APPENDIX E – MODELLING GOALS' ASSUMPTIONS

The modelling carried out as part of this project was done using WSP's local authority carbon model (which can also be applied to multiple local authorities, as it was done in this project). This model was created to assist in the quantification of baseline GHG emissions as well as the potential cumulative benefits of a range of project-specific carbon reduction measures or goals. Some of these processes have been automated. The main sources of this model are the sub-national dataset of total final energy consumption statistics[1], journey to work statistics[2], and government conversion factors[3].

In addition, for each of the measures or goals modelled, four levels ranging from "Very High" to "Low" have been developed, which vary the level of ambition for each goal. This was automated so that each scenario selected the right level of ambition for each goal.

The measures or goals were largely based on specific West Midlands literature or reports, input from the stakeholders consulted throughout this project, as well as wider available projections, such as those from the CCC, and WSP's own calculations.

A breakdown of the results is shown below, with carbon reductions provided for each goal and each scenario.

Table 1 - Summary Goal CO_2 Emission Reductions

Sector	Goal	Scenarios							
		Very High		High		Medium		Low	
		2025	2040	2025	2040	2025	2040	2025	2040
Domestic	Energy Efficiency Retrofit	-452.9	-452.9	-226.4	-452.9	-113.2	-452.9	-46.8	-187.1
Domestic	Heating System Retrofit	-2237.8	-2741.4	-559.4	-2741.4	-37.3	-1395.6	-26.5	-777.3
Domestic	Solar PV	-123.2	-47.8	-61.6	-47.8	-30.8	-47.8	-23.1	-35.9
Commercial	Energy Efficiency	-298.7	-218.3	-149.4	-218.3	-74.7	-218.3	-37.3	-218.3
Commercial	Heating System Retrofit	-161.5	-204.4	-40.4	-204.4	-2.7	-96.3	-1.9	-58.0
Commercial	Solar PV	-104.8	-40.7	-52.4	-40.7	-26.2	-40.7	-19.7	-30.5
Industrial	Energy Efficiency and Fuel Switching	-120.1	-682.2	-120.1	-682.2	-108.9	-619.2	-117.6	-610.6
Industrial	Solar PV	-14.2	-5.5	-7.1	-5.5	-3.6	-5.5	-2.7	-4.1
Transport	Demand Reduction (Digital Connectivity)	-148.1	-115.0	-37.0	-115.0	-27.8	-86.2	-18.5	-57.5
Transport	Bus and Taxi Electrification	-181.1	-181.1	-90.6	-181.1	-60.4	-181.1	-45.3	-181.1
Transport	Demand Reduction	-160.1	-156.7	-34.7	-107.4	-17.3	-53.7	-8.7	-26.8
Transport	HGV Electrification	-103.8	-499.1	-103.8	-499.1	-69.2	-332.7	-51.9	-249.6
Transport	Mode Shift	-1306.0	-1306.0	-213.3	-772.2	-187.9	-661.8	-146.4	-444.4
Transport	Accelerated EV Uptake	-197.5	-513.7	-197.5	-513.7	-188.1	-516.7	-161.2	-511.3
Land-Use	Afforestation	-31.6	-442.4	-31.6	-442.4	-19.9	-278.3	-14.9	-101.0
Land-Use	Renewables	-100.1	-38.9	-50.1	-38.9	-24.4	-38.7	-23.7	-38.5

[1] https://www.gov.uk/government/collections/total-final-energy-consumption-at-sub-national-level
[2] https://www.nomisweb.co.uk/census/2011/qs701ew
[3] https://www.gov.uk/government/collections/government-conversion-factors-for-company-reporting

A full breakdown of all assumptions per goal is provided below:

Domestic Energy Efficiency Retrofit

This goal considered a basic retrofit package considering the potential of a number on measured designed to reduce heating consumption. This goal considered the fact that some homes will have already had some of these measures installed. The energy efficiency measures are considered to only impact on energy consumption for space heating. The energy savings for each measure have been taken from a variety of sources, which is provided in the table below. Behavioural change is not captured in this goal, and as such the energy efficiency savings from each measure have been assumed in full. However, it is widely recognised that energy consumption typically increases after energy efficiency measures are installed (i.e. the 'rebound' effect), thereby reducing the amount of energy savings eventually achieved. Energy efficiency improvements from Minimum Energy Efficiency Standards regulations have been included under Business as Usual scenarios, and as such discounted from the effect of this goal.

