Regional Energy System Operator (RESO)

Smart Local Energy System Design

RESO

WP2-2.3.3:

CO_2 Emission Reduction Pathways for Coventry City Council Area

Version: 1.0.1

Date: 2021-02-02

Element	Description
Title	CO_2 Emission Reduction Pathways for Coventry City Council Area
Creator	Dr Joe Day, Dr Grant Wilson
Subject	Coventry Carbon emissions
Description	A document detailing the carbon reduction pathways that provide an upper and lower boundary for the Regional Energy Systems Operator Project
Publisher	Energy Informatics Group, University of Birmingham
Contributor	Contributions from WMCA, Coventry City Council, Electron, Enzen and Wattify
Date	2021-02-02
Type	text
Format	application/pdf
Identifier	10.5281/zenodo.4607181
Source	Various - detailed within the report
Language	en-GB
Relation	
Coverage	Carbon emissions relating to the RESO geographical area (Coventry Local Authority area) from 2020 beyond the RESO project target date of 2032
Rights	CC-BY-4.0
Dissemination /	☒ Public/ RESO webpage/ Social media ☒ ERIS/ IUK Consortiums

confidentiality	☒	Funder
	☒	Consortium
	☒	Internal (internal and consortium through draft stage, eventually to be made public)

Change log	Updated by	Date
Target pathways agreed across project work package discussions	Dr Grant Wilson	2020-04-30
Consolidated draft for internal project feedback	Dr Grant Wilson	2020-10-02
Consolidated draft for internal project feedback	Dr Grant Wilson	2020-11-04
Final draft - internal	Dr Grant Wilson	2020-11-19
Final draft – external (public)	Dr Grant Wilson	2020-02-02

Regional Energy System Operator (RESO) Smart Local Energy System (SLES) design is funded by the government's Department for Business, Energy and Industrial Strategy (BEIS) as part of the Industrial Strategy Challenge Fund (ISCF) (link).

West Midlands Regional Energy Systems Operator (RESO)

CO_2 Emission Reduction Pathways for Coventry City Council Area

TABLE OF CONTENTS

This report has been created for the Regional Energy Systems Operator (RESO) project where Coventry City Council is a partner organisation. The consortium of RESO project partners also includes West Midlands Combined Authority, Energy Capital, Transport for West Midlands, Enzen, PlacesInCommon, Camirus, University of Birmingham, University of Warwick, Electron, Wattify, Cadent and Western Power Distribution.

However, any views or recommendations within this report do not constitute official policy or adopted targets by Coventry City Council or the wider West Midlands Combined Authority. The CO_2 emission reduction pathways detailed here are illustrative to help the RESO project consider different options for a detailed energy systems design focussed on the City of Coventry. The RESO project will also consider how replicable and scalable the learning from approaches and design at Coventry City Council might be to the wider West Midlands Combined Authority area.

Summary

This report details the approach of the Regional Energy Systems Operator (RESO) project to define illustrative CO_2 emission pathways until 2050 for the area of interest (the entire Coventry local authority plus six neighbouring LSOAs). Emission reduction pathways are needed to calculate the cumulative CO_2 emissions over a period of time, and assess the impact of the recommendations made by the RESO project. This cumulative sum allows a comparison to any agreed remaining carbon budget for a given geographic area. Although a net zero target can be helpful as a singular objective, it is the amount of emissions released on the pathway to net zero that has the impact on the climate.

It was decided to adopt an approach that allowed for a range of target pathways between the most ambitious in reducing emissions and least ambitious in reducing emissions. Subsequently, the year-on-year CO_2 emission reductions through an exponential decay were respectively set at **-13.1%** (minus 13.1 percent) for the most ambitious and **-10%** for the least ambitious. Compared to 2017 values, these pathways would lead to a 90% reduction in annual CO_2 emissions by 2035 for the -13.1% pathway or 2041 for the -10% pathway. The creation of this document is to allow the sharing of the approach of the RESO project, as it may serve to aid in the derivation of target pathways for analysis of other local areas.

These emission reduction target pathways are for guidance only to aid the RESO project in its goal of a system design and in the project's external evaluation. At the date of publication, these metrics are not a reflection of any official government carbon reduction targets or adopted local authority targets.

1 Background

In 2019 the UK was the first developed country to pass a net zero emissions target into law. Being net zero by 2050 underpins the UK's commitment to the UNFCCC COP 21 2016 Paris Agreement to keep global warming under 2°C. However, the cumulative amount of emissions is ultimately the driver of climate change, *e.g.* it is the amount of CO_2 emissions released on the way to net zero rather than the net zero target itself which is the important factor (for an explicit example of this see Figure 1). Nonetheless, the net zero target by 2050 provides a singular and defined target whereby the UK will no longer be adding to the global total of Green House Gas emissions (from a territorial emissions perspective).

The Regional Energy System Operator (RESO) project is a detailed design project funded by Innovate UK from January 2020 to December 2021 with a focus on the decarbonisation of Coventry City Council local authority area. The aim of the RESO project is to create a cleaner, lower cost energy system for Coventry and the West Midlands region that maximises economic opportunities in clean growth and future mobility. Its aim is to help deliver local policy objectives towards the UK's net zero emissions in 2050 framed by the Paris agreement. The timeframe for focus for the RESO project is however 2032, a timeframe when significant decarbonisation must have already taken place within the Coventry City Council local authority area in order to put it on a trajectory appropriate for the UK's 2050 national ambitions.

An aim of the RESO project's detailed design methodology for Coventry is to demonstrate its relevance to the wider region by having an approach for other local authority areas that is repeatable. Within the overall RESO project context of creating a detailed energy system design, the Energy Informatics Group at the University of Birmingham provides input on data foundations with a particular focus on energy data. Data relating to CO_2 emissions is a vital piece of the puzzle of information required to design a local clean energy system. The benefit of this data includes disaggregating the emissions by sector and energy vector at the start of the energy system transition, which is important to inform the scale of the changes required. It also provides knowledge to create an emissions target pathway, so that a future smart local energy system can be quantitatively assessed against this goal.

