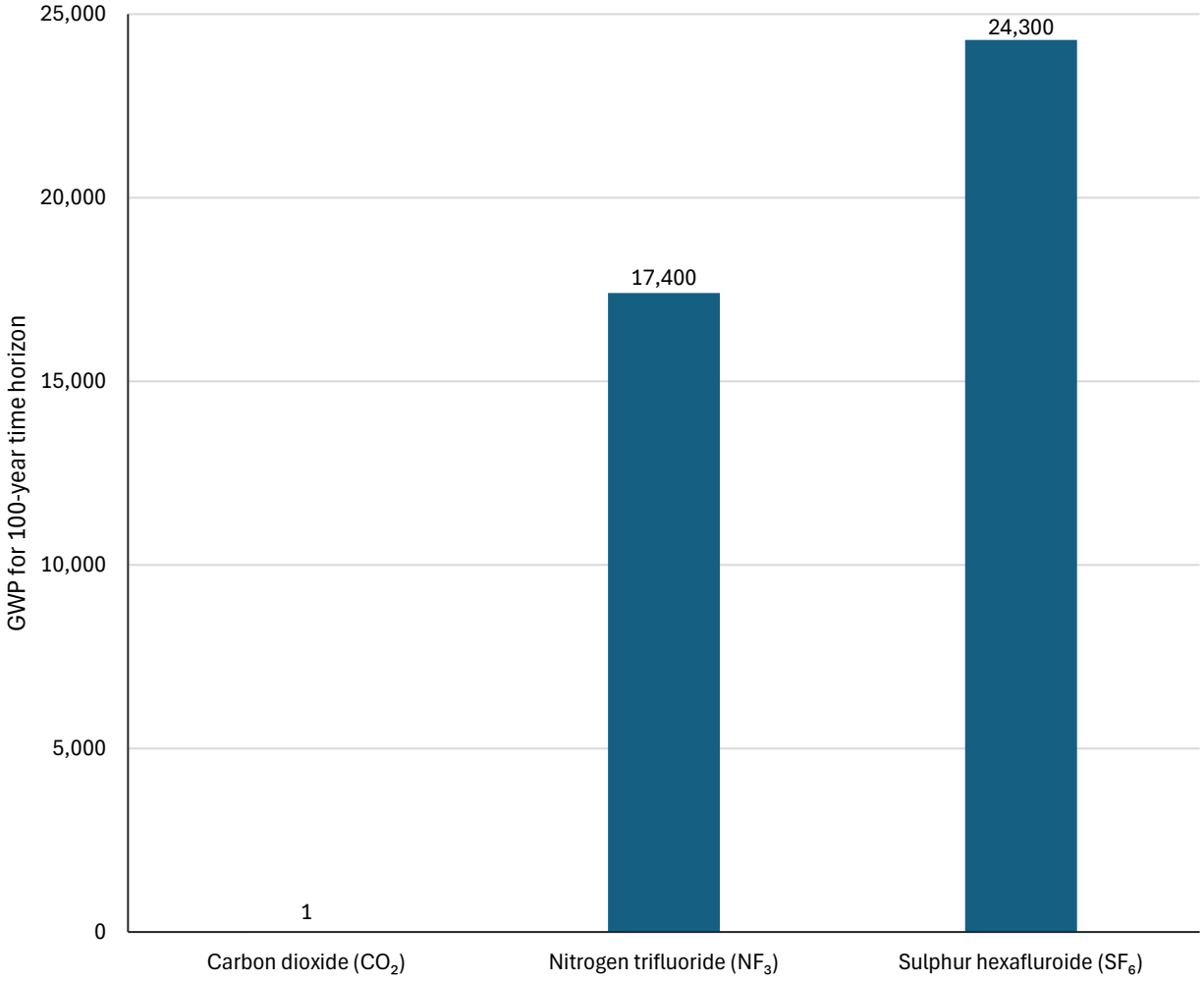

Figure 2-28: GWP for 100-year time horizon of carbon dioxide compared to two major F-gases[78].

Common sources of F-gases include their use as refrigerants in equipment like refrigeration, air conditioning, and heat pumps, as well as being used in aerosols, solvents, insulating gases, or blowing agents for foams. They can also be emitted as fugitive emissions from manufacturing processes. By 2040, F-gases are projected to still make up 2% of UK GHG emissions, remaining the 11th highest-emitting sector.[79] This is not because F-gas emissions are static or increasing, but rather because they are projected to decline at a slower rate compared to other sectors. While sectors such as energy, transport, and industry are expected to see steep reductions due to large-scale decarbonisation measures, F-gases are more challenging to eliminate due to their widespread use in cooling and the long lifetimes of equipment.[80]

Under the CCC's Balanced Pathway in its Seventh Carbon Budget, emissions from F-gases are projected to fall significantly relative to 2022 levels. The pathway anticipates a 73% reduction by 2040, reaching 2.0 $MtCO_2e$, and a 79% reduction by 2050, reaching 1.6 $MtCO_2e$. These reductions are primarily driven by regulatory measures such as the UK's F-gas Regulation, which aims to phase down the use of high-GWP F-gases and promote the adoption of lower-GWP alternatives.[81] This transition is expected across key applications, including refrigeration, air conditioning, heat pumps, and inhalers, with emissions from these subsectors falling to near zero by 2050 in the pathway. The CCC emphasises that the UK will need to align

[78] GHG Protocol (2024). Global Warming Potential Values. Available at: https://ghgprotocol.org/sites/default/files/2024-08/Global-Warming-Potential-Values%20%28August%202024%29.pdf
[79] CCC (2025). The Seventh Carbon Budget. Available at: https://www.theccc.org.uk/publication/the-seventh-carbon-budget/
[80] UK Department for Environment, Food and Rural Affairs (2022). F gas regulation in Great Britain. Available at: https://assets.publishing.service.gov.uk/media/63a2f8e9e90e075878e52448/F_gas_regulation_in_Great_Britain.pdf
[81] CCC (2025). The Seventh Carbon Budget. Available at: https://www.theccc.org.uk/publication/the-seventh-carbon-budget/

regulations with the EU's 2024 F-gas standards to provide certainty for supply chains and encourage investment in alternative technologies.

The CCC's analysis accounts for F-gas emissions from heat pumps in the Balanced Pathway. Their modelling baseline includes the projected take-up of heat pumps in line with the pathway for buildings, specifically to ensure that appliances containing F-gases are not undercounted. The F-gases Balanced Pathway then incorporates the actions necessary to mitigate F-gas emissions from these appliances, contributing to the overall projected reduction in the sector.

2.2.3.7 Waste

The waste sector accounts for less than 4% of total baseline GHG emissions in Bradford. Landfill sites are the dominant source, contributing approximately 61% of the waste-related emissions in 2022 (45.2 $ktCO_2e$ of 74.8 $ktCO_2e$ total). The remaining emissions stem from 'other' waste management activities, which are assumed to be split between composting and wastewater treatment, representing CH_4 and nitrous oxide (N_2O) emissions from biological processes. Although these emissions form a small proportion of the overall emissions profile, they remain significant for two main reasons. Firstly, the waste sector is a major source of CH_4, which accounted for 89% of the waste emissions in CO_2e terms, making its mitigation an early priority to avoid exacerbating near-term climate impacts. Secondly, waste-related emissions are notoriously difficult to eliminate, often representing a significant share of residual emissions in local carbon pathways after modelled energy-related mitigation.

Box 4: Production of Landfill gases.

Landfill Gas

Solid waste deposited in landfills causes emissions through the creation of landfill gas – a mixture that predominantly consists of CH_4 and CO_2. The carbon dioxide does not count towards GHG inventories as it is considered biogenic (i.e., part of the natural carbon cycle) – CH_4, on the other hand, does. The CH_4 starts to get generated through the aerobic (with oxygen) stage of waste decomposition; however, the majority of CH_4 arises when anaerobic (without oxygen) conditions are established and certain bacteria further decompose the waste.[82]

The largest share of emissions reduction in the CCC's waste sector pathway comes from reducing waste sent to landfill and Energy from Waste (EfW) plants. This is achieved through resource efficiency measures, increased recycling rates, and a reduction in food waste. Specific targets and goals mentioned in the Balanced Pathway for waste include:

- Increasing recycling rates to 68% by 2035. The combined recycling rate includes waste from households and commercial and industrial waste.
- Achieving the near elimination of biodegradable waste from landfill by 2028.
- Achieving the near elimination of all waste from landfill by 2045.
- Reducing per-capita food waste by 39% by 2030 and 45% by 2040, from 2021 levels. The 2030 reduction is consistent with the UN Sustainable Development Goal 12.3.
- Increasing the share of EfW capacity fitted with CCS to 80% by 2040 and 100% by 2050.
- Improving landfill CH_4 capture rates to 80% by 2050.

It should be noted that despite the early landfill ban, emissions from landfills do not reach zero within the modelling timeframe, as landfill gases continue to be emitted – potentially for hundreds of years.[83] As such, both early bans and landfill gas capture are crucial to reducing emissions from this source.

Improvements in wastewater treatment are also part of the pathway, addressing N_2O and CH_4 emissions through technologies like advanced anaerobic digestion (AD) and biogas upgrading. CBMDC is exploring the

[82] https://www.epa.gov/lmop/basic-information-about-landfill-gas
[83] SEPA (2002). Guidance on landfill gas flaring. Available at: https://www.sepa.org.uk/media/28988/guidance-on-landfill-gas-flaring.pdf

development of an AD facility to treat and convert organic waste (green waste, oils and food).[84] AD is well-established in the UK, and regulations requiring mandatory separate food waste collections in England are increasing the amount available for AD treatment. AD can help meet carbon reduction targets by diverting organic waste away from landfills, producing biomethane that can be injected into the gas grid or used as a low-carbon vehicle fuel, and producing bio-CO_2 at a lower carbon cost than standard production techniques.[85] Biogenic waste (like food waste) is identified as a major source of domestic bioenergy supply by 2050 in the CCC's Balanced Pathway.

The CCC highlights several challenges in delivering the waste sector decarbonisation pathway:

- Recycling rates have stalled since 2010, and planned policies are considered unlikely to achieve the necessary increase to 68% by 2035.
- There is a need for greater clarity on government plans regarding recycling, reuse, and resource efficiency.
- Local authorities, who manage around 40% of waste, require funding and policy certainty to deliver improved recycling and manage additional costs associated with using CCS with EfW.
- There is a risk of stranded assets if new EfW plants are licensed or built without a viable route to connecting to CCS infrastructure.
- Investment is needed in the wastewater sector to roll out required technologies and improve emissions monitoring.
- Delivering the Balanced Pathway for waste results in a net cost to the economy compared to the baseline, primarily driven by the costs of CCS installations at EfW plants.

2.2.3.8 Agriculture

Bradford's agriculture sector contributes less than 4% of the district's total greenhouse gas emissions. In 2022, the sector emitted 74.2 $ktCO_2e$, with livestock emissions making up the majority at 80% (59.2 $ktCO_2e$), predominantly in the form of CH_4. Emissions from agricultural soils contributed 12% (8.6 $ktCO_2e$) largely as N_2O, while the remaining 8% stemmed from the use of fuels such as electricity and gas in farming operations. Addressing livestock emissions involves local actions like switching to zero or low-carbon fuels, but also requires sector-specific measures such as changes in livestock feed. However, a significant portion of actions, being dependent on consumption patterns, cannot be addressed solely at the local farm level. Despite being a relatively small proportion of local emissions, emissions from agriculture are often difficult to mitigate and are projected to constitute a significant share of residual emissions in the future, similar to the waste sector.

The CCC's Balanced Pathway for the UK outlines specific targets and strategies for reducing emissions from the agriculture sector.

- By 2040, agricultural emissions are projected to fall by 39% relative to 2022 levels. The largest proportion of agricultural emissions is CH_4 directly emitted from livestock, and the pathway projects a steep fall in CH_4 emissions in the late 2020s and early 2030s, reaching almost half of today's levels by 2050. This reduction is primarily due to on-farm measures and projected shifts away from red meat and dairy consumption.
- N_2O emissions are also projected to decline steadily, reaching almost half of today's levels by 2050, mainly through reductions in agriculture. Specific measures for soils and livestock include feed additives to inhibit CH_4, breeding and livestock health measures, better management of animal waste, and practices like grass-legume mixes, which reduce the need for nitrogen fertiliser.
- The CCC balanced pathway also includes decarbonising agricultural machinery. Energy use emissions from machinery decline with reduced livestock numbers and land area. The remaining machinery use is expected to decarbonise fully by 2050, with a shift towards electrification. For larger vehicles where battery size and weight might be an issue for electrification, hydrogen-based options are projected to be used. Bioenergy is also mentioned as a transitional fuel for non-road mobile

[84] https://bidstats.uk/tenders/2025/W01/837877767

[85] Bio Capital, ashfords, ADBA (2022). Dood Waste Recycling. Anaerobic Digestion. The Net Zero Level for Local Authorities. Available at: https://www.letsrecycle.com/wp-content/uploads/2022/05/ADBA-briefing-foodwasterecyclying-the-net-zero-lever-for-local-authorities-April-22.pdf

machinery, being phased out by 2040. As such, this was not modelled for Bradford's Net Zero Scenario.

2.2.3.9 Land Use

Bradford's Land Use, Land-Use Change, and Forestry (LULUCF) sector has remained a net source of GHG emissions from 2005 through 2022; however, net emissions have significantly declined over this period. In 2005, total net emissions from the sector were 12.0 $ktCO_2e$, gradually falling to 4.0 $ktCO_2e$ by 2022, reflecting steady progress in reducing land-based emissions. Figure 2-29 shows a net decrease in the Bradford LULUCF sector as a whole, while Figure 2-30 demonstrates the breakdown of this decline by individual sub-components.

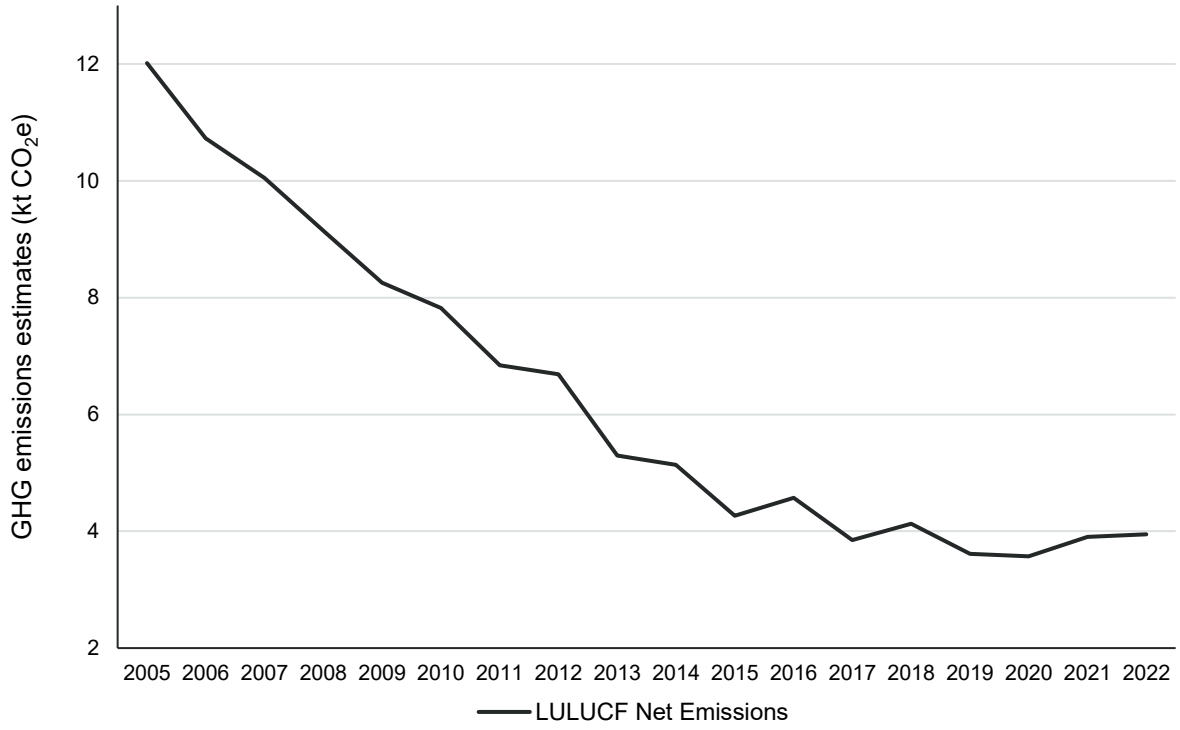

Figure 2-29: GHG emissions estimates from 2005-2022, in Bradford's LULUCF sector.

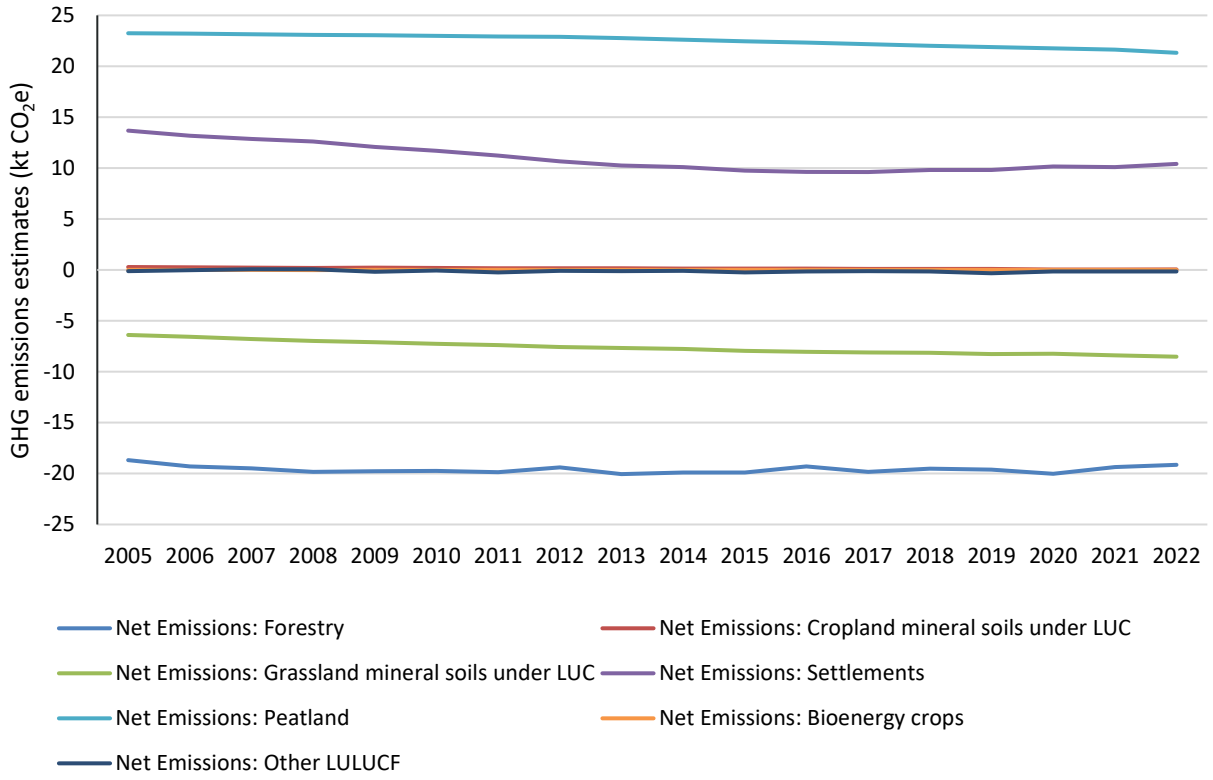

Figure 2-30: GHG emissions estimates from 2005-2022, in sub-components of Bradford's LULUCF sector.

The largest and most consistent sources of emissions have been peatland and settlements. Peatland emissions started at 23.2 $ktCO_2e$ in 2005 and only modestly decreased to 21.3 $ktCO_2e$ by 2022. Emissions from settlements also remained relatively steady, fluctuating between 13.7 $ktCO_2e$ and 9.8-10.4 $ktCO_2e$ across the years.

On the other hand, forestry has acted as a strong carbon sink, with net removals increasing from -18.7 $ktCO_2e$ in 2005 to -20.4 $ktCO_2e$ in 2021, slightly decreasing to -19.1 $ktCO_2e$ in 2022. Grassland mineral soils have also contributed to growing negative emissions, improving from -6.4 $ktCO_2e$ to -8.5 $ktCO_2e$ over the period. These removals have helped to significantly offset total sector emissions, though not enough to bring the LULUCF sector into net-negative territory.

Smaller sub-sectors such as ‘cropland mineral soils’ and ‘other LULUCF’ played minor roles but trended toward reduced or slightly negative emissions by 2022. While progress has been made, the sector remains a net emitter, demonstrating the need for continued improvements in peatland restoration, afforestation, and land-use management to help transition toward a net sink in the future.

In Bradford’s approach to reducing emissions within the LULUCF sector, we focused on two key areas: tree planting and peatland restoration. These priorities were selected based on both the clarity of available actions and the scale of potential impact.

Tree planting was identified as a strategic opportunity due to its dual role in sequestering carbon and delivering wider environmental co-benefits (see Section 3 for a qualitative exploration of possible co-benefits, such as biodiversity enhancement and improved air quality). Forestry has consistently acted as a significant carbon sink in Bradford, removing between 18.9 and 20.2 $ktCO_2e$ annually over the past two decades. Tree planting offers a relatively straightforward, scalable, and visible intervention that aligns with both climate and natural capital goals.

Meanwhile, peatland management is a core focus as Bradford’s largest source of emissions in the LULUCF sector. Emissions from degraded peatlands have remained persistently high, contributing over 21 $ktCO_2e$ each year. Unlike forestry, where carbon is actively removed from the atmosphere, degraded peatlands are net emitters due to drainage, oxidation, and land-use pressures. Restoring peatlands by rewetting, revegetating,

and protecting them from further degradation presents one of the most effective ways to halt these emissions. Addressing peatland degradation not only reduces emissions but also strengthens ecosystem resilience and supports water quality and flood management.

Together, these two focus areas reflect a balanced strategy of scaling up carbon sequestration through tree planting while tackling the most significant emission source in the LULUCF sector. This targeted approach positions Bradford to make measurable progress toward its climate commitments.

Tree planting has been a feature of environmental action in Bradford since the mid-1990s. A significant early initiative was the Forest of Bradford, established in 1998 under the umbrella of the Bradford Environmental Action Trust (BEAT). The Forest of Bradford operates in partnership with local communities, organisations, volunteers, and businesses with the overarching goal of creating a sustainable wooded landscape throughout both rural and urban areas of the Bradford district. The Forest of Bradford and its partners successfully planted over 330,000 broad-leaved trees across more than 250 sites across a 10-year period.[86]

Building on this local foundation, Bradford Council became a founding member of the White Rose Forest Partnership in the early 2000s. This major regional collaboration aims to significantly increase woodland cover across North and West Yorkshire, including Bradford. The White Rose Forest initiative has set an ambitious target for Bradford, aiming to increase the district's tree cover from 13% in 2021 to at least 17%, with an aspiration of reaching 20% by 2050.[87] Achieving this goal necessitates the planting of millions of trees and the strategic conversion of grassland to woodland.

In response to the climate emergency declared in 2019, Bradford Council, in partnership with Trees for Cities, launched the 'Tree for Every Child' Initiative in 2021. This initiative aimed to plant one tree for every primary school child in the district. Between 2021 and 2023, a significant milestone of 60,000 trees was achieved[88], with planting taking place across 90 schools and public spaces. Planting for this initiative commenced in 2020, actively involving local schools and community groups in the creation of four new children's woodlands.[89] The selection of native trees and hedgerows, facilitated through partnerships with Bradford Council and local delivery organisations such as YORGreencic, BEAT, BEES, and Fruit Works, was deliberate to maximise a range of benefits for Bradford, including providing shade, reducing flood risk, enhancing biodiversity, offering fresh fruit, protecting against pollution, and improving mental health and wellbeing.

Further engaging the community, Bradford became the first council in Yorkshire to join the 'Trees for Streets' national street tree sponsorship scheme in 2021. This initiative aims to plant thousands of street trees through local sponsorship and donations, supplementing council budgets and empowering residents to actively request and sponsor tree planting in their local areas.[90]

Beyond these specific initiatives, the Council's own Landscape Design and Conservation Team plays a role in designing and implementing various tree and plant planting projects across the district. Examples include the work undertaken in the Little Horton area, which encompassed projects at Horton Park Primary School and the Canterbury estate. These projects, primarily funded by the National Lottery, focused on greening urban spaces to create safer and healthier environments for families and young children within the Better Start Bradford area.

Modelling savings from carbon sequestration is always associated with significant uncertainties. However, given Bradford's ongoing actions and ambitious plans in this sector, it was deemed appropriate to model local ambitions with certain caution and buffers. Specifically, we modelled the target to increase tree cover from 13% in 2021 to 20% in 2050, as this high-level measure encompasses all specific intermediary targets.

The projection of tree-covered land area assumes a linear growth in tree cover between the baseline year of 2022 and the target year of 2050. To achieve the 7% increase in tree cover over this 28-year period, an equal area of new trees is assumed to be planted each year. Based on the total land area of Bradford (366 hectares), this translates to a required annual planting of 88.34 hectares of new woodland. This linear growth model

[86] https://www.beat.org.uk/bm/forest_of_bradford/index/
[87] CBMDC (N.D.). Tree planting - how we can work together. Available at: https://www.bradford.gov.uk/environment/climate-change/tree-planting-how-we-can-work-together/
[88] BBC (2025). Children planting trees to address climate change. Available at: https://www.bbc.co.uk/news/articles/cz038ldg5xxo
[89] Trees for Cities, Bradford Initiatives. Available at: https://www.treesforcities.org/bradford
[90] Trees for Streets (N.D.). Making Bradford Greener – One Tree at a Time. Available at: https://www.treesforstreets.org/making-bradford-greener-one-tree-at-a-time/

provides a simplified yet illustrative trajectory of land conversion to tree cover over the specified timeframe. Changes in tree-covered land area are summarised in Table 2-4 below.

Table 2-4: Summary of Bradford's target to increase tree-covered land area from 13% in 2021 to 50% in 2050, assuming a linear growth rate.

	Tree-covered land area	
	Percentage	Hectares
2021	13%	4,846 ha
2050	20%	7,320 ha
Annual increase	0.24%	88.34 ha
Total increase	7%	2,474 ha

The cumulative carbon sequestration resulting from this 7% increase in tree cover was projected using the UK's Woodland Carbon Code (WCC) Calculator. The WCC is a well-established, voluntary standard used in the UK to enable woodland creation projects to credibly claim the amount of carbon dioxide they will sequester over time. Its effectiveness has been demonstrated in larger woodland development projects across the UK, including the White Rose Forest planting strategy[91].

Specifically, the WCC Carbon Calculation Spreadsheet Version 2.4 for 'Standard Projects' was used. This calculator is designed for projects exceeding 5 hectares and allows for the projection of carbon sequestration based on several input variables and assumptions. For these projections, a planting density of 3 meters between trees was assumed. The calculator provides outputs of cumulative carbon sequestration in tCO_2e at five-year intervals, extending up to 100 years post-planting.

To account for potential variations in soil conditions and management practices, cumulative carbon sequestration was calculated for both a low and high soil disturbance scenario, with the current land type assumed to be pastureland in both cases. These scenarios provide a range of potential carbon sequestration outcomes based on different levels of impact on the existing soil carbon stocks during the woodland creation process.

It is important to note that the WCC mandates that every project registered under the code must contribute 20% of its total projected carbon sequestration into an overall scheme risk buffer. This buffer acts as an insurance mechanism to account for potential unforeseen events (e.g., disease, fire) that could impact the actual carbon sequestration achieved. Consequently, only 80% of the total carbon sequestration calculated using the WCC is actually claimable by the projects implementing the woodland creation. This claimable portion of the projected cumulative carbon sequestration is the value presented in Figure 2-31, providing a more realistic representation of the carbon credits that could be generated through Bradford's tree cover increase target.

[91] UBOC (2021). Informing a carbon-based tree planting strategy for the White Rose Forest. Available at: https://www.uboc.co.uk/wp-content/uploads/2021/11/UBoC_WRF_MainReport_Nov2021.pdf

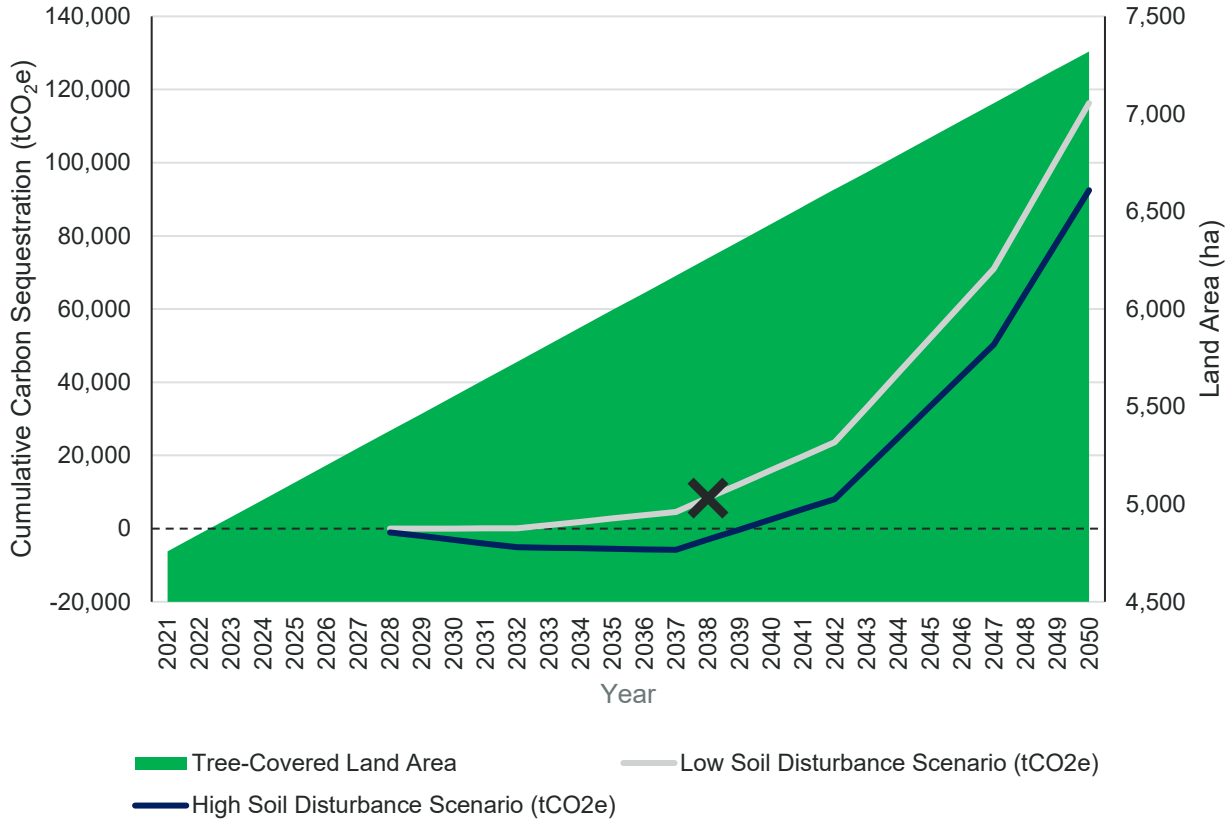

Figure 2-31: Projected tree-covered land area and claimable cumulative carbon sequestration in Bradford (2021-2050).

As depicted in Figure 2-31, under a high soil disturbance scenario, the cumulative carbon sequestration is projected to dip below zero until approximately 2040. This indicates a potential risk that the tree planting efforts could become a net source of greenhouse gas emissions in the short term, rather than functioning as a carbon sink.

This temporary reversal is attributed to the disturbance of the soil during ground preparation activities, which can release greenhouse gases directly from the soil. The magnitude of these emissions is directly correlated with the volume of soil disturbed. This is particularly pertinent for organomineral soils, which typically have a higher carbon content and therefore a greater potential for carbon loss when disturbed. The WCC explicitly accounts for these soil carbon emissions in the first year following planting.[92]

The WCC emphasises that the carbon benefits derived from woodland creation are generally most pronounced on soils with lower organic matter content, such as mineral soils, and in situations where establishment and management techniques minimise soil disturbance. Consequently, the WCC advocates for ground preparation methods that achieve successful establishment with the least possible impact on the soil structure. While ongoing research continues to refine our understanding of soil carbon dynamics in response to land use change and management, the WCC adopts a conservative approach to soil carbon accounting. This ensures that potential soil carbon emissions associated with woodland creation projects are not underestimated, and any potential soil carbon sequestration within the soil itself is not overestimated. This cautious methodology has been developed with the input of soil experts from across the UK.

Furthermore, Figure 2-31 highlights a significant lag time between the physical act of planting trees and the point at which substantial carbon savings begin to accrue. This demonstrates the long-term nature of carbon sequestration through afforestation. Unless the entirety of the targeted 2,474 hectares of additional tree-covered land were planted in a single year, which is not a recommended approach due to logistical constraints, resource limitations, and potential ecological impacts of such a large-scale, immediate intervention, and short-

[92] Woodland Carbon Code (2025). The Woodland Carbon Code. Available at: https://www.woodlandcarboncode.org.uk/standard-and-guidance/1-eligibility/1-2-eligible-activities

term carbon savings are unlikely to be realised. A phased planting approach, while more practical and ecologically sound, inherently leads to this delay in significant carbon sequestration.

It is important to acknowledge that these projections are subject to a range of uncertainties. Assumptions such as the linear planting rate, the assumed planting density, and the generalised soil conditions introduce potential variations in the actual outcomes. Therefore, the figures presented in Figure 2-31 should be considered illustrative rather than definitive, providing an insight into the potential trajectory of tree cover and carbon sequestration under the stated assumptions.

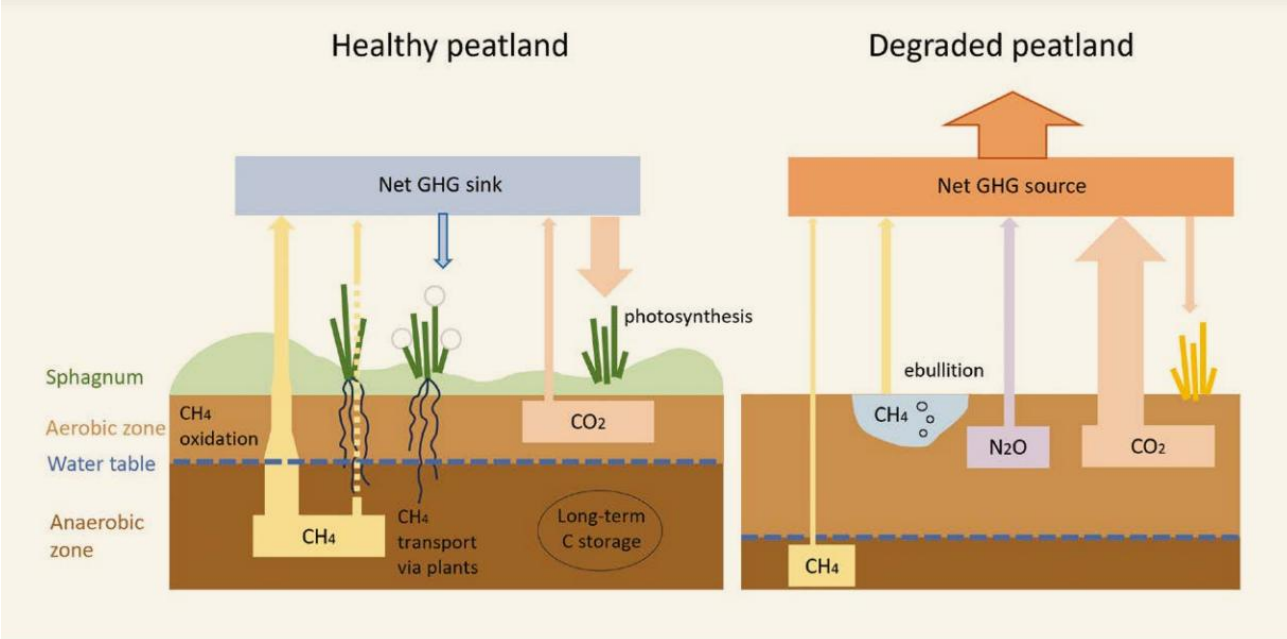

Figure 2-32: The GHG exchange between the different layers of peat and the atmosphere on a healthy bog peatland compared to a degraded peatland. Source: IUCN-UK.