Household energy use has been taken from NEED Framework data (End-Use tables). The number of properties in the West Midlands Combined Authority has been taken from Council Tax Data (Table CTSOP3.0). In addition, the number of properties per ownership type was obtained from Government data.

Table 2 – Energy savings and applicability of energy efficiency measures considered in the Domestic Efficiency Retrofit goal

Measure	Energy Saving	Applicability	Total Saving
Smart Thermostats	6.7%[4]	94.0%[5]	6.3%
Smart Meters	2.2%[6]	69.1%[7]	1.5%
Cavity Wall Insulation	10.2%[8]	14.0%[9]	1.4%
Solid Wall Insulation	17.7%[8]	27.0%[9]	4.8%
Loft Insulation	6.3%[8]	18.2%[9]	1.1%
Double Glazing	15.0%[10]	6.7%[11]	1.0%
MEES	-1.5%	41.3%	-0.6%

Domestic Heat Pump Retrofit

This goal considers the benefit of replacing current fossil fuel heating systems (assumed as gas boilers as they are the predominant technology) within dwellings with heat pumps. It has been assumed that the majority of them will be air source heat pumps, and a conservative heat pump seasonal CoP of 2.65 has been used.

The energy consumption of dwellings was based on that of the previous goal (based on NEED framework data[12]), with the effect of energy efficiency measures already considered, in order to avoid double counting. The pace of the energy efficiency goal is higher than that of the domestic heat pump retrofit, so it has been assumed that energy efficiency measures have taken place before or at the time of retrofitting a heat pump.

The number of dwellings considered was based around current targets set by the CCC[13] (of around a million heat pumps installed per year, nationally, by 2030) and the Government's Ten Point Plan[14] (of 600,000 heat pumps installed per year by 2028). In addition, the high scenario assumes a linear deployment trajectory to 2041, where all homes will be retrofitted (except the fraction which already has a heat pump). The number of installed heat pumps currently installed and total number of heat pumps installed were based on data from the Heat Pump Association[15].

[4] https://www.bi.team/publications/evaluating-the-nest-learning-thermostat/
[5] http://campaign.yougov.com/rs/060-QFD-941/images/YouGov_UK_2018_08_smart_homes.pdf
[6] https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/830668/smart-meters-benefits-realisation.pdf
[7] https://www.gov.uk/government/statistics/smart-meters-in-great-britain-quarterly-update-june-2020
[8] https://yougov.co.uk/topics/technology/articles-reports/2018/08/10/almost-quarter-britons-now-own-one-or-more-smart-h
[9] https://www.gov.uk/government/statistics/household-energy-efficiency-statistics-detailed-report-2018
[10] https://energysavingtrust.org.uk/home-energy-efficiency/energy-efficient-windows
[11] https://www.gov.uk/government/statistics/english-housing-survey-2018-energy-report
[12] https://www.gov.uk/government/statistics/energy-consumption-in-the-uk
[13] https://www.theccc.org.uk/publication/sixth-carbon-budget/
[14] https://www.gov.uk/government/publications/the-ten-point-plan-for-a-green-industrial-revolution
[15] https://www.heatpumps.org.uk/wp-content/uploads/2019/11/A-Roadmap-for-the-Role-of-Heat-Pumps.pdf

National figures were scaled down to the West Midlands Combined Authority based on the number of dwellings, obtained from UK[16], Scottish[17] and Northern Irish[18] Government sources. The uptake trajectories are provided below (new-build installations have been removed, as those are already considered under the Business as Usual scenario):

