Exeter's greenhouse gas reporting 2024

Centre for Energy and the Environment

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Author(s): R Rubia Rankin, TA Mitchell, ADS Norton

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Centre for Energy and the Environment
University of Exeter
Hope Hall
Prince of Wales Road
Exeter, EX4 4PL
+44(0)1392 724143/4/5
http://www.exeter.ac.uk/cee/

Cover image: Exeter quay

Management summary

Exeter City Council (ECC) declared a Climate Emergency in 2019 and pledged to work towards creating a carbon neutral city by 2030. The target year is 20 years in advance of the 2050 national net zero target required under the Climate Change Act and reported on in the Sixth Carbon Budget.

Exeter's greenhouse gas (GHG) emissions decreased by 45 kt CO_2e (9%) between 2019 (last GHG inventory update) and 2022, from 511 kt CO_2e in 2019 to 466 kt CO_2e in 2022. The decline reflects the continued decarbonisation of the power sector through national renewable electricity generation. More recently, after rising by 20 kt CO_2e from 2020 to 2021, emissions in the last year decreased by 21 kt CO_2e (4%), from 487 kt CO_2e in 2021 to 466 kt CO_2e in 2022. Again, this pattern is expected as the city emerged from the unique conditions of the Covid 19 pandemic and returned to the historic trend. The overall trajectory remains downward, albeit at a slowing pace.

By following a newly defined current (an exponential decline based on the 2008 to 2022 emissions) 2008 emissions would be halved by 2030 and result in annual emissions decline of 10 kt CO_2e with emissions in 2030 projected at 357 kt CO_2e. A linear decline in emissions from the projected 2024 value to zero in 2030 requires an annual reduction of 74 kt CO_2e, 16% of 2022 emissions, for each of the six years to 2030. This amount is 7.4 times the reduction rate of the current trend.

Cumulative emissions from 2021 to 2030, based on the current trend, are projected to reach 4.2 MtCO_2e, almost double the projection of 2.2 Mt CO_2e, had a linear decline been achieved as set out just two years ago.

Future emissions trajectories for Exeter following the Climate Change Committee's Sixth Carbon Budget show that the emissions reduction needed to meet net zero by 2050, as established under the Climate Change Act, also require emissions reductions in advance of the current trend.

Contents

1 Introduction

The 2008 Climate Change Act, with subsequent amendments, sets a legal obligation for net zero emissions in the UK by 2050. The Act established the Climate Change Committee (CCC). The CCC sets five-year carbon budgets for the UK, the most recent of which is the Sixth Carbon Budget[a] [1] covering the period from 2033 to 2037. In 2019, increasing urgency to address climate change led Exeter City Council (ECC) to declare a Climate Emergency and pledge to work towards net zero by 2030 [2].

In 2020 the Council announced a series of initiatives to drive forward the city's net zero ambitions [3] and, in addition, to establish a baseline greenhouse gas (GHG) inventory for the city. The Centre for Energy and the Environment (CEE) at the University of Exeter was commissioned to quantify emissions, quantify reductions required to achieve net zero in 2030, and identify more specific and timely metrics for monitoring progress towards carbon neutrality [4]. Initial projections examined the challenge of net zero by 2050 (the national timeline at the time). Further analysis assessed how Exeter might be able to develop a trajectory to net zero by 2030. The work included an assessment of Exeter's GHG emissions between 2008 and 2019.

This study provides an updated greenhouse gas (GHG) inventory for the city with the 2024 data and estimates the annual emission reduction to achieve zero GHG emissions in 2030. Publication of most of the required data occurs two years in arrears, so this update extends the historic time series to 2022.

2 GHG inventory update

This section presents the updated GHG inventory time series, extended to cover the period 2005 to 2022.

2.1 Methodology

The GHG inventory is compiled on a territorial basis. Territorial emissions are those arising from within the boundaries of Exeter City and are within the control of people living, working, and visiting the city[b]. The one exception is the power sector, which is assessed based on electricity consumption in the area, assuming national average electricity supply emission factors. The publication year of territorial GHG emissions for local authority areas lags the data year by 2 years, so the most recent data available is for 2022 [5].

[a] This study makes extensive use of material from the Sixth Carbon Budget. References to the CCC refer to the Sixth Carbon Budget unless stated otherwise.

[b] The territorial emissions method is consistent with the approach taken in UK national reporting, i.e. considers all the emissions arising from activity within Exeter. An alternative approach is a consumption-based footprint, which would include upstream and downstream emissions arising outside an area, e.g. the manufacture, use and disposal of goods, services, and food from/to elsewhere.

2.1.1 Methodology changes in this update

The methodology is generally the same as that followed for the 2019 footprint, outlined in Internal Document 964 [6]. Subsequently, there have been year-on-year improvements to the methodology for the 2020, 2021, and 2022 footprints outlined in Internal Documents 1017, 1036, and 1064, respectively [7–9].

Changes in the underlying datasets improved the data available for 2020 and affected the methodology as follows [7]:

1. Government data for greenhouse gas emissions at local authority level [10] now include methane (CH_4) and nitrous oxide (N_2O) emissions throughout the time series. These are now taken directly from reported data, when they were previously estimated by the CEE.
2. Agricultural emissions from livestock and crops have been added to the government dataset in recognition that these are significant sources of methane and nitrous oxide emissions[c]. Values are provided for 2020 with estimated historic values for 2019 and 2018, but no data are provided for years before 2018. The agricultural emissions data have been used (where available) in place of a previous assumption that these sources were negligible within Exeter.
3. Emissions from electricity consumption in agriculture are now reported separately in the government dataset (throughout the data series); previously they were included within the domestic, commercial, industrial, and public administration figures with consumption allocated based on the annual consumption and the load profile for each meter. Analysis suggests that most agricultural electricity consumption was previously reported under the commercial sector.

In the 2021 data, the only methodology change was for emissions from wastewater [8]. Previously, this used to be a historic figure for fugitive emissions supplied by South West Water pro-rated on the basis of the number of households. The latest South West Water Annual Performance Report and Regulatory Reporting [11] document provides an up-to-date figure for fugitive emissions, which has been used in this update. Again, this is apportioned based on the number of households. Historic values have been estimated based on wastewater volumes. The 2021 data also enabled the historic time series to be extended back from 2008 to 2005 to reflect updates to source data, and the discontinuity in emissions from agricultural livestock and crops to be eliminated since the previous data included estimates of emission from these sources for years prior to 2018, which were not previously available.

The only methodology change for the 2022 data is for emissions from fluorinated gases (F-gases) [9]. These were previously estimated using F-gas data published by the National Atmospheric Emissions Inventory (NAEI) and apportioning them based on commercial electricity consumption. F-gas data is now taken from the final UK greenhouse gas emissions national statistics [12] (also based on the NAEI data apportioned using commercial electricity

[c] Data has also been added for emissions from waste management processes. However, on examination they are calculated on a waste arisings basis, not a territorial basis. Therefore, the data source used previously (the National Atmospheric Emissions Inventory) has been retained.

consumption). There have also been revisions to the source data, including a sectoral re-classification of emissions and updates to some of the emission estimation models. These are described in more detail in Internal Document 1064[d] [9].