Peatlands are currently the largest source of emissions within Bradford's LULUCF sector (see Figure 2-30), making their restoration a priority for emissions reduction and ecosystem recovery. The city lies within a vast expanse of upland peat, the 'Great North Bog', and includes significant peatland areas such as Ilkley Moor and Harden Moor. Healthy peatlands are a net GHG sink, while degraded peatlands are a net source (see Figure 2-32). Across the UK, around 80% of peatlands are estimated to be degraded, and similar degradation also appears to be the case in Bradford. CBMDC has initiated restoration efforts across key sites, including Hebers Ghyll and Spicey Gill (Ilkley Moor), and Bingley and Penistone Hill (Harden Moor).[93]

[93] Wild Moors (2023). Bradford Council scales up peatland restoration following success on Ilkley Moor. Available at: https://www.wildmoors.org.uk/bradford-council-scales-up-peatland-restoration-following-success-on-ilkley-moor/

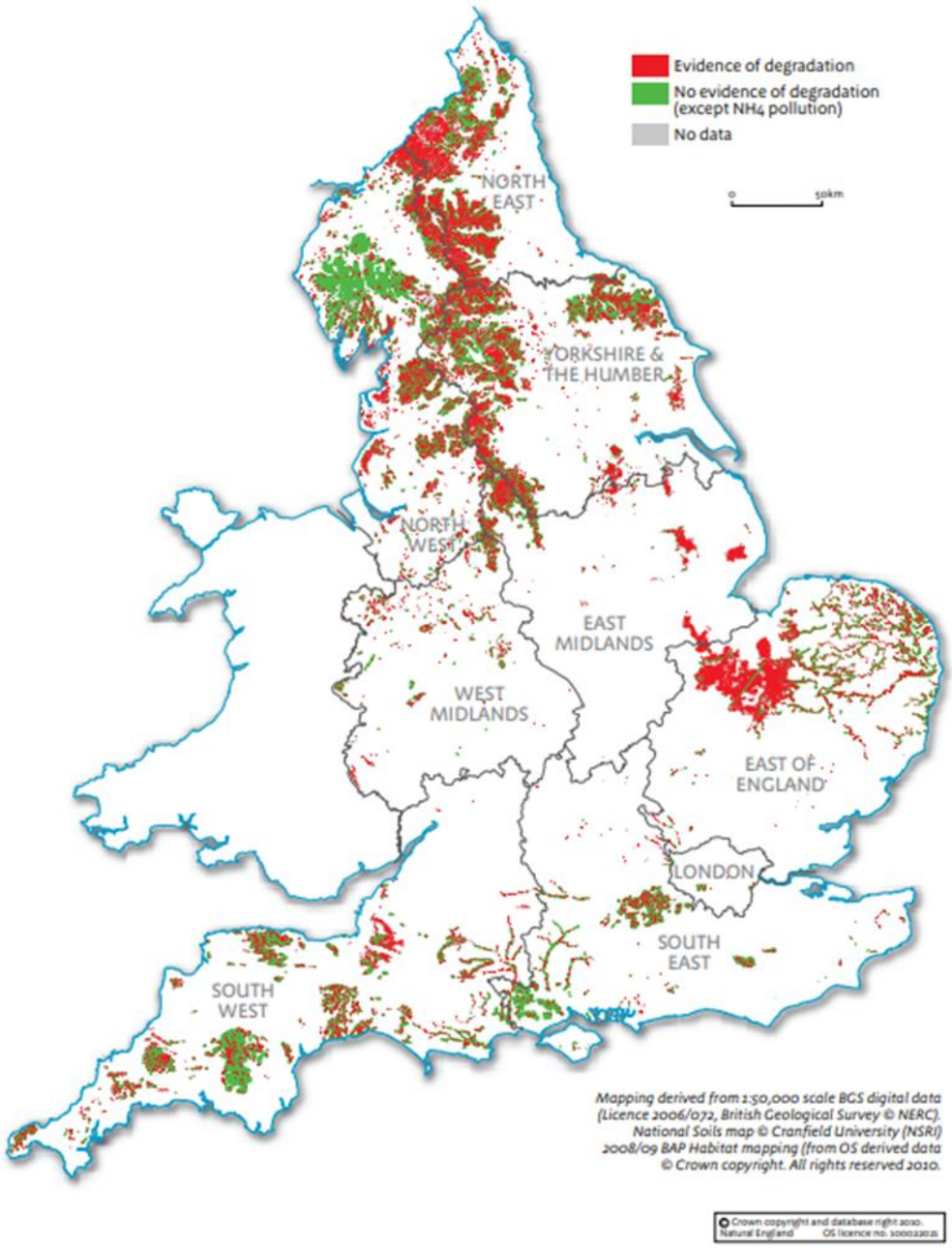

Figure 2-33: Map of UK Peatlands. Source: England's peatlands: carbon storage and greenhouse gases (NE257) [94].

Restoration methodology primarily includes rewetting, which halts peat oxidation and carbon loss, and in some cases, complementary tree-planting to stabilise eroded areas or enhance biodiversity. These interventions aim to transition degraded peatlands from a carbon source to a carbon sink. Between 2005 and 2022, emissions from peatlands decreased by around 8%, contributing to an overall 67% reduction in LULUCF emissions. However, peatland remains a net source, underlining the need for continued action.

CBMDC has nearly completed moorland restoration on Ilkley Moor and, building on this success, committed an additional £200,000 to expand rewetting efforts across other publicly owned moorlands.[95] These projects

[94] Natural England (2010). England's peatlands: carbon storage and greenhouse gases (NE257). Available at: https://publications.naturalengland.org.uk/publication/30021

[95] Wild Moors (2023). Bradford Council scales up peatland restoration following success on Ilkley Moor. Available at: https://www.wildmoors.org.uk/bradford-council-scales-up-peatland-restoration-following-success-on-ilkley-moor/

not only reduce emissions but also deliver co-benefits, including increased biodiversity, improved air and water quality, flood mitigation, wildfire resilience, and enhanced public access to nature.

Restoration efforts are embedded within the Local Nature Recovery Strategy (LNRS), coordinated by the West Yorkshire Combined Authority (WYCA), which is mapping key habitats and setting local nature priorities. Ongoing and planned peatland restoration will be integrated into Bradford's climate action modelling, ensuring these projects are recognised for their climate and ecological value.

The impact of peatland restoration on the GHG balance is highly complex and riddled with uncertainties. For example, the rewetting of peatlands establishes anoxic conditions, which allow for CH_4 production, *increasing* emissions by an average of 46% after restoration.[96] However, with successful rewetting and once typical vegetation has been established after 5-10 years, CH_4 emissions return to the low levels of natural peatlands (see Table 2-5). This challenge in rewetting peatlands should not detract from the importance and benefits of this action; however, it means that caution needs to be taken when modelling potential carbon savings to avoid overestimates. As such, it was assumed that the 2005-2022 trend explored under Task 1 is continued into future years as a result of ongoing peatland restoration (see Figure 2-34).

Table 2-5: Peatland Restoration Effects on the GHG Balance.

Time after restoration	CO_2	CH_4	Overall GHG balance
Short term	↓	↑↑↑	Often still a source
Medium term	↓↓	↑↑	Close to neutral
Long term	↓↓↓	↑	Often becomes a sink

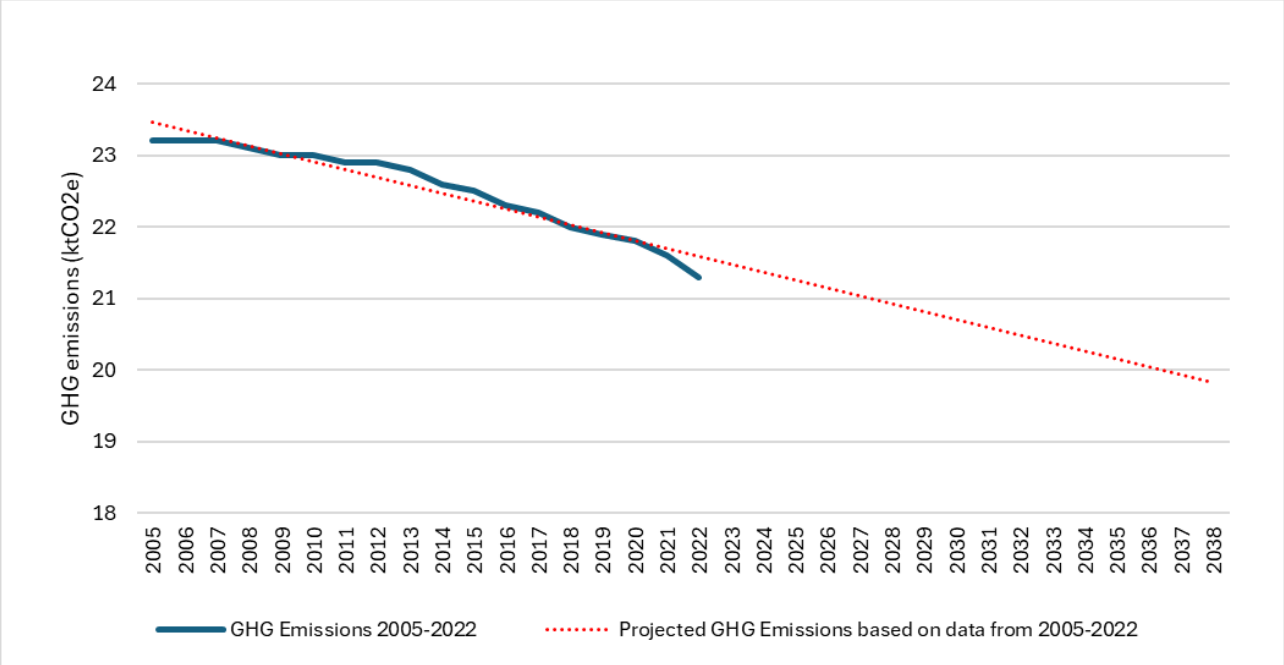

Figure 2-34: Projected peatland emissions reduction in line with the historic trend. Source: LA GHG.

It is estimated, albeit with high uncertainty, that emissions reduction of 14.5 ktCO2e can be achieved by 2038 with a full restoration of Bradford's peatlands (see Figure 2-35).

[96] Evans, C., Artz, R., Moxley, J., Smyth, M.-A., Taylor, E., Archer, N., Burden, A., Williamson, J., Donnelly, D., Thomson, A., Buys, G., Malcolm, H., Wilson, D., Renou-Wilson, F. and Potts, J. (2017). *Implementation of an Emissions Inventory for UK Peatlands A report to the Department for Business, Energy & Industrial Strategy*. [online] Available at: https://uk-air.defra.gov.uk/assets/documents/reports/cat07/1904111135_UK_peatland_GHG_emissions.pdf

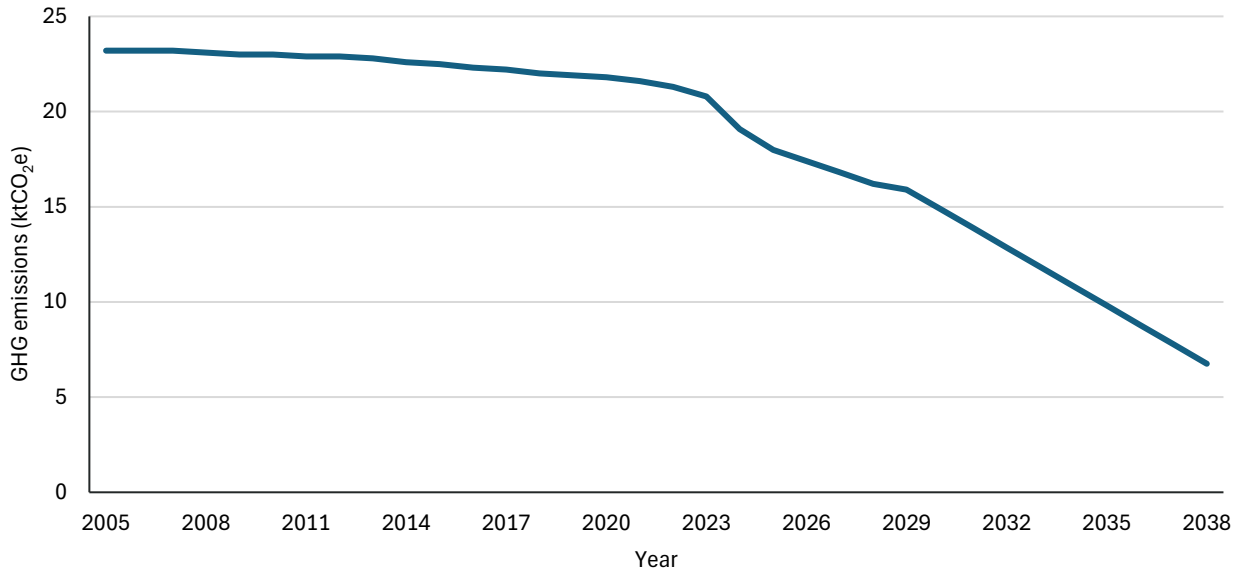

Figure 2-35: Illustrative emissions reduction from full, immediate peatland restoration.

2.2.4 Residual Emissions

The modelled measures across all sectors result in an estimated 82% emissions reduction between 2022 and 2038. The remaining emissions are dominated by the sectors with the highest baseline emissions, i.e. domestic combustion and transport, followed by non-fuel sectors with hard-to-abate emissions. Both domestic and stationary combustion energy sectors show significant *relative* reductions; however, given the large baseline emissions, there are still significant residual *absolute* emissions which will need to be tackled to reach Bradford's net zero target.

While the hard-to-abate sectors, such as agriculture, waste, and F-gases, do not make up a large proportion of current emissions, their contribution will become more apparent as emissions from fuel use are reduced through a combination of demand reduction and fuel switching measures.

Figure 2-36 illustrates baseline compared to residual emissions by sector.

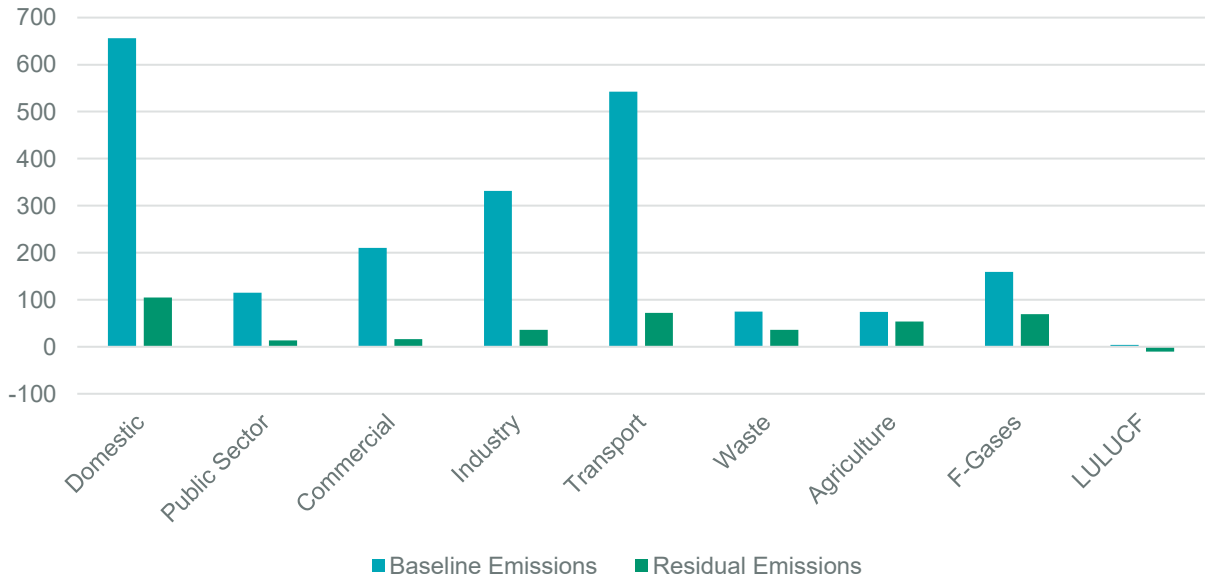

Figure 2-36: Baseline in 2022 vs Residual Emissions in 2038 by Sector. Source: NZPT

A higher reduction is theoretically possible; however, this brings a range of challenges. This is explored by fuel and non-fuel activities below.

2.2.4.1 Fuel Measures

Residual emissions in the stationary and mobile combustion sectors (i.e., domestic, commercial, public sector, industry, transport, and – to a small degree – agriculture) could be tackled by switching all remaining fuel use to renewable alternatives. In the domestic sector, it was assumed that around 14% of properties remain on natural gas heating due to several challenges associated with dual switching in this sector. The options for achieving a full decarbonisation in the domestic sector are:

- **Switching a higher proportion of properties to direct electric heating while assuming that all electricity is supplied through a fully decarbonised electricity grid** (which relies on national action). However, direct electric heating has an efficiency of only 100%, compared to over 300% for ASHPs. This means that, given current electricity costs, residents would face a significant increase in energy bills, which could exacerbate existing fuel poverty in Bradford. As such, a more realistic approximation was chosen, which assumed that only suitable properties, such as small flats, use direct electric heating.
- **Switching a higher proportion of properties to heat pumps.** The modelled assumption of around 50% of domestic properties on fossil fuel heating systems switching to heat pumps is ambitious yet achievable, as per CCC analysis. However, it should not be underestimated that this would require significant increases in Government funding and a rapid uptake in the relevant installation and maintenance skills, which are, to a degree, external factors over which Bradford has some, yet limited, influence. In addition to this, switching a higher proportion of properties to heat pumps would mean that existing but still functioning gas boilers would need to be removed ahead of time, creating both higher Scope 3 emissions, waste, and increased costs.
- **Switching a higher proportion of properties to heat networks.** Given Bradford's strong entry into networked heat with the BEN, it is reasonable to assume that this will be further explored and expanded beyond non-domestic customers. As such, it was assumed that 20% of domestic properties on the gas grid will switch to some form of heat network, whether large-scale, street-level, or a mixture of the two. However, increasing this already ambitious figure in the absence of local feasibility studies would not be recommended so as not to overestimate local decarbonisation potential.
- **Increasing demand reduction ambition.** Bradford's net zero pathway assumes that a demand reduction for space heating of around 30% can be achieved across the whole building stock. This is aligned with other assessments by LETI and the CCC. While a more ambitious figure could be chosen – of reductions of up to circa 90% for very ambitious, Passivhaus standards, for example – this would also come with significant implementation challenges and costs. As the pathway must be realistic and maximise possible co-benefits, a realistic value was chosen to ensure that the modelled climate actions strike a balance between emissions reductions and other benefits.

As such, to further accelerate emissions reductions, additional, stable and long-term funding support by the central government, large-scale training and certification for installers, electricians, retrofit coordinators, and energy assessors, and increases in manufacturing capacity or securing the required materials via supply chains. Similar considerations and barriers apply to the decarbonisation of energy consumption in the commercial and public sectors.

Similarly, in the transport sector, more ambitious actions are theoretically possible, but there are important barriers to consider.

- **More ambitious reduction in transport demand**. The Covid-19 pandemic has shown that ambitious reductions in the transport sector are possible and has led to long-lasting societal changes, such as increases in homeworking (albeit there are some trend reversals occurring). However, this ambitious action also highlights the limitations of further reductions, which may not be realistic, especially as certain firms are striving to reverse or weaken homeworking policies.
- **Higher vehicle occupancy**. Increases in vehicle occupancy can be very impactful on emissions, especially if this does not come with significant increases in travel demand from 'detours' to pick up and drop off passengers. However, without significant societal transformations, it is unlikely that the already ambitious target can be overshot.
- **Increased public transport uptake**. Buses and trains transport passengers far more efficiently than individual vehicles. As such, significant increases in public transport uptake have been modelled. Before determining whether more ambitious targets could be set for Bradford, a detailed, spatially disaggregated analysis of barriers needs to be undertaken. In addition to this, releasing funding for

additional routes can be challenging as funding often requires a showing of demand; however, demand often does not increase significantly until there are reliable and frequent services.

- **Increased active travel uptake**. As with public transport, it is important not to overestimate local potential. Due to Bradford's hilly topography, significant cycling and wheeling uptakes may be challenging and may require electric support (such as e-bikes). This, however, is more costly. As such, additional funding would need to be provided. Funding is already a challenge as only 2% of the transport budget is spent on active travel infrastructure – around £10 per person in England.[97]
- **More ambitious electrification of motorised vehicles** (while assuming a net zero electricity grid). While it would be possible to assume a more ambitious electrification of internal combustion engine (ICE) vehicles, this also comes with significant costs for individuals. As this would go against the equity & inclusion principles of the CAP, this option was not chosen. Instead, it is recommended that efforts are focused on public and shared solutions, as these not only realise deeper emissions reductions locally, but they also contribute to greater total (Scope 3) emissions reductions. However, it should be noted that private vehicles still form an essential part of the net zero transition. Therefore, it will be crucial to provide a reliable and affordable EV charging infrastructure.

As with the stationary energy sectors, additional funding remains a key barrier to overshooting the modelling assumptions in travel and transport. It is strongly encouraged that place-specific barriers are explored to truly understand the potential of these actions. High capex costs are a common challenge in realising more ambitious expansions of public transport and active travel. As such, a focus on their opex costs, high benefit-cost ratios, and wider benefits for the community should be emphasised to key funding bodies.

2.2.4.2 Non-Fuel Measures

Residual emissions show a high proportion of non-fuel emissions – much higher than in the baseline year. In addition to this, a high proportion of these emissions is from methane, with a high, short-term global warming potential. This makes early and ambitious emissions reductions critical; however, these are particularly challenging.

Emissions reductions from waste and agriculture can be increased; however, actions that go beyond the CCC analysis that these assumptions are built on rely on wide-reaching societal transformations, such as:

- **Fundamentally reducing waste through wide-reaching reductions in consumption**. At its core, waste emissions are a symptom of an economic system built on overconsumption — producing, purchasing, and discarding more than needed. Even with high recycling rates or energy recovery, there are limitations to emissions reductions unless fewer materials and products are consumed in the first place. However, this requires fundamental changes to both society and the economy, locally, nationally, and internationally. Circular economy initiatives are therefore instrumental to tackling this challenge, but there are limitations of local action which had to be reflected in the modelling.
- **Shift to predominantly plant-based diets**. The vast majority of agricultural emissions are from livestock. Nationally and globally, this can be addressed through a shift to plant-based diets. However, this is a challenging and often controversial action which cannot simply be imposed on people but only encouraged. However, minor 'enforcements' such as only serving plant-based foods at networking events are very actionable. It is essential that rural livelihoods are not harmed by this action.

These are significant challenges which Bradford cannot address on its own. However, this should not undermine the importance and impact of local initiatives and individual action. The pathway includes ambitious actions across waste and agriculture, which the district should focus on. CBMDC's CAP already goes beyond the modelling by looking at the district's overall consumption, not just in-boundary emissions. This action is strongly encouraged as it is essential for global emissions reductions.

In addition to these sectors, there are significant residual emissions from F-gases. These mainly rely on national-level regulations and technological innovations, which Bradford can support but not influence as directly as other activities, such as road transport.

These challenges do not mean that Bradford should not aim to exceed the emissions reduction efforts to meet the 100% emissions reduction target by 2038, but rather to ensure that the focus is on an inclusive and

[97] https://www.ippr.org/media-office/years-of-under-investment-in-englands-streets-has-left-people-walk-wary-and-cycle-cautious-says-new-report

equitable approach, which does not leave any residents behind in a just transition to net zero. If action cannot be accelerated in an equitable and inclusive manner, it would be preferable to achieve net zero slightly later – although all efforts should be made to meet this target – than to rely on actions which further exacerbate existing inequities. This ensures that local co-benefits are maximised, which not only increases stakeholder buy-in in climate action but helps create "a sustainable, healthy, vibrant and inclusive Bradford District".

2.2.4.3 Carbon sequestration

Net emissions are always a result of both GHGs emitted to and CO_2 sequestered from the atmosphere. The current modelling takes a conservative approach to carbon sequestration, as these are associated with high uncertainties, to avoid overestimating this potential. To get closer to Bradford's net zero target, more ambitious carbon sequestration action could be taken:

- **Accelerating peatland restoration efforts**. The majority of current LULUCF emissions are from peatlands. Restoring these can therefore bring significant carbon savings; however, these are also notoriously difficult to quantify. As such, a trend continuation was modelled, rather than deep emissions reductions. This approach was also chosen as peatland restoration results in initial increases in methane emissions – followed by long-term emissions reductions. As the research on the exact timings of these increases and reductions is not definitive, a more conservative approach was chosen in the modelling. However, even if all peatlands were restored, this would not close the gap to net zero.
- **Accelerating tree planting**. Tree planting, if soil disturbance is minimised, brings almost immediate emissions reductions from carbon sequestration. Bradford district has a significant scope to increase tree cover, which would not only reduce emissions but also bring a range of co-benefits. To model this action in the net zero scenario, a linear increase to 20% tree cover by 2050 was assumed. However, more ambitious tree planting efforts earlier would enable more significant carbon sequestration and relevant co-benefits. For example, if 2,474 ha of new woodland (with seedling spacing of 3 m) were established by 2030, c. 25 $ktCO_2$ could be sequestered by 2040.[98] This would bring Bradford's total emissions reduction to 83%, which is a significant but insufficient reduction. It should be noted that carbon sequestration from tree planting would not peak in 2040 but continue to bind CO_2 from the atmosphere – emphasising the importance of looking beyond net zero target dates.

The estimates above provide an understanding of the scale of reductions that could be achieved, but these figures are not definitive, as this would require more detailed inputs, such as ecologically suitable species and realistic seedling spacing. To better understand whether carbon sequestration could enable Bradford to meet its net zero target by 2038, a detailed assessment of nature-based solutions and their carbon sequestration potential could be undertaken. However, given resource limitations, from a GHG reduction point of view, the council should prioritise actions with deep emissions reduction potentials (e.g., energy demand reduction and fuel switching across domestic, commercial, public, industrial, and transport sectors). Further explorations of nature-based solutions are essential for tackling the ecological emergency and improving the quality of the district – as such, these should form the focus of these explorations, with carbon sequestration acting as an important co-benefit.

2.2.5 Offsetting

Given challenges with reducing local emissions net zero, some local authorities explore offsetting as an alternative. However, this is not generally recommended as the UK should meet its net zero target without the use of carbon credits or offsets. Bradford may choose to employ carbon credits in the transition to net zero, e.g. to bridge limitations in heat pump uptake or EVs. The CCC recommends that all local authorities prioritise emissions reductions over the use of offsets. By 2030, offsets should only be used for emissions that are

[98] This calculation was made creating a fictional tree planting project in the Woodland Carbon Calculator and accounts for several buffers.

genuinely unavoidable due to a lack of technical alternatives. After 2030, offsets should transition to permanent removals that demonstrate additionality and support sustainable development.[99]

2.2.6 Conclusion

Achieving net zero by 2038 is highly ambitious and will involve wide-reaching financial, technological, and behavioural changes across Bradford, West Yorkshire, and the UK. However, the modelling shows that the target is within reach if national-level drivers, such as the decarbonisation of the electricity grid, are to go ahead. The main challenge and opportunity sit with tackling the 88% of current emissions which come from fuel use – reducing fuel consumption and switching to renewable alternatives will enable Bradford to make substantial progress towards net zero. Achieving the modelled emissions reductions is only possible with significant legislative, regulatory, and financial support from the central government. Current national spending on critical public services, such as public transport, and funding for essential low-carbon technologies, such as heat pumps, is insufficient for either meeting or exceeding the modelled emissions reduction of 82%. With more ambitious government support, the 18% gap to net zero could likely be significantly reduced, especially in the buildings and transport sectors. As such, Bradford should still strive to meet its 2038 target by both realising the modelled actions and engaging with central government to push for more support on key actions.

To summarise, there are avenues for more ambitious emissions reductions and sequestration:

1. Greater reductions in emissions are possible, especially in the buildings and transport sectors, where solutions are technologically feasible but constrained by insufficient funding and green jobs.
2. Greater carbon sequestration is possible, specifically in tree planting, peatland restoration, and grasslands.

Moderate carbon sequestration was already considered in the modelling, but with conservative implementation trajectories of ambitious targets and conservative buffers to avoid overestimates. The priority must always be to reduce existing emissions, most of which are from fossil fuel use, but the remaining 12% of non-fuel emissions can realise significant reductions through a mixture of natural and engineered options. Bradford is in an excellent position to turn its currently small but still net-emitting LULUCF sector into a carbon sink to help close the gap to net zero.

Bradford may choose to explore offsetting as a transitional solution; however, it should ultimately strive to meet its net zero target within district boundaries.

[99] CCC (2020). Local Authorities and the Sixth Carbon Budget. Available at: https://www.theccc.org.uk/wp-content/uploads/2020/12/Local-Authorities-and-the-Sixth-Carbon-Budget.pdf

3. NET ZERO CO-BENEFITS

3.1 INTRODUCTION

As governments, local authorities, and communities transition towards a net zero future, it is essential to recognise that the benefits of this transformation extend far beyond just reducing GHG emissions. Co-benefits are defined as the positive effects that policies or measures aimed at one objective (reducing GHG emissions or air quality pollutants) can have on another objective, thereby increasing the total benefit to society or the environment.[100] These wider co-benefits are crucial for achieving a holistic and integrated approach to a net zero strategy, ensuring that the journey towards sustainability delivers comprehensive and long-lasting improvements for people, the economy, and the planet.

By reviewing co-benefits alongside the mitigation potential of climate action measures, synergies become clear that the measures not only advance climate objectives but can also enhance the quality of life for communities, stimulate local economies, reduce inequalities, and build stronger, more resilient systems. For example, promoting clean energy solutions can reduce air pollution, which in turn improves public health and reduces healthcare costs. Likewise, investments in green infrastructure can create jobs, improve social well-being, increase biodiversity, and protect communities from extreme weather events.

Considering these co-benefits is particularly important in securing broad support for net zero initiatives. Political leaders, businesses, and the public are more likely to champion climate action when there are clear linkages to how it could support and advance other policy priorities, lives, and livelihoods. Highlighting the economic, social, and health-related advantages of climate policies helps build a compelling case for investment and engagement. It demonstrates that the transition to net zero is not only about reducing emissions but also about creating a more sustainable, equitable, and prosperous future for all.

It has been suggested that it is at the city and regional level where co-benefits of climate action can be best incorporated into decision-making processes, as it is at these scales that the evidence for co-benefits is most palpable and where interventions can have a more immediate effect.[101] There is an argument to be made that framing actions through the lens of the alternative ancillary benefits they result in, such as focusing on the health benefits of active travel rather than the GHG emission reduction, could further encourage uptake of action, as the motivations are often more tangible to everyday lives and priorities.

At the same time, it is important to consider potential adverse impacts to ensure the journey to net zero does not disadvantage certain groups. For example, households already experiencing fuel poverty may face increased energy costs if they switch from gas to electric heating without substantial improvements in building energy efficiency. Similarly, if retrofitting measures are not implemented to a high standard, they can lead to unintended consequences such as damp, mould, or moisture issues — disproportionately affecting those already living in poor-quality housing and vulnerable conditions.

Ultimately, a net zero strategy that both promotes co-benefits and actively acknowledges and manages potential adverse impacts supports a more inclusive, dynamic, and resilient future — ensuring that the transition delivers meaningful and lasting change for everyone in Bradford.

3.2 METHODOLOGY

In this initial qualitative assessment of co-benefits, a four-step approach was undertaken to assess the potential co-benefits associated with the net zero modelling measures.

1. Bradford context review

A review of local data and strategic documents was undertaken to identify key local challenges that co-benefits might address. Documents reviewed included the Joint Strategic Needs Assessment (JSNA)[102], the Bradford

[100] IPCC (2022). Annex II: Glossary. Available at: https://www.ipcc.ch/report/ar6/wg2/downloads/report/IPCC_AR6_WGII_Annex-II.pdf

[101] Imperial College London (2019). Co-benefits of climate change mitigation in the UK: What issues are the UK public concerned about and how can action on climate change help to address them? Available at: https://www.imperial.ac.uk/media/imperial-college/grantham-institute/public/publications/briefing-papers/Co-benefits-of-climate-change-mitigation-in-the-UK.pdf

[102] CBMDC (N.D.). Joint Strategic Needs Assessment. Available at: https://jsna.bradford.gov.uk/

District Plan[103], findings from the Born in Bradford study[104], and feedback from the initial stakeholder workshop, amongst others.

2. National and sectoral literature review

To provide the evidence for the expected co-benefits from each of the net zero measures, national and sectoral evidence on the typical co-benefits for each mitigation measure was reviewed to establish a baseline understanding of likely impacts across sectors.

3. Compilation of co-benefits

Relevant co-benefits were identified for the measures in the net zero pathway, informed by both local context and wider evidence. These were organised into five thematic categories: economic, environment, health and wellbeing, social equity, and resilience.

4. Scoring of co-benefits

Each measure was assessed using a five-point qualitative scale (-2 to +2) to reflect the strength and direction of the co-benefits, acknowledging that some measures may result in adverse impacts depending on how they are implemented. A not applicable (N/A) score was included in addition for interactions that were not deemed to have clear links, such as fuel poverty and actions that would not impact domestic households. Scoring was informed by the literature review, local evidence, and expert judgement.

Table 3-1: Wider co-benefits scoring scale.

+2 Very positive
+1 Positive
0 Neutral
-1Negative
-2 Very negative
N/A

Limitations

This assessment is based on a high-level evidence review and is intended to provide an indicative overview of where the greatest co-benefits from the net zero measures may lie. Given the broad and interconnected nature of co-benefits, it is acknowledged that some interactions may be overlooked or influenced by more complex contextual factors, the nuances of which cannot be fully captured in the scoring. Instead, the approach aims to align potential benefits with Bradford's local priorities to support future decision-making. While full quantification of co-benefits was outside the scope of this work, scoring was grounded in available Bradford-specific data and stakeholder insights on common challenges and opportunities in Bradford.

3.3 TYPICAL NET ZERO CO-BENEFITS

3.3.1 Buildings

Transforming Bradford's buildings across the domestic, commercial, and public sectors presents a significant opportunity to deliver wider socio-economic and environmental benefits to households, asset owners, and employees. Energy efficiency and fuel switching measures in buildings cover a vast range of interventions from fabric improvements and smart controls/appliances to the installation of heat pumps and connection to heat networks. An overview of co-benefits from energy efficiency measures and fuel switching measures, including an explanation of what this means in more detail for Bradford, can be found in Table 3-2 and Table 3-3 below.

[103] CBMDC (N.D.). Our Plan for Bradford District 2021 – 2025. Available at: https://www.bradford.gov.uk/media/2312/bradford-district-plan-2021-2025.pdf

[104] Born in Bradford (2024). 10 Key Findings for Policy and Practice. Available at: https://borninbradford.nhs.uk/wp-content/uploads/2024/10/10-Key-Findings-for-policy-and-practice-2019.pdf

Table 3-2: Common co-benefits of energy efficiency measures in buildings.

Co-benefits	Elaboration and evidence
Boost local employment	Retrofitting measures can facilitate job creation in construction, manufacturing, installation and design. There is an acknowledged skills shortage and training gap in this area, which was highlighted at the first workshop. West & North Yorkshire Chamber of Commerce (WNYCC) identified in their Local Skills Improvement Plan[105] (LSIP) that there is a shortage of 30,000 people needed for retrofit, meaning that there is an opportunity there are also challenges to meeting demand.
Social equity	Benefits from local employment could particularly be realised for deprived areas through factors such as local employment, spending, and increased property values[106].
Reducing fuel poverty	Retrofitting can support the reduction of energy poverty by enhancing energy efficiency in homes, reducing the amount of fuel needed for heating and cooling. It is estimated that 10% of excess winter deaths (EWD) in the UK are directly attributed to fuel poverty, and 21.5% attributable to cold homes[107]. In Bradford, according to the JSNA ward RAG ratings[108], 19.2% of Bradford households are in fuel poverty (higher than the England average of 13.1%). Over 1/3 of Bradford wards have a higher score than the district average, with levels of fuel poverty between 20-37.6%.
Improved building quality	Retrofitting buildings with energy efficiency measures can improve the quality of homes if done well. The first workshop indicated that there is a perception that homes in Bradford suffer particularly with poor roof insulation and mould issues. In Bradford, 20.6% of buildings have an E EPC rating, 16.1% D rated, while 51.5% are C rated. This contrasts with the England and Wales average, where 14% of buildings have an E-rated EPC, 12.9% D-rated, and 57.6% are C-rated.[109] Higher energy efficiency ratings can be viewed more favourably amongst renters/buyers, which can increase the value of properties.
Improved health impacts	Improved insulation has been linked through various studies to reduced impacts for poor general mental health, poor general physical health, asthma, wheezing, and wall insulation has been significantly linked to a reduction in hospital admissions.[110] Using energy efficiency technologies such as smart heating controls provides users the ability to customise heating schedules, temperatures, and zones, which can contribute to improved thermal comfort in homes.