Table 3 – Domestic heat pump installation trajectories per scenario

Year	Annual Installations		
	High	Medium	Low
2020	809	809	809
2021	55,645	1,700	1,575
2022	55,645	2,266	1,874
2023	55,645	2,954	2,144
2024	55,645	4,249	2,790
2025	55,645	5,828	3,493
2026	55,645	11,493	7,444
2027	55,645	17,280	11,130
2028	55,645	22,825	14,304
2029	55,645	28,288	17,121
2030	55,645	34,804	20,340
2031	55,645	35,896	21,046
2032	55,645	37,029	21,778
2033	55,645	38,163	22,510
2034	55,645	39,215	23,190
2035	55,645	40,429	23,974
2036	55,645	41,675	24,780
2037	55,645	42,956	25,607
2038	55,645	44,270	26,456
2039	55,645	45,620	27,328
2040	55,645	47,005	28,224
2041	55,645	48,428	29,143
Total	**1,178,260**	**602,086**	**365,962**

Domestic Solar PV

This goal considers the impact of installing rooftop solar on existing dwellings. For this, the Birmingham PV Study (provided by the WMCA, as it is not publicly available) a GIS analysis to determine the potential for solar rooftop and ground-mounted potential across Birmingham City Council. This has been extrapolated to the rest of the WMCA based on the number of domestic dwellings[19]. The results of this were validated by comparing against regional Western Power Grid projections[20] for 2030 for the West Midlands, based on the Future Energy Scenarios methodology, and adjusted CCC projections[21] for rooftop solar PV potential by 2050 on a national scale.

A conservative capacity factor (which represents the energy yield of a technology) of 9.7% (equivalent to 850 kWh/kWp) was used.

[16] https://www.gov.uk/government/statistics/council-tax-stock-of-properties-2019
[17] https://www.nrscotland.gov.uk/statistics-and-data/statistics/statistics-by-theme/households/household-estimates/2019
[18] https://www.communities-ni.gov.uk/topics/housing-statistics
[19] https://www.gov.uk/government/statistics/council-tax-stock-of-properties-2019
[20] https://www.westernpower.co.uk/downloads/4025
[21] https://d423d1558e1d71897434.b-cdn.net/wp-content/uploads/2019/05/20200418-CCC-Accelerated-Electrification-final-report.pdf

A summary of the results of these calculations is shown below:

Table 4 – Results for the Domestic Solar PV goal

Local Authority	No. Dwellings	PV Potential	PV Generation
Birmingham	444,440	312,900 kW	265,965,000 kWh
Coventry	142,770	100,515 kW	85,437,456 kWh
Dudley	138,740	97,677 kW	83,025,794 kWh
Sandwell	133,620	94,073 kW	79,961,847 kWh
Solihull	92,500	65,123 kW	55,354,519 kWh
Walsall	116,210	81,816 kW	69,543,229 kWh
Wolverhampton	109,980	77,429 kW	65,815,027 kWh
WMCA	**1,178,260**	**829,533 kW**	**705,102,873 kWh**

Commercial Energy Efficiency

This goal considered the installation of a series of energy efficiency measures on a range a non-domestic building types. Data for the number and floor area of non-domestic properties per type and per local authority was obtained from UK government data[22], as well as energy usage per fuel and end-use for offices, retail and other commercial buildings[23]. The energy intensity (per floor area) for each type of building is then calculated at a national level and, using the number of different types of non-domestic properties across the WMCA, the total WMCA energy consumption is obtained. The results for offices, retail and other buildings are shown below:

The 'other buildings' category comprises several types of buildings and sectors, such as education, health, hospitality or arts and leisure. The combined energy consumption of these types of buildings was based on the number of jobs for each subsector, which were provided by WMCA.

The abatement potential for each type of building, (e.g. office, retail, other) was taken from the Business Energy Efficiency Survey[24]. A breakdown of those savings was provided as part of the description of Goal 5 in the main report.

Table 5 – Total energy usage in office buildings in the WMCA, per fuel and end-use

Energy Usage	Fuel (kWh)					
	Electricity	Gas	Oil	District Heating	Other	Total
Heating	95,431,128	532,719,490	76,938,265	6,424,585	63,875,061	775,388,530
Hot Water	28,477,797	37,901,308	35,818,889	361,088	4,893,086	107,452,168
Cooling	112,117,059	1,095,211	21,509,731	0	0	134,722,002
Fans	73,259,880	0	0	0	0	73,259,880
Lighting	152,260,363	0	0	0	0	152,260,363
Subtotal	**461,546,228**	**571,716,009**	**134,266,886**	**6,785,673**	**68,768,147**	**1,243,082,943**
Other	521,773,114	22,027,976	36,334,532	21,178	17,052	580,139,935
Total	**983,319,342**	**593,743,985**	**170,601,417**	**6,764,495**	**68,751,095**	**1,823,222,878**