2.1.2 Reporting categories (sectors)

The GHG inventory for Exeter reports emissions under the following categories:

- **Power:** emissions resulting from electricity consumption.
- **Buildings:** emissions resulting from fuel combustion in the domestic, commercial, and public administration sectors.
- **Industry:** emissions as categorised from industry in the government local authority CO_2 dataset [5], including large industrial installations but excluding electricity (reported under power).
- **Transport:** emissions from road and rail vehicles (emissions from electric vehicles are also reported under power; emissions from aviation and shipping have not been included due to lack of data).
- **Agriculture:** emissions from fuel use (excluding electricity), livestock, and arable operations in the sector.
- **Land use** (including land use change and forestry)**:** emissions are produced by biomass removal and are removed (sequestered) by biomass growth. Draining or wetting organic soils, soil mineralisation, and fertilizer application in the forestry industry are also included (however, fertilizer use in agriculture is reported under agriculture).
- **Waste:** emissions from the disposal of solid waste and wastewater.
- **F-gases:** emissions from the consumption of fluorinated gases.

2.2 Results

The data series has been extended to 2022, and values for previous years have been revised to account for the methodology changes described in Section 2.1.1 and revisions to underlying data.

2.2.1 Headline emission results for 2022

Total greenhouse gas emissions in Exeter in 2022 are estimated at 466 kilotonnes of carbon dioxide equivalent (kt CO_2e), a decrease of 45 kt CO_2e (9%) from 2019 and 21 kt CO_2e (4%) from 2021[e].

The breakdown of emissions reported for 2022 is shown in Figure 1, and in greater detail in Figure 2 (as detailed in Appendix A).

[d] In the absence of national data, waste emissions have been assumed to be the same as for 2021.

[e] The comparison is with the latest (revised) 2019 and 2021 figures of 511 kt CO_2e and 487 kt CO_2e, respectively.

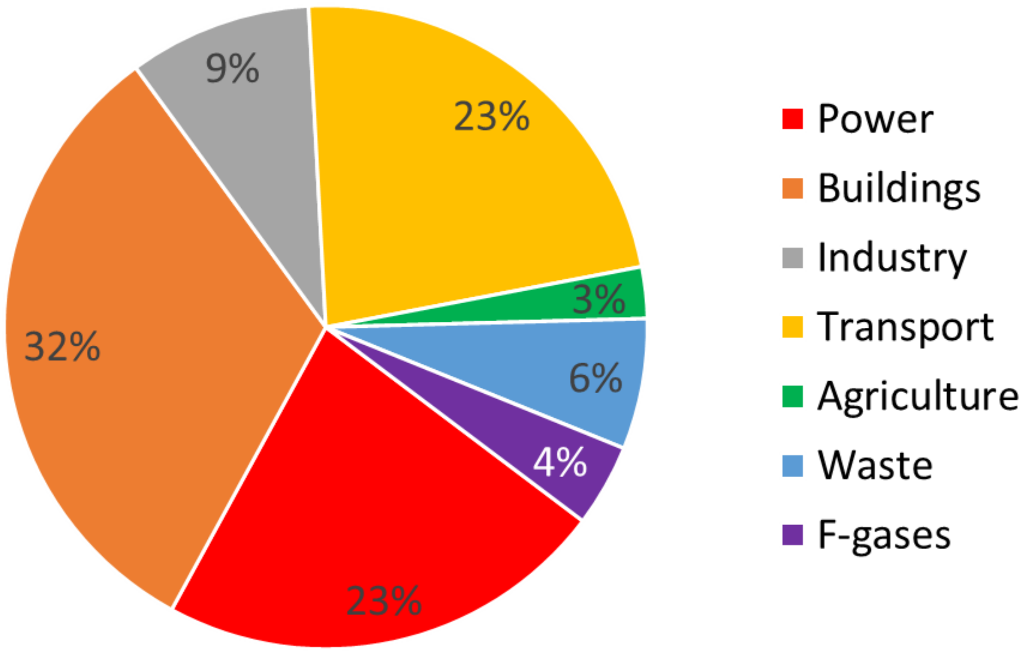

Figure 1. The sources of Exeter's GHG emissions in 2022[f]

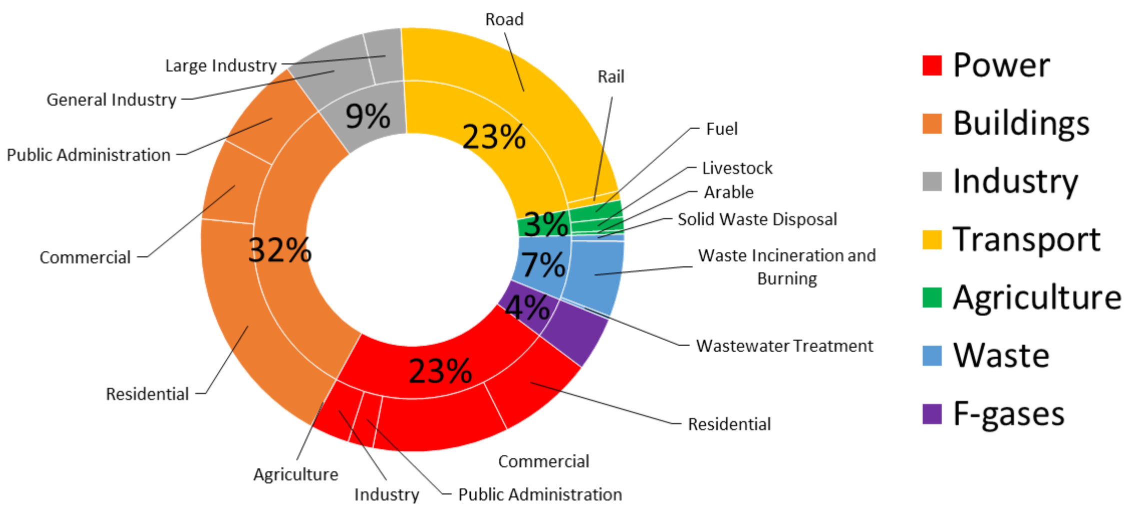

Figure 2. The sources of Exeter's GHG emissions in 2022[f]: detailed split between sectors

2.2.2 Impact of data revision and methodology changes

Exeter's 2019 greenhouse gas inventory and sector emissions monitoring report [4], released in 2022, estimated 2019 GHG emissions to be 476 kt CO_2e. However, with the revised methodology and additional data now included, the revised total GHG emissions figure for 2019 is 511 kt CO_2e, an increase of 35 kt CO_2e or 7%. The underlying data sources often include revisions to the historical time series data when data are released. Hence, differences between the values in the 2022 monitoring report [4] and the revised values presented in this report are partly attributable to data revisions and partly to methodology changes (described in Section 2.1.1).