[105] West and North Yorkshire Chamber of Commerce (2023). West Yorkshire Local Skills Improvement Plan. Available at: https://www.wnychamber.co.uk/app/uploads/2023/08/LSIP_West_Yorkshire_2023.pdf

[106] Gillard, R., Snell, C. and Bevan, M. (2017). Advancing an energy justice perspective of fuel poverty: Household vulnerability and domestic retrofit policy in the United Kingdom. *Energy Research & Social Science*, *29*, pp.53-61. Available at: https://doi.org/10.1016/j.erss.2017.05.012

[107] Institute of Health Equality (N.D.). Fuel poverty, cold homes and health inequalities in the UK. Available at: https://www.instituteofhealthequity.org/resources-reports/fuel-poverty-cold-homes-and-health-inequalities-in-the-uk/read-the-report.pdf

[108] CBMDC (N.D.). Public Health - Joint Strategic Needs Assessment. Available at: https://jsna.bradford.gov.uk/our-population/ https://jsna.bradford.gov.uk/our-population/

[109] https://www.plumplot.co.uk/Bradford-home-energy-efficiency.html

[110] Fyfe, C., Telfar, L., Howden-Chapman, P. and Douwes, J. (2020). Association between home insulation and hospital admission rates: retrospective cohort study using linked data from a national intervention programme. *bmj*, *371*. Available at: https://doi.org/10.1136/bmj.m4571

Co-benefits	Elaboration and evidence
	Better indoor environment quality is linked to better health outcomes for building occupants; this can contribute to reduced numbers of sick days taken, increased productivity amongst workers, and enhance the learning performance of students in schools through healthier indoor environments.[111]
Cost savings	People commonly undertake energy efficiency measures with a view to generating long-term savings. The payback time of various measures differs substantially depending on the current state of the home, the insulation type/efficiency improvement, and the energy prices. Since late 2021, the UK has been in an 'energy crisis' with household bills significantly increasing. Although energy prices have fallen since 2023, they are still well above 'pre-crisis' levels.[112] As a result of this, payback times for investments into retrofitting measures could be reduced, making more expensive measures, such as external wall insulation, more attractive. This also illustrates how efficiency measures reduce the vulnerability of households and businesses to energy price rises. A key co-benefit from smart heating controls is the ability to reduce costs for households through the avoidance of unnecessary heating use by adjusting heating patterns based on occupancy, patterns of household activity, weather, and user preferences. How much is saved depends on the use of the system. Energy System Trust suggests savings could be around £110 annually[113]. Energy savings from water efficiency measures, energy-efficient appliances, and LED lighting can also contribute to reducing energy bills for households. Equally, asset owners/tenants can save significantly on energy bills for commercial/public buildings when there are improved energy efficiency measures. Cost savings could also be felt by local services, such as the NHS, whereby 68% of health workers suggest high energy bills contribute to avoidable hospital admissions.[114]
Resilience	Smart heating controls, as well as more modern, energy-efficient appliances, can include demand-side response (DSR) programming or allow users to participate in demand reduction events during times of peak grid load. This can contribute to better grid management, and energy providers often provide incentives to users for taking part, such as cashback on bills. Demand side response could contribute to reducing the running costs of the British energy system by £3-8 billion annually by 2050[115]. Water demand from buildings, in particular domestic, can play a significant role in water stress in regions and managing water efficiency and domestic per capita water use through water efficiency measures can support better management of water resources. A Yorkshire Water study in 2019 revealed the utility company predicts there will be 100 million litres less in its daily supply by 2045.[116]

[111] C40 Cities, The Benefits of Healthy and Efficient Buildings – Synthesis Report. Available at: https://c40.my.salesforce.com/sfc/p/#36000001Enhz/a/Vo0000001g21/DrZX01IlHE4XP7K7CbF5UxPX1aRskvu2KcWlgi1GnIA

[112] UK Parliament (2025). Gas and electricity prices during the 'energy crisis' and beyond. Available at: https://commonslibrary.parliament.uk/research-briefings/cbp-9714/

[113] Energy Saving Trust (2025). Heating systems – Heating controls. Available at: https://energysavingtrust.org.uk/advice/thermostats-and-heating-controls/

[114] End Fuel Poverty Coalition (2025). Energy affordability and more insulation will support the NHS say medics. Available at: https://www.endfuelpoverty.org.uk/energy-affordability-and-more-insulation-will-support-the-nhs-say-medics/

[115] UK Parliament (2024). Demand side response: A tool for lowering household energy bills. Available at: https://researchbriefings.files.parliament.uk/documents/POST-PN-0715/POST-PN-0715.pdf

[116] Yorkshire Water (2018). Water Resilience in Yorkshire. Available at: https://www.yorkshirewater.com/media/qmsnlec1/water-resilience-in-yorkshire.pdf

Co-benefits	Elaboration and evidence
Environmental benefits	LEDs have a much longer lifespan than other traditional bulbs, lasting for c.50,000 hours of light in comparison to the 1,000 hours from incandescent bulbs and 10-15,000 hours from CFL bulbs. As a result of this additional longevity, there is reduced waste transferred to landfills.[117] LEDs do not contain toxic substances in comparison to other bulb types, which can contaminate land and water if they leak when disposed of.

Table 3-3: Common co-benefits from fuel switching measures in buildings.

Co-benefits	Elaboration and evidence
Boost local employment	A shift to heat pumps and heat networks will create employment opportunities related to energy system improvements, as well as heat pump and commercial-scale manufacturing, installation, and maintenance. In the UK, up to 170,000 new heat pump installer roles are expected to be required, which will outweigh the 60,000 gas installation jobs that will be lost as boilers are phased out. In Yorkshire and Humber, a study indicated there would be a 2.3% net positive impact for job creation from across green sectors.[118]
Socio-equity	A shift in the consumer market and with growing demand for heat pumps and the phase out of fossil fuels, there will be a shift in the job market, which may open up challenges for a Just Transition. Training should be made available for existing gas engineers to transition to installing heat pumps and heat networks. This is both a challenge and an opportunity, and it will need to be delivered with social equity in mind to ensure that long-standing engineers are also given the opportunity to acquire the additional skills required to adapt to the transition.
Reducing fuel poverty	With savings from more efficient heat pumps/heat networks, there is significant potential to alleviate fuel poverty through increased savings.
Improved health impacts	Heat pumps and heat networks eliminate CO_2 and pollutants from direct combustion within homes, thereby potentially improving air quality.[119] Low-carbon heating systems coupled with renewable electricity have been found to reduce the level of particulate matter (PM) and carbon emissions to near zero.[120] Indoor air quality can also be improved due to the increased warmth and comfort within homes. One study noted that for social housing residents with heat pumps, as the heating system was always left on and was cheaper to run, the majority of residents were found to open windows more often as compared to keeping windows closed, which resulted in an improvement in indoor-air quality.[121] Almost 25% of homes in Bradford are socially rented, meaning many households could benefit.[122]

[117] Green Lighting (2025). The Lifespan of an LED Bulb. Available at: https://greenlighting.co.uk/the-lifespan-of-an-led-bulb/
[118] Bain & Company (N.D.). Accelerating Together: How the UK Workforce Can Get Net Zero Done. Available at: https://www.bain.com/insights/accelerating-together-how-the-uk-workforce-can-get-net-zero-done/
[119] Padovani, F., Sommerfeldt, N., Longobardi, F. and Pearce, J.M. (2021). Decarbonizing rural residential buildings in cold climates: A techno-economic analysis of heating electrification. *Energy and Buildings*, *250*, p.111284. Available at: https://doi.org/10.1016/j.enbuild.2021.111284
[120] https://joint-research-centre.ec.europa.eu/jrc-news-and-updates/air-pollution-heating-and-cooling-stepping-clean-energy-use-urgently-needed-2025-01-07_en
[121] Gupta, R. and Zahir, S. (2022) Indoor air quality in social housing flats retrofitted with heat pumps. In *Proceedings of the 17th International Conference on Indoor Air Quality and Climate, INDOOR AIR, Kuopio, Finland* (pp. 12-16).
[122] ONS (2023). Subnational estimates of households by tenure, England. Available at: https://www.ons.gov.uk/peoplepopulationandcommunity/housing/datasets/subnationalestimatesofhouseholdsbytenureengland

Co-benefits	Elaboration and evidence
	Due to the efficiency of heat pumps and heat networks, studies indicate that households can spend more money on enhancing thermal comfort. With reduced energy costs, consumers can choose to heat their homes for longer and increase comfort. One study showed that 20% of the expected reduction of electricity consumption from more efficient heating use is converted into increased comfort in the homes, including extended heating areas and keeping a higher temperature in homes.[123] NO_2 concentrations in homes with gas cookers were measured to be double that of dwellings with electric cookers.[124]
Cost savings	Heat pumps are significantly more efficient than gas boilers, meaning for every unit of electricity used, heat pumps generate on average three to four times as much heat (300 to 400%) in return. This is compared to an A-rated gas boiler that would convert 90% of its fuel into usable heat. Heat pump efficiency depends on use and seasonal conditions; however, increased efficiency in comparison to natural gas and direct electric means there is a significant opportunity for energy and cost savings. However, electricity prices are more expensive per unit than gas prices, so savings may vary depending on the type and age of system being replaced. Energy Savings Trust (EST) calculations suggest savings could be as high as £700-1,200 annually when switching electric storage heaters to ASHPs, but may be £3 more expensive than a new A-rated boiler – see Figure 3-1.
Resilience	Reversible heat pumps can provide both cooling and heating, which can help homes adapt to rising temperatures and more frequent heatwaves. Smart-enabled heat pumps can help shift demand to off-peak times, easing pressure on the grid and lowering costs. Flexible operation could cut peak demand by up to 23%.[125]

[123] Gram-Hanssen, K., Christensen, T.H. and Petersen, P.E. (2012). Air-to-air heat pumps in real-life use: Are potential savings achieved or are they transformed into increased comfort?. *Energy and Buildings*, *53*, pp.64-73. Available at: https://doi.org/10.1016/j.enbuild.2012.06.023

[124] Raw, G.J., Coward, S.K., Brown, V.M. and Crump, D.R. (2004). Exposure to air pollutants in English homes. *Journal of exposure science & environmental epidemiology*, *14*(1), pp.S85-S94. Available at: https://doi.org/10.1038/sj.jea.7500363

[125] Scottish and Southern Electricity Networks (2022). Domestic flexibility could reduce peak demand by up to 23% according to new study. Available at: https://www.ssen.co.uk/news-views/2022/domestic-flexibility-could-reduce-peak-demand-by-up-to-23-percent-according-to-new-study/

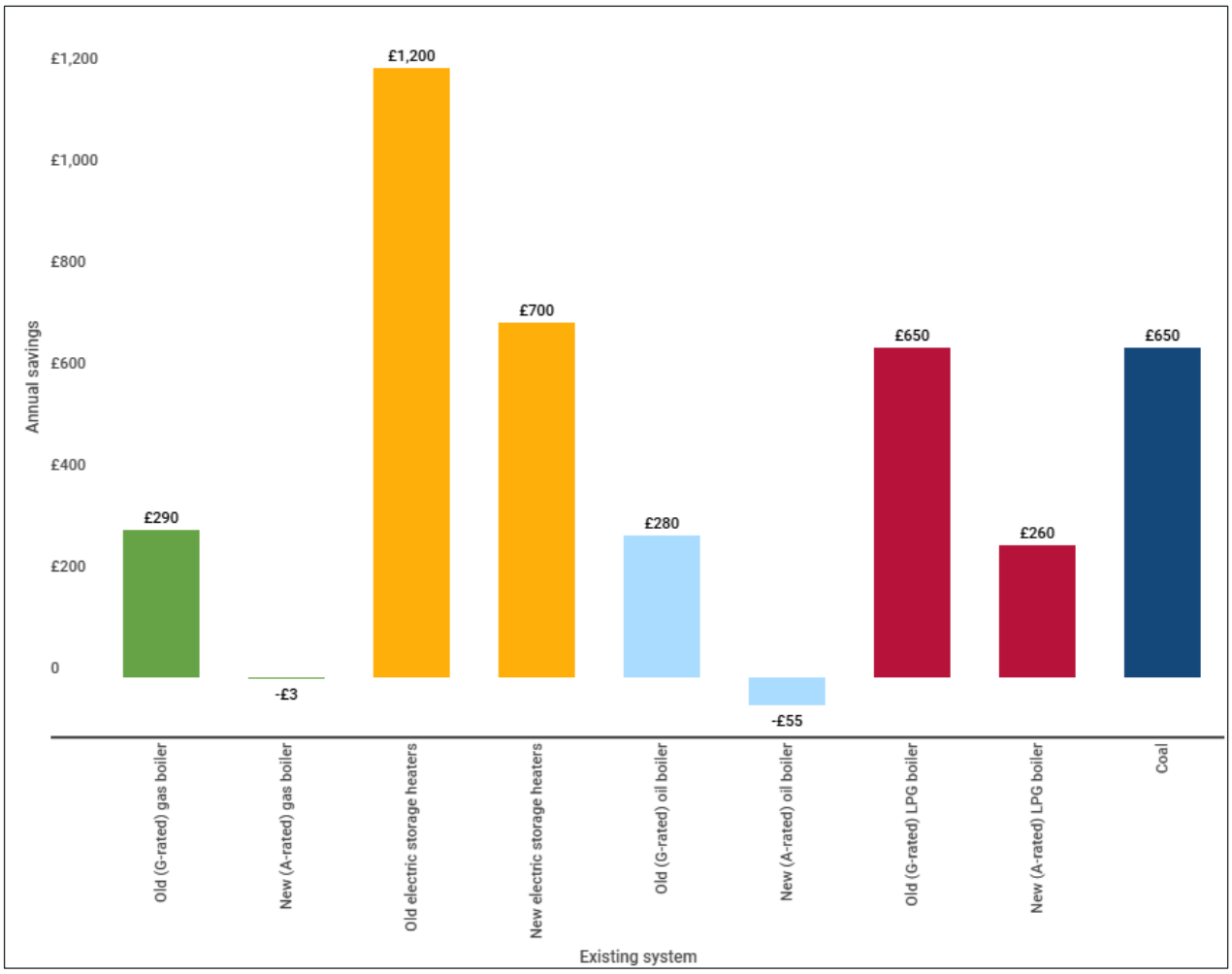

Figure 3-1: Potential annual savings of installing a standard air source heat pump in a three-bedroom semi-detached home in Great Britain, with radiator upgrades as needed[126] (Source: EST).

3.3.2 Energy System

Transitioning to a net zero energy system involves action at multiple scales, from national-level grid decarbonisation to local deployment of renewable energy. While the decarbonisation of the electricity grid is largely driven by national policy and investment, local areas play a key role in accelerating the transition through the installation of small-scale renewables such as solar panels on homes, public buildings, and businesses, as well as support for onshore wind. These actions not only contribute to emissions reductions but also generate important co-benefits. Table 3-4 provides an overview of these co-benefit opportunities.

Table 3-4: Common co-benefits for energy system measures.

Co-benefits	Elaboration and evidence
Energy system resilience	Diversifying and localising energy sources increases the resilience of the energy sector to external shocks such as disruption to supply (e.g. due to extreme weather events) and price fluctuations influenced by overseas imports and weather changes.[127]

[126] Savings are based on an electricity price of 24.5 p/kWh and a gas price of 6.29 p/kWh, calculated from a weighted average of projected, current and recent energy price caps
[127] Onunda (2024). The Imperative of Diversifying the UK's National Grid Electricity Production. Available at: https://onunda.com/newsroom/the-imperative-of-diversifying-the-uks-national-grid-electricity-production

Co-benefits	Elaboration and evidence
Energy bill savings	Individual installations, such as rooftop PV, usually generate cost savings after the upfront investment has been paid off. EST estimates that savings could be between £440 and £610 annually, depending on occupation patterns.[128] Savings would increase if the cost of electricity increases or if more electricity can be used onsite rather than exported. Community energy schemes also offer fuel savings and revenue opportunities for local businesses and services. An example already present in Bradford is Bradford Community Energy, which raised funds within the community, supported by Bradford Council, to install solar arrays on buildings to provide low-cost electricity for community centres. Community centre running costs have been reduced by more than £25,000, with 10% of profits supporting wider community actions such as community energy advice or audits[129].
Fuel poverty reduction	In residential areas, solar power can significantly contribute to tackling fuel poverty — especially when paired with battery storage and smart energy systems. Installing solar panels could reduce energy spending by almost 25% for the poorest fifth of households in England, equivalent to a 3% boost in disposable income.[130] High upfront costs for installations pose a significant challenge, meaning targeted support to reap these benefits is required.
Revenue generation	Local renewable energy projects have the potential to generate revenue for the council as well as their communities. They can provide long-term income as well as increased control over the available finances.[131] An existing example in the region is Bradford Community Energy, providing investors with a c.3.25% annual return on investment.[132] The Smart Export Guarantee requires that energy suppliers pay solar panel owners for any unused energy generated that is sold back to the grid. Although the rates are much lower than the previous Feed-in-Tariff (FiT) scheme, there is still potential for revenue to be generated, with an estimated income for an average home of £160 per year.[133] The benefits of this would typically be to the homeowner or landlord but if homeowner/landlord permission is granted, tenants can also benefit from the SEG payments. Landlords may instead choose to recoup these costs from increased rental prices or other agreements. In commercial or industrial settings, on-site generation can boost competitiveness and reduce operational costs.
Community building	Community energy projects can strengthen social cohesion, build local capacity, and empower residents to take an active role in shaping their energy future. Community Energy England highlights multiple benefits from involving the public in local energy projects, including collective ownership, increased public support for new initiatives,

[128] Energy saving trust (2025). Solar Panels. Available at: https://energysavingtrust.org.uk/advice/solar-panels – based on homes in Manchester
[129] Co-operatives UK (2024). Bradford Community Energy: Providing affordable solar power and tackling fuel poverty. Available at: https://www.uk.coop/BCE
[130] Resolution Foundation Briefing (2025) Sunny day savings. Available at: https://www.resolutionfoundation.org/app/uploads/2025/02/Sunny-day-savings-1.pdf
[131] Ashden (2025). The Value of Community Energy: a digest of supporting evidence for the Energy Learning Network. Available at: https://ashden.org/storage/2025/05/Digest-of-evidence-about-the-value-of-community-energy.pdf
[132] https://www.thetelegraphandargus.co.uk/news/18561782.mp-helps-launch-bradford-community-energy-initiative/
[133] The Eco Exports (2025). The Smart Export Guarantee explained. Available at: https://www.theecoexperts.co.uk/solar-panels/smart-export-guarantee

Co-benefits	Elaboration and evidence
	and ensuring the transition is fair and inclusive by allowing different voices to be heard.[134]
Job creation	Renewable energy is on the rise globally – this includes small-scale renewable energy installations. To meet the increasing demand, new jobs need to be created. If this is done locally (e.g., through upskilling programmes), it can tackle other issues such as unemployment and worklessness, which have been identified as an issue in Bradford. Meeting the UK Government's net zero target could result in over 71,000 jobs in the low-carbon and renewable energy economy in West Yorkshire by 2050[135] – for Bradford, this could equate to 19,000 new jobs.
Improved air quality	Renewable energy sources (excluding biomass) are often associated with lower levels of air pollution compared to fossil fuel sources. For example, flue gases from gas boilers can contain particulates, heavy metals and acidic gases alongside CO_2 and water vapour, and also incur a risk of carbon monoxide, which are not present with renewable electricity systems.

3.3.3 Transport

Decarbonising the transport system is a critical component of the net zero transition, particularly as the second-largest contributing sector in Bradford's GHG baseline. In the pathway, this involves both fuel switching—from petrol and diesel vehicles to low- and zero-emission alternatives such as electric or hydrogen vehicles—and shifting towards more sustainable modes of travel, including walking, cycling, and public transport. These switches can deliver a wide range of social, environmental, and economic co-benefits, which are captured in Table 3-5.

Table 3-5: Common co-benefits from net zero transport measures.

Co-benefits	Elaboration and evidence
Physical health and well-being	Motorised transport is closely linked to higher rates of chronic diseases such as heart disease, stroke, type 2 diabetes, and certain cancers, largely due to physical inactivity and sedentary lifestyles. In Bradford, where 65.7% of adults are overweight or obese and cardiovascular disease mortality is high, promoting more active forms of travel is especially important. Shifting to non-motorised modes of transport for those who are able, such as walking and cycling, can help reduce these health risks by encouraging regular physical activity[136], ultimately improving overall health and well-being.[137] Shifting to non-motorised modes of transport also reduces reliance on cars, which can in turn improve air quality. This reduces the incidence of respiratory illnesses and brings health benefits, especially for communities residing in densely populated areas. Similarly, electric vehicles (EVs) also produce zero tailpipe emissions, eliminating the release of local pollutants such as nitrogen

[134] Community Energy England (2025). Community Energy in Action: Demonstrating the value of community-led solutions to net zero. Available at: https://communityenergyengland.org/files/document/1038/1743511912_ELN-Community_Energy_in_Action.pdf

[135] West Yorkshire Combined Authority (2023). Green Jobs Taskforce Recommendations Report. Available at: https://www.westyorks-ca.gov.uk/media/11362/green-jobs-taskforce-report_digital_access-updated-logos.pdf

[136] Friel, C., Walsh, D., Whyte, B., Dibben, C., Feng, Z., Baker, G., Kelly, P., Demou, E. and Dundas, R. (2024). Health benefits of pedestrian and cyclist commuting: evidence from the Scottish Longitudinal Study. *BMJ Public Health*, *2*(1). Available at: https://doi.org/10.1136/bmjph-2024-001295

[137] Sugiyama, T., Chandrabose, M., Homer, A.R., Sugiyama, M., Dunstan, D.W. and Owen, N. (2020). Car use and cardiovascular disease risk: Systematic review and implications for transport research. *Journal of Transport & Health*, *19*, p.100930. Available at: https://doi.org/10.1016/j.jth.2020.100930

Co-benefits	Elaboration and evidence
	oxides (NO_x) and particulate matter ($PM_{2.5}$), which are linked to respiratory and cardiovascular diseases. Likewise, public transport, including rail travel, is also associated with positive effects on physical activity, as it often involves active modes to access rail stations and bus stops[138]. When services are reliable, efficient, and affordable, they can have several positive benefits for the well-being of the public.
Improved air quality	Road traffic is a significant source of urban air pollution, releasing harmful pollutants such as nitrogen dioxide, elemental carbon, ultrafine particles and fine particle matter. Decarbonising transport can therefore deliver significant air quality co-benefits, alongside GHG emissions reductions. To maximise on air quality benefits, especially short trips should be replaced with active travel. This can provide a large number of co-benefits in Bradford, where 55% of the population is exposed to levels of air pollution above EU exposure guidelines.[139] While air-quality standards have been seen to be improving, there are certain areas in Bradford District that remain of particular concern (i.e., Manchester Road, Queen's Road, Shipley Airedale Road)[140]. Developing consolidation centres in urban areas to ensure efficient freight distribution can likewise bring air quality improvements by limiting the impact of HGVs. By consolidating goods into a single delivery in order to reduce the number of HGVs in urban areas, air quality in densely populated areas can be significantly improved.[141] Similarly, switching from LGVs to cargo bikes is another way to improve Bradford's air quality, particularly in congested urban centres. Electrified rail transport is also associated with improved air quality and reduced noise pollution in urban areas, which can contribute positively to the health of Bradford residents.[142] **For quantification of air quality co-benefits from the net zero pathway, please see Section 4.**
Job creation and upskilling	The electrification of the transport sector supports labour market transitions through the creation of skilled green jobs in infrastructure deployment, renewable energy integration and electrical contractors.[143] In the UK

[138] Johnson, D., Ercolani, M. and Mackie, P. (2017). Econometric analysis of the link between public transport accessibility and employment. *Transport Policy*, *60*, pp.1-9. Available at: https://doi.org/10.1016/j.tranpol.2017.08.001

[139] Born in Bradford (2024). 10 Key Findings for Policy and Practice. Available at: https://www.westyorks-ca.gov.uk/media/11362/green-jobs-taskforce-report_digital_access-updated-logos.pdf

[140] Breathe better Bradford (N.D.). Annual Status Reports. Available at: https://www.bradford.gov.uk/breathe-better-bradford/air-quality/annual-status-reports/

[141] Daniela, P., Paolo, F., Gianfranco, F., Graham, P. and Miriam, R. (2014). Reduced urban traffic and emissions within urban consolidation centre schemes: The case of Bristol. *Transportation Research Procedia*, *3*, pp.508-517. Available at: https://doi.org/10.1016/j.trpro.2014.10.032

[142] Zitrický, V., Nedeliaková, E. and Valla, M. (2023). The position of road and rail transport in terms of carbon neutrality. *Transportation Research Procedia*, *74*, pp.210-216. Available at: https://doi.org/10.1016/j.trpro.2023.11.136

[143] Transport & Environment (2018). Electric buses arrive on time. Available at: https://www.transportenvironment.org/uploads/files/Electric-buses-arrive-on-time-1.pdf

Co-benefits	Elaboration and evidence
	specifically, 270,000 jobs could be supported by the EV and battery industry to 2040.[144] This could equate to 2,200 jobs in Bradford.[145] Switching to cargo bikes can also introduce employment opportunities in the form of local delivery jobs. These jobs are low-barrier and flexible, which can be beneficial for young people or those struggling to enter the labour market.[146] Investing in electric bus infrastructure could likewise encourage local industry manufacturing of clean buses or related infrastructure, which would contribute to job creation.[147] Similarly, decarbonising rail is also expected to introduce 3,000 highly specialised jobs to develop overhead line electrification.[148] Driver training initiatives also contribute greatly to the re-skilling and up-skilling of workers in the haulage sector; driver training programs can also deliver safety improvements to the haulage sector and to the local areas surrounding popular freight routes.
Cost savings for users and operators	Reduced car travel can significantly lower transportation costs for individuals and families.[149] A notable study conducted by the European Cycling Federation determined that the cost of car ownership, depending on the vehicle, can range between 11,400 and 18,200 EUR per year, while the cost of a new bicycle and its associated costs amounts to up to 2,400 EUR over 5 years.[150] Car sharing has also been shown to reduce transport costs for those who own a vehicle, as car-sharing apps allow users to 'rent' a vehicle for the type they require.[151] Public transport, especially buses, is an affordable and accessible mode of transport for the majority of the population to meet their travel needs. The recent West Yorkshire transport survey revealed that affordability and motoring are the most important aspects for local respondents. Seventy per cent of respondents stated that bus services are important to them; however, satisfaction remains low. However, of the districts in the combined authority, Bradford has the highest satisfaction with local bus services.[152] While shifting trips from car travel to bus travel can increase the occupancy rates on public transport and reduce transport costs, buses have also been

[144] Green Alliance (N.D.). Going electric. Available at: https://www.transportenvironment.org/uploads/files/Electric-buses-arrive-on-time-1.pdf

[145] If distributed by population

[146] Couve, C., Lam, T., and Verlinghieri, E. (2023). Delivering Good Work: Labour, employment and wellbeing in London's cargo bike sector. Available at: https://blog.westminster.ac.uk/ata/wp-content/uploads/sites/60/2023/01/221222_Delivering-good-work_Londons-Cargo-Bike-secton_V5-1.pdf

[147] Transport & Environment (2018). Electric buses arrive on time. Available at: https://www.transportenvironment.org/uploads/files/Electric-buses-arrive-on-time-1.pdf

[148] Department for Transport (2021). Decarbonising Transport. Available at: https://assets.publishing.service.gov.uk/media/610d63ffe90e0706d92fa282/decarbonising-transport-a-better-greener-britain.pdf

[149] Bond-Smith et al. (2022). The work-from-home revolution and the performance of cities. Available at: https://www.productivity.ac.uk/wp-content/uploads/2022/09/WP026-The-WFH-revolution-and-performance-of-cities-FINAL-cover-061022.pdf

[150] ECF (2022). Lean, green, money-making machines: A comparative breakdown of the financial benefits of bicycle ownership. Available at: https://www.ecf.com/en/news/lean-green-money-making-machines-a-comparative-breakdown-of-the-financial-benefits-of-bicycle-ownership/

[151] Henderson, A., Cao, M. and Liu, Q. (2022). Access-based consumption, behaviour change and future mobility: Insights from visions of car sharing in Greater London. *Future Transportation*, *2*(1), pp.216-236. Available at: https://doi.org/10.3390/futuretransp2010011

[152] West Yorkshire Combined Authority (2024). Residents' Perceptions of Transport Survey Summary 2024 Results. Available at: https://www.westyorks-ca.gov.uk/media/12750/public-perceptions-of-transport-23-24-survey.pdf

Co-benefits	Elaboration and evidence
	found to increase GHG emissions due to an increase in demand for bus services, leading to more buses in operation with a lower occupancy rate.[153] However, if buses are fully utilised, they have the potential to remove a large number of personal vehicles off the road[154]. Electric buses on green energy tariffs can mitigate the GHG impacts of the rise in demand for buses. EVs likewise present cost savings for households. From a user perspective, EVs offer lower total cost of ownership due to reduced fuel and maintenance costs.[155] Furthermore, driver training is acknowledged to be one of the most cost-effective means of reducing fuel consumption and GHG emissions in the road freight sector. Studies show that drivers undergoing training on safe and fuel-efficient driving for HGVs have, on average, improved the fuel efficiency of their driving by 7%.[156] Technical vehicle improvements, such as cruise, are also important in delivering these improvements. Therefore, driver training and technological improvements can also deliver economic savings for local businesses and operators. For the delivery of small goods, the use of HVGs can easily be avoided. 51% of all freight journeys in cities could be replaced by cargo bikes; however, there are local considerations, such as topography. Cargo bikes are more cost-effective than vans when delivery distances and parcel sizes are small.[157] In cases where HGVs are necessary, the uptake of biomethane can help bring cost savings. Biomethane can be produced from a variety of feedstocks; currently, biomethane used for road fuel is produced using landfill waste. This is an efficient circular economy as it recycles organic waste into energy.[158] This circular approach brings both environmental benefits, as it does not use raw materials for energy combustion, but it also improves the operational cost for fuel producers, due to the lower cost of materials like manure, agricultural residues and industrial or landfill waste. However, there are potential trade-offs for air quality from the use of biomethane that should be considered.
Increased social cohesion	The development of 15-minute neighbourhoods also fosters stronger local economies as they encourage residents to spend more time and money in local areas, which strengthens social cohesion and supports small businesses[159, 160].Bradford District's Economic Recovery Plan cites 15-minute

[153] Thomas, H. and Serrenho, A.C. (2024). Using different transport modes: An opportunity to reduce UK passenger transport emissions?. *Transportation Research Part D: Transport and Environment*, *126*, p.103989. Available at: https://doi.org/10.1016/j.trd.2023.103989

[154] UKERC (2020). Driving down emissions for low carbon public transport. Available at: https://ukerc.ac.uk/news/driving-down-emissions-for-low-carbon-public-transport/

[155] Green Alliance (N.D.). Going electric. Available at: https://www.transportenvironment.org/uploads/files/Electric-buses-arrive-on-time-1.pdf

[156] CSRF (2015). An assessment of the potential for demand-side fuel savings in the Heavy Goods Vehicle (HGV) sector. Available at: https://www.theccc.org.uk/wp-content/uploads/2015/11/CfSRF-An-assessment-of-the-potential-for-demand-side-fuel-savings-in-the-HGV-sector.pdf

[157] Sheth, M., Butrina, P., Goodchild, A. and McCormack, E. (2019). Measuring delivery route cost trade-offs between electric-assist cargo bicycles and delivery trucks in dense urban areas. *European transport research review*, *11*(1), p.11.

[158] EBA (2020). The potential of biomethane for a faster decarbonisation of transport should not go to waste. Available at: https://www.europeanbiogas.eu/wp-content/uploads/2020/09/Potential-of-biomethane-in-the-transport-sector.pdf

[159] Moreno, C., Allam, Z., Chabaud, D., Gall, C. and Pratlong, F. (2021). Introducing the "15-Minute City": Sustainability, resilience and place identity in future post-pandemic cities. *Smart cities*, *4*(1), pp.93-111. Available at: https://doi.org/10.3390/smartcities4010006

[160] Allam, Z., Nieuwenhuijsen, M., Chabaud, D. and Moreno, C. (2022). The 15-minute city offers a new framework for sustainability, liveability, and health. *The Lancet Planetary Health*, *6*(3), pp.e181-e183.

Co-benefits	Elaboration and evidence
	neighbourhoods as a long-term aim as part of a vision to create a 'Sustainable District'.[161] More flexible working arrangements can bring several social benefits by promoting a better work-life balance, giving people more time to engage with their families, neighbours and local environments. This can also contribute to a more resilient and connected community. However, Bradford stakeholders also acknowledged at the first stakeholder workshop that there are associated challenges to working from home, including impacts on economic and social activity in city centres, as well as impacts on mental health and loneliness.
Reduced noise pollution	The significantly lower operational noise of EVs contributes to reduced ambient noise levels, particularly in urban environments, improving public health and overall quality of life.[162] Electric HGVs are another valuable way to reduce noise pollution given the absence of internal combustion engines. Electric railways, like electric road vehicles, also reduce the noise pollution for those travelling and those in surrounding areas.[163]
Resilience against climate change	The use of EVs can mitigate and reduce the effects of urban heat islands[164]; the effects of which have been noted in residential and urban areas in Bradford and can contribute to the risk of heat-related illnesses and mortality.[165] As such, the electrification of transport modes, including cars, buses, rail, and HGVs, all foster resilience through energy and resource security, as they encourage a shift away from fossil dependence.[166] For example, electric buses likewise improve energy security as they rely on electricity as the main source of energy, energy which can be deployed from local renewable sources (e.g., bus operators could install solar panels or deliver energy to the grid during the day through Vehicle-to-Grid, thereby reducing costs).
Increased transport efficiency	Around 40% of the UK's rail network is currently electrified. Further electrifying UK railways could deliver benefits in several areas. Firstly, electric long-distance and suburban trains are 40% and 300% more reliable than diesel trains, which reduces delays both for freight and for passengers travelling via electric train, minimising delays and inconvenience.[167] Rail transport optimises the efficiency of freight delivery, both in terms of volumes and timeliness, is more cost-effective as it avoids financial delays and contributes to the resilience of the transport network.

[161] CBMDC (2021). Bradford District's Economic Recover Plan. Available at: https://www.bradford.gov.uk/media/6290/bradford-district-economic-recovery-plan.pdf
[162] Tsoi, K.H., Loo, B.P., Li, X. and Zhang, K. (2023). The co-benefits of electric mobility in reducing traffic noise and chemical air pollution: Insights from a transit-oriented city. *Environment International*, *178*, p.108116. Available at: https://doi.org/10.1016/j.envint.2023.108116
[163] Zhu, Y., Choma, E.F., Wang, K. and Wang, H. (2023). Electric vehicle adoption delivers public health and environmental benefits. *Eco-Environment & Health*, *2*(4), pp.193-194. Available at: https://doi.org/10.1016/j.eehl.2023.07.008
[164] Kolbe, K. (2019). Mitigating urban heat island effect and carbon dioxide emissions through different mobility concepts: Comparison of conventional vehicles with electric vehicles, hydrogen vehicles and public transportation. *Transport Policy*, *80*, pp.1-11. Available at: https://doi.org/10.1016/j.tranpol.2019.05.007
[165] Templeton, G. and Taleghani, M. (2024). Micro and macro urban heat islands in an industrial city: Bradford, UK. *Nature-Based Solutions*, *5*, p.100124. Available at: https://doi.org/10.1016/j.nbsj.2024.100124
[166] Gazda-Grzywacz, M., Grzywacz, P. and Burmistrz, P. (2024). Environmental benefits of hydrogen-powered buses: A case study of coke oven gas. *Energies*, *17*(20), p.5155. Available at: https://doi.org/10.3390/en17205155
[167] Network Rail (2020). Electric future: The value of Great Western Route Modernisation. Available at: https://www.railwaysarchive.co.uk/documents/NR_OurElectricFutureGWEP2020.pdf

Co-benefits	Elaboration and evidence
Social equity	Walking and driving in a personal car are the most commonly used forms of transport in West Yorkshire Combined Authority currently, with 50% of respondents claiming to only catch a bus on a monthly basis. Research shows that bus services in Britain have drastically declined which has a disproportional impact on those living on low incomes, people of colour, disabled and those who have given up driving due to age or health.[168] Investment in improved transport infrastructure and expansion outside of the city centre can improve social mobility and economic inclusion.[169] Car sharing can also reduce transport inequality and have social benefits by enabling low-income carless households to gain or maintain vehicle access without the full costs of car ownership. This can improve the mobility options for disadvantaged people.[170] Likewise, cycling can help address transport-related social exclusion caused by the high cost of fuel and poor public transport infrastructure, particularly in more deprived or isolated areas. A report by SMF finds that transport is the largest household expense (outside of mortgage repayments) for rural families, in part due to poorer regions being less well served by public transport[171]. Making cycling safer and more accessible could encourage a modal shift, in turn improving social cohesion and mobility.[172]
Efficient land use and reduced road congestion	Delivery and Serving Plans (DSPs) and Construction Logistics Plans (CLPs) were introduced in London to better manage freight vehicle movement. These plans better managed freight flows and were designed to cut emissions, congestion and collisions by reducing delivery and collection journeys at collection/delivery sites during peak hours. These practices resulted in a 20% reduction in total delivery journeys to the site.[173] Freight consolidation can therefore reduce inter-city congestion, pollution, and improve safety by minimising collisions. Similarly, cargo bikes for smaller deliveries also help reduce road congestion, contributing to safer streets for pedestrians and cyclists. Rail transport uses land more efficiently than roads and reduces the need for car parks. Equally, Figure 3-2, highlights the road space taken up by 69 bus passengers, cyclists, and car users.
Improved connectivity	Any investment in infrastructure for cargo bikes or active travel, such as additional cycling lanes, would positively impact the surrounding community. This could also promote active mobility in the area.