[22] https://www.gov.uk/government/statistics/non-domestic-rating-stock-of-properties-2020
[23] https://www.gov.uk/government/statistics/energy-consumption-in-the-uk
[24] https://www.gov.uk/government/publications/building-energy-efficiency-survey-bees

Table 6. Total energy usage in retail commercial buildings in the WMCA, per fuel and end-use

Energy Usage	Fuel (kWh)					
	Electricity	Gas	Oil	District Heating	Other	Total
Heating	11,302,206	444,668,199	57,743,813	17,427,020	38,783,712	418,537,522
Hot Water	6,674,418	107,918,752	14,407,747	1,789,681	9,251,832	104,616,291
Cooling	12,723,860	117,563	61,147	16,821	0	12,867,453
Fans	27,453,234	0	0	0	0	27,453,234
Lighting	44,945,732	0	0	0	0	44,945,732
Subtotal	**100,097,280**	**405,891,298**	**53,031,066**	**14,124,580**	**35,276,009**	**608,420,232**
Other	39,644,680	57,418,150	4,304,478	1,036,095	10,571,611	112,975,014
Total	**139,741,960**	**463,309,448**	**57,335,543**	**15,160,675**	**45,847,619**	**721,395,246**

Table 7. Total energy usage in other commercial buildings in the WMCA, per fuel and end-use

Energy Usage	Fuel (kWh)					
	Electricity	Gas	Oil	Distric Heating	Other	Total
Heating	11,302,206	444,668,199	57,743,813	17,427,020	38,783,712	418,537,522
Hot Water	6,674,418	107,918,752	14,407,747	1,789,681	9,251,832	104,616,291
Cooling	12,723,860	117,563	61,147	16,821	0	12,867,453
Fans	27,453,234	0	0	0	0	27,453,234
Lighting	44,945,732	0	0	0	0	44,945,732
Subtotal	**100,097,280**	**405,891,298**	**53,031,066**	**14,124,580**	**35,276,009**	**608,420,232**
Other	39,644,680	57,418,150	4,304,478	1,036,095	10,571,611	112,975,014
Total	**139,741,960**	**463,309,448**	**57,335,543**	**15,160,675**	**45,847,619**	**721,395,246**

Commercial Heat Pump Retrofit

This goal considers the benefit of replacing current fossil fuel heating systems (predominantly gas boilers) within commercial properties with air source heat pumps. It uses energy consumption data from the previous goal, in order to avoid double counting. The heating CoP of the replacement heat pumps has been assumed to be of 2.75.

The replacement trajectories have been assumed to be equivalent to those in the domestic heat pump retrofit goal, adjusted to cover all 74,040 retail, office and other commercial buildings. A breakdown of non-domestic buildings in the WMCA seven local authorities is provided below:

Table 8 – Breakdown of non-domestic buildings across WMCA's local authorities

LA	Type				
	Retail	Office	Industry	Other	All
Birmingham	11,230	8,960	9,980	17,510	47,680
Coventry	2,630	1,660	2,220	2,350	8,860
Dudley	2,790	1,730	3,760	2,380	10,670
Sandwell	2,920	1,030	4,490	2,790	11,220

Solihull	1,520	1,760	720	1,490	5,490
Walsall	2,480	1,080	3,080	1,960	8,600
Wolverhampton	2,430	1,630	2,930	1,710	8,690
WMCA	**26,000**	**17,840**	**27,180**	**30,200**	**101,220**
England and Wales	**515,960**	**430,170**	**538,740**	**619,710**	**2,104,570**

Commercial Photovoltaic Systems

This goal considers the impact of installing rooftop solar on existing commercial properties. For this, the Powering Growth: Black Country Energy Strategy was used to assess the solar PV potential for Dudley, Sandwell, Solihull and Wolverhampton. In addition, the Birmingham Solar PV Study was used for Birmingham City Council, and was extrapolated to Coventry and Walsall, for which no specific data was found, based on the number of non-domestic buildings for each local authority.