[f] Land use (0.95 kt CO_2e) is not plotted.

Figure 3 shows the revised figures with the extended historical data and Figure 4 compares the previously reported and revised values for each of the years 2008 to 2019, along with the values calculated for the new time series.

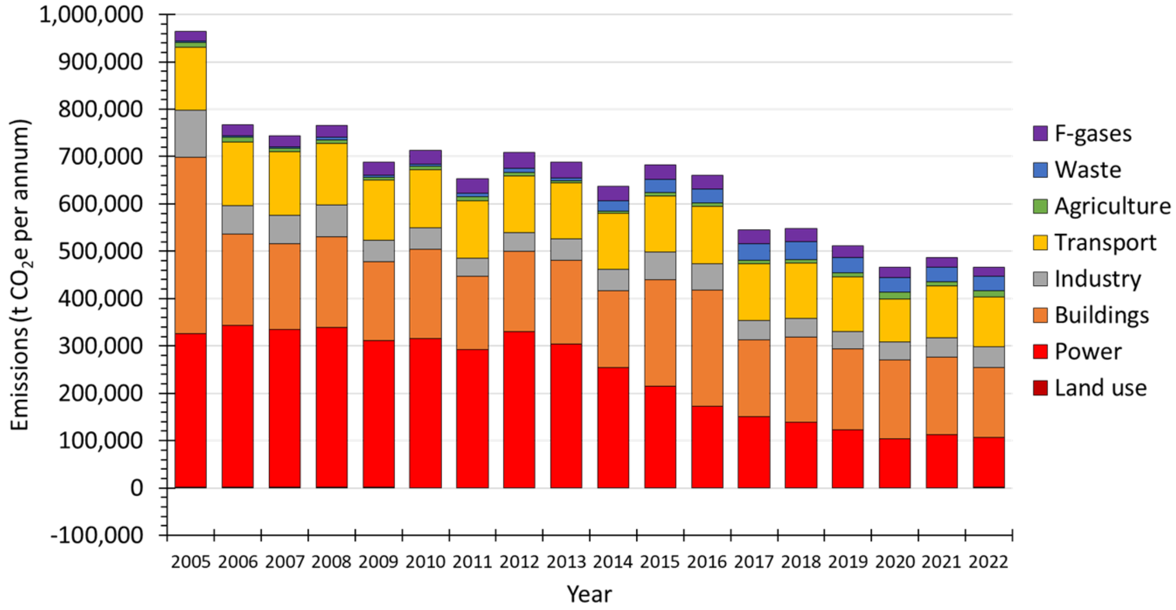

Figure 3. Sources of greenhouse gas emission in Exeter from 2005 to 2022

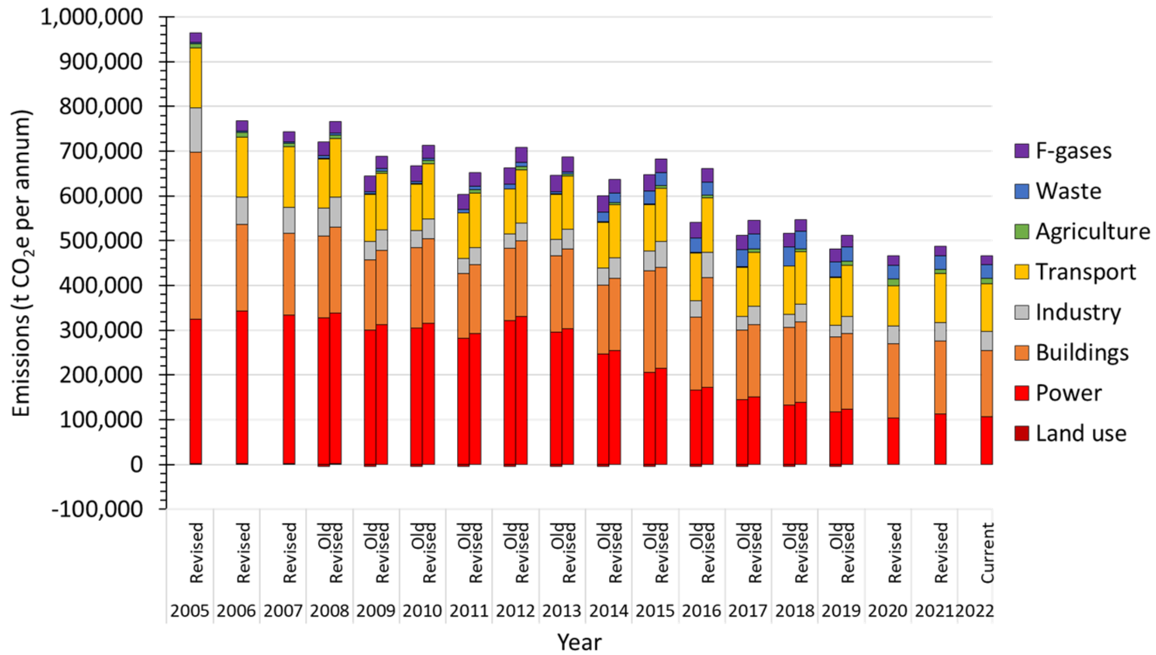

Figure 4. Comparison of previously reported [4] *and revised GHG emissions for the years 2005 to 2022*

The greatest absolute change in the 2019 emission estimates due to data revisions has been for the industry sector, with an increase of 10kt CO_2e or 39%. Emissions from industry fuels and large industrial installations have increased because of revisions to the government local authority CO_2 data [13]. Agriculture experienced the largest percentage change (774%) due to the methodology change described in Section 2.1.1. The government's local authority CO_2 dataset now includes methane and nitrous oxide emissions, providing more accurate estimates. Consequently, non-fuel emissions from livestock and arable operations have been added to the government's data and are now utilised; previously these were assumed to be zero in the predominantly urban jurisdiction of Exeter. However, agricultural emissions remain relatively insignificant at 3% of total GHG emissions. Land use emissions have also suffered a large percentage change (113%) by considering non-CO_2 emissions, changing from a net sink (-5 kt CO_2e) to a small source (0.6 kt CO_2e). Finally, there has been a -4kt CO_2e decrease (-15%) in reported fluorinated gas emissions due to the methodology and data revisions described in Section 2.1.1. Emissions from all other sectors changed by less than 10% due to methodology revisions.

2.2.3 Progress in reducing emissions

A general downward year-on-year trend in emissions is evident from the revised data series in Figure 3, except for the waste sector. The increase in the waste sector over the period from 2014 to 2018 is attributable to the commissioning of the Marsh Barton Energy from Waste (EfW) plant in July 2014. After the initial rise, emissions have trended slightly down over the past four years. Overall, GHG emissions have reduced by 39% (-300 kt CO_2e) since 2008. This is mainly attributable to the power sector, which has seen a 69% reduction in emissions through the national decarbonisation of electricity production.