[168] Friends of the Earth (2023). How Britain's bus services have drastically declined. Available at: https://policy.friendsoftheearth.uk/insight/how-britains-bus-services-have-drastically-declined
[169] LGA (2024). How local transport infrastructure influences economic inclusion. Available at: https://www.local.gov.uk/publications/how-local-transport-infrastructure-influences-economic-inclusion
[170] Pede, E. and Staricco, L. (2021). Car sharing and socio-spatial justice: Evidences from three Italian cities. Town Planning Review, 92(4), pp.479-505. Available at: https://www.liverpooluniversitypress.co.uk/doi/abs/10.3828/tpr.2021.5
[171] SMF (2023). Getting the measure of transport poverty. Available at: https://www.smf.co.uk/wp-content/uploads/2023/11/Getting-the-measure-of-transport-poverty-Nov-2023.pdf
[172] Sustrans (2012). Transport poverty in England. Available at: https://www.sustrans.org.uk/our-blog/research/transport-poverty-in-england/
[173] Browne, M., Allen, J., Nemoto, T., Patier, D. and Visser, J. (2012). Reducing social and environmental impacts of urban freight transport: A review of some major cities. Procedia-Social and Behavioral Sciences, 39, pp.19-33. Available at: https://doi.org/10.1016/j.sbspro.2012.03.088https://www.sciencedirect.com/science/article/pii/S1877042812005551

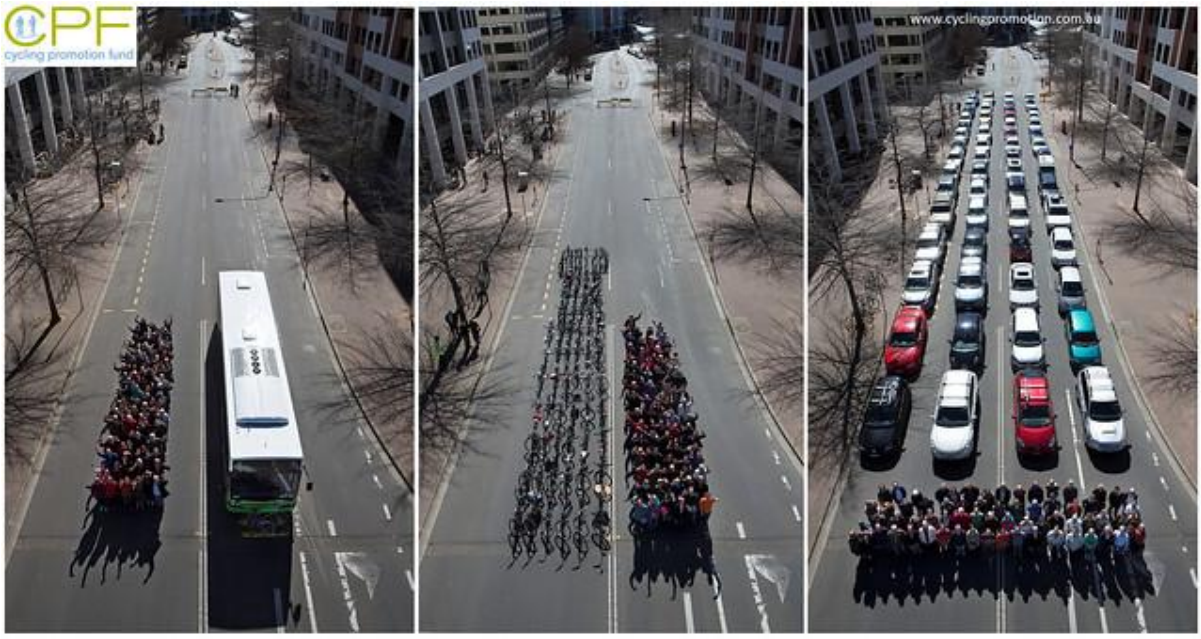

Figure 3-2: Road space taken up by 69 bus passengers, cyclists, and car passengers. Source: Cycling Promotion Fund.

3.3.4 Waste

Waste and environmental quality are closely linked, making the waste sector a particularly important area for identifying co-benefits in the transition to net zero. Actions such as reducing waste volumes, capturing CH_4 and other greenhouse gases from landfills, improving composting systems, and enhancing wastewater management can significantly cut emissions while also improving soil health, water quality, and overall environmental conditions. Given this strong connection, waste-related measures have high potential to deliver wide-ranging co-benefits, which are explored in Table 3-6.

Table 3-6: Common co-benefits from net zero waste measures.

Co-benefits	Elaboration and evidence
Improved soil and water quality	Sustainable waste management through reduced waste sent to landfills can prevent groundwater contamination, which can be detrimental to the environment and human health[174]. Likewise, composting can improve soil health and quality by reclaiming degraded or nutrient-depleted soils, thereby enhancing soil structure and fertility.[175] Composting can also reduce the volume of untreated organic and hazardous waste that can infiltrate water bodies and food systems.[176]

[174] WasteManaged (2025). UK Landfill Impact Guide 2025. Available at: https://www.wastemanaged.co.uk/our-news/general-waste/uk-landfill-impact-guide/

[175] Giagnoni, L., Martellini, T., Scodellini, R., Cincinelli, A. and Renella, G. (2020). Co-composting: an opportunity to produce compost with designated tailor-made properties. In *Organic waste composting through nexus thinking: Practices, policies, and trends* (pp. 185-211). Cham: Springer International Publishing.

[176] Lakhouit, A. (2024). Mitigating landfill emissions strategies for effective waste management in tabuk. Cleaner Waste Systems, 9, p.100187. Available at: https://doi.org/10.1016/j.clwas.2024.100187https://www.sciencedirect.com/science/article/pii/S2772912524000605

Co-benefits	Elaboration and evidence
	Wastewater treatment with integrated resource recovery also offers significant improvements in water quality through the prevention of acidification and eutrophication.[177]
Improved air quality	If waste arisings are reduced or waste diverted from landfill (re-used or recycled), this can lead to reduced landfill emissions and result in fewer toxic pollutants released into the air, benefiting respiratory health.[178] **For quantification of air quality co-benefits from the net zero pathway please see Section 4.**
Green job creation	Recycling, composting, and waste-to-energy industries can create employment opportunities across various skill levels.
Reduced waste management costs	Reducing the amount of waste sent to landfills decreases landfill management costs for local authorities and businesses that are all required to pay Landfill Tax.[179]
Increased income for farming communities	Composting offers economic and agricultural benefits by transforming organic waste into tailored fertilisers that enhance soil health and crop productivity. These benefits support farming communities by improving yields and lowering input costs.[180]
Social cohesion	Initiatives such as food waste collection and composting programs encourage community participation and engagement, fostering a sense of shared responsibility and environmental awareness.[181, 182]

3.3.5 Agriculture and Land Use

Agriculture and land use play a pivotal role in the net zero transition due to their dual potential to reduce emissions and enhance carbon sequestration. Bradford's LULUCF sector has potential, not only to become a substantial carbon sink but also to bring wide-ranging benefits across society, the economy, and particularly the environment. Measures include switching agricultural machinery to low-carbon fuels such as electricity and hydrogen, implementing soil and livestock management practices to reduce emissions, restoring degraded peatlands, and scaling up tree planting efforts. These actions not only contribute to emissions reductions but also influence biodiversity, water regulation, and landscape resilience. Table 3-7 provides a summary of the opportunities.

[177] Zheng, X. and Lam, K.L. (2024). An overview of environmental co-benefits and trade-offs to reduce greenhouse gas emissions in municipal wastewater management. *Sustainable Production and Consumption*, *46*, pp.1-10. Zheng, X. and Lam, K.L., 2024. An overview of environmental co-benefits and trade-offs to reduce greenhouse gas emissions in municipal wastewater management. *Sustainable Production and Consumption*, *46*, pp.1-10. Available at: https://doi.org/10.1016/j.spc.2024.02.002

[178] WasteManaged (2025). UK Landfill Impact Guide 2025. Available at: https://www.wastemanaged.co.uk/our-news/general-waste/uk-landfill-impact-guide/

[179] Greenbank Recycling Solutions (2023). Landfill Tax Rates: A Guide for Businesses. Available at: https://greenbankwastesolutions.com/landfill-tax-rates-what-you-need-to-know/

[180] Giagnoni, L., Martellini, T., Scodellini, R., Cincinelli, A. and Renella, G. (2020). Co-composting: an opportunity to produce compost with designated tailor-made properties. In *Organic waste composting through nexus thinking: Practices, policies, and trends* (pp. 185-211). Cham: Springer International Publishing.

[181] https://www.theguardian.com/environment/2025/jan/23/no-council-lorries-no-bonfires-how-community-composting-took-off-in-an-english-village

[182] C40 Cities (2023). 6 city actions to improve waste management and reduce emissions. Available at: https://www.c40knowledgehub.org/s/article/Six-city-actions-to-improve-waste-management-and-reduce-greenhouse-gas-emissions?language=en_US

Table 3-7: Common co-benefits from net zero agriculture and land use measures.

Co-benefits	Elaboration and evidence
Improved agricultural productivity	Soil measures which improve soil quality and organic matter increase soil fertility, animal health, and agricultural productivity. By improving crop yields and optimising animal performance, soil measures therefore enhance farm efficiency and productivity, presenting significant financial gains for farming communities.[183]
Green job creation	Peatland restoration can lead to rural job creation by increasing demand for skilled rural workers, such as specialist digger operators, ecologists, land managers, and hydrologists. Local contractors tend to benefit significantly from peatland restoration efforts, given the remote locations where such efforts are focused.[184]
Health benefits	The electrification of heavy machinery for agriculture brings numerous health and safety benefits. These include improved safety and drivability for operators, driven by design features including fewer gears and more effective automatic control options. Electric machinery, particularly hydrogen-powered machinery, also tends to be far quieter than traditional fuel-powered equipment, contributing to reduced noise pollution. Furthermore, by reducing emissions through electrification, operators can sidestep the exhaust emissions of diesel engines, which are carcinogenic to humans.[185] Soil measures which improve soil quality contribute to more reliable, healthy, and nutritious crop production, leading to dietary and nutrition improvements. Likewise, improved soil health also leads to strengthened animal health, welfare, and performance, given enhanced land for grazing; this in turn benefits communities through the consumption of healthier animal products.[186] Shifting to more sustainable diets can lead to reductions in morbidity and mortality by reducing disease burdens, including cardiovascular illnesses and diabetes.[187] Mortality rates in Bradford for cardiovascular diseases are higher than those for England and are one of the highest in Yorkshire and Humber.[188] Green urban infrastructure has been shown to increase the overall well-being of residents.[189] The Born in Bradford study identified that families living in deprived parts of Bradford have less access to quality green spaces and are less satisfied with their local green spaces. Annually, lack of access to green space contributes to around 16 preventable deaths.[190] Several mental health issues, such as anxiety and depression, have been shown to improve as a result of well-managed urban green spaces. Likewise, increasing tree cover improves air quality by absorbing pollutants, reducing health risks such as respiratory illnesses.

[183] McGuire, R., Williams, P.N., Smith, P., McGrath, S.P., Curry, D., Donnison, I., Emmet, B. and Scollan, N. (2022). Potential Co-benefits and trade-offs between improved soil management, climate change mitigation and agri-food productivity. *Food and Energy Security*, *11*(2), p.e352. Available at: https://doi.org/10.1002/fes3.352

[184] IUCN (2018). UK Peatland Strategy 2018 – 2040. Available at: https://www.iucn-uk-peatlandprogramme.org/sites/default/files/2019-07/2018_UK%20Peatland%20Strategy_DIGITAL_1.pdf

[185] Scolaro, E., Beligoj, M., Estevez, M.P., Alberti, L., Renzi, M. and Mattetti, M. (2021). Electrification of agricultural machinery: A review. *Ieee Access*, *9*, pp.164520-164541. Available at: https://ieeexplore.ieee.org/document/9648206/

[186] McGuire, R., Williams, P.N., Smith, P., McGrath, S.P., Curry, D., Donnison, I., Emmet, B. and Scollan, N. (2022). Potential Co-benefits and trade-offs between improved soil management, climate change mitigation and agri-food productivity. *Food and Energy Security*, *11*(2), p.e352. https://doi.org/10.1002/fes3.352

[187] Barrett, B. (2022). Health and sustainability co-benefits of eating behaviors: Towards a science of dietary eco-wellness. *Preventive Medicine Reports*, *28*, p.101878. https://doi.org/10.1016/j.pmedr.2022.101878

[188] https://jsna.bradford.gov.uk/media/s2wo1n4p/cardiovascular-disease-in-bradford-district-2024.pdf

[189] Mansor, M., Said, I. and Mohamad, I. (2012). Experiential contacts with green infrastructure's diversity and well-being of urban community. *Procedia-Social and Behavioral Sciences*, *49*, pp.257-267. Available at: https://doi.org/10.1016/j.sbspro.2012.07.024

[190] Born in Bradford (2024). 10 Key Findings for Policy and Practice. Available at: https://borninbradford.nhs.uk/wp-content/uploads/2024/10/10-Key-Findings-for-policy-and-practice-2019.pdf

Co-benefits	Elaboration and evidence
	Restoring peatlands results in greater access to clean drinking water, as water from healthy peatlands is of naturally higher quality given their natural filtration systems.[191] Peatland restoration also offers protection from wildfires and associated mortality risks[192], as well as holding importance for local communities' recreation.[193]
Reduced flood risk	Restoring peatlands and improving soil organic matter content through soil measures enhances water retention and infiltration, which stabilises water flows, reduces surface runoff, and mitigates flooding, particularly under extreme rainfall events.[194] Tree planting helps in disaster risk reduction (DRR) and enhances community resilience to flood and landslide impacts.[195] Green spaces can alleviate flooding by balancing water flows or help counteract the urban heat island effect by providing shade.[196]
Improved water quality	Practices such as food waste reduction, improved fertiliser management, and peatland restoration enhance soil structure and organic matter content, which helps to reduce nutrient runoff, sedimentation, and pollution, enhancing water quality in surrounding rivers, lakes, and aquifers.[197] Agricultural and animal husbandry practices are a significant driver of water use and therefore water scarcity – a shift away from this not only alleviates pressure on scarce resources, but also improves water quality, with cascading improvements in the health of the aquatic ecosystems and biodiversity.[198] Restoring peatlands improves water quality through filtration.[199] By acting as natural filters, purifying water by trapping sediment and pollutants before they enter rivers and streams, peatlands can therefore improve the overall health of aquatic ecosystems downstream.[200]

[191] IUCN (2018). UK Peatland Strategy 2018 – 2040. Available at: https://www.iucn-uk-peatlandprogramme.org/sites/default/files/2019-07/2018_UK%20Peatland%20Strategy_DIGITAL_1.pdf

[192] Marlier, M.E., Liu, T., Yu, K., Buonocore, J.J., Koplitz, S.N., DeFries, R.S., Mickley, L.J., Jacob, D.J., Schwartz, J., Wardhana, B.S. and Myers, S.S. (2019). Fires, smoke exposure, and public health: an integrative framework to maximize health benefits from peatland restoration. *GeoHealth*, *3*(7), pp.178-189. Available at: https://doi.org/10.1029/2019GH000191

[193] NABU (2023). The benefits of peatland restoration for Europe. Available at: https://cinea.ec.europa.eu/document/download/a31c8dde-b350-4970-b13b-36cac57fbf60_en?filename=Peatlands%20Policy%20Brief_CINEA.pdf

[194] Gao, J., Holden, J. and Kirkby, M. (2016). The impact of land-cover change on flood peaks in peatland basins. *Water Resources Research*, *52*(5), pp.3477-3492. Available at: https://doi.org/10.1002/2015WR017667

[195] Pagel, J., and Sileci, L. (2024). More Than Just Carbon: The Socioeconomic Co-Benefits of Large-Scale Tree Planting. Available at: https://www.lse.ac.uk/granthaminstitute/wp-content/uploads/2024/07/Working-paper-410-Pagel-Sileci.pdf

[196] Demuzere, M., Orru, K., Heidrich, O., Olazabal, E., Geneletti, D., Orru, H., Bhave, A.G., Mittal, N., Feliú, E. and Faehnle, M. (2014). Mitigating and adapting to climate change: Multi-functional and multi-scale assessment of green urban infrastructure. *Journal of environmental management*, *146*, pp.107-115. Available at: https://doi.org/10.1016/j.jenvman.2014.07.025

[197] McGuire, R., Williams, P.N., Smith, P., McGrath, S.P., Curry, D., Donnison, I., Emmet, B. and Scollan, N. (2022). Potential Co-benefits and trade-offs between improved soil management, climate change mitigation and agri-food productivity. Food and Energy Security, 11(2), p.e352. Available at: https://doi.org/10.1002/fes3.352

[198] Barrett, B. (2022). Health and sustainability co-benefits of eating behaviors: Towards a science of dietary eco-wellness. *Preventive Medicine Reports*, *28*, p.101878. Available at: https://doi.org/10.1016/j.pmedr.2022.101878

[199] IUCN (N.D.) Peatland Benefits. Available at: https://www.iucn-uk-peatlandprogramme.org/about-peatlands/peatland-benefits

[200] NABU (2023). The benefits of peatland restoration for Europe. Available at: https://cinea.ec.europa.eu/document/download/a31c8dde-b350-4970-b13b-36cac57fbf60_en?filename=Peatlands%20Policy%20Brief_CINEA.pdf

Co-benefits	Elaboration and evidence
Improved soil health	Enhanced soil measures and management increase soil organic carbon (SOC), improve soil structure and fertility, and support microbial diversity. These improvements result in greater soil productivity, nutrient cycling, and long-term sustainability.[201] Agricultural and animal husbandry practices are drivers of land use and soil deterioration. As such, a shift towards more sustainable diets improves both soil health by increasing nutrient contents and preserves biodiversity[202], as it drives down demand for animal products. This allowed farming communities to limit livestock numbers. Reducing livestock numbers frees up land that would otherwise be utilised for grazing, thereby preventing overgrazing and strengthening soil health and quality.[203]
Enhanced ecosystem biodiversity and services	Improved soil and water quality through soil management measures contributes to the stability of ecosystems by enhancing nutrient recycling, which in turn strengthens ecosystem services.[204] Reductions in livestock numbers alleviate pressure on ecosystems, reducing biodiversity losses that stem from livestock production.[205] Tree planting efforts foster biodiversity and ecosystem conservation, as trees and forests provide wildlife habitats and help maintain and enhance biodiversity. Tree planting also enhances soil health and quality.[206, 207] In the UK, peatlands present the country's largest source of semi-natural habitat and help protect an extensive range of species that are rare and/or declining.[208] Restoring peatlands, therefore, fosters wildlife protection and ecosystem enhancement.[209]
Enhanced resilience against climate change	Electrifying agricultural machinery supports climate-smart agriculture (CSA) goals by enabling the integration of renewable energy sources, which helps mitigate exposure to fossil fuel price fluctuations and supply chain disruptions—risks that are increasingly intensified by climate change.[210]

[201] McGuire, R., Williams, P.N., Smith, P., McGrath, S.P., Curry, D., Donnison, I., Emmet, B. and Scollan, N. (2022). Potential Co-benefits and trade-offs between improved soil management, climate change mitigation and agri-food productivity. *Food and Energy Security*, *11*(2), p.e352. Available at: https://doi.org/10.1002/fes3.352

[202] Barrett, B. (2022). Health and sustainability co-benefits of eating behaviors: Towards a science of dietary eco-wellness. *Preventive Medicine Reports*, *28*, p.101878. Available at: https://doi.org/10.1016/j.pmedr.2022.101878

[203] Notenbaert, A.M., Douxchamps, S., Villegas, D.M., Arango, J., Paul, B.K., Burkart, S., Rao, I., Kettle, C.J., Rudel, T., Vázquez, E. and Teutscherova, N. (2021). Tapping into the environmental co-benefits of improved tropical forages for an agroecological transformation of livestock production systems. *Frontiers in Sustainable Food Systems*, *5*, p.742842. Available at: https://doi.org/10.3389/fsufs.2021.742842

[204] McGuire, R., Williams, P.N., Smith, P., McGrath, S.P., Curry, D., Donnison, I., Emmet, B. and Scollan, N. (2022). Potential Co-benefits and trade-offs between improved soil management, climate change mitigation and agri-food productivity. *Food and Energy Security*, *11*(2), p.e352. Available at: https://doi.org/10.1002/fes3.352

[205] Notenbaert, A.M., Douxchamps, S., Villegas, D.M., Arango, J., Paul, B.K., Burkart, S., Rao, I., Kettle, C.J., Rudel, T., Vázquez, E. and Teutscherova, N. (2021). Tapping into the environmental co-benefits of improved tropical forages for an agroecological transformation of livestock production systems. *Frontiers in Sustainable Food Systems*, *5*, p.742842. Available at: https://doi.org/10.3389/fsufs.2021.742842

[206] Pagel, J. and Sileci, L. (2024). More than just carbon: the socioeconomic co-benefits of large-scale tree planting. Available at: https://www.lse.ac.uk/granthaminstitute/wp-content/uploads/2024/07/Working-paper-410-Pagel-Sileci.pdf

[207] Kirschbaum, M.U., Cowie, A.L., Peñuelas, J., Smith, P., Conant, R.T., Sage, R.F., Brandão, M., Cotrufo, M.F., Luo, Y., Way, D.A. and Robinson, S.A. (2024). Is tree planting an effective strategy for climate change mitigation?. *Science of the Total Environment*, *909*, p.168479. Available at: https://doi.org/10.1016/j.scitotenv.2023.168479

[208] IUCN (N.D.) Peatland Benefits. Available at: https://www.iucn-uk-peatlandprogramme.org/about-peatlands/peatland-benefits

[209] IUCN (2018). UK Peatland Strategy 2018 – 2040. Available at: https://www.iucn-uk-peatlandprogramme.org/sites/default/files/2019-07/2018_UK%20Peatland%20Strategy_DIGITAL_1.pdf

[210] Food and Agriculture Organization of the United Nations (2021). Strategic Framework 2022-31. Available at: https://openknowledge.fao.org/server/api/core/bitstreams/29404c26-c71d-4982-a899-77bdb2937eef/content

Co-benefits	Elaboration and evidence
	Tree planting also enhances green spaces, which helps to adapt to increasing temperatures by reducing urban heat island effects.[211] Peatland restoration can make communities more resilient to both drought and flooding. Peatland restoration can help store water and maintain base water flows during periods of extreme heat and drought. Peatlands also absorb and store rainfall and surface waters, slowly releasing them over time, thus reducing the risk of floods and maintaining a steady water supply during dry periods. Moreover, peatland restoration also enhances ecosystem resilience – healthier peatlands make ecosystems and species better able to cope with/adapt to changing climatic conditions and extremes.[212]
Reduced pressure on natural resources	Soil management measures help maintain yields and animal health under changing climatic conditions and extreme weather events. They likewise enhance ecosystem recovery from climate shocks.[213] Optimising food consumption to reduce wastage and transitioning towards plant-based diets can have positive environmental impacts on land and water resources. By reducing food waste and preventing production in excess, pressure on scarce resources can be alleviated.[214, 215]
Cost savings	The electrification of agricultural machinery has multiple economic benefits, driven by increased operational efficiency.[216] These significantly lower costs for farming communities in the long run. Electrification often simplifies maintenance and operation, leading to cost savings and longer operational lifespans than traditional machinery. This is particularly evident in hydrogen-powered machinery, which, through greater efficiency and reduced downtime, increases agricultural productivity[217]. Moreover, electrified agricultural machinery also tends to have lower operating costs due to reduced expenditure on fuel consumption. Upfront access costs for improved modern machinery, however, may be a barrier to access. Livestock measures, including the reduction of livestock numbers, present cost savings for farming communities[218]. Reducing livestock numbers also reduces management and input costs, which is especially valuable in smallholder farms where a large portion of income is directed towards maintaining livestock.[219]

[211] Kirschbaum, M.U., Cowie, A.L., Peñuelas, J., Smith, P., Conant, R.T., Sage, R.F., Brandão, M., Cotrufo, M.F., Luo, Y., Way, D.A. and Robinson, S.A. (2024). Is tree planting an effective strategy for climate change mitigation?. *Science of the Total Environment*, *909*, p.168479. Available: https://doi.org/10.1016/j.scitotenv.2023.168479

[212] Glenk, K., Faccioli, M., Martin-Ortega, J., Schulze, C. and Potts, J. (2021). The opportunity cost of delaying climate action: Peatland restoration and resilience to climate change. *Global Environmental Change*, *70*, p.102323. Available at: https://doi.org/10.1016/j.gloenvcha.2021.102323

[213] McGuire, R., Williams, P.N., Smith, P., McGrath, S.P., Curry, D., Donnison, I., Emmet, B. and Scollan, N. (2022). Potential Co-benefits and trade-offs between improved soil management, climate change mitigation and agri-food productivity. *Food and Energy Security*, *11*(2), p.e352. Available at: https://doi.org/10.1002/fes3.352

[214] BEIS (2016) Written evidence submitted by the Department for Business, Energy and Industrial Strategy (FOW0023). Available at: https://committees.parliament.uk/writtenevidence/71153/html/

[215] Barrett, B. (2022). Health and sustainability co-benefits of eating behaviors: Towards a science of dietary eco-wellness. Preventive Medicine Reports, 28, p.101878. Available at: https://doi.org/10.1016/j.pmedr.2022.101878https://www.sciencedirect.com/science/article/pii/S2211335522001851

[216] Chen, H.C., Rohman, Y.F., Ashlah, M.B., Lin, H.T. and Sean, W.Y. (2024). Electrification of Agricultural Machinery: One Design Case of a 4 kW Air Compressor. *Energies (19961073)*, *17*(15). Available at: https://www.mdpi.com/1996-1073/17/15/3647

[217] Scolaro, E., Beligoj, M., Estevez, M.P., Alberti, L., Renzi, M. and Mattetti, M. (2021). Electrification of agricultural machinery: A review. Ieee Access, 9, pp.164520-164541. Available at: https://ieeexplore.ieee.org/document/9648206 https://www.researchgate.net/publication/357004885_Electrification_of_Agricultural_Machinery_A_Review

[218] CCC (2025). The Seventh Carbon Budget. Available at: https://www.theccc.org.uk/publication/the-seventh-carbon-budget/

[219] Harrison, M.T., Cullen, B.R., Mayberry, D.E., Cowie, A.L., Bilotto, F., Badgery, W.B., Liu, K., Davison, T., Christie, K.M., Muleke, A. and Eckard, R.J. (2021). Carbon myopia: The urgent need for integrated social, economic and environmental action in the livestock sector. *Global Change Biology*, *27*(22), pp.5726-5761. Available at: https://doi.org/10.1111/gcb.15816

Co-benefits	Elaboration and evidence
	Shifting to healthier and sustainable diets could result in household cost savings. A recent analysis from the UK has confirmed that such shifts could be deemed affordable amongst all income groups.[220] A recent Lancet study identified that vegan and vegetarian diets could result in savings of 21-34%.[221] Reducing food waste holds multiple economic benefits for households, businesses, and local authorities. By optimising resource use and minimising wastage, households can secure cost savings on their regular food expenditure. Likewise, businesses can also reduce costs associated with produce procurement.[222] These practices can have spillover effects on local governments, which can then spend less on waste disposal activities. Peatland restoration also increases access to naturally cleaner drinking water, reducing the need for costly treatments and chemical use to clean and treat water. It is thus a more cost-effective and sustainable way to improve the quality of raw water.[223]
Air quality improvements	Trees and other green infrastructure can aid in improving air quality by absorbing pollutants such as particulate matter.[224] It is important for the right trees to be used in the right places to ensure wider benefits to biodiversity and avoid an increase in diesel use to maintain them. **For quantification of air quality co-benefits from the net zero pathway, please see Section 4.**
Reduced noise pollution	Electric machinery, particularly hydrogen-powered machinery, tends to be far quieter than traditional fuel-powered equipment, contributing to reduced noise pollution.[225] Some green spaces can provide screening from noise pollution by lessening the perception of noise and thereby alleviating risks of associated health impacts.[226]
Social cohesion and community involvement	Tree-planting programs have powerful socio-economic implications, particularly in rural areas, but also in urban areas with reduced access to green space. They help reduce poverty, engage marginalised communities, and create job opportunities.[227, 228] As noted above, there is an acknowledged challenge with fair access to green space in Bradford.[229]

[220] Barrett, B. (2022). Health and sustainability co-benefits of eating behaviors: Towards a science of dietary eco-wellness. *Preventive Medicine Reports*, *28*, p.101878. Available at: https://doi.org/10.1016/j.pmedr.2022.101878

[221] University of Oxford (2021). Sustainable eating is CHEAPER as well as healthier. Available at: https://www.oxfordmartin.ox.ac.uk/news/sustainable-eating-is-cheaper

[222] Hanson, C. and Mitchell, P. (2017). The business case for reducing food loss and waste. *A report on behalf of Champions*, *12*, pp.7-8.https://champions123.org/publication/business-case-reducing-food-loss-and-waste?ap3c=IGUUTduhm-81KOYAAGUUTdtGSNNMD0fzUTZFA-J7RtDPiS-hHQ

[223] IUCN (2018). UK Peatland Strategy 2018 – 2040. Available at: https://www.iucn-uk-peatlandprogramme.org/sites/default/files/2019-07/2018_UK%20Peatland%20Strategy_DIGITAL_1.pdf

[224] Demuzere, M., Orru, K., Heidrich, O., Olazabal, E., Geneletti, D., Orru, H., Bhave, A.G., Mittal, N., Feliú, E. and Faehnle, M. (2014). Mitigating and adapting to climate change: Multi-functional and multi-scale assessment of green urban infrastructure. *Journal of environmental management*, *146*, pp.107-115. https://doi.org/10.1016/j.jenvman.2014.07.025

[225] Scolaro, E., Beligoj, M., Estevez, M.P., Alberti, L., Renzi, M. and Mattetti, M. (2021). Electrification of agricultural machinery: A review. *Ieee Access*, *9*, pp.164520-164541. Available at: https://doi.org/10.1109/ACCESS.2021.3135037

[226] Dzhambov, A.M. and Dimitrova, D.D. (2014). Urban green spaces' effectiveness as a psychological buffer for the negative health impact of noise pollution: A systematic review. *Noise and health*, *16*(70), pp.157-165. Available at: https://pubmed.ncbi.nlm.nih.gov/24953881/

[227] World Bank Blogs (2024). Rooting out poverty: The socioeconomic co-benefits of large-scale tree planting. Available at: https://blogs.worldbank.org/en/impactevaluations/rooting-out-poverty--the-socioeconomic-co-benefits-of-large-scal

[228] Pagel, J., and Sileci, L. (2024). More Than Just Carbon: The Socioeconomic Co-Benefits of Large-Scale Tree Planting. Available at: https://www.lse.ac.uk/granthaminstitute/wp-content/uploads/2024/07/Working-paper-410-Pagel-Sileci.pdf

[229] Born in Bradford (2024). 10 Key Findings for Policy and Practice. Available at: https://borninbradford.nhs.uk/wp-content/uploads/2024/10/10-Key-Findings-for-policy-and-practice-2019.pdf

Co-benefits	Elaboration and evidence
	Increased access to green spaces can increase social cohesion, i.e., the connectedness and solidarity amongst community members. This is primarily a result of providing community members from different backgrounds with a space to interact with nature and each other.[230]
Social equity benefits	Implementing soil health practices can improve the livelihoods of smallholder and marginalised farmers through increased productivity and reduced vulnerability to climate impacts.[231] Reducing livestock numbers and shifting towards more plant-based diets can increase the availability and affordability of nutritious plant-based foods, thereby improving food security and nutrition, especially in low-income communities.[232] Actively reducing food wastage allows for the redistribution of surplus foods to underserved and low-income communities, leading to improved food security and nutrition.[233, 234]

[230] Jennings, V. and Bamkole, O. (2019). The relationship between social cohesion and urban green space: An avenue for health promotion. *International journal of environmental research and public health*, *16*(3), p.452. Available at: https://doi.org/10.3390/ijerph16030452

[231] McGuire, R., Williams, P.N., Smith, P., McGrath, S.P., Curry, D., Donnison, I., Emmet, B. and Scollan, N. (2022). Potential Co-benefits and trade-offs between improved soil management, climate change mitigation and agri-food productivity. *Food and Energy Security*, *11*(2), p.e352. Available at: https://doi.org/10.1002/fes3.352

[232] Food and Agriculture Organization of United Nations, Strategic Framework 2022-31. Available at: https://openknowledge.fao.org/server/api/core/bitstreams/29404c26-c71d-4982-a899-77bdb2937eef/content

[233] BEIS (2016) Written evidence submitted by the Department for Business, Energy and Industrial Strategy (FOW0023). Available at: https://committees.parliament.uk/writtenevidence/71153/html/

[234] World Resources Institute (2023). The Global Benefits of Reducing Food Loss and Waste, and How to Do It. Available at: https://www.wri.org/insights/reducing-food-loss-and-food-waste

3.4 BRADFORD CO-BENEFITS SCORING

Table 3-8 provides the qualitative scoring for each net zero measure from the pathways modelling (Section 2) against the co-benefit categories of: local environment impact, local economic impact, social equity, health, fuel poverty, and resilience. The scores are accompanied by a brief explanation of the reasoning and supporting evidence.

Table 3-8: Co-benefits scoring for net zero pathway measures.

Net Zero Pathway	Local economic impacts	Local environmental impacts	Social Equity	Health	Fuel poverty	Resilience
Energy in Buildings						
Retrofitting measures: Domestic	2 - Job creation, training opportunities, energy savings	1 - Improved air quality from reduced combustion, due to energy demand reductions. However, heat pumps can be considered noisy	1 - If targeted at vulnerable/low-income households, can be a significant boost to social equity	2 - Improved indoor air quality, warmer homes, insulation related to fewer hospital admissions / respiratory illnesses	2 - Can reduce energy demand significantly, reducing energy bills	1 - High potential for increasing resilience through choice of materials, ensuring inclusion of drainage systems, appropriate ventilation to prevent overheating etc, but depends on how this is implemented. Reduced exposure to energy price fluctuations
Retrofitting measures: Non-Domestic	2 - Job creation, training opportunities, energy savings	1 - Improved air quality from reduced combustion requirements depending on technology	N/A	1 - Better physical and mental health outcomes for workers	N/A	1 - High potential for increasing resilience through choice of materials, ensuring inclusion of drainage systems, appropriate ventilation to prevent overheating etc, but depends on how this is implemented. Reduced exposure to energy price fluctuations
Use of smart heating controls: Domestic	2 - Job creation, training opportunities, energy savings	1 - Improved air quality from reduced combustion requirements	1 - If targeted at vulnerable groups/low-income households can boost social equity and support improved comfort in homes, need to consider digital accessibility and not exclude groups. Without programme of support, upfront costs could prevent access	1 - Improved comfort supporting mental and physical wellbeing	1 - Improved control of bills and potential for energy reduction, visibility of energy expenditure may result in more restricted use, and upfront cost could prevent access	2 - Better data and control of heating in homes, support resilience against overheating in summer. Reduced exposure to energy price fluctuations
Use of smart heating controls: Non-Domestic	2 - Job creation, training opportunities, energy savings	1 - Improved air quality from reduced combustion requirements	N/A	1 - Better physical and mental health outcomes for workers	N/A	2 - Better data and control of heating in buildings, support resilience against overheating in summer. Reduced exposure to energy price fluctuations
Energy savings from water efficiency measures: Domestic	2 - Job creation, training opportunities, energy savings	2 - Supporting water savings, improved air quality from reduced combustion requirements	0 - Limited research on links for water efficiency measures. Upfront costs could prevent access, but could result in cost savings, wider water management policy, and equity need to be considered	N/A	1 - Savings on energy bills	2 - Reduced exposure to energy price fluctuations, reduced consumption of water
Energy savings from water efficiency measures: Non-Domestic	2 - Job creation, training opportunities, energy savings	2 - Supporting water savings, improved air quality from reduced combustion requirements	N/A	N/A	N/A	2 - Reduced exposure to energy price fluctuations, reduced consumption of water
Energy savings from LED lighting	2 - Job creation, training opportunities, energy savings	2 - Long lifespan and reduced wastage, reduced toxic materials	1 - An accessible, low-cost measure that can provide energy savings	N/A	1 - Savings on energy bills	1 - Reduced exposure to energy price fluctuations
Energy savings from energy efficient appliances	2 - Job creation, training opportunities, energy savings	1 - Lower energy demand and lower water demand, supporting air quality improvements. Requires resources for new products and the disposal of existing systems	0 - Upfront costs could prevent access, but if provided in a targeted way, an opportunity to provide low-income/vulnerable groups cost savings or revenue generation (DSR)	N/A	1 - Savings on energy bills	2 - Reduced exposure to energy price fluctuations, potential for demand side response to support resilience of the grid

Net Zero Pathway	Local economic impacts	Local environmental impacts	Social Equity	Health	Fuel poverty	Resilience
Energy savings from HVAC upgrades: Non-Domestic	2 - Job creation, training opportunities, energy savings	1 - Lower energy demand supporting air quality improvements	N/A	1 - Can support improved indoor air quality	N/A	2 - Better data and control of key systems in buildings, reduced exposure to energy price fluctuations
Switching from fossil fuel heating systems to heat pumps: Domestic	1 - Job creation (but loss in gas industry), training opportunities, potential uplift in energy costs	2 - Improved air quality	0 - Complex, higher electricity costs over gas means bills could increase, high upfront costs could exclude access so would need to be targeted	2 - Reduced indoor air pollution, no risk of carbon monoxide	0 - Complex, higher electricity costs over gas means bills are likely to increase	2 - Can provide heating and cooling, reduced energy demand supporting grid resilience
Switching from natural gas to heat networks	1 - Job creation (but loss in gas industry), training opportunities, potential uplift in energy costs	0 – Potential for improved air quality but also risk of single-source combustion for winter back up, potential for environmental and habitat disruption during construction of network	0 - Complex, potential for savings on energy bills from increased efficiencies of larger networked systems but less control of utility provider/Ofgem's energy price cap	2 - Reduced indoor air pollution, no risk of carbon monoxide	0 - Complex, potential for savings on energy bills from increased efficiencies of larger networked systems but less control of utility provider/Ofgem's energy price cap	2 - Can utilise diverse sources for heat/energy, reducing reliance on fossil fuels, improved reliability, boost energy resilience and reduced grid demand
Buildings remaining on or switching to direct electric heating	0 - More limited job creation opportunities (remaining/few switching), potential increase costs of energy-dependent	1 - Remaining on - limited impact, however switching (if away from fossil fuel) could support improved air quality	0 - Remaining on - limited impact, however switching could potentially lead to increased energy bills due to high electricity prices	1 - Remaining on - limited impact, however switching (if away from fossil fuel) could improve health through removal of combustion from homes	0 - Remaining on - limited impact, however switching could potentially lead to increased energy bills due to high electricity prices	0 - Vulnerability to high electricity prices, potential for control of heat zoning in homes to reduce overheating
Commercial / public buildings switch to electrified heat sources	1 - Job creation (but loss in gas industry), training opportunities, potential uplift in energy costs	2 - Improve air quality through reduced fossil fuel combustion	N/A	N/A	N/A	2 - Can utilise diverse sources for heat/energy, reducing reliance on fossil fuels, improved reliability, boosting energy resilience and reducing grid demand
Commercial / public buildings switch to district heating	1 - Job creation (but loss in gas industry), training opportunities, potential uplift in energy costs	2 - Improve air quality through reduced fossil fuel combustion	N/A	N/A	N/A	2 - Can utilise diverse sources for heat/energy, reducing reliance on fossil fuels, improved reliability, boosting energy resilience and reducing grid demand
Switching to electric cooking systems: Domestic	1 - Job creation (but loss in gas industry), training opportunities, potential uplift in energy costs	2 - Improved air quality	N/A	2 - Reduced indoor air pollution, no risk of carbon monoxide	-1 Potential for increased bills due to high electricity costs compared to gas cooking	1 - Reduced exposure to energy price fluctuations
Switching to electric cooking systems: Non-Domestic	1 - Job creation (but loss in gas industry), training opportunities, potential uplift in energy costs	2 - Improved air quality	N/A	2 - Reduced indoor air pollution, no risk of carbon monoxide	N/A	1 - Reduced exposure to energy price fluctuations
Energy Systems						

Net Zero Pathway	Local economic impacts	Local environmental impacts	Social Equity	Health	Fuel poverty	Resilience
Grid decarbonisation	2 - Job creation, training opportunities	0 – High potential for improved air quality but can mean more need for back-up short-term operating reserve, which can pollute urban areas, requirement for large-scale renewable sites means land use change, habitat and ecosystem disruption	N/A	2 - Improved air quality from renewable sources	1 - Cleaner energy mix, potentially reducing the overall cost of electricity and mitigating fuel poverty for households - in 2022, the global cost of electricity from newly commissioned utility-scale solar photovoltaics, onshore wind, concentrating solar power (CSP), bioenergy and geothermal energy all fell, despite rising materials and equipment cost	2 - Less reliance on fossil fuels and political energy market, enhanced grid security through integration of varied renewable sources
Solar PV - Domestic	2 - Employment through installation, maintenance, potentially manufacturing, savings on energy bills from self-generation	N/A	2 - If targeted at vulnerable/low-income households can be a significant boost to social equity through cost savings on bills	N/A	2 - Can significantly reduce energy bills (c.25%)	1 - Increases individual resilience to energy price fluctuations; however, increased reliance on non-domestic supply chains
Solar PV – Commercial / public	2 - Employment through installation, maintenance, potentially manufacturing, savings on energy bills from self-generation	N/A	N/A	N/A	N/A	1 - Increases public sector/business resilience to energy price fluctuations; however, increased reliance on non-domestic supply chains
Solar PV – industrial	2 - Employment through installation, maintenance, potentially manufacturing, savings on energy bills from self-generation	N/A	N/A	N/A	N/A	1 - Increases industry resilience to energy price fluctuations; however, increased reliance on non-domestic supply chains
On-shore wind	2 - Employment through installation, maintenance, potentially manufacturing	0 - Improved air quality, but requirement for large-scale sites means land use change, habitat and ecosystem disruption, impact to bird migration	1 - If installed locally - potential for discounted rates	2 - Improved air quality	1 - If installed locally - potential for discounted rates	2 - Less reliance on fossil fuels and political energy market, enhanced grid security through integration of varied renewable sources
Transport						
Avoiding car journeys through new ways of living and working	0 - WFH reduces economic activity in employment areas (city centres)/challenge for building operators. Employees save money from reduced commuting / may boost spending in local areas outside of city centre	2 - Improved air quality from reduced traffic in city centres and commuting routes	0 - WFH can improve work-life balance but also contributing to isolation and access to WFH differs for different groups, which may not be equitable. Studies find gender roles can be reaffirmed with women taking on more domestic chores alongside working role	0 - Improved air quality from reduced traffic, but physical/mental health outcomes from WFH very dependent	0 - Complex, WFH potentially increase costs from increased energy demand in the day, but may also result in savings from more time spent at home and no commuting costs	1 - Decreases exposure to climate-related transport disruptions (e.g. extreme weather)
Avoiding car journeys through behavioural changes such as car sharing	1 - Potential for individual savings from sharing costs of vehicle running	1 - Improved air quality through reduced number of vehicles on the road	1 - Can support social cohesion and increased sense of community	1 - Improved air quality through reduced number of vehicles	1 - Potential for individual savings from sharing costs of vehicle running	1 - Reducing demand for travel alleviates pressure on the electricity grid.