Finally, it should be noted for the purposes of the RESO project, only emissions of CO_2 are considered (which accounted for 81% of UK greenhouse gas emissions in CO_2 equivalent in 2018[1]). Local level point source information on other greenhouse gas and air pollutant emissions is available through the National Atmospheric Emissions Inventory[2]. Furthermore, the only CO_2 emissions accounted for are those produced in the area from the use or combustion of the following energy vectors: electricity, natural gas, liquid fuels (*e.g.* petrol, diesel, heating oil) and solid fuels (*e.g.* coal) and across the following sectors: large industrial installations, industrial,

[1] https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/862887/2018_Final_greenhouse_gas_emissions_statistical_release.pdf

[2] https://naei.beis.gov.uk/data/map-large-source

commercial, domestic, agriculture, road transport, railways and internal waterways. LULUCF and cement production are also excluded in line with equity principles of the Paris Agreement [3] as detailed in the Tyndall centre methodology. In addition, consumption or footprint-based emissions (*e.g.* from imported manufactured goods) are not included in the pathway values.

[3] https://carbonbudget.manchester.ac.uk/reports/E08000026/print/

2 Context for Coventry

The city of Coventry is an administrative centre and metropolitan borough in England with an area of 98.64 km^2. By land use, the local authority is 58% built on, 17% green urban, 25% farmland and <1% attributed to natural area[4]. According to the Office for National Statistics (ONS) estimates, the population of Coventry in mid-2018 was about 366,800[5] with the Gross Value Add per capita standing at £24,890[6] (ONS 2017). According to the Local Land and Property Gazetteer there are 145,500 domestic dwellings in Coventry and BEIS 2018 figures state 12.1% of households are in fuel poverty compared to the national average of 10.2%[7].

The RESO project boundary includes 201 LSOAs. This is made up of the 195 Coventry local authority area LSOAs (green area in Figure 1), and six additional LSOAs Warwick 005G, Rugby (004D, 001C), Nuneaton & Bedworth (015C, 015D, 015E), yellow areas in Figure 1. However, for the energy consumption and carbon emission analysis, these additional LSOAs areas were excluded since BEIS publishes the relevant statistics at a local authority level and the additional LSOA contributions will be small compared to the Coventry local authority area.

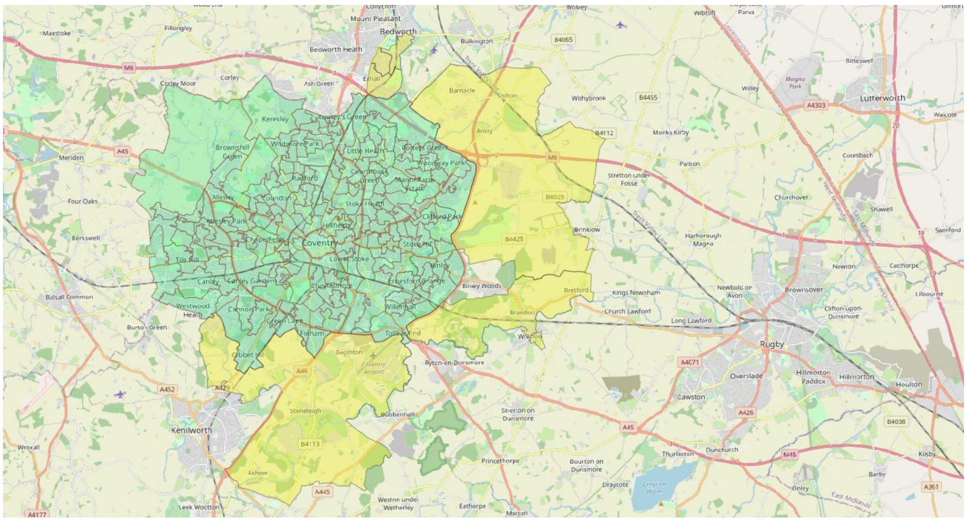


Figure 1 - Map of the 201 LSOAs of interest for the RESO area. The 195 Coventry local authority LSOAs are in green and the 6 LSOAs outside the local authority boundary are in yellow

[4] https://land.copernicus.eu/pan-european/corine-land-cover

[5] https://www.ons.gov.uk/peoplepopulationandcommunity/populationandmigration/populationestimates/bulletins/annualmidyearpopulationestimates/mid2019

[6] https://www.ons.gov.uk/economy/grossvalueaddedgva/bulletins/regionalgrossvalueaddedbalanceduk/1998to2017#interactive-map-gross-value-added-gva-per-head-for-nuts3-local-areas-1998-to-2017

[7] https://www.gov.uk/government/statistics/sub-regional-fuel-poverty-data-2020

3 SANKEY DIAGRAM

Using publicly available data, a Sankey diagram was produced to represent the multi-vector energy flows within the RESO area in terms of their energy in GWh, cost in £ million and carbon emissions in kt CO_2. The diagram for the carbon emissions Sankey diagram from that analysis is shown in Figure 2.

The methodology is based on 14 publicly available datasets, the core data is from BEIS total final energy consumption statistics 2017[8], and is largely consistent with the BEIS local CO_2 emissions from the same year[9] (differing very slightly from methodological differences and additional local data that was available to the RESO project). The methodology will be detailed in a separate Energy Informatics Group RESO report on creating the Sankey diagram to be published in 2021.