2.2.3.1 Annual incremental change from 2021 to 2022

The 2022 monitoring report [4] extrapolated the decline in emissions between 2016 and 2019 forward to create a linear trajectory that was referred to as "current trend", which was assumed to be followed in 2020 and 2021. This implied an annual decrease in emissions of 17.5 kt CO_2e, resulting in estimated emissions in 2021 of 448 kt CO_2e. In the absence of more recent reports with updated projections, it can be assumed that this trend was followed for 2022, giving estimated emissions of 431 kt CO_2e for that year[g]. Reported total emissions for 2022 of 466 kt CO_2e are 35 kt CO_2e higher, indicating that the anticipated level of decarbonisation has been overestimated. However, it is worth noting that the revised emissions estimate for 2019 has increased by 7%, hence the emissions reduction from 2019 to 2022 is greater than a comparison with the numbers in the 2022 monitoring report [4] would indicate.

Annual changes in emissions from 2021 to 2022 are shown in Table 1. The greatest year-on-year decrease in 2022 has been in the buildings and power sectors, with a decline of -15 ktCO_2e (-9%) and -6 kt CO_2e (-6%), respectively. Activity in the building sector was impacted by the warmer temperatures and higher energy prices in 2022, resulting in lower fuel demands in both domestic and commercial buildings. The reduction in emissions from the power sector is attributable to the decarbonisation of the grid through increased use of renewables. Transport has also seen a slight decrease in emissions of -3 kt CO_2e (-3%). After the fall in 2020 that resulted from COVID-19 restrictions, transport emissions have returned to pre-pandemic levels, with slight decreases in emissions because of lower fuel consumption and higher fuel efficiency. Agriculture has seen a rise in emissions of 3 kt CO_2e (34%) likely due to an increase in emissions from agricultural machinery. Other sectors have seen annual changes of between

[g] These figures are quoted from the 2022 monitoring report and do not include the impact of revisions to historic data

0% and 5%, except for land use (which is now a net source and has increased by 17% since 2021).

Table 1. Annual (2021 to 2022) changes achieved in sectoral GHG emissions, based on the revised data series

	2021	2022	Change achieved 2021 to 2022	
Sector	t CO_2e	t CO_2e	t CO_2e	%
Power	111,855	105,418	-6,437	-6%
Buildings	163,826	148,705	-15,121	-9%
Industry	41,240	42,777	1,538	4%
Transport	109,421	106,170	-3,251	-3%
Agriculture	9,009	12,054	3,046	34%
Land use	817	953	136	17%
Waste	30,449	30,529	79	0%
F-gas	20,347	19,235	-1,112	-5%
Total	486,963	465,841	-21,122	-4%

2.2.3.2 Progress from 2008 towards zero emissions

Figure 5 shows the changes achieved in each sector since 2008[h] and compares historic emissions for each sector with a linear trajectory from 2008 to zero in 2030. Only for the power and land use sectors are the trajectories on trend to achieve zero GHG emissions by 2030.

The increase in waste sector emissions after 2014 is a result of the development of the Marsh Barton EfW. Prior to 2014, the city's waste emissions were artificially low as Exeter's waste was landfilled outside of the city. Since 2014 the situation is partially reversed as the EfW plant treats some waste that originates outside of Exeter. The associated emissions are included because the inventory is performed on a territorial basis, but some are attributable to behaviours outside of the geographic area. Additionally, the emissions values do not consider the biogenic content of the waste nor emissions offset by the generation of electricity.

Progress in the power sector is attributable to rapid decarbonisation of grid electricity nationally; emissions are calculated using a national average emission factor for electricity generation, transmission, and distribution. Thus, changes in grid carbon intensity will largely take place outside the city.

Lack of progress in the buildings and transport sectors (where the sharp decline in transport emissions in 2020 attributable to the Covid-19 pandemic has been lost after travel restrictions were removed) is particularly concerning as these sectors are major sources of GHG emissions, and reductions fall well short of the level of change required to meet zero emissions.

[h] Updated versions of Tables 2 and 3 included in the 2022 monitoring report are available in Appendix B. These quantify changes since 2008 and since 2016.

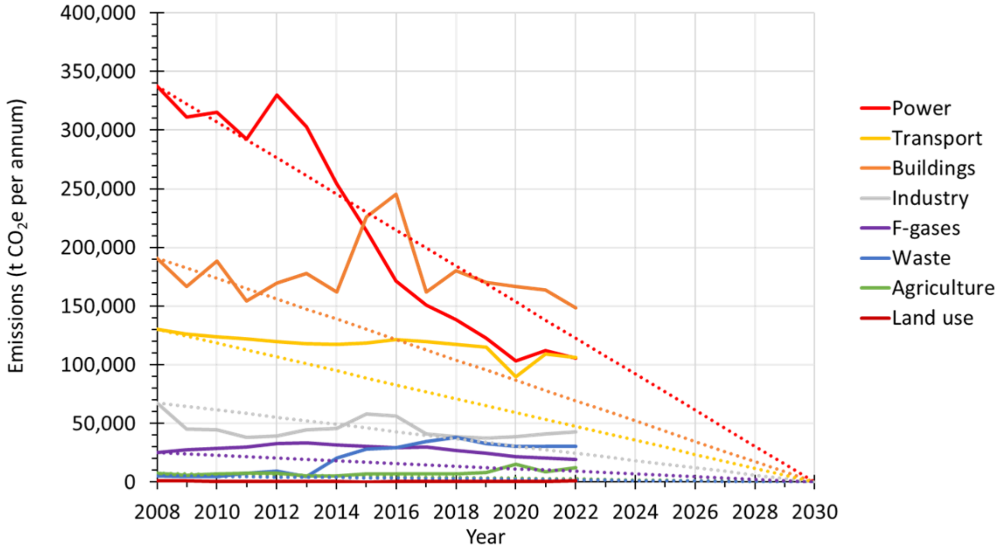

Figure 5. Emissions against a linear trajectory to zero by 2030 (dotted), 2008 base, by sector

Figure 6 shows the progress in reducing GHG emissions from all sectors combined. Progress again falls short of delivering zero in 2030. After the bounce back from lower emissions during the COVID-19 pandemic in 2020, emissions have returned to the rate of decline of the 2016 to 2019 trend. If this is continued, 2008 emissions would perhaps only be halved by 2030.