Net Zero Pathway	Local economic impacts	Local environmental impacts	Social Equity	Health	Fuel poverty	Resilience
Switching to active travel	1 - Individual savings from reduced vehicle running costs, requirement for active travel routes to be constructed, supporting local jobs	2 - Improved air quality from reduced number of vehicles on the road	0 - Potential for positive benefits, including improved health and cost savings, but implementation needs to address barriers such as safety concerns in neighbourhoods and ensuring active travel infrastructure is available everywhere	2 - Increased activity levels support various health outcomes, reduced air pollution	1 - Saving potential on commuting and other vehicle running costs	2 - Encouraging active over motorised transport allows road space to be reallocated to green space, which reduces flood risk and urban heat island effects
Switching to public transport	1 - Employment opportunities needed for public transport upgrades, local construction and manufacturing	2 - Improved air quality from reduced cars on the road if buses are zero emission	0 - Potential for positive benefits, including improved health and cost savings, but implementation needs to address barriers such as safety concerns in neighbourhoods and ensuring public transport routes are available everywhere	2 - Improved local air quality contributes to reduced respiratory diseases	0 - Dependent on the costs of public transport	2 - More efficient use of energy per passenger, less exposure to fluctuations in fossil fuel prices, and scalable for increased urban populations. Reduced congestion can reduce the effects of the urban heat island
Uptake of electric vehicles (cars, vans, motorcycles)	1 - Employment opportunities through EV charging facilities and operation, manufacturing	2 - Improved air quality with zero tailpipe emissions	-1 - High upfront costs may prevent access, need to ensure charging infrastructure deployed across city to support transition	2 - Improved local air quality contributes to reduced respiratory diseases	0 - High upfront costs but reduced running costs	2 - Reduced exposure to climate-related financial risks (taxes and ULEZ), and to future availability and price of fuel. Enhanced energy and resource security, as the update encourages a shift away from fossil dependence. Can reduce the effects of urban heat islands - the effects of which have been noted in residential and urban areas in Bradford and can contribute to the risk of heat-related illnesses and mortality. Need to consider local grid capacity to determine its resilience to increased uptake.
Improving HGV efficiency through technology improvements and driver training initiatives	1 - Cost saving for businesses from improved efficiencies	1 - Reduced air pollution from efficiencies in driving	N/A	1 - Reduced air pollution from efficiencies in driving	N/A	2 - Reduced risk of breakdowns, hence stronger supply chains.
Reducing demand for LGV and HGV movements through trip consolidation and changes in logistics	1 - Cost saving for businesses from improved efficiencies, potential impact on employment	1 - Reduced air pollution from efficiencies in driving	N/A	1 - Reduced air pollution from efficiencies in driving	N/A	2 - Supply chains are more resilient against disruptions with improved logistics e.g. optimised routes, diversifying sourcing locations, and consolidating trips
Electrification of railways	1 - Potential for job creation in local construction and maintenance	1 - Improved local air quality, but potential disruption to environments from construction of overhead lines	0 - Potential for improved air quality and related improvements in health (e.g. reduced respiratory issues), but deployment needs to ensure access across society	2 - Improved local air quality contributing to reduced respiratory diseases	0 - Complex, unclear how high upfront costs will be recouped, potentially passed onto customers. Long-term running costs are lower for operators, but may take a while for savings on ticket prices to be realised for customers	2 - Increases use of excess renewable energy, providing a solution to the storage challenge. Less reliance on fossil fuels and enhanced energy and resource security.
Switching from LGVs to cargo bikes	1 - Potential for business savings from reduced operational costs, particularly within CAZ, opportunity for new job creation, but also job losses	2 - Improved air quality	0 - Potential for improved air quality and related improvements in health (e.g. reduced respiratory issues), but deployment needs to ensure access across society	2 - Active occupation opportunity, can support reduced air pollution where operating	N/A	2 - Reduces reliance on fossil fuels and complex logistics, increases operational flexibility in dense urban areas, and mitigates risk from fuel price volatility and traffic disruptions.

Net Zero Pathway	Local economic impacts	Local environmental impacts	Social Equity	Health	Fuel poverty	Resilience
Uptake of electric / hydrogen buses	1 - Employment opportunities through EV charging facilities/hydrogen refuelling and operation, manufacturing, and training opportunities for existing bus operators	1 - Reduced air pollution (particularly NO_2, PM_{10} and $PM_{2.5}$) and noise pollution when using zero emission buses and right coloured hydrogen	0 - Potential for improved air quality and related improvements in health (e.g. reduced respiratory issues), but deployment needs to ensure access across society	2 - Reduced air pollution (particularly NO_2, PM_{10} and $PM_{2.5}$) and noise pollution	0 - Complex, unclear how high upfront costs will be recouped, potentially passed onto customers. Long-term running costs are lower for operators, but may take a while for savings on ticket prices to be realised for customers	2 - Reduced exposure to climate-related financial risks (taxes and ULEZ), and to future availability and price of fuel. Increases the use of excess renewable energy, providing a solution to the storage challenge. Less reliance on fossil fuels and enhanced energy and resource security.
Uptake of electric / hydrogen HGVs	1 - Employment opportunities through EV charging facilities/hydrogen refuelling and operation, manufacturing, and training opportunities for existing HGV operators	2 - Reduced air pollution (particularly NO_2, PM_{10} and $PM_{2.5}$) and noise pollution	N/A	2 - Improved local air quality contributes to reduced respiratory diseases	N/A	2 - Reduced exposure to climate-related financial risks (taxes and ULEZ), and to future availability and price of fuel. Increases the use of excess renewable energy, providing a solution to the storage challenge. Less reliance on fossil fuels and enhanced energy and resource security.
Uptake of biomethane HGVs	1 - Employment opportunities for construction and manufacturing, potential circular economy opportunities supporting local biomethane producers, training opportunities for existing HGV operators	0 - Supports the usage of waste resources; however, AQ modelling suggests the use of biomethane increases NO_x in comparison to diesel	N/A	-1 AQ modelling suggests increase NO_x in comparison to diesel which can be detrimental to health	N/A	1 - Provides diversification and reduces reliance on fossil fuels. However, long-term resilience is lower than electrification due to NO_x emissions and dependency on consistent feedstock.
Waste						
Landfill: reduce, recycle, bans, methane capture	2 - Local employment of waste management officers, refuse collectors, sorting and processing of recyclable materials, equipment operators. Construction of recycling facilities.	2 – Reduced CH_4 emissions, Reduced leaching of chemicals into soil and groundwater, protecting local ecosystems and drinking water systems.	1 - Improved waste management and encouragement of re-use, recycling, and diverting waste from landfills can reduce the impact of waste disposal/use of landfills often sited in low-income or minority communities, reducing exposure to environmental hazards, odours, and health risks. Local waste diversion initiatives can foster community engagement and awareness	1 - Improved waste management and waste diversion from landfill can improve health outcomes for communities near sites by reducing exposure to harmful air pollutants and VOCs	N/A	2 - Waste reduction and recycling contribute to climate change adaptation (reduced odour, dust, vermin build resilience to climate change), a more circular economy, and greater resource efficiency. Reducing dependence on finite resources, including reliance on imported or fossil-based energy.
Composting	1 - Employment related to composting facilities, sales of composting products, education and outreach. Local businesses can sell compost, mulch and soil amendments for landscaping/agriculture/gardening purposes	2 - Reduced soil contamination, reduced CH_4 production (during anaerobic respiration of organic waste), enhanced soil health (soil structure, water retention, nutrient content), reducing the need for chemical fertilisers and minimising soil erosion, overall healthier habitats for flora and fauna.	1 - Local composting programmes can foster social inclusion, enhance community self-reliance and stewardship, and support local food production	1 - Support improved quality of local food, which can support mental health	1 - Can support local food growth and self-reliance	2 - Healthier ecosystems are more resilient to climate shocks e.g. soils amended with compost can better retain moisture, supporting plants during drought periods. Healthy soils with improved moisture retention and ground cover can lower wildfire risk in certain contexts.
Wastewater improvements	1 - Employment through wastewater treatment facilities (engineering, operations, maintenance, administration)	2 - Cleaner water bodies, treated wastewater can be used for agriculture/irrigation, flood control and habitat preservation.	1 - Improved wastewater management and improvement in technologies could reduce exposure to environmental hazards, odours, and health risks, which are often sited in low-income or minority communities	1 - Reduced waterborne diseases and related illnesses, reduced strain on healthcare services	N/A	2 - Wastewater improvements can reduce demand for freshwater resources, and hence reduce vulnerability to drought. Combining wastewater and stormwater systems and implementing nature-based solutions and green infrastructure can help reduce vulnerability to floods.

Net Zero Pathway	Local economic impacts	Local environmental impacts	Social Equity	Health	Fuel poverty	Resilience
Agriculture & Land Use						
Agricultural machinery (fuel switch)	1 - Development and maintenance of new equipment, cost savings for farmers from decarbonisation measures	1 - Reduced CH_4 and N_2O from improvements to slurry and manure management, reduced ammonia and NO_x emissions from improved nitrogen use efficiency. Some potential for 'pollution swapping', i.e. decreasing one pollutant can increase another, but overall impact is likely to be broadly positive. Modernised machinery minimises soil erosion.	-1 Advanced machinery can displace traditional farming roles, and may impact cultural identity in farming communities, high upfront costs of machinery may prevent access	1 - More modern, safer machinery, reduction in local air pollutants, improving respiratory illness outcomes	N/A	2 - Allows farmers to adapt more effectively to changing environmental conditions and respond faster to shifts in climate or the emergence of new pests. More efficient and resilient machinery can improve responsiveness to weather events, reduce downtime, and enable precision farming that conserves water and reduces soil degradation.
Soil measures (grass-legume mixes, reduced fertiliser use)	2 - Reduced reliance on expensive synthetic fertilisers, improved soil fertility and therefore productivity, reduced input costs	2 - Reduced emissions from fertiliser production and application, improves soil health and biodiversity, and improved air quality	1 - Can benefit smaller farmers by reducing input dependency	1 - Reduce nitrate run-off/ammonia emissions, cleaner air and water, supporting health outcomes	N/A	2 - Improving soil organic matter through soil measures enhances water retention and infiltration, stabilising water flows, reducing surface runoff, and mitigating flooding, particularly under extreme rainfall events. This promotes increasing resilience to drought and extreme weather events. Improved soil biodiversity supports ecosystem stability, and healthier soils are better able to sequester carbon and recover from climate shocks.
Livestock measures (feed additives to reduce CH_4, breeding and health interventions, animal waste management)	1 - Healthier animals increase productivity and reduce costs, reduced use of fertilisers can save costs and generate value, and additives for feed may be more costly than alternatives	2 - Reduced nutrient run-off from animal waste/water pollution, reducing herd sizes, reduced impact of grazing, improved air quality	0 - Can benefit smaller farmers by reducing input dependency, but depends on whether upfront costs prevent access	1 - Reduce methane/ammonia emissions, cleaner air and water, supporting health outcomes	N/A	1 - Improved animal health and waste management systems can reduce the vulnerability of farms to disease outbreaks and environmental contamination during heavy rainfall or drought. However, benefits depend on adoption and local conditions.
Tree planting	1 - Employment opportunities associated with silviculture; volunteer organisations/work social value often can support tree planting	2 - Trees and other green infrastructure, if right species are planted in the right places, can aid in improving air quality by absorbing pollutants such as particulate matter	1 - Opportunity if targeted planting around low-income/vulnerable groups/where there is disparity between access to green infrastructure.	2 - Increased access to natural spaces contributes to improved mental and physical health outcomes	N/A	2 - Improved flood resilience and significant reduction of overheating risk/effects of urban heat island
Peatland restoration	1 - Employment opportunity associated with peatland management / conservation	1 - Peatland conservation contributes to improved local water quality, enhanced biodiversity, and carbon capture	0 - Restoration may impact traditional uses of peatland, communities that access or rely on peatland should be involved in restoration development. Improved peatland can increase access to natural spaces and contribute to mental and physical health outcomes	2 - Increased access to natural spaces contributes to improved mental and physical health outcomes	N/A	2 - Improved flood resilience, greater access to clean drinking water, improved protection from wildfires. Supports biodiversity.
Diet change	0 - Mixed impacts, potential positive impacts on local fruit, vegetables, legumes and grain farmers but negative impacts on local meat/dairy farmers who will need to diversify	1 - Changes in red meat consumption and farming practices leads to 'out of boundary' reductions in GHG pollution from livestock. There can be positive impacts on biodiversity and reduced agricultural runoff related to animal farming.	2 - Reduction in risk of developing chronic diseases, improved well-being. Community farming opportunities, strengthening social cohesion	2 - Reduction in risk of developing chronic diseases, improved well-being	2 - Vegan and vegetarian diets can reduce costs up to one-third	2 - Reduced land used for meat/dairy farming allows land to be used for other uses, including green spaces to enhance flood resilience and address the urban heat island effect. Plant-based diets are generally less energy-intensive compared to animal-based diets.

4. AIR QUALITY CO-BENEFITS

4.1 AIR QUALITY AND CLIMATE CHANGE CONTEXT

To enable Bradford to understand the air quality co-benefits of the CAP, an air quality emissions scenario has been calculated to assess the effects of the net zero Scenario measures on emissions of nitrogen dioxide (NO_2), particulate matter with an aerodynamic diameter of 10 micrometres or less (PM_{10}) and particulate matter with an aerodynamic diameter of 2.5 micrometres or less ($PM_{2.5}$), which are key air pollutants for the Council.

This chapter provides an overview of air quality and its links with climate change, the methodology used for calculating emissions from the Net Zero 2038 Scenario, and the results under the 2038 Net Zero Scenario against the modelled air quality baseline for 2023.

Air pollution is recognised as a major health concern worldwide, including in the UK. According to the UK Government, exposure to air pollution, particularly fine particulate matter ($PM_{2.5}$) and NO_2, is responsible for an estimated 28,000 to 36,000 deaths annually.[235].

In exploring the co-benefits between GHG emissions reductions and air pollutant emissions reductions, it is important to understand the relationship between three things: emissions-generating activity, the resulting air pollution concentrations, and their health impact, as illustrated in Figure 4-1.

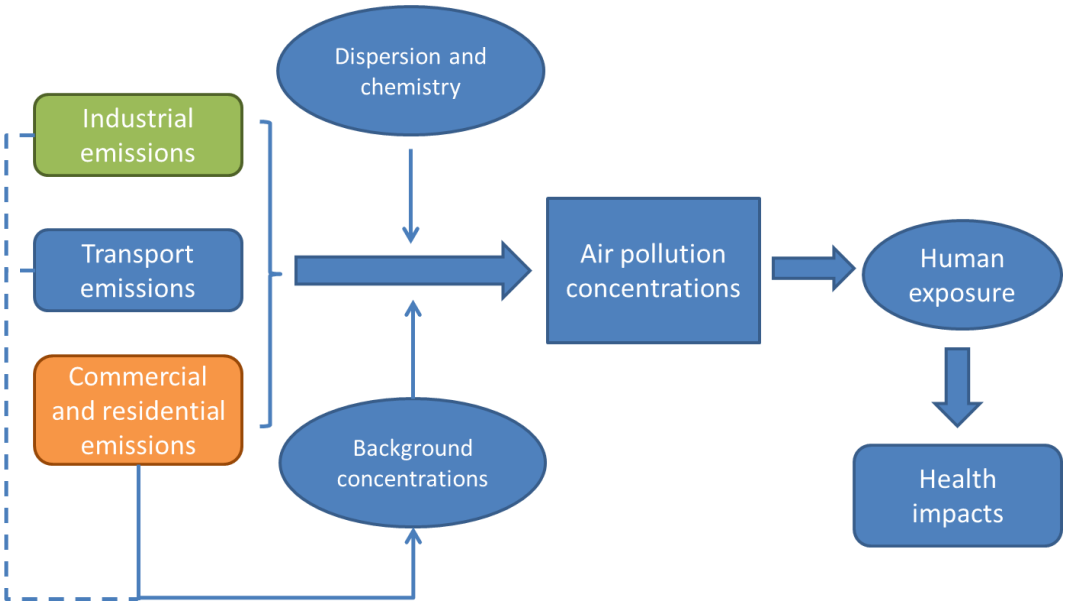

Figure 4-1: The relationship between emissions, concentrations and health impacts.

The common anthropogenic sources of NO_2, PM_{10} and $PM_{2.5}$ emissions generally also produce GHG emissions – for example, activities such as household fuel burning, industrial chimneys, traffic exhausts, power generation, open burning of waste and agricultural practices. Incomplete combustion or chemical reactions during these activities release both climate-damaging gases and pollutants that impact air quality. Additionally, there are chemical transformations within the atmosphere as GHGs and air pollutants react with each other, other pollutant gases, sunlight and water vapour within the atmosphere. Some of these reactions lead to further GHGs or air pollutants being formed. Therefore, actions to reduce GHGs often have the effect of also reducing air pollution, and vice versa. This creates significant potential for synergies between actions to reduce air pollution and actions to address climate change.[236]

[235] Public Health England (2019). Improving outdoor air quality and health: review of interventions. Available at: https://www.gov.uk/government/publications/improving-outdoor-air-quality-and-health-review-of-interventions
[236] EEA (2022). Cross-cutting story 5: Co-benefits of addressing climate change and pollution. Available at: https://www.eea.europa.eu/publications/zero-pollution/cross-cutting-stories/cross-cutting-story-5-co

It is important to assess reductions in air quality concentrations and emissions separately. This is because reductions of emissions of air pollutants reduce atmospheric concentrations, but the level of reduction in atmospheric concentrations is not always proportionate to the reduction in emissions. This is due to the relationship between emission sources and the transboundary nature of air pollution.[237]

It is also important to consider that there can be trade-offs between climate and air pollution.[238] There are some actions that can be taken to reduce GHG emissions, which can lead to higher emissions of air pollutants. For example, increased biomass burning has helped reduce fossil fuel consumption, but it may have led to higher emissions of PM and Volatile Organic Compounds (VOCs) from the renewable energy sector (especially from heating) in the EU[239].

The National Atmospheric Emissions Inventory (NAEI) programme calculated projected emissions for NO_x and PM as required by Defra, to meet international reporting requirements. The latest available Projected Air Quality Emissions Data: 2025-2050[240] is presented in Figure 4-2 demonstrates that emissions of air pollutants are projected to decrease nationally between 2023 and 2050, with a 46% total decrease in national NO_x emissions projected between 2023 and 2040. Emissions of $PM_{2.5}$ are also projected to decrease in this timeframe, but at a smaller scale (13% total decrease). Emissions of PM_{10} are projected to decrease slightly -5%) to 2030 and then increase from 2035 to 2050.

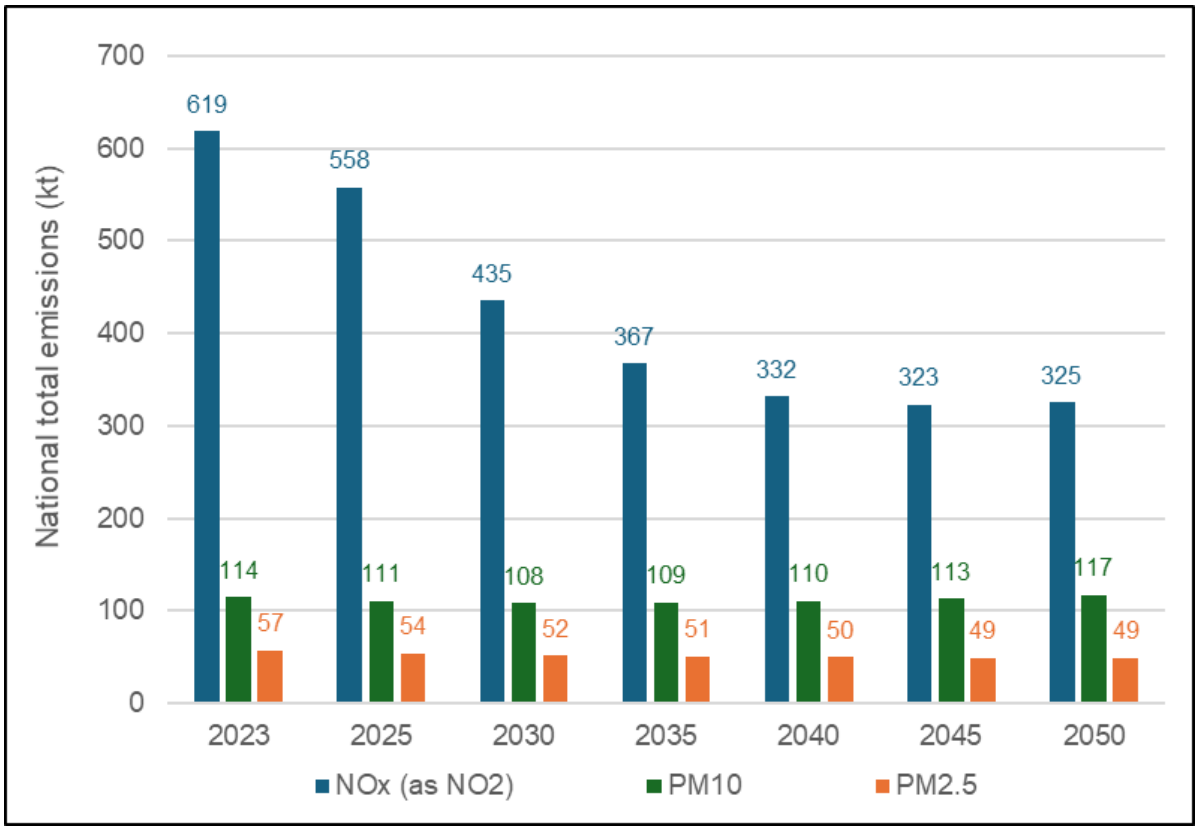

Figure 4-2: National total emissions projections 2023-2050 for NOx, PM_{10} and $PM_{2.5}$ (NAEI, 2025).

Emissions reductions of air pollutants at the national level will likely result in some reductions of air pollutant emissions and concentrations at the regional and local levels. The CAP provides an opportunity for climate

[237] Defra (2025). Emissions of air pollutants in the UK – background. Available at: Emissions of air pollutants in the UK - Background - GOV.UK

[238] Defra; Air Quality Expert Group (2020). Impacts of Net Zero pathways on future air quality in the UK. Available at: https://uk-air.defra.gov.uk/assets/documents/reports/cat09/2006240802_Impacts_of_Net_Zero_pathways_on_future_air_quality_in_the_UK.pdf

[239] EEA (2023). Dashboard - Impacts of renewable energy use on decarbonisation and air pollutant emissions. Available at: https://www.eea.europa.eu/en/analysis/maps-and-charts/impacts-of-renewable-energy-on-decarbonisation-and-air-quality-renewable-energy

[240] NAEI (2025). Air Pollutant Emissions Data. Available at: https://naei.energysecurity.gov.uk/air-pollutants/air-pollutant-emissions-data

change and GHG emissions reduction interventions to be planned and implemented at a local scale, going beyond nationally planned measures.

4.2 DATA SOURCES AND METHODOLOGY

This section details the methodology used to calculate emissions for the 2038 Net Zero Scenario, building upon the 2023 AQ Baseline. Some of the methodology of the Baseline modelling is provided in Appendix 2, with full detailed methodology available in the GHG Baseline, Stakeholder and Policy Mapping Report.

4.2.1 Calculating 2038 Net Zero Scenario emissions from road transport

The 2038 AQ Net Zero Scenario emissions from road transport from major roads (including emissions from Motorway, Primary, Trunk, Brake and Tyre wear and Road abrasion) are calculated by applying assumptions about future changes for the Net Zero Scenario to the 2023 baseline fleet and activity data. A summary of the methodology for the 2023 baseline fleet and activity data, as well as the baseline air quality dispersion modelling, is provided in Appendix 2.

For 2038, road transport emissions were calculated by projecting the baseline fleet composition to 2038 using the Defra Emissions Factor Toolkit (EFT) v13.1 projection tool. The fleet composition projections included in the tool (for areas outside of London) are developed from projections in the 2022 version of the NAEI programme, which in turn, uses information provided by DfT in December 2023 on future sales and activities of new petrol, diesel and electrically-powered cars and LGVs, combined with future forecasts in traffic (vehicle kilometres) including other vehicle types from DfT's National Transport Model.

In terms of road transport activity, adjustments were applied to the baseline road transport activity data to represent the Net Zero Scenario road transport in 2038 (as described by the measures in Table 2-3 in Section 2.2.2). These are presented by vehicle type in Table 4-1.

Table 4-1: Adjustments were applied to the baseline road transport activity data to represent net zero scenario road transport for the 2038 AQ modelling scenario.

Vehicle type	Adjustments made to the Net Zero Scenario road transport activity data
Private cars	Reducing the number of private cars in the AADT by a total of 44.7%, through new ways of living and working (3% reduction), car sharing (11.7% reduction), switching from car travel to walking and wheeling (1.1% reduction), cycling (6% reduction), bus travel (9% reduction) and rail travel (13.9% reduction).
Private cars and taxis	Increasing the proportion of EVs, hybrids and alternative fuels in the private car and taxi AADT, to 82% electric cars, 7% plug-in hybrid electric vehicles, and 2% hydrogen fuel cell vehicles.
LGVs	Reducing the number of LGV journeys in the AADT by 5%, through shifting from LGVs to cargo bikes.[241]
	Increasing the proportion of EVs in LGV AADT to 82% electric.
Buses	Increasing the proportion of EVs and alternative fuels in the bus AADT, to 66% electric and 34% hydrogen fuel cell vehicles.
HGVs	Reducing emissions from HGVs by 15% for 50% of HGVs, through technology improvements and driver training initiatives.
	Reducing the number of HGV journeys in the AADT by a total of 60%, through trip consolidation and changes in logistics (10%) and shifting from road to rail (50%).

[241] Cargo bikes could not be included in the AQ Net Zero Scenario Model, please see list of assumptions detailed in Tables 2.2 and 2.3.

Vehicle type	Adjustments made to the Net Zero Scenario road transport activity data
	Increasing the proportion of EVs and alternative fuels in the HGV AADT, to 79% electric, 2% hydrogen fuel cell vehicles, and 14% biomethane.

There were a number of limitations in applying the measures from the Net Zero Scenario to the AQ road transport modelling for 2038:

1. The EFT doesn't make specific emissions calculations for hydrogen-cell vehicles, which can be assumed to behave similarly on-road to electric vehicles (i.e. no tailpipe emissions, and similar PM emissions from brake, tyre-wear and road abrasion). Hydrogen-cell vehicles were modelled in the EFT as electric vehicles.
2. The CAZ + C preferred option traffic model, which underpins the baseline activity data, does not include motorcycles. Therefore, we could not model the measure "Ambitious uptake of electric motorcycles" (85% electric motorcycles in 2038).
3. The EFT does not have specific accommodations for cargo bikes, which could not be included in the traffic model. Therefore, we could not fully model the measure "Switching from LGVs to cargo bikes". We did model a 5% decrease in LGV emissions, but could not model the cargo bikes introduced to the road network to replace 5% of last-mile LGV journeys. As the cargo bikes are expected to be electric, there would be no NO_x emissions from cargo bikes. No suitable proxy vehicle for PM_{10} and $PM_{2.5}$ emissions from cargo bikes was available.
4. As the EFT does not include emissions calculations for biomethane HGVs, we derived an adjustment factor to convert 14% of diesel HGVs to biomethane HGVs in 2038. The adjustment factor was derived from the EFT emissions calculation for biomethane buses. Adjustment factors to convert diesel HGVs to biomethane HGVs were derived for each pollutant based on the emissions from a biomethane bus and emissions from a diesel bus on a road link with an average length and speed for the modelled road network. Therefore, we are assuming a similar difference in emissions between diesel and biomethane HGVs as seen in buses. The adjustment factors were applied equally to the rigid and articulated HGV AADT.

Additionally, we were advised by CBMDC that several roads in Bradford city centre were pedestrianised in late 2023/2024. No traffic flows were modelled for those road links, shown in Figure 4-3.

Emissions from minor roads and cold starts are not included in the road transport emissions modelling (due to lack of available data), with concentrations from minor road and cold start emissions being taken from Defra background map concentrations for 2038 (based on 2021 baseline reference year) and added to the modelled major road and other sources/background concentrations for the 2038 Net Zero Scenario. Therefore, the 2038 Minor Road concentrations only include national-level assumptions about emissions on minor roads in Bradford in 2038 (the Defra background maps are modelled based on NAEI projected emissions). The reference year for the 2038 background maps is 2021, the latest available at the time of this study.

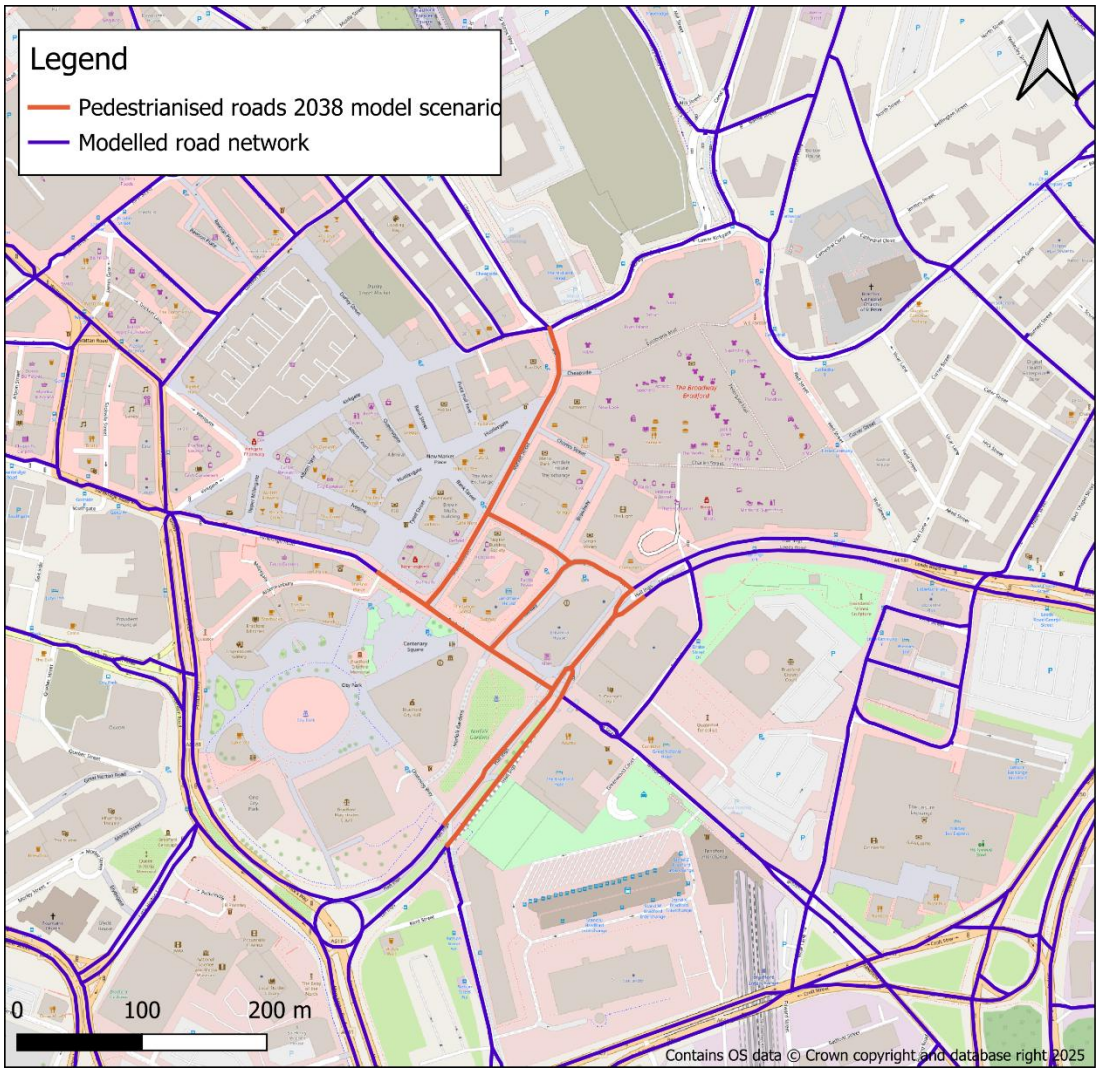

Figure 4-3: Map of pedestrianised roads (shown in red), for which no traffic flow was modelled for the 2038 Net Zero Scenario.

4.2.2 Calculating 2038 Net Zero Scenario emissions from other sources

The NAEI produces national emissions projections out to 2050, and the 2038 emissions were disaggregated to 1x1 km resolution following the standard NAEI spatial methodology.[242] These business-as-usual (BAU) emissions were then scaled to align with the net zero scenario.