A conservative capacity factor (which represents the energy yield of a technology) of 9.7% (equivalent to 850 kWh/kWp) was used.

A summary of the results of these calculations is shown below:

Table 9 – Results of the Commercial Rooftop Solar goal

LA	PV Potential	PV Generation
Birmingham	397,500 kW	337,875,000 kWh
Coventry	70,011 kW	59,509,019 kWh
Dudley	45,000 kW	38,250,000 kWh
Sandwell	45,000 kW	38,250,000 kWh
Solihull	45,000 kW	38,250,000 kWh
Walsall	58,202 kW	49,471,353 kWh
Wolverhampton	45,000 kW	38,250,000 kWh
WMCA	**705,712 kW**	**599,855,371 kWh**

Industrial Energy Efficiency and Fuel Switching

This goal explores efforts to decarbonise energy consumption used as part of industrial processes. Energy consumption data by fuel for a range of industrial was obtained from BEIS data[25] (NEED End-Use Tables). This was scaled down to the West Midlands level using data for the number of businesses within each industrial sector from ONS data[26]. It was then scaled down to the WMCA level based on the number of industrial buildings. The results are shown in the table below:

Table 10 - Industrial Energy Use in the WMCA, per fuel and sector

Industry Sector	Number of Enterprises	Energy Usage				
		Solid Fuel	Oil	Natural Gas	Electricity	Total
Steel and iron	153	340 GWh	17 GWh	600 GWh	542 GWh	1,500 GWh
Mineral Products	183	190 GWh	87 GWh	581 GWh	255 GWh	1,113 GWh
Chemicals	139	15 GWh	55 GWh	771 GWh	577 GWh	1,419 GWh

[25] https://www.gov.uk/government/statistics/energy-consumption-in-the-uk#history%20(End-Use%20Data%20Tables)
[26] https://www.ons.gov.uk/businessindustryandtrade/business/activitysizeandlocation/datasets/ukbusinessactivitysizeandlocation

Mechanical Engineering	2,387	5 GWh	0 GWh	742 GWh	428 GWh	1,176 GWh
Electrical Engineering	354	1 GWh	0 GWh	124 GWh	243 GWh	369 GWh
Vehicles	319	21 GWh	118 GWh	338 GWh	253 GWh	730 GWh
Food and beverages	380	17 GWh	42 GWh	718 GWh	407 GWh	1,184 GWh
Textiles, leather	315	16 GWh	18 GWh	101 GWh	95 GWh	229 GWh
Paper, printing	486	25 GWh	14 GWh	172 GWh	387 GWh	599 GWh
Other industries	1,709	205 GWh	29 GWh	495 GWh	1,325 GWh	2,054 GWh
Total	6,425	836 GWh	381 GWh	4,643 GWh	4,514 GWh	10,373 GWh

The role for each of the technologies and measures identified has been defined based on a literature review, which included Element Energy and Jacobs' Industrial Fuel Switching Market Engagement Study[27], WSP's Industry Decarbonisation Pathways report series[28], the EU hydrogen strategy[29] and an academic paper on the potential for electrification of industrial heat[30]. Further detail on how this goal was modelled is provided in this goal's description.

Industrial Photovoltaic Systems

This goal considers the impact of installing rooftop solar on existing industrial properties. The 2050 potential for rooftop PV[31] at a national scale, as estimated by Vivid Economics, is scaled down to the WMCA level based on the relative number of industrial buildings[32]. The amount of PV installed on industrial premises relative to domestic and commercial buildings is taken from Ofgem's FiTS data[33] from September 2020 on historical installations.

While there is potential for solar PV to contribute to industry's electricity demand, this is something that hasn't significantly been taken up so far in the WMCA area – with existing installations under the FiT scheme only amounting to 2.5 MW across 25 installations. This is also a trend at a national level, with only slightly over 5% of solar PV being installed in an industrial setting (as per the Ofgem data).

Transport Demand Reduction

This goal considers the potential of reducing the number of commuting, retail and personal business trips from increased remote working and digitalisation of services. This is assumed to be enabled by increased availability of fast broadband connections, a higher flexibility in public and private sector policies around working arrangements and other actions such as the creation of local flexible working spaces, thereby reducing commuting distances and the need for public or private transportation.