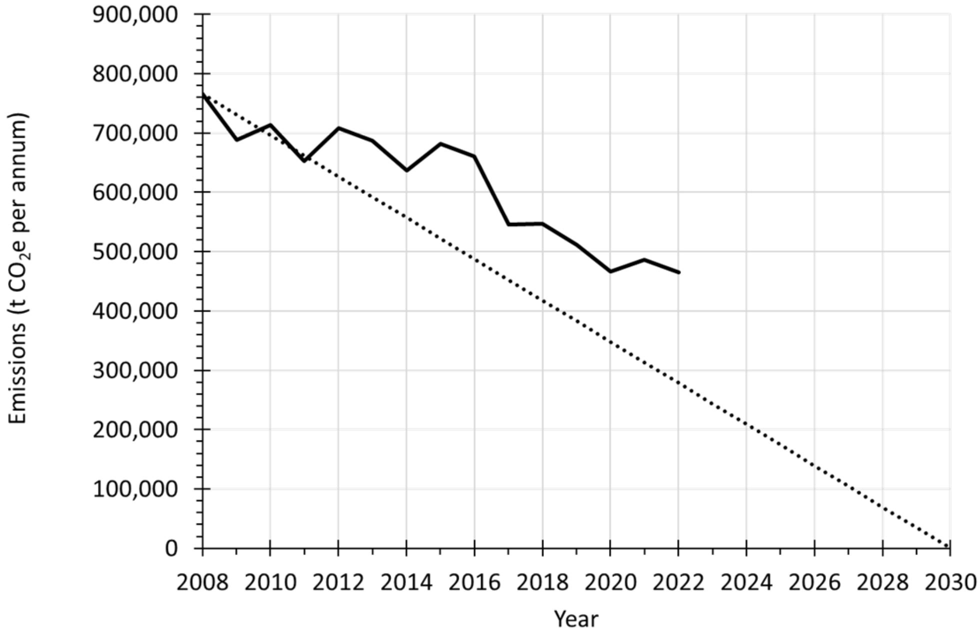

Figure 6. Emissions against a linear trajectory to zero by 2030 (dotted), 2008 base, total emissions

2.2.4 Future emissions trajectories to 2030

This section considers the magnitude of future GHG emissions reductions required to achieve zero emissions by 2030.

2.2.4.1 Definition of current trend

Figure 7 extrapolates Exeter's total GHG emissions from the city's 2022 actual emissions based on a newly defined "current trend" to depict future emissions reductions. This current trend was derived as an exponential decline based on the historical emissions data from 2008 to

2022, as the bulk of emissions reduction through grid decarbonisation has already been achieved and, based on the current trajectory, the amount of decarbonisation projected will diminish every year. The new "current trend" suggests that emissions reduce on average by 10 kt CO_2e per year between 2022 and 2050, with emissions in 2030 of 358 kt CO_2e. However, the continuation of the current trend without local GHG reduction relies on unrealistic grid decarbonisation that would imply zero carbon grid electricity in 2026[i]. While it may be realistic to assume current trend estimates for the near future may be achieved with grid decarbonisation, a reduction from non-power sectors will be required to continue to follow and exceed the current trend if net zero by 2030 is to be achieved.

2.2.4.2 Linear decline to 2030 from 2021 or 2024

Emissions reductions to zero in 2030 could take many alternative trajectories. For example, a possible but unlikely trajectory would be to follow the current trend from 2022 until 2029 with zero occurring in one step the following year. This would create cumulative emissions of 3.8 MtCO_2e from 2021 to 2030 (see Figure 8). The 2022 monitoring report [4] examined a linear decline in emissions from a 2021 value (based on the current trend) to zero in 2030. This showed a decline of 50 kt CO_2e per year and cumulative emissions of 2.2 Mt CO_2e. Re-working this analysis using the latest historic data revises these values to 54 kt CO_2e per year and cumulative emissions of 2.4 Mt CO_2e, as plotted in Figure 7 and Figure 8.

Historic data shows that radical reductions in emissions across all sectors were not delivered in 2021 nor in 2022, and it is unlikely that they were delivered in 2023. Thus, the annual linear reduction in emissions that would be necessary to deliver zero emissions in 2030 starting from 2024 has been determined. The two-year lag in emissions reporting has been addressed by assuming that emissions follow the "current trend" in 2023 and 2024. Achieving this endpoint will require concerted effort from all stakeholders within the city: businesses and residents as well as the council itself, as acknowledged by the IPCC.

Delaying the start of the linear decline to zero from 2021 to 2024 increases the required annual reduction in emissions from 54 to 74 kt CO_2e per year: the latter represents an additional 64 kt CO_2e (640%) reduction per year over and above the current trend (Figure 7).

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[i] The Climate Change Committee's assessment in the Sixth Carbon Budget is that electricity grid carbon intensity will approach zero (10 g CO_2/kWh, a reduction of 95% in 2022), in 2035.

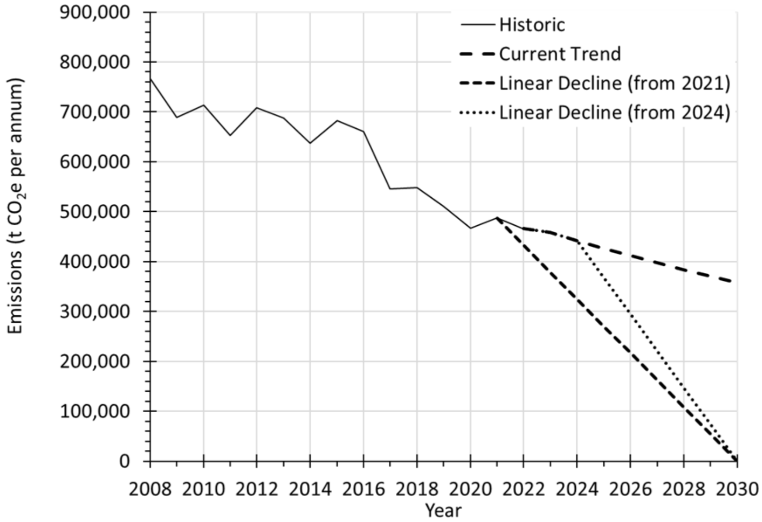

Figure 7. Emissions following the current trend with a linear decline trajectory from 2021 or 2024 to zero by 2030

Figure 8 shows the cumulative emissions from the current trend and linear decline trajectories. Current trend cumulative emissions from 2021 to 2030 reach 4.2 Mt CO_2e (previously 3.7 Mt CO_2e[j]) while linear declines for 2021 and 2024 reach 2.4 Mt CO_2e (2.2 Mt CO_2e previously), and 3 Mt CO_2e, respectively.