The output from the net zero modelling identified changes in energy use across various sectors from certain fuels, between the 2038 BAU GHG and 2038 Net Zero Scenario. This change in energy use was taken to be representative of the change in emissions from those fuels within those sectors, between the net zero modelled BAU and Net Zero Scenario. The change in energy use was then used to calculate scaling factors for gas oil, natural gas and coal for the domestic, commercial, industry, public sector and agriculture sectors. The scaling factors were applied to the NAEI BAU emissions for 2038.

Scaling the 2038 NAEI emissions to match the net zero scenario was preferable to scaling the CERC emission maps (used in the 2023 baseline modelling of non-road emission sources) to 2038, as the breakdown of the

[242] DESNZ (2022). NAEI: UK Spatial Emissions Methodology. Available at: https://naei.energysecurity.gov.uk/sites/default/files/2024-12/UK_Spatial_Emissions_Methodology_for_NAEI_2022.pdf

CERC maps was not detailed enough to accurately apply the scaling factors. For example, it was not possible to ascertain from the CERC maps how much of the emission in a grid cell was related to gas oil or natural gas.

The scaling factors applied to the BAU emissions are given in the table below.

Table 4-2: Scaling factors applied to 2038 BAU emissions from the NAEI.

Year	Sector	Fuel type	Factor
2038	Domestic	Natural gas	0.176624
2038	Domestic	Gas Oil	0
2038	Domestic	Coal	0
2038	Commercial	Natural gas	0.109564
2038	Commercial	Gas Oil	0
2038	Commercial	Coal	0
2038	Industry	Natural gas	0.145729
2038	Industry	Gas Oil	0
2038	Industry	Coal	0
2038	Public Sector	Natural gas	0.12326
2038	Public Sector	Gas Oil	0
2038	Public Sector	Coal	0
2038	Agriculture	Natural gas	0.073
2038	Agriculture	Gas Oil	0.499
2038	Agriculture	Coal	0

4.2.3 Air Quality dispersion and canyon model

The dispersion modelling was carried out using the same RapidAir dispersion modelling system that has been used to assess the 2023 AQ baseline pollutant concentrations.

The 2038 air quality dispersion modelling for the Net Zero Scenario uses the same data inputs as the baseline model:

- 2023 meteorological data as used in the 2023 baseline model.
- Street canyons as used in the 2023 baseline model (and previously used in the CAZ modelling).

This ensures that differences in concentration results for the 2038 scenario reflect the changes in emissions alone.

The primary NO_x adjustment factor of **2.28** from the 2023 Baseline Model validation was applied to the concentration results for the 2038 Net Zero Scenario to calculate:

- Citywide modelling results at monitoring locations for NO_2, PM_{10} and $PM_{2.5}$.
- Citywide 1 m resolution NO_2, PM_{10} and $PM_{2.5}$ annual mean concentration rasters providing a continuous representation of the spatial variation in modelled concentrations.

4.3 RESULTS: AIR POLLUTANT EMISSIONS

This section presents the results from the compilation of baseline emissions of air pollutants for 2023, and the net zero Scenario emissions of air pollutants for 2038. These results reflect the impact of national-level changes in emissions between the baseline and 2038, in addition to local Net Zero Scenario measures across the City of Bradford Metropolitan District, as set out in Section 2.2.

Table 4-3 shows the total emissions for NO_x, PM_{10}, and $PM_{2.5}$ within the City of Bradford Metropolitan District in tonnes/annum for road transport (including minor roads) and background emissions. Table 4-3 shows that NO_x emissions reduce by 60%, with road transport emissions decreasing by 93%. PM_{10} and $PM_{2.5}$ emissions decrease by 12% and 26%, respectively, with road transport emissions decreasing by 55% and 57%, respectively. There are also reductions in total background emissions by 19% for NO_x, 6% for PM_{10}, and 21% for $PM_{2.5}$.

Table 4-3: Emissions for each pollutant across the City of Bradford Metropolitan District for road transport (including minor roads) and background.

	NO_x tonnes/year				PM_{10} tonnes/year				$PM_{2.5}$ tonnes/annum			
	2023	2038	Change (t/yr)	Change (%)	2023	2038	Change (t/yr)	Change (%)	2023	2038	Change (t/yr)	Change (%)
Total emissions	**3,466**	**1,373**	**-2,094**	**-60%**	**622**	**547**	**-75**	**-12%**	**326**	**241**	**-85**	**-26%**
Road transport emissions	1,944	142	-1,802	-93%	80	36	-44	-55%	47	20	-27	-57%
Background emissions	1,522	1,231	-292	-19%	542	511	-31	-6%	279	221	-58	-21%

Table 4-3 provides tabulated emissions with the percentage change in emissions between the baseline and 2038 Net Zero Scenario. The results show that for NO_x, there are very significant reductions in total NO_x emissions from both minor roads by 1,275 tonnes per year (85% reduction for this sector) and major roads by 527.4 tonnes per year (96% reduction for this sector), and from domestic and commercial combustion by 169.2 tonnes per year (44% reduction for this sector). The production processes sector sees a 99.6% reduction in emissions from this sector, consisting of a 24-tonne per year decrease. There are also decreases in NO_x emissions within the industrial combustion (62.7 tonnes per year), point sources (55.9 tonnes per year), agriculture (4.3 tonnes per year) and solvents (-0.2 tonnes per year) sectors.

Some source sectors are projected to increase in air pollutant emissions between the baseline and 2038. For NO_x, the increases in emissions in tonnes per year are small; the greatest increase from any one sector is less than 0.6% of the total baseline NO_x emissions across the district in 2023. The sectors estimated to have increases in NO_x emissions in the 2038 Net Zero Scenario are other mobile sources and machinery (22.4 tonnes per year), energy production (1.1 tonnes per year), other sources and sinks (1.1 tonnes per year) and waste (0.1 tonnes per year). For energy production and other sources and sinks, the proportional increases are greater than 100% of the baseline emissions from these sectors.

Table 4-4: Emissions for each pollutant across the City of Bradford Metropolitan District for background sources.

	Change in air pollutant emissions between 2023 Baseline and 2038 Net Zero Scenario					
	NO_x		PM_{10}		$PM_{2.5}$	
	tonnes/yr	%	tonnes/yr	%	tonnes/yr	%
Energy production	1.1	>100%	<0.1	9%	<0.1	9%
Domestic and Commercial combustion	-169.2	-44%	-33.9	-30%	-35.2	-32%
Industry combustion	-62.7	-17%	-4.2	-8%	-5.6	-11%
Production processes	-24.0	-99.6%	15.7	6%	-10.2	-24%
Solvents	-0.2	-34%	4.5	27%	0.8	7%
Other mobile sources and machinery	22.4	9%	-6.7	-42%	-6.7	-42%

Waste	0.1	6%	0.9	4%	0.9	4%
Agriculture	-4.3	-15%	-4.8	-34%	-0.9	-28%
Other sources and sinks	1.1	>100%	0.9	8%	0.8	8%
Heather Burning	0.0	0%	0.0	0%	0.0	0%
Point Sources	-55.9	-12%	-2.9	-25%	-1.6	-23%
Major Roads	-1,275.0	-96%	-38.4	-53%	-20.9	-53%
Minor roads	-527.4	-85%	-6.2	-77%	-6.1	-77%
Total change (tonnes/year)	**-2,093.9**	**-60%**	**-75.1**	**-12%**	**-84.7**	**-26%**

Figure 4-4 and Figure 4-5 presents a comparison of NO_x, PM_{10} and $PM_{2.5}$ emissions by source sector between the Baseline and 2038 Net Zero Scenario. These graphs show the significant reductions in concentrations from minor and major roads across all three pollutants. The sectors with projected increases in emissions in the 2038 Net Zero Scenario constitute minor proportions of total NO_x emissions in the City of Bradford Metropolitan District – the bars representing these sectors are barely visible in Figure 4-5.

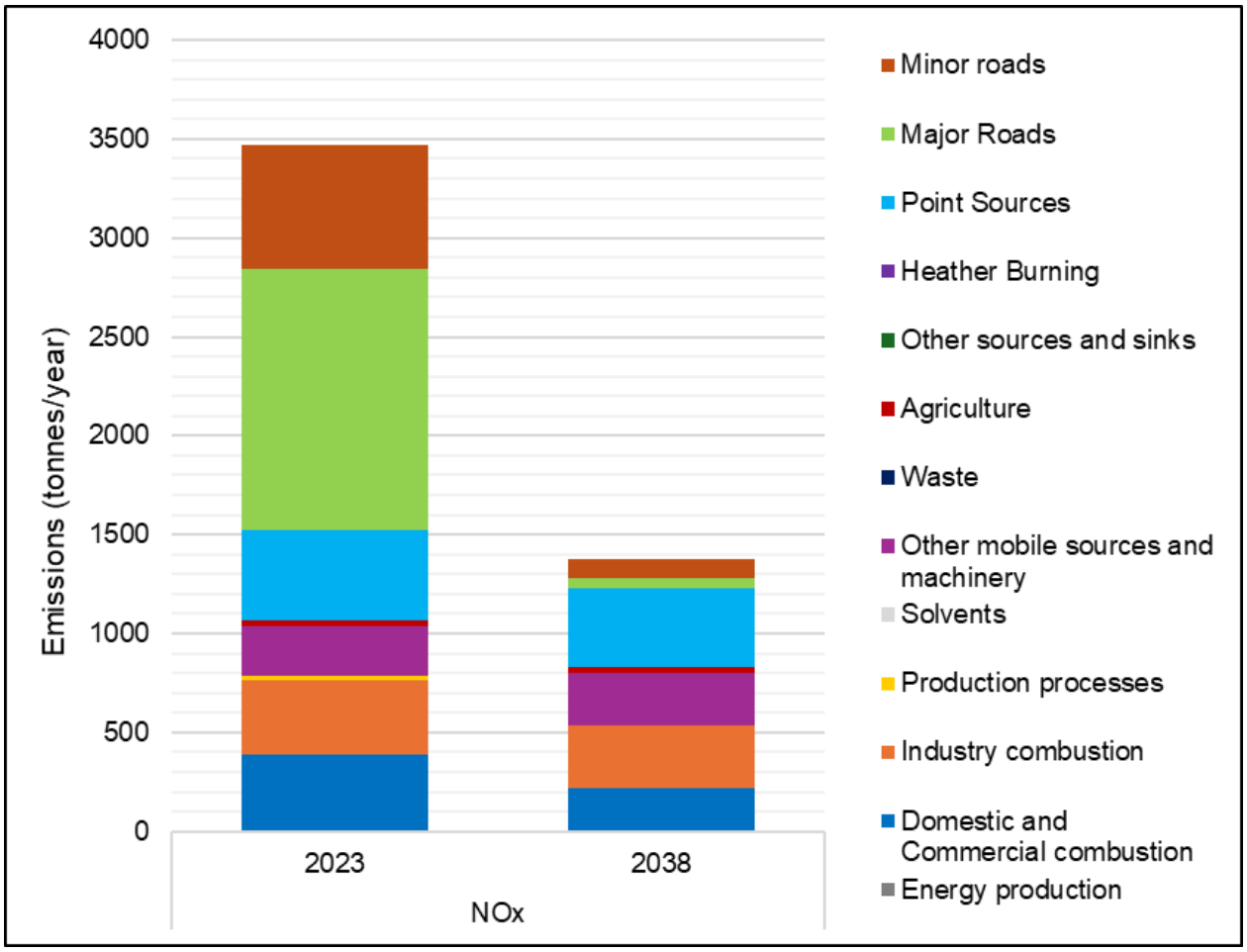

Figure 4-4: Comparison of 2023 Baseline and 2038 Net Zero Scenario NO_x emissions in Bradford Metropolitan District by Source Sector.

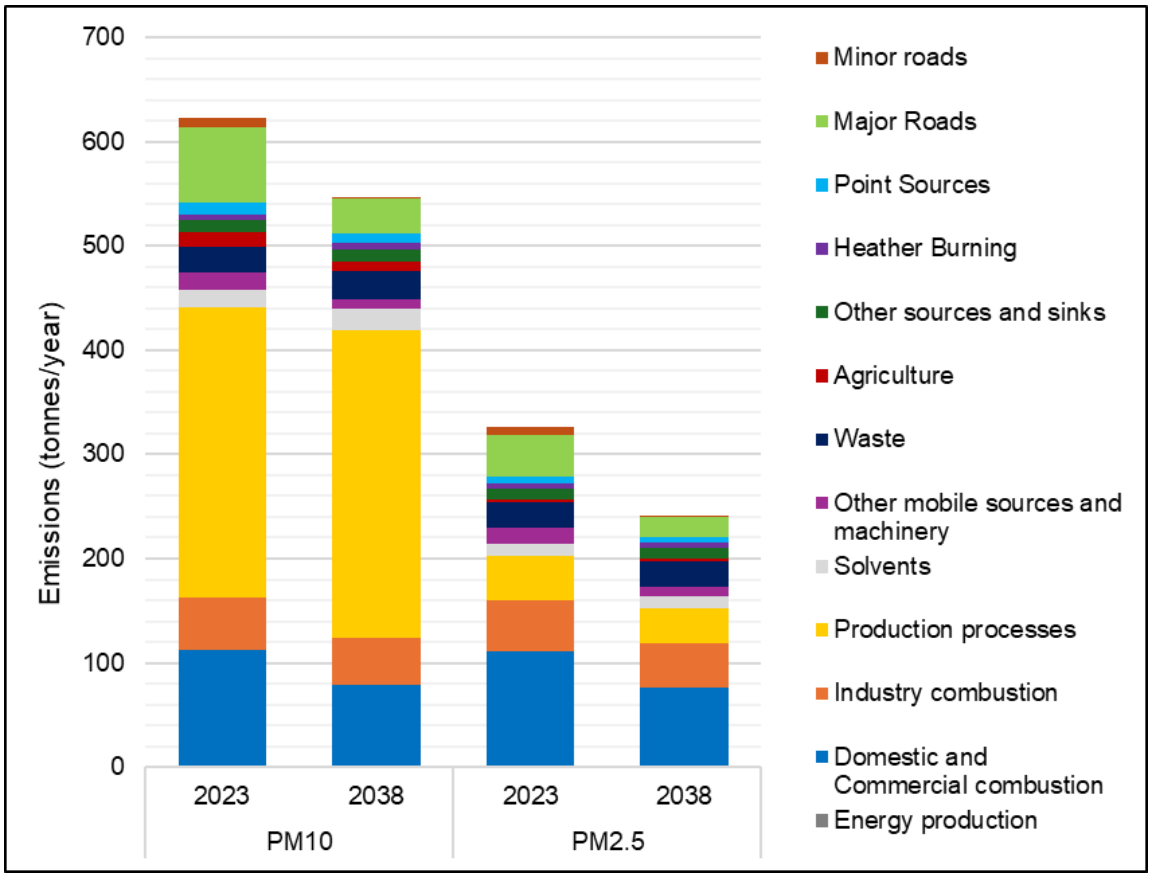

Figure 4-5: Comparison of 2023 Baseline and 2038 Net Zero Scenario PM_{10} and $PM_{2.5}$ emissions in Bradford Metropolitan District by Source Sector.

The emissions data is a spatial dataset, and it is important to note that there are certain sectors projected to show increases in NO_x, which are significant at specific locations in the district, as a result of the locations of activities with projected increases. This can be seen particularly with the 2038 projected NO_x emissions from point sources.

Figure 4-6 shows the difference in NO_x emissions in tonnes/year between the baseline and 2038 (2023 emissions minus 2038 emissions). There is largely very little change in point source NO_x emissions across the district; however, in the south of the district, there are point sources with some high projected increases. This is because the NAEI data predicts increases in the use of specific fuels in the chemical industry sector in 2038.

It is important to remember that the 2038 projected emissions are estimates based on the best available data and are not a prediction of the future. We do not consider it likely that NO_x emissions from point sources will increase to this extent in 2038. However, projected future emissions from point sources should be included for completeness of the dataset.

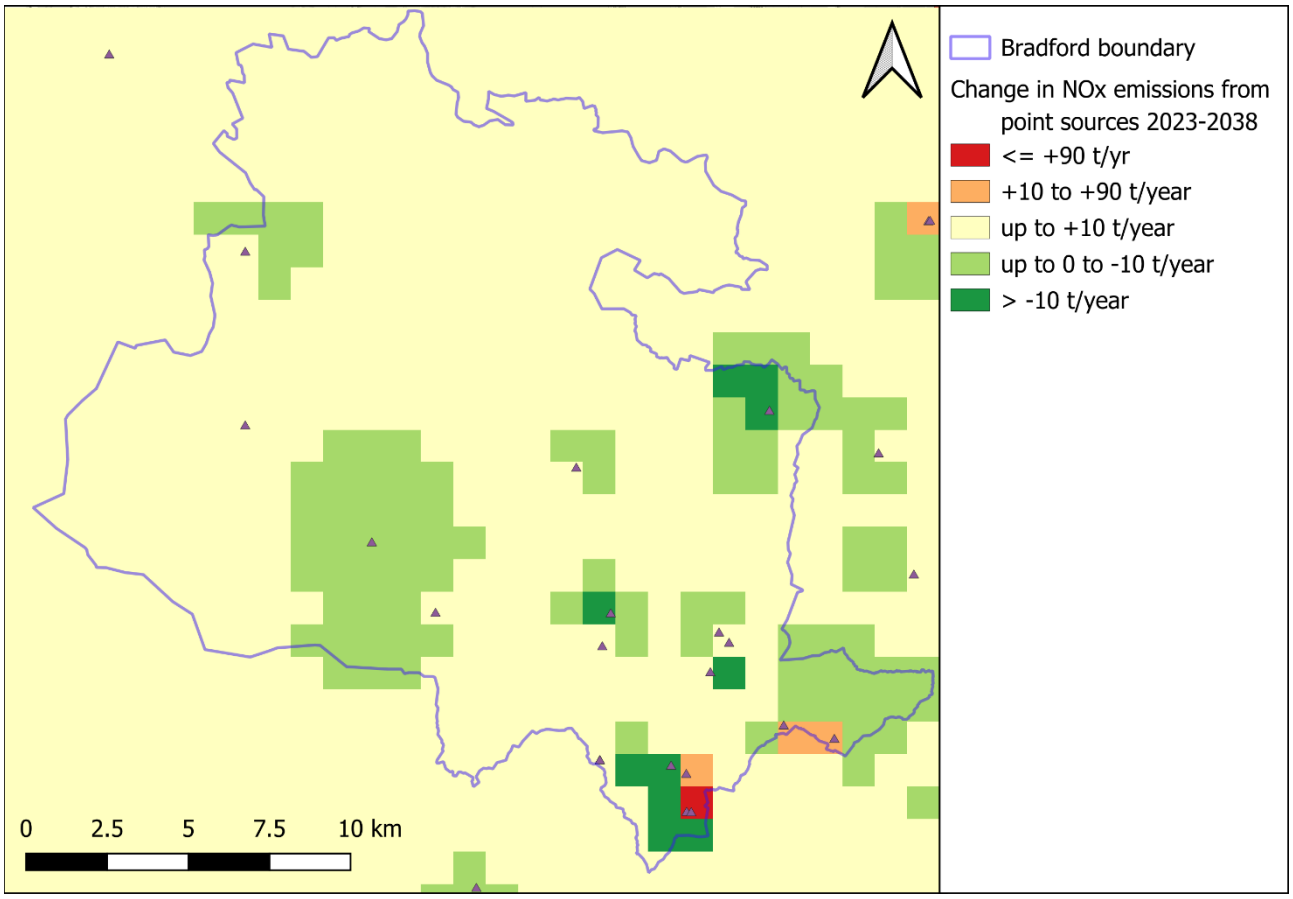

Figure 4-6: Map of the change in NO_x emissions for 2038 compared to the baseline, as predicted by the 2038 NAEI projections data.

4.3.1 Monetisation of Air Quality Impacts

The valuation of air quality impacts was conducted to assess the economic impacts due to changes in NO_x and $PM_{2.5}$ emissions for the net zero modelled scenario.

Monetisation of air quality impacts was calculated based on emissions reductions, computed against the air quality models' baseline and net zero scenario. Calculations have been conducted using the Defra Damage Costs Appraisal Toolkit[243] for the net zero year of 2038. Economic impact is presented as the NPV resulting from a change in emissions for NO_x and $PM_{2.5}$ separately, and as an aggregated NPV for both pollutants. The results for the monetisation of air quality impacts, as shown in Table 4-5, show a positive indication of net benefit (Central Value) by the year 2038, from the reduction in NO_x and $PM_{2.5}$.

Table 4-5: Monetisation of air quality impacts for the year 2038, from the net zero scenario emission modelling.

Scenario	NPV for NO_x (£)	NPV for $PM_{2.5}$ (£)	Total NPV (£)
Net zero scenario (2038) – Low Sensitivity	£2,783,457	£2,136,506	£4,919,963
Net zero scenario (2038) – Central value	£14,473,245	£5,391,124	£19,864,369
Net zero scenario (2038) – High Sensitivity	£53,788,988	£15,346,487	£69,135,475

[243] Defra (2023). Air quality appraisal: damage cost guidance. Available at: https://www.gov.uk/government/publications/assess-the-impact-of-air-quality/air-quality-appraisal-damage-cost-guidance

4.4 RESULTS: AIR POLLUTANT CONCENTRATIONS

This section presents the results from the compilation of baseline concentrations of air pollutants for 2023, and net zero scenario concentrations of air pollutants for 2038. As with the emissions, these results reflect the impact of national level changes in emissions between the baseline and 2038, in addition to local Net Zero Scenario measures across the City of Bradford Metropolitan District, as set out in Section 2.2.

4.4.1 Mapped modelled concentrations – comparison between 2023 Baseline and 2038 Net Zero Scenario

Figure 4-7 presents a comparison of modelled NO_2 concentrations in the 2023 baseline against the 2038 Net Zero scenario, across the full City of Bradford Metropolitan District, with Figure 4-8, Figure 4-9 and Figure 4-10 presenting closer views of modelled NO_2 concentrations in Bradford City Centre, Keighley and Shipley respectively.

These concentration maps show that in the Baseline, there are limited areas in the district where modelled NO_2 concentrations exceed the UK annual mean NO_2 Air Quality Objective limit of 40 µg/m^3 at the roadside in the Baseline scenario. In the 2038 Net Zero Scenario, there is a significant improvement in modelled NO_2 concentrations, bringing the majority of the district under the WHO guideline for annual mean NO_2 of 10 µg/m^3.

Reductions in modelled annual mean NO_2 concentrations can be particularly in the immediate vicinity of roads in the district, particularly in Bradford city centre (Figure 4-9). As discussed in Section 4.3, the NO_x emissions from road transport decrease in Bradford under the Net Zero Scenario by 93%, which can be seen clearly in the modelled concentration results for the Net Zero Scenario.

There are also some reductions which arise from background (non-road) sources, which are modelled at a 1 by 1 km resolution, so are visually distinct in 1 by 1 km grid squares in the concentration maps, where concentrations have increased.

As demonstrated Figure 4-6 at the end of Section 4.3, there are elevated NO_x emissions from point sources projected in the 2038 NAEI emissions data, which have subsequently resulted in elevated NO_2 concentrations in two 1 by 1 km grid squares to the south of the district. The 2038 modelled concentrations are derived from emissions projections estimated from the best available data and are not a prediction of the future. Again, we do not consider it likely that such considerably increased NO_x emissions from point sources and subsequent exceedances of the NO_2 concentrations at these locations are likely to occur 2038; however, modelled emissions and concentrations from point sources should be included for completeness of the dataset.

There are additional areas modelled to continue to be greater than the WHO guideline for annual mean NO_2 of 10 µg/m^3 in the 2038 net zero Scenario. There are two locations outside of where point sources have increased concentrations in the south, where modelled NO_2 concentrations are projected to exceed 20 µg/m^3 in the 2038 Net Zero Scenario. These are in Bradford city centre (Figure 4-8) and north east of Shipley (Figure 4-10). Additionally, there are areas with modelled NO_2 concentrations between 10-20 µg/m^3 in Bowling, West Bowling, East Bierley, Keighley and west of Queensbury.

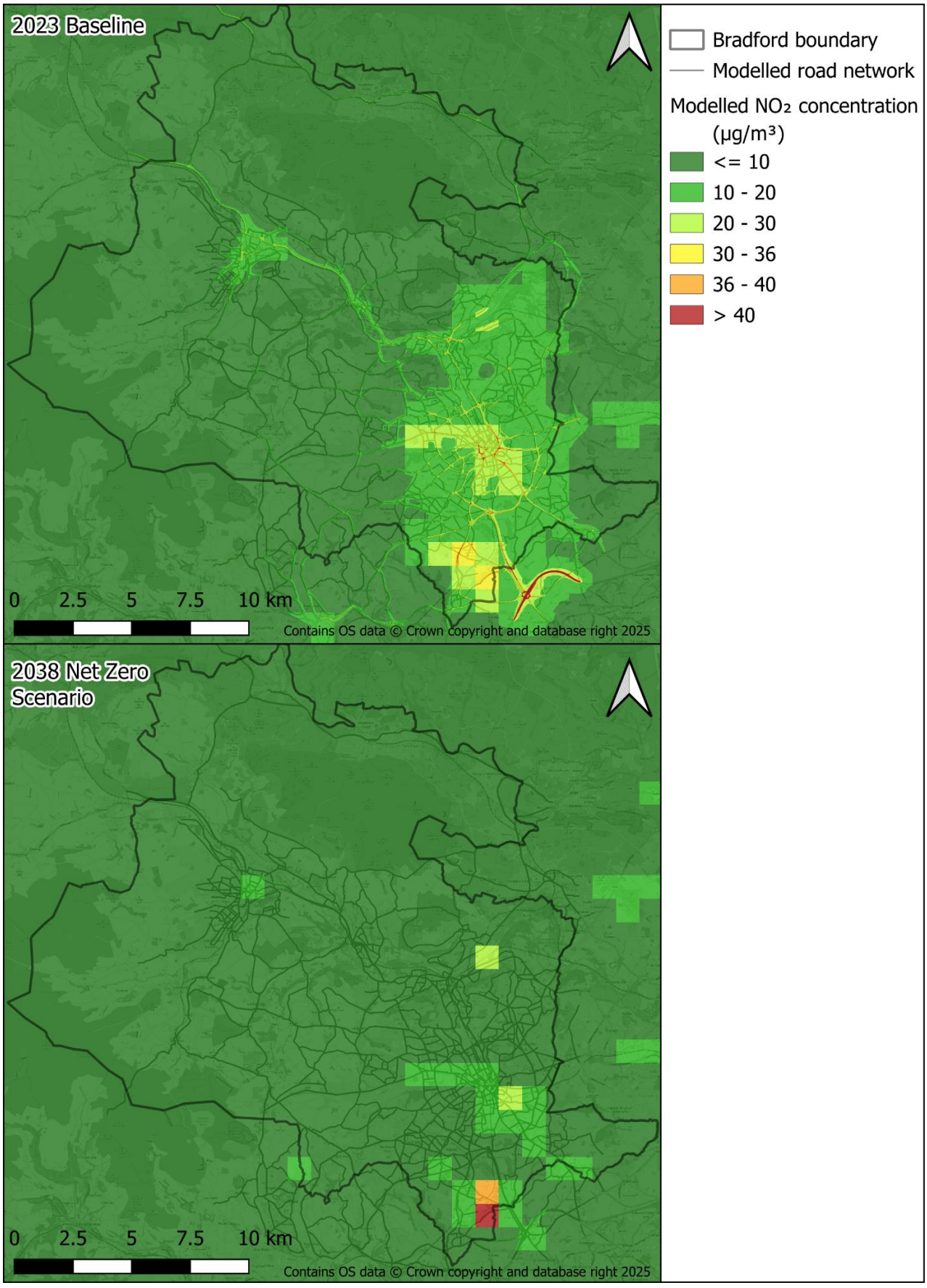

Figure 4-7: Comparison of 2023 Baseline and 2038 Net Zero Scenario modelled NO_2 concentrations across the City of Bradford Metropolitan District.

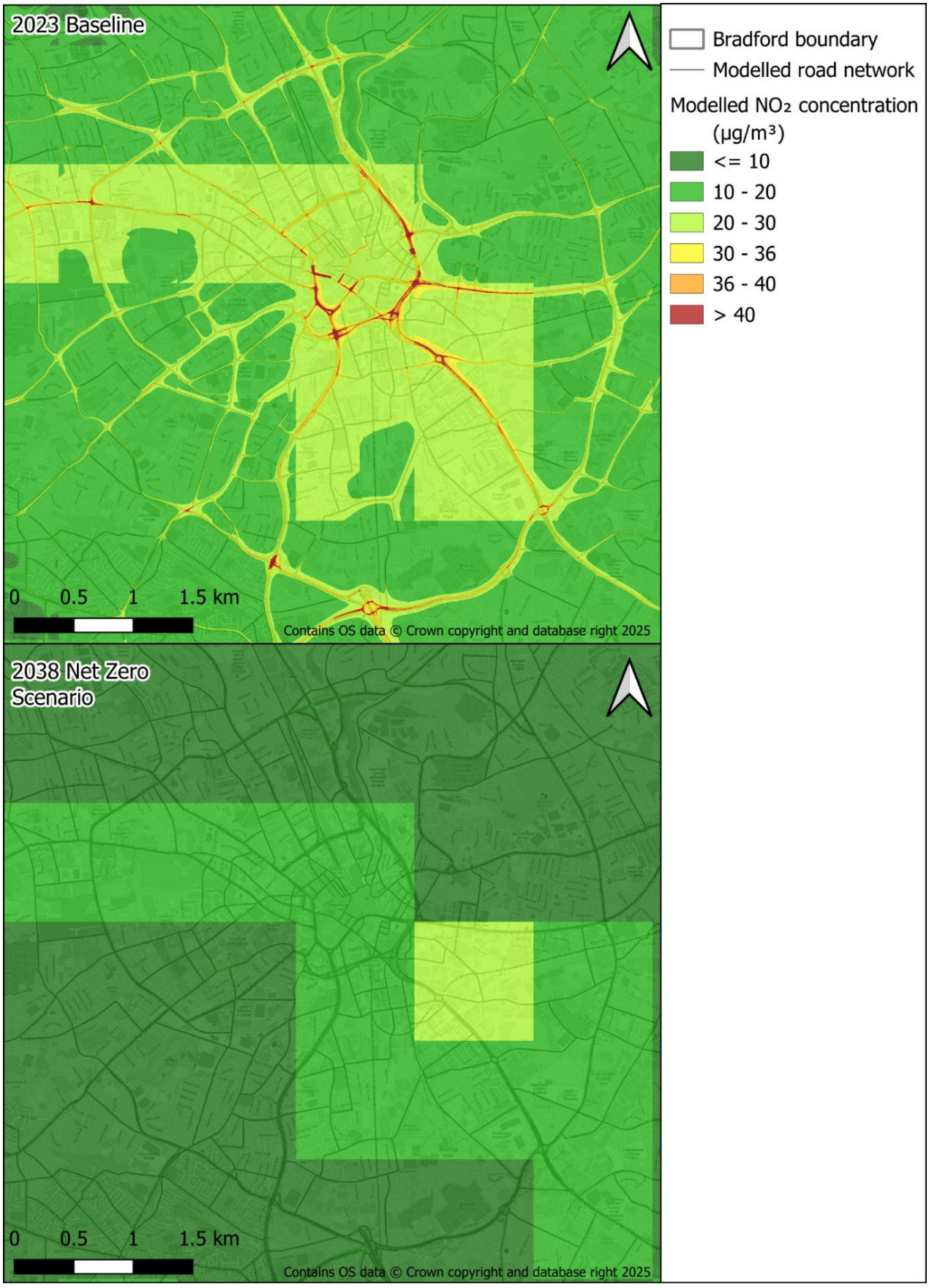

Figure 4-8: Comparison of 2023 Baseline and 2038 Net Zero Scenario modelled NO_2 concentrations in Bradford city centre.

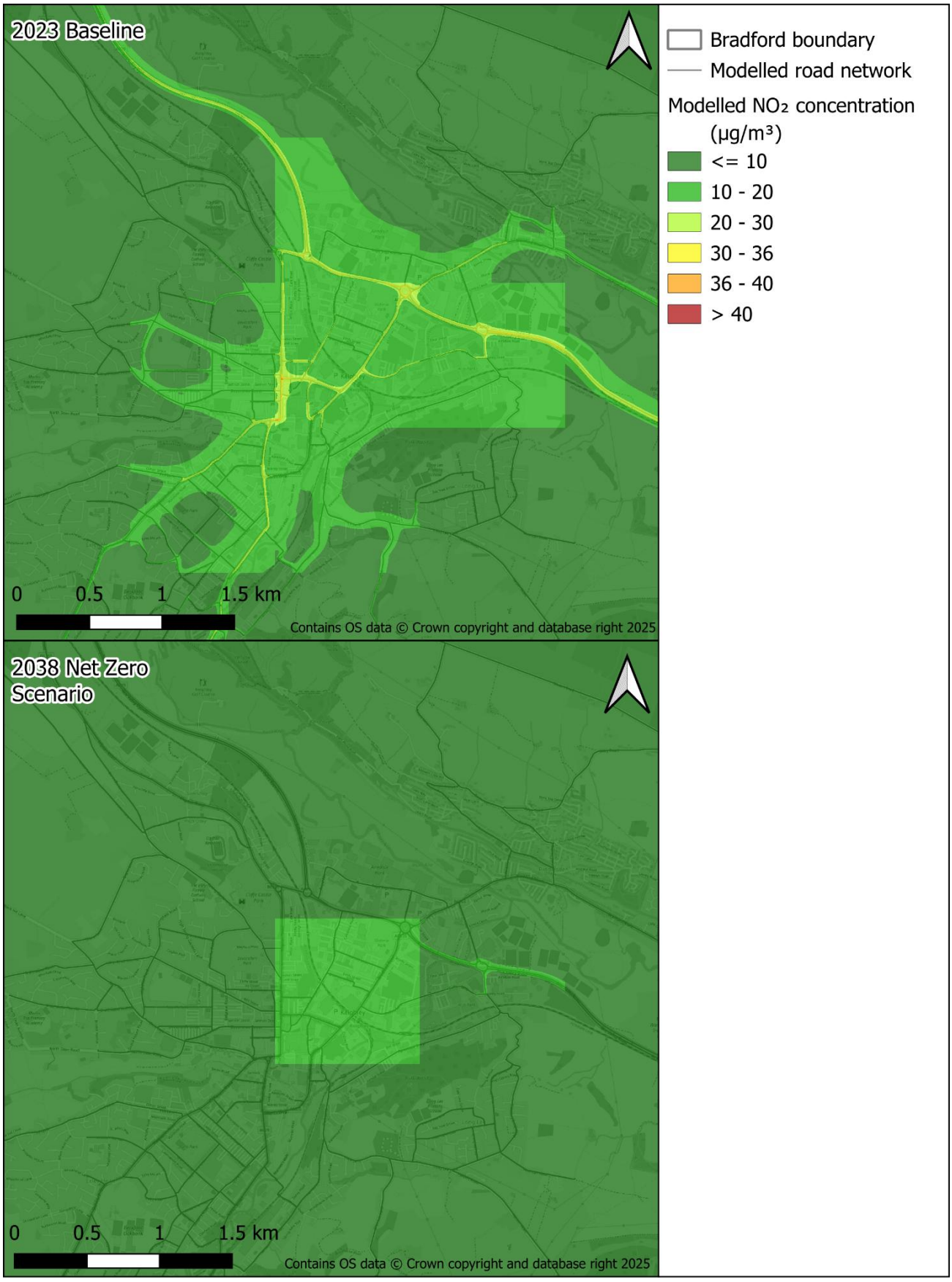

Figure 4-9: Comparison of 2023 Baseline and 2038 Net Zero Scenario modelled NO_2 concentrations in Keighley.