Working population, employment level data and the fraction of people who can work from home (35%) was identified from ONS research[34], and the frequency they are able to from an academic paper[35] from the Global e-Sustainability Initiative. The emissions savings are based on the number of miles saved across cars and public transport, taken from Government data[36], as well as fuel efficiency data for petrol and diesel cars[37]. Fuel efficiency data for buses was taken from real fuel consumption averages[38] of buses across a number of routes, published by Transport for London. Changes to the way in which we will travel in the future are considered to avoid double counting.

[27] https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/824592/industrial-fuel-switching.pdf
[28] https://www.gov.uk/government/publications/industrial-decarbonisation-and-energy-efficiency-roadmaps-to-2050
[29] https://ec.europa.eu/commission/presscorner/detail/en/FS_20_1296
[30] https://iopscience.iop.org/article/10.1088/1748-9326/abbd02/pdf
[31] https://d423d1558e1d71897434.b-cdn.net/wp-content/uploads/2019/05/20200418-CCC-Accelerated-Electrification-final-report.pdf
[32] https://www.gov.uk/government/statistics/non-domestic-rating-stock-of-properties-2020
[33] https://www.ofgem.gov.uk/environmental-programmes/fit/contacts-guidance-and-resources/public-reports-and-data-fit/feed-tariffs-quarterly-report
[34] https://www.ons.gov.uk/employmentandlabourmarket/peopleinwork/employmentandemployeetypes/bulletins/regionallabourmarket/march2020
[35] http://www.gesi.org/research/download/13
[36] https://www.gov.uk/government/statistical-data-sets/tsgb01-modal-comparisons
[37] https://www.gov.uk/government/statistical-data-sets/energy-and-environment-data-tables-env
[38] https://tfl.gov.uk/info-for/media/press-releases/2014/october/new-routemaster-buses-on-route-453

Data on the total retail and personal business trips distance is obtained from Government data. Reduction of car trips considers the increased penetration of electric vehicles over time, in order to avoid overestimating carbon savings.

Transport Modal Shift

This goal analyses the carbon savings that can be achieved through a modal shift in the way we travel. It specifically uses targets from the Movement for Growth strategy[39] for car and bicycle usage, set for 2041 and 2033, respectively, with car usage reducing from around 65% of trips to 35-45%, and bike trips make up 10% of all trips. In addition, public transport is envisaged to cover a much larger proportion of trips. This is in line with some other European cities, such as Munich, as reported in an academic paper[40].

The number of trips for the West Midlands and fuel efficiency data has been obtained from Government data[41,42] (specific to the West Midlands) to calculate savings. The total energy saving is split across fuels (petrol, diesel and electricity) on an annual basis to avoid double counting carbon savings from electrification of transport.

The present and future distribution of trips in the WMCA (as per the High scenario) is compared to that of Munich in the graph below:

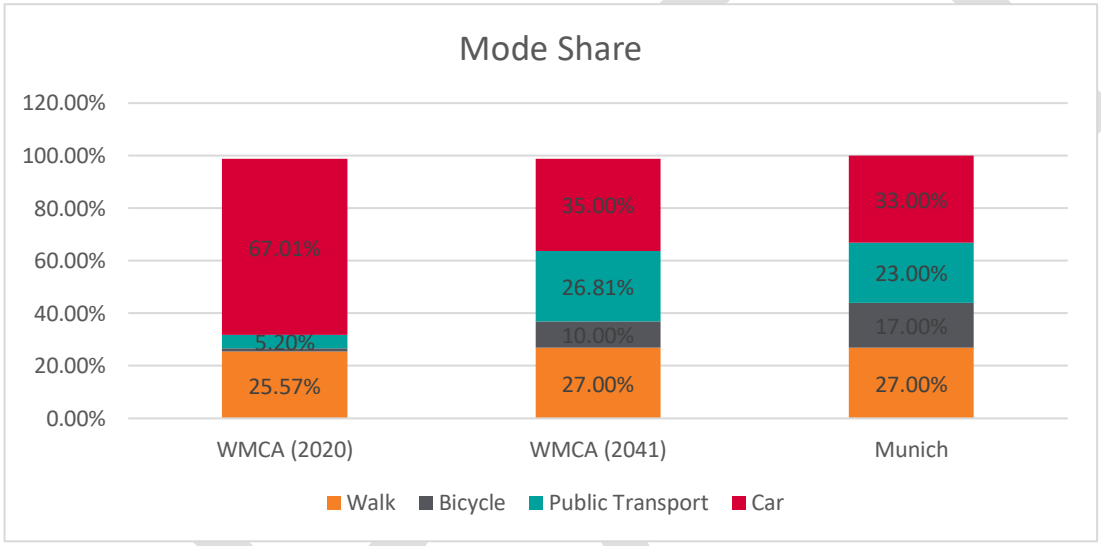

Figure 1 – Comparison of transport modal share distribution in WMCA (current), in WMCA by 2041 and in Munich.

Bus and Taxi Fleets

This goal explores the electrification of buses and taxis in the WMCA area. The number of licensed taxis and average distanced travelled per person in the WMCA is taken from Government data[43, 44]. Fuel consumption and efficiency data for ICE[45] (Government data) and electric cars[46] (Low Carbon Vehicle Partnership data) is used to calculate gasoline and diesel savings and increased electricity consumption.

Petroleum total consumption for buses in the WMCA is available from the model (based on sub-national Government data[47]) and fuel efficiency from London buses' consumption averages[48]. Electric bus energy consumption is taken from LowCVP data[49].

[39] https://www.tfwm.org.uk/strategy/movement-for-growth/
[40] https://www.researchgate.net/publication/301903071_Reducing_car_dependence_in_the_heart_of_Europe_Lessons_from_Germany_Austria_and_Switz_erland
[41] https://www.gov.uk/government/statistical-data-sets/nts03-modal-comparisons
[42] https://www.gov.uk/government/statistical-data-sets/energy-and-environment-data-tables-env
[43] https://www.gov.uk/government/statistical-data-sets/taxi01-taxis-private-hire-vehilces-and-their-drivers
[44] https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/833569/taxi-and-phv-england-2019.pdf
[45] https://www.gov.uk/government/statistical-data-sets/energy-and-environment-data-tables-env
[46] https://www.lowcvp.org.uk/initiatives/lceb/local-policy/lta-toolkit.htm
[47] https://www.gov.uk/government/collections/total-final-energy-consumption-at-sub-national-level
[48] https://tfl.gov.uk/info-for/media/press-releases/2014/october/new-routemaster-buses-on-route-453
[49] https://www.lowcvp.org.uk/initiatives/lceb/local-policy/lta-toolkit.htm

Heavy Goods Vehicle Fleet

This goal considers the decarbonisation of HGVs and its associated carbon reduction from lower consumption of diesel. While there is still uncertainty in terms of the technology which will displace conventional HGVs, it has been assumed that a direct-electric solution will be used, as it will provide the lowest operational costs. However, it is acknowledged that other solutions, such as hydrogen, could have a role in the decarbonisation of HGVs. A hydrogen solution will result in higher electricity requirements to decarbonise HGVs, owing to the energy lost in the production, transportation and storage of hydrogen when compared to a direct-electric solution.

Petroleum total consumption for buses in the WMCA is available from the model (based on sub-national Government data[50]). Fuel efficiency for HGVs is taken from Government data[51], and energy efficiency for electric HGVs is taken from an academic analysis carried out by Transport & Environment[52]. The amount of required electricity to decarbonise HGVs can therefore be calculated.

Accelerated EV uptake

The Business as Usual scenario already considers the 2030 ICE ban for cars and vans announced by the Government in November 2020, as part of their Ten Point Plan[53]. This has been modelled as a slow, natural replacement cycle of vehicles over their life period out to 2050. However, the CCC's most recent analysis, published in December 2020, to meet their advised Sixth Carbon Budget , projects a much higher uptake of electric vehicles during the 2020s and 2030s. As such, this goal considers the shift in carbon savings from the updated timeline.