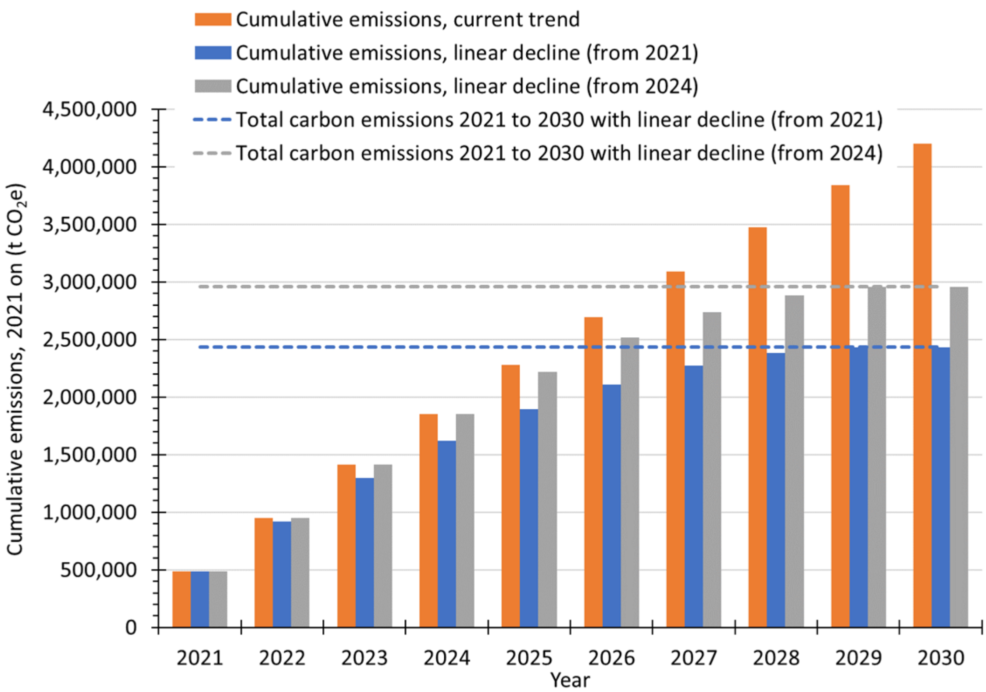

Figure 8. Cumulative emissions under alternative trajectories: extrapolating the current trend, or linear decline to zero in 2030 starting in either 2021 or 2024.

2.2.5 Comparison with previous years

Table 2 compares the linear GHG emission reduction strategies to zero emission in 2030 outlined in the previous monitoring report and the current report. The table shows that each

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[j] These figures are quoted from the 2022 monitoring report and do not include the impact of revisions to historic data

year that passes where the trajectory to zero emissions in 2030 is not met, adds to the rate of emissions reductions required in subsequent years and to the resulting cumulative emissions.

Table 2. GHG emissions linear reductions reported in 2021 and 2024[k]

Report year & decline start year	2021	2024
Annual GHG reduction required (kt CO_2e)	50	74
Increase in annual emissions reduction required from 2021 (kt CO_2e)		24 (48%)
Cumulative emissions from 2021 to 2030 (Mt CO_2e)	2.2	3
Increase in cumulative emissions from 2021 (kt CO_2e)		0.8 (36%)

Since 2021 the rate of GHG emissions reduction required to reach zero emissions in 2030 has increased by almost half and the cumulative emissions that result have increased by over a third. Under the current trend in this year's report the 2.2 Mt CO_2e cumulative emissions estimated for 2021 is likely to be exceeded in 2026 (Figure 8).

2.2.6 Future emission trajectories following the Sixth Carbon Budget to 2050

Future emissions trajectories for Exeter following the Climate Change Committee's Sixth Carbon Budget [1] Balanced Pathway to net zero in 2050 have been estimated. Emissions offset from land and GHG removals have not been included since they are impracticable on a large scale in Exeter, which is predominantly urban (reducing opportunities for sequestration through planting).

The future trajectories have been calculated from future national emissions set out in the CCC 2023 Report to Parliament [14] by scaling these to match emissions reported in Exeter in 2022. The historic national trajectories have also been calculated from historic national emissions set out in the 2024 Report to Parliament [15] by scaling these to match emissions reported in Exeter in 2005. No adjustment has been made to account for historic over or under performance of emission reduction in Exeter.

Figure 9 shows the future trajectory of total emissions in Exeter following the Balanced Pathway to net zero excluding offsets from land and GHG removals. Consequently, residual emissions of 28 kt CO_2e are projected in 2050. The comparison between the Balanced Pathway trajectory and the current trend illustrates that significant emissions reductions beyond the current trend are required to meet net zero by 2050 as established under the Climate Change Act.

[k] These figures are quoted from the 2022 monitoring report and do not include the impact of revisions to historic data

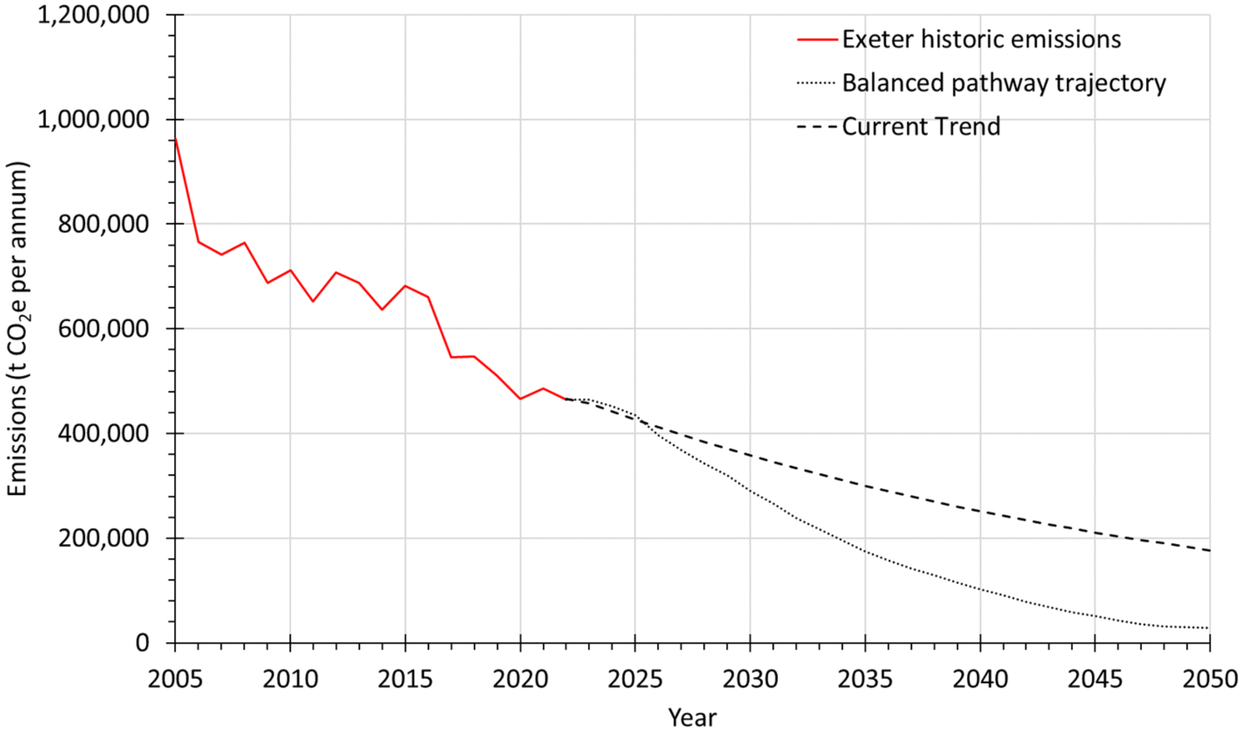
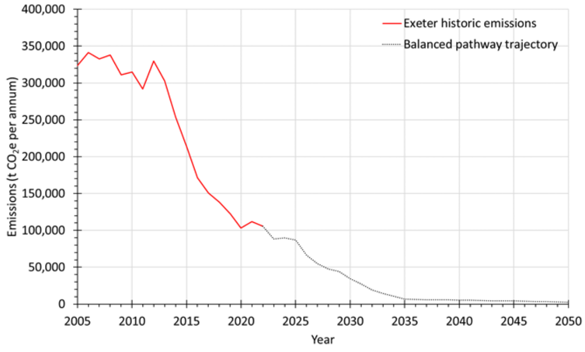
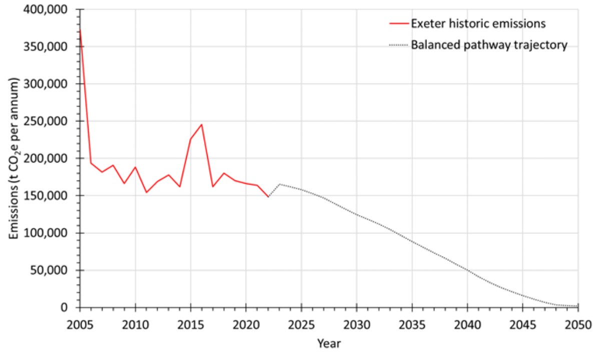