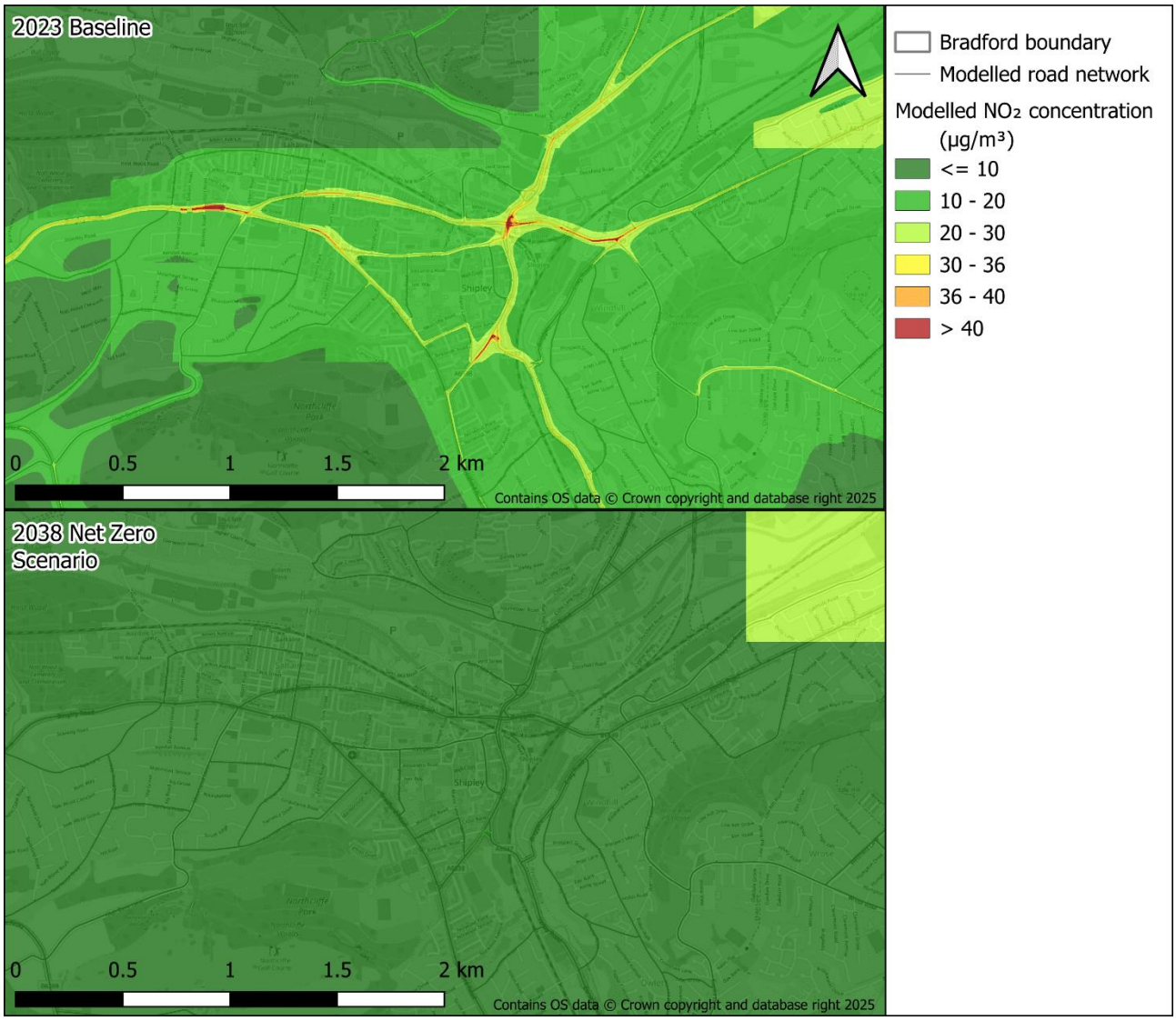

Figure 4-10: Comparison of 2023 Baseline and 2038 Net Zero Scenario modelled NO_2 concentrations in Shipley.

Figure 4-11 presents a comparison of modelled PM_{10} concentrations in the 2023 Baseline and 2038 Net Zero Scenario across the City of Bradford Metropolitan District, with Figure 4-12, Figure 4-13 and Figure 4-14 presenting closer views of PM_{10} concentrations in Bradford City Centre, Keighley and Shipley, respectively.

These concentration maps show that PM_{10} concentrations were all well below the UK annual mean PM_{10} Air Quality Objective limit of 40 µg/m^3 in both the Baseline and the Net Zero Scenario. The WHO guideline for annual mean PM_{10} is 15 µg/m^3. PM_{10} concentrations across the district are all below this threshold in the 2038 Net Zero Scenario.

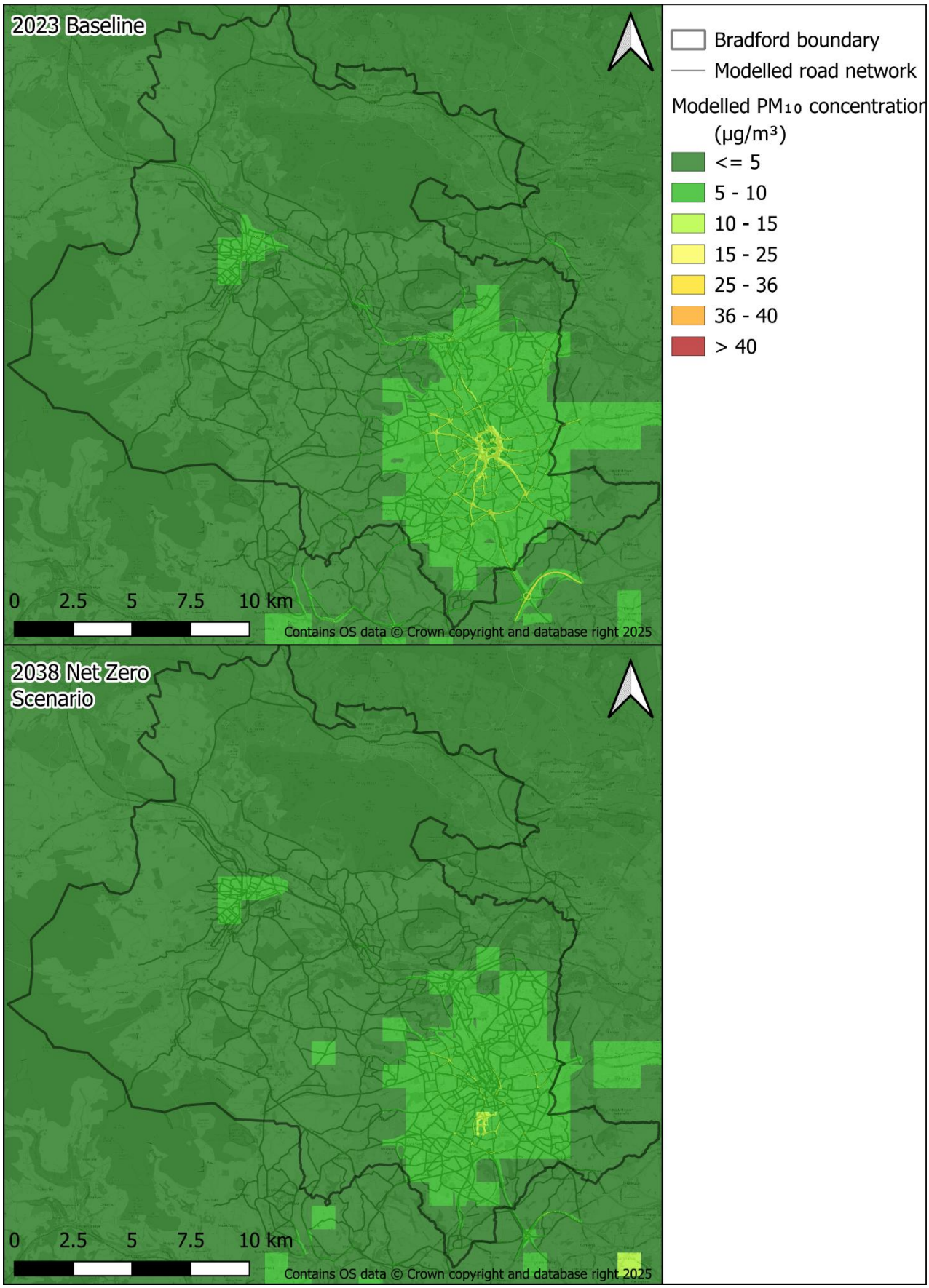

Figure 4-11: Comparison of 2023 Baseline and 2038 Net Zero Scenario modelled PM_{10} concentrations across the City of Bradford Metropolitan District.



Figure 4-12: Comparison of 2023 Baseline and 2038 Net Zero Scenario modelled PM_{10} concentrations in Bradford city centre.

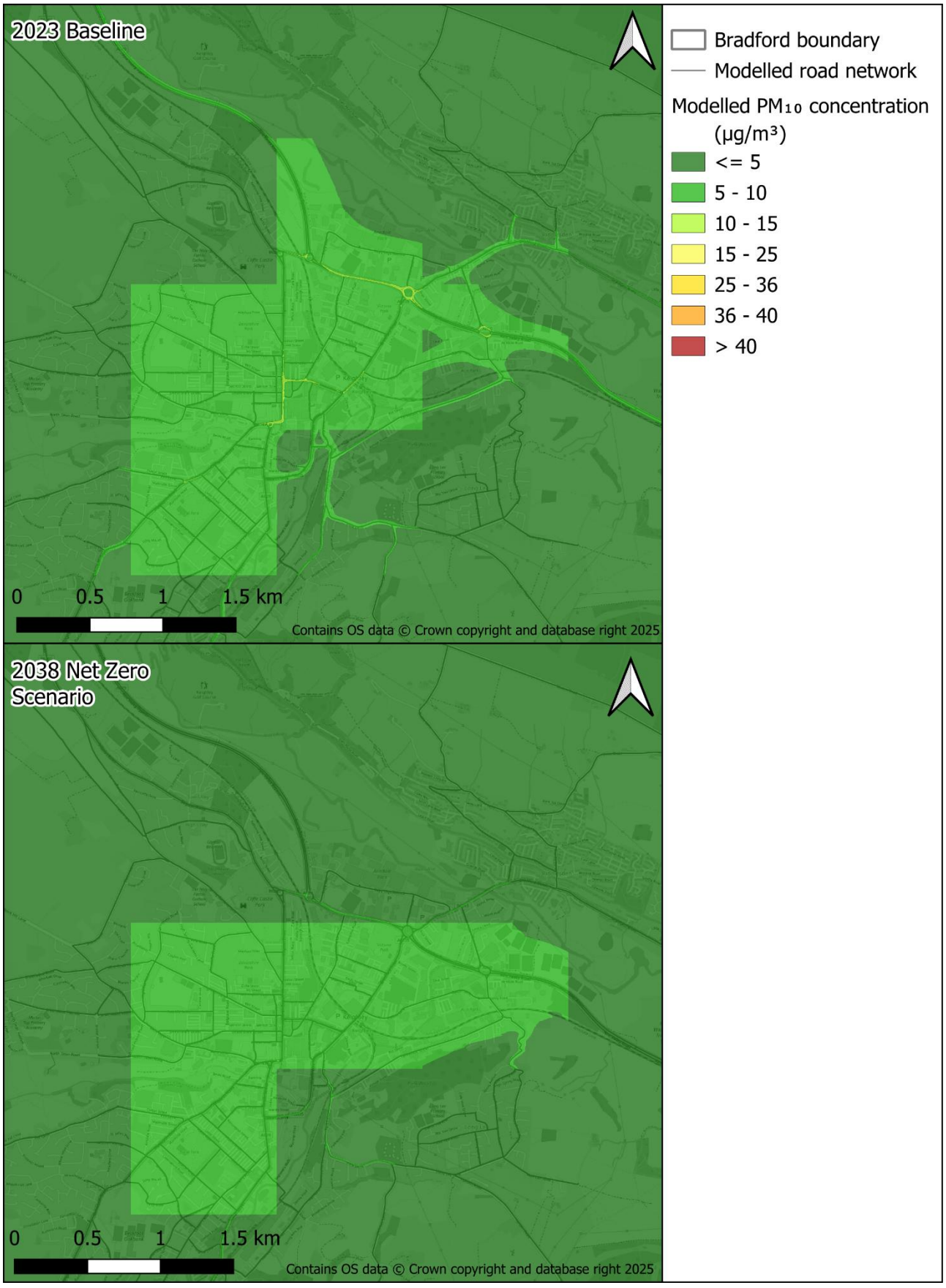

Figure 4-13: Comparison of 2023 Baseline and 2038 Net Zero Scenario modelled PM_{10} concentrations in in Keighley.

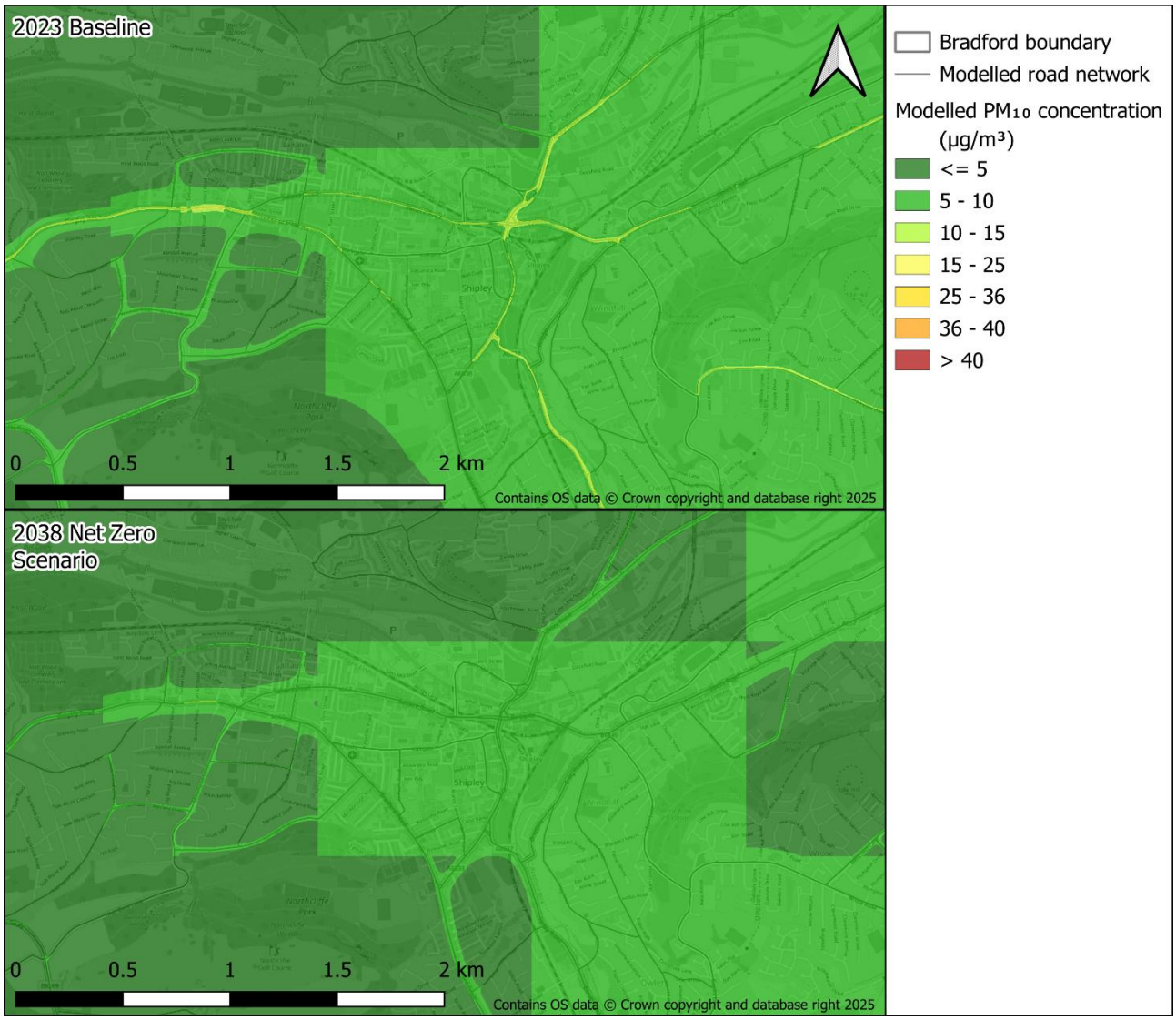

Figure 4-14: Comparison of 2023 Baseline and 2038 Net Zero Scenario modelled PM_{10} concentrations in Shipley.

Figure 4-15 presents a comparison of modelled $PM_{2.5}$ concentrations in the 2023 Baseline and 2038 Net Zero Scenario across the City of Bradford Metropolitan District, with Figure 4-16, Figure 4-17 and Figure 4-18 presenting closer views of $PM_{2.5}$ concentrations in Bradford City Centre, Keighley and Shipley respectively.

These concentration maps show similar spatial patterns to the PM_{10} concentration maps, where concentrations are higher and lower.

The figures show that across the district, modelled $PM_{2.5}$ concentrations across Bradford are compliant with the UK annual mean $PM_{2.5}$ Air Quality Objective limit of 20 µg/m^3 and are below 10% of the limit in both the Baseline and the Net Zero Scenario. The WHO recommended annual mean limit for $PM_{2.5}$ is 5 µg/m^3. In the 2038 Net Zero Scenario, the majority of the district is modelled to have $PM_{2.5}$ concentrations below 5 µg/m^3, with many rural and suburban areas showing concentrations below 2.5 µg/m^3. The are a few limited roads with concentrations remaining above 5 µg/m^3 in the 2038 Net Zero Scenario, located in Bradford city centre, Keighley and Shipley.

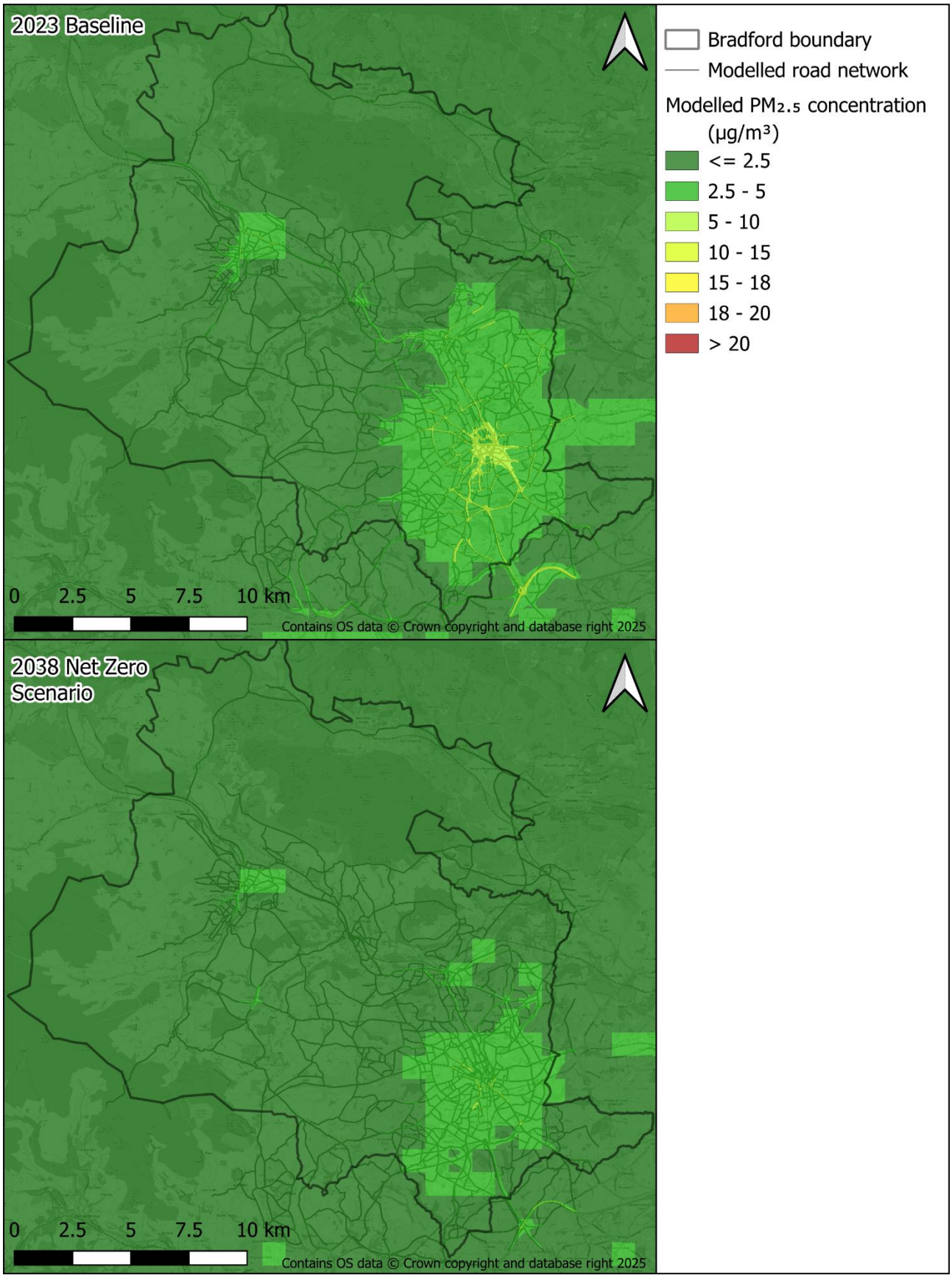

Figure 4-15: Comparison of 2023 Baseline and 2038 Net Zero Scenario modelled $PM_{2.5}$ concentrations across the City of Bradford Metropolitan District.



Figure 4-16: Comparison of 2023 Baseline and 2038 Net Zero Scenario modelled $PM_{2.5}$ concentrations in Bradford city centre.

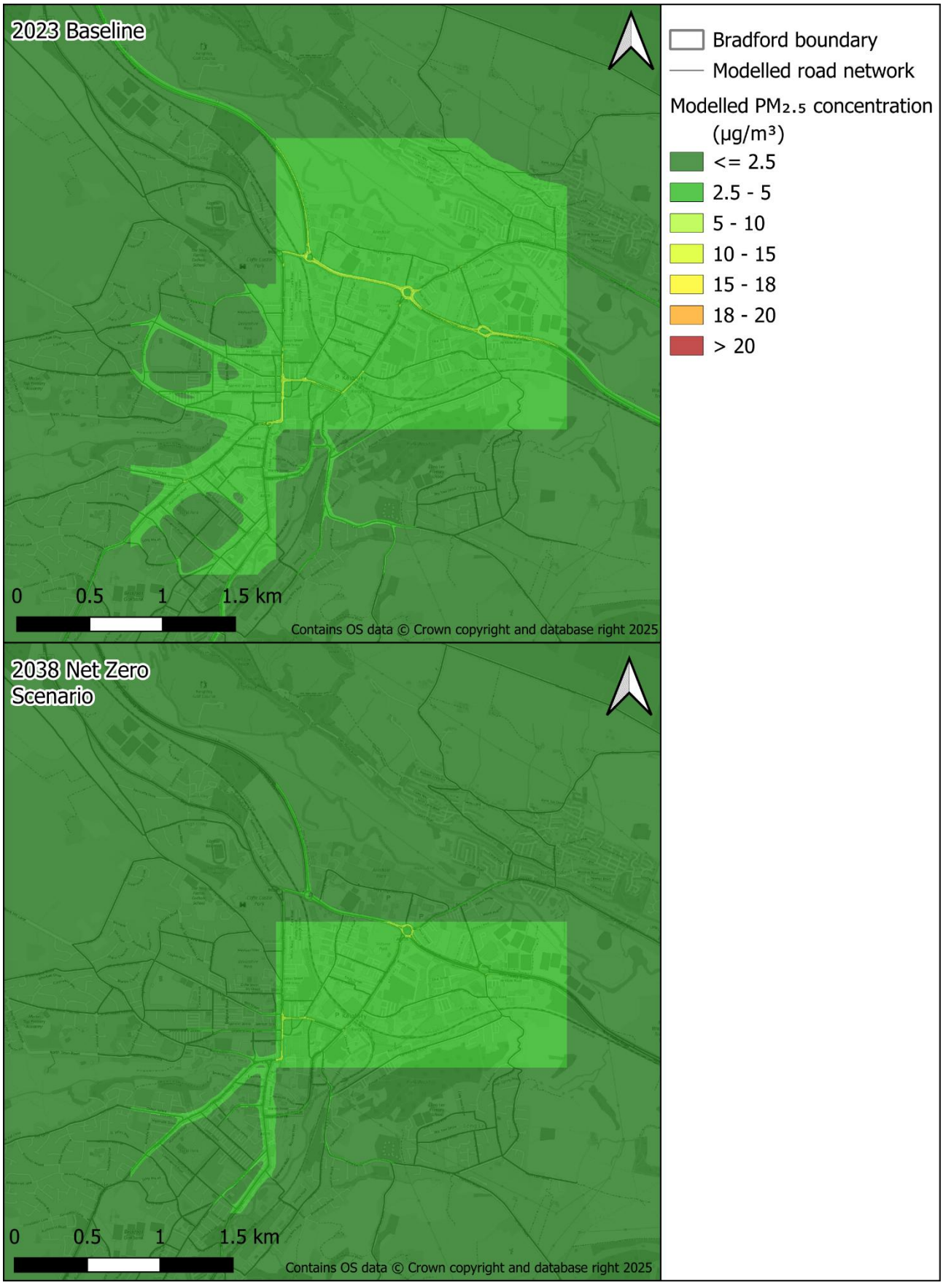

Figure 4-17: Comparison of 2023 Baseline and 2038 Net Zero Scenario modelled $PM_{2.5}$ concentrations in Keighley.

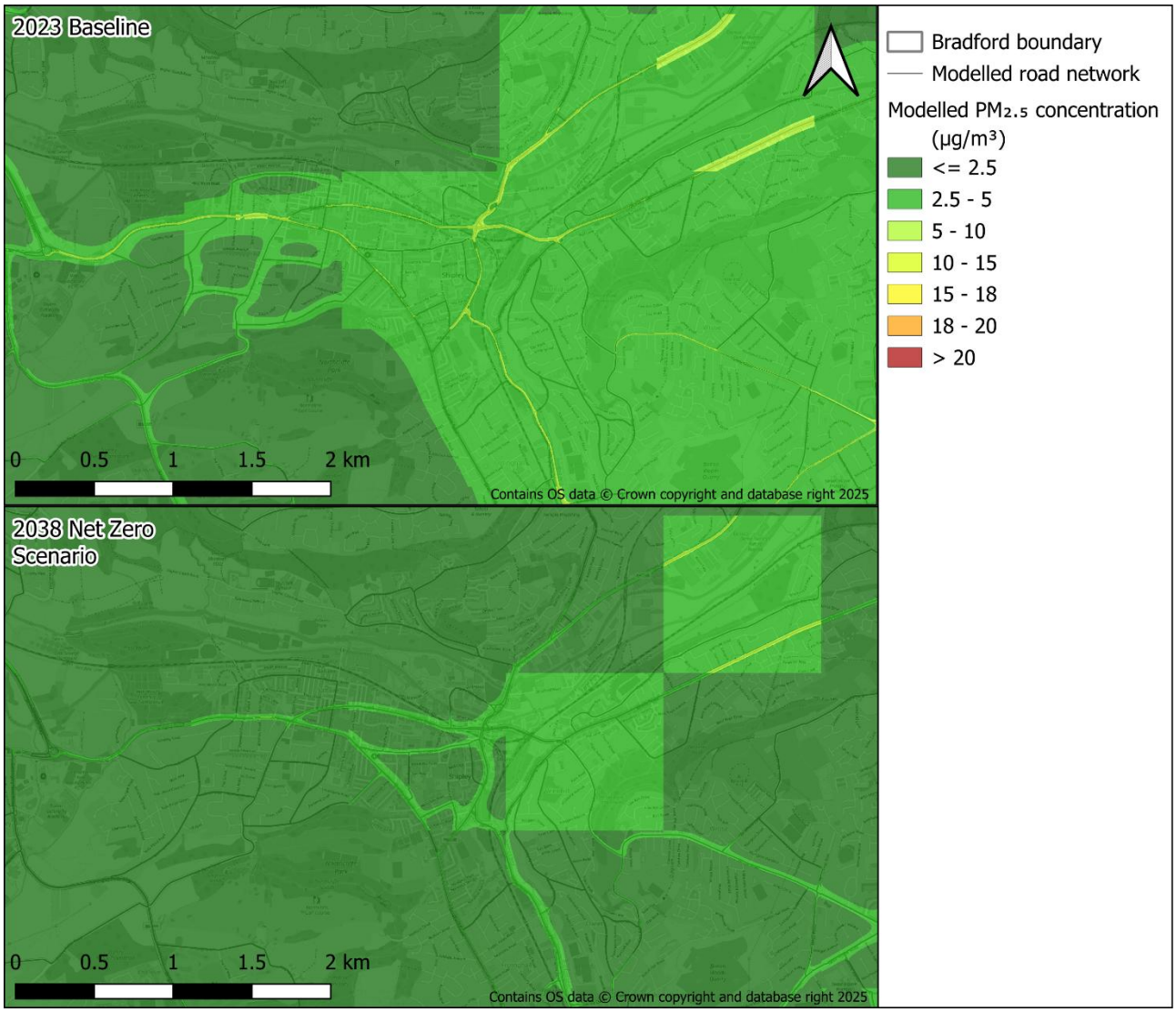

Figure 4-18: Comparison of 2023 Baseline and 2038 Net Zero Scenario modelled $PM_{2.5}$ concentrations in Shipley.

4.4.2 Interpolation of modelled concentrations between the 2023 Baseline and 2038 Net Zero Scenario

In addition to the concentration maps, Table 4-6 provides modelled NO_2 concentrations at monitoring points across the district for the 2023 Baseline and 2038 Net Zero Scenario, with a linear interpolation between these concentrations for every year between. This table focuses on the sites where there were modelled concentrations over or within 10% of the UK AQO annual mean NO_2 of 40 µg/m^3 in the baseline, automatic monitoring sites, and sites or within 10% of the AQO in the monitoring results for 2023.

The results show that, assuming linear reduction of concentrations, all sites would be compliant with the UK annual mean AQO for NO_2 by 2028, and below 10% of the AQO by 2030. Appendix 3 provides a table of NO_2 monitoring results for 2023, and modelling results for the 2023 Baseline and the 2038 Net Zero Scenario at every monitoring site in the district. The full results show that of the 214 NO_2 monitoring sites, all are below 25 µg/m^3 by 2038, and 162 sites (76%) are below the WHO guideline for annual mean NO_2 of 10 µg/m^3 by 2038.

Table 4-7 and Table 4-8 provide modelled and interpolated concentrations for PM_{10} and $PM_{2.5}$, respectively. Of the three monitoring sites which measure PM_{10} and $PM_{2.5}$, all sites are below the UK AQO for annual mean concentrations from the Baseline year, and two sites are below the WHO guideline for both annual mean PM_{10} (of 15 µg/m^3) and annual mean $PM_{2.5}$ (of 5 µg/m^3) from the Baseline year.

Table 4-6: Modelled annual mean NO_2 concentrations at monitoring points across the district in 2023, interpolated to modelled annual mean NO_2 concentrations at the same locations in 2038, under the Net Zero Scenario.

Site		Modelled NO_2 ($\mu g/m^3$)	Interpolated annual mean NO_2 concentrations ($\mu g/m^3$)													Modelled Net Zero Scenario NO_2 ($\mu g/m^3$)
		2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038
Sites >40 $\mu g/m^3$ in 2023 modelling																	
CM6	Shipley Airedale Road	41.6	39.6	37.6	35.6	33.7	31.7	29.7	27.7	25.7	23.8	21.8	19.8	17.8	15.8	13.8	11.9
DT50	outside no.203 Bradford Road	44.3	41.9	39.4	36.9	34.5	32.0	29.5	27.1	24.6	22.1	19.7	17.2	14.7	12.3	9.8	7.3
DT161A, DT161B, DT161C	Godwin Street LP 6	52.3	49.6	46.9	44.3	41.6	38.9	36.2	33.6	30.9	28.2	25.6	22.9	20.2	17.6	14.9	12.2
DT162A, DT162B, DT162C	Godwin Street LP 7	50.0	47.5	45.0	42.5	40.0	37.5	35.0	32.5	30.0	27.5	25.0	22.5	20.0	17.5	15.0	12.5
DT164A, DT164B, DT164C	Godwin St EASA training	46.7	44.4	42.1	39.8	37.5	35.2	32.9	30.6	28.3	26.0	23.7	21.4	19.1	16.8	14.5	12.2
DT183	Sunbridge Road near Tesco	41.5	39.5	37.4	35.4	33.4	31.3	29.3	27.2	25.2	23.1	21.1	19.0	17.0	14.9	12.9	10.9
DT184	Sunbridge Road near Tesco across road from DT183	45.1	42.8	40.6	38.3	36.0	33.7	31.4	29.1	26.9	24.6	22.3	20.0	17.7	15.4	13.2	10.9
DT12A, DT12B, DT12C*	Treadwell Mills - Shipley Airedale Rd	42.2	40.1	38.1	36.1	34.1	32.1	30.1	28.0	26.0	24.0	22.0	20.0	18.0	15.9	13.9	11.9
DT184	Sunbridge Road near Tesco across road from DT183	45.1	42.8	40.6	38.3	36.0	33.7	31.4	29.1	26.9	24.6	22.3	20.0	17.7	15.4	13.2	10.9
Sites >36 $\mu g/m^3$ in 2023 modelling (10% of the AQO)																	
DT31	Bradford Road / Bingley Road on traffic light opp Hirst Road	39.7	37.5	35.3	33.1	30.9	28.8	26.6	24.4	22.2	20.0	17.8	15.6	13.4	11.2	9.1	6.9
DT185A, DT185B, DT185C	Market St opposite DT167	38.3	36.5	34.6	32.8	30.9	29.1	27.2	25.4	23.5	21.7	19.8	18.0	16.1	14.3	12.4	10.5

DT101A, DT101B, DT101C	LP39 Bingley Rd, Saltaire nearest shops	37.3	35.3	33.2	31.2	29.1	27.1	25.0	23.0	20.9	18.8	16.8	14.7	12.7	10.6	8.6	6.5
DT163A, DT163B, DT163C	Godwin St LP 8	36.5	34.8	33.1	31.4	29.8	28.1	26.4	24.7	23.0	21.3	19.6	18.0	16.3	14.6	12.9	11.2
Additional automatic monitoring sites																	
CM2	Keighley	25.6	24.7	23.7	22.7	21.7	20.7	19.7	18.8	17.8	16.8	15.8	14.8	13.8	12.9	11.9	10.9
CM3	Manningham Lane	22.8	21.8	20.9	19.9	19.0	18.0	17.1	16.1	15.1	14.2	13.2	12.3	11.3	10.4	9.4	8.4
CM4	Manchester Road / Mayo Avenue	29.1	27.7	26.2	24.8	23.3	21.9	20.5	19.0	17.6	16.1	14.7	13.3	11.8	10.4	8.9	7.5
CM5	Thornton Road	29.2	28.2	27.1	26.1	25.1	24.0	23.0	21.9	20.9	19.9	18.8	17.8	16.8	15.7	14.7	13.6
CM7	Rook Lane	31.0	29.5	28.0	26.5	25.0	23.5	22.0	20.5	18.9	17.4	15.9	14.4	12.9	11.4	9.9	8.4
CM8	Tong Street	24.7	23.6	22.5	21.5	20.4	19.3	18.2	17.1	16.1	15.0	13.9	12.8	11.7	10.6	9.6	8.5
Sites >40 µg/m³ in 2023 monitoring																	
DT72	LP2 Queens Rd (traffic lights)	33.4	31.8	30.2	28.6	26.9	25.3	23.7	22.1	20.4	18.8	17.2	15.6	13.9	12.3	10.7	9.1
DT191	Low Mill Keighley - opposite DT190	24.4	23.5	22.6	21.7	20.8	19.9	19.0	18.1	17.2	16.3	15.4	14.5	13.6	12.7	11.8	10.9

* Also measured >40 µg/m³ in 2023 monitoring

Table 4-7: Modelled annual mean PM_{10} concentrations at all PM_{10} monitoring points across the district in 2023, interpolated to modelled annual mean PM_{10} concentrations at the same locations in 2038, under the Net Zero Scenario.

Site		Modelled PM_{10} ($\mu g/m^3$)	Interpolated annual mean PM_{10} concentrations ($\mu g/m^3$)													Modelled Net Zero Scenario PM_{10} ($\mu g/m^3$)
		2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038
Sites >40 $\mu g/m^3$ in 2023 modelling																	
CM2	Keighley	9.0	8.9	8.9	8.8	8.8	8.7	8.7	8.6	8.6	8.5	8.5	8.4	8.3	8.3	8.2	8.2
CM6	Shipley Airedale Road	8.4	9.0	9.5	10.1	10.7	11.2	11.8	12.3	12.9	13.5	14.0	14.6	15.2	15.7	16.3	16.9
CM8	Tong Street	7.1	7.3	7.4	7.6	7.7	7.9	8.0	8.2	8.3	8.5	8.7	8.8	9.0	9.1	9.3	9.4

Table 4-8: Modelled annual mean $PM_{2.5}$ concentrations at all $PM_{2.5}$ monitoring points across the district in 2023, interpolated to modelled annual mean $PM_{2.5}$ concentrations at the same locations in 2038, under the Net Zero Scenario.

Site		Modelled $PM_{2.5}$ ($\mu g/m^3$)	Interpolated annual mean $PM_{2.5}$ concentrations ($\mu g/m^3$)													Modelled Net Zero Scenario $PM_{2.5}$ ($\mu g/m^3$)
		2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038
Sites >40 $\mu g/m^3$ in 2023 modelling																	
CM6	Keighley	4.7	4.7	4.7	4.7	4.7	4.7	4.7	4.7	4.7	4.7	4.7	4.7	4.7	4.7	4.6	4.6
CM6	Shipley Airedale Road	8.7	8.5	8.2	8.0	7.7	7.5	7.2	7.0	6.7	6.5	6.3	6.0	5.8	5.5	5.3	5.0
CM8	Tong Street	4.8	4.7	4.6	4.5	4.4	4.3	4.2	4.1	4.0	3.9	3.8	3.6	3.5	3.4	3.3	3.2

5. SUMMARY

This report provided two modelled GHG scenarios to support Bradford District in developing its CAP. The first, the BAU scenario, assesses what emissions might look like for Bradford if no further mitigation action is taken at the local, regional, or national level. The second provides a realistic pathway for Bradford to achieve its net zero ambitions and assesses the level of emissions reduction that could be achieved.

The first scenario provides a BAU pathway for Bradford and achieves a 7.8% reduction in GHG emissions by 2030 and a 12.6% GHG reduction by 2038. Since no additional mitigation measures have been included at the national or local level, the main driver for this GHG emission decrease is the national decarbonisation of the electricity grid. Overall, the decarbonisation of the national grid alone will not get Bradford near its net zero target of 2038.