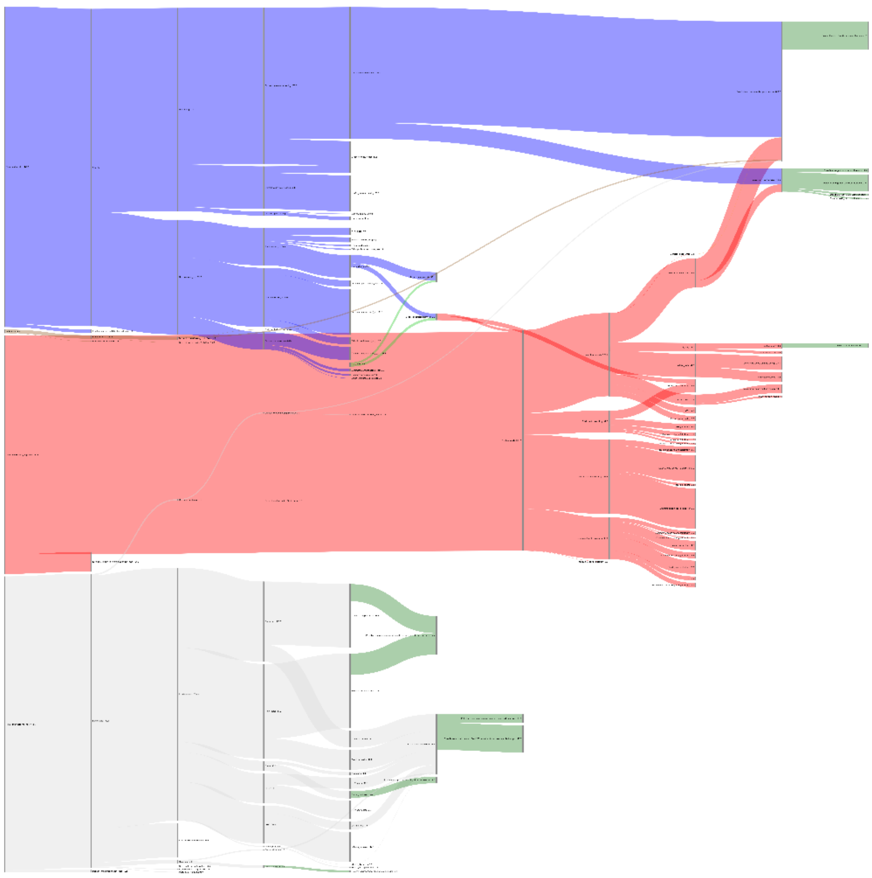


FIGURE 2 - SANKEY DIAGRAM FOR THE CARBON EMISSIONS OF THE RESO AREA BROKEN DOWN BY ENERGY VECTOR (RED FOR ELECTRICITY, BLUE FOR GAS AND GREY FOR LIQUID FUELS), CONSUMING SECTOR AND END USE

[8] https://www.gov.uk/government/statistical-data-sets/total-final-energy-consumption-at-regional-and-local-authority-level

[9] https://www.gov.uk/government/statistics/uk-local-authority-and-regional-carbon-dioxide-emissions-national-statistics-2005-to-2017

The BEIS dataset gives total emissions (excluding Land Use Land Use Change and Forestry) of 1331 kt CO_2 whereas the Sankey diagram methodology yielded a slightly lower 1290 kt CO_2. During the project, the latest 2018 BEIS local authority emissions were also released[10] which quote 1289 kt CO_2 and a revised value of 1318 kt CO_2 for 2017. These statistics are broadly in line with the reduction in total UK greenhouse gas emissions of 2.4% between 2017 and 2018[11]. For consistency with the values from the Tyndall centre methodology, the original 1331 kt CO_2 were used as the 2017 starting point.

The vectors shown in Figure 2 are natural gas in blue, electricity in red and liquid fuels in grey. Gas is responsible for the largest fraction of CO_2 emissions at 37%, closely followed by liquid fuels at 35%. Electricity contributes to 27% of emissions and has been the sector with the fastest reducing emissions at a national level over the 2010-2019 decade (Appendix 1 shows a chart from 1990 to 2017 by emissions and sectors). The remaining emissions arise from a small amount of solid fuel and municipal solid waste combustion. The respective carbon intensities used were 0.26 kg CO_2 / kWh for electricity (based on the UK national grid average for 2017), 0.25 kg CO_2 / kWh for liquid fuels and 0.18 kg CO_2 / kWh for gas[12]; the lower carbon intensity of gas is highlighted by the fact its share of overall energy consumption is 45% compared to 31% for liquid fuel and 23% for electricity. It is also noteworthy that the carbon intensity of grid electricity continues to fall (to 0.24 kg CO_2 / kWh in 2019[13]) due to increased generation from renewables and is expected to continue to do so throughout the 2020s. Indeed, the Future Energy Scenarios from National Grid published in June 2020 consider the net zero compliant scenarios to be net negative in emissions intensity with the introduction of bioenergy plus carbon capture and storage in the 2030s[14].

When the carbon emissions are segmented by end-users for the RESO area, it is found that the ratio between domestic and non-domestic consumers is 55% to 45% (assuming all cars are for private use and all LGVs are for commercial use). Similarly, the emissions can also be segmented by type of energy use (heat, transport or power) which was as follows: 51% heat (including space heating, hot water and process heat), 31% transport and 19% electrical power (not including electricity used for heating or transport purposes). Further dissecting these emissions by energy uses into domestic and non-domestic consumers yields: 29% domestic heat, 22% non-domestic heat, 22% private transport, 9% commercial transport, 6% domestic electrical power and 13% non-domestic electrical power.

[10] https://www.gov.uk/government/statistics/uk-local-authority-and-regional-carbon-dioxide-emissions-national-statistics-2005-to-2018

[11] https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/862887/2018_Final_greenhouse_gas_emissions_statistical_release.pdf

[12] https://www.gov.uk/government/publications/greenhouse-gas-reporting-conversion-factors-2019

[13] https://carbonintensity.org.uk

[14] https://www.nationalgrideso.com/future-energy/future-energy-scenarios/fes-2020-documents

TABLE 1 - A SUMMARY OF THE MAIN ENERGY VECTORS USED IN THE RESO AREA BY THEIR PERCENT OF ENERGY CONSUMPTION, CARBON INTENSITY AND PERCENT OF CO2 EMISSIONS. NOMINAL YEAR 2017.

Energy Vector	Percent of energy consumption	Carbon Intensity (kg CO_2 / kWh)	Percent of CO_2 emissions
Gas	45%	0.18	37%
Liquid fuel	31%	0.25	35%
Electricity	23%	0.26	27%

TABLE 2 - A SUMMARY OF THE ENERGY USES IN THE RESO AREA BY THEIR PERCENT OF TOTAL CO2 EMISSIONS AND CONSUMING SECTOR. ELECTRICAL POWER DOES NOT INCLUDE ELECTRICITY USED FOR HEATING AND TRANSPORT PURPOSES. NOMINAL YEAR 2017.

Energy use	Percent of total emissions from domestic users	Percent of total emissions from non-domestic users
Heat	29%	22%
Transport	22%	9%
Electrical power	6%	13%

Tables 1 and 2 may not total to 100% due to rounding.

4 CARBON BUDGETS

In public and political discourse, a target date of net zero emissions is often the focus, for theh UK at a national level, this is 2050. However, of greater importance is the overall carbon budget: the cumulative sum of greenhouse gas emissions released until the net zero target is reached. Introduced into UK law by the Climate Change Act of 2008[15], the UK is currently in its 3rd carbon budget (each one covers a 5-year period – see chart in Appendix 2). These budgets are set at least 12 years in advance, *e.g.* the 5th budget (2028-2032) has already been set at 1.7 Gt CO_{2e} (Gigatonnes of CO_{2e} = carbon dioxide equivalent which is a measure for all greenhouse gases) and the 6th budget (2033-2037) was announced in early December 2020[16]. This is the first

[15] https://www.gov.uk/guidance/carbon-budgets

[16] https://www.theccc.org.uk/publication/sixth-carbon-budget/

carbon budget target set in the context of the net zero target, itself a response to the Paris Agreement[17].