Figure 9. Future GHG emissions in Exeter compared to the national balanced net zero pathway

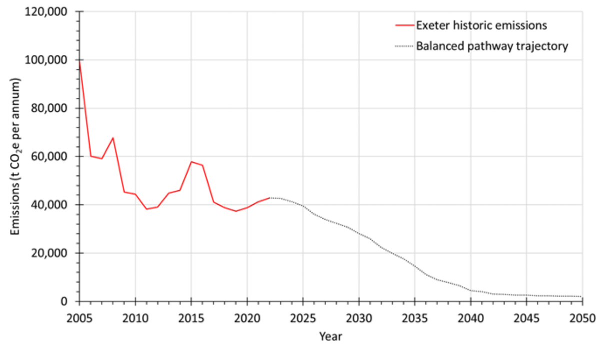
Figure 10 a to h depicts the future trajectory of total emissions in Exeter following the balanced net zero pathway for each sector. The trajectory for land use is shown for information but has not been included in the overall totals depicted in Figure 9. As on a national scale it is foreseen for land use to become a net sink (negative values), it cannot adequately be scaled to Exeter's emissions due to its urban nature. Most land use emissions derive from the conversion of land to settlement, counteracting any carbon sequestered by forests or grasslands and making land use a net source. Thus, the trajectory shows a linear decline and sets the target of eliminating these by 2050 by avoiding emissions from urbanisation.



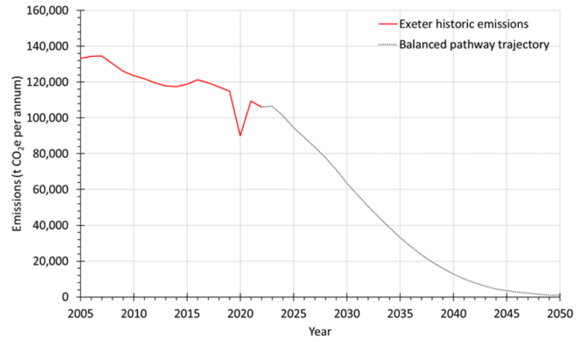
a. Power



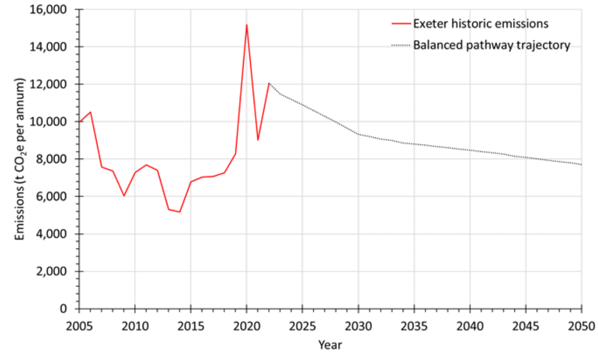
b. Buildings



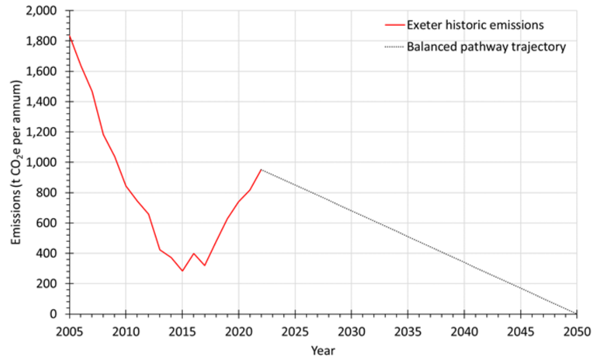
c. Industry



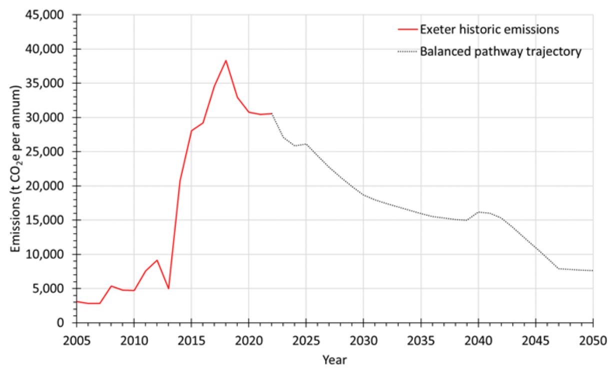
d. Transport



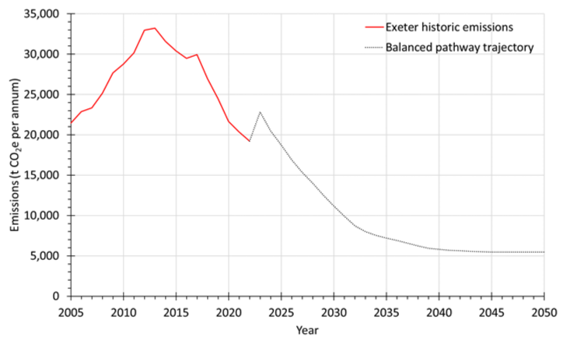
e. Agriculture



f. Land Use



g. Waste



h. F-gases

Figure 10. Future GHG emissions in Exeter by sector compared to the national balanced net zero pathway

References

[1] Climate Change Committee, The Sixth Carbon Budget - Methodology Report, 2020. https://www.theccc.org.uk/publication/sixth-carbon-budget/ (accessed August 9, 2024).