The net zero scenario, referred to as the Future-Ready Pathway, represents a technically robust and politically realistic trajectory towards Bradford's 2038 climate target. Designed to be ambitious yet feasible, this scenario combines cost-effective interventions with strategic co-benefits, grounded in Bradford's local strengths and stakeholder-identified challenges. In this pathway, mitigation actions are applied across all sectors. The measures deliver significant demand reduction from the installation of energy efficiency technologies, an increase in renewable deployment, and switches in behaviour, from an increase in active travel and modal shift, improved waste management, and diet changes. Equally, fuel switching measures are applied across sectors, with particular impact coming from domestic and non-domestic buildings and the transport sector.

The net zero pathway for Bradford would reduce GHG emissions by 40% by 2030 and by 82% by 2038 compared to the 2022 baseline. While emissions do not reach zero by the target year, the pathway is ambitious yet implementable and grounded in the local context. Critically, the pathway aligns with broader net zero efforts and political ambition for the West Yorkshire area.

The qualitative co-benefits review assessed the potential wider societal benefits that could be derived from the net zero pathway. Benefits from each mitigation measure were assessed across six different categories, which included: local economic impacts, local environmental impacts, social equity, health, fuel poverty, and resilience. Using contextual data from Bradford, along with challenges identified from the stakeholder engagement, the assessment demonstrates that there are significant opportunities for the net zero pathway to deliver positive impacts across all co-benefit categories. Particularly positive impacts are identified in the resilience, environmental, and economic categories, where fuel switching, uptake in renewables, and the roll-out of retrofit measures across sectors could positively support a more localised resilient energy network, reduced environmental impacts, as well as a variety of job opportunities. While many of the measures have the potential to demonstrate positive impact in social equity, this will, of course, depend on how the measures are implemented to ensure fair and equitable distribution of benefits and the consideration and removal of adverse impacts, as far as feasible.

In addition to modelling the GHG emission reductions of the net zero scenario, the co-benefits on local air quality were also quantitatively assessed. Building upon the 2023 baseline, future 20238 emissions and local concentrations for NO_x, $PM_{2.5}$ and PM_{10} were assessed using the net zero assumptions. Overall air quality emissions and concentrations within the Bradford District could be improved (for example, a 60% reduction in NO_X emissions) through the delivery of the net zero pathway, due to sources of GHG emissions often also generating air pollution.

Overall, achieving net zero by 2038 is highly ambitious and will require wide-reaching financial, technological, and behavioural changes across Bradford. Achieving both the modelled 82% reduction and the full decarbonisation ambition will only be possible with significant legislative, regulatory, and financial support from the central government. The project's next steps will be to build upon the net zero and co-benefit analysis and develop the CAP's enabling actions to achieve the net zero pathway.

APPENDICES

APPENDIX 1: UNDERLYING TECHNICAL ASSUMPTIONS

The emissions modelling is driven by a range of underlying technical assumptions, which are less variable than but just as important as the mitigation measures. Some of these assumptions are captured here to provide important context alongside the detail provided in Table 2-3.

To apply mitigation measures (such as switching to more efficient light bulbs), the energy consumption data has to be disaggregated beyond what is provided in the LA GHG inventory and subnational energy consumption statistics (e.g., to understand how much electricity is currently used for lighting). As no dataset provides figures on actual energy consumption split by space and water heating, lighting, cooking, and appliances, estimates had to be made using the Energy Consumption in the UK (ECUK) statistics.[244]

It is further crucial to consider the efficiencies of different technologies. Table 5-1 provides the figures considered in modelling the transition from high- to low-carbon heating systems. Heating system efficiency describes how much useful heat is delivered compared to the energy required to run the system. A system with 100% efficiency converts all input energy into useful heat, with no losses. For example, an electric heater delivers nearly all of the electricity it uses as heat. A gas boiler with 87% efficiency converts 87% of the fuel's energy into useful heat, with the remaining 13% lost through flue gases or system inefficiencies.

Table 5-1: Efficiencies of different heating systems. Source: CCC Sixth Carbon Budget

Energy carrier	Efficiency
Direct electric heating	100%
Gas boiler	87%
Biogas boiler	84%
Oil boiler	84%
Coal heater	70%
Air-source heat pump	300%
District heating	c. 230% - 240%[245]

Finally, Table 5-2 below shows emission factors for key energy carriers for both the baseline and target year.

Table 5-2: Key Emission Factors in 2022 and 2038

Energy carrier	2022 Value	2038 Value
Grid Electricity[246]	0.211 $kgCO_2e/kWh$	0.008 $kgCO_2e/kWh$
Hydrogen[247,248]	0.077 $kgCO_2e/kWh$	0.065 $kgCO_2e/kWh$
District Heating[249]	0.127 $kgCO_2e/kWh$	0.006 $kgCO_2e/kWh$

[244] DESNZ (2025). Energy Consumption in the UK. Available at: https://www.gov.uk/government/collections/energy-consumption-in-the-uk

[245] Includes assumptions around different fuel inputs (ASHPs, gas boiler) efficiency gains from system compared to individual systems and a distribution loss factor.

[246] DESNZ (2024). UK local and regional greenhouse gas emissions estimates for 2005-2022. Available at: https://assets.publishing.service.gov.uk/media/667ad7a7c7f64e234208ffc2/local-authority-ghg-technical-report-2022.pdf

[247] DESNZ (2023). UK Low Carbon Hydrogen Standard. Available at: https://assets.publishing.service.gov.uk/media/6584407fed3c3400133bfd47/uk-low-carbon-hydrogen-standard-v3-december-2023.pdf

[248] Arup (2025). BMF Decarbonisation Masterplan

[249] Note that this emission factor already has efficiency assumptions applied to it.

APPENDIX 2: SUMMARY OF METHODOLOGY FOR BASELINE AIR QUALITY MODELLING

A2.1 Data sources for calculating baseline emissions from road transport

This project builds on previous traffic modelling for CBMDC as part of the CAZ study in 2019. Annual average daily traffic (AADT) flows and daily average speed for each road link have been taken from the local SATURN traffic model and provided by WSP (Rev_3) under CAZ C+ (preferred option) operating conditions for the year 2022 (at the time of the previous modelling study, this was a projected future year).

The traffic model has provided vehicle flows for four highway user classes, which are: Car, HGV, LGV and Buses, with a further breakdown of the HGVs into rigid and articulated categories. These were defined separately for three model zones: city centre (within the inner ring road), between the inner and outer ring road, and the rest of the city, following the methodology we adopted in the previous CAZ study. The traffic model has also provided separate flows for CAZ compliant (vehicles that meet the CAZ emission standards) and CAZ non-compliant Cars, HGVs, LGVs and Buses. The proportion of cars that are attributed to taxis, hence enabling the car AADT to be split into passenger cars and taxis, was taken from the ANPR data (discussed below), which provided a breakdown of the proportion of the fleet which are cars, hackney (black cab) taxis, and private hire vehicle (PHV) taxis. The taxi fleet split was also produced for the same three model zones as identified for the HGVs rigid/articulated split above.

This traffic model scenario has been adapted to represent a 2023 baseline for use in this project. The following updates were applied to the CAZ C+ (preferred option) AADT:

- The model was extended to cover the full extent of the city of Bradford local authority domain (previous modelling was focused on the city of Bradford).
    - Traffic model AADT was extended along new roads which adjoined the previous model roads.
    - DfT Count Point AADT was applied along primary A roads.
    - For minor roads, concentrations were obtained from Defra Background Maps (see Section 4.2.2).
- 2023 ANPR data was applied to the CAZ C+ fleet in the following ways
    - Determining the proportions of AADT which were “CAZ compliant” and “CAZ non-compliant” for LGVs, HGVs and Taxis.
    - Determining proportions of AADT vehicle flows by fuel type (e.g. % diesel, % petrol, % electric, % hybrid petrol, % hybrid diesel).

Emission calculations for each vehicle category are based on vehicle age split by Euro classification. Information on the baseline Euro standard mix (traffic composition & age) was collected during ANPR surveys conducted by the Council across 313 cameras during 2023. An average distribution of Euro classifications calculated from the complete ANPR dataset can either be applied across the entire model domain or more localised splits at a zonal level. An assessment of the ANPR data suggested that for both light and heavy-duty vehicles, the Euro class distribution was reasonably consistent across the survey locations. Based on this, a common distribution of fuel types and Euro classifications was used across the whole model domain for each vehicle type.

Link-specific NO_x/NO_2, PM_{10}, $PM_{2.5}$ and CO_2 emissions were calculated using the COPERT v5.6 emissions functions for all vehicles up to and including Euro 6/VI. Emission rates have been calculated using the latest Emission Factor Toolkit (v13).

Gradient effects were included during emissions calculations for road links in the existing model area. The Emissions Factor Toolkit (EfT) v13, includes gradient effects to adjust the emission rates for links. The adjustment in the EfT applies to roads with gradients of 2.5% or greater.

The source sectors covered by “road transport” emissions modelling are: Motorway, Primary, Trunk, Brake and Tyre wear and Road abrasion. Emissions from minor roads and cold starts are not included in the road transport emissions modelling (due to lack of available data), so are included in the Background modelling using Defra background map concentrations (see Section 4.2.2). Total road transport emissions were calculated across the full model domain.

A2.2 Data sources for calculating baseline emissions from other sources

Background pollutant emissions from non-transport sources have been calculated by CERC as part of the West Yorkshire Emissions and Air Pollution Study for the West Yorkshire Combined Authority. These background emissions were then modelled in RapidAir for NO_x, PM_{10} and $PM_{2.5}$ to provide pollutant concentrations.

The West Yorkshire Emissions and Air Pollution Study emissions were compiled from NAEI 2021 sectoral emissions, supplemented by energy performance data and high-resolution energy consumption data; and with added emissions for biomass boilers, stoves and heather burning.[250]

The CERC background emissions were aggregated to 1 x 1 km to be consistent with other RapidAir model inputs. The CERC maps were available at a 500 x 500 m scale for totals but not for individual sectors; the CERC LSOA data were therefore aggregated to a 1 x 1 km scale for the individual SNAP sectors and sub-sectors. These emissions were modelled in the RapidAir air quality dispersion model using a 1 x 1 km kernel, underpinned by the same meteorological data detailed previously in Section 0.

As the CERC background emissions did not include any road sources, and the road emissions modelling does not include minor road and cold starts, concentration contributions from minor roads and cold starts were additionally extracted from Defra background concentration maps. Background maps were downloaded from the Defra website (base year 2021) for 2023, and concentration contributions from minor road and cold starts were extracted for NO_x, PM_{10} and $PM_{2.5}$. These were added to the CERC background concentrations.

A comparison of total background concentrations (CERC background concentrations and Defra background map minor road and cold start concentrations) was made against 12 background monitoring site concentrations for 2023 to check the validity of this approach.

A2.3 RapidAir Dispesion Modelling

The RapidAir dispersion modelling system has been used to assess pollutant concentrations in both the Baseline and Net Zero Scenario. This is Ricardo's proprietary modelling system developed for urban air pollution assessment. Pollutants modelled were NO_x/NO_2, PM_{10}, and $PM_{2.5}$.

The model is based on the convolution of an emissions grid with dispersion kernels derived from the USEPA AERMOD model. The physical parameterisation (release height, initial plume depth and area source configuration) closely follows guidance provided by the USEPA in their statutory road transport dispersion modelling guidance. AERMOD provides the algorithms which govern the dispersion of the emissions and is an accepted international model for road traffic studies (it is one of only two mandated models in the US and is widely used overseas for this application). The combination of an internationally recognised model code and careful parameterisation matching international best practice makes RapidAir demonstrably fit for purpose for this study.

The USEPA have very strict guidelines on use of dispersion models and in fact the use of AERMOD is written into federal law in 'Appendix W' of the Guideline on Air Quality Models. The RapidAir model uses AERMOD at its core and is therefore based on sound principles given the pedigree of the core model.

The model produces high-resolution concentration fields at the city scale (1 to 3 m scale), so it is ideal for spatially detailed compliance modelling. A validation study has been conducted in London using the same datasets as the 2011 Defra inter-comparison study. Using the LAEI 2008 data and the measurements for the same time period the model performance is consistent (and across some metrics performs better) than other modelling solutions currently in use in the UK. A RapidAIR model validation paper has also been published with our partners at Strathclyde University in the well-known Environmental Modelling and Software journal.

The RapidAir model includes the AEOLIUS model which was developed by the UK Met Office in the 1990s. The AEOLIUS model was originally developed as a nomogram procedure. The scientific basis for the model is presented in a series of papers by the Met Office. The model formulation shares a high level of commonality with the Operational Street Pollution Model (OSPM), which in turn forms the basis of the basic street canyon

[250] CERC 2024 "KMCEGS-151: Provision of a West Yorkshire Emissions and Air Pollution Study Final report" Prepared for West Yorkshire Combined Authority, supplied Bradford Metropolitan District Council for use in this project.

model included in the ADMS-Roads software. Therefore, the AEOLIUS based canyon suite in RapidAir aligns well with industry standards for modelling dispersion of air pollutants in street canyons.

For roads assigned as street canyons, the required information for the AEOLIUS street canyon model was populated – this included building height, emissions and number of vehicles per hour. The canyon model is only turned on if the wind is blowing parallel across the canyon (± 5 degrees) i.e. the wind must be between 40 and 50 degrees from the orientation of the canyon. For each hour in the meteorological data with wind direction matching the criteria to turn the street canyon on, the leeward, windward and parallel street canyon concentrations were calculated. To provide annual street canyon concentrations, the sum of the data contained within each of leeward, windward and parallel was calculated.

Street canyons previously used in the CAZ modelling were used here, with checks carried out to ensure these were still required and no new canyons should be added. The results from the street canyon module were combined with the concentrations modelled in the dispersion step of RapidAir. The annual leeward and annual windward concentrations were added together, then this was added to the dispersion modelled road emissions. The concentrations from the parallel contribution of the street canyon model were not included, as including this would result in double-counting of the road emissions when combined with the dispersion emissions.

The dispersion modelling was conducted using the 2023 annual surface meteorological dataset measured at Bingley. Data capture for 2023 at the Bingley site was high, with 100% for wind speed and direction and cloud cover, and 99.97% for temperature. A uniform surface roughness value of 1.0 m was modelled to represent a typical city/urban environment.

A2.4 Baseline model validation

A new model validation for 2023 was performed following the same steps as taken in the CAZ modelling, but with the most up-to-date tools and emissions model. A single road NO_x adjustment factor was derived from model verification, and this was used to calculate:

- Citywide modelling results at monitoring locations.
- Citywide 1 m resolution NO_2 annual mean concentration rasters providing a continuous representation of the spatial variation in modelled concentrations.

PM validation was not carried out due to there not being enough monitoring sites. Therefore, the NO_x adjustment factor has also been applied for PM.

To verify the model, the predicted annual mean Road NO_x concentrations were compared with concentrations measured at the various monitoring sites during 2023.

The model output of Road NO_x (the total NO_x originating from road traffic) was compared with measured Road NO_x, where the measured Road NO_x contribution is calculated as the difference between the total NO_x and the background NO_x value. Total measured NO_x for each diffusion tube was calculated from the measured NO_2 concentration using the latest version of the Defra NO_x/NO_2 calculator (v9.1-1).

The initial comparison of the modelled vs measured Road NO_x identified that the model was under-predicting the Major Road NO_x contribution at most locations. Refinements were subsequently made to the model inputs to improve model performance where possible.

The gradient of the best fit line for the modelled Road NO_x contribution vs. measured Road NO_x contribution was then determined using linear regression and used as a global/domain wide Road NO_x adjustment factor. This factor was then applied to the modelled Road NO_x concentration at each discretely modelled receptor point to provide adjusted modelled Road NO_x concentrations. A primary NO_x adjustment factor of 2.28 was calculated based on model verification using the roadside 2023 NO_2 measurements was derived and applied to all modelled Road NO_x concentrations prior to calculating an NO_2 annual mean. The same adjustment factor was used for PM_{10} and $PM_{2.5}$ roadside concentrations for the 2023 baseline.

To evaluate the model performance and uncertainty, the Root Mean Square Error (RMSE) for the observed vs predicted NO_2 annual mean concentrations was calculated, as detailed in Technical Guidance LAQM. The calculated RMSE is presented in Appendix 3, with further details of model verification and adjustment methodology. For NO_2, an RMSE below 4 $\mu g/m^3$ is ideal, and an RMSE below 10 $\mu g/m^3$ is acceptable. In this case, the RMSE when outliers were excluded was calculated at 5.38 $\mu g/m^3$, which is acceptable.

APPENDIX 3: COMPARISON OF MEASURED NO_2 CONCENTRATIONS IN 2023, AND MODELLED NO_2 CONCENTRATIONS IN THE 2023 BASELINE AND 2038 NET ZERO SCENARIO MODELS

Table 5-3: Measured annual mean NO_2 concentrations in 2023, and modelled annual mean NO_2 concentrations for the 2023 Baseline and the 2038 Net Zero Scenario, for every NO_2 monitoring site in the district in 2023 (214 sites total).

Site ID	Location	2023 Measured NO_2 (µg/m^3)	Modelled NO_2 (µg/m^3)	
			2023	2038
CM2	Keighley	20.0	25.6	10.9
CM3	Manningham Lane	25.4	22.8	8.4
CM4	Manchester Road / Mayo Avenue	31.8	29.1	7.5
CM5	Thornton Road	28.3	29.2	13.6
CM6	Shipley Airedale Road	35.0	41.6	11.9
CM7	Rook Lane	30.9	31.0	8.4
CM8	Tong Street	23.1	24.7	8.5
DT168	Rockhill Lane LP22 near M606	24.5	27.8	9.2
DT198	LP128 Rooley Lane/Gardiner Row	29.4	22.3	7.7
DT197	LP 116 outside Rooley Medical Centre	26.4	24.9	7.9
DT196	LP74 Rooley Lane opposite Toby Carvery	28.7	28.6	8.1
DT195	LP60 opposite DT194, Rooley Lane	29.9	27.4	8.0
DT194	LP61 Rooley Lane	23.6	26.8	8.0
DT76	post 12 junc Rook Ln/Tong St	23.9	18.3	13.4
DT45	Rook Lane lampost 17	23.5	26.9	8.1
DT214A, DT214B, DT214C	Post outside 221 Bierley Lane nr junction with Rockhill Lane	19.7	19.3	8.6
DT215A, DT215B, DT215C	Post corner of Sheldon Ridge	15.7	16.1	8.5
DT216A, DT216B, DT216C	Post 2 Shetcliffe Lane outside house 17	16.5	16.3	13.3
DT217A, DT217B, DT217C	Post 3 Shetcliffe Lane outside house 28	14.7	15.1	13.3
DT88	Tong Street lamp post no 18	23.8	28.7	13.9
DT89A, DT89B, DT89C	Tong St/Broadstone Way Car Park	26.5	24.7	8.5
DT199A, DT199B, DT199C	Tong Street LP 202 opposite DT89	19.9	18.8	8.2
DT64A, DT64B, DT64C	Tong Street	28.1	27.6	8.7
DT200A, DT200B, DT200C	Tong Street opposite DT200 near KFC	19.7	19.4	8.2

DT220A, DT220B, DT220C	Broadstone Way LP2 near junction with Tyersal Lane	17.3	16.4	6.6
DT221A, DT221B, DT221C	Broadstone Way LP3 near junction with Tyersal Lane	15.7	14.5	6.6
DT222A, DT222B, DT222C	LP on Wakefield Road near Busfield	22.3	28.3	10.4
DT223A, DT223B, DT223C	LP64 Wakefiled Road outside house no.705	37.3	35.1	10.8
DT218A, DT218B, DT218C	Near house 567 Sticker Lane LP 78&067	28.5	25.8	11.3
DT219A, DT219B, DT219C	Near house 528 Sticker Lane LP 76&666	23.0	24.5	11.2
DT116	Sticker Lane lp41	19.9	22.5	12.5
DT118	Fearnville Drive lp1	22.1	25.8	12.6
DT201	Bowling Back Lane / Parry Lane LP35 outside house 250	28.2	22.2	12.5
DT202	Parry Lane LP2	20.6	18.7	12.3
DT203	LP 43 Bowling Back Lane opposite entrance to recycling centre	25.5	21.7	12.4
DT160A, DT160B, DT160C	Laisterdyke	22.5	25.4	12.6
DT204A, DT204B, DT204C	Laisterdyke LP9 opp DT119	20.1	21.3	12.4
DT120A, DT120B, DT120C	Leeds Rd St Marys School	30.6	33.2	23.3
DT209A, DT209B, DT209C	LP57 Leeds Road opposite Steadman Terrace and 120	30.8	32.4	23.3
DT205	LP6 Killinghall Road across from house no. 17	25.3	23.8	8.6
DT206	LP5 Killinghall Road outside house no. 17 opp DT205	28.2	19.2	8.3
DT233	LP 23 Killinghall Rd nr house 105 and pharmacy near Ellerton Street	26.5	17.8	8.3
DT232	LP24 outside 78 Killinghall Road	23.2	23.5	8.5
DT230A, DT230B, DT230C	Post 18 Gain Lane near house 48 opp Morrisons HQ	19.8	14.5	5.6
DT231A, DT231B, DT231C	Post 17 Gain Lane opp house 48 outside Morrisons HQ	18.2	17.2	5.7
DT5	Harrogate Road (furthest from crossroads)	27.0	21.0	6.1
DT39A, DT39B, DT39C	Harrogate Road (nearest crossroads)	26.1	23.1	6.2
DT208A, DT208B, DT208C	Harrogate Road opposite DT5	20.6	19.4	6.0
DT99	Charnwood Grove/Harrogate Rd LP below junc	22.7	20.5	5.8
DT86	Otley Rd lamp post no 2	25.3	23.7	6.2
DT42A, DT42B, DT42C	Killinghall	29.6	26.8	6.4
DT207A, DT207B, DT207C	Killinghall Road opp DT42	23.3	27.6	6.4
DT228A, DT228B, DT228C	LP80 Killinghall Rd between Fagley Road and Nothcote Road	32.3	15.2	5.6
DT229A, DT229B, DT229C	LP83 Killinghall Road between Fagley Road and Northcote Road	22.2	19.0	5.8
DT92	Harrogate Rd	24.5	19.7	5.7

DT93	New Line (former school)	21.6	22.4	5.7
DT286	Lp at the end of Stockhill Road at junction with Harrogate Road	21.2	18.7	5.6
DT94	Stockhill Rd (school)	15.5	14.9	5.4
DT273	New Line, Greengates on LP across from ASDA & Bank	20.6	16.9	5.5
DT274	LP on Greengates X Roads	25.5	20.4	5.7
DT275	on LP across from 138 Harrogate Road (Binns Hearing)	25.7	17.7	5.6
DT276	Apperley Road (Canal Bridge) outside Apperley Cottage LP 29	12.9	15.6	7.2
DT306	LP outside Cavendish Primary, Hall Lane Enterance	12.7	11.3	5.1
DT307	Cavendish primary 3rd site	11.7	11.6	5.1
DT272	Barkerend Road - Traffic Light sign outside house no 293	23.7	25.2	8.4
DT224A, DT224B, DT224C	Barkerend Road LP24 opp Discovery House	23.3	25.3	8.3
DT225A, DT225B, DT225C	Barkerend Road outside alterations shop	32.6	28.4	8.4
DT227A, DT227B, DT227C	Otley Road LP 50 next to house 234	20.8	18.6	6.0
DT123A	Otley Rd/SunnyBank	28.6	31.1	9.0
DT123	lp5 Otley Rd CE School	29.8	18.7	5.0
DT124	lp4 Otley Rd terrace props	27.0	17.1	4.9
DT121	lp40 Bradford Rd nr Branch	19.2	14.9	4.8
DT122	lp33 Bradford Rd nr Branch	27.3	15.5	4.8
DT126	Bradford Rd pelican crossing	18.0	15.4	4.8
DT125	lp20 165 Otley Rd	16.4	17.1	4.9
DT127	lp36 Keighley Rd	33.3	24.4	6.4
DT128	lp11 Frizley Gardens	11.3	13.4	6.0
DT130	lp1 Midland Road	28.2	21.4	5.3
DT132	LP136 Manningham Lane	31.9	20.2	8.3
DT301	LP 5 Green Lane	18.9	15.6	8.2
DT302	LP 3 Green Lane	19.0	15.5	8.2
DT303	LP 7 Green Lane	19.4	15.7	8.2
DT304	LP 4 Green Lane	18.2	15.5	8.2
DT71A, DT71B, DT71C	LP53 Manningham Lane adj real time monitoring site	29.2	22.3	8.4
DT278	LP 46 Manningham Lane near DT71	37.1	23.0	8.5
DT172A, DT172B, DT172C	LP47 junction of Maninngham Ln and Springbank Ln opp DT71	28.0	26.6	8.6
DT72	LP2 Queens Rd (traffic lights)	44.2	33.4	9.1
DT235A, DT235B, DT235C	LP3 outside house 21 Marlborough Ave	34.1	25.5	8.7
DT156	LP33 Whetley Lane opp medical practice	32.6	26.9	6.6
DT236	LP19 Whetley Ln outside flats opp house 63	23.6	27.9	13.9
DT237	LP20 Whetley Ln A6177 opp DT236	25.8	28.2	13.9

DT288	LP in front of St Phillips School gates off Fairbank Road, Girlington	18.2	18.1	6.1
DT289	LP 7 Fairbank Road, Girlington	21.6	18.8	6.2
DT290	LP9 Fairbank Road, Girlington	19.5	18.7	6.1
DT238A, DT238B, DT238C	LP5 outside house 26 Wheltey Ln near junction with Thornton Rd	25.1	33.2	14.4
DT239A, DT239B, DT239C	LP6 Whetley Ln outside no. 27 tax investigation (opposite DT238)	33.0	28.6	14.0
DT139A, DT139B, DT139C	Eden School site Thornton Road	28.9	28.6	13.9
DT240A, DT240B, DT240C	LP92 Thornton Rd opposite DT139	32.0	32.1	14.0
DT152	LP119 outside no.620 Thornton Road	34.0	32.7	15.8
DT151A, DT151B, DT151C	LP3 outside no.12 Allerton Road	28.4	31.7	15.9
DT149A, DT149B, DT149C	LP53 Cemetery Rd nr hardware store	31.0	28.6	15.7
DT241A, DT241B, DT241C	LP15 Cemetery Rd outside house no.137 opp cemetery	24.2	19.6	6.1
DT242A, DT242B, DT242C	LP18 outside house no.97 Clayton Road	18.3	21.3	6.1
DT243A, DT243B, DT243C	LP17 outside house no. 110 Clayton Rd	22.8	19.4	6.1
DT244	LP16 Hollingwood Lane nr Tanner Hill	17.7	14.7	6.2
DT245	LP17 Hollingwood Lane opp DT244	17.3	14.7	6.2
DT246A, DT246B, DT246C	Concrete LP013 outside house no.65 Horton Grange Rd	26.1	18.9	7.4
DT247A, DT247B, DT247C	Metal post 13A outside house no.66 Horton Grange Road on opp side of road to 246	23.8	23.0	7.6
DT144A, DT144B, DT144C	LP26 Horton Grange Road opp medical centre	29.5	24.2	7.6
DT146	LP3 All Saints Rd	22.0	23.2	9.3
DT143A, DT143B, DT143C	LP64 Bridal Shop Great Horton Rd	36.6	24.7	7.7
DT142	LP74 464 Great Horton Rd	30.2	26.4	7.8
DT248	LP34 outside St Oswalds CofE academy A6177 Cross Ln	26.5	16.7	6.8
DT249A, DT249B, DT249C	LP10 outside 76 Southfield Ln (A6177) just before Quaker Ln turn off	26.9	22.9	7.1
DT250A, DT250B, DT250C	LP12 opp DT249 across from house no.100 Southfield Ln side of Co-op Academy Grange	23.1	18.5	6.9
DT252A, DT252B, DT252C	LP6 Southfield Rd (A6177) outside house no.35	29.3	27.2	8.1
DT251A, DT251B, DT251C	LP7 Southfield Rd (A6177) opp DT252	23.9	19.3	7.7
DT253A, DT253B, DT253C	LP6 Holdroyd Hill near house no.72 just after Sanderson Ave	25.2	22.3	7.0
DT254A, DT254B, DT254C	LP17 Fair Rd, Wisbey nr Oakdale Cres and Medical Centre	18.6	20.0	6.9
DT255A, DT255B, DT255C	LP16 Fair Rd Wisbey nr caravan shop opp Oakdale Cres	19.0	17.0	6.8
DT257A, DT257B, DT257C	LP17 Moore Ave outside house no. 60	15.5	14.1	6.7
DT256A, DT256B, DT256C	LP18 Moore Ave outside house no. 113	13.3	13.3	6.7
DT283	LP 237 junction of Cardigan Street and Sand Beds, Queensbury - outside no. 21	18.1	13.7	4.4
DT284	Post on the corner of Foster Street and West End, Queensbury	18.1	13.6	4.4
DT285	LP 8 Brighouse Road Near Cottages after Tesco	14.0	13.3	4.4
DT259A, DT259B, DT259C	LP25 Beacon Rd house no.246	19.4	19.2	5.2
DT258A, DT258B, DT258C	LP26 Beacon Rd house no.167	19.0	14.6	5.1

DT298	LP 29 Reevy Avenue, Wibsey	12.2	14.1	6.3
DT299	LP 26 Reevy Avenue, Wibsey	11.3	12.6	6.2
DT261A, DT261B, DT261C	LP7 Netherlands Ave outside house 51	13.5	17.2	7.8
DT260A, DT260B, DT260C	LP8 Netherlands Ave near scout hut	13.1	14.8	7.7
DT262A, DT262B, DT262C	LP12 outside house 50 Cleckheaton Rd	25.1	16.6	7.8
DT133	lp121 Canal Road gasworks	28.1	25.5	9.4
DT111A, DT111B, DT111C	Midland Terrace (Canal Rd)	30.1	26.5	5.8
DT234A, DT234B, DT234C	Opposite side of road to 111 LP 106 house no. 11	29.5	21.5	9.2
DT73A, DT73B, DT73C	LP61 Canal Road (opp garden centre)	35.0	25.2	6.6
DT173A, DT173B, DT173C	LP 62 Canal Road same side as the garden centre opposite DT73.	25.9	18.9	6.2
DT74	LP4 Gaisby Lane	14.7	16.9	6.1
DT129	lp24 Valley Road	25.2	18.8	5.8
DT112A, DT112B, DT112C	Canal Road LP nearest flats by car wash	23.3	21.1	6.0
DT174A, DT174B, DT174C	LP18 Valley Rd opposite car wash and DT112	21.0	27.5	6.5
DT131	Fox Corner Shipley	34.1	36.1	8.6
DT269	Victoria Street LP4	17.4	15.5	5.1
DT91A, DT91B, DT91C	Dove St / Saltaire Rd	26.6	22.9	5.4
DT175A, DT175B, DT175C	Saltaire Road opposite Dove St	26.9	21.0	5.3
DT30A, DT30B, DT30C	29 Saltaire Road	27.1	20.9	5.3
DT180A, DT180B, DT180C	Saltaire Road outside Methodist Church	20.7	21.1	5.3
DT49A, DT49B, DT49C	outside house no.9 Moorhead Lane	21.0	19.2	5.2
DT176A, DT176B, DT176C	Moorhead Lane opp DT49	18.7	18.6	5.2
DT50	outside no.203 Bradford Road	35.2	44.3	7.3
DT177A, DT177B, DT177C	LP 30 outside dress shop, Bradford Rd (Bingley Rd)	29.6	41.3	7.0
DT31	Bradford Road / Bingley Road on traffic light opp Hirst Road	39.4	39.7	6.9
DT101A, DT101B, DT101C	LP39 Bingley Rd, Saltaire nearest shops	30.9	37.3	6.5
DT179A, DT179B, DT179C	LP40 Bradford Rd (Bingley Rd) Saltaire	29.2	34.6	6.4
DT102A, DT102B, DT102C	LP43 Bingley Rd, Saltaire	26.2	34.3	6.2
DT178A, DT178B, DT178C	Bingley Rd Saltaire LP 44 opposite D102	27.6	31.5	6.1
DT270	Bingley Road outside COOP	31.4	19.4	5.3
DT271	Bingley Road across from DT270	34.2	25.4	5.7
DT287	LP outside Willow Cottage, Main Road, East Morton	11.0	6.1	5.0
DT78	LP11 Aireworth Road, Keighley	16.6	15.9	9.8
DT68, DT69, DT70	Keighley AQMS	19.9	25.0	10.9
DT190	Low Mill Keighley near Aldi	27.1	23.4	10.8
DT191	Low Mill Keighley - opposite DT190	42.0	24.4	10.9
DT21	12 Prospect Street Keighley	8.1	6.6	3.2
DT134	Lp2 Rylstone Street KLY	32.1	27.0	11.0
DT135	LP17 Hard Ings Road KLY	26.3	19.3	8.5

DT136	LP18 Hard Ings Road KLY	28.8	21.0	8.6
DT137	LP21 Hard Ings Road KLY	32.5	20.6	8.6
DT138	LP28 Hard Ings Road KLY	32.6	17.9	8.5
DT282	LP 9 Bolton Road, Silsden - outside no. 75	23.4	12.3	3.9
DT263	LP12 A65 outside house no.31 Springbank near All Saints school	14.6	12.7	5.4
DT264	The Grove - Ilkley - outside Crew clothing	13.2	5.7	5.2
DT265	LP8 outside Midland pub, Station Rd , Ilkley	19.6	5.7	5.2
DT266	LP 6 Brook St, Ilkley near Banyan	18.9	6.0	5.2
DT267	LP TC 19 Leeds Rd, Ilkley near Woody's barbers	21.6	18.5	5.6
DT268	Leeds Road Ilkley - Outside Daniels Cafï¿½ junction with Victory Road	20.3	14.8	5.5
DT293	Concrete LP on Cotewall Road, West Bowling	17.4	19.0	7.6
DT294	LP outside Newby Primary School enterance, Ryan Street	23.5	19.0	7.6
DT308	Downpipe on Newby Primary School House	21.3	20.1	7.6
DT103A, DT103B, DT103C	Mayo Ave first LP left of AQMS	30.8	29.6	7.5
DT104A, DT104B, DT104C	Mayo Ave first LP right of AQMS	32.7	28.6	7.4
DT188A, DT188B, DT188C	Mayo Avenue LP20 opposite DT104	24.6	21.7	7.1
DT189A, DT189B, DT189C	LP16 Mayo Avenue outside Matalan car park opp DT103	25.0	22.8	7.2
DT105	Manchester Rd LP nearest house 793	39.4	26.5	7.2
DT281	Manchester Road LP 79B near DT105	39.8	25.3	7.1
DT186A, DT186B, DT186C	Manchester Road opp DT105 on LP81A end of Chellow St	21.3	20.3	7.0
DT187A, DT187B, DT187C	Smiddles Lane LP4 in front of houses. Opposite school and DT106	24.3	21.5	7.1
DT106A, DT106B, DT106C	Smiddles Lane LP nearest fence to Bankfoot School	22.3	28.3	7.5
DT192A, DT192B, DT192C	Mayo Avenue LP32 outside house no 144	21.7	22.2	8.4
DT193A, DT193B, DT193C	Mayo Avenue LP31 opposite 192	26.5	32.8	9.0
DT212A, DT212B, DT212C	Rooley Avenue LP11 outside house 49	23.1	30.1	9.1
DT213A, DT213B, DT213C	Rooley Avenue LP12 opposite house 212	21.7	35.7	9.7
DT211A, DT211B, DT211C	Manchester Road LP63B opposite 210	38.2	26.4	7.9
DT295	LP outside All Saints Church on Kenion Street	17.5	19.6	9.1
DT297	LP further down from church on Little Horton Green	16.3	18.3	9.1
DT84	Wilton St- Omar Khanï¿½s	25.3	26.1	14.8
DT79	Centenary Square	23.9	26.8	14.8
DT161A, DT161B, DT161C	Godwin Street LP 6	39.2	52.3	12.2
DT162A, DT162B, DT162C	Godwin Street LP 7	35.4	50.0	12.5
DT163A, DT163B, DT163C	Godwin St LP 8	35.1	36.5	11.2
DT164A, DT164B, DT164C	Godwin St EASA training	33.6	46.7	12.2
DT109A, DT109B, DT109C	LP 20 Thornton Road near AQMS	27.3	28.6	13.6
DT181A, DT181B, DT181C	LP opposite DT109 Thornton Road	26.9	24.3	13.5

DT108A, DT108B, DT108C	LP18 Thornton Road near AQMS	29.3	29.3	13.6
DT182A, DT182B, DT182C	LP opposite DT108 Thornton Road	25.0	24.2	13.5
DT110	LP adjacent to student accommodation Thornton Road	25.3	24.2	13.5
DT279	Lister Hills Road LP3 near junction with Thornton Road	28.4	25.0	13.5
DT280	Thornton Road LP 32 near junction with Lister Hills Road	31.5	25.9	13.5
DT183	Sunbridge Road near Tesco	39.4	41.5	10.9
DT184	Sunbridge Road near Tesco across road from DT183	37.1	45.1	10.9
DT167A, DT167B, DT167C	LP 4 Market St	36.2	31.2	10.5
DT185A, DT185B, DT185C	Market St opposite DT167	33.0	38.3	10.5
DT277	Market Street, Attached to Hot Crazes Building	33.9	29.7	10.5
DT12A, DT12B, DT12C	Treadwell Mills - Shipley Airedale Rd	47.8	42.2	11.9



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