> *"The Paris Agreement's central aim is to strengthen the global response to the threat of climate change by keeping a global temperature rise this century well below 2 degrees Celsius above pre-industrial levels and to pursue efforts to limit the temperature increase even further to 1.5 degrees Celsius."*[18]

It is accepted that nations across the globe must agree their own strategies suited to the needs and character of their own geographically administrative areas, but also, for the climate change agreements to succeed, that these must be informed by the overall carbon budget at a global level. Within the borders of a nation itself, this can be further disaggregated with different geographically distinct administrative areas creating their appropriate plans to decarbonise their distinct areas within the context of an overall national carbon budget. As the majority of emissions are still from the consumption of natural gas, liquid fuels and electricity, all delivered through energy systems, there is a clear rationale to focus on the decarbonisation of these energy systems. This global to national, national to local cascade of carbon budgets leads to an inevitable focus on local energy systems, and whether and how they may be decarbonised.

The illustrative emission reduction targets for the RESO project for Coventry are therefore set within the wider context of climate ambition and emission reduction pathways at a national UK level, itself set in the framework of global carbon budgets.

5 Cumulative Emissions are important

To demonstrate the importance of the choice of pathway to net zero in comparison to the end point of net zero itself, an example of an arbitrary region with existing CO_2 emissions of 1 Mt CO_2 can be considered. This could reach essentially net zero emissions in 30 years either by a linear or exponential decay pathway as shown in Figure 3. The area under the blue -10% reduction exponential decay curve (*i.e.* the cumulative emissions over the next 30 years) is equal to 9.1 Mt CO_2, whereas the area under the red line is equal to 15 Mt CO_2. This means almost 40% less total CO_2 emissions occur under the exponential decay pathway. Due to the asymptotic nature of the exponential function, net zero is not reached within 30 years (although it can be assumed to be effectively net zero, once the value is low enough). If the exponential decay function continued at the same rate after year 30, only another 0.4 Mt CO_2 would be emitted between year 30 and year 80 (which is still much less than the additional emissions released over the 30 years of the linear pathway).

[17] https://www.lse.ac.uk/granthaminstitute/news/uk-climate-legislation-must-closely-aligned-paris-agreement-2020/

[18] https://unfccc.int/process-and-meetings/the-paris-agreement/what-is-the-paris-agreement

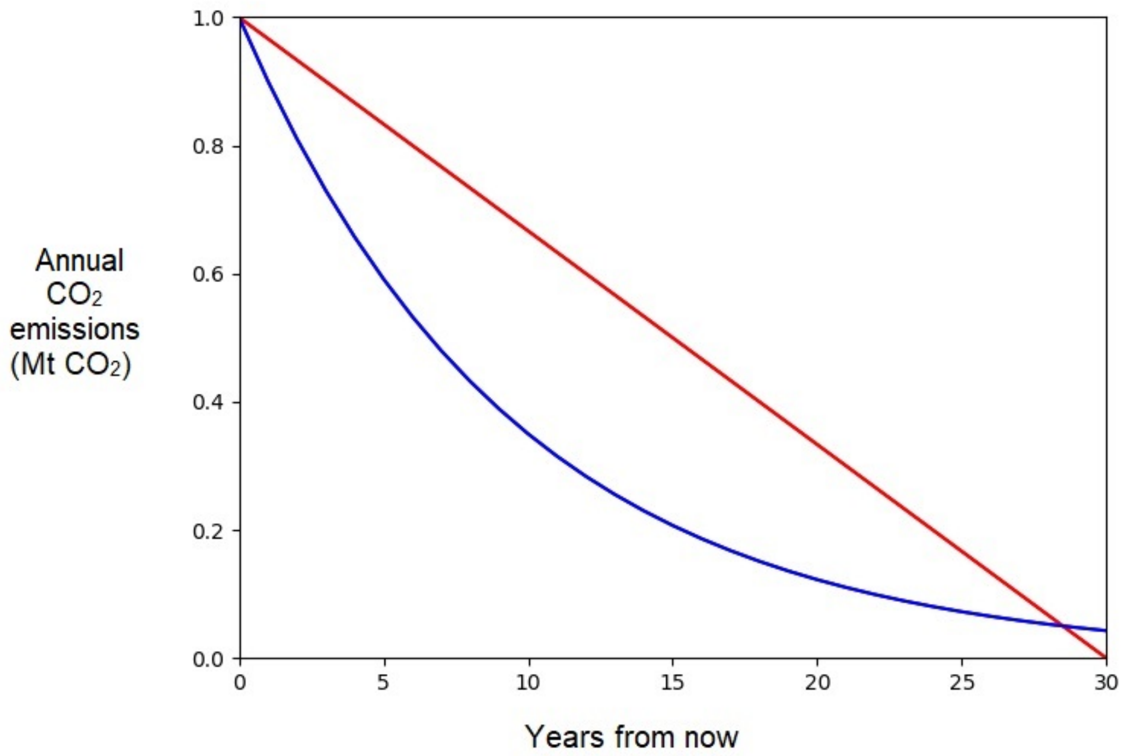


FIGURE 3 - EXAMPLE EMISSIONS PATHWAYS FOR AN ARBITRARY AREA UNDER TWO SCENARIOS: A LINEAR REDUCTION TO NET ZERO WITH A CONSTANT DECREASE IN EMISSIONS EACH YEAR (RED) AND AN EXPONENTIAL REDUCTION SO THAT THE EMISSIONS DECREASE EACH YEAR AT A CONSTANT PERCENTAGE (-10%) FROM THE PREVIOUS YEAR (BLUE)

6 RESO EMISSION PATHWAYS UNTIL 2050

The Tyndall Centre based at the University of Manchester have produced a series of reports for each local authority in the UK[19]. These reports use a Paris Agreement compliant, carbon budget approach to outline the emissions pathway required for a local authority to make its equitable contribution to a global and national science based target. The method considers the terrestrial energy related emissions of an area excluding LULUCF and cement process emissions (as the latter has an allowance deducted from the global carbon budget to ensure equity between developed and developing nations). In their methodology, the UK Carbon Budget until 2100 is 3.7 Gt CO_2, which then has a 1.5 Gt CO_2 nationwide allocation for aviation, shipping and military transport activities (all of these are deemed beyond the control of local authorities). The remaining 2.2 Gt CO_2 budget then needs to be split between the 435 local authorities which make up the UK.