[2] Exeter City Council, Council adopts Exeter's roadmap to a carbon neutral future, (2020). https://news.exeter.gov.uk/council-adopts-exeter-s-roadmap-to-a-carbon-neutral-future/ (accessed August 15, 2024).

[3] Exeter City Council, New role to drive forward city's net zero ambitions, (2020). https://news.exeter.gov.uk/new-role-to-drive-forward-city-s-net-zero-ambitions/ (accessed August 15, 2024).

[4] T. A. Mitchell, A. Norton, A. Rowson, Exeter's 2019 greenhouse gas inventory and sector emissions monitoring, 2022. Centre for Energy and the Environment Internal Document 1007.

[5] Department for Energy Security and Net Zero, UK local authority and regional greenhouse gas emissions statistics, 2005 to 2022, (2024). https://www.gov.uk/government/statistics/uk-local-authority-and-regional-greenhouse-gas-emissions-statistics-2005-to-2022 (accessed July 9, 2024).

[6] T. A. Mitchell, Greenhouse gas inventories for SWEEG: methodology paper., 2020. Centre for Energy and the Environment Internal Document 964.

[7] T. A. Mitchell, Greenhouse gas inventories for SWEEG: updated methodology for 2020 reporting year., 2022. Centre for Energy and the Environment Internal Document 1017.

[8] T. A. Mitchell, Greenhouse Gas Inventories for SWEEG: Updated Methodology for 2021 Reporting Year, 2023. Centre for Energy and the Environment Internal Document 1036.

[9] R. Rubia Rankin, Greenhouse Gas Inventories for SWEEG: Updated Methodology for 2022 Reporting Year, 2024. Centre for Energy and the Environment Internal Document 1064.

[10] Department for Business, Energy & Industrial Strategy, UK local authority and regional greenhouse gas emissions national statistics, 2005 to 2020, (2022).

[11] South West Water, Annual Performance Report and Regulatory Reporting 2023 - Version 2, 2024. https://www.southwestwater.co.uk/about-us/performance/how-we-are-performing (accessed July 9, 2024).

[12] Department for Energy Security and Net Zero, Final UK greenhouse gas emissions national statistics: 1990 to 2022, (2024). https://www.gov.uk/government/statistics/final-uk-greenhouse-gas-emissions-national-statistics-1990-to-2022 (accessed July 31, 2024).

[13] Department for Energy Security and Net Zero, UK local and regional greenhouse gas emissions estimates for 2005-2022 Technical Report, 2024. https://www.gov.uk/government/statistics/uk-local-authority-and-regional-greenhouse-gas-emissions-statistics-2005-to-2022 (accessed August 6, 2024).

[14] Climate Change Committee, Progress in reducing emissions. 2023 Report to Parliament, 2023. https://www.theccc.org.uk/publication/progress-in-reducing-emissions-2024-report-to-parliament/ (accessed August 10, 2024).

[15] Climate Change Committee, Progress in reducing emissions: 2024 Report to Parliament, 2024. https://www.theccc.org.uk/publication/2023-progress-report-to-parliament/ (accessed August 10, 2024).

Appendix A. Breakdown of Exeter's 2022 GHG emissions

Table A-1. Sub-sector breakdown of CO_2e emissions in Exeter in 2022

Sub-sector	t CO_2e	Sector
Residential Electricity	34,145	Power
Residential Fuel	86,594	Buildings
Commercial Electricity	48,250	Power
Commercial Fuel	28,833	Buildings
Public Administration Electricity	8,904	Power
Public Administration Fuel	33,279	Buildings
Industry Electricity	14,066	Power
Industry Fuel	29,323	Industry
Large Industry	13,454	Industry
Industrial Processes	0	Industry
Industry Product Use	19,235	F-Gases
Agriculture Electricity	53	Power
Agriculture Fuel	6,062	Agriculture
Agriculture Livestock	4,627	Agriculture
Agriculture Arable	1,365	Agriculture
Land Use and Land Use Change	953	Land Use
Road Transport (exc. Electricity)	102,979	Transport
Rail Transport (exc. Electricity)	3,191	Transport
Solid Waste Disposal	2,573	Waste
Biological Waste Treatment	0	Waste
Waste Incineration and Burning	26,793	Waste
Wastewater Treatment	1,163	Waste
TOTAL	465,841	

Appendix B. Updated emissions compared to 2008 and 2016 baselines

Table A-2. Changes achieved from a 2008 and 2016 baseline in kt CO_2e. Negative values indicate a reduction. Values in green exceed the annual reduction required for zero carbon by 2030 on a linear trajectory; those in red do not

Sector	Change achieved (kt CO_2e)		Average annual change achieved (kt CO_2e)		Annual change required to achieve zero carbon by 2030 (kt CO_2e)	
	2008 to 2022	2016 to 2022	2008 to 2022	2016 to 2022	2008 to 2030	2016 to 2030
Power	-232.4	-66.1	-16.6	-11.0	-15.4	-12.2
Buildings	-42.2	-96.9	-3.0	-16.1	-8.7	-17.5
Industry	-24.9	-13.7	-1.8	-2.3	-3.1	-4.0
Transport	-24.3	-15.1	-1.7	-2.5	-5.9	-8.7
Agriculture	+4.7	+5.0	+0.3	+0.8	-0.3	-0.5
Land use	-0.2	+0.6	-0.0	+0.1	-0.1	-0.0
Waste	+25.2	+1.3	+1.8	+0.2	-0.2	-2.1
F-gases	-5.9	-10.3	-0.4	-1.7	-1.1	-2.1
Total	-300.1	-195.0	-21.4	-32.5	-34.8	-47.2

Table A-3. Changes achieved from a 2008 and 2016 baseline in percentage terms. Negative values indicate a reduction. Values in green exceed the annual reduction required for zero carbon by 2030 on a linear trajectory; those in red do not

Sector	Change achieved (%)		Average annual change achieved (%)		Annual change required to achieve zero carbon by 2030 (%)	
	2008 to 2022	2016 to 2022	2008 to 2022	2016 to 2022	2008 to 2030	2016 to 2030
Power	-69%	-39%	-5%	-6%	-5%	-7%
Buildings	-22%	-39%	-2%	-7%		
Industry	-37%	-24%	-3%	-4%		
Transport	-19%	-12%	-1%	-2%		
Agriculture	+64%	+71%	+5%	+12%		
Land use	-19%	+139%	-1%	+23%		
Waste	+469%	+5%	+34%	+1%		
F-gases	-24%	-35%	-2%	-6%		
Total	-39%	-30%	-3%	-5%		