This goal uses data from the CCC's recently released Sixth Carbon Budget[54] on the projected trajectory for new EV car sales[55]. Car sales in 2020 are taken from Government data. Car life is assumed as 14 years. The high goal uses the Tailwinds scenario, the medium goal uses the Balanced Pathway scenario and the low goal uses the Headwinds scenario. The EV uptake trajectory for each scenario can be seen below:

Table 11. EV uptake trajectories according to each of the CCC scenarios.

Year	Tailwinds	Balanced Pathway	Headwinds
2020	1.19%	1.19%	1.19%
2021	1.48%	1.45%	1.37%
2022	2.43%	2.31%	2.01%
2023	3.96%	3.66%	2.89%
2024	6.45%	5.80%	4.11%
2025	10.48%	9.16%	5.80%
2026	14.95%	13.02%	7.98%
2027	19.93%	17.44%	10.81%
2028	25.47%	22.51%	14.50%
2029	31.65%	28.34%	19.32%
2030	38.54%	35.05%	25.64%
2031	45.37%	41.81%	32.03%
2032	52.14%	48.61%	38.50%
2033	58.85%	55.35%	45.04%
2034	65.50%	62.03%	51.68%
2035	71.57%	68.17%	57.97%
2036	77.26%	73.96%	64.05%
2037	82.38%	79.26%	69.86%
2038	86.60%	83.82%	75.32%
2039	89.40%	87.23%	80.30%
2040	91.75%	90.16%	84.79%
2041	93.60%	92.53%	88.65%

[50] https://www.gov.uk/government/collections/total-final-energy-consumption-at-sub-national-level
[51] https://www.gov.uk/government/statistical-data-sets/energy-and-environment-data-tables-env
[52] https://www.transportenvironment.org/sites/te/files/publications/20180725_T%26E_Battery_Electric_Trucks_EU_FINAL.pdf
[53] https://www.gov.uk/government/publications/the-ten-point-plan-for-a-green-industrial-revolution
[54] https://www.theccc.org.uk/publication/sixth-carbon-budget/
[55] https://www.gov.uk/government/statistical-data-sets/all-vehicles-veh01

Land Use Natural Capital

This goal and the assumptions behind the calculations have been provided separately in Appendix C.

Land Use Renewables

This goal considered the potential for the development of large-scale renewable installations, namely onshore wind and solar PV. This goal used input from the GIS analysis, which identified areas that are ideally suited for solar and wind development. The list of constraints includes requirements on the type of land as well as resource constraints.

For wind developments, a density of 9 ha per MW was used, as per the West Midlands Renewable Capacity Study[56]. This was validated against a range of UK wind farms (Whitelee[57], Scout Moor[58] and Cefn Croes[59]). For areas of less than 20 ha, a density of 1 MW per 3 ha was used, as projects with very few turbines (e.g. in a farm) require less spacing. The average UK wind factor of 26.6% was used to calculate energy generation (conservative assumption, as new wind farms are better designed), taken from BEIS data[60].

For solar developments, a density of 2 ha per MW[61] was used. The average UK solar PV factor of 11.1% was used to calculate energy generation, taken from BEIS data[62].

[56] https://www.stratford.gov.uk/doc/205885/name/ED481%20Renewable%20Energy%20Capacity%20Study%20for%20the%20West%20Midlands%20March%202011.pdf/ https://www.stratford.gov.uk/doc/205885/name/ED481%20Renewable%20Energy%20Capacity%20Study%20for%20the%20West%20Midlands%20March%202011.pdf/
[57] https://www.scottishpowerrenewables.com/pages/whitelee.aspx
[58] http://www3.lancashire.gov.uk/council/meetings/displayFile.asp?FTYPE=M&FILEID=8454
[59] https://www.thewindpower.net/wind-farm-1452-cefn-croes-inc-devils-bridge-bryn-du-nffo-contract-nd-nd.php
[60] https://www.gov.uk/government/statistics/energy-trends-section-6-renewables
[61] https://www.solar-trade.org.uk/solar-farms/#:~:text=Some%20facts%20about%20solar%20farms&text=%E2%80%93%20For%20every%205MW%20installed%2C%20a,megawatts%20(MW)%20of%20installation
[62] https://www.gov.uk/government/statistics/energy-trends-section-6-renewables