In the Tyndall Centre's methodology, it was deemed that the fairest way to divide the budget into smaller geographical areas was through a 'grandfathering of emissions' approach as opposed to allocating it by population or size of the local economy

[19] https://carbonbudget.manchester.ac.uk/reports/

(Figure 4). The grandfathering approach means that the average emissions of Coventry (as per BEIS statistics) were calculated over the period 2011-2016 and compared with the average for the UK over the same timescale.

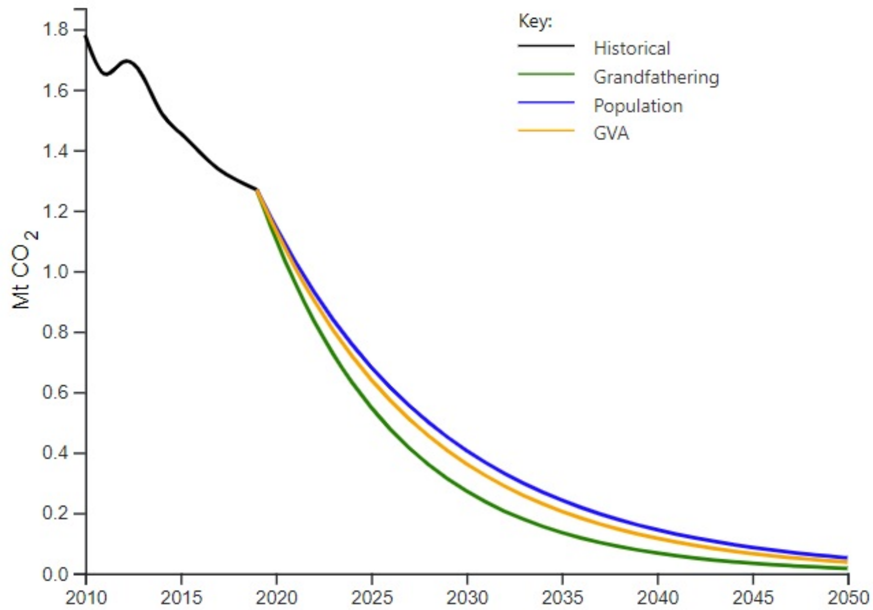


FIGURE 4 - EMISSIONS PATHWAYS FOR COVENTRY UNTIL 2050 UNDER THE TYNDALL CENTRE REPORT. THE GREEN LINE IS BASED ON ALLOCATING THE CARBON BUDGET BY GRANDFATHERING, BLUE BY POPULATION AND YELLOW BY THE SIZE OF COVENTRY'S GROSS VALUE ADD

Coventry is then allocated a percentage of the Tyndall Centre's 2.2 Gt CO_2 Carbon Budget 2020-2100 for the UK, based on a grandfathering method of its fraction of historical UK CO_2 emissions from 2011-2016[20]. This method leads to a carbon budget for Coventry of 8.4 Mt CO_2 over the period 2020-2100[21]. This total budget is then disaggregated into the 5-year timeframes that align with the UK Climate Change Act carbon budget timeframes, as shown in Table 2 and Figure 5:

[20] (non-air, shipping, military, cement process or LULUCF)

[21] https://carbonbudget.manchester.ac.uk/reports/E08000026/print/

Carbon Budget Period	Recommended Carbon Budget (Mt CO_2)
2018 - 2022	5.5
2023 - 2027	2.8
2028 - 2032	1.4
2033 - 2037	0.7
2038 - 2042	0.3
2043 - 2047	0.2
2048 - 2100	0.2

TABLE 2 – CARBON BUDGETS FOR COVENTRY LOCAL AUTHORITY AREA AS RECOMMENDED BY THE TYNDALL CENTRE

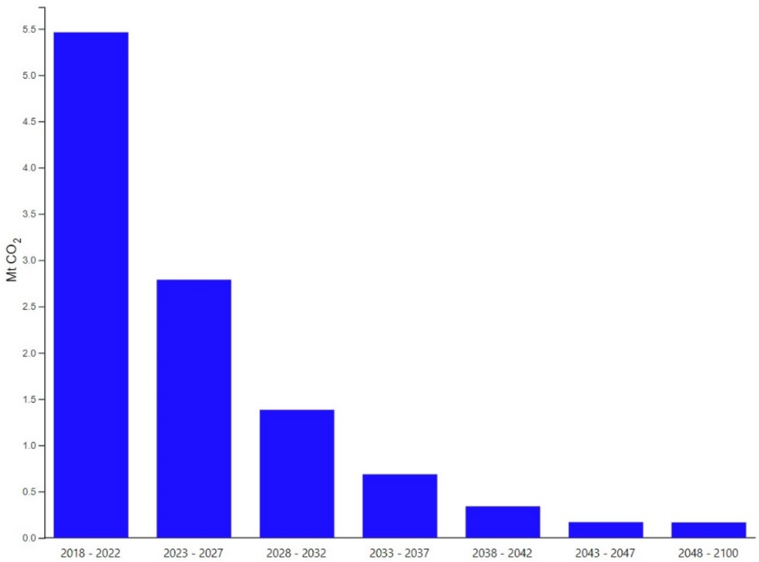


FIGURE 5 - CARBON BUDGETS FOR COVENTRY LOCAL AUTHORITY AREA FROM THE TYNDALL CENTRE METHODOLOGY

If Coventry continued to emit CO_2 at the same rate as its 2017 annual emissions of 1.3 Mt CO_2[22], it would exceed its allocated budget to 2050 (8.4 Mt CO_2) by 2027. For the purposes of starting the pathways from 2020, the Tyndall methodology assumed that Coventry's emissions in 2018 and 2019 were reduced at the same rate as UK national emissions between 2017 and 2018 (-2.4%). With this value providing the 2020 starting point, and with a known cumulative budget, an annual compound reduction of -13.1% in CO_2 emissions from 2020 was then calculated as keeping the local authority within the overall budget of 8.4 Mt CO_2 to 2050.

To reiterate: the Tyndall Centre global and national budgets are based on applying the principles of IPCC targets (keeping temperature increases well below 2 °C, and to pursue efforts to limit the temperature increase even further to 1.5 °C).

The values and the approach of the Tyndall centre methodology differ from the measures used to calculate the existing published UK Carbon Budgets to 2032 (Appendix 2). The main difference is that the existing UK Carbon Budgets (carbon budgets 3, 4 and 5) are based on the previous 2050 reduction target that was an 80% reduction from 1990 values. The 6th carbon budget was published by the Committee on Climate Change in early December 2020 and is more ambitious in terms of the trajectory of previous carbon budgets. However, if the 6th Carbon Budget reduction in emissions value from 2019 and 2035 is taken as a 63% reduction, using Figure 6 on page 14 below this equates to a value of 469 kT CO_2 (the 2019 value of 1268 * the 63% reduction = 469). Looking at the year-on-year reduction columns to provide a 469 kT CO_2 value by 2035 – suggests the national level year-on-year reduction is 6%. However, this is merely indicative as the methodologies are different.

Regardless of this level of increased ambition over previous carbon reduction pathways, the value for the overall cumulative budget to 2050 from the Committee on Climate Change is expected to continue to be greater than the Tyndall Centre's. This means that the amount that the UK can emit under the Tyndall Centre methodology will be more stringent, and will always be lower and will have a smaller overall budget envelope than the values put forward by the Committee on Climate Change. Publication of the 6th Carbon Budget in December 2020 confirms that this is the case.

This is due to a difference in methodologies such as the Tyndall Centre explicitly rejecting negative emissions technologies (such as bioenergy plus carbon capture and storage or direct air capture of CO_2). These negative emissions technologies effectively allow an increase the size of the UK's overall carbon budget if taken into account as they can offset additional emissions.

Therefore, given the Tyndall Centre is expected to always have a lower overall cumulative budget than that put forward by the Committee on Climate Change, the Tyndall Centre pathway was chosen as the higher ambition pathway for the RESO

22 https://www.gov.uk/government/statistics/uk-local-authority-and-regional-carbon-dioxide-emissions-national-statistics-2005-to-2017

project. This has a **-13.1%** year-on-year reduction in CO_2 emissions starting from 2020.

Having chosen the Tyndall Centre values to bound the most ambitious levels of emission reduction for the RESO project, choosing a lower bound for emissions reduction was subject to a number of discussions.

When discussing the options for a lower bound of ambition for the RESO project, previous commitments from local authorities and other regional administrations were themselves considered. Coventry City Council had an official target to reduce emissions 27.5% on 1990 levels by 2020, which it achieved in 2014. At the time of the RESO project and writing of this report there was no official long-term target for Coventry City Council, therefore the higher tier regional council, the West Midlands Combined Authority (consisting of Coventry and 6 other local authorities) was used as a reference for local views of political bodies on decarbonisation.

The West Midlands Combined Authority has produced a report and action plan (called: Actions to meet the climate crisis with inclusivity, prosperity and fairness[23]) in 2020, outlining a regional strategy for decarbonisation with a target of net zero emissions no later than 2041 (defined as a 96% reduction in emissions), and intermediate targets of a 36% reduction on 2018 emissions by 2022 and 67% reduction by 2027: all reductions are in comparison to the baseline year of 2015. West Midlands Combined Authority also used the Tyndall Centre to undertake the analysis, and this calculated a carbon budget of 126 Mt CO_2 for the whole West Midlands Combined Authority area from 2020-2100. This was subsequently shared between each local authority and allocated Coventry a budget of 9.6 Mt CO_2, which is greater than the 8.4 Mt budget allocated from the Tyndall analysis linked to earlier. It is not immediately clear why there is the difference between these two values for the Coventry specific Tyndall value and the West Midlands Combined Authority allocation of the 126 Mt CO_2. Coventry's emissions in 2015 were 1460 kt CO_2, and thus a 96% reduction from this would be a target of 58.4 kt CO_2 in one year.

For the RESO analysis to consider the value for a lower bound of ambition, the starting year values from the Tyndall centre (based on BEIS values) were used to create carbon emission reduction pathways over the 2020 to 2050 timeframe. The baseline value was 1268 kt CO_2 in 2019 (this was the BEIS 2017 published emissions value of 1331 kt CO_2 with two subsequent years of -2.4% reduction). The analysis also considered a linear reduction in emissions of 41 kt CO_2 per year with a range of year-on-year reduction pathways increasing in ambition from -5% to -12% (in intervals of -1%) and the -13.1% reduction pathway from the Tyndall Centre. The values for these pathways are shown in Figure 6 and Figure 7.

[23] https://www.wmca.org.uk/media/4008/wm2041-final-003.pdf

exponential decay % reduction from 2020			5%	6%	7%	8%	9%	10%	11%	12%	13.1%
sum of emissions from 2017 to 2050 kt CO2		22921	23081	20849	18971	17383	16032	14877	13883	13022	12203
sum of emissions from 2020 to 2050 kt CO2		19022	19182	16950	15072	13484	12133	10978	9984	9123	8304
Emissions (ex. LULUCF) kt CO2	year	Straightline to net-zero pathway	5% exponential decay reduction pathway	6% exponential decay reduction pathway	7% exponential decay reduction pathway	8% exponential decay reduction pathway	9% exponential decay reduction pathway	10% exponential decay reduction pathway	11% exponential decay reduction pathway	12% exponential decay reduction pathway	13.1% exponential decay reduction pathway
Estimated by assuming 2.4% yearly reduction as per national level statistics	2017	1331	1331	1331	1331	1331	1331	1331	1331	1331	1331
Estimated by assuming 2.4% yearly reduction as per national level statistics	2018	1299	1299	1299	1299	1299	1299	1299	1299	1299	1299
Other reductions start from 2020 onwards	2019	1268	1268	1268	1268	1268	1268	1268	1268	1268	1268
	2020	1227	1205	1192	1179	1167	1154	1141	1129	1116	1102
yellow highlight denotes the years where emissions hit 10% of the 2020 start	2021	1186	1145	1121	1097	1073	1050	1027	1005	982	958
	2022	1145	1087	1053	1020	988	956	924	894	864	832
	2023	1105	1033	990	949	909	870	832	796	761	723
	2024	1064	981	931	882	836	791	749	708	669	628
	2025	1023	932	875	820	769	720	674	630	589	546
	2026	982	886	822	763	707	655	607	561	518	475
	2027	941	841	773	710	651	596	546	499	456	412
	2028	900	799	727	660	599	543	491	444	401	358
	2029	859	759	683	614	551	494	442	395	353	311
	2030	818	721	642	571	507	449	398	352	311	271
	2031	777	685	604	531	466	409	358	313	274	235
	2032	736	651	567	494	429	372	322	279	241	204
	2033	695	618	533	459	395	339	290	248	212	178
	2034	655	588	501	427	363	308	261	221	186	154
	2035	614	558	471	397	334	280	235	197	164	134
	2036	573	530	443	369	307	255	211	175	144	117
	2037	532	504	416	343	283	232	190	156	127	101
	2038	491	479	391	319	260	211	171	139	112	88
	2039	450	455	368	297	239	192	154	123	98	76
	2040	409	432	346	276	220	175	139	110	87	66
	2041	368	410	325	257	203	159	125	98	76	58
	2042	327	390	306	239	186	145	112	87	67	50
	2043	286	370	287	222	171	132	101	77	59	44
	2044	245	352	270	207	158	120	91	69	52	38
	2045	205	334	254	192	145	109	82	61	46	33
	2046	164	317	239	179	133	99	74	55	40	29
	2047	123	302	224	166	123	90	66	49	35	25
	2048	82	287	211	155	113	82	60	43	31	22
	2049	41	272	198	144	104	75	54	38	27	19
	2050	0	259	186	134	96	68	48	34	24	16

FIGURE 6 – PATHWAY EMISSION VALUES FOR COVENTRY'S EMISSIONS UNDER VARIOUS SCENARIOS WITH THEIR CUMULATIVE EMISSIONS. THE HIGHLIGHTED YELLOW CELLS SHOW THE YEARS OVER WHICH A 90% REDUCTION ON 2017 EMISSIONS IS REACHED

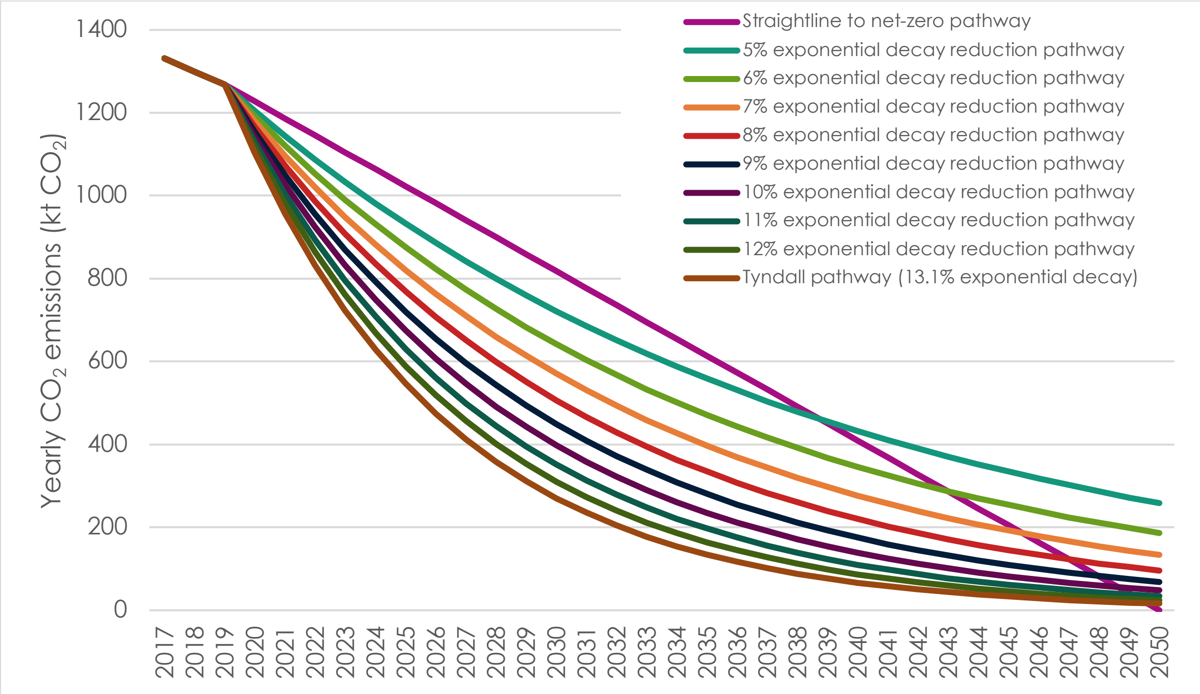


FIGURE 7 – CHART OF THE CO_2 EMISSIONS PATHWAYS FOR COVENTRY UNDER THE SCENARIOS INDICATED IN THE LEGEND.

The cumulative emissions were also calculated in the period 2020-2050 and compared with Tyndall Centre carbon budget figures. The worst scenarios which were the linear reduction to net zero and the -5% and -6% year-on-year exponential decay all exceeded double the Tyndall Centre Coventry 2020-2050 cumulative carbon budget of 8.4 Mt CO_2.

After discussion within the RESO project, the -10% annual reduction was chosen as the lower bound level of ambition due to its ability to reach almost net zero emissions by 2050 (it reaches the 96% reduction defined by WMCA but by 2050 rather than the WMCA target of 2041) and the expectation that this would likely be in line with the UK government target and potentially subsequent UK carbon budgets. It was also a much higher level of ambition than a linear reduction too.

After publication of the 6th Carbon Budget in December 2020, the 10% year-on-year reduction is a more ambitious pathway than the UK pathway that the 6th Carbon Budget suggests. Therefore the 10% year-on-year reduction pathway was kept as the lower boundary of ambition, which was still more ambitious than the national level pathway.

7 Conclusion

In summary, the RESO project considered a range of emissions pathways and took a collective view that rather than having one pathway as a target, an upper and lower bound of ambition would be more appropriate. The Tyndall Centre report for Coventry was used to derive the upper bound of ambition for the CO_2 emissions reduction target of -13.1% per year (minus 13.1 per cent per year). A range of pathways were created for annual reduction rates from -5% to -12% and the cumulative emissions of these scenarios were calculated and contrasted with Coventry's allocated budget from the Tyndall Centre methodology. An annual reduction rate of -10% was agreed, and this would provide the lower bound for ambition for the RESO project.

To give context, **in the RESO project target design year of 2032, these pathways would have reduced the annual emissions to a level of 204 kt CO_2 for the more ambitious -13.1% year-on-year reduction pathway and 322 kt CO_2 for the -10% year-on-year reduction pathway**. This equates to an **overall 84% and 75% reduction** on the 2019 emissions respectively. The scale of this challenge can be conceptualised by the thought that even at the less ambitious (-10% year-on-year) level of emissions reductions, by 2032 there would have to be either only passenger transport or domestic heat as the only sectors not to have undergone full decarbonisation. This is a much more rapid system change than envisioned by either WPD's DFES under the Community Renewables scenario[24] or National Grid's FES 2020[25].

Many of the decarbonisation efforts that affect Coventry's potential to meet any decarbonisation pathway are beyond the governance of the local authority, such as the rate of wider electrical grid decarbonisation that will be heavily influenced by the rate of construction of offshore wind farms, or large scale hydrogen production using autothermal reformation with carbon capture and storage (blue hydrogen). Increased local investment in renewables, low carbon heat, system flexibility and increasing building efficiency through targeted retrofits at city or regional level will help local authorities to position themselves as leaders rather than laggards in national decarbonisation efforts.

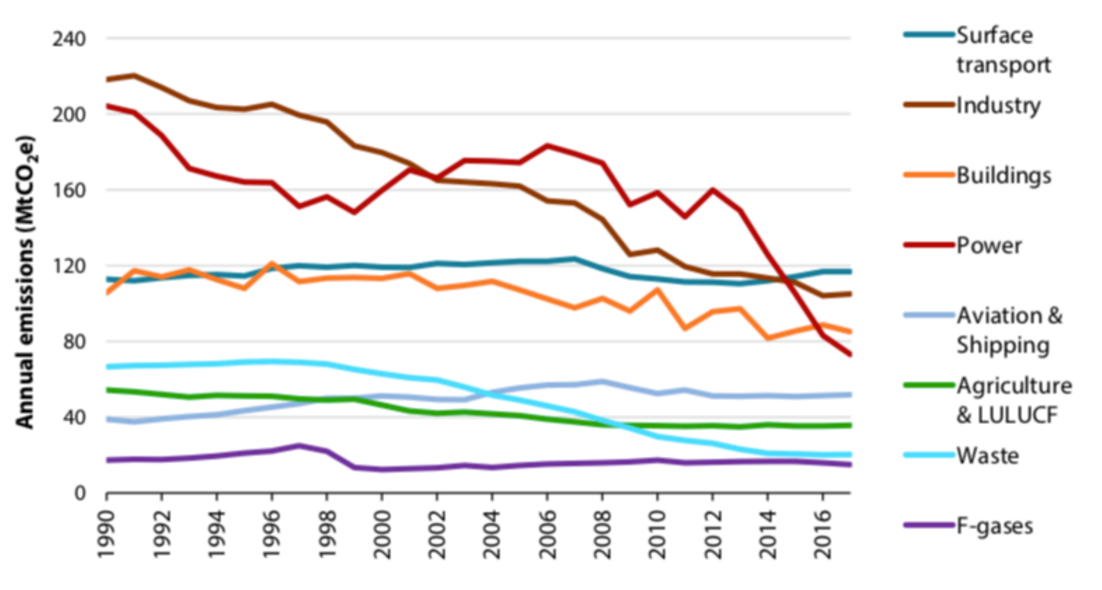
Part of the evaluation of RESO and other Prospering from the Energy Revolution projects will be their ability to impact or accelerate CO_2 emission reductions within their given areas. This report sets out the background to the upper and lower bounds of ambition of emission reduction for the RESO project and it is hoped this can provide some value to other projects considering energy system decarbonisation at a local level.

[24] https://www.westernpower.co.uk/distribution-future-energy-scenarios-map

[25] https://www.nationalgrideso.com/future-energy/future-energy-scenarios/fes-2020-documents

Appendix 1

Figure 1.4. Progress reducing emissions in the UK has been imbalanced

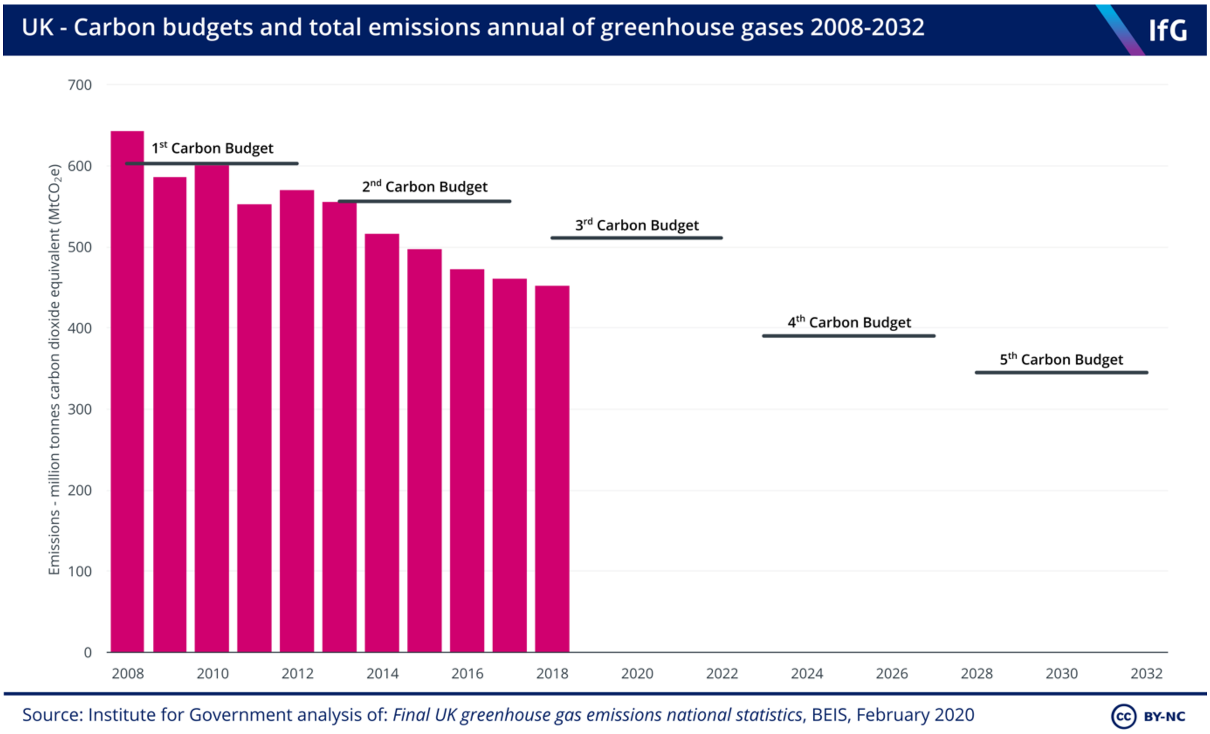


Source: BEIS (2019) *Final UK greenhouse gas emissions national statistics 1990-2017*; CCC analysis. LULUCF = land use, land use change and forestry.

Source: https://www.theccc.org.uk/wp-content/uploads/2019/05/Net-Zero-The-UKs-contribution-to-stopping-global-warming.pdf

(accessed 19/11/2020)

Appendix 2



https://www.instituteforgovernment.org.uk/explainers/net-zero-target

(accessed 19/11/2020)